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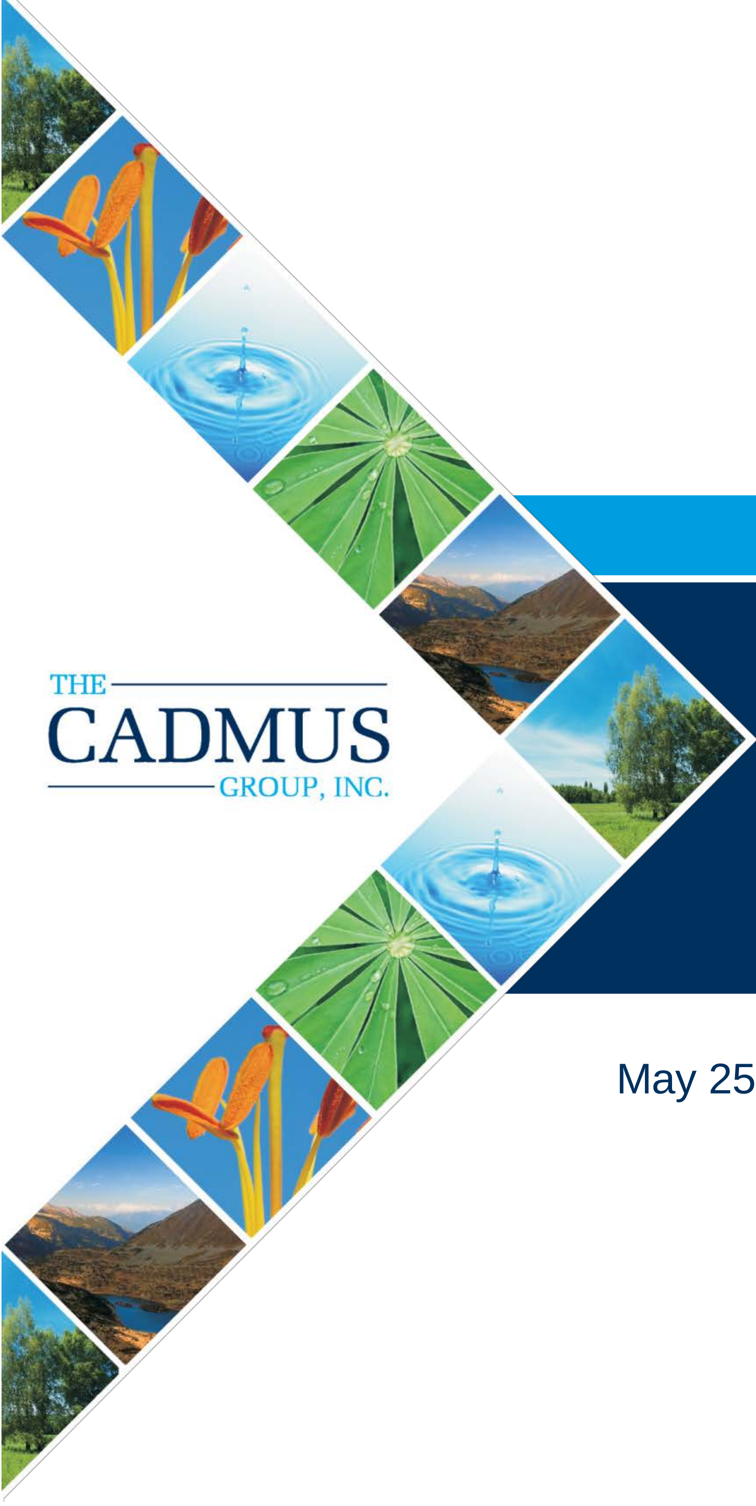
REPRESENTING

THE CADMUS GROUP, INC.



THE CADMUS GROUP, INC.

Avista 2010–2011 Multi-Sector Electric Impact Evaluation Report

May 25, 2012

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Table of Contents

PORTFOLIO EXECUTIVE SUMMARY

The Cadmus Group, Inc. was contracted by Avista Corporation to complete process and impact evaluations of the 2010 and 2011 gas and electric demand-side management (DSM) programs. This report only presents our impact findings for the PY 2010-2011 electric portfolio.

Evaluation Activities

For each of the three sectors—residential, nonresidential, and low-income— plus the Contingency Program, we employed a variety of evaluation methods and activities. These are shown in Table ES-1.

Table ES-1. 2010-2011 Electric Programs Evaluation Activities

Sector	Program	Document/ Database Review	Metering	Verification 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	✓		✓	✓		
	Renewables						
Nonresidential	Prescriptive Programs	✓	✓	✓	✓	✓	
	Site-Specific	✓	✓	✓	✓	✓	✓
	EnergySmart Grocer	✓	✓	✓	✓		
Low-Income	Low-Income Programs	✓				✓	
Residential/ Nonresidential	CFL Contingency	✓			✓		

Key Findings and Conclusions

Residential

For PY2010 and PY2011, Avista's residential electric programs produced 76,928,027 kWh in savings (33,491,536 kWh from the CFL Contingency Program and 43,436,491 kWh from all other programs), which yielded an overall realization rate of 83%. All residential electric savings achieved 184% of IRP goals.

The major residential program conclusions are:

- Overall, residential electric program customers responded well to the programs and often installed several measures within the same program year.
- Avista's program and tracking databases were sufficient for evaluation purposes, providing adequate contact, measure and savings information. The database review confirmed that the information was reliable and accurate.
- All measures rebated through the program were installed and were operating. With only a few minor exceptions, all measures were determined to meet program qualification standards.

Nonresidential

The Cadmus team evaluated 223 of 4,215 measures installed through the program, representing 29% of reported savings.

For PY2010 and PY2011, Avista's nonresidential electric programs produced 104,060,197 kWh in savings (6,972,374 kWh from the CFL Contingency Program and 97,087,824 kWh from all other programs), which yielded an overall realization rate of 96%. All nonresidential electric savings achieved 118% of IRP goals.

Cadmus identified the following key findings that adjusted energy savings:

- Some participants did not operate the incented equipment correctly or did not complete the improvements expected for the measure.
- Some participant heating or cooling loads did not achieve the level projected for post-installation usage.
- Some simulation models did not accurately represent the actual as-built building or system operation.
- HVAC fan VFD deemed savings estimates may have been too conservative and were based on an older study from 1995.
- Avista implementation staff may not have conducted thorough analysis of energy savings calculations provided by participants or third-party contractors for all projects.
- Avista implementation staff made errors on some projects in entering data to characterize building or measure performance.
- Cadmus could have streamlined the sampling process if Avista's database had recorded site addresses and contact information. Having measure-level data, such as specific measure type and quantity, for each project would have improved the range and depth of our evaluation activities.

Low-Income

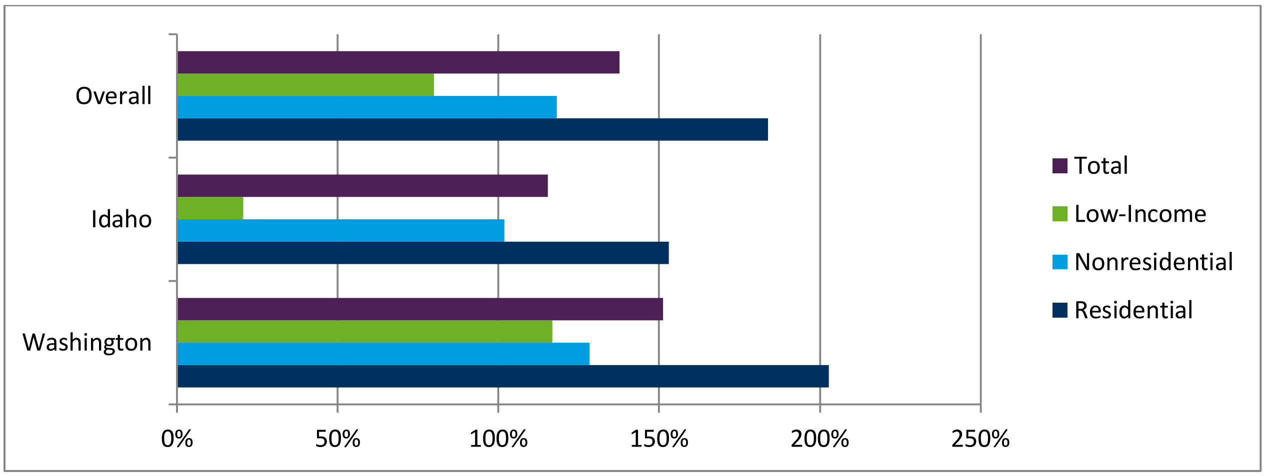
For PY2010 and PY2011, Avista's low-income electric programs produced 3,225,929 kWh in savings, which yielded an overall realization rate of 66%. Low-income electric savings achieved 80% of IRP goals.

Billing analysis results for electric (non-conversion) and conversion participant impacts yielded high levels of precision. To place Avista program savings estimates in context, we compared billing analysis results from other low-income weatherization efforts from across the country. Avista's results were on the higher end of the range of values.

Savings Results

Figure ES-1 displays the portfolio achieved gross savings relative to reported goals by sector, state, and overall. All sectors in both states achieved the stated goals except for Idaho's Low-Income Program. The portfolio overall achieved 138% of the stated goals.

Figure ES-1-1. Gross Achieved Savings Percentages of IRP Goals



The following two tables show sector-level gross savings values and realization rates compared to reported savings and IRP goals (CFL Contingency savings are included in the residential and nonresidential sector totals).

Table ES-1-2. 2010-2011 Reported and Gross Verified Savings by State and Sector (kWh)

Sector	Washington			Idaho			Total		
	Expected Savings	Gross Verified Savings	Real-ization Rate	Expected Savings	Gross Verified Savings	Real-ization Rate	Expected Savings	Gross Verified Savings	Real-ization Rate
Residential	63,340,690	52,463,788	83%	29,838,695	24,464,240	82%	93,179,385	76,928,027	83%
Nonresidential	73,583,693	69,837,841	95%	34,549,236	34,222,356	99%	108,132,929	104,060,197	96%
Low-Income	3,749,264	2,910,327	78%	1,156,559	315,602	27%	4,905,823	3,225,929	66%
Total	140,673,647	125,211,956	89%	65,544,490	59,002,198	90%	206,218,137	184,214,154	89%

Table ES-1-3. 2010-2011 IRP Goals and Gross Verified Savings by State and Sector (kWh)

Sector	Washington			Idaho			Total		
	Savings Goal	Gross Achieved	% Achieved	Savings Goal	Gross Achieved	% Achieved	Savings Goal	Gross Achieved	% Achieved
Residential	25,871,685	52,463,788	203%	15,986,226	24,464,240	153%	41,857,911	76,928,027	184%
Nonresidential	54,405,239	69,837,841	128%	33,617,010	34,222,356	102%	88,022,249	104,060,197	118%
Low-Income	2,492,905	2,910,327	117%	1,540,377	315,602	20%	4,033,282	3,225,929	80%
Total	82,769,829	125,211,956	151%	51,143,613	59,002,198	115%	133,913,442	184,214,154	138%

In summary, the 2010-2011 electric portfolio achieved a realization rate of 89% of reported savings, and a 138% of the IRP goals. The great majority of claimed installations were verified. The major driver in the derived values of the realization rates was the change in per unit savings as a result of the evaluation. The nonresidential sector had the highest realization rate of 96% from reported savings, but the residential sector had the highest goal achievement rate of 184% of Avista IRP goals. Washington had higher goal achievement overall at 151%.

Recommendations and Further Analysis

Residential

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.
- Move all clothes washer rebates to the electric program unless there is a large penetration of gas dryers. Forthcoming Residential Building Stock Assessment data can support future analysis.
- Include a SEER requirement to increase savings for high-efficiency heat pump participation. Consider continuing the Variable Speed Motor measure in conjunction with any change to equipment efficiency requirements. Often, an electrically commutated motor (ECM) is standard on the highest efficiency heat pump systems.
- Consider restricting dual fuel customers who acquire multiple rebates that have interactive effects. If program changes are made to reduce the participation of dual fuel customers in certain measure categories, future evaluation activities should reassess the participant penetration of the dual fuel home.
- 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 estimating savings and incenting systems separately for all-electric heating systems.

- Consider tiered incentives by SEER rating as higher SEER systems generally require ECM fan motors to achieve certain SEER ratings.

The following are recommended future research areas for this program:

- Perform a review of all available secondary research and/or collect primary data on the penetration of gas heated clothes dryers within Avista's gas territory.
- Perform a targeted billing analysis on weatherization participants that use both electricity and gas to heat their home.
- 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.
- Identify new, cost-effective measures that can be added to portfolio.

Nonresidential

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 effectiveness of the evaluations:

- Avista should create a quality control system to double-check all projects with savings over 300,000 kWh. An Avista EM&V engineer reported he has begun to review these types of projects.
- Avista should consider performing three- to six-month post-installation random inspections to confirm measure persistence and to identify opportunities to improve performance.
- Avista should consider conducting future studies to quantify less conservative assumptions for HVAC fan VFD deemed savings estimates.
- Avista should consider revising its methodology for calculating and tracking HVAC/lighting interactive effects.
- Avista should consider adding a program for recommissioning measures that were identified as non-functional during the previous year's evaluation process and report the energy savings these measures achieve in the subsequent year.

Low-Income

The impact evaluation revealed several areas where program performance and savings accuracy could be improved:

- Standardize calculation of expected savings between states and agencies.
- Work with Idaho agencies to provide refrigerator replacements.
- Perform quality checks on expected savings estimates.
- Track alternative heating sources.
- Consider performing quantitative, non-energy benefit analyses.

- Include high-use customers in program targeting.

Recommendations for possible future analysis include:

- Consider additional analyses of measure-level impacts. Billing analysis is used for estimating whole-house energy savings and measure-level savings, given a sufficient sample and large energy savings relative to household consumption.
- Consider undertaking a non-energy benefits estimation task.

1 2011 Residential Electric Impact Report

Executive Summary

Avista's residential electric demand-side management (DSM) programs reported savings of 48,361,828 kWh during the 2010 and 2011 program years. This report explains the methods undertaken to qualify and verify these savings. The PY 2010 and 2011 DSM residential electric programs are Simple Steps, Smart Savings™; Second Refrigerator and Freezer Recycling; ENERGY STAR® Products; ENERGY STAR Homes; Heating and Cooling Efficiency; Space and Water Conversions; Water Heating; and Weatherization and Shell Measures. Cadmus reviewed every prescriptive measure with the one exception of photovoltaic installations.

Evaluation Methodology

Evaluation methods and activities employed are displayed in Table 1-1.

Table 1-1. 2011 Residential Electric Programs Evaluation Activities

Sector	Residential Program	Document/ Database Review	Verification Site Visit	Survey	Metering	Billing Analysis	Modeling
Residential	Simple Steps, Smart Savings™	✓					
	Second Refrigerator and Freezer Recycling	✓		✓			
	ENERGY STAR Products	✓	✓	✓			
	Heating and Cooling Efficiency	✓	✓	✓	✓		
	Space and Water Conversions	✓	✓	✓			
	Weatherization and Shell Measures	✓	✓	✓		✓	
	Water Heating	✓	✓	✓			
	ENERGY STAR® Homes	✓	✓	✓			✓
	Residential Renewables						

Energy Savings

Cadmus adjusted the claimed savings to reflect updated values following our engineering analysis and reference to recent studies. We found significant changes in savings for all programs. Some changes were due to updating baseline and measure levels of efficiency to meet changes in federal and ENERGY STAR standards. Other changes were the result of specific activities completed as part of this evaluation, such as site visits to confirm measure installation and qualification, a billing analysis to investigate the impact of the installation of insulation or windows on energy consumption, and metering of residential heat pumps to understand annual consumption patterns and savings achieved through high-efficiency installations.

The aggregated adjusted gross savings and resulting realization rates for each program are shown in Table 1-2. Overall, the residential electric programs achieved an adjusted gross realization rate of 90%.

Table 1-2. Reported and Adjusted Gross Savings

Program Name	Reported Savings (kWh)	Adjusted Gross (kWh)	Realization Rates
Simple Steps, Smart Savings™	18,097,253	24,601,728	136%
Second Refrigerator and Freezer Recycling	4,529,827	4,054,783	90%
ENERGY STAR Products	3,000,261	3,623,509	121%
Heating and Cooling Efficiency	9,432,431	4,743,627	50%
Space and Water Conversions	3,169,151	3,577,879	113%
Weatherization/Shell	8,993,856	2,164,907	24%
Water Heating	312,156	124,460	40%
ENERGY STAR Homes	688,267	406,972	59%
Residential Renewables	138,626	138,626	100%
PROGRAM TOTAL	48,361,828	43,436,491	90%

Table 1-3. Reported and Adjusted Gross Savings by State

Program Name	Washington			Idaho		
	Reported Savings (kWh)	Adjusted Gross (kWh)	Realization Rates	Reported Savings (kWh)	Adjusted Gross (kWh)	Realization Rates
Simple Steps, Smart Savings™	12,064,835	16,401,152	136%	6,032,418	8,200,576	136%
Second Refrigerator and Freezer Recycling	3,421,329	3,062,439	90%	1,108,498	992,344	90%
ENERGY STAR Products	2,016,007	2,444,129	121%	984,254	1,179,380	120%
Heating and Cooling Efficiency	5,616,729	2,751,306	49%	3,815,702	1,992,321	52%
Space and Water Conversions	2,245,319	2,463,378	110%	923,832	1,114,501	121%
Weatherization and Shell Measures	6,064,022	1,447,434	24%	2,929,834	717,472	24%
Water Heating	253,253	100,997	40%	58,903	23,463	40%
ENERGY STAR Homes	539,437	336,246	62%	148,830	70,726	48%
Residential Renewables	109,143	109,143	100%	29,483	29,483	100%
PROGRAM TOTAL	32,330,075	29,116,224	90%	16,031,753	14,320,267	89%

Table 1-4. Avista 2010 and 2011 DSM Programs Participation Counts

Program	Washington Measure Count	Idaho Measure Count	Total Measure Count
Simple Steps, Smart Savings™ (Units Sold)	523,677	261,839	785,516
Second Refrigerator and Freezer Recycling	2,939	952	3,891
ENERGY STAR Products	14,907	7,229	22,136
Heating and Cooling Efficiency	3,730	2,120	5,850
Space and Water Conversions	321	120	441
Weatherization and Shell Measures	4,717	1,891	6,608

Program	Washington Measure Count	Idaho Measure Count	Total Measure Count
Water Heating	848	197	1,045
ENERGY STAR® Homes	261	45	306
Residential Renewables	26	7	33
Total Measures	551,426	274,400	825,826

Cadmus verified that a total of 43,436,491 kWh have been saved through the installation of 825,826 measures during PY 2010 and 2011 of the electric DSM programs.

1.1 Introduction

We designed our impact evaluation to verify reported program participation and energy savings. For the evaluation, we used data collected and reported in the tracking database, online application forms, phone surveys, on-site visits, on-site metering, billing analyses, and applicable updated deemed savings values.

1.2 Methodology

1.2.1 Sampling

Site Visit Sampling

Cadmus randomly selected participants for verification site visits from the 2010 and 2011 electric program population and the 2011 gas program population. Participants were scheduled by Cadmus staff via telephone. If a selected participant could not be reached or refused to participate in the site visit, then we selected a replacement within the same geographic region from the backup sample. Each recruited site visit participant received a $25 gift card in appreciation for making time for this evaluation.

A participant was initially sampled using one measure record. However, if a customer received multiple rebates during the program year, then all measures for both fuels were verified during the site visit.

Table 1-5 shows that Cadmus completed site visits at 174 homes, which covered 258 unique measures across both program fuels.

Table 1-5. Electric Measure Site Visits Completed

Total Homes Visited	174
Total Measures Verified	258

Survey Sampling

The participant sampling plan was based on multiple factors, including feasibility of reaching customers, program participant population, and research topics of interest. Customer fuel type was not a factor in survey sampling.

Cadmus did not conduct participant surveys with Simple Steps, Smart Savings customers, as this is an upstream program and therefore does not track participant contact information. Similarly, for ENERGY STAR Homes, we surveyed the builders, not the buyers.

Table 1-6- shows the number of surveys achieved, and the resulting absolute precision for each program.

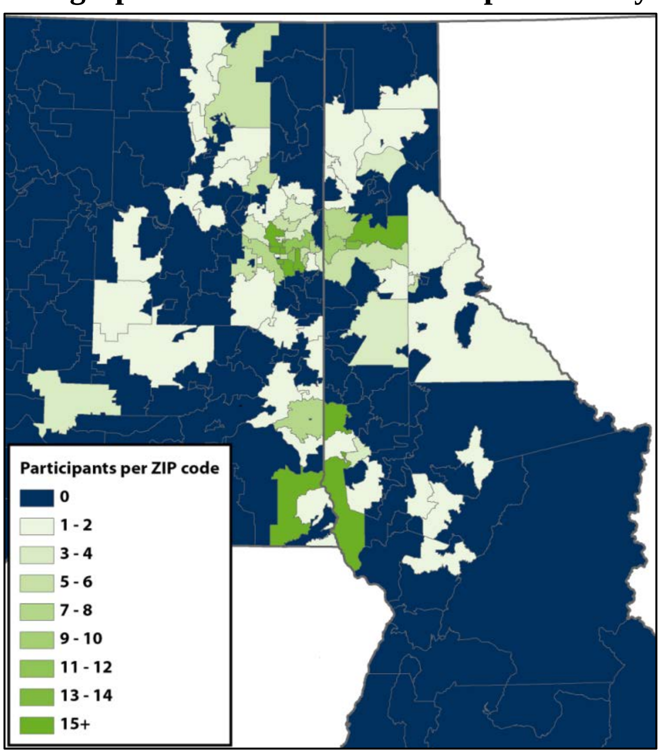
Table 1-6. Participant Survey Sample Sizes and Savings-Weighted Precision Estimates by Program (Both Gas and Electric Participants)

Program	Total Program Participants	Survey Completes	Absolute Precision at 90% Confidence
ENERGY STAR® Products	10,983	79	±9.3%
Heating and Cooling Efficiency	4,156	126	±7.2%
Weatherization and Shell Measures	3,981	72	±9.6%
Home Energy Audit Pilot	664	56	±10.3%
Second Refrigerator and Freezer Recycling	1,903	74	±9.3%
Space and Water Conversions	314	57	±9.1%
Overall	22,001	464	±5.2%

Not surprisingly, the geographic distribution of survey respondents was clustered around urban centers, especially the cities of Spokane, Pullman, Moscow and Lewiston, shown in Figure 1-1.

Additional specific surveys were completed as part of the CFL Contingency Plan impact analysis and are discussed in more detail in Chapter 4.

Figure 1-1. Geographic Distribution of Participant Survey Completes



1.2.2 Data Collection and Analysis

Site Visits

The on-site verification of measures included visually inspecting the measure(s), verifying documentation, ensuring that the unit is still operable, recording make and model information, recording home characteristics, and determining program qualification. Specific details on our verification and analysis activities for each measure are included in the Program Results and Findings section below.

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 measures that were incorrectly classified and measures with duplicate records because rebates were paid in two parts. Cadmus reported all cases to Avista. Specific adjustments are described in detail later in the report. In most cases, we made measure count adjustments to correct inconsistencies.

Metering

Cadmus metered 79 high-efficiency air source heat pump installations. We used the metered data to estimate the unit’s annual heating and cooling consumption and its annual energy savings.

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 billing data to determine the adjusted gross savings and realization rates for electric weatherization/windows in PY 2010 and PY 2011. We used a pre- and post-installation combined Conditional Savings Analysis (CSA) and Princeton Score Keeping Method (PRISM) approach.

1.2.3 Verification Rates

Cadmus determined verification rates for each program, but not for each measure. 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 a 100% verification rate for the programs.

1.2.4 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 site visit verification sample. One was a floor insulation project in which the base case condition 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:

1. Review program database to determine if the adjusted measure counts correctly represent the number of installations.
2. Conduct a phone survey or site visit to verify that the installation is within Avista’s service territory.
3. Calculate verification and qualification rates.
4. Calculate deemed measure savings for products rebated during the program period.
5. 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 the utility's 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 finding 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 CFL Contingency Program (discussed in Chapter 4).

This program incents various CFL products from standard twist bulbs 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.

Analysis

Similar to CFL Contingency Program, 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:

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

Where:

CFL Watts = Wattage of the CFL

DWM = Delta watt multiplier, or the difference in wattage between baseline bulb and the CFL divided by the wattage of the CFL

HOU = Hours-of-use, daily lighting operating hours

DAYS = Days per year, 365

WHF = Waste heat factor is the 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 (CFL Watts) and Multiplier (DWM)

According to Avista's reported sales, the program incented over 832,000 CFLs, as shown in Table 1-7. We reviewed Avista's sales database and were able to verify roughly 785,000 CFLs. 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 claimed number CFLs.[1]

Table 1-7. Total Reported and Evaluated CFLs Sold by Year

Program Year	Reported			Evaluated		
	Twist	Specialty	Total	Twist	Specialty	Total
2010	177,007	90,320	267,327	175,514	87,291	262,805
2011	394,858	169,841	564,699	367,134	155,577	522,711
Total	571,865	260,161	832,026	542,648	242,868	785,516

Avista sales data included CFL wattage, units sold, estimated kWh, and bulb type. CFL wattage came directly from the database for each bulb; however, 46,484 bulbs (less than 6% of the total) did not include wattage in the database. We used an average of each bulb type, standard, and specialty to estimate the missing wattage information. The average CFL wattage, weighted across PY 2010 and PY 2011, for standard twist and specialty, was 16.18 watts and 14.28 watts, respectively.

Cadmus relied on the RTF for both standard twist and specialty bulbs to determine the DWM. The DWM from the RTF workbooks was 2.60 for twist and 3.13 for specialty.[2] The product of the DWM and the average CFL wattage is the reduction in wattage achieved through the installation of the average CFL.

Hours of Use

Cadmus had estimated hours of use (HOU) for the CFL Contingency Program and applied the same HOU for this program to maintain consistency with both programs. Cadmus used a multistate modeling approach, which built on light logger data collected from studies in four states: Missouri, Michigan, Ohio, and Maryland.[3] Base on this multistate modeling approach, Cadmus calculated an average HOU of 2.45. This approach is calculated using ANCOVA model coefficients, drew from combined, multistate, multiyear data from recent CFL HOU metering studies. These data were combined into a regression model with HOU as the dependent variable.

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1 The database included two worksheets of sales and adjusted sale for each month.

2 The RTF DWM represents the 2011 baseline and does not include federal EISA impacts starting in 2012.

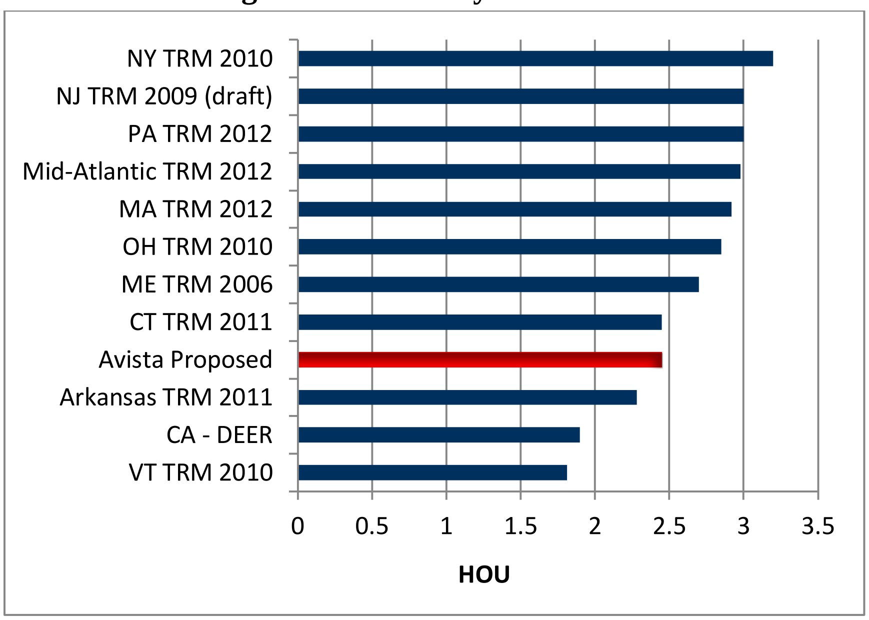
3 The Cadmus Group, Inc. *2010 Evaluation, Measurement, and Verification Report*. Dayton Power and Light. March 15, 2011

Explanatory variables included presence of children, existing CFL saturation, day type (weekend/weekday), and room type. The multistate model was used to estimate HOU by room type. The room type HOUs were then weighted using CFL Contingency surveys to calculate the program average HOU of 2.45.

We believe the HOU we estimated for the CFL Contingency Program is more appropriate for Avista's territory than other estimates available. It is important to compare Cadmus' estimate of HOU to other estimates used in the region. The RTF currently utilizes an HOU estimate of 1.9, which represents the average across ***all*** residential bulbs in California. Cadmus believes CFLs are placed in a higher use area than the average residential bulb and therefore do not support the use of 1.9 as the average CFL HOU. Cadmus advocates for the use of the multi-state study over the California study for the following reasons. The multi-state study controls not only for room type, but also for existing CFL saturation, the presence of children in the home, and day type (weekday/weekend). Not only does this result in more precise estimates than one would achieve by simply taking a weighted average, but it allows us to estimate a value more appropriate to Avista's customer base. The 2.45 hours per day results in an annual 895 hours per year.[4]

When compared to various technical reference manuals (TRMs) across the country, our value of 2.45 is in line and appears to be conservative compared with the TRMs as shown in Figure 1-2.

Figure 1-2. HOU By Jurisdiction



* VT TRM 2010: Projected estimate for 2011. Daily usage is DPS-VEIC agreement March 2009 (see ref doc). Based on November 2008 CFL Reduction Model. Annual operating hours are calculated as (Daily usage * 365). CA (DEER): 2008 metered evaluation of an average across all bulbs in CA. Arkansas TRM 2011: CFL METERING STUDY FINAL REPORT 2005, Pacific Gas & Electric Company, San Diego Gas & Electric Company, and Southern California

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4 Cadmus found a discrepancy between the RTF standard CFL workbook and the RTF specialty CFL workbook in terms of the number of days per year, 365 and 365.25 respectively. For consistency within Avista's CFL programs, we used 365 days for all bulb types.

Edison Company, 2005. CT TRM 2011: Residential Lighting Markdown Impact Evaluation, Nexus Market Research, January 20, 2009. Maine TRM 2006: Impact evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs. Nexus Market Research & RLW Analytics. October 1, 2004. OH TRM 2010 (draft): Based on weighted average daylength adjusted hours from Duke Energy, June 2010; "Ohio Residential Smart Saver CFL Program" MA TRM 2012: Nexus Market Research and RLW Analytics (2008). Residential Lighting Measure Life Study. Prepared for New England Residential Lighting Program Sponsors. Mid-Atlantic TRM 2012: Based on EmPOWER Maryland DRAFT 2010 Interim Evaluation Report; Chapter 5: Lighting and Appliances. PA TRM 2012: US Department of Energy, ENERGY STAR Calculator. Accessed 3-16-2009. NJ TRM 2009: US Department of Energy, ENERGY STAR Calculator. NY TRM 2010: "Extended residential logging results" by Tom Ledyard, RLW Analytics Inc. and Lynn Heofgen, Nexus Market Research Inc., May 2, 2005, p.1.

Waste Heat Factor

The WHF is used to account for the change in annual HVAC energy, either lost or gained, due to the reduction in facility lighting energy. Similar to the CFL Contingency Program, Cadmus based the WHF on SEEM building models developed by the Northwest Power and Conservation Council. The SEEM building models estimate the change in HVAC equipment energy use due to the change in lighting technology; incandescent lamps to CFLs. In general, the models account for the interaction using load shape profiles of the HVAC and lighting equipment based on dwelling occupancy.

Cadmus aggregated the available models based 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]

Cadmus believes the utilized Council method is inherently conservative because it assumes a closed shell, i.e., all interior lamps including ceiling recessed cans are contained in a closed system so any heat put out by the bulbs goes into the building. In reality, the waste heat could transfer out of the conditioned space, therefore increasing the savings achieved through installation. Even though the methodology is conservative, Cadmus believes it is the best available method at this time.

In-Service Rate

The ISR for the Simple Steps, Smart Savings ™ program is based on the CFL Contingency Program, which determined a three year cumulative ISR of 91% from the logistic model with an upper limit of 98% to account for breakage/removal. This is likely to be a conservative value as participants are paying for bulbs in a different delivery mechanism than an unsolicited giveaway. In addition, one-third of all bulbs are expensive specialty bulbs and likely to have an ISR close to

5 Avista equipment type saturations are based on the 2011 participant survey for the CFL Contingency Program.

6 The RTF WHF is 86.4% for standard and 86.7% for specialty, which were adjusted to Avista's territory to be 89.8%.

or at 100%.[7,8] We believe that the Simple Steps program is sufficiently different from the one-time CFL Contingency Plan program and does not need a segmented three-year ISR. This is because Simple Steps is a continuous program so, for any given year, bulbs will be installed from the current year, one year prior, and two years prior.

Results and Findings

The calculated Unit Energy Savings (UES) is shown in Table 1-8. Unit Energy Savings by Year and Bulb Type. Avista's reported per unit savings was derived from RTF workbooks and assumed the average per unit of 24 kWh for twist bulbs and 17 kWh for specialty bulbs.

Table 1-8. Unit Energy Savings by Year and Bulb Type

Program Year	Reported		Evaluated	
	Twist	Specialty	Twist	Specialty
2010	24.00	17.00	31.03	31.47
2011	24.00	17.00	30.69	33.35
Average kWh	24.00	17.00	30.80	32.68

The reported per unit savings weighted across both bulb types is 21.81 kWh and the evaluated unit savings across both bulb types is 31.38 kWh.

Overall Program Savings

For PY 2010 and PY 2011, Avista's total reported savings is 18,097,253 kWh and evaluated savings is 24,601,728 kWh, as found in Table 9. Regional distribution of purchased CFLs is based on Avista's service territory of residential customers, two-thirds live in Washington and one-third lives in Idaho.

Table 1-9. Simple Steps, Smart Savings ™ PY 2010 and PY 2011 Reported and Verified Total Savings

Program Year	Region	Measure Count	Reported Savings	Verified Savings	Realization Rate
2010	WA	178,218	3,855,739	5,462,335	142%
	ID	89,109	1,927,869	2,731,167	142%
	Total	267,327	5,783,608	8,193,502	142%
2011	WA	376,466	8,209,097	10,941,773	133%
	ID	188,233	4,104,548	5,470,886	133%
	Total	564,699	12,313,645	16,412,659	133%
Total		832,026	18,097,253	24,601,728	136%

The realization rates for PY 2010 and PY 2011 are 142% and 133% for all bulbs, respectively, with an overall two-year realization rate of 136%. The ISR and HOU values are the main drivers for the difference between the reported and evaluated savings.

7 Expensive interior fixtures, like expensive specialty bulbs, were found have high installation rates (94.8%) according to Nexus Market Research, "Impact Evaluation of the Massachusetts, Rhode Island and Vermont 2003 Residential Lighting Programs", Final Report, October 1, 2004, p. 43 (Table 4-9).

8 The Massachusetts 2012 TRM assume 100% for specialty bulbs.

1.3.3 Second Refrigerator and Freezer Recycling

Summary of Program Participation

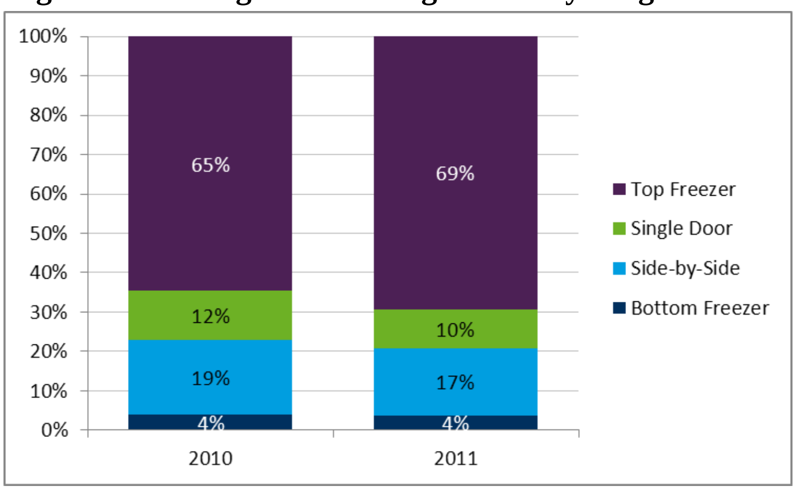
Cadmus reviewed the participant database, maintained by JACO, the program implementer, to test the reliability of program data. There were 3,891 total participant units during PY 2010 and PY 2011. Some participants recycled more than one appliance through the program. (See Table 1-10).

Table 1-10. Program Participation by Measure

Year	Measure	Idaho	Washington	Total
2010	Recycled Refrigerator	317	1,150	1,467
	Recycled Freezer	75	301	376
	Total	392	1,451	1,843
2011	Recycled Refrigerator	412	1,152	1,564
	Recycled Freezer	121	363	484
	Total	533	1,515	2,048
Total	Recycled Refrigerator	729	2,302	3,031
	Recycled Freezer	196	664	860
	Total	925	2,966	3,891

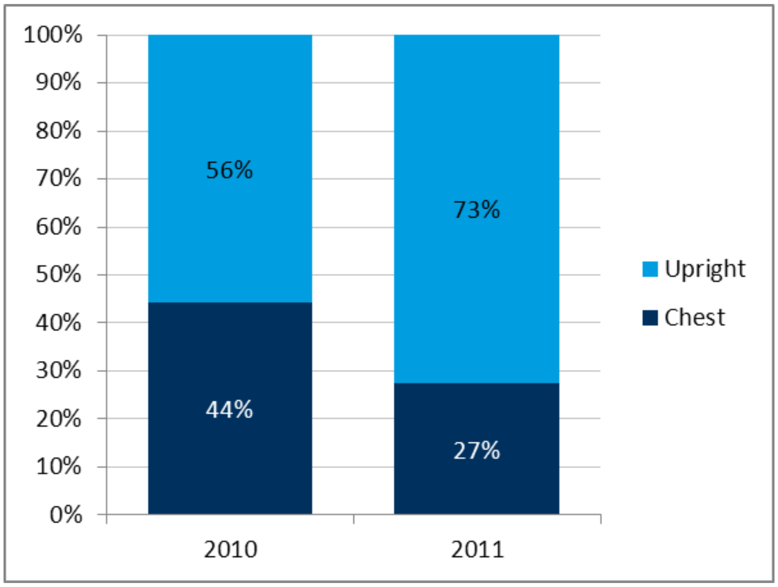
As shown in Figure 1-3, refrigerator configurations have not changed substantially during the last two program years.

Figure 1-3. Refrigerator Configuration by Program Year



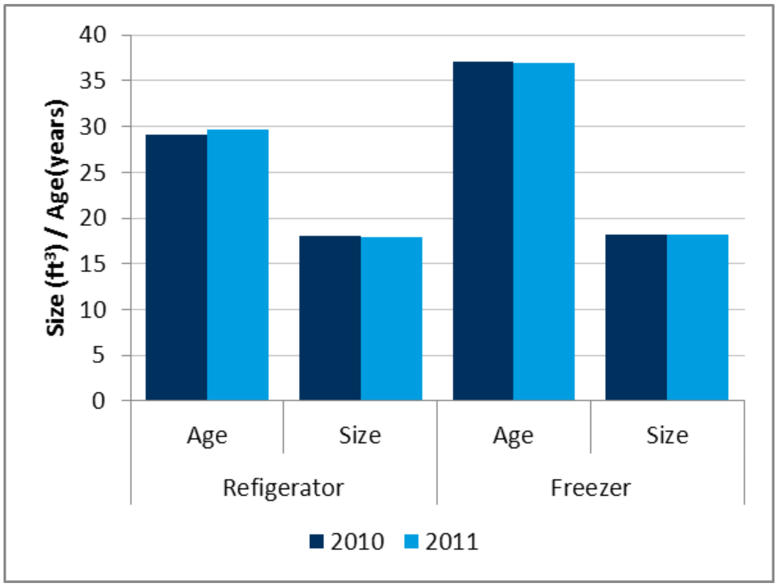
Substantially more upright freezer units were recycled in 2011, as shown in Figure 1-4.

Figure 1-4. Freezer Configuration by Program Year*



In 2011, recycled refrigerators averaged 29 years old, with 18 cubic feet of internal capacity. Recycled freezers averaged 37 years old, with 18 cubic feet of internal capacity. As seen in Figure 1-5, average appliance age and size did not change considerably from 2010.

Figure 1-5. Appliance Age and Size by Program Year



Determination of Average Annual Gross Savings

Cadmus developed a multivariate regression model to estimate gross UEC for retired refrigerators and freezers; model coefficients were estimated using an aggregated *in situ* metering dataset,[9] which is composed of over 400 appliances (metered as part of four California and Michigan evaluations conducted between May 2009 and April 2011).[10] These evaluations offered a wide distribution of appliance ages, sizes, configurations, usage scenarios (primary or secondary), and climate conditions. The diversity of the Avista participant dataset provided an effective secondary data source for estimating energy savings when Avista-specific metering could not be conducted.

For two reasons, Cadmus prefers using in-home metering data for estimating energy consumption, rather than the U.S. Department of Energy's (DOE) testing protocols:

- Metering an appliance in its original location captures impacts of critical external factors on appliance energy use (such as door openings, unit locations, and weather).
- Second, most existing DOE databases estimate energy consumption at the time of appliance manufacture, not by unit retirement.[11]

Each observation in the aggregated dataset represented an appliance metered for a minimum of 10 days, in a manner consistent with its preprogram use (e.g., in the same location, cooling food, used by the home's occupants). Cadmus mapped weather data to participating homes' ZIP code-specific National Oceanic and Atmospheric Administration (NOAA) weather stations, and collected additional on-site data on relevant appliance characteristics to ensure data consistency with administrator tracking databases.

Cadmus' approach to model specification weighed the impacts of including alternative independent variables, using a variety of criteria. The model specification process sought to include variables adequately reflecting program design, while maintaining model simplicity. For each set of estimated parameters, the analysis assessed variance inflation factors (VIFs), adjusted R^2s, and measures of statistical significance.[12]

Cadmus used the following modeling considerations in the specification process:

- **Considering all relevant appliance characteristics for inclusion in the model.** These included configuration, defrost type, age, size, and (in the case of refrigerators) primary or secondary designations. Age was considered as a continuous variable (capturing degradation); dummy variables for decades of manufacture (to approximate vintages); and a dummy variable for units manufactured before enactment of 1990's National Appliance Energy Conservation Act (NAECA), which required new refrigerators and freezers to be more energy-efficient.

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9 *In situ* metering involves metering units in the environment in which they are typically used. This contrasts with lab testing, where units are metered under controlled conditions.

10 Southern California Edison, Pacific Gas & Electric, San Diego Gas & Electric, DTE Energy, and Consumers Energy.

11 The California Energy Commission maintains one such database, which can be accessed online at: http://www.energy.ca.gov/appliances/database/historical_excel_files/Refrigeration/

12 VIFs, R^2s, and statistical significance are tests of the validity of a regression model.

- **Considering two environmental factors in the *in situ* model.** In addition to terms pertaining to appliance characteristics, the analysis considered two environmental factors in the *in situ* model: cooling/heating degree-days (CDD/HDD) and primary or secondary appliances. Appliances in warmer climate zones were assumed to consume greater energy—as were primary appliances—due to more frequent door openings.
- **Including interaction terms only due to theoretical importance to the model.** The model included only one interaction term, between units located in garages and CDDs, to account for additional impacts of warmer temperatures on refrigerators in unconditioned spaces.
- **Considering transformations of explanatory variables**. These included logged and squared values, based on theoretical and empirical grounds.

Cadmus used regression models to estimate consumption for refrigerators and freezers (Table 1-11, Table 1-12). Each independent variable's coefficient indicated the influence of that variable on daily consumption, holding all other variables constant. A positive coefficient indicated an upward influence on consumption; a negative coefficient indicated a downward effect.

The coefficient's value indicated the marginal impact of a one-point increase in the independent variable on the UEC. For instance, a 1 cubic foot increase in refrigerator size resulted in a 0.083 kWh increase in daily consumption. In the case of dummy variables, the value of the coefficient represented the difference in consumption, if the given condition was true. For example, in the refrigerator model, the coefficient for the variable indicating a refrigerator as a primary unit was 0.642, which means, all else being equal, a primary refrigerator consumed 0.642 kWh per day more than a secondary unit.

Refrigerator Regression Model

Table 1-11 shows the model used to estimate refrigerators' annual energy consumption, and its estimated parameters.

Table 1-11. Refrigerator UEC Regression Model Estimates (Dependent Variable = Average Daily kWh, Adj. R^2 = 0.33)

Independent Variables	Coefficient	p-Value	VIF
Intercept	0.769	<.0001	0.0
Age (years)	0.008	0.016	2.0
Dummy: Manufactured Pre-1990	0.827	<.0001	1.7
Size ($ft.^3$)	0.083	<.0001	1.9
Dummy: Single Door	-1.316	<.0001	1.3
Dummy: Side-by-Side	0.862	<.0001	1.6
Interaction: Unconditioned Space x CDDs	0.031	<.0001	1.3
Interaction: Unconditioned Space x HDDs	-0.049	<.0001	1.2
Dummy: Primary	0.642	<.0001	1.5

Results indicate:

- Older refrigerators experienced higher consumption due to year-on-year degradation.
- Refrigerators manufactured before the 1990 NAECA standard consumed more energy.

- Larger refrigerators consumed more energy.
- Single-door units consumed less energy, as these units typically do not have full freezers.
- Side-by-side refrigerators experienced higher consumption due to greater exposure to outside air when opened and through-door features, which are 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 1-12 details final freezer model.

Table 1-12. Freezer UEC Regression Model Estimates (Dependent Variable = Average Daily kWh, Adj. R^2 = 0.47)

Independent Variables	Coefficient	p-Value	VIF
Intercept	-0.372	0.043	0.0
Age (years)	0.036	<.0001	2.0
Dummy: Unit Manufactured Pre-1990	0.632	<.0001	2.1
Size ($ft.^3$)	0.107	<.0001	1.2
Dummy: Chest Freezer	-0.293	<.0001	1.2
Interaction: Unconditioned Space x CDDs	0.047	<.0001	1.1
Interaction: Unconditioned Space x HDDs	-0.052	<.0001	1.0

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 1-13 summarizes program averages or proportions for each independent variable.

Table 1-13. 2010-2011 Participant Mean Explanatory Variables*

Appliance	Independent Variables	2010 Participant Population Mean Value	2011 Participant Population Mean Value
Refrigerator	Age (years)	29.43	29.59
	Dummy: Manufactured Pre-1990	0.81	0.76
	Size (ft^3)	18.06	17.63
	Dummy: Single Door	0.13	0.10
	Dummy: Side-by-Side	0.19	0.16
	Interaction: Unconditioned Space x CDDs	0.33	0.34
	Interaction: Unconditioned Space x HDDs	6.91	6.86
	Dummy: Primary	0.51	0.51
Freezer	Age (years)	36.79	36.62
	Dummy: Unit Manufactured Pre-1990	0.94	0.93
	Size (ft^3)	17.92	18.08
	Dummy: Chest Freezer	0.26	0.26
	Interaction: Unconditioned Space x CDDs	0.43	0.44
	Interaction: Unconditioned Space x HDDs	9.04	9.01

*CDDs/HDDs are weighted average CDDs/HDDs from TMY3 data for weather stations mapped to participating appliance ZIP codes. TMY3 is a typical meteorological year, using median daily values for a variety of weather data collected from 1991–2005.

For example, using values from Table 1-12 and Table 1-13, the estimated annual UEC for 2011 freezers was calculated as:[13]

Figure 1-6. 2010–2011 Distribution of Estimated Annual UECs by Appliance Type

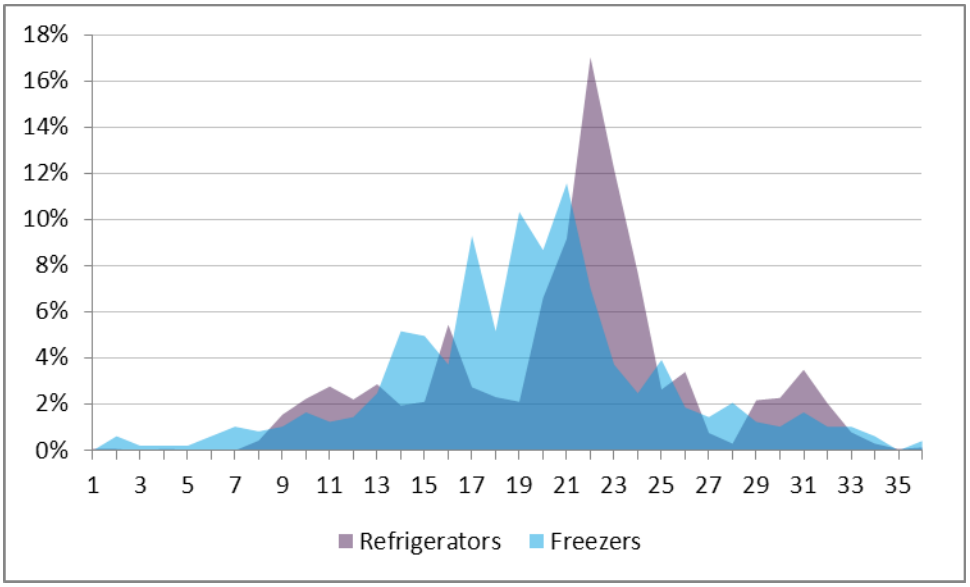

Table 1-14 presents estimated per-unit average annual energy consumption for refrigerators and freezers recycled by Avista in 2011. The next section describes how we adjusted these estimates to arrive at gross per-unit saving estimates for participant refrigerators and freezers.

Table 1-14. Estimate of Per-Unit Annual Energy Consumption

Appliance	2010 Evaluated Annual UEC (kWh/year)	Relative Precision (90% confidence)	2011 Evaluated Annual UEC (kWh/year)	Relative Precision (90% confidence)
Refrigerators	1,158	±3.4%	1,147	±3.4%
Freezers	1,073	±4.6%	1,074	±4.7%

Applying the Part Use Factor

To determine average per-unit gross energy savings for refrigerators and freezers, Cadmus calculated and applied the program's part-use factor, which accounted for participating appliances not plugged in year-round prior to participation. Retirement of appliances not previously in operation or operated for only part of the year would not yield the full year of energy savings presented in Table 1-15. We analyzed data from the 2010 participant survey to calculate part-use factors, which we then used in the following three participant categories:

- Participating units **not used for at least one full year** prior to being recycled were assigned a part-use factor of **0**. As the unit did not consume electricity, no savings were generated by its retirement.
- Recycled units **operating the full year** prior to participation were assigned a part-use factor of **1**.

- To determine part-use factors for units **used only a portion of the previous year**, we divided the average number of months such units were used by 12. The part-use factor for these appliances ranged between **0** and **1**.

Based on the per-unit gross annual energy savings presented in Table 1-15, and after adjusting for part-use, we determined gross energy savings generated by Avista's participation in 2010 and 2011, as presented in Table 1-16.

Table 1-15. 2010-2011 Per-Unit Gross Annual Energy Savings

Year	Measure	In Situ UEC (kwh/yr)	Part-Use Factor	Per-Unit Gross Energy Savings (kWh/yr)	Relative Precision (90% Confidence)
2010	Recycled Refrigerator	1,158	0.94	1,093	±4%
	Recycled Freezer	1,073	0.82	880	±14%
2011	Recycled Refrigerator	1,147	0.94	1,083	±4%
	Recycled Freezer	1,074	0.82	881	±14%

Using the above per-unit values, we calculated total program savings for the Second Refrigerator and Freezer Recycling program in Idaho to be 547 MWh per year (Table 1-16).

Table 1-16. Idaho 2010-2011 Annual Second Refrigerator and Freezer Recycling Program Savings

Year	Measure	Idaho		
		Units	Gross Savings (kWh/yr)	Net Savings (kWh/yr)
2010	Refrigerator	317	363,504	195,027
	Freezer	75	80,551	37,303
	Total	392	444,055	232,330
2011	Refrigerator	412	474,618	254,678
	Freezer	121	129,908	60,160
	Total	533	604,526	314,839
Total	Refrigerator	729	838,122	449,705
	Freezer	196	210,459	97,463
	Total	925	1,048,581	547,169

As shown in Table 1-17, we calculated total program savings for the Second Refrigerator and Freezer Recycling program in Washington to be 1,747 MWh per year.

Table 1-17. Washington 2010-2011 Annual Second Refrigerator and Freezer Recycling Program Savings

Year	Measure	Washington		
		Units	Gross Savings (kWh/yr)	Net Savings (kWh/yr)
2010	Refrigerator	1,150	1,318,704	707,510
	Freezer	301	323,277	149,711
	Total	**1,451**	**1,641,982**	**857,221**
2011	Refrigerator	1,152	1,320,998	708,741
	Freezer	363	389,866	180,548
	Total	**1,515**	**1,710,864**	**889,289**
Total	Refrigerator	2,302	2,639,702	1,416,251
	Freezer	664	713,143	330,259
	Total	**2,966**	**3,352,846**	**1,746,510**

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)

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

Analysis

The energy savings credited to the ENERGY STAR Products program must meet several criteria. First, the measure must still be installed and operating properly at the time of verification. Second, the number of installed pieces of equipment and their corresponding model numbers (if available) need to match Avista's database. Lastly, the unit must have been ENERGY STAR-qualified at the time of the program offering.

Clothes Washers

Cadmus calculated savings based on a 2009 study,[14] which metered more than 100 clothes washers in California homes for three weeks. The largest *in situ* metering study on residential clothes washers and dryers conducted in the last decade, this study indicated higher consumption and savings values than are often estimated. The dryers experienced the majority of energy

[14] The Cadmus Group, Inc. "Do the Savings Come Out in the Wash? A Large Scale Study of In-Situ Residential Laundry Systems." 2010. http://www.cadmusgroup.com/pdfs/Do_the_Savings_Come_Out_in_the_Wash.pdf

consumption and savings, as high-efficiency washing machines removed more moisture from clothes, allowing shorter drying times.

Four of the twelve clothes washers we verified had listed electricity as their domestic hot water fuel on the application, but during site visits to these homes we found that water was heated with gas. Cadmus therefore assumed that one-third of all clothes washer applications did not achieve electric domestic hot water savings. Finally, most of the energy savings resulting from these installations are from decreased dryer usage as the clothes exiting the washer are dryer when an ENERGY STAR model is used compared to a standard model. As a result, it is important to estimate the percent of homes that have gas domestic water heaters but use an electric dryer. We used the RTF assumption of 82% for this analysis as it represents the best available regional estimate.[15]

We made the following additional input assumptions:

- Washing cycles are estimated at 377 per year based on recent evaluation surveys conducted in the region.[16,17]
- We adjusted the average base case and efficient case Modified Energy Factor (MEF), which are both based on the same data utilized by the RTF. The baseline MEF equals the average market efficiency of units that did not qualify for the program. The efficient MEF equals the average market efficiency of units that did qualify for the program.

Dishwashers

Cadmus calculated dishwasher savings using the current method in the ENERGY STAR Calculator.[18] This is the only calculator available that provides consistent calculation of energy savings for either a gas or electric domestic hot water heater.

Three of the ten dishwashers we verified had listed electricity as their domestic hot water fuel on the application, but during site visits to these homes we found that water was heated by gas. Cadmus therefore assumed that 30% of all dishwasher applications did not achieve electric domestic hot water savings. All gas savings achieved by the electric programs are shown in Appendix D.

We made the following input assumptions:

- Cadmus calculated the average base case and efficient case EF. Both are based on the same data utilized by the RTF. The baseline EF equals the average market efficiency of units that did not qualify for the program. The efficient EF equals the average market efficiency of units that did qualify for the program at the time they were rebated.

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15 http://www.nwcouncil.org/energy/rtf/measures/measure.asp?id=118

16 Pacific Power Washington 2009-2010 Residential Home Energy Savings Evaluation, January 2012.

17 Rocky Mountain Power 2009-2010 Idaho Residential Home Energy Savings Evaluation, February 2012.

18 http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls?7182-1c92

- We used recent evaluation surveys conducted in the region to estimate washing cycles at 245 per year.[16,17]
- Fifty-six percent of the electricity required to run a dishwasher when connected to an electric domestic hot water heater is for water heating.[19]

Refrigerators

Cadmus used the methodology shown in the RTF's FY11v2_1 refrigerator analysis to estimate gross per-UES.[20] The RTF's analysis assumes 32% of baseline units were ENERGY STAR-qualified. This assumption embeds NTG in the calculated savings. We modified the analysis to assume that 0% of baseline units would be ENERGY STAR-qualified. The resulting savings is the gross savings achieved by the installation of an ENERGY STAR refrigerator.

Freezers

Cadmus used the methodology shown in the RTF's FY10v2_0 freezer analysis to estimate gross per-UES.[21] The RTF's analysis assumes 10% of baseline units were ENERGY STAR-qualified. This assumption embeds NTG in the savings calculated. We modified the analysis to assume that 0% of baseline units would be ENERGY STAR-qualified. The resulting savings is the gross savings achieved by the installation of an ENERGY STAR freezer.

Results and Findings

Table 1-18 shows the total reported and adjusted gross savings for the ENERGY STAR Products program by measure.

Table 1-18. ENERGY STAR Products Measure and Program Reported and Adjusted Savings

Measure Name	Measure Count		Savings per Unit (kWh)		Program Savings (kWh)		Realization Rate
	Reported	Adjusted	Reported	Adjusted	Reported	Adjusted	
E Clothes Washer	6,624	6,624	240	433	1,589,760	2,868,192	180%
E Dishwasher	4,124	4,124	132	26	544,368	108,049	20%
G ES Dishwasher (kWh Savings)	1,914	1,914	36	22	68,904	42,587	62%
E Freezer	835	835	65	47	54,275	38,828	72%
E Refrigerator	8,639	8,639	86	66	742,954	565,855	76%
PROGRAM TOTAL	22,136	22,136			3,000,261	3,623,509	121%

The low dishwasher savings achieved is due to the small difference in efficiency between the base case and efficient case products. Avista is aware that the dishwasher market appears to have fully accepted the ENERGY STAR efficiency threshold and has eliminated this measure from their 2013 program offering.

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19 http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorConsumerDishwasher.xls?7182-1c92

20 http://www.nwcouncil.org/energy/rtf/measures/measure.asp?id=122

21 http://www.nwcouncil.org/energy/rtf/measures/measure.asp?id=120

1.3.5 Heating and Cooling Efficiency

Program Description

The electric Heating and Cooling Efficiency program included the following equipment during all or part of PY 2010 and PY 2011:

- Ductless Heat Pump (Electric)
- Air Source Heat Pump (Electric)
- Ground Source Heat Pump (Electric)
- Variable Speed Furnace Fan (Electric)
- Air Conditioner Replacement (Electric)
- Shade Tree (Electric)

Analysis

To evaluate electric heating and cooling efficiency, Cadmus first calculated energy savings based on consistent assumptions about the energy required to heat and cool a home in Avista's territory. It is possible that self-selection and circumstance can lead to unique characteristics within a measure's population. Cadmus used consistent assumptions until evidence suggested otherwise.

We used two sources to calculate energy savings. Cadmus performed a billing analysis for Avista of homes receiving a high-efficiency gas furnace in 2010. This analysis provided a confident estimate of the savings associated with this measure. Using the resulting savings and assumptions of equipment efficiency, we estimated that 41,553 kBtu of heating output are required annually to heat the average participant home in Avista's territory. This assumption was compared to RTF SEEM energy simulations for Spokane, Washington, which estimate energy requirements for three different sizes and configurations of homes. Table 1-19 compares these estimates for the three models to the Cadmus estimate for Avista. We deemed our estimate to be reasonable and used it as the basis from which consistent savings estimates were determined for this electric Heating and Cooling Efficiency program.

Table 1-19 Annual Home Heating Output Estimates

Model	Annual Heating Output (kBtu)
SEEM 1,344 Square Foot Home	33,674
SEEM 2,200 Square Foot Home	63,700
SEEM 2,688 Square Foot Home, Conditioned basement	51,988
Avista 2,000 Square Foot Home	41,553

Ductless Heat Pumps

Four of the units installed as part of the Northwest Energy Efficiency Alliance's (NEEA) 2010 ductless heat pump metering study are included in Avista's program. For these four units, we assumed the base case heating system was electric resistance baseboard heating. The installed efficient ductless heat pump is assumed to provide 50% of the required home heating load and operate at an average system coefficient of performance (COP) of 2.15 over the entire heating season.[22] No cooling penalty is assessed for this measure. We assumed that the home owner would only use the heat pump system for cooling if they had previously had a cooling system for the spaces.

We assume the remaining rebated ductless heat pumps in Avista's program to have achieved the installation of a higher efficiency unit than would have been installed in the absence of the program. Again, the ductless heat pump is assumed to provide 50% of a home's heating load. The base case system is assumed to operate with an average system COP of 2.15. The installed efficient case is assumed to operate with an average system COP of 2.30. This is equivalent to a 7% improvement in the ductless system's heating efficiency. Improvements in cooling efficiency are not considered for this measure. The cooling load in Avista's territory is estimated to be 5% of the heating load. Any increase in cooling efficiency will have a negligible impact on annual savings.

Air Source Heat Pumps

Avista supported 388 conversions from an electric forced air furnace to a heat pump system. For this measure, Cadmus assumed that the heating system provides 100% of the heating load for the home. The base case system is assumed to be an electric resistance forced air furnace. The installed efficient system is a heat pump supported by a furnace. Two percent of the customers who participated in this measure also received a rebate for a high-efficiency gas furnace. The installed efficient system for these customers is assumed to be a heat pump supported by a gas furnace. We assumed the remaining 98% of participants to have an installed efficient system of a heat pump supported by an electric resistance furnace.

In a separate measure, Avista supported the installation 1,494 high efficiency heat pumps with a heating season performance factor (HSPF) of 8.5 or greater. To evaluate this measure, Cadmus conducted a metering study of a random selection of 89 heat pump participants; metering was successful completed at 79 homes. Meters were installed in May or July of 2011 and removed in February of 2012. We used these metering results to estimate the average annual energy savings achieved by this measure. A detailed discussion of this metering study and the measure's participants is documented in Appendix C.

Ground Source Heat Pumps

Avista supported two conversions from an electric forced air furnace to a ground source heat pump system in 2010. This measure was not supported 2011. For this measure, Cadmus assumed that the heating system provides 100% of the heating load for the home. The base case system is assumed to be an electric resistance forced air furnace. The installed efficient system is a ground source heat pump with an HSPF of 10.6.

In a separate measure, Avista supported the installation of 17 high-efficiency ground source heat pumps in 2010. This measure was not supported 2011. For this measure, Cadmus assumed that

[22] Cadmus' assumption of 50% matches the assumption used by Avista. Cadmus does not have evidence to confidently argue for an alternative assumption and has therefore maintained Avista's original assumption. The average annual heating COP was estimated using models developed for this evaluation.

the heating system provides 100% of the heating load for the home. The base case system is a ground source heat pump with an HSPF of 10.6. The installed efficient system is a ground source heat pump with an HSPF of 12.

Variable Speed Furnace Fans

Avista supported the installation of 3,687 variable speed furnace fans within its electric territory. The number of measures was originally 3,762, but Cadmus reduced the measure count to 3,687 because the 95 units were found to have been installed in gas furnaces outside of Avista's electric service territory. Avista stopped supporting these installations during the program year once it was discovered. The records remained in the data in order to keep track of the rebates paid. Avista had already removed the claimed savings from these measures when we received the participant dataset.

Adjusted gross savings are based on a field study of furnaces in Wisconsin.[23] Cadmus believes this study provides the best available estimate of savings for this technology. We calculated gross savings for Avista's territory by performing a linear ratio adjustment using typical heating and cooling degree days.

Air Conditioner Replacements

Avista supported the replacement of 44 air conditioners in 2010 with high efficiency units within its electric territory. This measure was not supported in 2011. Using the same SEEM model outputs discussed above, Cadmus estimated the required annual cooling output to be 5,762 kBtu per home. The base case system efficiency is assumed to have a seasonal energy efficiency rating of 10. The installed efficient equipment is assumed to have an efficiency SEER of 15.

Shade Trees

Avista supported the installation of 129 trees within its territory. Given the limited impact of this measure on the total program savings, no evaluation activities were performed.

Results and Findings

Table 1-20 shows the overall program savings for heating and cooling efficiency measures.

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[23] Electricity Use by New Furnaces: A Wisconsin Field Study, Technical Report 230-1, October 2003, p34 and table 3. http://www.ecw.org/ecwresults/230-1.pdf

Table 1-20. Heating and Cooling Efficiency Measures and Reported and Adjusted Savings

Measure Name	Measure Count		Savings per Unit (kWh)		Program Savings (kWh)		Realization Rate
	Reported	Adjusted	Reported	Adjusted	Reported	Adjusted	
E SHADE TREE	129	129	21	21	2,709	2,709	100%
E FAF TO AIR HPUMP CONVERSION	388	388	5,646	6,589	2,190,648	2,556,648	117%
E FAF TO GROUND HPUMP CONVERSION	2	2	5,646	8,255	11,292	16,510	146%
E HE A/C REPLACEMNT	44	44	1,889	243	83,116	10,674	13%
E DHP	85	85	804	185	68,340	15,691	23%
E DHP (NEEA)	4	4	8,519	3,256	34,076	13,024	38%
E HE AIR SOURCE HP	1,497	1,494	3,237	337	4,845,789	503,478	10%
E HE GROUND SOURCE HP	17	17	4,615	457	78,455	7,774	10%
E VARIABLE SPEED MOTOR	3,762	3,687	563	439	2,118,006	1,617,118	76%
PROGRAM TOTAL	5,928	5,850	N/A	N/A	9,432,431	4,743,627	50%

1.3.6 Space and Water Conversions

Program Description

The Space and Water Conversions program incents three measures which are available to residential electric customers who currently use electricity to heat their homes and water, but have the opportunity to use natural gas instead:

- Electric Forced Air Furnace to Natural Gas Forced Air Furnace.
- Electric Zonal Heat to a Gas Wall Unit Heater
- Electric Water Heater to Gas Water Heater

Avista customers receive a rebate to reduce the cost of purchasing new equipment when the conversion is made. These measures may be claimed in addition to the heating and cooling efficiency measures described above. The installed efficient equipment case is therefore assumed to be the standard efficiency equipment assumed for the base case equipment in the measures above.

Analysis

Electric Forced Air Furnace to Natural Gas Forced Air Furnace

Matching the analysis for the heating and cooling efficiency program, Cadmus utilized the same assumption that each home requires 41,553 kBtu per year of heating output. Ninety-one percent of participants achieved savings through the conversion of a whole house forced air furnace from electricity to gas. The annual energy savings are equal to the entire electrical input required to produce the energy output. No fan savings are achieved by this measure as the fan is assumed to operate the same in both cases. The remaining 9% of measure participants received this rebate and a rebate for a high efficiency air source heat pump. These customers converted from an electric forced air furnace to a dual fuel air source heat pump and gas furnace heating system. The reduction in electricity consumption achieved for these participants is less than those that did not also install a heat pump, therefore requiring a reduction in the average electricity savings achieved per participant. Savings for each scenario are calculated separately. The adjusted gross savings is the weighted average of the two participant scenarios.

Electric Zonal Heat to a Gas Wall Unit Heater
Cadmus assumed that the installed gas wall unit provided 50% of the annual heating output required for the home since these units are typically placed in the main living areas of a house. The savings achieved by this measure are equivalent to a 50% reduction in the required input of an electrically heated home.

Electric Water Heater to Gas Water Heater
The savings achieved by this measure is equal to the total input energy required to heat a home's water using electricity for an entire year. Cadmus used the most recent data available for the region and end use to estimate the total water consumption of a typical home and the total required energy to overcome standby loses. The annual energy savings is equal to the energy required to heat the total water consumption plus the energy required to overcome the standby losses. Cadmus assumed an average electric unit energy factor of 0.91 for this measure.

Results and Findings
Table 1-21 shows the overall program savings for space and water conversion measures. Overall the program achieved a realization rate of 113%.

Table 1-21. Space and Water Conversion Measures and Reported and Adjusted Savings

Measure Name	Measure Count		Savings per Unit (kWh)		Program Savings (kWh)		Realization Rate
	Reported	Adjusted	Reported	Adjusted	Reported	Adjusted	
E TO G FURNACE CONVERSION	224	224	8,655	12,012	1,938,720	2,690,778	139%
E TO G WALL UNIT CONVERSION	6	6	9,299	6,087	55,794	36,524	65%
E TO G H2O CONVERSION	211	211	5,567	4,031	1,174,637	850,577	72%
PROGRAM TOTAL	441	441			3,169,151	3,577,879	113%

1.3.7 Residential Weatherization

Program Description
The Residential Weatherization program incents six categories of measures, which are available to residential electric and gas customers whose homes are heated with fuel provided by Avista:

- Fireplace Dampers (Electric and/or Gas Savings)
- Insulation - Ceiling/Attic (Electric and/or Gas Savings)
- Insulation - Floor (Electric and/or Gas Savings)
- Insulation - Wall (Electric and/or Gas Savings)
- Window Replacement (Electric and/or Gas Savings)

Avista customers who heat primarily with electric or natural gas and that have a wood burning fireplace may receive up to $100 for installing a rooftop damper.

To qualify for the program, ceiling and attic insulation (both fitted/batt type and blown-in) must have increased the R-value by 10 or more; this insulation was incented at $0.25 per square foot of new insulation up to 50% of the installation cost. Homes were eligible if their existing attic insulation was less than R-19.

Floor and wall insulation (both fitted/batt type and blown-in) that increases the R-value by 10 or more was incented at $0.50 per square foot of new insulation up to 50% of the installation cost. Homes were eligible if their existing floor and/or wall insulation was less than R-5.

For upgrading windows with a U-factor of 0.30 or lower, the program provides an incentive of $3.00 per square foot of qualifying windows installed up to 50% of the installation cost. This measure in the program ended on April 1, 2011. Customers had until June 30, 2011, to install windows and submit a rebate form to Avista.

Billing Analysis

Cadmus conducted a statistical billing analysis to determine the adjusted gross savings and realization rates for the electric weatherization and windows measures installed through the electric Residential Weatherization rebate program in PY 2010 and PY 2011. In order to increase the accuracy of the analysis, we included only participants with at least 11 months of pre- and post-billing data in the analysis. Therefore, the billing analysis includes PY 2010 participants and January PY 2011 participants.

To estimate the weatherization and windows measure energy savings from the program, Cadmus used a pre- and post-installation combined CSA and PRISM approach using monthly billing data. We calculated electric model savings estimates for the electric weatherization and windows measures and for the gas windows measures.

Billing Analysis Methodology

Avista provided Cadmus with monthly billing data for all the 2010 and 2011 electric weatherization and windows participants from January 2008 through January 2012. Avista also provided participation and measure data that included all additional gas and electric measures installed in conjunction with the electric weatherization and windows measures, with participant information such as customer details, account numbers, type of measure installed, rebate amounts, measure installation costs, measure installation dates, and deemed savings per measure.

We matched weatherization/windows measure information with the electric billing data. We obtained daily average temperature weather data from 2008 through January 2012 for the 14 NOAA weather stations that represent all the ZIP codes in Avista's Washington and Idaho service territories. From the daily temperatures, we determined base 65 heating degree days (HDDs) and base 65 cooling degree days (CDDs) for each station. Using ZIP code mapping for all of the U.S. weather stations, we determined the nearest station for each ZIP code. We then matched the billing data periods with the HDDs and CDDs from the associated station.

In order to prevent bias from differing reading cycles in assigning pre- and post-periods, and to simplify the analysis, we allocated the kWh billing usage and the associated matched HDDs and

CDDs to calendar months. Since the latest available billing data were from January 2012, and the weatherization and windows measures were installed primarily in 2010, we defined the analysis *pre* period as 2009, before any participation installations occurred. We defined the *post* period as the months following the installation date. Where *post* period data was available for all 2010 participants, we defined the *post* period as 2011.

Due to billing data limitations, there were fewer than the standard 12 months of pre- and post-installation billing data months for all customers. For this reason, we paired the pre- and post-months used in the billing analysis. For example, if a customer installed measures in January 2011, we defined the post-period as February 2011 through December 2011, while the pre-period was the corresponding months from February 2009 through December 2009. This ensured that we used the same months in both the pre- and post-periods, in order to prevent bias from mismatched months.

Data Screening

General Screens

We performed the following screens to remove accounts that could possibly skew our weatherization and windows savings estimation.

- **For Weatherization measures:** To accurately isolate the weatherization savings, weatherization participants installing other electric measures were excluded from the analysis.
- **For Electric Windows measures:** To accurately isolate the electric windows savings, participants installing other electric measures were excluded from the analysis.
- **For Gas Windows measures with electric savings:** To accurately isolate the electric savings from the gas windows participants, gas windows participants installing other electric measures were excluded from the analysis.
- **Customers who indicated unit numbers in the address.** Unit numbers for addresses could potentially indicate weatherization or windows installations occurred in apartments.
- **Accounts with fewer than 11 paired months (330 days) of billing data in either the pre- or post-period**. This screen also excluded customers who changed addresses between the pre- and post-periods, since there would not be sufficient pre-month data for analysis. It is unlikely that the household characteristics and weatherization and windows usage behavior of the previous residents would match that of the current residents who installed the weatherization or windows measures.

PRISM Modeling Screens

We ran PRISM models for the pre- and post-billing data to obtain weather-normalized pre- and post-annual usage for each account and to provide an alternate check of the weatherization and windows savings obtained from the CSA model.

For each participant home, we estimated three models: heating and cooling, heating only, and cooling only in both the pre- and post-periods to weather-normalize raw billing data.

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

From the model above, we computed the weather-normalized annual consumption (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	=	the normalized annual kWh consumption
α_i	=	the intercept that is the average daily or base load for each participant; represents the average daily base load from the model
$\alpha_i * 365$	=	the annual base load kWh usage (non-weather sensitive)
β_1	=	the heating slope; in effect, this is the usage per heating degree from the model above
$LRHDD_i$	=	the annual, long-term HDDs of a typical month year (TMY3) in the 1991-2005 series from NOAA, based on home location
$\beta_1 * LRHDD_i$	=	the weather-normalized annual weather sensitive (heating) usage, also known as HEATNAC
β_2	=	the cooling slope; in effect, this is the usage per cooling degree from the model above
$LRCDD_i$	=	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

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-period was the model with the highest R-square that still had positive heating and/or cooling slopes. After obtaining the final pre- and post-period NAC we applied the additional set of screens on the PRISM model output to remove outlier participants from the weatherization and windows billing analysis:

- **Accounts where the post weather-normalized (POSTNAC) usage was 80% higher or lower than the pre weather-normalized (PRENAC) usage**. Such large changes could indicate property vacancies, when adding or removing "other" gas equipment (such as pools or spas), unrelated to weatherization/windows installations.
- **Accounts with negative intercepts (base load) were removed.** 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; therefore, these accounts were removed from the analysis.

Once we placed these screens on the data, there remained 195 weatherization-only participants, 673 windows-only participants, and 1,714 gas windows participants with electric savings. We used these in the CSA model outlined below to determine the overall savings.

Table 1-22 summarizes the weatherization account attrition from the various screens listed above. The primary screen was for accounts that installed non-weatherization electric measures.

Table 1-22. Weatherization Account Attrition

Screen	Number Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original	477	100%	0	0%
Accounts that Installed Other Measures	278	58%	199	42%
Insufficient Pre/Post Months or Moved During Pre or Post	212	44%	66	14%
PRISM Screens: Low Heating Usage	200	42%	12	3%
Changed Usage Between Pre and Post Period (> 70%)	198	42%	2	0%
Multifamily (Unit Number Present)	195	41%	3	1%
Final Analysis Group	195	41%	282	59%

Table 1-23 summarizes the windows measures account attrition from the various screens listed above. The primary screen was for accounts that installed non-windows electric measures.

Table 1-23. Windows Account Attrition

Screen	Number Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original	1,523	100%	0	0%
Accounts that Installed Other Measures	1,090	72%	433	28%
Insufficient Pre/Post Months or Moved During Pre or Post	817	54%	273	18%
PRISM Screens: Low Heating Usage	807	53%	10	1%
Changed Usage Between Pre and Post Period (> 70%)	792	52%	15	1%
Multifamily (Unit Number Present)	673	44%	119	8%
Final Analysis Group	673	44%	850	56%

Table 1-24 summarizes the gas windows measures with electric savings attrition from the various screens listed above. The primary screen was for accounts that installed non-windows gas measures with electric savings.

Table 1-24. Gas Windows Account Attrition

Screen	Number Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original	3,388	100%	0	0%
Accounts that Installed Other Measures	2,359	70%	1,029	30%
Insufficient Pre/Post Months or Moved During Pre or Post	1,804	53%	555	16%
PRISM Screens: Low Heating Usage	1,788	53%	16	0%
Changed Usage Between Pre and Post Period (> 70%)	1,751	52%	37	1%
Multifamily (Unit Number Present)	1,714	51%	37	1%
Final Analysis Group	1,714	51%	1,674	49%

CSA Modeling Approach

To estimate weatherization and windows energy savings from this program, we used a pre-post CSA fixed-effects modeling method that uses pooled monthly time-series (panel) billing data. The fixed-effects modeling approach corrects for differences between the pre- and post-installation weather conditions, as well as for differences in usage consumption between participants, by including a separate intercept for each participant. Our modeling approach ensures that model savings estimates will not be skewed by any unusually high usage or low usage participants. We used the following model specification to determine the overall weatherization and windows savings

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \beta_2 AVGCDD_{it} + \beta_3 POST_i * AVGHDD_{it} + \beta_{4..14} M_t + \varepsilon_{it}$$

Where for participant ‘i’ and monthly billing period ‘t’:

ADC_{it} = the average daily kWh consumption during the pre- or post-program period

α_i = the average daily kWh base load intercept for each participant (this is part of the fixed effects specification)

β_1 = the baseline usage per HDD

$AVGHDD_{it}$ = the average daily base 65 HDDs based on home location

β_2 = the baseline usage per CDD

$AVGCDD_{it}$ = the average daily base 65 CDDs based on home location

β_3 = the kWh savings per HDD for the weatherization or windows measures

$POST_i$ = an indicator variable that is 1 in the post-period (after the weatherization or windows installation), and 0 in the pre-weatherization period

$POST_i * AVGHDD_{it}$ = an interaction between the post indicator ($POST_i$) and the HDDs ($AVGHDD_{it}$)

M_t = an array of bill month dummy variables (Feb, Mar, …, Dec), 0 otherwise[24]

ε_{it} = the modeling estimation error

The model above estimates the savings per heating degree for the weatherization or windows measures with β_3. In order to obtain the actual annual savings under normal weather conditions, we applied the 1991-2005 TMY3 normal HDDs from NOAA.

The per-HDD modeling approach resolves much of the potential bias from customers where predominantly winter month data were available. Since weatherization and windows measures affect the heating usage, a per heating degree savings allows for allocating savings across all the calendar months, as well as being based on the HDDs. Furthermore, the per heating degree savings estimation allows for obtaining savings under normal weather conditions. Using just a post-period indicator would have been influenced by any predominance of winter or summer months, resulting in savings being biased upwards or downwards.

Results and Findings

Weatherization and Windows Billing Analysis Model Results

Table 1-25 summarizes the electric model savings results for the 195 weatherization participants, the 673 windows measure participants, and the 1,714 windows gas participants. The model savings for weatherization measures are 953 kWh, for electric windows measures the savings are 485 kWh, and for gas windows measures the electric savings are 91 kWh. The precision level indicates that the percent error of the savings estimate is 26% for the electric weatherization and windows participants and 60% for the gas windows participants.

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

Table 1-25. Weatherization and Windows Savings Summary

Group	N	PRENAC	Model Savings Per HDD	Normal HDDs	Model Savings (kWh)	Precision at 90% Confidence	Savings Lower 90% (kWh)	Savings Upper 90% (kWh)
Weatherization	195	17,156	0.15029	6,338	953	26%	708	1197
Windows Electric	673	17,803	0.07667	6,327	485	26%	358	612
Windows Gas Heat, Electric Cooling Savings	1,714	10,894	NA	NA	91	60%	36	146

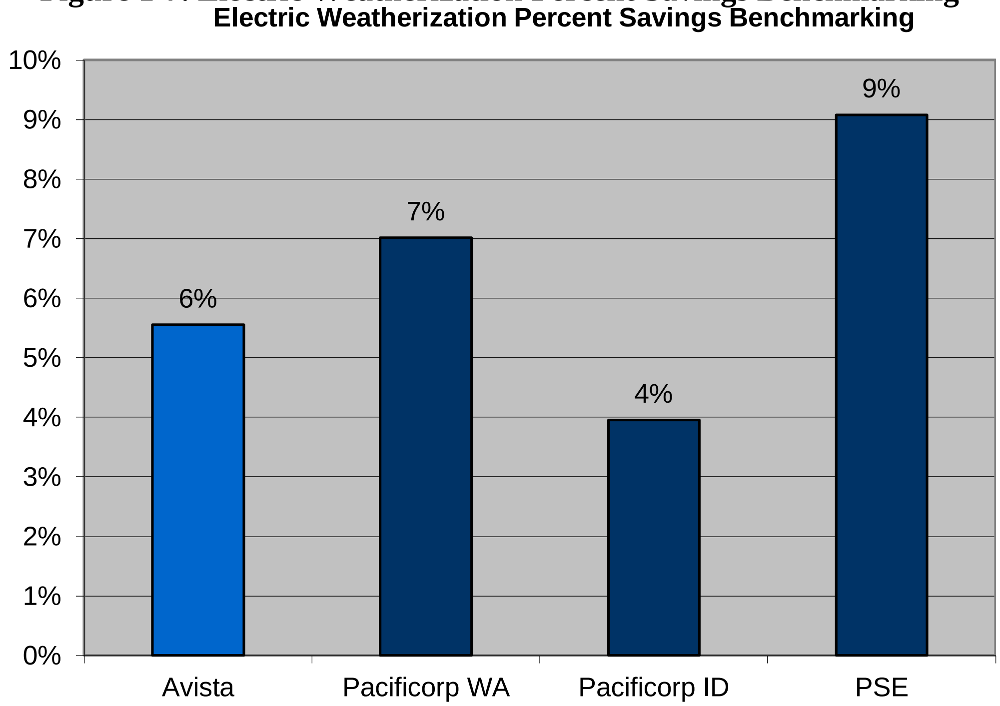
Table 1-26 compares the modeled savings with the expected deemed savings to obtain realization rates (35% and 23% for weatherization and windows measures, respectively). The realization rate for the electric savings from the gas windows measure installation is 14%.

Table 1-26. Realization Rate Summary

Group	N	PRENAC	Model Savings (kWh)	Expected Savings	Realization Rate	Savings as Percent of Pre
Weatherization	195	17,156	953	2,720	35%	6%
Windows	673	17,803	485	2,148	23%	3%
Windows Gas Heat, Electric Cooling Savings	1,714	10,894	91	657	14%	1%

Figure 1-7 compares the weatherization percent savings to similar electric weatherization evaluations. To improve the comparisons, the respective chart includes only the attic insulation savings that are the predominant component of Avista's Weatherization Program. Generally the percent savings is similar to other programs, except the attic percent savings of the Puget Sound Energy (PSE) program were higher.

Figure 1-7. Electric Weatherization Percent Savings Benchmarking



To extrapolate the billing analysis results of the entire program population, the realization rates shown in Table 1-26 were applied to the total savings for the measure reported in the Avista database. The one measure not included in the billing analysis was Fireplace Dampers, for which we maintained the deemed savings value developed for the 2011 Avista TRM. Table 1-27 shows the total reported and adjusted savings for the gas Weatherization program measures.

Table 1-27. Weatherization Measure and Program Reported and Adjusted Savings

Measure Name	Measure Count		Savings per Unit (kWh)		Program Savings (kWh)		Realization Rate
	Reported	Adjusted	Reported	Adjusted	Reported	Adjusted	
E FIREPLACE DAMPER	27	27	2,304	163	62,208	4,401	7%
E WINDOWS	2,162	2,162	2,057	464	4,446,636	1,004,033	23%
G WINDOWS (kWh Savings)	3,422	3,422	569	78	1,946,893	267,737	14%
E INSULATION	997	997	2,546	891	2,538,119	888,736	35%
PROGRAM TOTAL	6,608	6,608			8,993,856	2,164,907	24%

We found that the energy savings achieved by the weatherization measures were in line with similar programs we have evaluated. The one exception is PSE's weatherization program. Changes in program design may have contributed to the difference in percent savings achieved because the mix of measures for the PSE program was different than for Avista's program. The evaluation process also has shown the increasing penetration of dual fuel heated homes in Avista's territory. Some of the participant homes may use both electricity and gas to heat their home. We recommend Avista create a mechanism through which participants can explain that they use both fuels to heat their home. A future billing analysis should then evaluate the impact of weatherization on both fuels serving the home.

1.3.8 Water Heater Efficiency

Program Description

The Water Heater Efficiency program has one measure:

- High-Efficiency Water Heater (Electric)

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

Analysis

Avista supported 1,045 installations of a high-efficiency electric water heater. To calculate savings for this measure, Cadmus used the WHAM method.[25] The average base case energy factor is assumed to be 0.909. The average installed efficient energy factor is assumed to be 0.934. We believe it likely that the average efficiency of the equipment installed under Avista's program is higher than 0.934, but no information is available to support this. The base and installed average efficiencies were taken from the RTF's file ResDHWFY10v2_1.xls.[26]

Results and Findings

Table 1-28 shows the total reported and adjusted savings for the electric Water Heater Efficiency program measure.

Table 1-28. Water Heater Efficiency Measure and Reported and Adjusted Savings

Measure Name	Measure Count		Savings per Unit (kWh)		Program Savings (kWh)		Realization Rate
	Reported	Adjusted	Reported	Adjusted	Reported	Adjusted	
E HE WH	1,044	1,045	299	119	312,156	124,460	40%
PROGRAM TOTAL	1,044	1,045	N/A	N/A	312,156	124,460	40%

1.3.9 ENERGY STAR Homes

Program Description

This program offers incentives to builders for constructing single-family or multifamily homes that comply with ENERGY STAR criteria and are certified as ENERGY STAR Homes. Avista provides a $900 incentive for homes that use its electric or electric and natural gas service for space and water heating.

25 http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/d-2.pdf

26 http://www.nwcouncil.org/energy/rtf/measures/measure.asp?id=125

Analysis

Dual Fuel Homes

For Avista's 2010 Gas Impact Report, Cadmus used ENERGY-10® modeling software to simulate models of an ENERGY STAR home and a standard built-to-code home with gas heating equipment. The results of this modeling effort were reviewed and retained for this program year. The gas savings achieved by this measure are reported in Appendix D

All Electric Homes

Cadmus updated its 2010 gas models to adjust for the use electricity as the heating fuel. We completed one model for each state (Washington and Idaho) to account for all differences in state building codes. The savings resulting from each simulation were nearly equal; the difference was 10 kWh. Overall, the modeled savings ranged between 2,138 kWh and 2,894 kWh depending on the penetration of CFL lighting assumed. The RTF used a more sophisticated modeling method that produced savings of 2,510 kWh for the Washington envelope option with heat pump in heating zone 2 and cooling zone 2. Since this estimate is consistent with Cadmus' modeling results and the sophistication of the RTF's modeling method is greater than Cadmus', the value of 2,510 kWh is chosen as the deemed savings for an all-electric ENERGY STAR home.

Results and Findings

Table 1-29 shows the total reported and adjusted savings for the gas and electric/gas ENERGY STAR Homes program measures.

Table 1-29. ENERGY STAR Homes Measure and Program Reported and Adjusted Savings

Measure Name	Measure Count		Savings per Unit (kWh)		Program Savings (kWh)		Realization Rate
	Reported	Adjusted	Reported	Adjusted	Reported	Adjusted	
E ESTAR HOME ALL ELEC	58	58	7,415	2,510	430,052	145,580	34%
E ESTAR HOME ELEC/GAS (kWh)	248	248	1,041	1,054	258,215	261,392	101%
PROGRAM TOTAL	306	306	N/A	N/A	688,267	406,972	59%

1.3.10 Residential Renewables

Avista supported the installation of 33 residential renewable projects. Cadmus performed no evaluation activities on ENERGY STAR Homes program. For this report, all installations are assumed to achieve a 100% adjusted gross realization rate.

Table 1-30. Residential Renewables Reported and Adjusted Savings

Measure Name	Measure Count		Savings per Unit (kWh)		Program Savings (kWh)		Realization Rate
	Reported	Adjusted	Reported	Adjusted	Reported	Adjusted	
E RENEWABLE	33	33	VARIES	N/A	138,626	138,626	100%
PROGRAM TOTAL	33	33	N/A	N/A	138,626	138,626	100%

1.3.11 Residential Programs Confidence and Precision

Cadmus determined the overall precision of the adjusted gross savings by estimating the standard error associated with each measure. For measures based on deemed savings estimates only, the error in the deemed savings is due to error in each of the input assumptions. Typically, this is due to the sampling error associated with research into each input. To simplify this analysis, Cadmus has conservatively estimated that the standard error associated with each deemed measure is 20% of the unit energy savings unless recent evaluation research has developed a more accurate estimate. This estimate is greater than values Cadmus typically determines, but provides for a conservative estimate of program precision.

The following programs use more accurate estimates of error based on recent research:

- The standard error estimated for Simple Steps, Smart Savings™ is based on the errors associated with the estimates of daily hours of use and in-service rate for each purchased bulb.
- The standard error estimated for Second Refrigerator and Freezer Recycling is based on the regression model errors existing within the analysis.
- The standard error for air source heat pumps within the Heating and Cooling efficiency program is based on the sampling error within the metering project. The standard error for all other equipment measures within the program is based on the billing analysis performed last year since the estimate of annual heating load is based on this previous analysis' result.[27]
- The standard error for all HVAC equipment measures within the Space and Water Conversions program is also based on the billing analysis performed last year.
- The standard error for the Weatherization/Shell program is based on the billing analysis performed this year.

Following the determination of program measure savings based error, Cadmus applies the verification error determined through this year's surveys to each program except the two using billing analysis results and the Simple Steps, Smart Savings™ program. Verification rates are not applied to savings determined through a billing analysis as their results include any homes where the installation was stated to have occurred, but did not occur. The Simple Steps, Smart Savings™ program is an upstream lighting program for which verification rates do not apply.

Table 1‑16 shows the program level error and precision for the residential portion of the portfolio. Overall the residential programs achieved 16% relative precision at the 90% confidence interval.

Table 1-31. Program Savings Precision at the 90% Confidence Interval

[27] Avista 2010 Multi-Sector Gas Impact Evaluation Report, August 2011.

Program	Adjusted Gross Savings (kWh)	Standard Error (kWh)	Relative Precision at 90% Confidence
Simple Steps, Smart Savings™	24,601,728	4,124,873	28%
Second Refrigerator and Freezer Recycling	4,054,783	83,527	3%
ENERGY STAR® Products	3,623,509	589,297	27%
Heating and Cooling Efficiency	4,743,627	342,824	12%
Space and Water Conversions	3,577,879	210,856	10%
Weatherization/Shell	2,164,907	286,216	22%
Water Heater Efficiency	124,460	25,007	33%
ENERGY STAR® Homes	406,972	60,341	24%
PROGRAM TOTAL	43,297,865	4,197,261	16%

1.4 Conclusions

For PY2010 and PY2011, Avista's residential electric programs produced 43,436,491 kWh in savings, which yielded an overall realization rate of 90%. Table 1-32 through Table 1-34 show reported and verified gross savings and realization rates per program and by state.

Table 1-32. Total Program Reported and Verified Gross Savings and Realization Rates

Program	Reported Savings (kWh)	Adjusted Gross (kWh)	Realization Rate
Simple Steps, Smart Savings™	18,097,253	24,601,728	136%
Second Refrigerator and Freezer Recycling	4,529,827	4,054,783	90%
ENERGY STAR Products	3,000,261	3,623,509	121%
Heating and Cooling Efficiency	9,432,431	4,743,627	50%
Space and Water Conversions	3,169,151	3,577,879	113%
Weatherization/Shell	8,993,856	2,164,907	24%
Water Heating	312,156	124,460	40%
ENERGY STAR Homes	688,267	406,972	59%
Residential Renewables	138,626	138,626	100%
PROGRAM TOTAL	48,361,828	43,436,491	90%

Table 1-33. Program Gross and Net Verified Savings and Realization Rates - Washington

Program	Reported Savings (kWh)	Adjusted Gross (kWh)	Realization Rate
Simple Steps, Smart Savings™	12,064,835	16,401,152	136%
Second Refrigerator and Freezer Recycling	3,421,329	3,062,439	90%
ENERGY STAR Products	2,016,007	2,444,129	121%
Heating and Cooling Efficiency	5,616,729	2,751,306	49%
Space and Water Conversions	2,245,319	2,463,378	110%
Weatherization/Shell	6,064,022	1,447,434	24%
Water Heating	253,253	100,997	40%
ENERGY STAR Homes	539,437	336,246	62%
Residential Renewables	109,143	109,143	100%
PROGRAM TOTAL	32,330,075	29,116,224	90%

Table 1-34. Program Gross and Net Verified Savings and Realization Rates - Idaho

Program	Reported Savings (kWh)	Adjusted Gross (kWh)	Realization Rate
Simple Steps, Smart Savings™	6,032,418	8,200,576	136%
Second Refrigerator and Freezer Recycling	1,108,498	992,344	90%
ENERGY STAR Products	984,254	1,179,380	120%
Heating and Cooling Efficiency	3,815,702	1,992,321	52%
Space and Water Conversions	923,832	1,114,501	121%
Weatherization/Shell	2,929,834	717,472	24%
Water Heating	58,903	23,463	40%
ENERGY STAR Homes	148,830	70,726	48%
Residential Renewables	29,483	29,483	100%
PROGRAM TOTAL	16,031,753	14,320,267	89%

Table 1-35 shows the rate of achievement of gross savings compared to the IRP goal for the residential sector.

Table 1-35 IRP Goals and Gross Verified Savings by State

	Washington			Idaho			Total		
Sector	Savings Goal	Gross Achieved	Goal Achiev-ement	Savings Goal	Gross Achieved	Goal Achiev-ement	Savings Goal	Gross Achieved	Goal Achiev-ement
Residential	25,871,685	29,116,224	113%	15,986,226	14,320,267	90%	41,857,911	43,436,491	104%

1.5 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.
- Move all clothes washer rebates to the electric program unless there is a large penetration of gas dryers. Forthcoming RBSA data can support future analysis.
- Include a SEER requirement to increase savings for high-efficiency heat pump participation. Consider continuing the Variable Speed Motor measure in conjunction with any change to equipment efficiency requirements. Often, an electrically commutated motor (ECM) is standard on the highest efficiency heat pump systems.
- Consider restricting dual fuel customers who acquire multiple rebates that have interactive effects. If program changes are made to reduce the participation of dual fuel customers in certain measure categories, future evaluation activities should reassess the participant penetration of the dual fuel home.
- 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 estimating savings and incenting systems separately for all-electric heating systems.
- Consider tiered incentives by SEER rating as higher SEER systems generally require ECM fan motors to achieve certain SEER ratings.

1.5.1 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.

- Perform a review of all available secondary research and/or collect primary data on the penetration of gas heated clothes dryers within Avista's gas territory. This information can be used to refine the estimated gas and electric savings associated with the purchase of an ENERGY STAR clothes washer in a home with a gas domestic hot water tank.
- Perform a targeted billing analysis on weatherization participants that use both electricity and gas to heat their home.
- 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.
- Identify new, cost-effective measures that can be added to its portfolio.

2 2010–2011 Nonresidential Electric Impact Report

Executive Summary

Program Overview

Avista's nonresidential programs promote the purchase of industry-proven, high-efficiency equipment for commercial utility customers. They provide rebates to partially offset the difference in cost between high-efficiency and standard equipment.

Avista's nonresidential electric portfolio has sixteen programs in three major categories: Prescriptive, Energy Smart Grocer, and site-specific (custom):

- Prescriptive:
  - ENERGY STAR Residential Products (APP)
  - Commercial Clothes Washer (PCW)
  - Commercial Shell (PCS)
  - Demand Controlled Ventilation (PDCV)
  - Food Service (PFS)
  - LED Traffic Signals (PTS)
  - Lighting Exterior (PL)
  - Lighting Interior (PL)
  - Motors (PM)
  - PC Network Controls (PNC)
  - Refrigerated Warehouse (PRW)
  - Side-Stream Filtration (PSSF)
  - Vending Machine Controls (PVC)
  - Renewables (REN)
- Energy Smart Grocer (ESG)
- Site Specific (SS)
  - HVAC (SSHVAC)
  - Lighting (SSL)
  - Other (SSO)
  - Shell (SSS)

Avista implements the Prescriptive and site specific programs and Portland Energy Conservation, Inc. (PECI) implements the Energy Smart Grocer program. Cadmus assessed and documented savings of all programs for this evaluation. We also documented the evolution of these programs and provided timely feedback to enable recommended improvements.

Key Findings

Cadmus evaluated 223 of 4,215 projects, representing 29% of reported savings for nonresidential electric measures installed during PY 2010 and 2011. Throughout the impact evaluation, we documented programs' achievements and, where savings were lower than expected, we identified issues that need to be resolved.

Reported and evaluated savings are shown in Table 2-1 through Table 2-3. The gross evaluated savings for all nonresidential electric programs were 97,087,824 kWh.

Table 2-1. Program Summary

Measure Category	Number of Measure	Gross Reported Savings (kWh)	Gross Evaluated Savings (kWh)	Realization Rate
Prescriptive	2,310	30,744,663	24,469,769	80%
ESG	757	18,314,967	14,665,926	80%
SSHVAC	328	17,719,269	21,966,665	124%
SSL	377	21,489,162	20,768,632	97%
SSO	194	14,013,381	12,911,517	92%
SSS	249	2,667,193	2,305,315	86%
Total	4,215	104,948,636	97,087,824	93%

Table 2-2. Program Summary - Idaho

Measure Category	Number of Measure	Gross Reported Savings (kWh)	Gross Evaluated Savings (kWh)	Realization Rate
Prescriptive	878	9,764,945	8,137,296	83%
ESG	289	7,376,731	5,907,004	80%
SSHVAC	117	5,183,634	6,279,138	121%
SSL	133	7,033,160	7,289,607	104%
SSO	85	2,810,585	2,539,103	90%
SSS	113	1,078,833	924,062	86%
Total	1,615	33,247,888	31,076,211	93%

Table 2-3. Program Summary - Washington

Measure Category	Number of Measure	Gross Reported Savings (kWh)	Gross Evaluated Savings (kWh)	Realization Rate
Prescriptive	1,432	20,979,718	16,332,473	78%
ESG	468	10,938,236	8,758,922	80%
SSHVAC	211	12,535,635	15,687,527	125%
SSL	244	14,456,002	13,479,024	93%
SSO	109	11,202,796	10,372,414	93%
SSS	136	1,588,360	1,381,252	87%
Total	2,600	71,700,748	66,011,612	92%

Avista did not report goals for number of project participants but did report energy savings goals, as shown in Table 2-4. The overall PY 2010 and 2011 nonresidential electric portfolio achieved 110% of the original IRP energy savings goals.

Table 2-4. IRP Energy Savings Achievements Compared to Goals

Program	Program Gross Goals (kWh)	Evaluated Gross Program (kWh)	Goal Achievement
Idaho	33,617,010	31,076,211	92%
Washington	54,405,239	66,011,612	121%
Total	88,022,249	97,087,824	110%

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 effectiveness of the evaluations:

- Avista should create a quality control system to double-check all projects with savings over 300,000 kWh. An Avista EM&V engineer reported he has begun to review these types of projects.
- Avista should consider performing three- to six-month post-installation random inspections to confirm measure persistence to identify opportunities to improve performance.
- Avista should consider conducting future studies to quantify less conservative assumptions for HVAC fan VFD deemed savings estimates.
- Avista should consider revising its methodology for calculating and tracking HVAC/lighting interactive effects.
- Avista should consider adding a program for recommissioning measures that were identified as non-functional during the previous year's evaluation process and report the energy savings these measures achieve in the subsequent year.

2.1 Introduction

Avista's nonresidential portfolio of programs 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 sixteen programs in three major categories: Prescriptive, Energy Smart Grocer, and site-specific (custom). The programs are described below.

2.1.1 ENERGY STAR Residential Products (APP)

This program is available to nonresidential customers who use residential-grade appliances in a small business application. Savings are determined through deemed estimates.

2.1.2 Prescriptive Commercial Clothes Washer (PCW)

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

2.1.3 Prescriptive Commercial Shell (PCS)

Beginning in January 2011 the installation of commercial insulation has been processed through a prescriptive program in addition to the site-specific program. Projects eligible for the prescriptive commercial shell program are those with pre-existing:

- Wall insulation levels of less than R4 that are improved to R11 or better
- Attic insulation of less than R11 that are improved to R30 or better
- Roof insulation of less than R11 that are improved to R30 or better

2.1.4 Prescriptive Demand Controlled Ventilation (PDCV)

Under this program, nonresidential electric and natural gas customers receive direct incentives to install DCV in existing buildings. This type of ventilation measures carbon dioxide levels as an indicator of fresh ventilation in relation to approximate number of people occupying a space—based on —and adjusts the outdoor air intake rate to match occupant need for ventilation. To be eligible for the program, the existing equipment must maintain the temperature of the conditioned spaces between 65 and 75 degrees during operating hours. Also, the controlled conditioned space must be a minimum of 2,000 square feet.

2.1.5 Prescriptive Food Service (PFS)

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

2.1.6 Prescriptive LED Traffic Signals (PTS)

This program targets nonresidential electric customers (primarily municipalities) that own traffic signals and offers incentives to replace incandescent with high-efficiency LED signals. These LED signals are designed for use in pedestrian signals, red-yellow-and-green traffic signals, and traffic arrows. Since market saturation has nearly been reached, this program was scheduled to run only until the end of 2011.

2.1.7 Prescriptive Lighting (PL)

Since there is a significant opportunity for lighting improvements in commercial facilities, this program offers direct financial incentives to customers who increase the efficiency of their lighting equipment. The rebate is available to existing commercial and industrial electric customers whose facilities have rate schedules 11 or above. This program provides pre-determined incentive amounts for 38 measures, including:

- T12 fluorescent to T8 fluorescent
- High bay, high intensity discharge lighting to T5 fluorescent or T8 fluorescent
- High bay, high intensity discharge lighting to induction fluorescent

- Incandescent to compact fluorescent or cold cathode fluorescent
- Incandescent to LED
- Incandescent exit signs to LED exit signs

2.1.8 Prescriptive Motors (PM)

Avista offers rebates and incentives to help pay for qualifying premium motors. Participants can choose one of two options. They can develop a comprehensive motor inventory using the Department of Energy's (DOE) Motormaster program and submit that with the rebate application paperwork. Or they can purchase a new premium efficiency motor, select the motor from the CEE Premium Efficient Motor List, fill out the rebate form, and then attach the appropriate invoices and manufacturer's specification sheet.

2.1.9 Prescriptive PC Network Controls (PNC)

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

2.1.10 Prescriptive Refrigerated Warehouse (PRW)

This program offers nonresidential electric customers a direct incentive for efficiency improvements in refrigerated warehouses. Although the customer base for this program is limited, the opportunities for energy savings from the program's measures are significant.

2.1.11 Prescriptive Side Stream Filtration (PSSF)

This program provides incentives to nonresidential electric customers who install permanent side-stream filtration systems on their new or existing open-loop evaporative cooling tower/chiller systems. With incentives for this program paid at $18 per ton—or 50% of the installed cost, whichever is less—these systems help the equipment operate more efficiently between normal cleanings and inspections.

2.1.12 Renewables (REN)

This program provides prescriptive incentives for residential and nonresidential projects that install photovoltaic (solar electric) systems and/or wind turbines.

2.1.13 Energy Smart Grocer (ESG)

Refrigeration has high potential for energy savings but is often overlooked because of the technical aspects of the equipment. The Energy Smart Grocer program assists grocery store customers with technical aspects of their refrigeration systems while providing a clear view of what savings they can achieve. A field energy analyst offers customers technical assistance, produces a detailed report of the potential energy savings at their facility, and guides customers through the ESG process from inception through the payment of incentives for qualifying equipment.

2.1.14 Site Specific (SS)

The site-specific program is for nonresidential measures that do not fit under any of the prescriptive applications and thus 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 gas saving measures included in the program are:

- Site Specific HVAC (SSHVAC)
  - HVAC Combined
  - HVAC Cooling
  - HVAC Heating
    - Motor Controls HVAC
  - Site-specific Lighting (SSL)
  - Lighting Exterior
  - Lighting Interior
- Site-specific Other (SSO)
  - Appliances
  - Compressed Air
  - Green Motors Rewind
  - Industrial Process
  - Motor Controls Industrial
  - Multifamily
  - Standby Generator Block Heater
- Site-specific Shell (SSS)

Avista implements the site-specific and prescriptive programs and 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 managed projects by reviewing and approving applications at all stages of the process, calculating project savings, and populating the database with relevant information.

2.2 Methodology

Cadmus designed the impact evaluation to verify 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 worked with a subcontractor, SBW, to review Avista's reported gross energy savings and available documentation, such as audit reports, 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 to ask their experience 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.

2.2.1 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 2-5. We used preliminary program population data provided by Avista and determined we needed to meter 75 projects and visit 125 sites. We anticipated achieving 90/10 precision at the overall nonresidential program 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 for the stratum. The cutoff for the census savings for each stratum is shown in Table 2-6 below. 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 2-5. Proposed PY 2010-2011 Nonresidential Evaluation Activities

Stratum	Precision Target	Proposed Metering Projects	Proposed Site Visits
Prescriptive	90/15	14	10
ESG	90/15	19	22
SSHVAC	90/20	17	33
SSL	90/15	12	4
SSO	90/20	13	34
SSS	90/20	0	22
Total	90/10	75	125

Table 2-6. Census Level Cutoff by Stratum

Stratum	Reported Savings (kWh)
Prescriptive	500,000
ESG	500,000
SSHVAC	500,000
SSL	500,000
SSO	750,000
SSS	200,000

In Table 2-7, 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, our initial sampling plan 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 2-7. Final FY 2011 Gas Evaluation Activity Sample

Stratum	Achieved Precision	Completed Metering Projects	Completed Site Visits
Prescriptive	90/22	10	38
ESG	90/15	17	19
SSHVAC	90/16	17	32
SSL	90/14	8	22
SSO	90/33	11	13
SSS	90/11	0	17
Total	90/9	63	141

As explained above, we selected projects with large reported savings. In selecting the rest of our sample, we found that the extract from Avista's database did not include addresses so that we could 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 selected projects of interest, asked Avista for additional data to determine how many and what types of projects were at various locations, and obtained their project files, until we completed the final primary and backup samples.

We also found that the database extract provided program-level, 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. To establish this distribution, we would have required an exhaustive review of project files, which was not within the scope of the evaluation.

2.2.2 Data Collection

Cadmus collected data from 63 metering sites and 141 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. Our review included 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 and Long-Term Metering

Cadmus performed short-term (two weeks) and long-term (multiple months) metering for projects across the nonresidential electric portfolio. We installed power meters, temperature 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 we also verified the operational characteristics of the installed equipment, such as temperature set points 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.

2.2.3 Engineering Analysis

Prescriptive and site-specific programs 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 and compared these with the values we developed for the new technical reference manual (TRM).[28] 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 with 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 that either short-term metering over a period of two weeks or long-term metering over a period of several months presented the most effective method for achieving precision in a particular project's energy saving calculations. Specific metering details for each measure category are discussed in the Findings section. Installed metering equipment is listed:

- HOBO light loggers for 24 lighting projects, including six for LED refrigeration case lighting and one for a refrigerated warehouse.
- Energy Logger Pros for metering 11 Energy Smart Grocer projects such as anti-sweat heater controls and refrigeration compressors.
- Energy Logger Pros for metering variable frequency drive energy on seven site-specific HVAC fan projects.
- Energy Logger Pros for metering energy use for eight heat pump and air conditioning projects.
- Energy Logger Pros for metering energy use for eight compressed air, wastewater blower, and industrial process motor projects.
- Energy Logger Pros for metering energy use and temperature for two standby generator block heater projects.
- An Energy Logger Pro for metering energy use on one efficient elevator motor replacement project.

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

Billing Analysis

Cadmus analyzed Avista's metered billing data for two 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 heating degree days (HDDs). It also determined savings based on normalized weather conditions, since the actual weather conditions may have been milder or more extreme than the TMY3 (typical meteorological year) 15-year normal weather averages from 1991-2005 obtained from the NOAA.

[28] Avista's new iteration of the TRM is expected in July 2012.

From NOAA, we also obtained daily weather data for each weather station associated with the participant projects and calculated the base 65 reference temperature HDDs. We matched the participant billing data to the nearest weather station by zip code, and 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 average daily consumption in kWh as a function of some combination of average standing base load, HDD, 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 occur 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-period model. This scenario extrapolated the counterfactual consumption, i.e., what the consumption would have been in the absence of 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. Both scenarios used 15-year TMY3 data 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 the building of 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. From these data, energy savings are estimated through algorithms programmed by Avista. For each spreadsheet, we reviewed 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 (eQuest or Trane TRACE), which it chose because of the complex interactions between heating and cooling loads and the building envelope. Avista provided the original energy simulation models, and we reviewed the models to determine the relevant parameters and operating details (such as temperature set points) for the applicable measure. We updated the models as necessary based on our on-site verification data.

2.3 Results and Findings

2.3.1 Overview

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

2.3.2 Prescriptive

The Cadmus team evaluated savings for a sample of sites across fourteen prescriptive programs. Table 2-8 through Table 2-10 show our evaluated results by program. Specific evaluation details are described in each program subsection below.

Table 2-8. Evaluated Results for Nonresidential Prescriptive Sample

Program	Number of Measure Installations	Evaluated Sample	Gross Reported Savings (kWh)	Gross Evaluated Savings (kWh)	Realization Rate
APP	125	10	1,368	1,703	124%
PCW	15	1	869	1,111	128%
PCS	57	1	6,093	6,093	100%
PDCV	10	0	N/A	N/A	N/A
PFS	181	3	27,762	14,597	53%
PTS	17	2	130,947	106,067	81%
PL	1,807	24	3,405,128	1,560,358	46%
PM	74	3	62,046	53,547	86%
PNC	4	2	360,302	358,760	100%
PRW	3	1	121,135	146,759	121%
PSSF	6	1	84,214	84,214	100%
PVC	2	0	N/A	N/A	N/A
REN	10	0	N/A	N/A	N/A
Total	2,311	48	4,199,864	2,333,209	56%

Table 2-9. Evaluated Results for Nonresidential Prescriptive Sample - Idaho

Program	Number of Measure Installations	Evaluated Sample	Gross Reported Savings (kWh)	Gross Evaluated Savings (kWh)	Realization Rate
APP	36	2	172	131	76%
PCW	2	0	N/A	N/A	N/A
PCS	18	1	6,093	6,093	100%
PDCV	7	0	N/A	N/A	N/A
PFS	59	2	14,597	14,597	100%
PTS	12	2	130,947	106,067	81%
PL	716	9	161,598	155,211	96%
PM	25	1	2,080	2,080	100%
PSSF	2	0	N/A	N/A	N/A
REN	2	0	N/A	N/A	N/A
Total	879	17	315,487	284,179	90%

Table 2-10. Evaluated Results for Nonresidential Prescriptive Sample - Washington

Program	Number of Measure Installations	Evaluated Sample	Gross Reported Savings (kWh)	Gross Evaluated Savings (kWh)	Realization Rate
APP	89	8	1,196	1,572	131%
PCW	13	1	869	1,111	128%
PCS	39	0	N/A	N/A	N/A
PDCV	3	0	N/A	N/A	N/A
PFS	122	1	13,165	0	0%
PTS	5	0	N/A	N/A	N/A
PL	1091	15	3,243,530	1,405,147	43%
PM	49	2	59,966	51,467	86%
PNC	4	2	360,302	358,760	100%
PRW	3	1	121,135	146,759	121%
PSSF	4	1	84,214	84,214	100%
PVC	2	0	N/A	N/A	N/A
REN	8	0	N/A	N/A	N/A
Total	1,432	31	3,884,377	2,049,030	53%

Overall, the Prescriptive program analysis achieved a level of 90/22 confidence and precision. Cadmus identified several necessary adjustments to the reported savings for the Prescriptive programs. We note that the calculations often rely on reported equipment and operations data, which may vary from parameters identified during on-site verification visits and metering.

Our adjustments decreased savings by 46%, primarily as the result of a low realization rate on one large Prescriptive Lighting project. Typical adjustments were to correct equipment efficiency, fuel type, operating schedules, and operating parameters as described below:

- A dishwasher measure used gas water heating instead of electric, so this reduced electric energy savings. Cadmus attributed the gas savings to the nonresidential gas program. In addition, one dishwasher and one clothes washer measure used electric water heating instead of gas, as reported. This increased the evaluated electric savings.
- For ENERGY STAR clothes washers we applied the results from a previous Cadmus clothes washer study.[29] The Cadmus study estimated larger energy savings for this measure than the reported values.
- One Prescriptive Food Service project installed a commercial dishwasher that relied on gas heating instead of electric, which reduced electric energy savings. The gas savings were attributed to the nonresidential gas program.
- One Prescriptive LED Traffic Signal project double-counted savings for pedestrian signals. Deemed savings of 498 kWh for a pedestrian signal assume 22 hours of operation per day, and therefore include both the "Don't Walk" and "Walk" portion of the

[29] The Cadmus Group, Inc. "Do the Savings Come Out in the Wash? A Large Scale Study of In-Situ Residential Laundry Systems." 2010. http://www.cadmusgroup.com/pdfs/Do_the_Savings_Come_Out_in_the_Wash.pdf

savings. Avista reported 498 kWh for both "Walk" and "Don't Walk" cycles. The realization rate for this project was 52%.

- Avista implementation staff made a data entry error on the largest prescriptive lighting project. The participant replaced 94 metal halide fixtures with 94 T5 high output fixtures. An implementation staff member recorded the baseline as 994 fixtures. This error greatly increased baseline energy usage. Cadmus calculated the realization rate at 16%, a reduction of 1,419,473 kWh. This one site represented 77% of the overall savings reduction of 1,835,347 kWh.
- Avista reported another census-level prescriptive lighting project at a grocery store that operated 8,760 hours per year. During the site visit verification, Cadmus determined the store operated only 6,570 hours per year. The project realization rate was 80%, a reduction of 111,603 kWh.
- Cadmus used lighting logging and verification data to confirm or adjust operating hours for all other projects. These adjustments, in addition to those made from verified fixture counts, reduced energy savings by 27%.
- One Prescriptive Refrigerated Warehouse measure involved high efficiency lighting and occupancy sensors. We adjusted estimates of the occupancy sensor savings and operating hours and evaluated savings at a realization rate of 121%.

2.3.3 Energy Smart Grocer

Cadmus performed on-site or metering visits to 36 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 2-11 lists the two measure types we evaluated and the number of projects and reported savings. Table 2-12 shows our evaluated results for the program.

Table 2-11. Energy Smart Grocer Measure Types and Projects Evaluated

	Idaho		Washington		Total	
Measure Type	Evaluated Projects	Reported Savings (kWh)	Evaluated Projects	Reported Savings (kWh)	Evaluated Projects	Reported Savings (kWh)
Case Lighting	3	51,360	6	161,655	9	213,015
Refrigeration Equipment	13	1,717,158	14	1,104,120	27	2,821,278
Total	16	1,768,518	20	1,265,775	36	3,034,293

Table 2-12. Evaluated Results for Nonresidential Energy Smart Grocer Sample

State	Total FY11 Measure Installations	Evaluated Sample	Gross Reported Sample Savings (kWh)	Gross Evaluated Sample Savings (kWh)	Sample Realization Rate
Idaho	289	16	1,768,518	1,352,713	76%
Washington	468	20	1,265,775	1,077,032	85%
Total	757	36	3,034,293	2,429,746	80%

Overall, the Energy Smart Grocer analysis achieved a level of 90/15 confidence and precision. Cadmus identified several necessary adjustments to the reported savings for the Energy Smart Grocer program. We note that the calculations often rely on reported equipment and operations data, which may vary from parameters identified during on-site verification visits and metering.

Our adjustments decreased savings by 20%. Typical adjustments were to correct equipment efficiency, operating schedules, and operating parameters as described below:

- Cadmus metered operating hours for six case lighting projects. We found an average realization rate of 118% on these projects, based on the logged data, verified equipment data, and assumptions for the refrigeration equipment efficiency (COP).
- One participant reported energy savings for installing efficient refrigerated cases, but included savings for LED case lights both in the equipment measure and as a separate lighting measure, thereby double-counting energy savings. Cadmus corrected this resulting in a realization rate of 18%.
- Several new construction projects for one grocery chain reported savings for efficient refrigerated cases. Cadmus verified equipment specifications and operating hours, but on average evaluated lower savings than the reported values.
- Cadmus metered compressor operation on several projects and found the actual operating hours were lower than the reported hours.
- Cadmus metered anti-sweat heater power at one grocery store and found the operating hours were lower than the value used in the savings calculation. The project realization rate was 65%.
- Cadmus applied more conservative energy savings for several measures based on secondary sources. The affected measures and secondary sources are:
  - ➢ Night covers, using values estimated by the American Society of Heating Refrigeration, and Air-Conditioning Engineers (ASHRAE).[30]
  - ➢ Special doors with low/no anti-sweat heaters, using data from a Southern California Edison (SCE) study.[31]
  - ➢ ECMs, using data from the Regional Technical Forum developed by PECI.[32]

2.3.4 Site Specific

Cadmus performed site visits on 120 site-specific program projects, which represent a variety of measure types. Cadmus calculated an overall realization rate for all projects in Idaho and Washington, and then we applied the resulting realization rate to the savings for each state.

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30 ASHRAE 2010 Refrigeration Handbook, Chapter 15.10. “Six hours of night cover use can reduce the cooling load by 8% and the compressor power requirements by 9%.”

31 http://asset.sce.com/Documents/Business%20-%20Services%20for%20Your%20Business/Anti_Sweat_Heater_Report.pdf

32 http://www.nwcouncil.org/energy/rtf/meetings/2010/01/SP%20to%20ECM%20in%20Display%20Case%20for%20RTF%20updated%20efficiencies.xls

Table 2-13 lists the different measure types we evaluated, as well as the number of projects and reported savings. Table 2-14 shows our evaluated results for the program.

Table 2-13. Site-Specific Measure Types and Projects Evaluated

	Idaho		Washington		Total	
Measure Type	Evaluated Projects	Reported Savings (kWh)	Evaluated Projects	Reported Savings (kWh)	Evaluated Projects	Reported Savings (kWh)
SSHVAC	22	2,715,552	27	4,317,457	49	7,033,009
SSL	8	2,828,836	22	4,699,164	30	7,528,000
SSO	4	1,397,649	20	6,548,497	24	7,946,146
SSS	10	255,664	7	664,358	17	920,022
Total	44	7,197,701	76	16,229,476	120	23,427,177

Table 2-14. Evaluated Results for Nonresidential Site-Specific Sample

State	Total FY11 Measure Installations	Evaluated Sample	Gross Reported Sample Savings (kWh)(	Gross Evaluated Sample Savings (kWh)	Sample Realization Rate
Idaho	448	44	7,197,701	8,317,696	116%
Washington	700	76	16,229,476	15,637,482	96%
Total	1,148	120	23,427,177	23,955,178	102%

Overall, the site-specific program analysis achieved a level of 90/11 confidence and precision. Cadmus identified many adjustments to site-specific program project reported savings. Site-specific projects tend to be more complex, and energy savings parameters and impacts can be 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 2%, driven primarily by the high realization rate for the HVAC stratum.

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

Site-specific HVAC Adjustments

- Cadmus found Avista's assumptions for the post-installation heating load on a large HVAC heating project resulted in a savings reduction. Based on analysis of billing data and heating degree days, we calculated lower than reported savings with a realization rate of 88%.
- During a site visit at a university, Cadmus found two HVAC fan VFDs had been manually overridden to operate at 100-percent speed. This required more energy than in the baseline condition.

- Cadmus installed power meters on twelve HVAC fan VFDs for periods ranging from two weeks to six months. The metered energy savings estimates were substantially higher than the reported values, with a realization rate of 247%. Avista reported the deemed savings estimates had been derived from a study performed by a third-party engineering firm in 1995. We applied our metered results to all HVAC fan VFDs in the sample, which increased savings for the site-specific HVAC measure category.
- Cadmus identified multiple discrepancies and simulation model errors on an office project with HVAC DDC control upgrades. The electric realization rate was 49%. The discrepancies between model and site visit were:
  - The proposed window U-values did not match installed values.
  - The modeled computer room area was smaller than the actual area.
  - Avista included VFDs in the retrofit model, but also reported VFD savings using the site-specific HVAC deemed savings calculator. Therefore, the VFD savings appear to have been double-counted.
  - The model listed one system zone per floor whereas the as-built zoning used one system for the building perimeter and one system for the building interior.
  - The model used 8,760 hours per year for the occupancy, lighting, and plug load schedules in the model baseline and followed normal office schedules in the case of retrofit. The schedule should have used the same conventional office operating schedule for both baseline and retrofit conditions. The higher baseline operating hours inflated savings.
- One church reported electric savings for HVAC combined and shell measures. Cadmus conducted a site visit and found the original HVAC equipment only used gas heat without cooling. We determined there were no electric energy savings at this site.
- Cadmus evaluated site-specific HVAC projects using a combination of metering, simulation, utility billing, and verification data. In general, the results indicated the reported values were somewhat conservative, and the measure category had a realization rate of 124%.

Site-Specific Lighting Adjustments

- Two sampled 2010 electric projects had duplicate savings in the Avista database extract. As an example, one census-level retail store lighting project reported savings of 455,484 kWh in the project file. Cadmus evaluated slightly higher savings than this value, but the database extract reported savings of 910,968 kWh. The realization rate for this project was 53 %. This issue involved a reporting error in Avista software and was resolved for the 2011 database extract.
- The Cadmus team inspected another census-level lighting project for a postal distribution center and found eight of the reported spaces on site did not have efficient lighting installed. This reduced the project realization rate to 70%.
- Cadmus inspected three census-level lighting projects on a university campus and conducted light logging. The logged data and verified information indicated savings were higher than reported. The three projects combined had a realization rate of 116%.

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

Site-Specific Other Adjustments

- Cadmus performed a site visit on a compressed air project where the trim compressor was outfitted with a VFD. During the site visit, we found the participant had adjusted the control system so the smaller VFD compressor provided the base load (with continuous operation) while a larger and less efficient compressor performed trim operations. This configuration uses more energy than the baseline condition due to losses in the VFD drive at 100-percent speed.
- We performed metering on a compressor at an industrial facility. To determine energy savings, Avista had applied baseline energy use from 2008, which was during the beginning of the nationwide economic slowdown and when the plant's compressed air usage was significantly lower than in current conditions. Therefore we considered the 2008 baseline too conservative. We adjusted the baseline upward based on current operating conditions and our detailed understanding of compressed air energy use. The project's evaluated realization rate was 594%.
- Cadmus metered seven other compressed air and industrial process motor projects. The average project achieved slightly lower energy savings than reported, and the realization rate for these projects was 94%.
- We metered one elevator motor replacement project for three months. The metered savings indicated operating time and energy usage were much less than reported. The project achieved a realization rate of 8%.
- Cadmus also metered two standby generator block heaters. The reported savings were based on interpolating energy savings from a study performed on two block heater sizes. The metered data indicated the energy savings were lower than the interpolated value. Each block heater project achieved an 84% realization rate.
- We verified two pump replacement projects for water pumping stations and recalculated savings based on participant reported flow volume data and utility billing data. We adjusted the analysis to compare only pre- and post-installation periods when these pumps operated. Both projects achieved energy savings, but the data showed savings were lower than the values reported by the participant. The combined realization rate for both projects was 47%.
- 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, and the measure category had a realization rate of 92%.

Site-specific Shell Adjustments

Cadmus performed a site visit at one census-level site-specific shell project which installed new, efficient windows in an apartment complex. Our verification visit showed one building was oriented incorrectly in the original analysis. The original analysis indicated the building had 759 square feet of windows facing west, therefore absorbing significant heat from the late afternoon sun. Cadmus verified the west face of the building had only 30 square feet of window area. This reduced energy savings to 90%.

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 too much from verified values, and the savings calculators produced reasonable results. On average, the results indicated the achieved energy savings were less than the reported values, and the measure category had a realization rate of 86%.

2.3.5 Extrapolation to Program Population

For our evaluation of the nonresidential gas 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) to apply to the programs at 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:

$$RR_{ij} = \frac{Verified_{ij}}{Claimed_{ij}};\ for\ measure\ j\ at\ site\ i \qquad (1)$$

$$RR_{j} = \frac{\sum_{i} Verified_{i}}{\sum_{i} Claimed_{i}};\ for\ measure\ j\ across\ all\ sample\ sites \qquad (2)$$

$$\sum_{k} Verified_{k} = RR_{j}\, x \sum_{k} Claimed_{k};\ for\ measure\ j\ across\ all\ sites\ in\ measure\ population \qquad (3)$$

$$RR_{l} = \frac{\sum_{k} Verified_{k}}{\sum_{k} Claimed_{k}};\ for\ the\ population\ (all\ sites\ and\ measures) \qquad (4)$$

Where:

RR	=	the realization rate
i	=	the sample site
j	=	the measure type
k	=	the total population for measure type ‘j’
l	=	the total program population

We calculated realization rates for each individual site in the sample based on measure type (Equation 1). We then 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 (Equation 2). We calculated the population verified savings for projects not in the census category by multiplying the measure type realization rate from the random sample by the claimed savings for the non-census population of each measure type (Equation 3). We then 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 (Equation 4).

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 2-15 through Table 2-17. The overall portfolio gross realization rate was 93%.

Table 2-15. PY 2010 and 2011 Gross Program Realization Rates

Program	Gross Sample Reported Savings (kWh)	Gross Sample Evaluated Savings (kWh)	Realization Rate*	Gross Program Reported Savings (kWh)	Gross Program Evaluated Savings (kWh)
Prescriptive	4,204,571	2,346,164	80%	30,744,663	24,469,769
ESG	3,034,293	2,429,746	80%	18,314,967	14,665,926
SSHVAC	7,263,552	8,587,587	124%	17,719,269	21,966,665
SSL	7,528,000	7,186,741	97%	21,489,162	20,768,632
SSO	7,946,146	7,430,332	92%	14,013,381	12,911,517
SSS	920,022	808,795	86%	2,667,193	2,305,315
Total	30,896,583	28,789,365	93%	104,948,636	97,087,824

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

Table 2-16. PY 2010 and 2011 Gas Gross Program Realization Rates - Idaho

Program	Gross Sample Reported Savings (kWh)	Gross Sample Evaluated Savings (kWh)	Realization Rate	Gross Program Reported Savings (kWh)	Gross Program Evaluated Savings (kWh)
Prescriptive	315,559	284,224	83%	9,764,945	8,137,296
ESG	1,768,518	1,352,713	80%	7,376,731	5,907,004
SSHVAC	2,443,517	4,095,261	121%	5,183,634	6,279,138
SSL	2,828,836	3,242,789	104%	7,033,160	7,289,607
SSO	1,397,649	594,230	90%	2,810,585	2,539,103
SSS	255,664	197,058	86%	1,078,833	924,062
Total	9,009,743	9,766,275	93%	33,247,888	31,076,211

Table 2-17. PY 2010 and 2011 Gas 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	3,889,012	2,061,940	78%	20,979,718	16,332,473
ESG	1,265,775	1,077,032	80%	10,938,236	8,758,922
SSHVAC	4,820,035	4,492,326	125%	12,535,635	15,687,527
SSL	4,699,164	3,943,952	93%	14,456,002	13,479,024
SSO	6,548,497	6,836,101	93%	11,202,796	10,372,414
SSS	664,358	611,737	87%	1,588,360	1,381,252
Total	21,886,840	19,023,090	92%	71,700,748	66,011,612

2.3.6 Achievements Compared to Goals

Avista outlined goals for various programs to save a total of 88,022,249 kWh as its integrated resource planning (IRP) goal, as shown in Table 2-18. The overall Avista nonresidential portfolio's evaluated gross savings achieved 110% of its goals.

Table 2-18. PY 2010 and 2011 Electric Program Achievements Compared to IRP Goals*

Program	Program Gross Goals (kWh)	Evaluated Gross Program (kWh)	Goal Achievement
Idaho	33,617,010	31,076,211	92%
Washington	54,405,239	66,011,612	121%
Total	88,022,249	97,087,824	110%

*These savings are exclusive of the CFL Contingency Plan savings which are discussed in another chapter.

2.4 Conclusions

The Cadmus team evaluated 223 of 4,215 measures installed through the program, representing 29% of reported savings.

In general, Cadmus determined that Avista implemented the programs well. Gross evaluated savings achieved 110% of reported program savings goals. The overall portfolio achieved a 93% realization rate when we compare gross evaluated savings to gross reported savings.

Cadmus identified the following key issues that adjusted energy savings:

- Some participants did not operate the incented equipment correctly or did not complete the improvements expected for the measure.
- Some participant heating or cooling loads did not achieve the level projected for post-installation usage.
- Simulation models did not accurately represent the actual as-built building or system operation.
- HVAC fan VFD deemed savings estimates may have been too conservative and were based on an older study from 1995.

- Avista implementation staff may not have conducted thorough an analysis of energy savings calculations provided by participants or third-party contractors for all projects.
- Avista implementation staff 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:

- Cadmus could have streamlined the sampling process if Avista's database had recorded site addresses and contact information. Having measure-level data, such as specific measure type and quantity, for each project would have improved the range and depth of our evaluation activities.

2.5 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 effectiveness of the evaluations:

- Avista should create a quality control system to double-check all projects with savings over 300,000 kWh. An Avista EM&V engineer reported he has begun to review these types of projects.
- Avista should consider performing three- to six-month post-installation random inspections to confirm measure persistence and to identify opportunities to improve performance.
- Avista should consider conducting future studies to quantify less conservative assumptions for HVAC fan VFD deemed savings estimates.
- Avista should consider revising its methodology for calculating and tracking HVAC/lighting interactive effects.
- Avista should consider adding a program for recommissioning measures that were identified as non-functional during the previous year's evaluation process and report the energy savings these measures achieve in the subsequent year. Recommissioning measure costs would primarily be for utility and implementer staff to resolve issues and to re-inspect the measure. We recommend that recommissioning measures be evaluated through a census sample, and the verified energy savings should not be extrapolated to the overall program population.

3 2011 Low-Income Electric Impact Report

Executive Summary

Program Overview

Avista's Low-Income Weatherization Program in Washington and Idaho seeks to lower customers' energy consumption and utility bills. At no cost to income-qualified customers, the program provides: a complete home energy audit, and installation of energy-efficient measures.

Evaluation Approach

This impact evaluation assessed electric energy impacts resulting from measure installations in homes within Avista's Washington and Idaho service territories. Electric impacts have been presented separately for homes receiving electric-to-gas conversion measures (i.e., water heater and furnace replacements) from homes receiving electric-saving measures without conversions. Major tasks performed for the evaluation are described in greater detail below.

Data Collection

Table 3-1 lists data required for this evaluation and their sources.

Table 3-1. Data Sources

Data	Source
Program participant and measure data	Avista
Expected savings by measure installation	Avista/CAP agencies
Participant billing histories	Avista
Weather data	NOAA

Evaluation of Program Energy Savings

Cadmus reviewed Avista's estimated savings, and calculated average achieved household and total savings, as described below:

- **Expected Savings:** Based on expected measure-level electric savings estimates, provided by Avista from their program participant database.
- **Actual Savings:** Calculated using a pre/post-conditional savings analysis (CSA), fixed-effects regression model, estimating weather-normalized, program-induced energy savings, based on participant billing data. This analysis was performed on the 2010 participant population in the previous gas impact report; in this report, state-specific savings per participant calculated in that billing analysis have been applied to the 2011 participant population.

Electric Impact Findings and Conclusions

Billing Analysis Electric Savings

Table 3-2 and Table 3-3 and summarize model savings results of weatherization measure installations for electric non-conversion and conversion participants, respectively.

Electric savings for non-conversion participants were estimated at approximately 10% and 14% of pre-participation annual consumption in Idaho and Washington, respectively. For conversion participants, those receiving both conversions achieved savings at 64% of the pre-period annual consumption, while furnace-only and water heater-only conversion participant percentages both achieved approximately 31%.

Based on the billing analysis sample (e.g., 2010 participants), we calculated the following realization rates:

- 44% in Idaho;
- 93% in Washington; and
- 68% overall for electric non-conversion participants, relative to reported expected savings.

For conversion participants, realization rates were:

- 85% for combo;
- 53% for furnace-only; and
- 70% for hot water-only conversion customers.

Table 3-2. Low-Income Weatherization Non-Conversion Participant Savings Summary

Group	n	Average Expected Savings (kWh)	Model Savings (kWh)	Realization Rate
Idaho	73	3,626	1,602	44%
Washington	128	2,256	2,099	93%
Overall Electric	201	2,753	1,864	68%

Table 3-3. Low-Income Weatherization Conversion Participant Savings Summary

Group	n	Average Expected Savings (kWh)	Model Savings (kWh)	Realization Rate
Furnace Only	5	8,902	4,683	53%
DWH Only	58	5,738	4,019	70%
Combo	74	14,361	12,233	85%
Overall Conversion	137	10,511	8,394	80%

Overall Electric Savings

In applying savings estimates from the billing analysis to the electric-saving, 2010–2011, participant program population, 3,225,930 total kWh savings were achieved. Table 3-4 provides more detail on overall savings calculations by state and by participant type.

Table 3-4. Overall 2010-2011 Electric Savings by State and Participant Type

Participant Type	State / Type	Total Participants	Total Expected Savings (kWh)	Model Savings Per Participant (kWh)	Total Savings (kWh)	Realization Rate
Electric (Non-Conversion)	Idaho	197	1,156,559	1,602	315,602	27%
	Washington	232	650,482	2,099	487,046	75%
Conversion (WA only)	Furnace Only	22	238,280	4,683	103,020	43%
	DWH Only	139	792,851	4,019	558,688	70%
	Combo	144	2,067,651	12,233	1,761,573	85%
Overall		734	4,905,823	N/A	3,225,930	66%

Table 3-5 summarizes electric savings by state, rolling up conversion participant savings to reflect both the conversion and non-conversion savings in Washington.

Table 3-5. Overall 2010-2011 Electric Savings by State

State	Total Expected Savings (kWh)	Total Savings (kWh)	Realization Rate
Idaho	1,156,559	315,602	27%
Washington	3,749,264	2,910,327	78%
Overall	4,905,823	3,225,930	66%

We compared evaluated savings for the 734 electric participants (conversion and non-conversion) against Avista's IRP goals. Table 3-6 summarizes overall evaluated savings, IRP savings goals, and the goal achievement rates, overall and by state.

Table 3-6. IRP Program Goals Comparison

State	Reported Savings (kWh)	Evaluated Electric Savings (kWh)	Goal Achievement
Idaho	2,492,905	315,602	13%
Washington	1,540,377	2,910,327	189%
Overall	4,033,282	3,225,930	80%

Recommendations

The impact evaluation revealed several areas where program performance and savings accuracy could be improved:

- Work with Idaho agencies to provide refrigerator replacements.
- Perform quality checks on expected savings estimates.
- Track alternative heating sources.
- Consider performing quantitative, non-energy benefit analyses.
- Include high-use customers in program targeting.

3.1 Introduction

Cadmus conducted a statistical billing analysis to determine adjusted gross savings and realization rates for energy-efficient measures installed through the Low-Income Weatherization

Program for 2010 customers. Analysis and results examined the household- or participant-level, rather than the measure-level. Billing analysis was performed on 2010 participants, given the availability of full years of energy consumption data, before and after the weatherization period (i.e., 2009 and 2011). Analysis results for 2010 participants were then applied to 2011 participants, reporting total 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, utilizing monthly billing data. We analyzed savings estimates for Idaho and Washington, and ran a series of diagnostics, such as a savings review by pre-consumption usage quartile and outlier analysis. A detailed discussion of the regression model used for this billing analysis follows, accompanied by resulting savings.

3.1.1 Program Description

Five programs comprise the Low-Income Weatherization Program, listed in Table 3-7. Local community action program agencies (CAPs) within Avista's Idaho and Washington service territories implemented all the low-income programs. CAPs holistically evaluate homes for energy-efficiency measure applicability, combining funding from different programs to apply appropriate measures to a home, based on results of a home energy audit.

While both states operated very similar weatherization programs, each state has individual programs, with different sovereign statewide administrators, implementation agencies, and weatherization protocols. Table 3-7 describes measures installed under each program component, along with counts of electric measures installed in each year, and included in our electric impact analysis.

Table 3-7. 2010 and 2011 Electric Efficiency Installations by Program Component

Low-Income Program Component	Measure Description	Measure Installations	
		2010	2011
Shell/Weatherization	Insulation, window/door, air infiltration, programmable thermostat	332	544
ENERGY STAR Appliance	High-efficiency refrigerator replacement	131	45
Fuel Conversion	Electric furnace and water heater replacement with gas units	216	233
Hot Water Efficiency	High-efficiency water heater replacement	6	15
HVAC Efficiency	High-efficiency gas furnace replacement	N/A	N/A

3.1.2 Data Collection

Cadmus obtained impact evaluation data from multiple sources, including:

- ***Program participant database***: Avista provided information regarding program participants and installed measures for each state. Specifically, these data included: a list of measures installed per home; and expected savings from each completed installation. The data did not, however, include the quantity of measures installed (such as the number of square feet of installed insulation) or per-unit savings estimates.
- ***Billing records***: Avista provided participant meter records from January 2008 through December 2011.

- ***Weather data***: Cadmus collected Idaho and Washington weather data from eight representative stations, drawn for the corresponding time period; data derived from the NOAA.

Cadmus first matched participant accounts from program data with billing data. We then matched daily heating degree days (HDD) and cooling degree days (CDD) to each, respective monthly read date periods in billing data, for use in the weather-adjusted savings model. Finally, we paired pre- and post-consumption periods to compare consistent time frames.

3.2 Methodology

3.2.1 Sampling

The billing analysis used a census of 2010 program participants (139 electric accounts receiving conversion measures, and 218 accounts receiving non-conversion electric measures).

3.2.2 Data Collection Activities

Documentation Review/Database Review

Cadmus used the 2010–2011 Idaho and Washington Program participant database, provided by Avista, to develop a complete 2010 population for use in both billing analyses.

Billing Analysis

Avista provided monthly billing data for all participants, from January 2008 through December 2011. Avista also provided the participant database, which contained participation and measure data for 2010 and 2011, including all gas and electric measures installed per home by the different CAPs.

We obtained daily average temperature weather data from 2008 to 2011 for the eight NOAA weather stations, representing all 2010 electric participant ZIP codes in Avista's Washington and Idaho service territories. 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 stations closest to each participant.

As we received billing data through December 2011, we could only perform the billing analysis for the 2010 program year. We defined the analysis pre- period as 2009, before all participation installations occurred, and the post- period as 2011, following all installations occurring in 2010.

Analysis results for 2010 participants were then applied to the 2011 participant population, thus reporting overall impacts across the 2010 and 2011 program years.

3.2.3 Data Screening

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

General Screens

The following screens removed accounts that could have skewed the savings estimation:

- Accounts with fewer than three paired months (90 days) of billing data, in either the pre- or post-period; and
- Accounts with annual usage outside of reasonable bounds in either the pre- or post-period (i.e., less than 1,000 kWh, or more than 50,000 kWh).

PRISM Modeling Screens

The screening process then utilized PRISM models for pre- and post-billing data. We used these models to obtain weather-normalized pre- and post-annual usage for each account, and to provide an alternate check on weatherization savings obtained from the CSA model.

For each participant home, we estimated three models in both the pre- and post-periods 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 post-program period

α_i = the participant intercept; represents the average daily kWh base load

β_1 = the model space heating slope (used only in the heating only, heating + cooling model)

$AVGHDD_{it}$ = the base 65 average daily HDDs for the specific location (used only in the heating only, heating + cooling model)

β_2 = the model space cooling slope (used only in the cooling only, heating + cooling model)

$AVGCDD_{it}$ = the base 65 average daily CDDs for the specific location (used only in the cooling only, heating + cooling model)

ε_{it} = the error term

From the model above, we computed the weather-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 above

$LRHDD_i$ = 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 above

$LRCDD_i$ = 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

Table 3-8 and Table 3-9 summarize electric and conversion account attrition from the screens listed above.

Table 3-8. Electric Account Attrition

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original Electric Accounts (2010)	218	100%	0	0%
Dropped in Merge with Billing Data	215	99%	3	1%
Insufficient Pre- and Post-Period Months	212	97%	3	1%
Low or High Usage in Pre- or Post-Periods	210	96%	2	1%
Changed Usage from the Pre to Post (> 90%)	206	94%	4	2%
PRISM Screen: Low R-Squared, Low Heating Usage	206	94%	0	0%
Outliers	201	92%	5	2%
Final Analysis Group	201	92%	229	8%

Table 3-9. Conversion Account Attrition

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original Conversion Accounts (2010)	139	100%	0	0%
Dropped in Merge with Billing Data	137	99%	2	1%
Insufficient Pre- and Post-Period Months	137	99%	0	0%
Low or High Usage in Pre- or Post-Periods	137	99%	0	0%
Changed Usage from the Pre to Post (> 90%)	137	99%	0	0%
PRISM Screen: Low R-Squared, Low Heating Usage	137	99%	0	0%
Final Analysis Group	137	99%	2	1%

3.2.4 CSA Modeling Approach

To estimate energy savings from this program, we 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 the inclusion of a separate intercept for each participant. Our modeling approach ensures model savings estimates will not be skewed by unusually high usage or low usage participants. Monthly consumption is also paired between pre- and post-months to maintain the same time frame for evaluating unique participants. We used the following model specification to determine state-level savings used for electric (non-conversion) participants:

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \beta_2 AVGCDD_{it} + \beta_3 POST\_ID_i + \beta_{4..14} M_t + \varepsilon_{it}$$

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \beta_2 AVGCDD_{it} + \beta_4 POST\_WA_i + \beta_{4..14} M_t + \varepsilon_{it}$$

And overall savings for conversion customers:

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \beta_2 AVGCDD_{it} + \beta_5 POST_i + \beta_{4..14} M_t + \varepsilon_{it}$$

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

ADC_{it} =	average daily kWh consumption during the pre- or post-program period
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 HDD, based on home location
β_2 =	the model space cooling slope
$AVGCDD_{it}$ =	the average daily base 65 CDD, based on home location
β_3 =	kWh savings per day for efficient measures in Idaho

$POST\_ID_i$ = an indicator variable, which is 1 in the post-period (after the weatherization installations) for Idaho participants, and 0 in the pre-weatherization period

β_4 = kWh savings per day for the efficient measures in Washington

$POST\_WA_i$ = an indicator variable, which is 1 in the post-period (after the weatherization installations) for Washington participants, and 0 in the pre-weatherization period

β_5 = the kWh savings per day for the efficient measures (conversion participant model)

$POST_i$ = an indicator variable, which is 1 in the post-period (after the weatherization installations) for participants, and 0 in the pre-weatherization period (conversion participant model)

M_t = an array of bill month dummy variables (Feb, Mar, …, Dec), 0 otherwise[33]

ε_{it} = the modeling estimation error

The above models estimate non-conversion electric savings for Idaho and Washington, respectively, with β_3 and β_4, and the conversion electric savings overall with β_5.

3.3 Results and Findings

3.3.1 Billing Analysis Results

Table 3-10 and Table 3-11 summarize model savings results of the weatherization measure installations for electric non-conversion and conversion participants, respectively.

Table 3-10. Low-Income Weatherization Non-Conversion Participant Savings Summary

Group	n	PRENAC	Normal HDDs	Normal CDDs	Model Savings (kWh)	Precision 90%	Savings Lower 90% (kWh)	Savings Upper 90% (kWh)
Idaho	73	15,773	6,551	504	1,602	28%	1,195	2,143
Washington	128	14,608	6,326	543	2,099	17%	1,823	2,551
Overall Electric	201	15,031	6,407	529	1,864	15%	1,650	2,234

Model savings averaged: 1,602 kWh in Idaho; 2,099 in Washington; and 1,864 overall.

33 We excluded one of the dummy variables from the independent variables, otherwise the 12 monthly indicators would form perfect co-linearity with the intercepts. We excluded January, thus the intercepts include the seasonality from January.

Table 3-11. Low-Income Weatherization Conversion Participant Savings Summary

Group	n	PRENAC	Normal HDDs	Normal CDDs	Model Savings (kWh)	Precision 90%	Savings Lower 90% (kWh)	Savings Upper 90% (kWh)
Furnace Only	5	15,019	6,233	568	4,683	36%	3,227	6,844
DWH Only	58	12,981	6,246	519	4,019	11%	3,830	4,814
Combo	74	19,264	6,297	510	12,233	4%	12,604	13,704
Overall Conversion	137	16,449	6,273	516	8,394	4%	8,619	9,432

Combination conversion customers (receiving furnace and water heater conversions) saved 12,233 kWh per participant. Furnace-only participants saved 4,683 kWh, and participants only receiving hot water heater conversions saved 4,019 kWh. The overall precision at 90% confidence was 4%. The combination conversion results also shared a very high level of precision, at 4%.

Table 3-12 provides a distribution of electric measures, paid for by Avista, for participants in the final model.

Table 3-12. Measure Distribution of Final Model Sample, by State and Participant Type

Measures	Non-Conversion		Conversion
	ID	WA	WA
Air infiltration controls	45	31	2
Windows	40	31	3
Doors	28	22	2
Floor Insulation	23	19	3
Attic Insulation	39	17	3
Duct Insulation	2	4	0
Water heater replacement	0	4	0
Wall Insulation	0	3	3
T-stat (No AC)	0	1	0
Refrigerator replacement	0	88	22
Furnace replacement	0	1	35
Furnace conversion	0	0	79
Water heater conversion	0	0	132
Sample (n)	73	128	137

This distribution above indicates a similar mix of measures by state, aside from refrigerator replacements not being performed in Idaho using Avista funding. Given the 2010 average expected savings estimate for refrigerator replacement was nearly 900 kWh, this likely resulted in the discrepancy of average model savings between the two states.

Additionally, billing analysis results encompass all measure installations made at participant households, including those not paid for through Avista's program. As the program implemented through CAP agencies seeks to utilize a variety of funding sources per home, it is possible Avista-participant homes received measures paid for by federal, state, and other utility dollars. Specifically, Avista does not pay for CFLs offered through the low-income weatherization program, which likely had a significant impact on electric savings of participant homes.

Along with non-Avista funded measures, differences between state protocols for guiding agency measure installations (e.g., number of bulbs installed per home, hours of use thresholds for installation) as well as differences between agency (and individual contractor) delivery procedures (e.g., direct install vs. leave behind CFLs) likely affected savings estimates between the states.

Table 3-13 and Table 3-14 compare evaluated to expected savings, along with realization rates, for electric non-conversion and conversion participants, respectively. In these tables, expected savings estimates, along with model savings, have been calculated specifically for participant samples included in the final models (based on 2010 participants).

Table 3-13. Electric Non-Conversion Participant Realization Rate Summary

Group	n	PRENAC	Model Savings (kWh)	Expected Savings (kWh)	Realization Rate	Model Savings as Percent of Pre-Usage	Expected Savings as Percent of Pre-Usage
Idaho	73	15,773	1,602	3,626	44%	10%	23%
Washington	128	14,608	2,099	2,256	93%	14%	15%
Overall Electric	201	15,031	1,864	2,753	68%	12%	18%

For electric non-conversion participants, Washington model impacts had nearly identical expected savings, showing only a 1% difference between model and expected savings, as a percent of weather-normalized, pre-period annual consumption. Idaho model impacts were slightly lower than Washington's (10% of pre-period usage, compared to 14%), and approximately 13% lower than the expected savings percent of pre-usage (23%).[34]

Table 3-14. Conversion Participant Realization Rate Summary

Group	n	PRENAC	Model Savings (kWh)	Expected Savings (kWh)	Realization Rate	Model Savings as Percent of Pre-Usage	Expected Savings as Percent of Pre-Usage
Combo	74	19,264	12,233	14,361	85%	64%	75%
Furnace Only	5	15,019	4,683	8,902	53%	31%	59%
DWH Only	58	12,981	4,019	5,738	70%	31%	44%
Overall Conversion	137	16,449	8,394	10,511	80%	51%	64%

[34] By comparison, the 2008 Ecotope evaluation reported total expected savings of 948,427 kWh for the 117 non-conversion participants, resulting in average expected savings of 8,106—over 5,000 kWh higher than average model expected savings in 2010 (2,753 kWh). Assuming a comparable PRENAC of approximately 15,031 kWh on average, 2008 expected savings would reflect over 50% savings, relative to average pre-weatherization usage.

Model savings estimates as a percent of pre-usage were all lower for conversion participants than percentages relative to expected savings estimates.[35]

3.3.2 Review of Expected Savings

Starting in 2011, Avista reported changes to the method for calculating expected savings estimates. Table 3-15 compares the average expected savings per participant type (conversion vs. non-conversion) for 2010 and 2011.

Table 3-15. Expected Savings Comparison by State and Year

Participant Type	State	2010	2011	Percent Change
Electric (Non-Conversion)	Idaho	3,792	7,205	90%
	Washington	2,185	3,722	70%
Conversion	Washington	10,440	9,925	-5%

Average savings per participant increased for all non-conversion customers from 2010 to 2011. Average expected savings totals for conversion participant households showed a slight decrease, likely driven by a different mix of electric-savings measures installed at these sites. As shown in the measure-level expected savings summary in Table 3-16, average expected savings for furnace and water heater conversions remained constant between the two years.

Table 3-16. Expected Savings Comparison by Measure, State, and Year (in kWh)

Measures	Idaho		Washington	
	2010	2011	2010	2011
Duct insulation	427	5,485	4,329	760
Floor insulation	1,884	4,408	3,340	4,137
Wall insulation	4,726	3,466	3,333	3,447
Windows	2,623	2,432	1,516	1,205
Infiltration controls	1,539	1,871	1,552	1,456
Attic insulation	800	1,478	1,547	3,329
Water heater replacement	N/A	299	299	299
Doors	513	287	431	287
Refrigerator replacement	N/A	N/A	876	691
T-stat (no AC)	N/A	N/A	717	717
Furnace replacement (conversion)	N/A	N/A	8,655	8,655
Water heater replacement (conversion)	N/A	N/A	5,567	5,567

In considering average expected savings by measure in the table above, a few significant changes can be noted.

[35] By comparison, the 2008 Ecotope evaluation found similar conversion savings estimates for homes receiving both furnace and water heater conversions (12,687 kWh), though slightly higher estimates of water heater only conversions.

First, average duct insulation savings significantly increased in Idaho between the two years, and decreased just as drastically in Washington. In reviewing individual records, one Idaho project in 2011 listed expected savings of 15,200 kWh, while another Washington project in 2010 showed 16,644 kWh. In both cases, associated costs paid by Avista were below $1,000, while other projects showing higher costs reflected lower expected savings estimates.

Average expected floor insulation savings increased by over 2,500 kWh in Idaho and about 800 kWh in Washington. Similar to duct insulation, savings estimates for floor insulation were not consistent with cost trends (i.e., noting certain high-savings projects with lower costs, and vice versa).

Additionally, attic insulation savings increased by 85% and 115% for Idaho and Washington, respectively.

Consequently, changes in average measure-level expected savings between 2010 and 2011 appeared significant, in some cases. These measure-specific changes, along with changes in the mix of measures installed, and, potentially, these instances of outliers, affect changes in average per-participant expected savings between these years.

Table 3-17 provides more measure-specific detail for 2011 installations, including count of installations, expected savings, and average cost per installation type (using the “Cost” field in the participant database).

Table 3-17. 2011 Measure Installation Information by State

	Idaho			Washington		
Measures	Count	Avg kWh	Avg Cost	Count	Avg kWh	Avg Cost
Duct insulation	9	5,485	$402	8	760	$1,034
Floor insulation	71	4,408	$1,084	30	4,137	$1,750
Wall insulation	14	3,466	$875	9	3,447	$1,146
Windows	66	2,432	$1,469	32	1,205	$1,208
Infiltration controls	108	1,871	$710	46	1,456	$699
Attic insulation	51	1,478	$626	20	3,329	$1,596
Water heater replacement	3	299	$817	12	299	$1,220
Doors	52	287	$555	26	287	$899
Refrigerator replacement	N/A	N/A	N/A	45	691	$668
T-stat (no AC)	N/A	N/A	N/A	2	717	$373
Furnace replacement (conversion)	N/A	N/A	N/A	86	8,655	$2,594
Water heater replacement (conversion)	N/A	N/A	N/A	147	5,567	$2,128

In considering average expected savings of the final model participants, 30 electric non-conversion participants (out of a total of 201) showed expected savings as a percent of pre-usage over 30%, with three instances with this percentage over 100%. Similarly, for conversion participants, 20 accounts (out of 137) showed expected savings as a percent of pre-usage over more than 100%. While the model sample only included 2010 participants, such instances demonstrated irregularities in expected savings calculations, intimating historical consumption data may not have been used to calibrate these estimates.

3.3.3 Overall Program Results

In applying savings estimates from the billing analysis to the electric-saving 2010–2011 participant program population, total energy savings of 3,225,930 kWh were achieved. Table 3-18 provides more detail on overall savings results by state and participant type.

Table 3-18. Overall 2010-2011 Electric Savings by State and Participant Type

Participant Type	State / Type	Total Participants	Model Savings Per Participant (kWh)	Total Savings (kWh)	Total Expected Savings (kWh)	Realization Rate
Electric (Non-Conversion)	Idaho	197	1,602	315,602	1,156,559	27%
	Washington	232	2,099	487,046	650,482	75%
Conversion	Furnace Only	22	4,683	103,020	238,280	43%
	DWH Only	139	4,019	558,688	792,851	70%
	Combo	144	12,233	1,761,573	2,067,651	85%
Overall		734	N/A	3,225,930	4,905,823	66%

Table 3-19 provides the electric savings summary by state, rolling up conversion participant savings to reflect conversion and non-conversion savings in Washington.

Table 3-19. Overall 2010-2011 Electric Savings by State

State	Total Savings (kWh)	Total Expected Savings (kWh)	Realization Rate
Idaho	315,602	1,156,559	27%
Washington	2,910,327	3,749,264	78%
Overall	3,225,930	4,905,823	66%

3.3.4 Goals Comparison

We compared evaluated savings for the 734 electric participants (both conversion and non-conversion) against Avista's IRP goals. Table 3-20 provides a summary of overall evaluated savings, IRP savings goals, and realization rates overall and by state. Overall, the low-income weatherization program has achieved approximately 80% of its electric savings goals, largely driven by Washington impacts.

Table 3-20. IRP Program Goals Comparison

State	Reported Savings (kWh)	Evaluated Electric Savings (kWh)	Goal Achievement
Idaho	1,540,377	315,602	20%
Washington	2,492,905	2,910,327	117%
Overall	4,033,282	3,225,930	80%

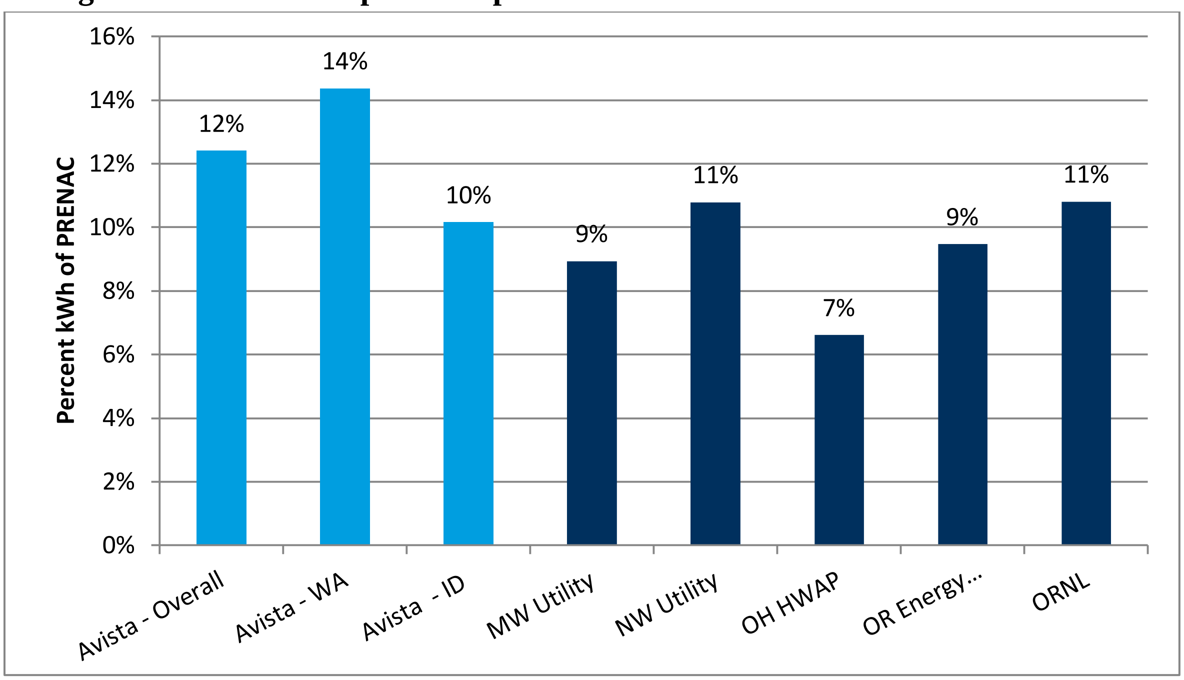
3.4 Conclusions

Billing analysis results for electric (non-conversion) and conversion participant impacts yielded high precisions, indicating reliable energy saving estimates for the program. In considering savings relative to expected savings for 2010 participants used in the billing analysis, Washington impacts were nearly 100% of expected savings totals. While a high realization rate was achieved for the model participant group, changes in expected savings calculations (increasing expected savings) resulted in reduced realization rates for the overall 2010–2011 savings totals.

3.4.1 Benchmarking

To place Avista program savings estimates in context, we compared billing analysis results from other low-income weatherization efforts from across the country. As variations in weather, costs, delivery, and measure offerings make individual programs rather distinct, comparison can be achieved by using the percent energy savings, relative to pre-usage. While conversion programs are less common, we have identified a number of other electric billing analyses of low-income weatherization impacts, as shown in Figure 3-1, comparing savings as a percent of pre-period weather-normalized annual energy consumption.

Figure 3-1. Electric Impact Comparison of Low-Income Weatherization Studies



In comparing overall Avista electric savings percentage to other studies, the Avista program achieves among higher percent savings.

3.5 Recommendations

The following subsections outline our suggestions for program enhancements to help improve program impact results.

- **Standardize calculation of expected savings between states and agencies.** This will help align actual acquisition with expectations and decrease the discrepancy in realization rates between states.

- **Work with Idaho Agencies to Provide Refrigerator Replacements.** Refrigerator replacements can result in significant electric savings; the lack of delivering these measures in Idaho likely contributes to higher savings estimates in Washington. Avista should work with local CAP agencies and other Idaho stakeholders to identify the best ways to encourage integrating these measures into program delivery.

- **Perform Quality Checks on Expected Savings Estimates.** Avista claims changes were made to expected savings calculations starting in 2011, as evident in comparing these estimates between program years; however, it appears additional quality checks on values will strengthen the robustness and reliability of these estimates.

  Specifically, Avista should screen savings relative to historical consumption, making sure the percent of savings is never more than 100% of typical annual usage, and most non-conversion projects experience no more than 50%. Typically, over 30% savings as a percent of pre-period usage is considered high, and may indicate other changes occurring within a household, aside from weatherization provided through the program (e.g., changes in occupancy, take-back, change in heating/cooling usage).

  Understanding primary heating and cooling equipment and fuel types also helps inform the accuracy of expected savings estimates. Thresholds surrounding reasonable savings estimates could be developed, based on household configurations. For example, electrically-heated participants have a much higher potential of electric savings through weatherization than gas-heated participant homes. Identifying such customer distinctions provides as opportunity to create savings ranges or thresholds, which can also be used for quality checks for calculating expected savings.

- **Track Alternative Heating Sources.** As inexpensive alternatives to gas heat, gas customers may turn to electric room heaters and wood stoves, thereby reducing impacts of weather-sensitive measures installed through weatherization (e.g., insulation). Collecting information on a customer's primary heating usage at the time of weatherization will allow more reliable estimates, in cases where, despite being a gas-heated customer, gas is used as a secondary heating source.

  We recommend working with agencies to develop explicit on-site tracking protocols surrounding participant heating sources. Agencies 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;
  - Quantity of secondary heating, if applicable (e.g., number of electric room heaters); and
  - Any indicators suggesting discrepancies between actual and reported primary heating.

- **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 with particularly high energy consumption. In fact, DOE and Washington state 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 are equipped to incorporate energy-consumption characteristics into their program participant prioritization. Not only would weatherizing high-use customers likely result in higher energy savings, it is possible some customers are overly burdened with energy bills, due to their housing characteristics, and the program could provide some relief.

Methods exist for identifying high-usage customers, while controlling for factors contributing to consumption (e.g., square footage, income, number of people per household). Using such an approach would allow Avista to identify high-use customers.

- **Consider Performing Quantitative Non-Energy Benefit Analyses.** With respect to ongoing Advisory Group discussions surrounding quantifying non-energy benefits we recommend Avista consider pursuing additional analyses, aimed at quantifying some non-energy benefits associated with low-income weatherization that are applicable to the TRC test.

  In particular, analyses of economic impacts and payment pattern improvements (including reduced arrearages, collections costs, etc.) can produce monetized values of benefits to program stakeholders, techniques which have been used by other utilities reporting low-income weatherization cost-effectiveness in both Idaho and Washington. While standard cost-effectiveness testing using the TRC test accounts for all program costs, only including energy savings as program benefits clearly omits some genuine non-energy benefits experienced by participants (as discussed in more detail in the 2010 Process Evaluation).

3.6 Future Research Areas

In light of impact evaluation findings, Cadmus recommends Avista consider the following research areas for future evaluations:

- Consider additional analyses of measure-level impacts. Cadmus has successfully performed similar analyses using combined billing and engineering analyses to refine savings estimates for low-income weatherization programs, down to the measure-level. Billing analysis is used for estimating whole-house energy savings and measure-level savings, given a sufficient sample and large energy savings relative to household consumption. Engineering analysis will supplement the evaluation for measures with smaller per-UES (e.g., faucet aerators, showerheads), and for measures where reliable billing data are unavailable. Given our previous work for Avista, and the availability of 2010 and 2011 program populations, a sufficient year of post-treatment billing data would be available by January 2013.
- Consider undertaking a non-energy benefits estimation task.

4 CFL Contingency Program

4.1 Program Description

This program was designed to deliver highly cost-effective energy-efficiency resources to Avista's customer base (both residential and small commercial) and simultaneously maintain the utility's flexibility to meet anticipated energy acquisition targets (established under (Washington's I-937) at a lower ratepayer cost and with a minimum of uncertainty.

Starting in July and running through November 2011, residences and small businesses within Avista's territory were sent 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.

Customers were also given information about returning the CFLs, at no cost to the customer, should they decide not to keep them. It was also possible for customers to request additional bulbs.

4.2 Analysis

For the evaluation of the CFL Contingency Program, Cadmus conducted two rounds of a residential surveys and one round of a commercial survey. These surveys provided both impact and process results, which were used in an engineering review to determine the adjusted gross savings achieved by the program.

Six parameters inform 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 =	Delta watt multiplier, or the difference in wattage between baseline bulb and the CFL divided by the wattage of the CFL
HOU =	Hours-of-use, daily lighting operating hours
DAYS =	Days per year, 365
WHF =	Waste heat factor is the 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 Northwest RTF. Each input is discussed in detail below.

4.2.1 CFL Wattage and Multiplier

The program delivered over 2.3 million CFLs to both residential and commercial customers in Avista's territory; the distribution is shown in Table 4-1. The CFL wattage is based on the weighted average of delivered units to each sector. For the residential sector, the average delivered CFL wattage is 18.30 watts and for commercial sector the average delivered CFL wattage is 18.25 watts.

Table 4-1. Total Units of Delivered CFLs by State and Sector Type

	Residential			Commercial			
CFL Wattage	WA Units	ID Units	Total Units	WA Units	ID Units	Total Units	Total Delivered
13	389,006	170,774	559,780	18,960	15,590	34,550	594,330
19	55,116	-	55,116	-	-	-	55,116
20	1,056,786	512,322	1,569,108	56,880	46,770	103,650	1,672,758
23	55,116	-	55,116	-	-	-	55,116
Total	1,556,024	683,096	2,239,120	75,840	62,360	138,200	2,377,320

Cadmus relied on the RTF (for residential) and 6th Power Plan (for commercial) to determine the DWM. We adjusted the RTF's residential DWM to incorporate Avista's survey results that had documented room distribution of installed bulbs. The DWM for residential installation thus changed from the RTF's 2.60 to 2.63.[36] The commercial DWM is 2.70, which is based on 6th Power Plan lighting workbook. The product of the DWM and the average CFL wattage is the reduction in wattage achieved through the installation of the average CFL.

4.2.2 HOU

Cadmus estimated CFL HOU for residential installations using Avista's survey of room types and a multistate modeling approach built on light logger data collected from four states: Missouri, Michigan, Ohio, and Maryland.[37] The average HOU was calculated using a regression statistical model using combined multistate, multiyear data. We used the multistate model's estimate of HOU by room type, which we then weighted based on Avista's survey results to determine the overall average of HOU of 2.45.

The RTF provides a value of 1.9, which is an average HOU across ***all*** bulbs in California, not just installed CFLs. One would expect CFLs to be placed in a higher use area than the average bulb. We advocate the use of the multi-state study over the California study for several reasons. The multi-state study controls not only for room type, but also for existing CFL saturation, the presence of children in the home, and day type (weekday/weekend). Not only does this result in more precise estimates than one would achieve by simply taking a weighted average, but it allows us to estimate a value more appropriate to Avista's customer base.

When compared to various TRMs across the country, our value of 2.45 is in line, and appears to be conservative, compared with the TRMs as shown in Figure 4-1.

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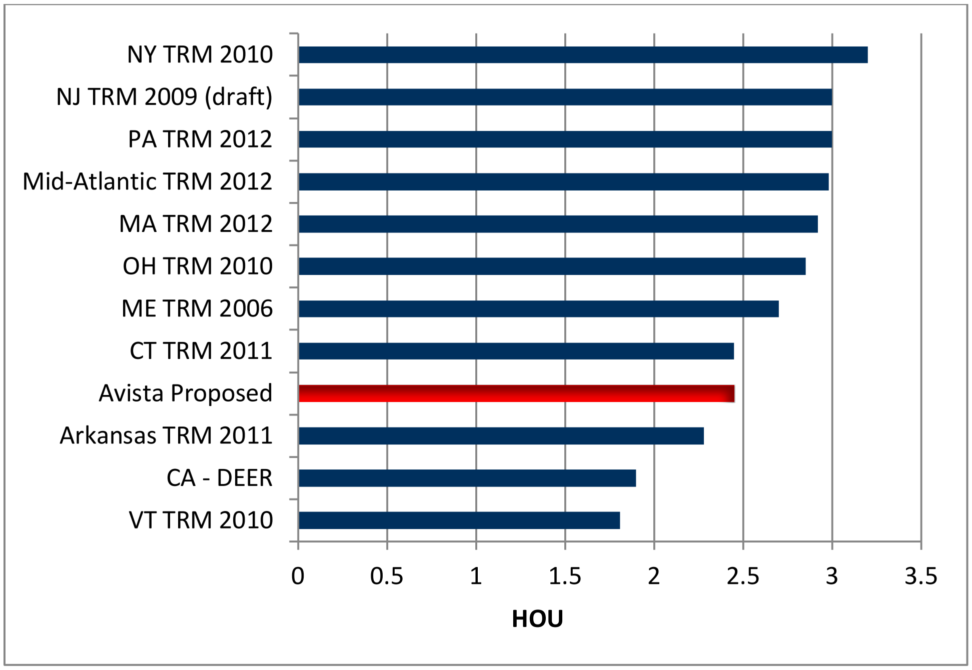
36 The RTF DWM represents the 2011 baseline and does not include federal EISA impacts starting in 2012.

37 The Cadmus Group, Inc. *2010 Evaluation, Measurement, and Verification Report*. Dayton Power and Light. March 15, 2011

Figure 4-1. HOU By Jurisdiction



* VT TRM 2010: Projected estimate for 2011. Daily usage is DPS-VEIC agreement March 2009 (see ref doc). Based on November 2008 CFL Reduction Model. Annual operating hours are calculated as (Daily usage * 365). CA (DEER): 2008 metered evaluation of an average across all bulbs in CA. Arkansas TRM 2011: CFL METERING STUDY FINAL REPORT 2005, Pacific Gas & Electric Company, San Diego Gas & Electric Company, and Southern California Edison Company, 2005. CT TRM 2011: Residential Lighting Markdown Impact Evaluation, Nexus Market Research, January 20, 2009. Maine TRM 2006: Impact evaluation of the Massachusetts, Rhode Island, and Vermont 2003 Residential Lighting Programs. Nexus Market Research & RLW Analytics. October 1, 2004. OH TRM 2010 (draft): Based on weighted average daylength adjusted hours from Duke Energy, June 2010; “Ohio Residential Smart Saver CFL Program” MA TRM 2012: Nexus Market Research and RLW Analytics (2008). Residential Lighting Measure Life Study. Prepared for New England Residential Lighting Program Sponsors. Mid-Atlantic TRM 2012: Based on EmPOWER Maryland DRAFT 2010 Interim Evaluation Report; Chapter 5: Lighting and Appliances. PA TRM 2012: US Department of Energy, ENERGY STAR Calculator. Accessed 3-16-2009. NJ TRM 2009: US Department of Energy, ENERGY STAR Calculator. NY TRM 2010: "Extended residential logging results” by Tom Ledyard, RLW Analytics Inc. and Lynn Heofgen, Nexus Market Research Inc., May 2, 2005, p.1.

For 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, we weighted the 10.16 lighting hours from the 6th Power Plan to calculate 10.02 for Avista’s commercial HOU.

4.2.3 Waste Heat Factor

The WHF is used to account for the change in annual HVAC energy, either lost or gained, due to the reduction in facility lighting energy. Cadmus based the WHF on SEEM building models developed by the Northwest Power and Conservation Council. The SEEM building models 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 account for the interaction using load shape profiles of the HVAC and lighting equipment based on dwelling occupancy.

The Council method is inherently conservative because it assumes a closed shell, i.e., all interior lamps including ceiling recessed cans are contained in a closed system so any heat put out by the bulbs goes into the building. In reality, the waste heat could transfer out of the conditioned space.

We based our calculation on Avista's share of electric heating equipment,[38] along with its associated efficiencies and its surveys of interior and exterior distribution, to obtain a WHF of 89.8%.[39]

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

4.2.4 In-Service Rate

The ISR, or installation rate, represents the percentage of shipped bulbs that are installed. We determined the ISR using results of our residential survey, which was completed in two rounds: the first in November and the second in March. This allowed for different amounts of time to have passed from when a respondent was sent a box of CFLs to when they were surveyed. These data allowed Cadmus to model the change in the ISR over time.

The residential and commercial phone surveys consisted of several important questions to determine how many CFLs had been installed (at the time of the survey) and any reasons if they had not been installed. These questions were:

- How many bulbs were broken?
- How many bulbs were missing?[40]
- How many bulbs did you install?
- Have you removed any of the bulbs that you installed? If yes, how many?

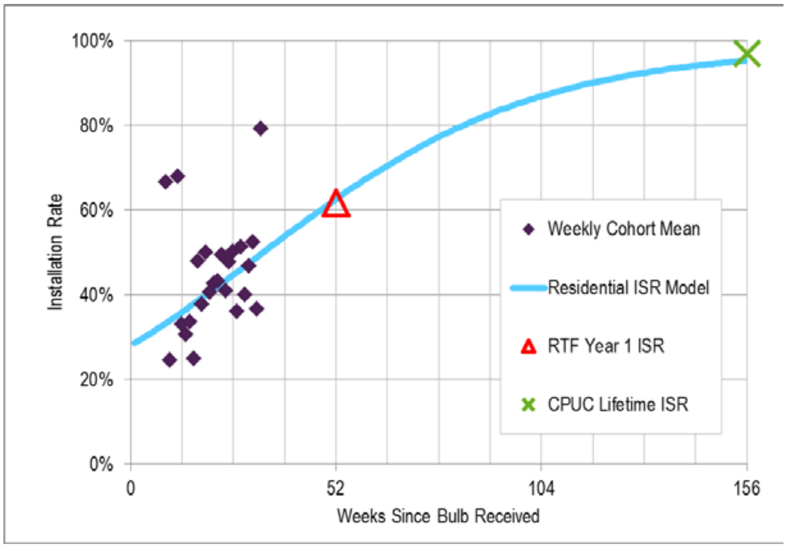
Cadmus performed a weighted least squares regression to develop a logistic function modeling ISR over time. The regression was based on survey result cohorts aggregated by the number of weeks between the bulb shipment date and the date of the survey. To account for the overall shipment breakage rate, the maximum potential ISR for the model was set to 98.1%.

The model has the following form:

Weeks =	The number of weeks since the bulbs were received.
MaxISR =	The maximum potential ISR to account for bulb breakage, 98.1%.
A, B =	Coefficients determined by the regression.

Figure 4-2 shows the weekly cohorts used to develop the regression and the resulting ISR model. For comparison, the first year ISR assumed by the RTF and the lifetime ISR assumed by the California Public Utilities Commission (CPUC) are also shown. The figure shows excellent alignment between the results of the residential surveys and the estimates by the RTF and the CPUC.[41,42,43] The RTF ISR shown in Figure 4-2 was calculated using an original install rate of 64% and a 3.57% removal rate, which resulted in the 61.7% ISR.

Figure 4-2. ISR Over Time Using Weighted Logistic Regression



Cadmus applied the ISR model to all shipments of bulbs to determine what percentage of bulbs were installed before the conclusion of the program year (which is the calendar year). The model was applied to each week's shipment separately.

We also developed a logistic regression function similar to the residential model to determine the commercial ISR. The commercial model was also applied to each week's commercial shipment to determine the ISR for the program year. Table 4-2 shows the results of the ISR modeling. No installations are estimated for 2014 or later.

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41 Research Into Action Inc. 2010. *Lighting Program Assessment: Residential Direct Distribution*. Portland, Ore.: Bonneville Power Administration.

42 KEMA, Inc. and The Cadmus Group, Inc. 2010. *Final Evaluation Report: Upstream Lighting Program, Volume 1*. San Francisco, Calif.: California Public Utilities Commission.

43 KEMA, Inc. 2005. *CFL Metering Study, Final Report*. Pacific Gas & Electric Company (San Francisco, CA); San Diego Gas & Electric Company (San Diego, CA); and Southern California Edison Company (Rosemead, CA)

Table 4-2. Annual and Cumulative In-service Rate by Sector

Program Year	Residential ISR		Commercial ISR	
	Annual	Cumulative	Annual	Cumulative
2011	39%	39%	33%	33%
Est. 2012	35%	74%	36%	68%
Est. 2013	18%	91%	21%	90%

We propose reporting PY2011 savings using only the PY2011 ISR and completing additional surveys later in 2012 and 2013 to achieve a more confident estimate of the ISR for those years.

4.3 Results and Findings

The resulting UES per bulb installed (exclusive of the ISR) for residential and commercial is 38.6 kWh and 154.3 kWh, respectively, as shown in Figure 4-3.

Table 4-3. Unit Energy Savings by Sector

Component	Residential	Commercial
CFL Watt	18.30	18.25
DWM	2.63	2.70
HOU	2.45	10.02
DAYS	365	365
WHF	90%	85%
UES (kWh)	38.58	154.30
PY2011 ISR	39%	33%
PY2011 UES (kWh)	15.05	50.92

Avista's Contingency Program started mid-year in 2011. Avista originally estimated per unit savings would be 21 kWh for all shipped residential and commercial CFL bulbs.

4.3.1 Overall Program Savings

Cadmus incorporated the ISR to determine the savings associated with the installation of bulbs in each program year. Table 4-4 shows the achieved annual savings by year, state, and sector. In 2011, the numbers are the evaluated savings; for 2012 and 2013, the numbers represent expected savings. Cadmus proposes completing additional surveys later in 2012 and 2013 to more confidently estimate savings for those years.

Table 4-4. CFL Contingency Program Evaluated and Expected Savings by State and Year

Sector	Region	2011 Evaluated	2012 Expected*	2013 Expected*	2011-2013 TOTAL*
Residential	WA	23,347,564	20,746,085	10,618,504	54,712,153
	ID	10,143,973	9,013,691	4,613,493	23,771,156
	Total	33,491,536	29,759,776	15,231,996	78,483,309
Commercial	WA	3,826,229	4,156,411	2,500,208	10,482,848
	ID	3,146,145	3,417,640	2,055,815	8,619,599
	Total	6,972,374	7,574,051	4,556,023	19,102,447
Total		40,463,910	37,333,827	19,788,019	97,585,756

* Does not include federal EISA impacts starting in 2012.

Avista's 2011 reported savings (mid-year estimate) across both sectors is 49,923,720 kWh and evaluated 2011 savings is 40,463,910 kWh, as shown in Table 4-5. For 2011, the evaluated savings is 81% of the reported savings for bulbs installed by December 31, 2011.

Table 4-5. CFL Contingency Program 2011 Reported and Evaluated Total Savings

Sector	Region	Reported Savings	2011 Evaluated Savings	Percent of Reported Savings
Residential	WA	32,676,504	23,347,564	71%
	ID	14,345,016	10,143,973	71%
	Total	47,021,520	33,491,536	71%
Commercial	WA	1,592,640	3,826,229	240%
	ID	1,309,560	3,146,145	240%
	Total	2,902,200	6,972,374	240%
Total		49,923,720	40,463,910	81%

Appendix A: Residential Weatherization Billing Model Outputs

The following tables summarize the model result outputs from our billing analysis of the PY 2010 and January 2011 participants.[44]

Table A1. Weatherization Measure Savings Regression Model (Overall Savings)

	Analysis of Variance				
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	14	926766	66198	222.69	<.0001
Error	4626	1375114	297.25757		
Corrected Total	4640	2301880			
Root MSE	17.24116		R-Square	0.4026	
Dependent Mean	-4.6706E-16		Adj R-Square	0.4008	
Coeff Variable	-3.69143E+18				
	Parameter Estimates				
Source	DF	Parameter Estimates	Standard Error	t value	Prob. t
AVGHDD	1	0.92444	0.15156	6.1	<.0001
AVGCDD	1	1.28935	0.25167	5.12	<.0001
POST * AVGHDD	1	-0.15029	0.02345	-6.41	<.0001
Feb	1	-3.59791	1.325	-2.72	0.0066
Mar	1	-6.52003	1.72455	-3.78	0.0002
Apr	1	-10.63089	2.6195	-4.06	<.0001
May	1	-12.35676	3.88904	-3.18	0.0015
Jun	1	-12.85246	4.91615	-2.61	0.009
Jul	1	-13.99908	5.61128	-2.49	0.0126
Aug	1	-14.4091	5.72553	-2.52	0.0119
Sep	1	-13.58621	4.95715	-2.74	0.0062
Oct	1	-11.89302	2.97338	-4	<.0001
Nov	1	-6.2642	1.64659	-3.8	0.0001
Dec	1	0.3675	1.27078	0.29	0.7724

44 To minimize the output, we ran an equivalent fixed-effects approach, where the dependent and independent variables are subtracted from their respective averages for each customer. This modeling approach produces identical results to the fixed effects specification with separate intercepts and reduces the amount of output considerably.

Table A2. Windows Measure Savings Regression Model (Overall Savings)

	Analysis of Variance				
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	14	3933681	280977	1027.93	<.0001
Error	15988	4370190	273.34188		
Corrected Total	16002	8303871			
Root MSE	16.53305		R-Square	0.4737	
Dependent Mean	5.87013E-16		Adj R-Square	0.4733	
Coeff Variable	2.81647E+18				
	Parameter Estimates				
Source	DF	Parameter Estimates	Standard Error	t value	Prob. t
AVGHDD	1	1.15045	0.07774	14.8	<.0001
AVGCDD	1	1.19448	0.12232	9.77	<.0001
POST * AVGHDD	1	-0.07667	0.01218	-6.29	<.0001
Feb	1	-3.07608	0.69015	-4.46	<.0001
Mar	1	-6.20763	0.8941	-6.94	<.0001
Apr	1	-9.64822	1.35761	-7.11	<.0001
May	1	-10.95025	1.97949	-5.53	<.0001
Jun	1	-10.27566	2.50606	-4.1	<.0001
Jul	1	-10.1097	2.83638	-3.56	0.0004
Aug	1	-9.97253	2.89142	-3.45	0.0006
Sep	1	-10.67712	2.51364	-4.25	<.0001
Oct	1	-11.50444	1.53114	-7.51	<.0001
Nov	1	-6.82986	0.84482	-8.08	<.0001
Dec	1	-1.83751	0.6597	-2.79	0.0054

Table A3. Windows Measure Savings (Gas Windows) Regression Model (Overall Savings)

Source	Analysis of Variance				
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	14	601629	42973	555.67	<.0001
Error	40718	3149002	77.33685		
Corrected Total	40732	3750630			
Root MSE	8.79414		R-Square	0.1604	
Dependent Mean	1.82642E-16		Adj R-Square	0.1601	
Coeff Variable	4.81495E+18				

Source	Parameter Estimates				
Source	DF	Parameter Estimates	Standard Error	t value	Prob. t
AVGHDD	1	0.52331	0.02656	19.7	<.0001
AVGCDD	1	1.79701	0.04749	37.84	<.0001
POST	1	-0.2489	0.0913	-2.73	0.0064
Feb	1	-1.70693	0.22937	-7.44	<.0001
Mar	1	-1.6126	0.29947	-5.38	<.0001
Apr	1	-0.86615	0.45369	-1.91	0.0563
May	1	1.18539	0.66831	1.77	0.0761
Jun	1	3.26945	0.84397	3.87	0.0001
Jul	1	2.70073	0.95455	2.83	0.0047
Aug	1	2.4365	0.97216	2.51	0.0122
Sep	1	2.62652	0.84397	3.11	0.0019
Oct	1	0.21556	0.51287	0.42	0.6743
Nov	1	-0.8324	0.28538	-2.92	0.0035
Dec	1	0.20087	0.22022	0.91	0.3617

*Heating savings were not expected in this model, a POST indicator was used to obtain the savings overall for this measure.

Appendix B: Residential ENERGY STAR Home Model Inputs

The following table summarizes the standard building codes in Washington and Idaho, along with the standards for new ENERGY STAR Homes.

Table B1. ENERGY STAR, Washington, and Idaho Construction Standards for New Homes

Measure	Type	ENERGY STAR Home	WA Code - Climate Zone II, R-3	ID Code - IECC 2006 Zone 5
Insulation	Ceiling	R-38	R-38	R-38
	Wall	R-19	R-19 + R-5	R-19
	Floors Over Unconditioned Space	R-30	R-30	R-30
	Slab Floors	R-10	R-10	R-10
Windows & Doors	Windows	0.35	0.35	0.35
	Max Glazing Area	0.21	Unlimited	Set to ENERGY STAR standards
	Doors	R-5	0.2 U-factor	Set to ENERGY STAR standards
Ducts	Insulation	R-8	R-10	R-8
	Sealing	Mastic only	Tapes allowed	Tapes allowed
	Max Leakage	<0.06 CFM/sqft or 75 CFM total @50Pa	Set to ENERGY STAR standards	Set to ENERGY STAR standards
Ventilation & Air Sealing	Ventilation System	Exhaust ventilation	Exhaust ventilation	Exhaust ventilation
	Envelope Tightness	0.35 normal ACH	0.35 normal ACH	0.35 normal ACH
Heating & Cooling Equipment	Gas Furnace	90 AFUE	78 AFUE	80 AFUE
	Air Conditioner	SEER 13	SEER 13	SEER 13

Appendix C: Residential High-Efficiency Heat Pump Metering Study

Introduction

This metering study was designed to investigate the energy consumption, savings, and operation of high efficiency air source heat pump equipment and their associated back up furnaces. All of the air source heat pump equipment studied was rebated as part of Avista's Residential Heating and Cooling Efficiency program.

Methodology

Site Visit Sampling

Cadmus designed a statistically significant sample for the site metering visits, based on 90% confidence and 10% precision. Avista provided Cadmus with the final FY 2010 and partial PY2011 database extracts from which to sample. Cadmus randomly selected 89 heat pump participants for metering. Some of these participants had multiple measures installed through the program so the metering site visits were also used to verify measure installations.

Forty percent of the heat pump rebate recipients in the metering sample also received a gas furnace rebate. This compares closely to the total population of heat pump rebate recipients for whom 39% also received a gas furnace rebate.

Participant Recruitment

Avista sent letters to a sample of participants and Cadmus called these customers to explain the study and schedule a time for meter installation for those who were willing to participate. Each participant received a $50 gift card during the installation of metering equipment and a second $50 gift card when the metering equipment was removed.

Sample Attrition

Of the 89 sites initially proposed for the heat pump metering project, 11 data sets were not used for analysis. The reasons for sample attrition are:

- Meter could not be retrieved because home-owner was gone for an extended period of time (2)
- Meter failure due to water damage (3)
- Installation error (3)
- HVAC technician removed meters during service visit (2)

Through quality control visits Cadmus attempted to remedy some of the issues listed above. In some cases a new meter was installed but the metering duration was too short to confidently extrapolate the meter data to estimate energy use and savings for the entire season. The composition of the heat pumps used in the final analysis is shown in the table below.

Heat Pump Metering Completes

Measure	Sample	Percent of Sample
Heating – HP with gas furnace backup	59	76%
Heating – HP with electric furnace backup	19	24%
Total	79	100%

Data Collection

Document Reviews

Cadmus reviewed rebate applications and invoices for each metering participant. We found the systems installed matched the AHRI rating reported by the HVAC contractor. The reported efficiency of each system was used to estimate savings as described in Section 1.8.1.2.

Metering Equipment and Points

To meet International Performance Measurement and Verification Protocol (IPMVP) Option A requirements, Cadmus performed the following evaluation activities to gather the necessary data capturing each unit's performance:

- **Outdoor Unit Demand/Consumption:** Grounded 240V Wattnode connected to voltage leads, 50A AC Current Transformers on each phase line (on line side), and Electronic Switch Pulse Input Adapter S-UCC-M006, data recorded on HOBO Micro Station H21-002 (2 minute logging interval)
- **Outdoor Ambient Temperature/RH**: HOBO S-THB-M00x Temperature/RH sensor mounted onto the outdoor unit via HOBO Solar Shield, data recorded on HOBO Micro Station H21-002 (2 minute logging interval)
- **Indoor Ambient Temperature/RH**: HOBO U10 mounted at thermostat (5 minute logging interval)
- **Furnace Fan Activity/Amperage**: 50A AC Current Transformer (on line side of the fan motor), HOBO SmartSensor TRMS module, data recorded on HOBO Micro Station H22-001 (2 minute logging interval)
- **Electric Back Up Heat Demand/Consumption**: 50A AC Current Transformer (on line side of the resistive coils), HOBO SmartSensor TRMS module, data recorded on HOBO Micro Station H22-001 (2 minute logging interval)
- **Supply/Return Duct Temperature/RH**: HOBO S-THB-M00x Temperature/RH sensor placed in each duct (in the center of the air stream and as close to the fan as possible), data recorded on HOBO Micro Station H22-001or H21-002 (2 minute logging interval)

All data points metered were verified by spot measurements to ensure meters were recording data accurately. Equipment was removed and sensors were tested to ensure they were not damaged during the metering period. Field staff downloaded and reviewed the data to ensure reasonable measurements were recorded for the duration of the metering study. Any discrepancies or points of interest were communicated to the analysis team. For example a typical furnace is 120V but some, especially those with backup resistance heat, are 240V. To estimate the backup electric resistance heat energy consumption and fan energy consumption, the field staff made notes to ensure the analysis was performed with the correct conversions. Spot power measurements were provided for all fans and fan power was estimated with metered current.

Analysis Methodology

Metering Heating and Cooling

Cadmus analyzed data for 79 high efficiency heat pumps. Meters were installed in either May or July 2011 and removed in February 2012. Heating and cooling savings were modeled individually for each site. Each recorded interval within a heat pump run was categorized as either heating or cooling by comparing average temperatures recorded in the system's supply and return ducts for that interval. There were a few instances where sites did not have complete or valid supply temperature data. If this occurred, indoor and outdoor temperature data were used to classify the interval as heating or cooling.

Savings Analysis

Metered energy consumption was used to estimate the heating and cooling capacity provided by the heat pump. The team used manufacturers' data to develop COP and Energy Efficiency Ratio (EER) vs. outdoor temperature curves for each installed heat pump that was metered.[45] The metered unit use was compared with a baseline 13 SEER, 7.7 HSPF code-compliant heat pump that would have been installed in the program's absence. The energy savings analysis assumes the baseline system would provide equivalent heating or cooling capacity, but at a lower COP/EER. An example of a manufacturer's cut sheet showing capacity vs. temperature is shown in the figure below for a heat pump in heating mode.

Manufacturers Heat Pump Capacity Versus System Power

INDOOR AIR		OUTDOOR COIL ENTERING AIR TEMPERATURES °F (°C)														
		−3 (−19.4)			7 (−13.9)			17 (−8.3)			27 (−2.8)			37 (2.8)		
EDB °F (°C)	CFM	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†	Capacity MBtuh		Total Sys. KW†
		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*		Total	Integ*	
25HCC518A30 Outdoor Section With FX4DNF019 Indoor Section																
65 (18.3)	525	5.13	4.72	1.02	7.34	6.75	1.07	9.76	8.90	1.12	12.54	11.13	1.18	15.15	13.78	1.24
	600	5.22	4.80	1.02	7.46	6.85	1.07	9.91	9.03	1.11	12.68	11.27	1.17	15.35	13.97	1.22
	675	5.30	4.87	1.02	7.55	6.94	1.07	10.04	9.15	1.11	12.80	11.37	1.16	15.51	14.12	1.20
70 (21.1)	525	4.84	4.45	1.07	7.04	6.47	1.12	9.43	8.60	1.18	12.28	10.90	1.24	14.86	13.52	1.31
	600	4.92	4.53	1.07	7.15	6.57	1.12	9.58	8.74	1.17	12.44	11.04	1.23	15.05	13.70	1.28
	675	4.99	4.59	1.07	7.25	6.66	1.12	9.71	8.85	1.16	12.56	11.16	1.21	15.21	13.84	1.26
75 (23.9)	525	4.50	4.14	1.11	6.70	6.16	1.17	9.09	8.29	1.23	11.98	10.64	1.30	14.56	13.25	1.37
	600	4.59	4.22	1.12	6.82	6.27	1.17	9.24	8.42	1.22	12.15	10.79	1.29	14.75	13.43	1.34
	675	4.66	4.29	1.12	6.92	6.36	1.17	9.36	8.54	1.22	12.29	10.91	1.27	14.91	13.57	1.33

The team estimated savings for meter interval 'i' and temperature 'T' as follows:

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45 COP and EER curves were created for SEER values from 13 SEER through 18.5 SEER. The SEER value for every metered heat pump was rounded to the nearest half value (ex. 13.7 became 13.5) for the purposes of applying the COP and EER curves.

Reducing Uncertainty from Physical Measurement Error

Cadmus took the following steps to minimize uncertainty resulting from bias/error that could have been introduced through the measurement process.

- **Outliers:** Field metering occasionally produces unexpected data or numbers beyond the normal range, compared with the other metered data. To identify and address possible outliers, the team divided questionable data into two categories:
  - Data physically unexplainable; and
  - Data outside the range of most other data.

  Due to outlier filtering, the study used no unexpected data. Less than 0.1% of data were identified as outliers. Almost all of the outliers occurred during the first two metering intervals.[46]
- **Calibration:** To minimize measurement error from meters, Cadmus' field staff checked all sensors used in the field to ensure they operated properly. Staff took parallel measurements with sensors to ensure variability fell within the expected tolerance.
- **Data Recording:** To ensure the team recorded realistic data, indoor conditions were monitored and compared to air conditioner use.

  To ensure data such as energy consumption and temperature were recorded simultaneously, our field staff used consistent measurement intervals, synchronized for all metering equipment at each site. This consistency ensured data from multiple sites could be compared across a uniform time period.

Reducing Uncertainty from Engineering Analysis Bias

Several types of engineering analysis bias can introduce errors and uncertainty into savings estimates, including: model types, modeler analysis bias, modeler mistakes, and data collection bias. Cadmus took these steps were taken to minimize uncertainty arising from engineering analysis error:

- ***Modeler analysis bias/mistakes***. Our team of experienced evaluation analysts reviewed all project analysis findings. We compared findings to findings from similar studies to confirm results were reasonable.
- ***CDD Model results bias.*** Metering energy consumption was compared with Energy 10 models, a well-known and widely used computer simulation model. Well-developed techniques and procedures for conducting engineering analyses with Energy 10 were utilized, subject to rigorous internal reviews.

  Every home had unique thermal characteristics; each cooling system operated differently; and homeowners often wait longer-than-predicted periods before using their cooling systems. The field staff asked questions about operation patterns. If, for example, participants noted they did not run their system until June 1, the predicted energy use model started on June 1 and the energy consumption predicted for May was set to zero.

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[46] When the watt node is connected, it begins recording pulses and the first two intervals sometimes have unexpectedly high pulse counts.

Reducing Uncertainty in Sampling and Participant Operation of Units

- ***Self-selection bias.*** Self-selection bias arises if people agreeing to participate in the study differ from those refusing to participate in a way correlated with the study findings. Self-selection was not an issue for the replacement metering sample as every potential participant contacted by Cadmus (selected through a randomized process) agreed to participate.

- ***Participant operational use bias (Hawthorne Effect).*** In any human subject study, some participants may change their behaviors due to the study itself. In this case, they would use their cooling equipment differently than they normally would have. This potential bias is known in social psychology literature as the Hawthorne effect. Cadmus mitigated this potential bias by instructing all study participants not to change their equipment use habits due to participating in the study and notifying the participants that their individual usage was confidential. Compliance with this instruction is believed to be reasonably high and any minor, initial behavioral changes are likely to fade over the 7- to 10-month period the meters remained in place.

Results

The table below shows the savings of the metering study and analysis described above. The savings shown in the table below are 10% of the reported savings assumed by Avista. The resulting savings are well calibrated to the assumptions used for the other measures within the Heating and Cooling Efficiency program. The heating savings of 321 kWh for a high efficiency air source heat pump shown in the table is equivalent to a seasonal COP increase from 2.15 to 2.28 for a home requiring 41,553 kBtu of heating annually. The cooling savings shown is equivalent to an increase in efficiency from 13 SEER to 15 SEER for a home requiring 7,278 kBtu of cooling annually.

Annualized Electric Savings

Measure	Sample	Percent of Sample	Average Annual Savings (kWh)
Heating – HP with gas furnace backup	59	76%	244
Heating – HP with electric furnace backup	19	24%	321
Cooling – All HP Units	79	100%	74
Weighted Total Annual Savings			337

Note that application of the weighted energy savings to the population assumes 76% of the population uses a gas furnace for backup.

Conclusions

The following conclusions are a direct result of this study:

- ***The HSPF may be too low.*** Multiple instances existed where the HSPF threshold of 8.5 was met with a 13.5 SEER heat pump. The analysis assumes a 13 SEER system would have been installed and matched with the same furnace (and in some cases ECM motor). For these cases, the installed system is only slightly more efficient that the base case.

- ***There is currently a high penetration of dual fuel participants.*** Cadmus believes 76% of participants have a heat pump that is supported by a non-electric furnace. The heat pump cannot run when backup fuel heat is used. This reduces the annual operating hours of the heat pump and therefore the savings achieved through its installation. This is not the case when the backup heat is electrical resistance since the heat pump and resistance can run simultaneously. This is supported by the study. The data shows heat pumps backed up by electric resistance heat running a greater percent of hours in the coldest weather bins than those backup up by gas.

  Cadmus agrees with Avista that the dual fuel system represents the lower operating cost for the homeowner. However, since the heat pump is serving a smaller fraction of the home's heating load, savings due to the installation of a high efficiency unit will be less.

- ***Cooling energy consumption is low.*** Meter data showed that some participants never ran their air conditioners or only ran them for a few hours during the summer. Evaluation staff reviewed the data and confirmed system runtime where possible to ensure the results were not erroneous. We believe the metered energy consumption represents the usage patterns of a typical home within this region. The table below compares cooling energy savings determined from this study with an engineering estimate determined using the RTF's SEEM model outputs. As the table shows, the two estimates are nearly identical.

Comparison of Cooling Savings

Model	Annual Cooling Savings (kWh)
SEEM 1,344 Square Foot Home	53.1
SEEM 2,200 Square Foot Home	81.2
SEEM 2,000 Square Foot Home, Linear Interpolation	*74.6*
Metering Study Result	74.0

Recommendations

Consider estimating savings and incenting systems separately for all-electric heating systems.

Consider tiered incentives by SEER rating as higher SEER systems generally require ECM fan motors to achieve certain SEER ratings.

Additional Findings

Fans with Electrically Commutated Motors

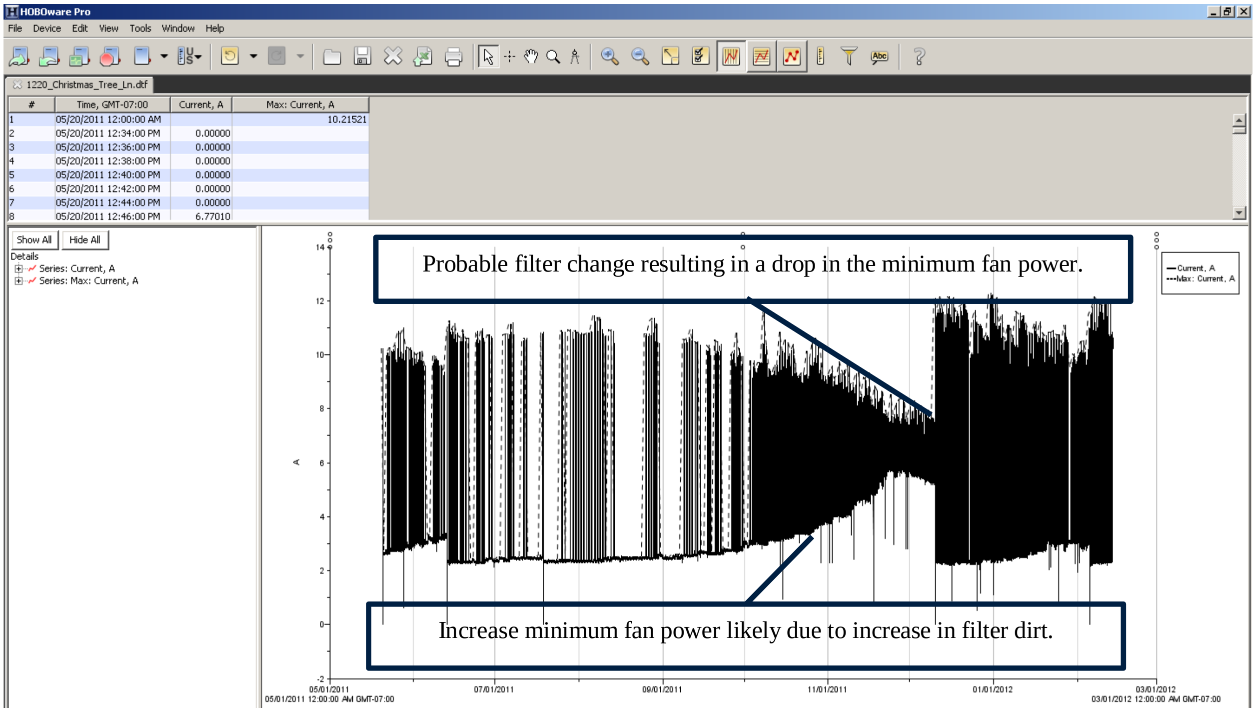
Data collected during the study show fans running during 56% of the metering period on average. This is much higher than the actual equipment runtime. Customers therefore appear to be encouraged to run fans more than just when the equipment is heating the home. When discussing their systems with metering staff, several participants said their HVAC contractor suggested they keep the fan on all the time.

An example of this is shown in the figure below. The figure shows that the metering participant ran the fan continuously. Furthermore, as the filter became dirtier the ECM motor power increased to maintain the constant airflow setpoint. The result is an increase in fan energy consumption over time while maintaining system heating and cooling efficiency.

It is not possible to quantify the effects of a similar system with a constant speed fan that cannot adjust speed as the filter collects dirt. It is reasonable to assume that the system efficiency would decrease over time requiring increased runtime to meet space temperature setpoints.

This customer stated they were encouraged to run the ECM fan continuously to maintain air quality and uniform temperature distribution throughout the home. Prior to installation of the ECM measure the participant did not run the fan continuously. The increased runtime might lead to increased fan energy consumption but the system efficiency improvements may offset the increase. Without verifying the baseline energy consumption of a furnace fan, we are unable to estimate ECM savings with the meter data collected.

Data Logger Readout of Fan Current



Appendix D: Gas Savings Achieved

The electric program achieved gas savings through multiple measures. The table below documents the savings achieved.

Measure Name	Measure Count	UES (therms)	Total Savings (therms)
E Clothes Washer	6,624	3.0	19,872
E Dishwasher	4,124	0.9	3,712
TOTAL	10,856		45,540

The evaluation found a significant percentage of Clothes Washer and Dishwasher participants had the incorrect domestic hot water heater fuel type on their application. This resulted in a reduction in the average electricity saved per installation and the creation of an average therms saved per installation. The numbers in the table above represent the average across all products installed, not just the applications with the incorrect fuel selected.