Exhibit No. ___ (MSK-3)

BEFORE THE WASHINGTON UTILITIES AND TRANSPORTATION COMMISSION

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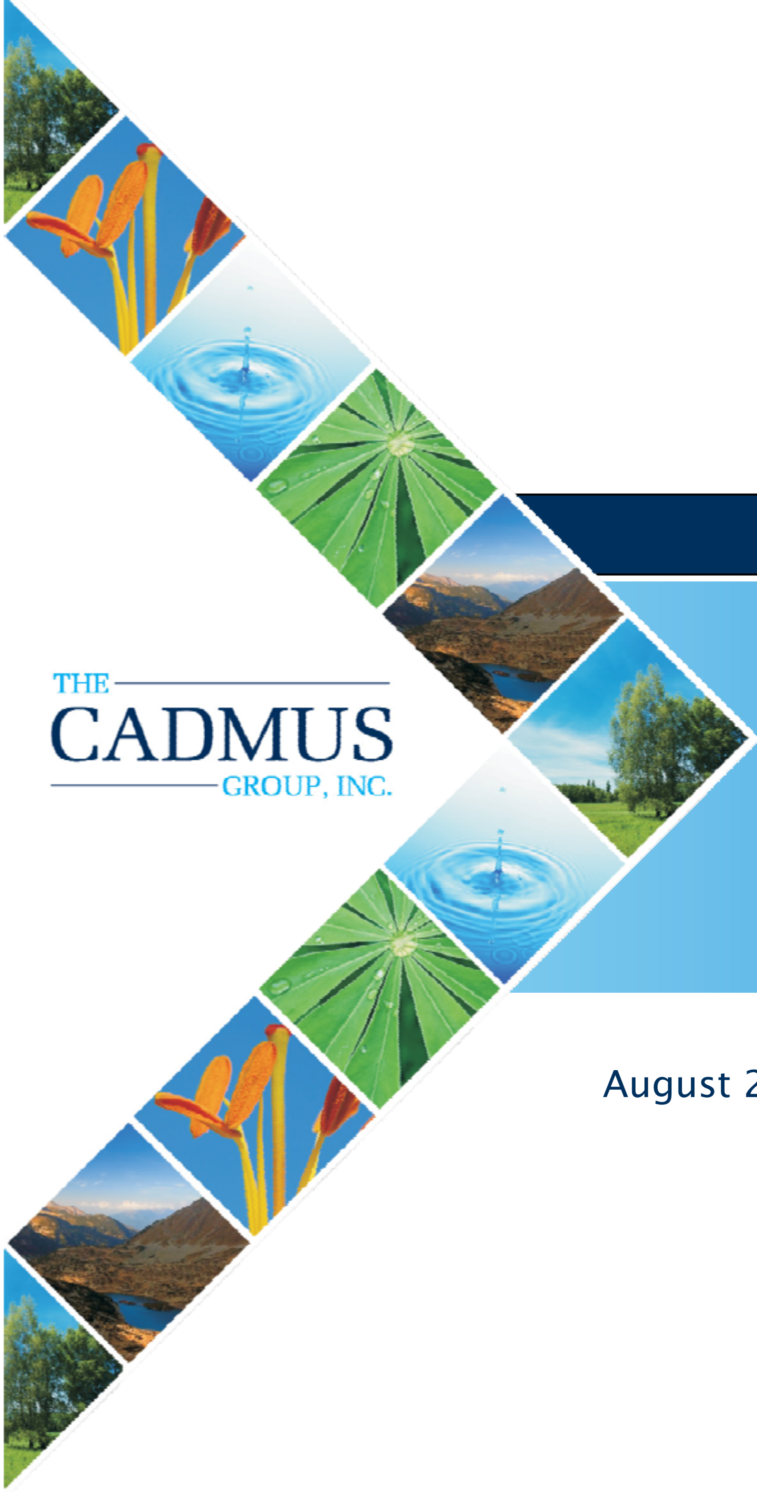
EXHIBIT NO._____(MSK-3)

DR. M. SAMI KHAWAJA

REPRESENTING

THE CADMUS GROUP, INC.



THE CADMUS GROUP, INC.

Avista 2010 Multi-Sector Gas Impact Evaluation Report

August 2, 2011

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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 gas portfolio. A process evaluation report is due to Avista in September 2011.

Evaluation Activities

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

Table 1-1. 2010 Gas Programs Evaluation Activities

Sector	Program	Document/ Database Review	Metering	Verification Site Visit	Survey	Billing Analysis	Modeling
Residential	ENERGY STAR Products	✓		✓	✓		
	Heating and Cooling Efficiency	✓		✓	✓	✓	
	Weatherization/Shell	✓		✓	✓		
	Water Heater Efficiency	✓		✓	✓		
	ENERGY STAR Homes	✓		✓			✓
Non-Residential	Prescriptive Programs	✓		✓	✓		
	Site-Specific	✓	✓	✓	✓	✓	✓
	Energy Smart Grocer	✓		✓			
Low-Income	Low-Income Programs	✓			✓	✓	

Key Findings and Conclusions

Residential

The major residential program conclusions are:

- Overall, residential gas 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 information, measure and savings information, and the database review confirmed that the information was reliable and accurate.
- The great majority of measures were determined to meet program qualification standards.
- The billing analysis performed to calculate average annual gas savings for furnaces produced interesting and conclusive results. The subsequent electric savings report will further inspect the interaction of gas furnaces and electric heat pumps to determine the overall energy usage of the home for heating.

Non-Residential

The Cadmus team successfully evaluated 104 of 453 measures installed through the program, representing 65 percent of reported savings.

In general, Cadmus determined that Avista implemented the programs well. Gross *ex post* evaluated savings achieved 76 percent of IRP program savings *goal* (892,886 compared to 1,172,269 therms). The overall portfolio achieved a 113 percent realization rate (comparing gross *ex post* evaluated savings at 892,886 therms to gross *ex ante* reported savings at 791,983 therms).

Cadmus developed a number of additional conclusions:

- The evaluation process was complicated due to some limitations in Avista's database extract. Cadmus could have streamlined the sampling process with the addition of site addresses and contact information. Measure-level data for each project, such as specific measure type and quantity, would have improved the range and depth of our evaluation activities.
- Cadmus is unable to reliably estimate interactive savings (e.g., between HVAC and lighting) impacts through the data available in Avista's current database extracts.

Low-Income

Overall, gross savings for program participants from the billing analysis averaged 123 therms in Idaho, 104 in Washington, and 112 across both states. This is approximately 15 percent energy savings for participants in both Washington and Idaho relative to their pre-participation annual consumption.

By comparing the estimated model savings to the expected savings, we calculated realization rates of 60 percent in Idaho, 30 in Washington, and 38 overall. The average expected savings provided by Avista appeared particularly high for Washington participants (46 percent of pre-usage), which accounts for the lower realization rate. Several other factors may have contributed to the low results:

- High saturation of alternative heating sources (e.g., wood, fuel oil, portable electric heaters) not accounted for when developing expected savings estimates.
- Different approaches in developing expected savings estimates are not accounting for pre-weatherization annual consumption, square footage, or measure interaction.

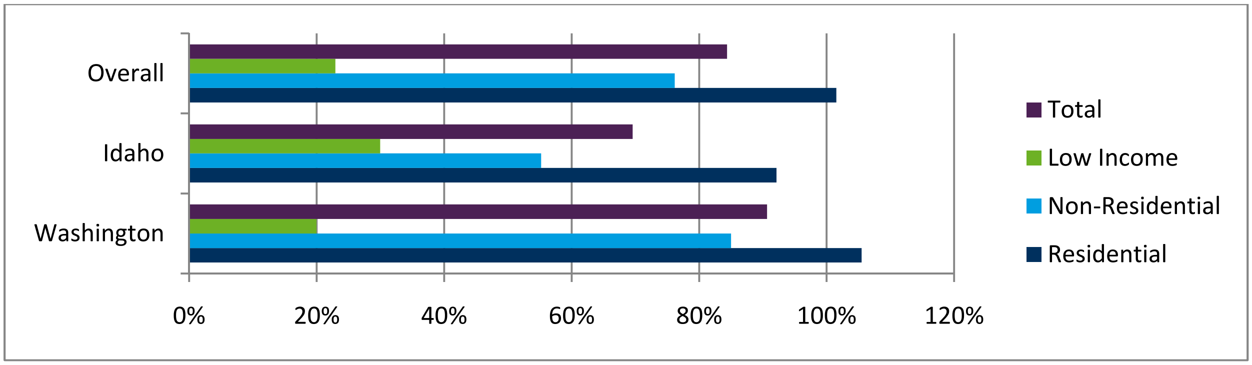
There were some homes not included in the billing analysis because they were converted from electric to gas heating.

Overall sector realization rate was 23% compared to the program goal.

Savings Results

Figure 1 displays the portfolio achieved gross savings relative to reported goals by sector, state, and overall. The residential sector exceeded goals in Washington and overall. The portfolio overall achieved 84% of the stated goals.

Figure 1. Gross Achieved Savings Percentages of IRP Goals



The following four tables show sector-level gross and net savings values and realization rates compared to reported savings and IRP goals. Net savings were estimated using results of a recent study conducted by Cadmus for Avista.

Table 1-2. Reported and Gross Verified Savings by State and Sector

	Washington			Idaho			Total		
Sector	Reported Savings	Gross Verified Savings	Real-ization Rate	Reported Savings	Gross Verified Savings	Real-ization Rate	Reported Savings	Gross Verified Savings	Real-ization Rate
Residential	823,926	683,313	83%	303,069	251,757	83%	1,126,995	935,070	83%
Non-Residential	611,681	700,883	115%	180,302	192,003	106%	791,983	892,886	113%
Low-Income	45,990	14,049	31%	15,286	8,886	58%	61,276	22,937	37%
Total	1,481,597	1,398,245	94%	498,657	452,646	91%	1,980,254	1,850,893	93%

Table 1-3. Reported and Net Verified Savings by State and Sector

	Washington			Idaho			Total		
Sector	Reported Savings	Net Verified Savings	Real-ization Rate	Reported Savings	Net Verified Savings	Real-ization Rate	Reported Savings	Net Verified Savings	Real-ization Rate
Residential	823,926	425,336	52%	303,069	155,630	51%	1,126,995	580,966	52%
Non-Residential	611,681	524,358	86%	180,302	147,986	82%	791,983	672,344	85%
Low-Income	45,990	14,049	31%	15,286	8,886	58%	61,276	22,937	37%
Total	1,481,597	963,743	65%	498,657	312,502	63%	1,980,254	1,276,247	64%

Table 1-4. IRP Goals and Gross Verified Savings by State and Sector

	Washington			Idaho			Total		
Sector	Savings Goal	Gross Achieved	Achiev-ement Rate	Savings Goal	Gross Achieved	Achiev-ement Rate	Savings Goal	Gross Achieved	Achiev-ement Rate
Residential	647,788	683,313	105%	273,281	251,757	92%	921,069	935,070	102%

Non-Residential	824,457	700,883	85%	347,812	192,003	55%	1,172,269	892,886	76%
Low-Income	70,330	14,049	20%	29,670	8,886	30%	100,000	22,937	23%
Total	1,542,575	1,398,245	91%	650,763	452,646	70%	2,193,338	1,850,893	84%

Table 1-5. IRP Goals and Net Verified Savings by State and Sector

	Washington			Idaho			Total		
Sector	Savings Goal	Net Achieved	Achieve-ment Rate	Savings Goal	Net Achieved	Achieve-ment Rate	Savings Goal	Net Achieved	Achieve-ment Rate
Residential	647,788	425,336	66%	273,281	155,630	57%	921,069	580,966	63%
Non-Residential	824,457	524,358	64%	347,812	147,986	43%	1,172,269	672,344	57%
Low-Income	70,330	14,049	20%	29,670	8,886	30%	100,000	22,937	23%
Total	1,542,575	963,743	62%	650,763	312,502	48%	2,193,338	1,276,247	58%

In summary, using gross savings as the primary measure, the 2010 gas portfolio achieved a realization rate of 93 (Table 2) percent from reported savings, and an 84 percent achievement rate from the IRP goals (Table 4). The non-residential sector had the highest realization rate of 113 percent from reported savings (Table 2), but the residential sector had the highest achievement rate of 102 percent of Avista stated goals (Table 4). Washington overall had consistently higher realization rates from reported savings and achievement rates from goals in comparison to Idaho. The low-income sector was the exception to this overall conclusion, with both realization rates and achievement rates higher in Idaho than Washington.

Recommendations and Further Analysis

Residential

The majority of our recommendations center around increasing measure level detail capture on the applications and inclusion in the databases. Some of this information includes:

- List energy factors, or at least model numbers, for appliances
- Include baseline information, such as for insulation
- Request square footage, particularly for ENERGY STAR homes

- The interaction of gas furnaces and heat pumps on both savings and incentive structure will be revisited in both the electric report and the 2010 process report. Residential heat pumps, many homes with a gas furnace as well, are currently undergoing a metering study and those data will provide important information to assist the Heating and Cooling Efficiency program going forward.

Non-Residential

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

- While Avista's databases house the information necessary to streamline evaluation, such as site addresses, site contact information, and measure-level details, a simpler extraction process could help improve the process.
- Avista may want to consider providing incentives for demand controlled ventilation, refrigerated warehouses, and steam trap replacements through the Site Specific program.
- Avista should consider revising the methods for calculating and tracking HVAC/lighting interactive effects.

Low-Income

Our suggestions for enhancements that could help improve program impact results include:

- Standardize Expected Savings Calculations. Standardizing expected savings calculations across both states will help avoid discrepancies in realization rates.
- Account for Additional Factors in Savings Calculations. Accounting for pre-period annual consumption, square footage, and interaction effects will help create a more robust savings estimate and avoid over-estimates that may occur through a prescriptive application of deemed estimates.
- Track Alternative Heating Sources. Collecting information on a customer's primary heating usage at the time of weatherization will allow for more reasonable estimates in cases where, despite being a gas customer, gas is used as a secondary heating source.
- Include High-Use Customers in Program Targeting. Targeting high-use customers may help to achieve higher energy savings and aid overly burdened customers with usage higher than average customers.

1 2010 Residential Gas Impact Report

Executive Summary

Avista's residential gas demand-side management (DSM) programs claimed savings of 1,126,990 therms during the 2010 program year. This report explains the methods undertaken to qualify and verify these savings and the adjustments made to the final savings values. The Avista 2010 DSM residential gas programs included ENERGY STAR® Products, ENERGY STAR® Homes, Heating and Cooling Efficiency, Water Heating, and Weatherization measures. Cadmus reviewed every prescriptive measure in Avista's DSM programs to create a TRM.

Evaluation Methodology

For each of the programs we employed a variety of evaluation methods and activities. These are shown in Table 1-1.

Table 1-1. 2010 Gas Programs Evaluation Activities

Sector	Program	Document/ Database Review	Verification Site Visit	Survey	Billing Analysis	Modeling
Residential	ENERGY STAR Products	✓	✓	✓		
	Heating and Cooling Efficiency	✓	✓	✓	✓	
	Weatherization/Shell	✓	✓	✓		
	Water Heater Efficiency	✓	✓	✓		
	ENERGY STAR Homes	✓	✓			✓

Energy Savings

Cadmus adjusted the claimed savings associated with each measure to reflect our TRM updates. This resulted in significant changes in savings for all programs except ENERGY STAR Homes (which was not listed in the most recent version of the TRM). Most of the changes were due to updated baseline and measure levels of efficiency as a result of changes in federal and ENERGY STAR standards.

A billing analysis for gas furnaces was completed on a total of 1,714 sites with efficient gas furnace installations. As can be seen in Table 1-2, the results of the billing analysis model had a large effect on furnace measures savings, which impacted the overall savings for the Heating and Cooling Efficiency program and for the entire gas portfolio (furnaces have the largest share of savings).

Table 1-2. Furnace Billing Model and Reported Savings

Group	N	Model Savings (Therms)	Avista Reported Savings	Realization Rate
Idaho	586	100	123	81%
Washington	1,128	105	124	85%
Overall	1,714	103	124	83%

The aggregated adjusted gross savings and resulting realization rates for each program are shown in Table 1-3. Overall, the residential gas programs achieved an adjusted gross realization rate of 84 percent.

Table 1-3. Reported and Adjusted Gross Savings

Program Name	Reported Savings (Therms)	Adjusted Gross (Therms)	Total Realization Rates
ENERGY STAR Products	44,400	60,878	137%
Heating and Cooling Efficiency	483,882	408,015	84%
Weatherization/Shell	553,876	434,960	79%
Water Heater Efficiency	12,010	7,511	63%
ENERGY STAR Homes	32,822	34,146	104%
Total	1,126,990	945,510	84%

Table 1-4. Reported and Adjusted Gross Savings by State

Program Name	Washington			Idaho		
	Reported Savings (Therms)	Adjusted Gross (Therms)	Realization Rates	Reported Savings (Therms)	Adjusted Gross (Therms)	Realization Rates
ENERGY STAR Products	32,377	44,599	138%	12,028	16,282	135%
Heating and Cooling Efficiency	324,228	273,371	84%	159,654	134,644	84%
Weatherization/Shell	432,891	340,397	79%	120,985	94,563	78%
Water Heater Efficiency	9,049	5,701	63%	2,961	1,810	61%
ENERGY STAR Homes	25,381	26,423	104%	7,441	7,724	104%
Total	823,926	690,491	84%	303,069	255,023	84%

In order to produce applicable results and findings that could be used for evaluating the residential gas programs, we chose a sample of 230 records for surveys and 68 measures for on-site verification, and used that sample to calculate qualification and verification. We chose these sample sizes to ensure industry standard levels of confidence and precision within and across programs.

We first analyzed the collected data to determine the number of measures with verified installs. Out of 230 surveys, we verified a total of 305 measures, as some participants had more than one measure. Cadmus determined measure characteristics to ensure that all qualifications were met. We analyzed application records for qualification either by visual inspection during our site visits or by conducting online database searches of model numbers when applicable. Table 1-5 shows the final verified adjusted gross savings and verified savings rates after we applied verification to each programs' savings, followed by state level savings tables. The overall realization rate for all the residential programs was 83 percent after application of the verification rates. Tables are also provided to break out Washington and Idaho savings.

Table 1-5. Avista 2010 DSM Programs Total Gross Gas Savings

Program	Measure Count	Adjusted Gross (Therms)	Verification Rate	Verified Savings (Therms)	Overall Realized Savings Rate
ENERGY STAR Products	5,876	60,878	96%	58,475	132%
Heating and Cooling Efficiency	3,934	408,015	98%	400,317	83%
Weatherization/Shell	5,667	434,960	100%	434,960	79%
Water Heater Efficiency	774	7,511	95%	7,170	60%
ENERGY STAR Homes	168	34,146	100%	34,146	104%
Total	16,419	945,510	98%	935,068	83%

Table 1-6. Avista 2010 DSM Programs Total Gross Gas Savings - Washington

Program	Measure Count	Adjusted Gross (Therms)	Verification Rate	Verified Savings (Therms)	Overall Realized Savings Rate
ENERGY STAR Products	4,269	44,599	96%	42,815	132%
Heating and Cooling Efficiency	2,636	273,371	98%	267,904	83%
Weatherization/Shell	4,426	340,397	100%	340,397	79%
Water Heater Efficiency	603	5,701	95%	5,416	60%
ENERGY STAR Homes	130	26,423	100%	26,423	104%
Total	12,064	690,491	98%	682,955	83%

Table 1-7. Avista 2010 DSM Programs Total Gross Gas Savings - Idaho

Program	Measure Count	Adjusted Gross (Therms)	Verification Rate	Verified Savings (Therms)	Overall Realized Savings Rate
ENERGY STAR Products	1,608	16,282	96%	15,631	130%
Heating and Cooling Efficiency	1,298	134,644	98%	131,951	83%
Weatherization/Shell	1,241	94,563	100%	94,563	78%
Water Heater Efficiency	171	1,810	95%	1,720	58%
ENERGY STAR Homes	38	7,724	100%	7,724	104%
Total	4,356	255,023	98%	251,588	83%

We verified that a total of 935,068 therms have been saved through the installation of 16,419 measures during PY 2010 of the gas DSM programs.

Net-to-gross values per program were computed in a previous Cadmus study in 2011. Table 1-8 shows the net savings per program.

Table 1-8. Total Program Gross and Net Verified Savings and Realization Rates

Program	Reported Savings (Therms)	NTG Ratio	Net Verified (Therms)	Net Realization Rate
ENERGY STAR Products	44,400	52%	30,408	68%
Heating and Cooling Efficiency	483,882	61%	244,193	50%
Weatherization/Shell	553,876	63.8%	277,505	50%
Water Heater Efficiency	12,010	52%	3,728	31%
ENERGY STAR Homes	32,822	73.6%	25,131	77%
Total	1,126,990	N/A	580,965	52%

1.1 Introduction

The Avista PY 2010 DSM residential gas programs included ENERGY STAR Products, ENERGY STAR Homes, Heating and Cooling Efficiency, Water Heating, and Weatherization. The electric savings associated with these programs will be reported in the Q2 2012 electric programs savings report.

We designed our impact evaluation to verify reported program participation and energy savings. For the evaluation, we utilized data collected and reported in the program tracking database, online application forms, on-site visits, phone surveys, and applicable deemed values we developed for the Avista TRM.[1]

Throughout the impact evaluation, Cadmus documented program achievements, validated savings, and identified items that should be investigated further, such as potential discrepancies in calculation assumptions and methodology.

1.2 Methodology

1.2.1 Sampling

We chose a statistically significant sample for the surveys and site visits separately, based on industry standard levels of confidence and precision. The following subsections describe the methods we employed to select a sufficient sample.

1.2.1.1 Survey Sampling

Cadmus determined sample sizes for participant surveys based on the desired confidence and precision levels for the derived verification rates. A 90 percent confidence level ensured that the findings adequately represent the larger population, and a 10 percent precision level ensured an error margin of 10 percent or less. The 90 percent confidence interval and 10 percent precision (90/10) are generally accepted as the industry standard. Table 1-9 shows our sample size goals and completions for participant surveys across the various programs.

[1] Cadmus created a TRM in the first quarter of 2011 for use in deemed measure savings.

Table 1-9. Participant Survey Sample Sizes for Residential 2010 Gas Savings Programs

Program	Sample Size	Surveys Completed
ENERGY STAR Products	70	73
Heating and Cooling Efficiency	70	72
Weatherization and Shell	70	70
Water Heater Efficiency	20	20
Total Residential Gas Surveys	230	235

Cadmus determined that the smaller sample size for the Water Heater Efficiency program (with a consequential higher margin of error) was appropriate, given the program's relatively small size within the portfolio.

Cadmus also determined that no impact-related participant surveys were necessary for the ENERGY STAR Homes program or the Home Audit Pilot program. Although the ENERGY STAR Homes program produces gas savings, the evaluation examines these homes through methods other than survey-based verification. Savings that are attributable to the Home Audit Pilot program appear in the other residential programs, and therefore do not need to be verified separately.

1.2.1.2 Site Visit Sampling

Avista provided Cadmus with the final FY 2010 database extract, which we used to revise the initially proposed sample distribution based on the final program populations and energy savings.

Our final proposed set of site visit verifications by measure is shown in Table 1-10.

Table 1-10. Gas Measure Level Site Visit Goals and Completes

Measure	Proposed Site Visits	Completed Site Visits
ENERGY STAR Home	5	4
High-Efficiency Boiler	4	2
High-Efficiency Furnace	27	32
Insulation – Ceiling/Attic	8	7
Insulation – Wall	8	5
Insulation – Floor	0	1
Windows	16	14
ENERGY STAR Clothes Washer	0	3
High-Efficiency Water Heater - 50 gallon	0	1
High-Efficiency Water Heater - Tankless	0	1
Total	68	70

Cadmus attempted to verify savings for every incented measure at each site, regardless of whether it achieved gas or electric savings. As noted previously, Cadmus will report electric measure savings in 2012.

1.2.2 Data Collection and Analysis

1.2.2.1 Document Reviews

Cadmus completed document reviews for our sample to ensure that each measure met all program specifications and that rebate amounts were properly calculated. This involved a careful review of rebate applications and invoices. We found all model numbers in online databases and matched the measure characteristics to what was claimed in the invoice and application.

1.2.2.2 Surveys

Cadmus contracted with market-research firm Discovery Research Group (DRG) to conduct surveys with participants of the four gas-saving programs with the greatest impact: ENERGY STAR Products, Heating and Cooling Efficiency, Weatherization, and Water Heater Efficiency.

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 individual participants. Cadmus monitored survey phone calls to ensure accuracy, professionalism, and objectivity. DRG delivered response data to Cadmus in Microsoft Excel® format, and Cadmus conducted analysis using SAS. We analyzed the survey data at the program level, rather than at the measure level, and in order to ensure accuracy, we included a random and proportional distribution of measures in each program-level sample.

1.2.2.3 Site Visits

Cadmus randomly selected a sample of the participant population and performed site visits to verify measure installation and record measure characteristics. This on-site verification of measures included a visual inspection of 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.

1.2.2.4 Database Analysis

We analyzed the database to make sure that savings for measures were accurate and to check for any duplications or deletions. The analysis revealed that the database does not exhibit any systematic problems and that it accurately reflects the information provided by the applicant. We did not find any inaccuracies on the part of the applicant through our verification and qualification analysis during the documentation review.

1.2.2.5 Engineering Analysis

Cadmus reviewed every prescriptive measure in Avista's DSM programs to create a TRM. Avista's DSM prescriptive measure information was listed in a MS Excel spreadsheet with deemed savings values. According to Avista, the savings numbers required a detailed review and updating where necessary.

Cadmus' review required:

- In depth knowledge and understanding of the specifics of each measure to ensure that the appropriate baseline was used and that savings calculations reflect the best possible *ex ante* value for the region;

- Engineer coordination to ensure consistency in inputs and calculations and to ensure that the most up-to-date sources were referenced;
- Knowledge and understanding of federal minimum codes and standards; and
- Detailed review of the engineering calculations Avista used.

Ultimately, Cadmus provided recommendations for every measure and included source references, engineering algorithms, and inputs for algorithms.

Cadmus reviewers examined savings methodologies from the Regional Technical Forum (RTF) that are applicable for gas savings, as well as Northwest Power Planning 6th Plan savings. Reviewers also assessed other TRMs and engineering studies from the Northwest and around the country when applicable. Reviewers also interviewed our internal industry experts for each technology type. For certain measures, engineering modeling was necessary to validate savings estimates.

Cadmus completed our review at the end of March 2011, and presented the findings to Avista on April 6. The Implementation Team program managers and engineers reviewed the TRM document and held a meeting on April 26 to discuss the findings and address questions. One final review meeting was held on May 12, 2011.

1.2.3 Billing Analysis

Cadmus conducted a statistical billing analysis to determine the adjusted gross savings and realization rates for the gas furnace measures installed through the residential Heating and Cooling Efficiency gas rebate program in PY 2010.

To estimate the furnace energy savings due to the program, Cadmus used a pre and post-installation combined Conditional Savings Analysis (CSA) and Princeton Score Keeping Method (PRISM) approach using monthly billing data. We calculated model savings estimates for Idaho, Washington, and for the states in combination.

1.2.3.1 Billing Analysis Methodology

Avista provided Cadmus with monthly billing data for all the furnace participants from January 2008 through April 2011. Avista also provided us with a measure detail file that contains participation and measure data for the furnace participants, including all additional gas and electric measures installed in conjunction with the gas furnaces. The participant information included customer details, account numbers, type of measure installed, rebate amounts, measure installation costs, measure installation dates, and deemed savings per measure.

The first step Cadmus performed was to match up the furnace measure information with the gas furnace billing data. We obtained daily average temperature weather data from 2008 to 2011 for the 10 National Oceanic and Atmospheric Administration (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) for each station. Using a 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 from the associated station.

In order to prevent bias from the differing reading cycles in assigning the pre and post periods, and to simplify the analysis, we allocated the therm billing usage and the associated matched HDDs to calendar months. Since the latest available billing data were in April 2011, and the furnaces were installed 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.

Due to post-period data limitations (with the available data only extending through April 2011), most participants had fewer than the standard 12 months of pre- and post-installation billing data months. For this reason, we paired the pre and post months used in the billing analysis. For example, if a customer installed measures in August 2010, we defined the post-period as September 2010 through April 2011, while the pre-period was the corresponding months from September 2009 through April 2010. This ensured that we used the same months in both the pre and post periods, in order to prevent bias from using mismatched months.

Furthermore, for Washington participants, we were able to perform automated queries on a realty website (www.zillow.com) to obtain the square footage of homes by address.

1.2.3.2 Data Screening

General Screens

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

- **Furnace participants that installed other gas measures.** To accurately isolate gas furnace savings, participants installing additional measures were excluded from the analysis. [2]
- **Customers that indicated unit numbers in the address.** These could potentially indicate furnace installations that occurred in apartments.
- **Accounts with fewer than three paired months (90 days) of billing data in either the pre or post period**. This screen also excluded customers that moved 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 furnace usage behavior of the previous tenants would match that of the current tenant who installed the furnace.

PRISM Modeling Screens

The second step in our screening process was to run PRISM models for the 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 of the furnace savings obtained from the CSA model.

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

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[2] For the 654 furnace participants that installed other measures, the expected savings from the new furnace was 110 therms. The expected savings from the other measures is nearly as high as for the furnace installs. As a result, the model would have difficulty disaggregating the impacts from a furnace from another measure that affects the space heating usage.

The PRISM model specification we used was:

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

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

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

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

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

Where for each customer 'i':

NAC_i	=	the normalized annual therm 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 therm 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 (TMY2) in the 1971-2000 series from NOAA, based on home location[3]
$\beta_1 * LRHDD_i$	=	the weather-normalized annual weather sensitive (heating) usage, also known as HEATNAC
ε_i	=	the error term

Once we ran the models, we applied the following first set of screens on the PRISM model output to remove participant from the furnace billing analysis:

- **Accounts with a PRISM model r-squared of less than 0.75.** These indicate a bad fit of the monthly gas usage and the actual HDDs, which is unexpected when a furnace is used in both the pre and post periods.
- **Accounts with a HEATNAC of less than 100 therms in either the pre or post period**. If the annual heating usage is that low, the heating system was likely not used at all, and gas

[3] In billing analysis we typically use 30 year normal heating degree averages to weather normalize the usage. The latest 30 year series available for this analysis was the TMY2 (1971-2000) series from NOAA/NCDC. We also ran the billing analysis using the 15 year TMY3 (1991-2005) heating degree days and the overall savings were not very different (5% lower).

was probably only used for backup secondary heating. This screen also removed accounts with negative heating slopes from the analysis, since it is unlikely that the usage would have decreased in the heating months.

- **Accounts where the post-weather-normalized (POSTNAC) usage was more than 70 percent of 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, that are unrelated to the furnace installation.
- **Accounts where the pre-period base load was 0 and the post-period base load was greater than 0.** Since the base load indicates the usage that occurs in non-winter and shoulder months, this outcome suggests that a gas water heater, gas dryer, or gas range was added to the participant home. In this situation, the additional base load usage in the post period is not related to the furnace installation.
- **Accounts with negative intercepts, and hence negative base load,** were included in the analysis but truncated to 0. These negative intercepts typically occur in homes with gas space heating and without gas water heating. The base load for these homes is expected to be 0, thus we set the base load to 0.

Once we placed these screens on the data, there were 1,714 participants remaining that we used in the CSA model outlined below to determine the overall savings.

Table 1-11 summarizes the account attrition from the various screens listed above.

Table 1-11. Furnace Account Attrition

Screen	Number Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original	3,800	100%	0	0%
Accounts that Installed Other Measures	3,146	83%	654	17%
Insufficient Pre/Post Months or Moved During Pre or Post	2,437	64%	709	19%
PRISM Screens: Low R-Squared, Low Heating Usage	1,942	51%	495	13%
Changed Usage Between Pre and Post Period (> 70%)	1,918	50%	24	1%
Added Base Load	1,741	46%	177	5%
Multifamily (Unit Number Present)	1,714	45%	27	1%
Final Analysis Group	1,714	45%	2,086	55%

1.2.3.3 CSA Modeling Approach

To estimate furnace 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 with the inclusion of 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 state-level furnace savings

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

Where for participant 'i' and monthly billing period 't':

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

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

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

β_2 = the therm savings per HDD for the efficient furnace measure in Idaho

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

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

β_3 = the therm savings per HDD for the efficient furnace measure in Washington

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

$POST\_WA_i * AVGHDD_{it}$ = an interaction between the Washington post indicator ($POST\_WA_i$) and the HDDs ($AVGHDD_{it}$)

M_t = an array of bill month dummy variables (Feb, Mar, …, Dec), 0 otherwise[4]

ε_{it} = the modeling estimation error

The model above estimates the savings per heating degree for Idaho and Washington respectively with β_2 and β_3. In order to obtain the actual annual savings under normal weather conditions, we applied the 1971-2000 TMY2 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 furnaces have seasonality to their usage, a per heating degree savings allows for allocating savings across all the calendar months, as well as being based on the HDDs. Using just a post-period indicator would have had a predominance of the winter months, resulting in savings being biased upwards.

[4] 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.

1.2.4 Measure Qualification Rates

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

The only non-qualified measure we found (out of the entire site visit verification sample) was a wall insulation project. The installed foam board insulation is listed on the invoice as R-9.4, but program qualification requires a minimum increase of R-10. Since all of the existing insulation was removed prior to installation, the final R-value does not meet the qualifying criterion, but results in a qualification rate of 96 percent. All other measures had qualification rates of 100 percent, and the total qualification rate for all residential gas programs was 99 percent.

1.2.5 Verification Rates

Cadmus determined verification rates for each program, but not for each measure. We administered verification site visits and surveys, where applicable. This verification included checking that the correct measure was tracked in the database, the correct quantity was accounted for, and that the unit was still in place and operable. We gave equal weight to the site visit and survey observations.

1.3 Program Results and Findings

1.3.1 Overview

After completing surveys and site visits, we analyzed and applied the data to the reported savings. We applied the savings from the updated TRM to each measure and then applied the verification rates to 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. In the following sections, we describe each program, explain our analysis steps, and discuss the results and findings.

1.3.2 ENERGY STAR Products

1.3.2.1 Program Description

The ENERGY STAR Products program includes the following measures:

- Clothes Washer (Electric and Gas)
- Dishwasher (with Electric or Gas water heater)
- Freezer
- Refrigerator

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 only considers gas savings.[5]

1.3.2.2 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.

The method we used for verifying measure savings entailed the following steps:

1. Conducting a phone survey or site visit to verify installation of the measure within Avista's service territory.
2. Calculating a realization rate, which is the ratio of verified to claimed units by measure type within the sample.
3. Apply the realization rate to the entire population.

Clothes washer savings have a single deemed value in the TRM, which we applied directly to the entire verified and qualified population of ENERGY STAR clothes washers. There are, however, two savings values for dishwashers depending on the baseline and efficient energy factor (EF) values. Due to the lack of baseline and efficient EF values being collected on the application and in the database tracking system, Cadmus applied an average of the two savings values to the entire verified and qualified population of ENERGY STAR dishwashers.

1.3.2.3 Results and Findings

Table 1-12 shows the total reported and adjusted gross savings for the gas ENERGY STAR Products program by measure.

Table 1-12. ENERGY STAR Products Measure and Program Reported and Adjusted Savings

Measures	Reported Values			Adjusted Gross	
	Count	Unit Savings (Therms)	Reported Savings	Average Unit Savings (Therms)	Total Adj Gross Savings
ENERGY STAR Clothes Washer	3,755	9.0	33,795	14.8	55,649
ENERGY STAR Dishwasher	2,121	5.0	10,605	2.5	5,229
Program Total	5,876	7.6	44,400	10.1	60,878

As can be seen in Table 1-12, there are considerable differences between the savings per measure from the reported savings and those derived from the TRM. This difference is driven by the adjustments Cadmus made to the TRM savings values. The adjusted clothes washer savings of 14.8 therms are the result of an exhaustive study we performed for the California Public Utilities

5 We will complete the 2010-2011 electric savings report in Q2 of 2012.

Commission, where we determined greater savings than the 9.0 therms/measure reported by Avista. The new ENERGY STAR dishwasher values are based on calculations using federal standards and averages of dishwashers in the market that meet ENERGY STAR standard of 0.72 EF.

Our site visits and participant surveys produced a verification rate of 96 percent using a sample of 76 participants.[6] Table 1-13 shows program-level reported, adjusted gross, and verified savings.

Table 1-13. ENERGY STAR Products Total Gas Savings

Region	Measure Count	Reported Savings	Adjusted Gross Savings	Verification Rate	Verified Savings	Verified Savings Rate
WA	4,269	32,377	44,599	96%	42,838	132%
ID	1,608	12,028	16,282	96%	15,639	130%
Total	5,876	44,400	60,878	96%	58,475	132%

The decreased dishwasher savings are offset by the increased clothes washer savings, and are due to considerably more clothes washer than dishwasher installations. The realized adjusted gross savings rate is 137 percent for the ENERGY STAR gas measure savings. This verification rate decreased the savings slightly to 58,475 therms, and produced an overall verified realized savings of 132 percent of the reported savings.

1.3.3 Heating and Cooling Efficiency

1.3.3.1 Program Description

The Heating and Cooling Efficiency program includes the following measures:

- Gas Boiler
- Gas Furnace
- Ductless Heat Pump (Electric)
- Air Source Heat Pump (Electric)
- Variable Speed Furnace Fan (Electric)

This program offers five categories of incentives for residential electric and gas customers seeking to purchase high-efficiency heating and cooling equipment. In this report, we only discuss installations resulting from the $400 incentive available for installing a high-efficiency natural gas furnace of 90 percent AFUE (heating efficiency) or greater, or a natural gas boiler of 90 percent AFUE or greater.

6 Confidence and precision information on verification rates are presented in the Verification Confidence and Precision section of this report.

1.3.3.2 Analysis

In PY 2010, 3,860 efficient furnaces were installed in 3,800 residences. Of these residences, 3,146 (83 percent) installed only a furnace measure. The remainder also installed additional gas measures in their home. The 2010 Avista deemed savings estimate for each furnace installation was 123 therms, based on converting a standard code 78 percent efficient furnace to a 90 percent or more efficient furnace. Cadmus conducted a statistical billing analysis to determine the adjusted gross savings and realization rates to modify this value.

With only 74 efficient boilers being installed during PY 2010, we decided that a billing analysis would not be feasible for determining the adjusted gross savings. Engineering algorithms assume a baseline boiler of 80 AFUE and an efficient boiler of 95 AFUE. We chose the value of 95 AFUE due to the results of our site visit analysis, in which all the efficient boilers we reviewed were at least 95 AFUE.

1.3.3.3 Results and Findings

Table 1-14 shows the total reported and adjusted savings for the gas Heating and Cooling Efficiency program measures.

Table 1-14. Heating and Cooling Efficiency Measures and Reported and Adjusted Savings

	Reported Values			Adjusted Gross	
Measures	Count	Unit Savings (Therms)	Reported Savings	Average Unit Savings (Therms)	Total Adj Gross Savings
High-Efficiency Boiler	74	123.0	9,102	141.0	10,435
High-Efficiency Furnace	3,860	123.0	474,780	103.0	397,580
Program Total	3,934	123.0	483,882	103.7	408,015

As can be seen in Table 1-14, the adjusted gross savings increased significantly for boilers. This is due to Cadmus increasing the measure efficient level from 90 to 95 AFUE. Furnace savings decreased as a result of our furnace billing analysis, explained in greater detail below.

Furnace Billing Analysis Model Results

Table 1-15 summarizes the model savings results for the 1,714 furnace measure participants. The model savings for Idaho are 100 therms, 105 for Washington, and 103 overall.[7] The precision level indicates that the percent error of the savings estimate is less than 10 percent.

[7] Cadmus also ran the analysis including participants who received rebates for a water heater and a furnace. Savings for the furnace measure increased by approximately 0.5%.

Table 1-15. Furnace Savings Summary

Group	N	PRENAC	Model Savings Per HDD	Normal HDDs	Model Savings (Therms)	Precision at 90% Confidence	Savings Lower 90% (Therms)	Savings Upper 90% (Therms)
Idaho	586	1,009	0.01458	6,873	100	7%	94	107
Washington	1,128	1,031	0.01566	6,700	105	5%	100	110
Overall	1,714	1,024	0.01527	6,759	103	4%	99	107

Table 1-16 compares the modeled savings with the expected deemed savings to obtain realization rates (81 and 85 percent for Idaho and Washington, respectively).[8] The percent savings are similar in each state, at 10 percent of the weather-normalized pre-period usage.

Table 1-16. Realization Rate Summary

Group	N	PRENAC	Model Savings (Therms)	Expected Savings*	Realization Rate	Savings as Percent of Pre
Idaho	586	1,009	100	123	81%	10%
Washington	1,128	1,031	105	124	85%	10%
Overall	1,714	1,024	103	124	83%	10%

* The deemed per measure savings are 123 therms; however, since some customers installed multiple furnaces, the per customer savings are closer to 124 therms.

In our review of the measure data, we found that approximately 10 percent of furnace participants also installed heat pumps. In these cases, the additional furnaces were installed mainly to supplement the heat pump space heating usage, and to provide backup heating when the weather is too cold for the heat pumps to cover the entire homes' heating requirements.

Table 1-17 summarizes the savings, comparing the 10 percent of customers that installed heat pumps to the 90 percent of customers that only received a furnace.[9] The savings are considerably lower when excluding the heat pump group (82 versus 103 overall). The savings from the heat pump participants is 285 therms, because a portion of the gas heating load is being supplied by the heat pump.

[8] The average home size for the Washington furnace participants was 1,728 square feet. It is possible that the engineering assumptions use a larger home average. Moreover, the homes in the bottom quartile of usage saved only 38 therms. Since the furnace measure was offered to all homes, participants with smaller homes were not expected to yield high furnace savings. Finally, we examined the participant surveys to determine if gas is used as a secondary heating system, as wood and electric may also used to heat the homes, which would lead to lower savings.

[9] In the population of furnace installations, 385 out of 3,800 customers (10 percent) installed a heat pump as well as a furnace.

Table 1-17. Furnace Savings Summary With Heat Pumps and Without Heat Pumps

State	Heat Pumps Installed	N	PRENAC	Model Savings Per HDD	Normal HDDs	Model Savings (Therms)	Precision 90%	Savings Lower 90% (Therms)	Savings Upper 90% (Therms)
Idaho	No	524	1,008	0.01130	6,880	78	9%	71	85
Washington	No	1,017	1,034	0.01250	6,700	84	6%	79	89
Overall	No	1,541	1,025	0.01207	6,761	82	5%	77	86
Idaho	Yes	62	1,018	0.04051	6,814	276	7%	256	296
Washington	Yes	111	1,010	0.04341	6,702	291	5%	275	307
Overall	Yes	173	1,013	0.04230	6,742	285	5%	272	298
Idaho	Overall	586	1,009	0.01458	6,873	100	7%	94	107
Washington	Overall	1,128	1,031	0.01566	6,700	105	5%	100	110
Overall	Overall	1,714	1,024	0.01527	6,759	103	4%	99	107

The overall results should be used, since they represent the savings that occurred as a result of the program.

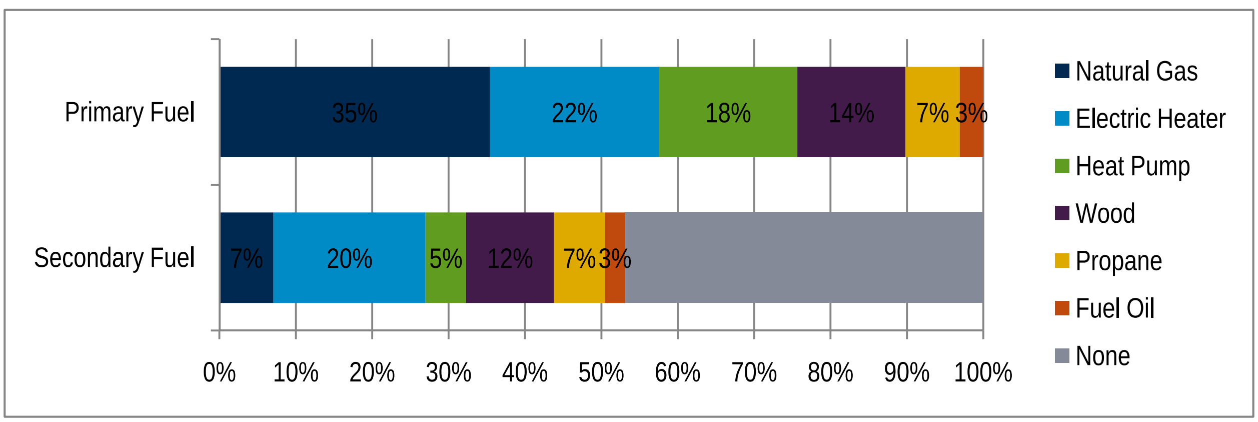
Findings from Participant Surveys

To inform the results of the gas furnace billing analysis (and other heating efficiency measures), the residential participant survey asked homeowners what fuel they "primarily" use to heat their homes, and whether they use "any other kind of heating in addition."

Figure 1-1 shows the responses from 226 participants surveyed. It is apparent that Avista customers use a diverse mix of fuels. Also, slightly more than half of the households reported using a secondary fuel, with electric heaters and wood being the most frequently mentioned.

We explored a few possible reasons for the lower-than-expected savings from the gas furnace measure. One possibility is that Avista customers that primarily heat with natural gas are supplementing their heating with other fuels. A second explanation is that customers may use their gas furnace only as a secondary heating device.

Figure 1-1. Primary and Secondary Heating Fuel Reported by Residential Participants



Expected savings from gas furnace measures assume that an inefficient furnace was replaced with a high-efficiency unit AND that the gas furnace is the only heating method for the home. Whenever these assumptions are not correct, realized savings are likely to be lower than expected.

Table 1-18Table 1-18. Heating Fuel Reported by Furnace Measure Participants summarizes the survey results for participants who received the furnace measure. These data are generally consistent with the results of the billing analysis and the fuel mix data above. As noted, expected savings assume that natural gas is the only fuel used for heating the home; which the survey results show as being the case for 67 percent of participants.[10] As shown, the other 33 percent of participants either supplement with electric heat or wood, or they use the natural gas furnace itself as a supplement to their heat pump.

Table 1-18. Heating Fuel Reported by Furnace Measure Participants

Primary Fuel	Secondary Fuel	Responses	Percent
Natural Gas	None	28	67%
Natural Gas	Electric Heater / Wood	6	14%
Heat Pump	Natural Gas	8	19%
Total		42	100%

Furnace Billing Analysis Conclusions

At present, our billing analysis provides a strong basis for assigning savings to the gas furnace measures during the evaluation period. However, our billing analysis and survey data also show that a significant number of participants receive incentives for installing both a heat pump and a gas furnace. The gas savings for these participants are much larger than expected, because they are presumably using heat pumps to heat their homes until extreme temperatures require the use of a gas furnace. The high savings reflect replacement of an older furnace with BOTH a heat pump and a gas furnace. Our current analysis does not consider the electric impact of the heat pump on the household’s overall energy usage, but will in future reports.

Future research can focus on the issues we found with our present study. These include:

- Whether the energy benefits from participants that receive multiple incentives are consistent with Avista’s objectives. Specifically, determine whether it is cost-effective to incent customers to install heat pumps, gas furnaces, and (in some cases) to also pay a conversion incentive.
- Whether incentives for gas furnaces are cost-effective in all cases or if some additional restrictions, such as minimum square footage requirements or use of other fuels, might improve program performance.

[10] We designed the survey to provide statistical validity across all Heating and Cooling Efficiency program measures. Since furnaces are just one measure in this program, only 45 furnace participants were surveyed for this study. Generally, a sample size of 67 is expected to produce results at the 90/10 levels of confidence and precision.

Overall Program Savings

Our site visits and participant surveys produced a verification rate of 98 percent from 106 total observations.[11] Table 1-19 shows program-level reported, adjusted gross, and verified savings.

Table 1-19. Heating and Cooling Efficiency Total Gas Savings

Region	Measure Count	Reported Savings	Adjusted Gross Savings	Verification Rate	Verified Savings	Verified Savings Rate
WA	2,636	324,228	273,371	98%	268,213	83%
ID	1,298	159,654	134,644	98%	132,104	83%
Total	3,934	483,882	408,015	98%	400,317	83%

The decreased furnace savings are not offset by the increased boiler savings due to considerably more furnace than boiler installations. We determined the realized adjusted gross savings rate to be 84 percent for the Heating and Cooling Efficiency program gas savings. The verification rate decreased the savings slightly, to 400,317 therms, and the program produced an overall verified realized savings rate of 83 percent.

1.3.4 Weatherization/Shell

1.3.4.1 Program Description

This 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)
- Programmable Thermostat with AC (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 increase the R-value by 10 or more, and is incented at $0.25 per square foot of new insulation. Homes are eligible if their existing attic insulation is less than R-19. Floor and wall insulation (both fitted/batt type and blown-in) that increases the R-value by 10 or more is incented at $0.50 per square foot of new insulation. Homes are eligible if their existing floor and/or wall insulation is less than R-5.

[11] Confidence and precision on verification rates are presented in the Verification Confidence and Precision section.

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. This measure in the program ended on April 1, 2011. Customers have until June 30, 2011 to install windows and submit a rebate form to Avista.

1.3.4.2 Analysis

For all insulation and efficient windows measures, the square footage and baseline and efficient R-values (insulation) and U-factors (windows) were not reported in the program tracking database. The records we sampled contained these values in both the application and supporting invoices. Using these data, we determined qualification rates, but the sample size was too small to apply area and type of insulation or windows to the entire population. In order to safely assume an amount of area for each measure, we averaged the total rebate amount for each measure for each database applicant by measure type. We then divided these averages by the respective rebate amount per square foot, which resulted in an average of installed area by measure.

The main source of error in this methodology is the assumption that all total rebates were calculated correctly. With a large total quantity being averaged—1,295 ceiling, 205 floor, and 388 wall insulations, and 3,762 window records in the database—any rebate mistakes should be diluted. The resulting area of installation per measure was 103 (ceiling), 497 (floor), 526 (wall), and 97.6 (window) square feet.

1.3.4.3 Results and Findings

Table 1-20 shows the total reported and adjusted savings for the gas Weatherization program measures.

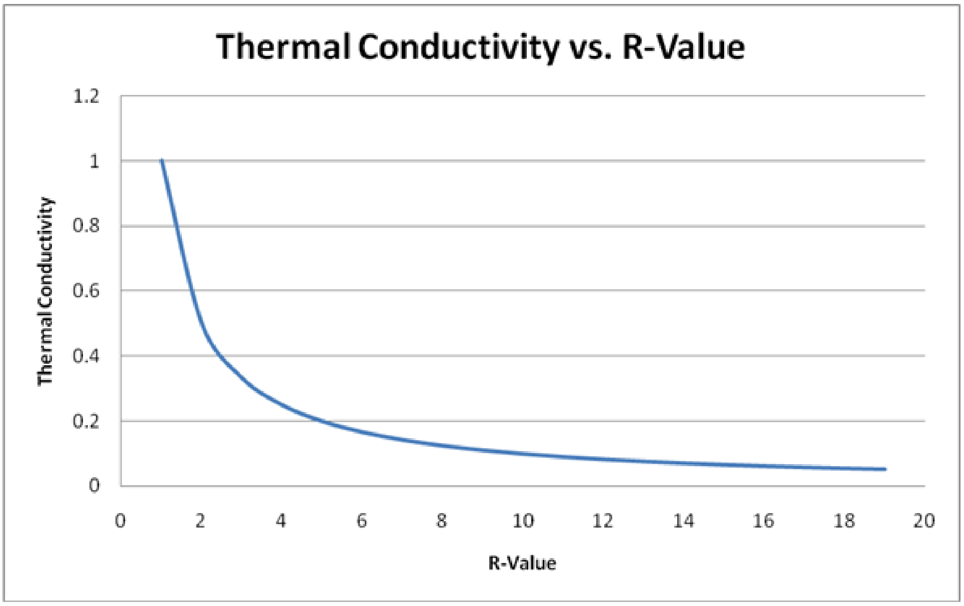
Table 1-20. Weatherization Measure and Program Reported and Adjusted Savings

Measures	Reported Values			Adjusted Gross	
	Count	Unit Savings (Therms)	Reported Savings	Average Unit Savings (Therms)	Total Adj. Gross Savings
Fireplace Damper	14	76.0	1,064	5.6	78
Insulation – Ceiling/Attic	1,295	102.9	133,212	102.6	132,775
Insulation – Floor	205	230.5	47,261	163.6	33,542
Insulation – Wall	388	227.0	88,078	154.6	59,985
Programmable Thermostat with AC	3	31.0	93	87.3	262
Replacement Windows	3,762	75.5	284,168	55.4	208,318
Program Total	5,667	76.8	553,876	57.6	434,960

It can be seen in Table 1-20 that for most measures (excluding ceiling insulation), we significantly adjusted savings from reported values due to updated TRM values. We applied TRM values to these measures on an installed area basis. The process we used for extracting the average area is detailed in the Analysis section above.

Residential insulation for a floor or wall has a relatively low baseline R-value compared to roof insulation. Thermal conductivity and the associated heat loss do not vary linearly with increasing R-value. For example, upgrading from R-4 to R-9 creates a much greater savings per square foot than upgrading from R-25 to R-30. This variability, shown in Figure 1-2, cannot be accounted for in the adjusted savings due to the lack of baseline and efficient R-values being documented in the database. We could apply more accurate savings adjustments in the future with the documentation of the amount of change in R-value for all sites.

Figure 1-2. Thermal Conductivity as a Function of R-value of Insulation



The fireplace damper savings reported in the "*Avista Technical Reference Manual Prescriptive.xls*" is 5.56 therms. The gas savings reported by Avista for 2010 measures was 76 therms. Since this measure accounts for less than 0.1 percent of the overall therm savings, we could not complete a detailed review of these estimates. There were 14 participants in 2010, so a billing analysis would not show savings with a sufficient level of certainty. Heat loss from an open draft is described with air flow heat loss calculations in the tool "*ChimneyCapCalculations (2_24_10).xlsm.*" Cadmus did not verify the parameters used to estimate these savings. We believe that a gap size of 5/8-inch and a chimney of 8-inch width and 20-foot height might represent a typical home in Avista's service territory. The result is an estimated savings of 52 therms/year.

According to the ENERGY STAR calculator, a programmable thermostat saves 11 percent of the heating energy consumed with a 5-degree setback. Assuming that a typical home uses 794 therms in a season, 11 percent energy savings is 87 therms. Avista reports 31 therms of savings for installing a programmable thermostat. Although this measure is not separately metered, we will estimate temperature setback use and percent savings based on our winter meter data from 67 heat pumps. Most of these heat pumps have programmable thermostats, and we will also meter the thermostat set points to determine operational characteristics.

Our site visits and participant surveys produced a verification rate of 79 percent and a qualification rate of 96 percent from 97 total observations. Table 1-21 shows program-level reported, adjusted gross, and verified savings.

Table 1-21. Weatherization Total Gas Savings

Region	Measure Count	Reported Savings	Adjusted Gross Savings	Verification Rate	Verified Savings	Verified Savings Rate
WA	4,426	432,891	340,397	100%	340,397	79%
ID	1,241	120,985	94,563	100%	94,563	78%
Total	5,667	553,876	434,960	100%	434,960	79%

We determined the realized adjusted gross savings rate to be 79 percent for the Weatherization program. The 100 percent verification rate did not affect the savings of 434,960 therms, resulting in an overall verified savings of 79 percent.

1.3.5 Water Heater Efficiency

1.3.5.1 Program Description

The Water Heater Efficiency program includes the following measures:

- High-Efficiency Water Heater (Electric)
- High-Efficiency 40-Gallon Water Heater (Gas)
- High-Efficiency 50-Gallon Water Heater (Gas)
- High-Efficiency Tankless Water Heater (Gas)

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, and natural gas water heaters with a tank must have 0.60 EF or greater for 50-gallon, and 0.62 EF or greater for 40-gallon. We only consider the above gas measures in our analysis for this report.

1.3.5.2 Analysis

All of the water heaters we analyzed were qualified for rebates. Our calculations of the adjusted savings for water heaters are lower than the reported savings due to using figures from the updated TRM.

1.3.5.3 Results and Findings

Table 1-22 shows the total reported and adjusted savings for the gas Water Heater Efficiency program measures.

Table 1-22. Water Heater Efficiency Measure and Reported and Adjusted Savings

Measures	Reported Values			Adjusted Gross	
	Count	Unit Savings (Therms)	Reported Savings	Average Unit Savings (Therms)	Total Adj Gross Savings
High-Efficiency Water Heater - 40G	174	8.0	1,392	8.2	1,425
High-Efficiency Water Heater - 50G	518	11.0	5,698	6.4	3,303
High-Efficiency Water Heater - Tankless	82	60.0	4,920	33.9	2,783
Program Total	774	15.5	12,010	9.7	7,511

Our site visits and participant surveys produced a verification rate of 95 percent from 22 total observations. Table 1-23 shows program-level reported, adjusted gross, and verified savings.

Table 1-23. Water Heater Efficiency Total Gas Savings

Region	Measure Count	Reported Savings	Adjusted Gross Savings	Verification Rate	Verified Savings	Verified Savings Rate
WA	603	9,049	5,701	95%	5,442	60%
ID	171	2,961	1,810	95%	1,728	58%
Total	774	12,010	7,511	95%	7,170	60%

Due to using numbers from the updated TRM, we calculated the realized adjusted gross savings rate as 63 percent for the Water Heater Efficiency program. The verification rate slightly lowered the adjusted gross savings to a verified 7,170 therms, giving an overall verified realized savings rate of 60 percent.

1.3.6 ENERGY STAR Homes

1.3.6.1 Program Description

This program offers incentives to builders for constructing single family or multifamily homes that comply with ENERGY STAR criteria and are verified as ENERGY STAR Homes. Avista provides a $900 incentive for homes using their electric or electric and natural gas service for space and water heating. Avista provides a $650 incentive for homes that use only their natural gas service (both the hot water and space heating must be natural gas).

1.3.6.2 Analysis

Using the ENERGY-10 modeling software, we simulated models of an ENERGY STAR home and a standard built-to-code home. We completed one model for each state (Washington and Idaho) to account for all the differences in state building codes (see Appendix B). We averaged the savings results of each simulation according to the proportion of ENERGY STAR home rebates given in each state. Finally, we applied the weighted averaged savings to the entire population of ENERGY STAR homes that Avista provided rebates for during PY 2010. We calculated the square footage from RASS survey data of newly constructed homes specific for the PacifiCorp service territory.

1.3.6.3 Results and Findings

Table 1-24 shows the total reported and adjusted savings for the gas and electric/gas ENERGY STAR Home program measures.

Table 1-24. ENERGY STAR Home Measure and Program Reported and Adjusted Savings

Measures	Reported Values			Adjusted Gross	
	Count	Unit Savings (Therms)	Reported Savings	Average Unit Savings (Therms)	Total Adj Gross Savings
ENERGY STAR Home - Electric/Gas	140	195.0	27,306	203.3	28,455
ENERGY STAR Home - Gas Only	28	197.0	5,516	203.3	5,691
Program Total	168	195.4	32,822	203.3	34,146

Our site visits produced a verification rate of 100 percent from four observations. Table 1-25 shows program-level reported, adjusted gross, and verified savings.

Table 1-25. ENERGY STAR Home Total Gas Savings

Region	Measure Count	Reported Savings	Adjusted Gross Savings	Verification Rate	Verified Savings	Verified Savings Rate
WA	130	25,381	26,423	100%	26,423	104%
ID	38	7,441	7,724	100%	7,724	104%
Total	168	32,822	34,146	100%	34,146	104%

All of the ENERGY STAR Homes we analyzed met program requirements. We determined a savings of 203 therms through modeling as the verified savings value for a home that operates with gas and electric energy.

We determined the realized adjusted gross savings rate to be 104 percent for the ENERGY STAR Home program measure savings. The verification rate did not change the savings of 34,146 therms, and the overall verified realized savings is also 104 percent.

1.3.7 Net-To-Gross

In Q1 of 2011, Cadmus performed a net-to-gross (NTG) analysis on 2011 program participants. Table 1-26 shows the results from that study. These results span both Washington and Idaho and are applied to adjusted gross savings to determine the net verified savings per program.

Table 1-26. ENERGY STAR Home Total Gas Savings

Program Category	Responses	FR %	Spillover %	NTG
Residential Appliances and Water Heaters	67	48%	0.0%	52.0%
Residential HVAC	67	39%	0.0%	61.0%
Residential Shell	67	45%	8.8%	63.8%
EnergyStar Homes	7	26%	0.0%	73.6%

1.3.8 Verification Confidence and Precision

We determined the precision of verification activities for each program given a 90 percent confidence level. We calculated verification rates using site visits and surveys as equally weighted observations. Table 1-27 shows the number of observations for each program and the corresponding precision level.

Table 1-27. Program Verification Observations and Precision

Program	Measure Count	Verification Observations	Verification Rate	Precisions at 90% Confidence
ENERGY STAR Products	5,876	76	96%	4%
Heating and Cooling Efficiency	3,934	106	98%	2%
Weatherization/Shell	5,667	97	100%	N/A
Water Heater Efficiency	774	22	95%	8%
ENERGY STAR Homes	168	4	100%	N/A
Total	16,419	305	98%	1.3%

The ENERGY STAR Products, Heating and Cooling Efficiency, and Weatherization programs comprised 96 percent of the reported savings for the PY 2010 gas portfolio. Therefore, we focused the majority of our verification activities on those programs, which resulted in the greatest possible confidence and precision levels. The Water Heating Efficiency program had a small proportion of savings, and therefore we concentrated less effort for this program. The same was true for ENERGY STAR Homes; however, we did prepare ENERGY 10 models to determine the average savings per home to apply to the program population. The verification precision for the portfolio verification rate was 1.3 percent with 90 percent confidence.

1.4 Conclusions

The 2010 residential gas programs achieved 935,068 gross verified therms and 580,966 net verified therms overall. Verification activities produced an overall sector verification rate of 98 percent. Table 1-28 through Table 1-30 show total and state level gross and net savings per program.

Table 1-28. Total Program Gross and Net Verified Savings and Realization Rates

Program	Reported Savings (Therms)	Gross Verified (Therms)	Gross Realization Rate	Net Verified (Therms)	Net Realization Rate
ENERGY STAR Products	44,400	58,475	132%	30,408	68%
Heating and Cooling Efficiency	483,882	400,317	83%	244,193	50%
Weatherization/Shell	553,876	434,960	79%	277,505	50%
Water Heater Efficiency	12,010	7,170	60%	3,728	31%
ENERGY STAR Homes	32,822	34,146	104%	25,131	77%
Total	1,126,990	935,068	83%	580,965	52%

Table 1-29. Program Gross and Net Verified Savings and Realization Rates - Washington

Program	Reported Savings (Therms)	Gross Verified (Therms)	Gross Realization Rate	Net Verified (Therms)	Net Realization Rate
ENERGY STAR Products	32,377	42,815	132%	22,276	69%
Heating and Cooling Efficiency	324,228	267,904	83%	163,610	50%
Weatherization/Shell	432,891	340,397	79%	217,173	50%
Water Heater Efficiency	9,049	5,416	60%	2,830	31%
ENERGY STAR Homes	25,381	26,423	104%	19,447	77%
Total	823,926	682,955	83%	425,336	52%

Table 1-30. Program Gross and Net Verified Savings and Realization Rates - Idaho

Program	Reported Savings (Therms)	Gross Verified (Therms)	Gross Realization Rate	Net Verified (Therms)	Net Realization Rate
ENERGY STAR Products	12,028	15,631	130%	8,132	68%
Heating and Cooling Efficiency	159,654	131,951	83%	80,583	50%
Weatherization/Shell	120,985	94,563	78%	60,331	50%
Water Heater Efficiency	2,961	1,720	58%	898	30%
ENERGY STAR Homes	7,441	7,724	104%	5,684	76%
Total	303,069	251,588	83%	155,630	51%

Table 1-31 shows the rate of achievement of gross savings compared to the IRP goal for the residential sector. Table 1-32 shows the net savings and IRP goals.

Table 1-31 IRP Goals and Gross Verified Savings by State

Sector	Washington			Idaho			Total		
	Savings Goal	Gross Achieved	Achiev-ement Rate	Savings Goal	Gross Achieved	Achiev-ement Rate	Savings Goal	Gross Achieved	Achiev-ement Rate
Residential	647,788	683,313	105%	273,281	251,757	92%	921,069	935,070	102%

Table 1-32 IRP Goals and Net Verified Savings by State

Sector	Washington			Idaho			Total		
	Savings Goal	Net Achieved	Achieve-ment Rate	Savings Goal	Net Achieved	Achieve-ment Rate	Savings Goal	Net Achieved	Achieve-ment Rate
Residential	647,788	425,336	66%	273,281	155,630	57%	921,069	580,966	63%

Overall, residential gas program customers responded well to the programs and often installed several measures within the same program year. The residential programs drew enough participation to meet IRP achievement goals overall, which was the only sector to do so. Avista's program and tracking databases were sufficient for evaluation purposes, providing adequate contact, measure and savings information, and the database review confirmed that the information was reliable and accurate. The majority of measures (all but one) were determined to meet program qualification standards. The billing analysis performed to calculate average annual gas savings for furnaces produced interesting and conclusive results. The subsequent electric savings report will further inspect the interaction of gas furnaces and electric heat pumps to determine the overall energy usage of the home for heating.

1.5 Recommendations

The majority of our recommendations center around increasing measure level detail capture on the applications and inclusion in the databases. These measure detail information includes:

- List energy factors (EF and MEF), or at least model numbers, for appliances
- Include baseline information, such as for insulation R-values, type or thickness
- Request square footage, particularly for ENERGY STAR homes

Customers also indicated some confusion on door rebates. If Avista wishes to give incentives on doors explicitly, customers seem to be receptive.

The interaction of gas furnaces and heat pumps on both savings and incentive structure will be revisited in both the electric report and the 2010 process report. Residential heat pumps, many homes with a gas furnace as well, are currently undergoing a metering study and those data will provide important information to assist the Heating and Cooling Efficiency program going forward.

2 2010 Non-Residential Gas Impact Report

Executive Summary

Program Overview

Avista's non-residential 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, reducing the first cost barrier and making the high-efficiency equipment a more viable option for commercial customers.

Avista's non-residential gas portfolio has eight programs in three major categories: prescriptive, site specific (custom), and the Energy Smart Grocer program. The full list of programs is:

- Prescriptive:
  - ENERGY STAR Residential Products (APP)
  - Prescriptive Commercial Clothes Washer (PCW)
  - Prescriptive Demand Controlled Ventilation (PDCV)
  - Prescriptive Food Service (PFS)
  - Prescriptive Refrigerated Warehouse (PRW)
  - Prescriptive Steam Trap Replacement (PSTR)
- Energy Smart Grocer (ESG)
- Site Specific (SS)

The Site Specific and prescriptive programs are implemented by Avista, while the Energy Smart Grocer program is implemented by PECI. Cadmus conducted both qualitative (process) and quantitative (impact) evaluations of these programs. For the evaluations, we assessed and documented program savings (both the gross realization rate and savings net of freeriders and adjusted for spillover). We also sought to document the evolution of these programs and provide timely feedback to enable program improvements. Cadmus will examine electric savings impacts and report our process evaluation findings in subsequent reports.

Key Findings

Throughout the impact evaluation, the Cadmus team documented program achievements and identified issues to be resolved in regard to lower than expected achieved savings.

Ex ante reported and *ex post* evaluated savings are shown in Table 2-1 through Table 2-3. The net evaluated program savings were 672,344 therms. Net-to-gross (NTG) was determined in a previous Cadmus study in early 2011, and those results were applied to the verified gross savings in this evaluation.

Table 2-1. Program Summary

Program	Number of Measure Installations	*Ex Ante* Gross Program Reported Savings	*Ex Post* Gross Program Evaluated Savings	Net-to-Gross	*Ex Post* Net Program Evaluated Savings
APP	2	17	17	0.87	15
ESG	5	20,100	15,191	0.9	13,672
PCW	6	1,495	1,495	0.87	1,301
PDCV	5	2,256	2,256	0.87	1,963
PFS	31	29,165	29,115	0.87	25,330
PRW	1	12,542	6,936	0.87	6,034
PSTR	2	43,898	30,612	0.87	26,632
SS	401	682,509	807,293	0.74	597,397
Total	453	791,982	892,915	0.75	672,344

Table 2-2. Program Summary - Idaho

Program	Number of Measure Installations	*Ex Ante* Gross Program Reported Savings	*Ex Post* Gross Program Evaluated Savings	Net-to-Gross	*Ex Post* Net Program Evaluated Savings
APP	1	9	9	0.87	8
ESG	1	2,318	2,318	0.90	2,086
PCW	2	477	477	0.87	415
PDCV	3	1,240	1,240	0.87	1,079
PFS	7	12,001	11,980	0.87	10,423
PSTR	1	39,706	28,686	0.87	24,957
SS	122	124,551	147,323	0.74	109,019
Total	137	180,302	192,033	0.77	147,986

Table 2-3. Program Summary - Washington

Program	Number of Measure Installations	*Ex Ante* Gross Program Reported Savings	*Ex Post* Gross Program Evaluated Savings	Net-to-Gross	*Ex Post* Net Program Evaluated Savings
APP	1	9	9	0.87	8
ESG	3	17,782	12,873	0.90	11,586
PCW	4	1,018	1,018	0.87	886
PDCV	2	1,016	1,016	0.87	884
PFS	24	17,164	17,135	0.87	14,907
PRW	1	12,542	6,936	0.87	6,034
PSTR	1	4,192	1,926	0.87	1,676
SS	279	557,958	659,971	0.74	488,378
Total	316	611,681	700,883	0.75	524,358

Avista did not report participation goals in terms of number of projects, but did report energy savings goals as shown in Table 2-4. The net overall PY 2010 non-residential gas portfolio achieved 57 percent of the original energy savings goal.

Table 2-4. Energy Savings Achievements Compared to Goals

Program	*Ex Ante* Program Gross Goals	Evaluated *Ex Post* Gross Program	Net-to-Gross	Evaluated *Ex Post* Net Program	Net Realization Rate
Idaho	347,812	192,033	55%	147,986	43%
Washington	824,457	700,883	85%	524,358	64%
Total	1,172,269	892,916	76%	672,344	57%

The portfolio results shown in Table 2-4 do not account for therm penalties due to increased lighting efficiency. Lighting systems convert a large portion of their input energy to useful light output, but a substantial fraction is converted to heat. Any reduction in lighting input energy also reduces waste heat. This waste heat reduction lowers the site's required cooling load while increasing the heating load. Cadmus noted that Avista tracked these HVAC interactive effects for calculating cost-effectiveness, but did not include them in energy savings goals or reported savings values. Avista noted their methodology for calculating interactive impacts was not as robust as that for energy savings. The Avista database extract did not provide sufficient detail for Cadmus to calculate those impacts.

2.1 Introduction

Avista's non-residential portfolio of programs promote the purchase of industry-proven, high-efficiency equipment for commercial utility customers. Avista provides rebates to partially offset the difference in cost between high-efficiency equipment and standard equipment, reducing the first cost barrier and making the high-efficiency equipment a more viable option for commercial customers.

The non-residential gas portfolio has eight programs in three major categories: prescriptive, site specific (custom), and the Energy Smart Grocer program.

2.1.1 ENERGY STAR Residential Products (APP)

This program is available to non-residential 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 non-residential 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 Demand Controlled Ventilation (PDCV)

Under this program, non-residential electric and natural gas customers receive direct incentives to install DCV in existing buildings. This type of ventilation measures the approximate number of people occupying a space—based on carbon dioxide levels—and resets the outdoor air intake rate for occupant ventilation in accordance with the measurement. To be eligible for the program, the temperature of the conditioned spaces must remain between 65 and 75 degrees during operating hours. Also, the controlled conditioned space must be a minimum of 2,000 square feet.

2.1.4 Prescriptive Food Service (PFS)

Applicable to non-residential 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.

2.1.5 Prescriptive Refrigerated Warehouse (PRW)

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

2.1.6 Prescriptive Steam Trap Replacement (PSTR)

This program offers rebates to non-residential gas customers who repair or replace failed steam traps on the steam distribution lines of a boiler heating system. The key criteria for this rebate are:

- A replacement must be a new working steam trap of the same duty as what was replaced.
- Each steam trap repair or replacement is only eligible for a rebate once every five years.
- The repaired or replaced trap must include a strainer.

2.1.7 Energy Smart Grocer (ESG)

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

2.1.8 Site Specific (SS)

The Site Specific program addresses non-residential measures that do not lend themselves to 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 who receive electric or natural gas service from Avista and want to make cost-effective, energy-efficiency improvements to their business. Electric and gas saving measures included in the program are:

- Appliances
- Compressed air
- HVAC

- LEED
- Industrial process
- Motors and HVAC Variable Frequency Drive
- Shell measures
- Multifamily measures
- Custom lighting projects

The Site Specific and prescriptive programs are implemented by Avista, while the Energy Smart Grocer program is implemented by PECI. As the implementers, Avista and PECI were responsible for designing and managing program details. Avista developed algorithms for use in determining measure savings, as well as measure and customer eligibility.

Avista staff fielded inquiries from potential participants and contractors, and developed a tracking database for projects. Throughout the program, Avista has managed projects by reviewing and approving applications at all stages of the process, determining project savings, and populating the database with relevant information.

2.2 Methodology

We designed the impact evaluation to verify reported program participation and estimate energy and demand savings. Our impact evaluation included:

- Determining *ex post* gross savings through engineering calculations;
- Leveraging freeridership estimates from a previous study we performed; [12] and
- Determining net savings.

Cadmus worked with a subcontractor for this evaluation, SBW (collectively referred to as the Cadmus team). The Cadmus team reviewed *ex ante* gross reported energy savings and available documentation for a sample of sites (e.g., audit reports, savings calculation work papers), giving particular attention to the calculation procedures and documentation for savings estimates. The Cadmus team also verified the appropriate analyses to calculate savings, as well as the operating and structural parameters of the analysis. We then determined *ex post* gross evaluated energy savings through site visits, engineering calculations, and verification surveys of a sample of projects.

The Cadmus team collected baseline, tracking, and program implementation data through on-site interviews with facility staff. We used on-site visits to verify installations and determine any changes to the operating parameters since the measures were first installed. The Cadmus team used the savings realization rate from site visits to estimate savings and develop recommendations for future studies. We also interviewed facility staff to determine the operating

[12] The Cadmus Group, Inc. *Net-to-Gross Evaluation of Avista's Demand-Side Management Programs*. April 19, 2011.

conditions of the installed system and any additional benefits or shortcomings of the installed system.

2.2.1 Sampling

Cadmus developed a sampling calculation tool to estimate the proposed number of metered projects, site verifications, and phone verifications in order to achieve the rigor levels shown in Table 2-5. This table also shows the initial estimates for evaluation activities, which relied on preliminary program population data provided by Avista.

Table 2-5. Originally Proposed PY 2010 Non-Residential Evaluation Activities

Fuel	Proposed Rigor Level*	Proposed Metering Projects	Proposed Site Visits	Proposed Verification Surveys
Electric	90/10	61	58	259
Gas	90/10	49	59	116

* The rigor is the confidence level and interval. These values for gas projects, for example, indicate that Cadmus is 90 percent certain the correct answer is with ±10 percent of the evaluated savings.

After the evaluation contract was awarded, Avista provided Cadmus with the final PY 2010 database extract. Cadmus revised the sample distribution based on the final program populations and energy savings. Cadmus converted both electric and gas savings to MBTUs to more effectively compare savings by fuel, shown in Table 2-6 below.

Table 2-6. PY 2010 Non-Residential Savings Analysis by Fuel

Fuel	Measures	Sites	Savings (kWh)	Savings (therms)	Savings (MBtu)	Portion of Total Savings
Electric	1,891	982	49,484,353	0	168,841	65%
Gas	453	277	2,873,354	791,982	89,002	35%

Based on the weighted proportion of savings, Cadmus determined that 35 percent of the sample should be represented by gas projects. These included purely gas and dual fuel projects in which gas savings exceeded electric savings.

Next, Cadmus selected the appropriate verification activities for each measure type and project, including metering, on-site verification, and phone verification. Cadmus received the final database in the spring of 2011, after the heating season ended. Therefore, we could not effectively meter savings from heating equipment.

The only appropriate measures for metering were for the Site Specific, Energy Smart Grocer, and Prescriptive Steam Trap Replacement programs. However, the Avista PY 2010 population only included a small number of these projects, significantly less than the proposed sample for gas metered projects. Cadmus determined the PY 2010 gas heating measures could be evaluated with on-site verification alone, applying additional rigor. Based on these revisions, we developed a revised evaluation activity sample, shown in Table 2-7.

Table 2-7. Revised PY 2010 Non-Residential Evaluation Activities

Fuel	Metering Projects	Site Visits	Verification Surveys
Electric	61	62	333
Gas	11	55	180

The final achieved evaluation activities for gas measures are shown in Table 2-8. Subsequent sections will detail the variation between revised and achieved evaluation activities. As noted previously, Cadmus will report on electric measure savings in 2012.

Table 2-8. Final FY 2010 Gas Evaluation Activity Sample

Fuel	Achieved Metering Projects	Achieved Site Visits	Achieved Verification Surveys
Gas	7	65	55

The sampling process was iterative, requiring Cadmus to select projects of interest, request data from Avista to determine how many and what types of projects were at various locations, and then obtain contact information and project files for the relevant sites. Cadmus repeated this process until we completed the final primary and backup samples.

In addition, the database extract provided program-level, not measure-level information. The Cadmus team attempted to verify savings for every incented measure at each site, regardless of whether it achieved gas or electric savings. Cadmus was unable to determine whether an accurate distribution of measure types within each program was evaluated. This effort would have required an exhaustive review of project files, which was not within the scope of the evaluation.

2.2.2 Data Collection

The primary methods we used to collect data were metering, on-site verification, and telephone verification. For each activity, we first conducted a document review to determine measure type, quantity, operational parameters, and calculation methodology.

2.2.2.1 Document Review

As the first step in the impact evaluation process, the Cadmus team reviewed documentation, calculation spreadsheets, and energy simulation models relevant to the evaluation effort. Avista provided documentation of the energy-efficiency projects undertaken at the sample sites. The Cadmus team paid particular attention to calculation procedures and documentation for savings estimates. The documentation we reviewed included program forms, the tracking database, audit reports, and savings calculation work papers for each rebated measure.

The Cadmus team reviewed each application to determine whether the following types of information were provided:

- Documentation for the equipment being replaced, including (1) descriptions, (2) schematics, (3) performance data, and (4) other supporting information.
- Documentation for the new equipment installed, including (1) descriptions, (2) schematics, (3) performance data, and (4) other supporting information.

- Information about the savings calculation methodology, including (1) the methodology used, (2) specifications of assumptions and sources for these specifications, and (3) correctness of calculations,

2.2.2.2 Site Visits

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

On-site visits accomplished three primary tasks:

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 boiler capacity or operational temperature, needed to analyze the energy savings realized from the installed improvements and measures.
3. The Cadmus team conducted interviews with facility personnel to obtain additional information on the installed system to complement the data we collected from other sources.

2.2.2.3 Short-Term Metering

Most metering projects involved a billing analysis to calibrate Avista's hourly meter data against site conditions and production data, where relevant. The Cadmus team metered one Energy Smart Grocer project involving hot water reclamation from a desuperheater. All other ESG gas savings projects involved HVAC equipment, and could not be metered effectively outside the heating season.

2.2.2.4 Surveys

Cadmus also conducted phone verification as a component of the participant process evaluation surveys to supplement the installation rate determined through on-site verification. Cadmus attempted to reach at least one participant for each major measure type and program. We were unable to achieve the full revised sample of verification surveys due to participant refusals and others who could not be reached.

2.2.3 Engineering Analysis

Each of the three major types of programs in Avista's non-residential portfolio (prescriptive and the Site Specific and ESG programs) required significantly different methods for analysis.

2.2.3.1 Overview

The procedures we used to verify savings through an engineering analysis depended on the type of measure being analyzed. The major analyses types included in this evaluation are:

- Prescriptive deemed savings
- Short-term metering
- Billing analysis

- Calculation spreadsheets
- Energy simulation modeling

The following sections describe the procedures we followed to verify savings from the different types of measures installed in the program.

2.2.3.2 Prescriptive Deemed Savings

For most prescriptive measures, Cadmus verified the deemed savings estimates that Avista used for savings calculations, and compared those with values we developed for the new TRM. Our verification activities focused on the installed quantity and equipment nameplate data, as well as the proper installation of equipment and operating hours. Where appropriate, the Cadmus team used data from site verification visits to re-analyze prescriptive measure savings through Avista's Microsoft Excel calculation tools, ENERGY STAR calculation tools, and other secondary sources.

2.2.3.3 Short-Term Metering

The Cadmus team metered one Energy Smart Grocer project involving hot water reclamation from the refrigeration system. The reclaimed hot water offset water heating that would otherwise have been supplied by a natural gas water heater. To determine the amount of heat exchange, the Cadmus team installed temperature sensors with dataloggers on the inlet and outlet streams of both the conventional water heater and the refrigeration heat exchange loops, as well as an ultrasonic meter to record water flow rates.

2.2.3.4 Billing Analysis

Cadmus analyzed the two Prescriptive Steam Trap Replacement and the four largest Site Specific industrial process projects through an analysis of Avista's metered billing data. Our pre–post modeling approach allowed us to directly develop retrofit savings estimates for each site. The modeling approach accounted for differences in HDDs and, where applicable, production. It also determined savings based on normalized weather conditions, since the actual weather conditions may have been milder or more extreme than the 15-year normal weather averages from 1991-2005 we obtained from the National Oceanic and Atmospheric Administration (NOAA).

Cadmus obtained daily weather data from NOAA for each weather station associated with the participant projects. From the daily weather data, we calculated the base 65 reference temperature HDDs. Cadmus 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 with all the models. Cadmus normalized all dependent and independent variables for the days in each billing period; allowing for model coefficients to be interpreted as average daily values. Cadmus used this methodology to account for differences in the length of billing periods. For each project, we modeled the average daily consumption in therms 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. Cadmus chose this methodology over a single standard treatment effects model to account for structural changes in demand that might occur due to retrofits. For instance, one site eliminated the standing load as a result of the retrofit program. This pre-post modeling approach enabled Cadmus to estimate an intercept model for the pre period and a no-intercept model for the post period to reflect his change.

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; that is, what the consumption would have been in the absence of the program. The difference between this scenario and the actual consumption represents actual savings.

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

2.2.3.5 Calculation Spreadsheets

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

2.2.3.6 Energy Simulation Modeling

Avista determined savings for many Site Specific HVAC and shell projects with energy simulation modeling. This approach was chosen due to complex interactions between heating and cooling loads and the building envelope. Avista provided the original energy simulation models, and the Cadmus team reviewed those 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.

2.2.4 Most ESG program measures involved electric savings from more techniques. PECI determined ESG refrigeration measure energy proprietary modeling software based on the DOE 2.2R module. The the capability to run this custom software, and used other techniques ESG gas projects primarily included HVAC measures, such as which we analyzed with the methods outlined in the Energy Smart Grocer (ESG)

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

Site Specific (SS) section.

2.3 Results and Findings

2.3.1 Overview

The Cadmus team adjusted gross savings estimates based on our evaluated findings. Further details are outlined in the following sections.

2.3.2 Prescriptive

The Cadmus team evaluated savings for a sample of sites across six prescriptive programs. Table 2-9 through Table 2-11 show our evaluated results by program. Specific evaluation details are noted in each program subsection below.

Table 2-9. Evaluated Results for PY10 Non-Residential Gas Prescriptive

Program	Total FY10 Measure Installations	Evaluated Sample	*Ex-Ante* Gross Reported Savings	*Ex-Post* Gross Evaluated Savings	Realization Rate
APP	2	0	17	17	100%
PCW	6	1	463	463	100%
PDCV	5	1	300	300	100%
PFS	31	11	21,002	20,996	100%
PRW	1	1	12,542	6,936	55%
PSTR	2	2	43,898	30,612	70%

Table 2-10. Evaluated Results for PY10 Non-Residential Gas Prescriptive - Idaho

Program	Total FY10 Measure Installations	Evaluated Sample	*Ex-Ante* Gross Reported Savings	*Ex-Post* Gross Evaluated Savings	Realization Rate
PCW	2	1	463	463	100%
PDCV	3	1	300	300	100%
PFS	7	3	10,166	10,149	100%
PSTR	1	1	39,706	28,686	72%

Table 2-11. Evaluated Results for PY10 Non-Residential Gas Prescriptive - Washington

Program	Total FY10 Measure Installations	Evaluated Sample	*Ex-Ante* Gross Reported Savings	*Ex-Post* Gross Evaluated Savings	Realization Rate
PFS	24	8	10,836	10,817	100%
PRW	1	1	12,542	6,936	55%
PSTR	1	1	4,192	1,926	46%

2.3.2.1 ENERGY STAR Residential Products (APP)

Cadmus attempted to perform phone verification surveys with the two participants of this program, but could not reach either. We assigned a 100 percent realization rate due to the low level of participation and reported savings.

2.3.2.2 Prescriptive Commercial Clothes Washer (PCW)

Cadmus performed a phone verification survey with one participant of this program. The participant confirmed that the measure was installed in the appropriate quantity at the program-listed address, and therefore the full savings should be achieved. We determined that the reported deemed savings were appropriate.

2.3.2.3 Prescriptive Demand Controlled Ventilation (PDCV)

Cadmus performed a phone verification survey with one participant of this program. The participant confirmed that the measure was installed in the appropriate quantity at the program-listed address, and therefore the full savings should be achieved. We determined that the reported deemed savings were appropriate.

2.3.2.4 Prescriptive Food Service (PFS)

Cadmus performed verification visits to eight sites with Prescriptive Food Service program measures, as well as three phone surveys. In most cases, the field engineer or participant confirmed that the measure was installed in the appropriate quantity at the program-listed address, and therefore the full savings should be achieved. We determined that the reported deemed savings were appropriate.

The Cadmus team identified two adjustments to the reported savings. The combined effect of both adjustments reduced sample savings by six therms, much less than 1 percent of the total reported value.

- A grocery store installed a new dishwasher and reported electric savings. Our site verification visit determined that hot water was actually provided by a gas water heater, and the dishwasher had a gas booster. Cadmus updated the project savings to reflect the gas dishwasher measure deemed savings.
- During site visits at a series of locations in a school district, we identified a number of measures not listed in the updated deemed savings tables. Cadmus applied values from previous deemed savings tables.

Cadmus calculated an overall realization rate for all projects in both states, and then applied the resulting realization rate to the savings for each state.

2.3.2.5 Prescriptive Refrigerated Warehouse (PRW)

The Cadmus team performed a site visit of the one gas participant in this program. The participant installed 22 doors to further insulate heated spaces within the warehouse, and thereby reduced the heating load. Cadmus determined that site heating was minimal, and deemed savings estimates were likely overstated. The revised savings estimate adjusted savings to 55 percent of the reported value.

2.3.2.6 Prescriptive Steam Trap Replacement (PSTR)

Cadmus performed site visits to both participants of this program. We determined that the deemed savings estimates could be overstated due to potential variation in measure operation and site production. Therefore, we conducted a billing analysis of hourly metered billing data for each participant, calibrated to site conditions and reported production values. The resulting analysis identified large variation from deemed savings estimates, and Cadmus adjusted the reported savings values. The combined impact of these adjustments changed the savings values downward by 30 percent.

2.3.3 Site Specific

Cadmus performed site visits on 54 Site Specific program projects, and conducted verification surveys of an additional 50 projects. The Site Specific program projects represented a variety of measure types. Cadmus calculated an overall realization rate for all projects in both states, and then applied the resulting realization rate to the savings for each state. Table 2-12 through Table 2-14 list the different measure types we evaluated, as well as the number of projects and reported savings. Table 2-15 through Table 2-17 show our evaluated results for the program.

Table 2-12. Site Specific Measure Types and Projects Evaluated

Measure Type	Evaluated Projects	*Ex Ante* Reported Gas Savings
Appliances	4	1,362
HVAC	50	251,290
Industrial Process	3	101,782
Shell	47	61,785
Total	104	416,219

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

Measure Type	Evaluated Projects	*Ex Ante* Reported Gas Savings
Appliances	1	73
HVAC	11	21,059
Industrial Process	2	26,782
Shell	19	12,552
Total	33	60,466

Table 2-14. Site Specific Measure Types and Projects Evaluated - Washington

Measure Type	Evaluated Projects	*Ex Ante* Reported Gas Savings
Appliances	3	1,289
HVAC	39	230,231
Industrial Process	1	75,000
Shell	28	49,233
Total	71	355,753

Table 2-15. Evaluated Results for PY 2010 Non-Residential Gas Site Specific Sample

Program	Total FY10 Measure Installations	Evaluated Sample	*Ex-Ante* Gross Reported Sample Savings	*Ex-Post* Gross Evaluated Sample Savings	Sample Realization Rate
SS	401	104	416,219	492,317	118%

Table 2-16. Evaluated Results for PY 2010 Non-Residential Gas Site Specific - Idaho

Program	Total FY10 Measure Installations	Evaluated Sample	*Ex-Ante* Gross Reported Savings	*Ex-Post* Gross Evaluated Savings	Realization Rate
SS	122	33	124,551	147,323	118%

Table 2-17. Evaluated Results for PY 2010 Non-Residential Gas Site Specific - Washington

Program	Total FY10 Measure Installations	Evaluated Sample	*Ex-Ante* Gross Reported Savings	*Ex-Post* Gross Evaluated Savings	Realization Rate
SS	279	71	557,958	659,971	118%

The Cadmus team 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 18 percent. This indicates that Avista's approach to reporting savings was appropriately conservative when considering the nature of these measures.

Typical adjustments we made to the savings values included corrections to equipment efficiency, operating schedules, temperature set points, and building parameters. The Cadmus team also identified errors in simulation models and MS Excel calculation tools, which resulted in adjustments when corrected. Two project-specific adjustments included:

- One office project involved a lake water cooling system which was modeled in eQuest. The simulation model applied a cooling cutoff to the chilled water system, artificially eliminating cooling during many hours. The building contained a dual duct system, so the cooling reduction also resulted in a large drop in heating energy.

  The Cadmus team revised the model to allow for mechanical cooling during all hours, then subtracted cooling energy for all hours when the outside air temperature was below the cutoff temperature. The resulting impact increased savings by 230 percent of the reported value (a significant increase in savings for this large project). The Cadmus team also confirmed the savings impact through pre- and post-installation utility bills.

- A church installed shell measures, including wall and ceiling insulation. However, the ceiling insulation was installed between the basement and main level. The main level of the church is under construction, and plans to operate out of the basement for one to two years until the main level is complete. For the first two years, the wall insulation will not achieve savings because the main level is unconditioned. Following that time, the basement insulation will not achieve savings because it separates to conditioned spaces. The pastor reported the ceiling insulation was installed primarily for soundproofing purposes.

  Cadmus resolved the analysis by discounting ceiling insulation savings, but allowed the wall insulation savings, which should achieve persistence. Cadmus also adjusted the savings calculator based on our on-site verification visit, and determined that overall savings should be reduced by 7 percent.

2.3.4 Energy Smart Grocer (ESG)

Cadmus performed site visits on all three ESG sites with gas savings, which included four reported measures. Two refrigeration measures involved hot water heat reclaim and case doors on medium temperature reach-in display cases. The two HVAC measures involved demand controlled ventilation and replacement of gas furnace units with heat pumps. Table 2-18 through Table 2-20 show our evaluated results for the program.

Table 2-18. Evaluated Results for FY10 Non-Residential Gas ESG Measures

Program	Total PY 2010 Measure Installations	Evaluated Sample	*Ex Ante* Gross Reported Savings	*Ex Post* Gross Evaluated Savings	Realization Rate
ESG	4	4	20,100	15,191	76%

Table 2-19. Evaluated Results for FY10 Non-Residential Gas ESG Measures - Idaho

Program	Total PY 2010 Measure Installations	Evaluated Sample	*Ex Ante* Gross Reported Savings	*Ex Post* Gross Evaluated Savings	Realization Rate
ESG	1	1	2,318	2,318	100%

Table 2-20. Evaluated Results for FY10 Non-Residential Gas ESG Measures - Washington

Program	Total PY 2010 Measure Installations	Evaluated Sample	*Ex Ante* Gross Reported Savings	*Ex Post* Gross Evaluated Savings	Realization Rate
ESG	3	3	17,782	12,873	72%

The Cadmus team identified three adjustments to the reported savings. The combined effect of these adjustments reduced the sample savings by 24 percent of the total reported value.

- One grocery store installed a heat reclaim measure to use waste heat from the refrigeration process to offset domestic gas water heating. The Cadmus team performed two weeks of temperature and flow metering, and determined that achieved savings were only 18 percent of the reported value. Savings were reduced primarily due to a domestic hot water recirculation loop which returned building hot water back to the inlet side of the reclaim tank, instead of to the gas water heater tank. This resulted in an inlet water temperature greater than the reclaim tank temperature for much of the time.
- The same grocery store also claimed gas savings for fuel switching by replacing gas furnace units with heat pumps. The savings assumed no gas backup heat. However, the site installed gas heating units for low temperature operations. During our site visit, we also determined that operating hours and temperature set points were slightly greater than shown in the energy simulation model, which increased gas savings. The combined impact increased gas savings by 2 percent.
- A grocery store in Clarkston, Washington installed a demand controlled ventilation system. Cadmus determined that the energy simulation model settings were appropriate compared to the data we obtained on the site. However, the simulation used weather data from Spokane to model outdoor temperature impacts. Cadmus corrected the weather file to Lewiston, Idaho (which is directly across the Snake River from Clarkston). This resulted in a 28 percent decrease in gas savings.

2.3.5 Extrapolation to Program Population

For most programs, our measurement and verification process involved a minority of sites with incented projects, but we selected these sites to provide the most impactful information. We designed the site visits to achieve a statistically valid sample for the major strata, as discussed previously. Cadmus calculated realization rates (the ratio of claimed to verified savings) to apply to the programs at the remaining non-sampled sites. Cadmus calculated realization rates as weighted averages, based on the verification sample and using the following 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). The Cadmus team 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 sample for each measure type (Equation 2). We calculated the total population verified savings by multiplying the measure type realization rate from the sample by the total claimed savings for the population of each measure type (Equation 3). 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, as shown in Table 2-21 through Table 2-23. The overall portfolio gross realization rate was 113 percent.

Table 2-21. PY 2010 Gas Gross Program Realization Rates

Program	*Ex Ante* Gross Sample Reported Savings	*Ex Post* Gross Sample Evaluated Savings	Realization Rate	*Ex Ante* Gross Program Reported Savings	*Ex Post* Gross Program Evaluated Savings
APP	17	17	100%	17	17
ESG	20,100	15,191	76%	20,100	15,191
PCW	463	463	100%	1,495	1,495
PDCV	300	300	100%	2,256	2,256
PFS	21,002	20,966	100%	29,165	29,115
PRW	12,542	6,936	55%	12,542	6,936
PSTR	43,898	30,612	70%	43,898	30,612
SS	416,219	492,317	118%	682,509	807,293
Total	514,541	566,802	113%	791,982	892,915

Table 2-22. PY 2010 Gas Gross Program Realization Rates - Idaho

Program	*Ex Ante* Gross Sample Reported Savings	*Ex Post* Gross Sample Evaluated Savings	Realization Rate	*Ex Ante* Gross Program Reported Savings	*Ex Post* Gross Program Evaluated Savings
APP	n/a	n/a	100%	9	9
ESG	2,318	2,318	100%	2,318	2,318
PCW	463	463	100%	477	477
PDCV	300	300	100%	1,240	1,240
PFS	10,166	10,149	100%	12,001	11,980
PSTR	39,706	28,686	72%	39,706	28,686
SS	124,551	147,323	118%	124,551	147,323
Total	177,504	189,239	107%	180,302	192,033

Table 2-23. PY 2010 Gas Gross Program Realization Rates - Washington

Program	*Ex Ante* Gross Sample Reported Savings	*Ex Post* Gross Sample Evaluated Savings	Realization Rate	*Ex Ante* Gross Program Reported Savings	*Ex Post* Gross Program Evaluated Savings
APP	n/a	n/a	100%	9	9
ESG	17,782	12,873	72%	17,782	12,873
PCW	n/a	n/a	100%	1,018	1,018
PDCV	n/a	n/a	100%	1,016	1,016
PFS	10,836	10,817	100%	17,164	17,135
PRW	12,542	6,936	55%	12,542	6,936
PSTR	4,192	1,926	46%	4,192	1,926
SS	557,958	659,971	118%	557,958	659,971
Total	603,310	692,523	115%	611,681	700,883

2.3.6 Net-To-Gross

This section outlines Cadmus' approach and results from conducting a NTG analysis. All programs include participants who would have installed an energy-efficiency measure in the program's absence. These customers are described as freeriders: they only participated in the program to take advantage of the rebate or incentive. In those cases, energy savings from the measures they install cannot be attributed to the program because the program did not actually cause them to install the measure. Table 2-24 through Table 2-26 show the net program evaluated savings after accounting for freeridership.

Table 2-24. PY 2010 Gas Net Program Realization Rate

Program	*Ex Ante* Gross Program Reported Savings	*Ex Post* Gross Program Evaluated Savings	Net-to-Gross	*Ex Post* Net Program Evaluated Savings	Realization Rate
APP	17	17	0.87	15	88%
ESG	20,100	15,191	0.9	13,672	68%
PCW	1,495	1,495	0.87	1,301	87%
PDCV	2,256	2,256	0.87	1,963	87%
PFS	29,165	29,115	0.87	25,330	87%
PRW	12,542	6,936	0.87	6,034	48%
PSTR	43,898	30,612	0.87	26,632	61%
SS	682,509	807,293	0.74	597,397	88%
Total	791,982	892,915	N/A	672,344	88%

Table 2-25. PY 2010 Gas Net Program Realization Rate - Idaho

Program	*Ex-Ante* Gross Program Reported Savings	*Ex-Post* Gross Program Evaluated Savings	Net-to-Gross	*Ex-Post* Net Program Evaluated Savings	Realization Rate
APP	9	9	0.87	8	87%
ESG	2,318	2,318	0.90	2,086	90%
PCW	477	477	0.87	415	87%
PDCV	1,240	1,240	0.87	1,079	87%
PFS	12,001	11,980	0.87	10,423	87%
PSTR	39,706	28,686	0.87	24,957	63%
SS	124,551	147,323	0.74	109,019	88%
Total	180,302	192,033	N/A	147,986	82%

Table 2-26. PY 2010 Gas Net Program Realization Rate - Washington

Program	*Ex-Ante* Gross Program Reported Savings	*Ex-Post* Gross Program Evaluated Savings	Net-to-Gross	*Ex-Post* Net Program Evaluated Savings	Realization Rate

APP	9	9	0.87	8	87%
ESG	17,782	12,873	0.90	11,586	65%
PCW	1,018	1,018	0.87	886	87%
PDCV	1,016	1,016	0.87	884	87%
PFS	17,164	17,135	0.87	14,907	87%
PRW	12,542	6,936	0.87	6,034	48%
PSTR	4,192	1,926	0.87	1,676	40%
SS	557,958	659,971	0.74	488,378	88%
Total	611,681	700,883	N/A	524,358	88%

2.3.7 Achievements Compared to Goals

During the program planning process, Avista outlined goals for various programs to save a total of 1,172,269 therms, as shown in Table 2-27.

Table 2-27. PY 2010 Gas Program Achievements Compared to Goals

State	*Ex-Ante* Program Gross Goals	*Ex-Post* Gross Program Evaluated Savings	Gross Realization Rate	*Ex-Post* Net Program Evaluated Savings	Net Realization Rate
Idaho	347,812	192,033	55%	147,986	43%
Washington	824,457	700,883	85%	524,358	64%
Total	1,172,269	892,916	76%	672,344	57%

The overall portfolio evaluated *ex post* gross savings achieved 76 percent of goals. The NTG impact reduced *ex post* net savings to 57 percent of the original portfolio goal.

2.3.8 HVAC / Lighting Interactive Impacts

The portfolio results did not account for gas heating penalties due to increased lighting efficiency. Lighting systems convert a large portion of their input energy to useful light output, but a substantial fraction is converted to heat. Any reduction in lighting input energy also reduces waste heat. This waste heat reduction lowers the site's required cooling load but increases its heating load.

Cadmus noted that Avista tracked these HVAC interactive effects for many projects and reported those impacts for determining program cost-effectiveness. Most interactive effects involved prescriptive or site specific lighting projects, although some therm penalties were reported for the Energy Smart Grocer and Site Specific HVAC program projects.

Cadmus typically applies interactive factors based on values supplied by the RTF of the Northwest Power and Conservation Council. Those values rely on the fixture savings, building type, and HVAC system; however, that information was not available for most affected projects. Avista noted their methodology for calculating interactive effects was not as robust as that for their energy savings methodology.

In addition, Avista did not factor interactive effects into their portfolio energy savings goals, which would have reduced goals.

2.4 Conclusions

The Cadmus team evaluated 104 of 453 measures installed through the program, representing 65 percent of reported *ex ante* savings.

In general, Cadmus determined that Avista implemented the programs well. Gross *ex post* evaluated savings achieved 76 percent of reported program savings goals. The overall portfolio achieved a 113 percent realization rate comparing gross *ex post* evaluated savings to gross *ex ante* reported savings. However, the NTG impact reduced the savings realization rate to 57 percent of the goals.

Cadmus developed a number of additional conclusions throughout the evaluation process:

- Cadmus could have streamlined the sampling process with the addition of site addresses and contact information. Measure-level data for each project, such as specific measure type and quantity, would have improved the range and depth of our evaluation activities.
- Certain measures (demand controlled ventilation, refrigerated warehouse, and steam trap replacements) are less conducive to deemed savings estimates due to complex HVAC/lighting interactions and significant variation of site conditions.
- Interactive effects between HVAC and lighting represent a significant impact on gas demand. Cadmus is unable to reliably estimate interactive savings impacts through the data available in Avista's current database extracts.

2.5 Recommendations

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

- Avista may want to consider a method to provide more robust tracking database extracts to improve evaluation activities. The database extract should include site addresses, site contact information, and measure-level details.
- Avista may want to consider providing incentives for demand controlled ventilation, refrigerated warehouses, and steam trap replacements through the Site Specific program.
- Avista should consider revising their methodology for calculating and tracking HVAC/lighting interactive effects.

3 2010 Low-Income Gas Impact Report

Executive Summary

Program Overview

Avista's Low-Income Weatherization Program in Washington and Idaho is aimed at lowering customers' energy consumption and utility bills. The program provides, at no cost to income-qualified customers, a complete home energy audit and installation of energy-efficient measures.

Evaluation Approach

For this impact evaluation, we assessed gas energy impacts associated with measure installations in homes in Avista's Washington and Idaho service territories. The major tasks we performed for the evaluation are described in more detail below.

Data Collection

The data required for this evaluation and their sources are listed in Table 3-1.

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 the average achieved household and total savings as described below:

- **Expected Savings:** Were based on expected measure-level gas savings estimates provided by Avista from their program participant database.
- **Actual Savings:** Were calculated using a pre-post conditional savings analysis (CSA) fixed effects regression model to estimate weather-normalized, program-induced energy savings based on participant billing data. In addition, we leveraged work from Avista's Residential evaluation to determine savings achieved for those participants receiving an electric to high-efficiency gas furnace conversion.

Gas Impact Findings and Conclusions

Billing Analysis Gas Savings

Model savings were applied to the 186 gas-saving participants, summarized in Table 3-2. An additional 42 participants received electric to gas fuel-conversion measures; savings for these installations are discussed below.

Table 3-2. Billing Analysis Gas Savings by State

State	Total Participants	Model Savings Per Participant (Therms)	Total Savings (Therms)
Idaho	72	123	8,886
Washington	114	104	11,862
Overall	186	112	20,749

From the billing analysis, gross savings for program participants averaged 123 therms in Idaho, 104 in Washington, and 112 across both states. This is approximately 15 percent energy savings for participants in both Washington and Idaho relative to their pre-participation annual consumption.

We calculated realization rates of 60 percent in Idaho, 30 in Washington, and 38 overall. Cadmus determined that the average expected savings provided by Avista appeared particularly high for Washington participants, which may account for the lower realization rate. Several other factors may have contributed to the low results:

- High saturation of alternative heating sources (e.g., wood, fuel oil, portable electric heaters) not accounted for when developing expected savings estimates.
- Different approaches in developing expected savings estimates, maybe not always accounting for pre-weatherization annual consumption, square footage, or measure interaction.

Fuel-Conversion Savings

In addition to the 186 participants modeled in the billing analysis, 42 received fuel conversions for electric heating and/or water heating equipment. Conversion installations occurred only in Washington. Of the 42 conversion participants, only 36 received high-efficiency furnace installations, for which estimated savings of 61 therms was adapted from the billing analysis for residential single-family furnace replacements.[13] For these participants, we estimated an additional 2,188 therms.

Overall Gas Savings

Table 3-3 below compares the reported gas savings for PY2010 against the evaluated savings from our analysis. Overall, the program is achieving a 37 percent realization rate compared against the expected therms savings totals from the 228 participants. These results include both model savings applied to the 186 gas-saving participants and the furnace savings applied to the 36 participants receiving furnace conversions.

Table 3-3. Overall Gas Savings Comparison

State	Total Customers	Reported Savings (Therms)	Evaluated Gas Savings (Therms)	Program Realization Rates

[13] The program participant database did not indicate water heater conversions were replaced with efficient units; therefore, no additional gas savings were applied.

Idaho	72	15,286	8,886	58%
Washington	156	45,990	14,049	31%
Overall	228	61,276	22,937	37%

Recommendations

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

- Standardize expected savings calculations.
- Account for additional factors in savings calculations, such as historical consumption, interaction effects, square footage, and primary heating source.
- Track alternative heating sources in homes.
- Include high-use customers in program targeting.

3.1 Introduction

Cadmus conducted a statistical billing analysis to determine the adjusted gross savings and realization rates for the energy-efficient measures installed through the Low-Income Weatherization Program in PY 2010. We performed the analysis and provided results at the household- or participant-level, rather than at the measure-level. In this report, we describe our approach and findings for the PY 2010 gas savings.

To estimate the energy savings due to the program, Cadmus used a pre- and post-installation combined CSA and Princeton Score Keeping Method (PRISM) approach using monthly billing data. We analyzed savings estimates for Idaho and Washington, in addition to running a series of diagnostics, such as a review of savings by pre-consumption usage quartile and outlier analysis. Below we include a detailed discussion of the regression model we used for this billing analysis and the resulting savings.

In the 2010 program year, 228 out of 556 total program participants received gas-saving measures, 186 of which we included in the billing analysis.[14] These 186 participants received a mix of energy-efficiency measures, encompassing insulation, infiltration controls, doors, windows, and efficient furnace and water heater replacements. Both Avista and the community action program agencies (CAPs) which implement the program, contributed to developing expected measure-level savings estimates for each participant home.[15]

3.1.1 Program Description

Five programs comprise the Low-Income Weatherization Program, listed in Table 3-4. All of the low-income programs are implemented by local CAPs within Avista's Idaho and Washington service territories. CAPs holistically evaluate homes for energy-efficiency measure applicability,

[14] The analysis excluded 42 customers who also received electric to gas conversion measures.

[15] CAPs in Idaho developed expected savings and provided these estimates to Avista. In Washington, the CAPs did not report expected savings and Avista developed their own savings estimates.

combining funding from different programs to apply appropriate measures to a home based on the results of a home energy audit.

While both states operate very similar weatherization programs, it is important to note that each state has individual programs, with different sovereign statewide administers, implementation agencies, and weatherization protocols. Table 3-4 provides a description of the measures installed under each program component, along with the count of gas measures installed in PY 2010 and included in our gas impact analysis (we will include our findings of the evaluated electric measures in a subsequent report).

Table 3-4. 2010 Gas Efficiency Installations by Program Component

Low-Income Program Component	Measure Description	Measure Installations
Shell / Weatherization	Insulation (ceiling, floor, wall, duct), window/door installation, air infiltration	612
ENERGY STAR® Appliance	High-efficiency refrigerator replacement	N/A
Fuel Conversion*	Electric furnace and water heater replacement with gas units	N/A
Hot Water Efficiency	High-efficiency water heater replacement	8
HVAC Efficiency	High-efficiency gas furnace replacement	42

3.1.2 Data Collection

Cadmus obtained impact evaluation data from a number of different sources, including:

- ***Program participant database***: Avista provided information regarding the program participants and installed measures for each state. Specifically, these data included the list of measures installed per home and the expected savings from each completed installation; however, these data did not include the quantity of measures installed (such as the number of square feet of installed insulation) or the per unit savings estimates.
- ***Billing records***: Avista provided participant meter records from January 2008 through April 2011.
- ***Weather data***: Cadmus collected Idaho and Washington weather data from 10 representative stations for the corresponding time period from the National Oceanic and Atmospheric Administration (NOAA).

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

3.2 Methodology

3.2.1 Sampling

We used a census of program participants in the billing analysis (186 gas accounts, not including any of the gas customers who received conversion measures).

3.2.2 Data Collection Activities

3.2.2.1 Documentation Review/Database Review

Cadmus used the 2010 Idaho and Washington Program participant database provided by Avista to develop a complete population for use in both our billing analysis and for developing the telephone survey sample. The participant data also included customer information, account numbers, type of measure installed, rebate amounts, measure installation costs, measure installation dates, and expected savings per measure. Upon reviewing these data, Cadmus identified the few impact-related issues discussed below. We will include a detailed discussion of our process-oriented findings in the 2010 Process Report.

3.2.2.2 Surveys

Cadmus performed a telephone survey of 123 program participants to collect information about measure installations, energy education, non-energy benefits, and satisfaction with the program. This information contributed only slightly to our impact analysis and most findings will be reported in the 2010 Process Report.

3.2.2.3 Billing Analysis

Avista provided monthly billing data for all the Low-Income Weatherization Program participants from January 2008 through April 2011. Avista also provided the program participant database with participation and measure data, including all the gas and electric measures installed per home by the different CAPs. Cadmus summarized the data in the database for each participant by unique customer account and matched these data to the gas billing data for analysis.

We obtained daily average temperature weather data from 2008 to 2011 for the 10 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-degree HDD for each station. We obtained the nearest weather station for each territory using a zip code map of all the U.S. weather stations. We then matched the billing data periods with the HDDs from the station closest to each participant.

In order to prevent bias in assigning the pre- and post-periods from the different reading cycles (i.e., billing cycles that do not align exactly with the days per month, and different billing cycles for individual customers), and to simplify the analysis, we allocated the therm billing usage and the associated matched HDDs to calendar months.

Since the latest available billing data were for April 2011 and the measures were installed in 2010, we defined the analysis *PRE* period as 2009, before all participation installations occurred. We defined the *POST* period as the months following the installation.

Due to post-period data limitations, most participants had fewer than the desired 12 months of pre- or post-installation billing data. For this reason, we paired the pre- and post-months used in the billing analysis. For example, if a customer had measures installed in August 2010, we defined the post period as September 2010 through April 2011, and defined the pre-period as the corresponding months—from September 2009 through April 2010. This ensured that we used the same calendar months in both the pre and post periods, preventing bias from using mismatching months.

3.2.3 Data Screening

Once we had a subset of participant billing data with only the gas participants that did not receive conversion measures, Cadmus conducted a series of steps to screen participant usage data. These screens ensured that the analysis was conducted with a clean, reliable dataset.

3.2.3.1 General Screens

We performed the following screens to remove accounts that could possibly skew the savings estimation:

- Customers that indicated unit numbers in the address. These could potentially indicate weatherization installations that occurred in apartments.
- Accounts with fewer than three paired months (90 days) of billing data in either the pre- or post- period.

3.2.3.2 PRISM Modeling Screens

The second step in our screening process was to run PRISM models for the 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 of the weatherization savings obtained from the CSA model.

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

The PRISM model specification we used was:

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

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

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

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

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

Where, for each customer 'i':

NAC_i	=	the normalized annual therms 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 therms 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 (TMY2) in the 1971-2000 series from NOAA, based on home location[16]
$\beta_1 * LRHDD_i$	=	the weather-normalized annual weather sensitive (heating) usage, also known as HEATNAC
ε_i	=	the error term

Once we ran the models, we applied the following first set of screens on the PRISM model output to remove participants from the billing analysis:

- **Accounts with a PRISM model r-squared of less than 0.75.** These indicate a bad fit of the monthly gas usage and the actual HDDs, which is unexpected when gas appliances are used in both the pre and post periods.
- **Accounts with a HEATNAC of less than 100 therms in either the pre or post period**. If the annual heating usage is that low, the heating system was likely not used at all, and gas was probably only used for backup secondary heating. This screen also removed accounts with negative heating slopes from the analysis, since it is unlikely that the usage would have decreased in the heating months.
- **Accounts where the change between the pre weather-normalized usage (PRENAC) and the post weather-normalized usage (POSTNAC) was more than 80 percent of PRENAC.** Such large changes could indicate property vacancies when adding or removing “other” gas equipment, such as pools or spas, that are unrelated or outside of program activities.
- **Accounts where the pre-period base load was 0 and the post-period base load was greater than 0.** Since the base load indicates the usage that occurs in non-winter and shoulder months, those months outside of the heating season, this outcome suggests that a gas water heater, gas dryer, or gas range was added to the participant home. In this situation, the additional base load usage in the post period should not correspond to the weatherization measures installed through the program.
- **Accounts with negative intercepts, and hence negative base load**, were included in the analysis but were truncated to 0. These negative intercepts typically occur in homes with gas space heating and without gas water heating. The base load for these homes is expected to be 0, thus we set the base load to 0.

[16] In billing analysis we typically use 30 year normal heating degree averages to weather normalize the usage. The latest 30 year series available for this analysis was the TMY2 (1971-2000) series from NOAA/NCDC. We also ran the billing analysis using the 15 year TMY3 (1991-2005) heating degree days and the overall savings were not very different (7% lower).

- **Multifamily accounts.** We removed these accounts to avoid any issues associated with multifamily metering, as well as to avoid the interactive effects of heating usage across units.
- **Outliers.** Finally, model outlier diagnostic testing revealed four outliers that had a large influence on the participant HDD savings coefficient, and hence we removed these from the final model.

After applying these screens, there were 111 participants remaining that we used in the CSA model outlined below to determine average per home gas savings.

Table 3-5 summarizes the account attrition from the various screens listed above.

Table 3-5. Weatherization Account Attrition

Screen	Participants Remaining	Percent Remaining	Number Dropped	Percent Dropped
Original Gas Accounts	228	100%	0	0%
Gas-Only Accounts (No Conversion Measures)	186	82%	42	18%
Insufficient Pre- and Post-Period Months	178	78%	8	4%
Low R-Squared, Low Heating Usage	143	63%	35	15%
Changed Usage from the Pre to Post (> 80%)	142	62%	1	0%
Added Base Load	132	58%	10	4%
Multifamily (Unit Number Present)	115	50%	17	7%
Outliers	111	49%	4	2%
Final Analysis Group	111	49%	117	51%

3.2.4 CSA Modeling Approach

To estimate 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 with the inclusion of 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. Monthly consumption is also paired between the pre and post months to maintain the same timeframe for evaluating unique participants. We used the following model specification to determine the state-level savings:

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

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

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

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

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

β_2 = the therm savings per HDD for the efficient measures in Idaho

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

$POST\_ID_i * AVGHDD_{it}$ = an interaction between the Idaho post indicator ($POST\_ID_i$) and the HDDs ($AVGHDD_{it}$)

β_3 = the therm savings per HDD for the efficient measures in Washington

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

$POST\_WA_i * AVGHDD_{it}$ = an interaction between the Washington post indicator ($POST\_WA_i$) and the HDDs ($AVGHDD_{it}$).

M_t = an array of bill month dummy variables (Feb, Mar, …, Dec), 0 otherwise.[17]

ε_{it} = the modeling estimation error

The above model estimates the savings per heating degree for Idaho and Washington respectively with β_2 and β_3. In order to obtain the actual annual savings under normal weather conditions, we applied the 1971-2000 TMY2 normal HDDs from NOAA.

The per-HDD modeling approach resolves much of the potential bias from customers where predominantly winter month data was available. Since furnaces and shell measure impacts reflect seasonality in gas consumption, a per heating degree savings allows for allocating savings across all the calendar months, as well as being based on the HDDs. Using just a post-period indicator would have had a predominance of the winter months, resulting in savings being biased upwards.

3.3 Results and Findings

3.3.1 Billing Analysis Results

Table 3-6 summarizes the model savings results of the weatherization measure installations for the group of 111 participants. The model savings are an average of 123 therms in Idaho, 104 in Washington, and 112 overall.[18] The precision level indicates that the percent of error in the savings estimates is very low: at 12 percent in the combined model.

[17] 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.

[18] Similar savings were reported in Ecotope's 2008 evaluation of Avista's Low-Income Weatherization Program, where they cited an average of 113 therm savings per gas participant.

Table 3-6. Low-Income Weatherization Program Savings Summary

Group	n	PRENAC	Model Savings Per HDD	Normal HDDs	Model Savings (Therms)	Precision 90%	Savings Lower 90% (Therms)	Savings Upper 90% (Therms)
Idaho	43	850	-0.01735	7,113	123	17%	102	144
Washington	68	753	-0.01572	6,619	104	16%	88	121
Overall	111	791	-0.01638	6,810	112	12%	98	125

Table 3-7 compares the evaluated to expected deemed savings, along with the realization rates. The percent savings are similar by state, at roughly 15 percent of the weather-normalized pre-period usage. By comparison, the expected savings estimates per home relative to pre-period usage represents 24 percent in Idaho, and are nearly doubled in Washington at 46 percent .[19]

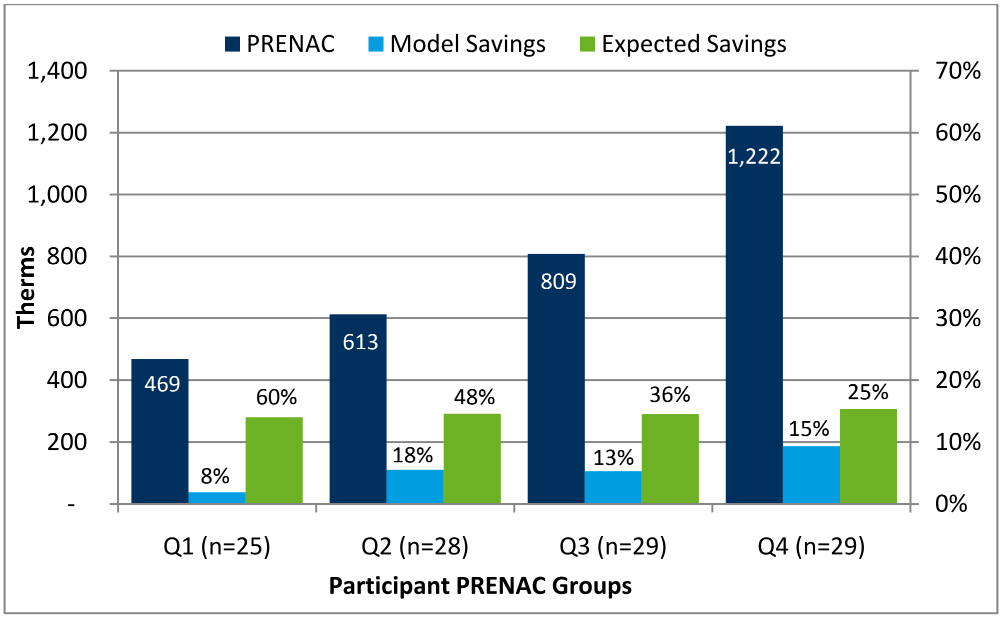
Table 3-7. Realization Rate Summary

Group	n	PRENAC	Model Savings (Therms)	Expected Savings (Therms)	Realization Rate	Model Savings as Percent of Pre-Usage	Expected Savings as Percent of Pre-Usage
Idaho	43	850	123	207	60%	15%	24%
Washington	68	753	104	347	30%	14%	46%
Overall	111	791	112	293	38%	14%	37%

To further illustrate the irregularity with expected savings, Figure 3-1 compares PRENAC to model savings and to expected savings estimates. We made these comparisons across categories of customers grouped by PRENAC usage quartiles (i.e., distribution of participants into four equal groups based on usage), which reflect different groups of customers that vary by their energy use.

[19] By comparison, the 2008 Ecotope evaluation reported a total expected savings of 110,665 therms for the 222 participants, resulting in an average expected savings of 498 therms, which is nearly 200 therms higher than the average expected savings in 2010. Assuming a comparable PRENAC of approximately 800 therms on average, the 2008 expected savings would reflect over 60% savings relative to the average pre-weatherization usage.

Figure 3-1. Savings Comparison by Customer Usage Category



Note: Each PRENAC column represents therm totals, while model savings and expected savings include the percentage of therm savings relative to PRENAC.

Intuitively, PRENAC increases through each quartile (across the different customer usage categories), and the model savings estimates reflect this as an increasing trend. In other words, customers that use more energy have a higher potential for energy savings. In contrast, the expected savings estimates are relatively flat across each customer usage category, with the percent of PRENAC being relatively higher for lower use customers.

Given the fairly similar distribution of installed measures between quartiles 1 and 4, it is surprising that the expected savings do not reflect the pre-period consumption trends.

We compared the average expected measure savings and noticed some discrepancies between the two states. Table 3-8 provides the average expected savings for each installed gas measure by state.

Table 3-8. Average Expected Savings by Measure and by State

Measure	Expected Therms Savings		Number of Installations	
	ID	WA	ID	WA
Ceiling/attic insulation	58.5	183.5	30	81
Wall insulation	74.6	155.4	11	35
Floor insulation	88.0	130.7	32	51
Duct insulation	41.8	67.8	23	18
Air infiltration controls	45.9	83.1	65	84
ENERGY STAR door replacement	23.4	23.6	23	64
ENERGY STAR window replacement	131.9	54.0	41	54
High-efficiency furnace replacement	n/a	150.0	0	42
High-efficiency water heater replacement	n/a	11.0	0	8

Note: Frequencies reflect all gas savings measures from the participant database

For most shell measures (aside from window and door replacements), expected therm savings in Washington are significantly higher than in Idaho. This distinction is clearly driving the difference in expected savings between the two states. The largest discrepancies in savings are with insulation and infiltration measures, which are the most frequently installed measures in participant homes in both states.

To better understand the model results and trends indicative of these expected savings, we assessed two other factors: 1) the average home square footage (primarily available for Washington homes)[20] and 2) HDDs per state. Washington participant homes average approximately 1,250 square feet, which helps to explain why the pre-usage numbers are so low, at 731 therms.

Secondly (and as shown in Table 3-6), Idaho has higher average HDDs (7,113) than Washington (6,619). This indicates that Idaho residents should average higher heating usage due to weather conditions (holding all other factors constant). While higher Idaho HDDs appear to be reflected in the PRENAC values for each state, it is surprising that Washington exhibits such a high expected savings estimate for heating and shell measures. Even assuming that homes in Washington have a higher average square footage than homes in Idaho is not significant enough to account for the differences in expected savings (e.g., average savings for Washington ceiling and wall insulation are twice the savings reported in Idaho for these measures).

3.3.2 Overall Program Results

In applying the state-level savings estimates from the billing analysis to the gas participant program population, a total therms savings of 20,749 is achieved. Table 3-9 provides more detail on the overall savings calculation by state.

Table 3-9. Overall Gas Savings by State

State	Total Participants	Model Savings Per Participant (Therms)	Total Savings (Therms)
Idaho	72	123	8,886
Washington	114	104	11,862
Overall	186	112	20,749

A remaining 42 participants in Washington received electric to gas conversion measures, including high-efficiency gas furnaces and water heaters. For these customers, there is a net increase in therms usage; however, in this report, we calculated therm savings generated from installations of high-efficiency gas equipment compared to standard gas equipment.[21] Table 3-10 provides a distribution of all Avista-funded measure installations for these 42 conversion participants.

[20] Source: Zillow square footage information applied to participant addresses for Washington (www.zillow.com).

[21] Electric savings associated with conversion measure installations will be accounted for in the 2010-2011 Avista Electric Impact Report, along with the increase in therms associated with installation of standard efficiency gas equipment to replace the electric equipment (considered by Avista to be a secondary impact under their electric program).

Table 3-10. Measure Installations for Conversion Participants

Description	Freq
Electric ENERGY STAR Refrigerator	7
Electric to Gas High Efficiency Furnace Conversion	36
Electric to Gas Hot Water Heater Conversion	38
Gas Air Infiltration Reduction	2
Gas ENERGY STAR Door Replacements	2
G ENERGY STAR Window Replacements	3
Gas High Efficiency Furnace	36
Gas Insulation - Ceiling/Attic	3
Gas Insulation – Floor	3
Gas Insulation – Wall	3
Health and Human Safety	1

The majority of these participants received both water heater and high-efficiency furnace conversion (n = 32), while 4 received only high-efficiency furnace conversions and 6 received only water heater conversions.

To account for the gas savings experienced through high-efficiency furnace replacement, we used the savings calculated through for Avista's residential furnace replacement program (84 therms for Washington participants) and scaled this value to reflect low-income participant home square footage.[22] The 36 conversion participants receiving a high-efficiency furnace conversion instead of a standard-efficiency gas furnace will generate a total of 2,188 therms.

Table 3-11 provides the overall savings gas savings by state, including only the savings generated from fuel conversion participants receiving high-efficiency equipment instead of standard-efficiency equipment.

Table 3-11. Overall Gas Savings by State

State	Total Model Savings (Therms)	Conversion Participant Savings (Therms)	Total Savings (Therms)
Idaho	8,886	n/a	8,886
Washington	11,862	2,188	14,049
Overall	20,749	2,188	22,937

[22] For Washington, low-income participants averaged 1,250 square feet per home, while single-family participants averaged 1,728 square feet per home.

3.3.3 Goals Comparison

We compared the evaluated savings for the 228 gas participants against the estimated therms savings for these participants listed in Avista's program participant database. Table 3-12 provides a summary of overall evaluated savings, expected savings goals, and the realization rates overall and by state. Overall, the low-income weatherization program is reaching approximately 37 percent of their gas savings goals.

Table 3-12. IRP Program Goals Comparison

State	Total Customers	Reported Savings (Therms)	Evaluated Gas Savings (Therms)	Program Realization Rates
Idaho	72	15,286	8,886	58%
Washington	156	45,990	14,049	31%
Overall	228	61,276	22,937	37%

3.4 Conclusions

Model savings as a percent of pre-period weather-normalized usage (15 percent) may be the best reference point for assessing the program impacts relative to other programs. In a 2005 national evaluation of the Weatherization Assistance Program, Oak Ridge National Laboratory found that the average gas savings compared to pre-weatherization consumption is approximately 23 percent.[23] Similarly, in a 2006 weatherization evaluation for the state of Ohio, Quantec, LLC (now Cadmus) determined that gas participants save 25 percent of their pre-period normalized annual consumption.[24] However, it is important to take into account the age of these comparison reports and the recent economic factors and changing energy rates that may affect customer behavior. While the ORNL national study did not provide data with enough detail to use in comparison, we were able to use some of the details from our Ohio study to help understand Avista's impacts:

1. Average square footage was slightly higher (1,384 in Ohio compared to 1,250 in Washington).
2. Ohio participant PRENAC averaged 1,290 therms, while Avista participant PRENAC was 791 therms.

Using a savings distribution by PRENAC category from the Ohio study, we can scale the percent savings reported for Ohio using the Avista distribution. Table 3-13 provides details of this comparison, which result in an average percent savings of approximately 14 percent, nearly identical to the percentage found in the Avista study. This finding reinforces the conclusion that lower savings were experienced in the Avista program due to average lower pre-treatment consumption, as a higher percent savings should be realized by weatherizing larger homes with higher pre-treatment consumption.

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[23] ORNL, 2005. *Estimating the National Effects of the U.S. Department of Energy's Weatherization Assistance Program With State-Level Data: A Metaevaluation Using Studies from 1993 to 2005.* http://weatherization.ornl.gov/pdfs/ORNL_CON-493.pdf

[24] http://www.development.ohio.gov/cms/uploadedfiles/Development.ohio.gov/Divisional_Content/Community/Office_of_Community_Services/HWAPImpactEvaluation.pdf

Table 3-13. OH HWAP Savings Comparison

Pre-Treatment Usage	Avista Study			Ohio HWAP % Savings	Weighted Average % Savings Using Avista Participant Distribution
	Participant Count	% Participant Distribution	Average PRENAC		
High Use (>1,800)	1	1%	2,688	26%	
Mid Use (1,000-1,800)	21	19%	1,240	21%	
Low Use (<1,000)	89	80%	663	13%	
Overall	111	100%	791		14%

Additionally, several factors may be contributing to lower realization rates:

- First, low-income programs often experience different types of take-back effects. In some cases, additional family members may move into the newly weatherized home because of the increased comfort provided by the installations, thus increasing usage in the post period. Alternatively, perceived energy savings with respect to new insulation or a new furnace may result in behavior changes where customers turn up the heat, thereby using more energy. Participants who were formerly heating only part of their home may also be able to heat their entire home because of the savings provided by weatherization.
- Second, the use of different types of heating equipment (such as using wood or portable electric heaters instead of an electric or gas furnace) can result in lower savings than expected. A survey of 123 program participants revealed that approximately 10 percent use neither electricity nor natural gas for primary heating, but are instead using wood, propane, or fuel oil.[25] Additionally, nearly one-third of respondents (n=40) indicated using a supplemental heat source, such as a space heater or wood. These results indicate the program may have inaccurate expected savings estimates by assuming primarily gas heating in the home.
- Third, different approaches in deriving expected savings may results in different savings estimates for the same measure. With Avista's program, expected savings for Idaho come directly from the agencies, while the expected savings for Washington are calculated by Avista using a deemed measure-level savings approach that does not appear to account for square footage or historical energy consumption. Deemed savings estimates in low-income programs tend to over-estimate actual savings by not accounting for nuances such as behavior, weather, and alternative fuels.

3.5 Recommendations

The following subsections outline our suggestions of program enhancements that could help to improve program impact results.

[25] Of the 10 percent of respondents who reported using alternative fuel as their primary source of heat, 7 respondents indicated using wood or wood stoves and 4 respondents indicated using fuel oil.

Standardize Expected Savings Calculations

Standardizing expected savings calculations across both states will help avoid wide discrepancies in realization rates.

Account for Additional Factors in Savings Calculations

Accounting for pre-period annual consumption, square footage, and interaction effects will help create a more robust savings estimate and avoid over-estimates that may occur through a prescriptive application of deemed estimates.

Track Alternative Heating Sources

As inexpensive alternatives to gas heat, gas customers may turn to electric room heaters and wood stoves, thereby reducing the impact of the 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 for more reasonable estimates in cases where, despite being a gas customer, gas is used as a secondary heating source.

Include High-Use Customers in Program Targeting

While prioritization guidelines for targeting low-income weatherization participants are set at the federal level, some utilities actively track customer usage and provide agencies with lists of customers that have particularly high energy consumption for targeting purposes. In these 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 that some customers are overly burdened with energy bills due to their housing characteristics, and the program could provide relief.

There are methods for identifying high usage customers while also controlling for factors that contribute to consumption (e.g., square footage, income, number of people per household). Using such an approach would allow Avista to identify their high-use customers.

Appendix A: Residential Furnace Billing Model Outputs

The following tables summarize the model result outputs[26] from our billing analysis of PY 2010 participants.

Table A1. Furnace Savings Regression Model (State-Level Savings)

	Analysis of Variance				
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1,728	350,619	202.90468	305.95	<.0001
Error	25,794	17,107	0.6632		
Corrected Total	27,522	367,726			
Root MSE	0.81437		R-Square	0.9535	
Dependent Mean	2.35167		Adj R-Square	0.9504	
Coeff Variable	34.62944				
	Parameter Estimates				
Source	DF	Parameter Estimates	Standard Error	t value	Prob. t
Average Intercept	1714	0.84145	0.2158976	4.16	<.0001
AVGHDD	1	0.11299	0.00239	47.34	<.0001
POST_ID * AVGHDD	1	-0.01458	0.0005853	-24.92	<.0001
POST_WA * AVGHDD	1	-0.01566	0.0004522	-34.62	<.0001
Feb	1	-0.15754	0.02125	-7.41	<.0001
Mar	1	-0.38654	0.02745	-14.08	<.0001
Apr	1	-0.6308	0.04133	-15.26	<.0001
May	1	-0.71512	0.06195	-11.54	<.0001
Jun	1	-0.59065	0.07668	-7.7	<.0001
Jul	1	-0.42269	0.08506	-4.97	<.0001
Aug	1	-0.45796	0.08448	-5.42	<.0001
Sep	1	-0.6534	0.07399	-8.83	<.0001
Oct	1	-0.7657	0.04867	-15.73	<.0001
Nov	1	-0.42187	0.02634	-16.01	<.0001
Dec	1	-0.07407	0.02066	-3.58	3E-04

26 We ran all of the models with a fixed effects specification, which is a separate intercept for each participant. Due to the large amount of output from showing the model coefficients for each of the intercepts, we only present the average of all the separate intercepts in the output.

Table A2. Furnace Savings Regression Model (Overall Savings)

	Analysis of Variance				
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1,727	350,618	203.02126	306.11	<.0001
Error	25,795	17,108	0.66323		
Corrected Total	27,522	367,726			
Root MSE	0.81439		R-Square	0.9535	
Dependent Mean	2.35167		Adj R-Square	0.9504	
Coeff Variable	34.63034				
	Parameter Estimates				
Source	DF	Parameter Estimates	Standard Error	t value	Prob. t
Average Intercept	1714	0.83624	0.21584	4.13	<.0001
AVGHDD	1	0.11312	0.00238	47.44	<.0001
POST * AVGHDD	1	-0.01527	0.00037601	-40.61	<.0001
Feb	1	-0.15712	0.02125	-7.39	<.0001
Mar	1	-0.38533	0.02744	-14.04	<.0001
Apr	1	-0.62855	0.0413	-15.22	<.0001
May	1	-0.71172	0.06191	-11.5	<.0001
Jun	1	-0.58645	0.07664	-7.65	<.0001
Jul	1	-0.41807	0.08501	-4.92	<.0001
Aug	1	-0.4534	0.08443	-5.37	<.0001
Sep	1	-0.64931	0.07394	-8.78	<.0001
Oct	1	-0.76302	0.04864	-15.69	<.0001
Nov	1	-0.42086	0.02634	-15.98	<.0001
Dec	1	-0.07408	0.02066	-3.59	0.0003

Table A3. Furnace Savings Regression Model (Quartile 1: 207-735 therms)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
	Analysis of Variance				
Model	442	34,242	77.47122	501.12	<.0001
Error	7,230	1,117.73374	0.1546		
Corrected Total	7,672	35,360			
Root MSE	0.39319		R-Square	0.9684	
Dependent Mean	1.38872		Adj R-Square	0.9665	
Coeff Variable	28.31295				

Source	DF	Parameter Estimates	Standard Error	t value	Prob. t
	Parameter Estimates				
Average Intercept	429	0.51271	0.11794	4.56	<.0001
AVGHDD	1	0.07084	0.00214	33.03	<.0001
POST * AVGHDD	1	-0.0056	0.00035135	-15.94	<.0001
Feb	1	-0.08354	0.02074	-4.03	<.0001
Mar	1	-0.25164	0.02598	-9.69	<.0001
Apr	1	-0.43941	0.03834	-11.46	<.0001
May	1	-0.5412	0.05586	-9.69	<.0001
Jun	1	-0.44099	0.06926	-6.37	<.0001
Jul	1	-0.31625	0.07699	-4.11	<.0001
Aug	1	-0.33503	0.0765	-4.38	<.0001
Sep	1	-0.48238	0.06692	-7.21	<.0001
Oct	1	-0.55694	0.04416	-12.61	<.0001
Nov	1	-0.29982	0.0244	-12.29	<.0001
Dec	1	-0.03962	0.01964	-2.02	0.0436

Table A4. Furnace Savings Regression Model (Quartile 2: 736-939 therms)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
	Analysis of Variance				
Model	441	59,377	134.64169	651.35	<.0001
Error	6,461	1,335.56723	0.20671		
Corrected Total	6,902	60,713			
Root MSE	0.45466		R-Square	0.978	
Dependent Mean	2.04783		Adj R-Square	0.9765	
Coeff Variable	22.20182				

Source	DF	Parameter Estimates	Standard Error	t value	Prob. t
	Parameter Estimates				
Average Intercept	428	0.51987	0.14719	3.77	<.0001
AVGHDD	1	0.10243	0.00266	38.5	<.0001
POST * AVGHDD	1	-0.01277	0.00041839	-30.52	<.0001
Feb	1	-0.11737	0.0236	-4.97	<.0001
Mar	1	-0.27638	0.0307	-9	<.0001
Apr	1	-0.43793	0.0459	-9.54	<.0001
May	1	-0.54731	0.06944	-7.88	<.0001
Jun	1	-0.44015	0.08589	-5.12	<.0001
Jul	1	-0.28605	0.09521	-3	0.0027
Aug	1	-0.30825	0.09452	-3.26	0.0011
Sep	1	-0.50876	0.08276	-6.15	<.0001
Oct	1	-0.64131	0.05454	-11.76	<.0001
Nov	1	-0.33758	0.02956	-11.42	<.0001
Dec	1	-0.07396	0.02303	-3.21	0.0013

Table A5. Furnace Savings Regression Model (Quartile 3: 940-1210 therms)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
	Analysis of Variance				
Model	440	91,198	207.26707	757.29	<.0001
Error	6,410	1,754.39792	0.2737		
Corrected Total	6,850	92,952			
Root MSE	0.523216		R-Square	0.9811	
Dependent Mean	2.56575		Adj R-Square	0.9798	
Coeff Variable	20.39014				

Source	DF	Parameter Estimates	Standard Error	t value	Prob. t
	Parameter Estimates				
Average Intercept	427	0.419695972	0.170254848	2.8270726	0.03
AVGHDD	1	0.1325	0.00309	42.83	<.0001
POST * AVGHDD	1	-0.01697	0.00048389	-35.08	<.0001
Feb	1	-0.10991	0.02734	-4.02	<.0001
Mar	1	-0.27635	0.03526	-7.84	<.0001
Apr	1	-0.47098	0.05312	-8.87	<.0001
May	1	-0.58867	0.08019	-7.34	<.0001
Jun	1	-0.42928	0.09913	-4.33	<.0001
Jul	1	-0.2029	0.10998	-1.84	0.0651
Aug	1	-0.25344	0.10922	-2.32	0.0203
Sep	1	-0.49487	0.09561	-5.18	<.0001
Oct	1	-0.59265	0.06265	-9.46	<.0001
Nov	1	-0.31833	0.03374	-9.44	<.0001
Dec	1	-0.04687	0.02642	-1.77	0.0761

Table A6. Furnace Savings Regression Model (Quartile 4: Over 1211 therms)

Source	Analysis of Variance				
	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	443	173,443	391.51809	421.01	<.0001
Error	5,655	5,258.87108	0.92995		
Corrected Total	6,098	178,701			
Root MSE	0.96434		R-Square	0.9706	
Dependent Mean	3.77279		Adj R-Square	0.9683	
Coeff Variable	25.56037				

Source	Parameter Estimates				
	DF	Parameter Estimates	Standard Error	t value	Prob. t
Average Intercept	430	0.065836349	0.342176605	0.428930233	0.67
AVGHDD	1	0.19838	0.00611	32.48	<.0001
POST * AVGHDD	1	-0.0254	0.00092502	-27.46	<.0001
Feb	1	-0.1792	0.05009	-3.58	0.0004
Mar	1	-0.33048	0.06684	-4.94	<.0001
Apr	1	-0.52291	0.10334	-5.06	<.0001
May	1	-0.49647	0.15775	-3.15	0.0017
Jun	1	-0.23818	0.19484	-1.22	0.2216
Jul	1	0.0394	0.21533	0.18	0.8548
Aug	1	0.02262	0.21386	0.11	0.9158
Sep	1	-0.26928	0.18798	-1.43	0.1521
Oct	1	-0.61218	0.12365	-4.95	<.0001
Nov	1	-0.42436	0.06559	-6.47	<.0001
Dec	1	-0.09208	0.05022	-1.83	0.0668

Table A7. Furnace Savings Regression Model Without Heat Pumps (State-Level Savings)

	Analysis of Variance				
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1,555	322,211	207.20972	322.74	<.0001
Error	23,253	14,929	0.64203		
Corrected Total	24,808	337,140			
Root MSE	0.80127		R-Square	0.9557	
Dependent Mean	2.36585		Adj R-Square	0.9528	
Coeff Variable	33.8681				
	Parameter Estimates				
Source	DF	Parameter Estimates	Standard Error	t value	Prob. t
Average Intercept	1,541	0.80182	0.21433	3.99	<.0001
AVGHDD	1	0.11383	0.00246	46.24	<.0001
POST_ID * AVGHDD	1	-0.0113	0.00061049	-18.5	<.0001
POST_WA * AVGHDD	1	-0.0125	0.00046939	-26.62	<.0001
Feb	1	-0.152	0.02206	-6.89	<.0001
Mar	1	-0.36082	0.02843	-12.69	<.0001
Apr	1	-0.59322	0.04278	-13.87	<.0001
May	1	-0.6728	0.06379	-10.55	<.0001
Jun	1	-0.53892	0.07903	-6.82	<.0001
Jul	1	-0.37086	0.08769	-4.23	<.0001
Aug	1	-0.41219	0.0871	-4.73	<.0001
Sep	1	-0.61516	0.07631	-8.06	<.0001
Oct	1	-0.72472	0.05026	-14.42	<.0001
Nov	1	-0.4033	0.02732	-14.76	<.0001
Dec	1	-0.07937	0.02151	-3.69	0.0002

Table A8. Furnace Savings Regression Model Without Heat Pumps (Overall Savings)

	Analysis of Variance				
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1,554	322,209	207.34194	322.92	1,554
Error	23,254	14,931	0.64208		23,254
Corrected Total	24,808	337,140			24,808
Root MSE	0.8013		R-Square	0.9557	
Dependent Mean	2.36585		Adj R-Square	0.9528	
Coeff Variable	33.86929				
	Parameter Estimates				
Source	DF	Parameter Estimates	Standard Error	t value	Prob. t
Average Intercept	1,541	0.79603	0.21428	3.96	<.0001
AVGHDD	1	0.11399	0.00246	46.33	<.0001
POST * AVGHDD	1	-0.01207	0.00039101	-30.87	<.0001
Feb	1	-0.15153	0.02205	-6.87	<.0001
Mar	1	-0.35948	0.02842	-12.65	<.0001
Apr	1	-0.59071	0.04276	-13.82	<.0001
May	1	-0.66902	0.06375	-10.49	<.0001
Jun	1	-0.53428	0.07898	-6.76	<.0001
Jul	1	-0.36574	0.08763	-4.17	<.0001
Aug	1	-0.40705	0.08705	-4.68	<.0001
Sep	1	-0.61056	0.07626	-8.01	<.0001
Oct	1	-0.72172	0.05023	-14.37	<.0001
Nov	1	-0.40217	0.02731	-14.72	<.0001
Dec	1	-0.07936	0.02151	-3.69	0.0002

Table A9. Furnace Savings Regression Model With Heat Pumps (State-Level Savings)

Source	Analysis of Variance				
	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	187	28,882	154.44973	229.1	<.0001
Error	2,527	1,703.57301	0.67415		
Corrected Total	2,714	30,586			
Root MSE	0.82107		R-Square	0.9443	
Dependent Mean	2.21626		Adj R-Square	0.9402	
Coeff Variable	37.04731				
	Parameter Estimates				
Source	DF	Parameter Estimates	Standard Error	t value	Prob. t
Average Intercept	173	0.865818439	0.357330058	2.446589595	0.0148
AVGHDD	1	0.11406	0.00809	14.1	<.0001
POST_ID * AVGHDD	1	-0.04051	0.00178	-22.76	<.0001
POST_WA * AVGHDD	1	-0.04341	0.00143	-30.3	<.0001
Feb	1	-0.17295	0.06735	-2.57	0.0103
Mar	1	-0.54103	0.08936	-6.05	<.0001
Apr	1	-0.82699	0.1351	-6.12	<.0001
May	1	-0.87454	0.21595	-4.05	<.0001
Jun	1	-0.74537	0.26326	-2.83	0.0047
Jul	1	-0.52422	0.29097	-1.8	0.0717
Aug	1	-0.52633	0.28809	-1.83	0.0678
Sep	1	-0.74051	0.25125	-2.95	0.0032
Oct	1	-0.96829	0.16315	-5.93	<.0001
Nov	1	-0.52143	0.08465	-6.16	<.0001
Dec	1	-0.03305	0.0638	-0.52	0.6045

Table A10. Furnace Savings Regression Model With Heat Pumps (Overall Savings)

Source	Analysis of Variance				
	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	186	28,881	155.2736	230.25	<.0001
Error	2,528	1,704.78295	0.67436		
Corrected Total	2,714	30,586			
Root MSE	0.82119		R-Square	0.9443	
Dependent Mean	2.21626		Adj R-Square	0.9402	
Coeff Variable	37.05313				
Source	Parameter Estimates				
	DF	Parameter Estimates	Standard Error	t value	Prob. t
Average Intercept	173	0.85206	0.35705	2.41	0.016
AVGHDD	1	0.11442	0.00809	14.15	<.0001
POST * AVGHDD	1	-0.0423	0.00117	-36.09	<.0001
Feb	1	-0.17191	0.06736	-2.55	0.0108
Mar	1	-0.53795	0.08935	-6.02	<.0001
Apr	1	-0.82128	0.13506	-6.08	<.0001
May	1	-0.86546	0.21588	-4.01	<.0001
Jun	1	-0.73354	0.26316	-2.79	0.0054
Jul	1	-0.51162	0.29086	-1.76	0.0787
Aug	1	-0.516	0.28804	-1.79	0.0733
Sep	1	-0.73068	0.25118	-2.91	0.0037
Oct	1	-0.96158	0.1631	-5.9	<.0001
Nov	1	-0.5189	0.08465	-6.13	<.0001
Dec	1	-0.03349	0.06381	-0.52	0.5997

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: Non-Residential Impact Analysis

Overview

For this analysis, we evaluated four non-residential projects. These sites differed substantially; therefore, we evaluated them on a case-by-case basis. The four sites we evaluated are outlined in Table C1.

Table C1. Site Descriptions

Site Number	Business Type	Location	Claimed Savings (therms/year)
19652963	Church	Spokane, WA	4,192
1500385	Wastewater Treatment	Sandpoint, ID	21,883
17739130	Concrete Pre-Mix Facility	Spokane, WA	75,000
18524903	Linen Supply Company	Lewiston, ID	39,706

Billing Analysis Methodology

Our pre–post modeling approach allows for directly developing retrofit savings estimates for each site. The modeling approach accounts for differences in HDDs and, where applicable, production. It also allows for determining savings for normalized weather conditions, since the actual weather conditions may be milder or more extreme than the 15 year (1991-2005) normal weather averages from the NCDC.

Cadmus obtained daily weather data from NCDC for each weather station associated with the participants. From the daily weather data, we calculated the base 65 reference temperature HDDs. We then matched the participant billing data to the nearest weather station by zip code, and matched each monthly billing period to the associated base 65 HDDs.

All models follow a modified PRISM approach. We normalized all dependent and independent variables for the days in each billing period; therefore, model coefficients can be interpreted as average daily values. We did this to account for differences in the length of billing periods. For each model, we took the average daily consumption in therms as a function of some combination of average standing baseload, HDD, and (where appropriate) daily consumption.

For each site, we 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. For instances, we eliminated the standing load for one site as a results of the retrofit program. Using our pre-post modeling approach, we estimated an intercept model for the pre period and a no-intercept model for the post period to reflect this change.

After estimating model coefficients for each site, we calculated three scenarios. First, we estimated a reference load for the past 12 billing cycles using the pre period model. This scenario extrapolates the counterfactual consumption; that is, what the consumption would have been in the absence of the program. The difference between this scenario and the actual consumption represents actual savings.

We then estimated two normalized scenarios—one using the pre model and one using the post model—using 15 year TMY3 data as the annual HDD and mean annual values for the production data. The difference between these two scenarios represents the long-term expected annual savings.

Summary of Estimated Savings

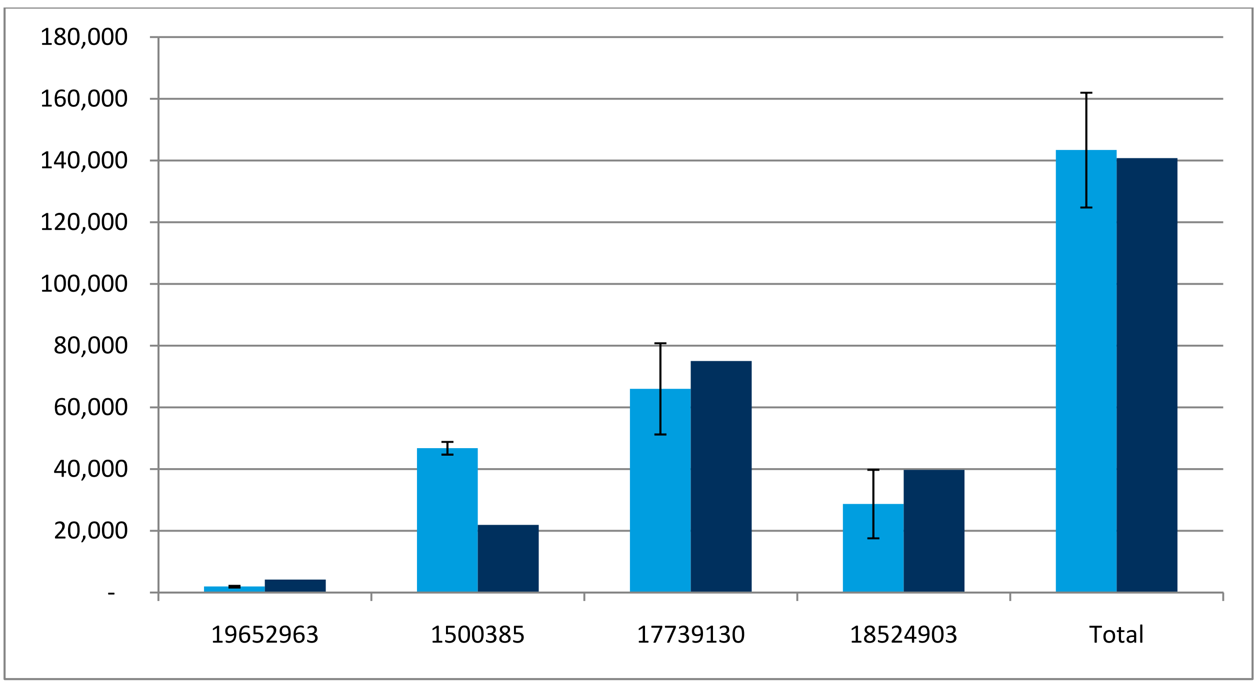
As a result of our site reviews and billing analysis, we found that savings differ substantially from what was claimed in many cases. For all but one of the projects, claimed savings appeared to overstate actual achieved savings.

Table C2. Claimed and Evaluated Savings by Project

Site	Claimed Savings	Evaluated Savings	Relative Precision
19652963	4,192	1,926	14%
1500385	21,883	46,769	4%
17739130	75,000	66,015	22%
18524903	39,706	28,686	39%
Total	140,781	143,396	13%

Despite consistently high claimed savings for the other programs, the offset from low claimed savings for site #1500385 caused the total evaluated savings for the program to closely match claimed savings at the 95 percent confidence level (as shown in Figure C1).

Figure C1. Claimed and Evaluated Savings (with 95% Confidence Intervals)



Case Study - Site # 19652963

Site #19652963 is a church with a congregation of approximately 60 members located in Spokane, Washington.

Site Review

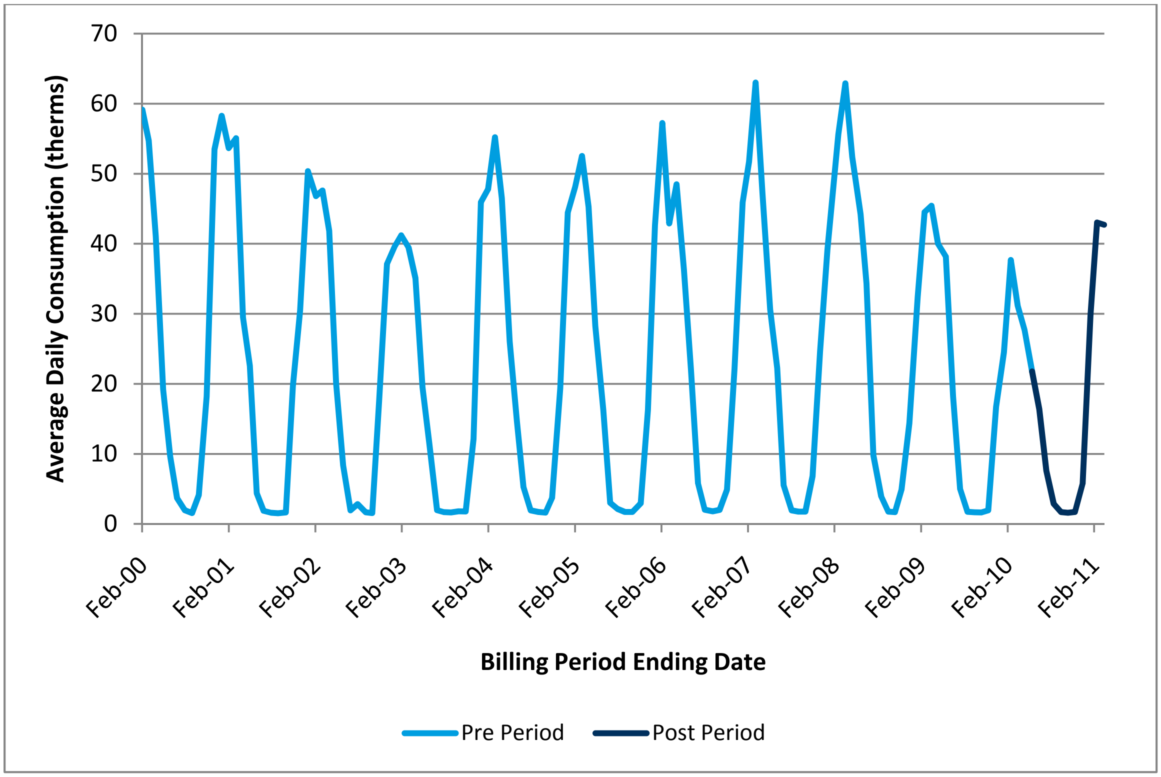
The church has four stories of brick construction with a commercial kitchen, multiple offices, a meeting room, and classrooms. The sanctuary is on the first floor and the rest of the rooms are on the upper levels.

The main church boiler is 76 to 80 percent efficient and 500,000 BtuH in size. The system has a low-pressure steam of 6 psig and a condensate return. The steam distribution lines are mostly 4-inches in diameter; 12-inches where insulated. Most of the radiators have 1/2-inch steam traps installed. The steam traps are thermostatic type.

The congregation stopped heating the two upper floors of the building in the last few years, and only heats the sanctuary and the first floor. Gas heat is used only on Sundays, while electric space heaters are used the remainder of the week.

The site has three water heaters. The primary unit, which is gas-fired, has a tank capacity of 75 gallons and is always on. A 50-gallon gas-fired unit operates on pilot only. The third water heater is electric, is for the commercial kitchen, and is primarily for dishwasher use.

Figure C2. Site #19652963 Average Daily Consumption for the Past 11 Years



Billing Analysis

We obtained Spokane weather data from WBAN #24157, located at the Spokane airport. There were 6,821 HDD in the 12 billing cycles beginning March 29, 2010 and ending March 29, 2011. There are 6,712 TMY3 HDD for this weather station, implying that this past winter season was slightly colder than average.

Given that the gas load is virtually entirely weather sensitive, we did not use intercept models for the pre and post periods. We tested intercept models and found—in all cases—that they did not differ significantly from zero. We estimated models as identical univariate regressions with the following specification:

$$therms_t = \beta_1 HDD_t + e_t$$

Where:

$therms_t$ = average daily therms for billing period '*t*'

HDD_t = average HDD for billing period '*t*'

Findings

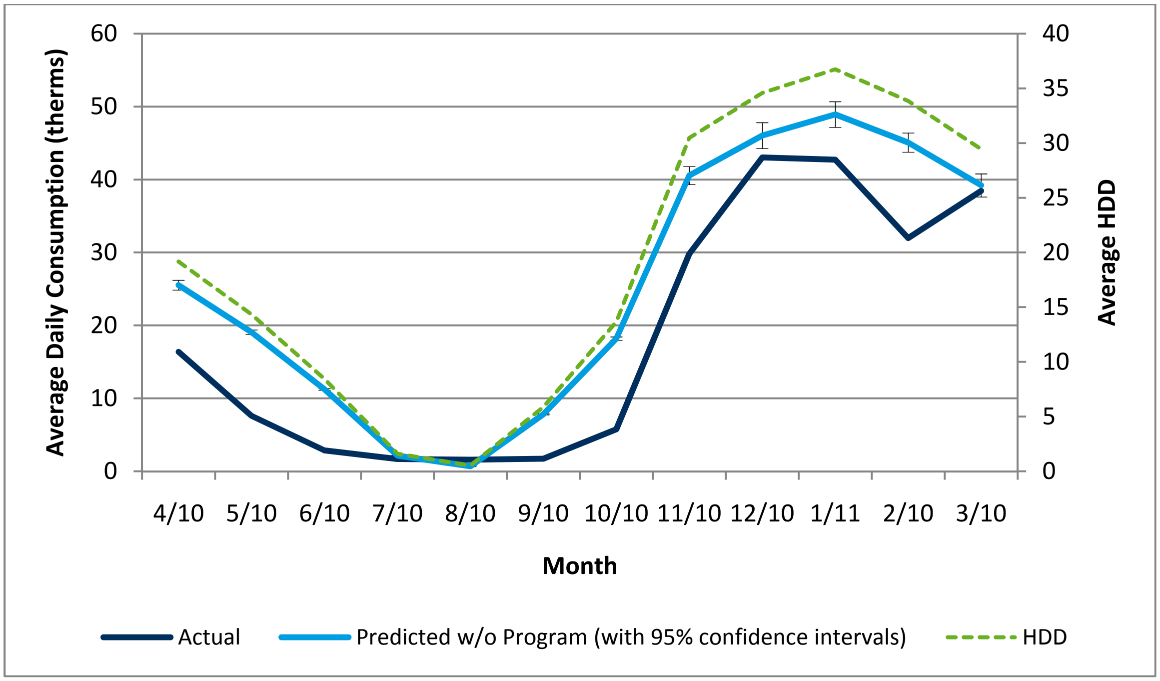
The estimated coefficients from the models support the hypothesis that consumption was decreased as a result of the retrofits. Table C3 shows the coefficients we estimated for each model and their respective fit indices.

Table C3. Site #19652963 Model Fit and Parameters

Model	n	R^2	Coefficients			
			Variable	Parameter	Standard Error	p-value
Pre	123	0.97	HDD	1.331	0.021	<.0001
Post	15	0.96	HDD	1.044	0.065	<.0001

These model coefficients indicate that there was a net decrease of 0.29 therms per HDD on average because of the program. Given that there were 6,821 HDD in the past 12 billing cycles, the model estimates that consumption would have been 9,081 therms; when in fact it was 6,636 therms. We therefore estimate gross savings for the past 12 billing periods at 2,445 therms. The relationship between the actual consumption, estimated consumption, and HDD can be seen in Figure C3.

Figure C3. Site #19652963 Reference vs. Actual Load for Past 12 Billing Cycles



Based on the results of our billing analysis, we conclude that the retrofits did result in savings, albeit lower than those originally claimed. Using TMY3 HDD, we estimate that this project will result in an average annual gross savings of 1,926 therms.

Table C4. Site #19652963 Normalized Annual Gross Savings

Consumption Type	Units	Pre-Retrofit Estimate	Post-Retrofit Estimate	Difference	Normalized Units/Day	Daily Savings	Annual Savings
Weather Sensitive	HDD	1.33	1.04	-0.29	18.4	5.3	1,926
Total						5.3	1,926

Case Study - Site # 1500385

Site #1500385 is a municipal wastewater plant in Sandpoint, Idaho. We installed two measures at this site before January 21, 2009.

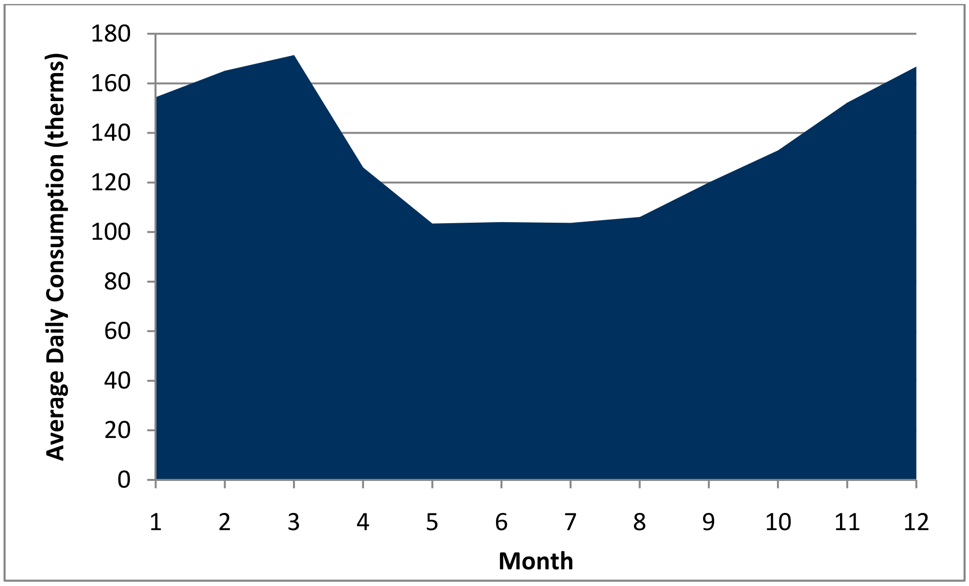
For application #23037, clean digester gas was set up to heat the facility. This involves replacing natural gas with methane gas to feed the main boiler. The boiler subsequently keeps the heat at 98°F for the digester. This project had an anticipated savings of 20,604 therms per year.

For application #23040, installers replaced the gravity thickener with a rotary screen. This reduces the quantity of water going to the digester, where it has to be removed. This project had an anticipated savings of 1,279 therms per year.

Site Review

The throughput for wastewater treatment is normally in the high two million gallons/day (MGD). In past four years, it has been closer to the low two MGD. In the spring, throughput can often climb to ten MGD for two to three weeks. This pattern appears to take place in March, as can be seen in Figure C4. The typical heating season is from October to the end of May, when the unit heaters are being used and consuming gas.

Figure C4. Site #1500385 Average Daily Consumption by Month



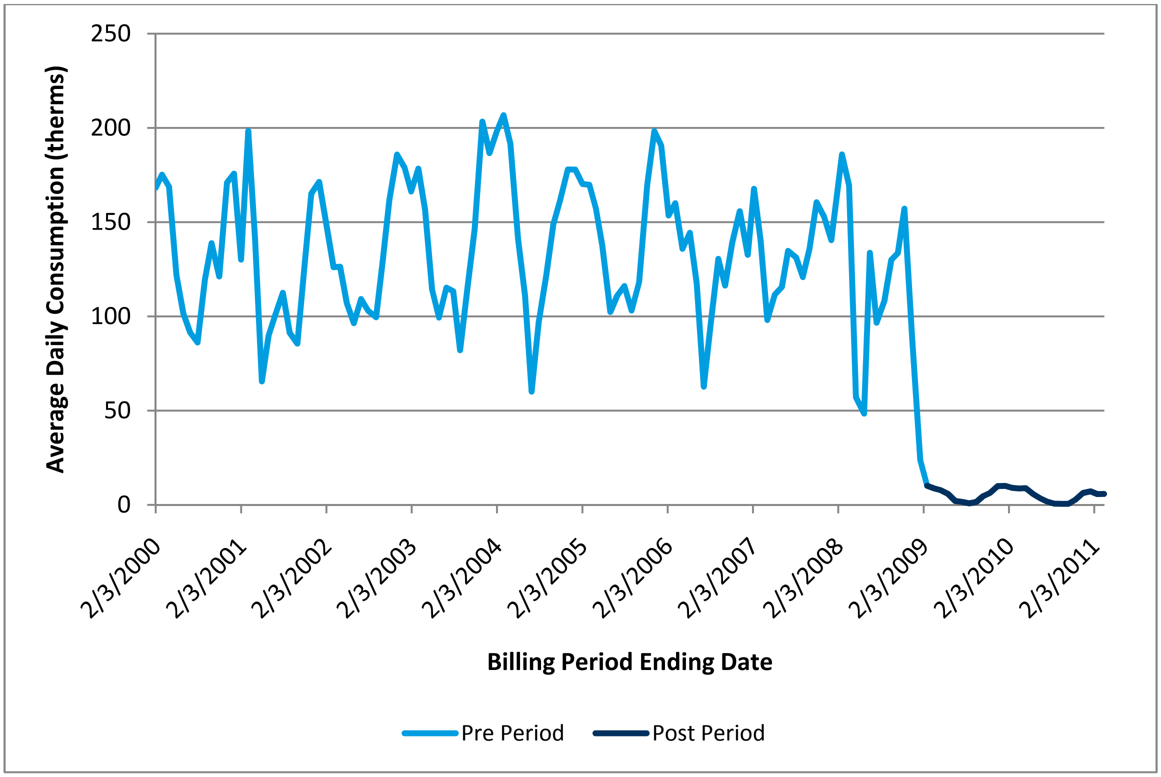
The application #23037 project provides a waste stream of gas to one of the boilers that provides heat for the digester. The digester must remain around 98°F all year to function properly. Because of the low pressure on the methane waste gas being used, only one of two boilers has been converted to use this gas. The second boiler is still on natural gas, and is now used as a backup.

The application #23040 project reduced the amount of water going to the digester. This reduced the amount of heat needed from the boiler to eliminate extra water in the digester. This project therefore reduced the demand for natural gas. The installation of the gravity thickener has improved process control. This project also included the installation of new primary pumps to the digester to improve the process control.

Other minor process improvements are ongoing, such as the installation of an electronic spark ignition at the flare to keep it going (as methane gas is not available).

This site has shown a very large drop in the use of natural gas since the projects were completed. Hourly meter data show a drop from an average of approximately 133 therms/day to 5 therms/day on average (see Figure C5).

Figure C5. Site #1500385 Average Daily Consumption for the Past 11 years



Billing Analysis

The nearest major weather station to Sandpoint is WBAN #24157, located at the Spokane airport. There were 6,808 HDD in the 12 billing cycles beginning March 17, 2010 and ending March 17, 2011. There are 6,712 TMY3 HDD for this weather station, implying that this past winter season was slightly colder than average.

Since wastewater treatment involves both weather-sensitive demand and a certain standing production demand, we used intercept models for the billing analysis of this site. We estimated two separate models for the pre and post periods. The pre period model was as follows:

$$therms_t = \beta_0 + \beta_1 HDD_t + \beta_2 March_t + e_t$$

Where:

$therms_t$ = average daily therms for billing period '*t*'

HDD_t = average HDD for billing period '*t*'

$March_t$ = a dummy variable that equals 1 if '*t*' is during the March peak period and equals 0 otherwise

The model for the post period was nearly identical, with the exception that we excluded the March dummy variable. We chose to exclude this variable for two reasons: 1) we should not expect a spike in consumption now that the boiler is being run on methane, and 2) the coefficient was not found to differ significantly from zero. The final post period model was as follows:

$$therms_t = \beta_0 + \beta_1 HDD_t + e_t$$

Where:

$therms_t$ = average daily therms for billing period *'t'*

HDD_t = average HDD for billing period '*t*'

Findings

The estimated coefficients from the models support the hypothesis that consumption decreased substantially as a result of the retrofits. Table C5 shows the estimated coefficients for each model and their respective fit indices.

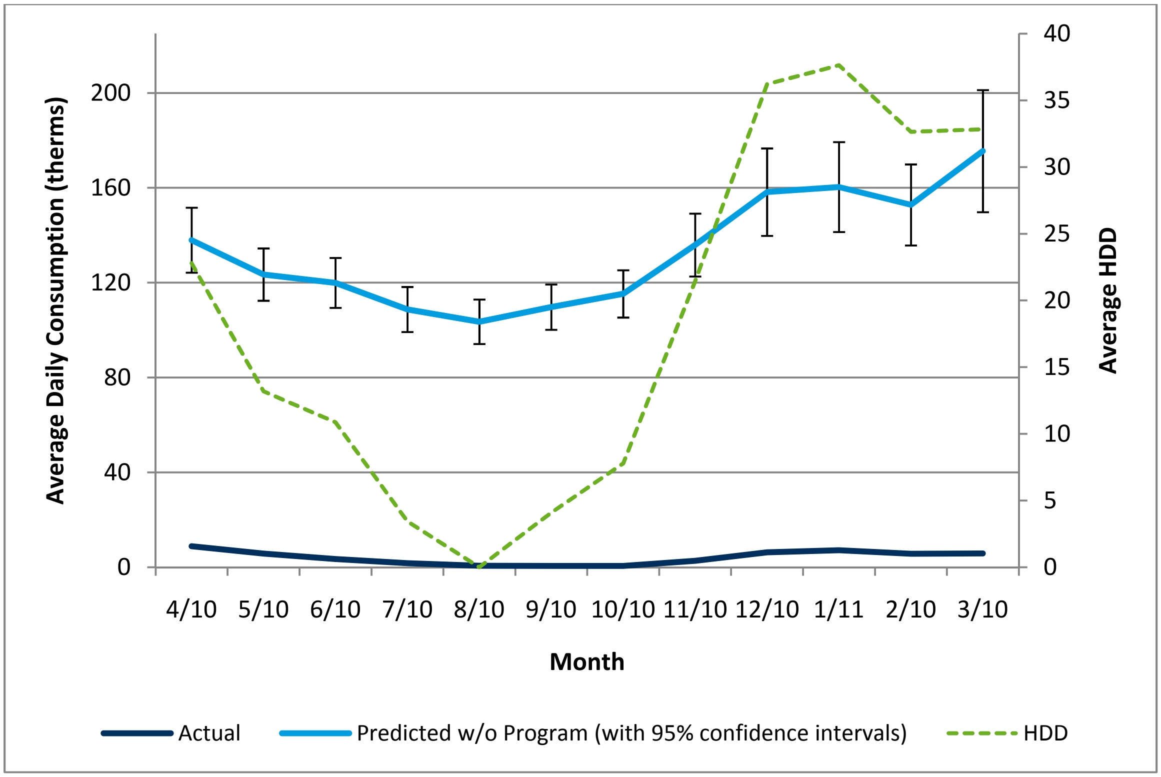
Table C5. Site #1500385 Model Fit and Parameters

Model	n	R^2	Coefficients			
			Variable	Parameter	Standard Error	p-value
Pre	108	0.39	Intercept	103.54	4.79	<.0001
			HDD	1.51	0.22	<.0001
			March Dummy	22.40	9.77	0.0239
Post	26	0.75	Intercept	1.10	0.59	0.07
			HDD	0.22	0.03	<.0001

These model coefficients indicate that there was a net decrease of 1.3 therms per HDD on average because of the program, as well as an average daily decrease to the standing load of 101.9 therms. In addition, the March spike in production does not appear to be significant, resulting in a 22.4 therms per day during the March billing period.

Given that there were 6,808 HDD in the past 12 billing cycles, the model estimates that weather sensitive consumption would have been 10,277 therms. There would have been a standing baseload of 37,792 therms and 672 therms for the March production spike. Actual total consumption over this period was 1,507 therms. We therefore estimate gross savings for the past 12 billing periods at 47,234 therms. The relationship between the actual consumption, estimated consumption, and HDD can be seen in Figure C6.

Figure C6. Site #1500385 Reference vs. Actual Load for Past 12 Billing Cycles



Given the results of our billing analysis, we conclude that the retrofits resulted in substantial savings. Using TMY3 HDD, we estimate that this project will result in an average annual gross savings of 46,769 therms.

Table C6. Site #1500385 Normalized Annual Gross Savings

Estimate	Units	Pre-Retrofit	Post-Retrofit	Difference	Normalized Units/Day	Daily Savings	Annual Savings
Standing Production	Day	103.5	1.1	-102.4	1.0	102.4	37,415
March Production Spike	Day	22.4	0.0	-22.4	1.0	1.8*	672
Weather Sensitive	HDD	1.5	0.2	-1.3	18.4	23.8	8,682
Total						128.0	46,769

*Since this savings only takes place during the month of March, we adjusted the annual average daily savings for this factor by the proportion of March billing period days in the total year: 30/365 = 0.082.

Case Study - Site # 17739130

Site #17739130 is a concrete pre-mix facility in Spokane, Washington. Two projects were completed for this site.

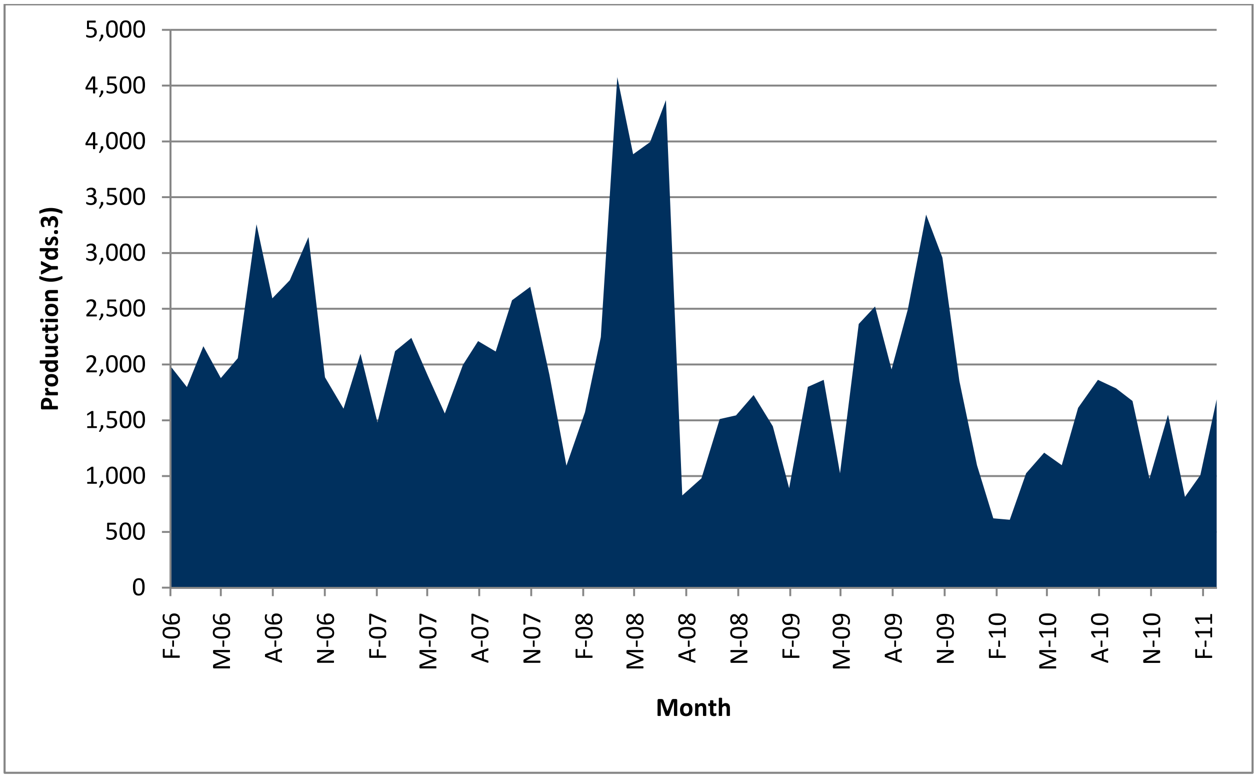
Application #27543 involved the replacement and insulation of outdoor steam lines used in curing beds. We completed a final inspection of measure installation for this project on June 18, 2009. The claimed savings for this project was 63,500 therms per year.

The second project, application #27545, was for the installation of condensing economizers for the site's two gas-fired boilers. We completed the final inspection of measure installation for this project on June 22, 2010. The claimed savings for this project was 11,500 therms per year.

Site Review

Concrete production at this site has only recently started to increase after a notable decline in concrete demand due to the 2007-08 recession. The variation in production has a large effect on the overall gas consumption. Figure C7 shows the variation in monthly production over the past five years.

Figure C7. Site #17739130 Concrete Production for the Past Five Years



We observed three main pipelines that feed the steam mains for the curing beds. The mains and beds are all located outside. Thermocouples are imbedded into the concrete to control the steam valves to maintain roughly 98ºF in the beds for approximately 12 to 24 hours, depending on the product being manufactured.

The pipelines are 6-inches in diameter with 1-1/2-inches of foam glass insulation and an aluminum jacket for lines that are outside. We measured the steam pressure at 12 to 14 psig. The steam line is only a few feet above ground, then goes into the ground at a depth of approximately 3 to 4-feet. After the new steam mains were installed, about 30 traps that were blowing through had to be replaced.

The entering city water temperature was 80ºF, as measured at the water meter located inside the boiler room. When examining the water line discharge from the stack heat exchanger, we observed discharge at 135ºF for one line and at 165 ºF for another line.

Figure C8 is based on monthly billing data. In addition to these billing data, we received hourly data for the past five months. These data (shown in Figure C9 for one week in December 2010 and in Figure C10 for one week in January 2011) reinforce the hypothesis that the majority of gas usage is associated with production. Consumption is much less on weekends, with a standing base load of only around 10 therms per hour.

Figure C8. Site #17739130 Average Daily Consumption for Past 11 Years

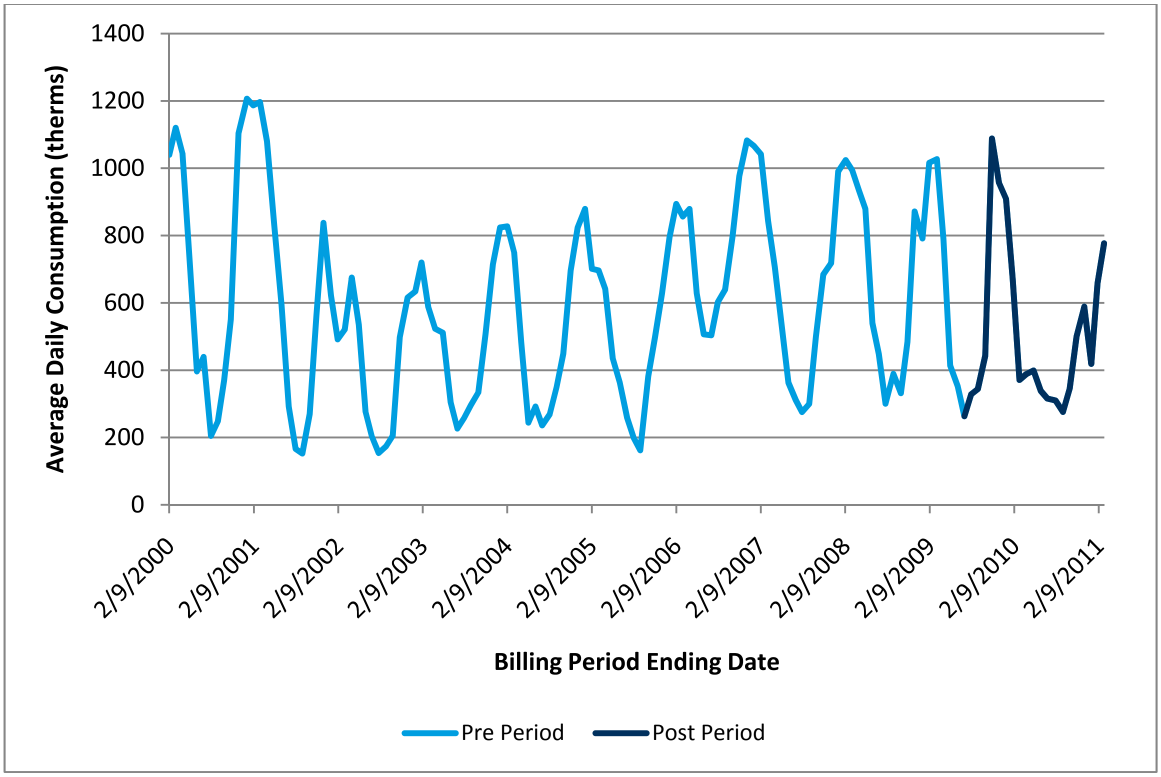


Figure C9. Site #17739130 Hourly Consumption (12/21/10 - 12/28/10)

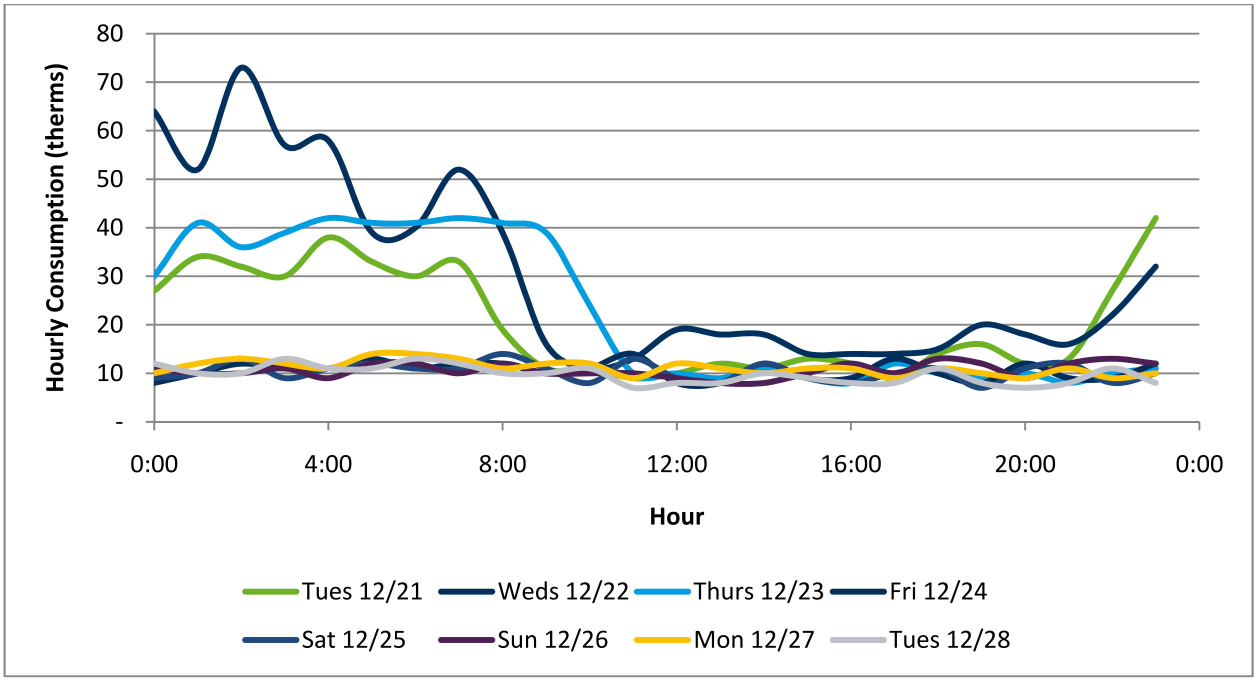
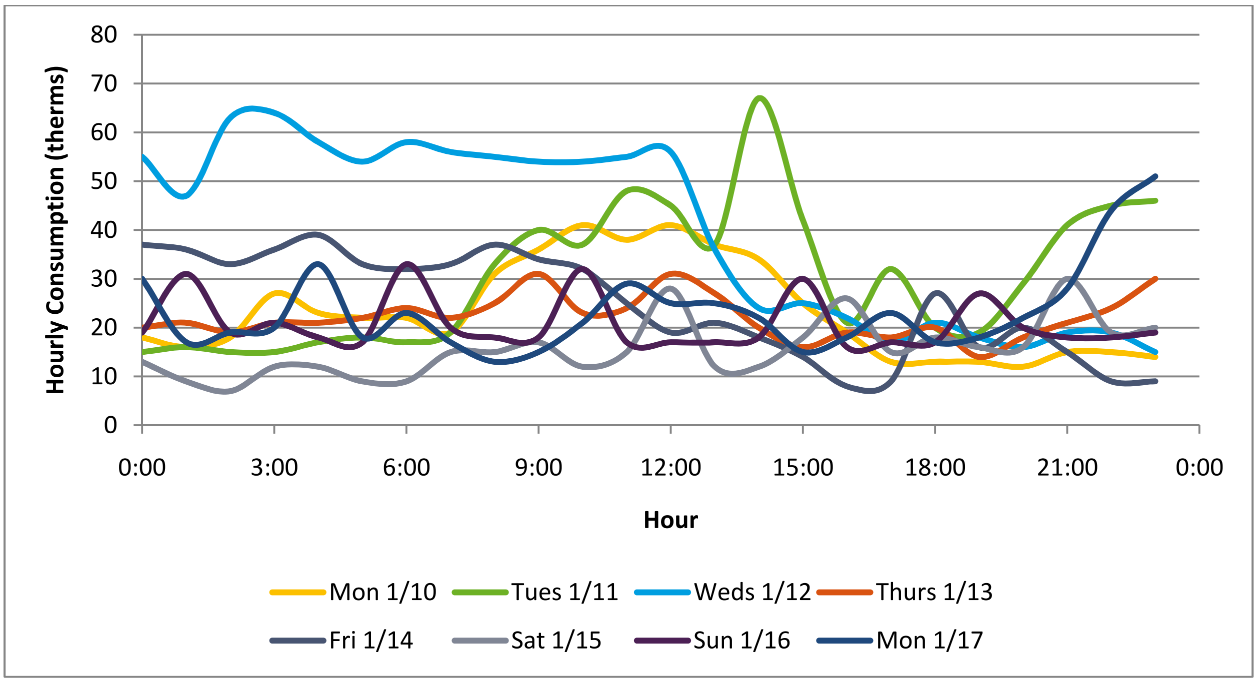


Figure C10. Site #17739130 Hourly Consumption (1/10/11 – 1/17/11)



Our independent calculation for the steam pipeline losses is noted below. We used the NAIMA 3E Plus 4.0 program to independently determine the amount of heat lost in the steam pipe to the beds. The NAIMA computer run showed bare pipe loss of 1,279 BTU/Hr/ft (with 1/2-inch of insulation, 134 BtuH/ft for pipe, and a jacket). The NAIMA run gave the heat loss parameters shown in Table C7.

Table C7. Site #17739130 NAIMA 3EPlus Parameters

Input	
Parameter	Value
Average Temp (F)	47.6
Wind Speed (MpH)	9.75
Pipe	4"
Process Temp (F)	250
Outer Jacket	0.9 Aluminum Service
Hours	8,760
Given Load (BtuH)	860,000 (389 per ft.)

Given these values, we ran calculations using the linear feet of piping we measured during the site visits. Our initial calculations estimate a savings value within a range near the claimed savings of 63,500 therms.

Table C8. Site #17739130 Initial Engineering Estimates

Insulation	Heat Loss, (BTU/hr/ft)	Length of Steam Pipe Line (ft.)	Hours/yr	BthH/ft	BtuH Required	Saved BtuH	Saved Therms
Bare	389	2,212	8,760	860,000	7,533,600,000	-	-
0.5	134	1,060	8,760	141,934	1,243,341,840	6,290,258,160	62,903
1	75	1,060	8,760	79,903	699,948,528	6,833,651,472	68,337

Billing Analysis

We obtained Spokane weather data from WBAN #24157, located at the Spokane airport. There were 6,819 HDDs in the 12 billing cycles beginning March 3, 2010 and ending March 4, 2011. There are 6,712 TMY3 HDDs for this weather station, implying that this past winter season was slightly colder than average.

Due to the complexity of the relationship between weather and production for this site, along with the fact that measures were installed in two stages a year apart, we estimated one model for this site. By using a single model, we were able to include greater variation in production and model different aspects of each retrofit stage. We estimated the model as follows:

$$therms_t = \beta_0 + \beta_1 HDD_t + \beta_2 production_t + \beta_3 post1_t + \beta_4 post2HDD_t + e_t$$

Where:

$therms_t$ = average daily therms for billing period 't'

HDD_t = average HDDs for billing period 't'

$production_t$ = average daily production in cubic yards of concrete for billing period 't'

post1$_t$	=	a dummy variable that equals 1 if '*t*' is after replacement and insulation of outdoor steam lines, and equals 0 otherwise
post2HDD$_t$	=	a variable which equals HDD if '*t*' is after installation of condensing economizers and equals 0 otherwise

Findings

The estimated coefficients from the model supports the hypothesis that consumption decreased substantially as a result of the retrofits. Table C9 shows the estimated coefficients for the model and their respective fit indices.

Table C9. Site #17739130 Model Fit and Parameters

n	R^2	Coefficients			
		Variable	Estimate	Standard Error	p-value
62	0.78	Intercept	161.192	60.442	0.010
		HDD	17.801	1.354	<.0001
		Production	2.700	0.612	<.0001
		Dummy: Steam Pipes	-74.838	40.736	0.071
		Interaction: HDD Economizers	-5.763	2.195	0.011

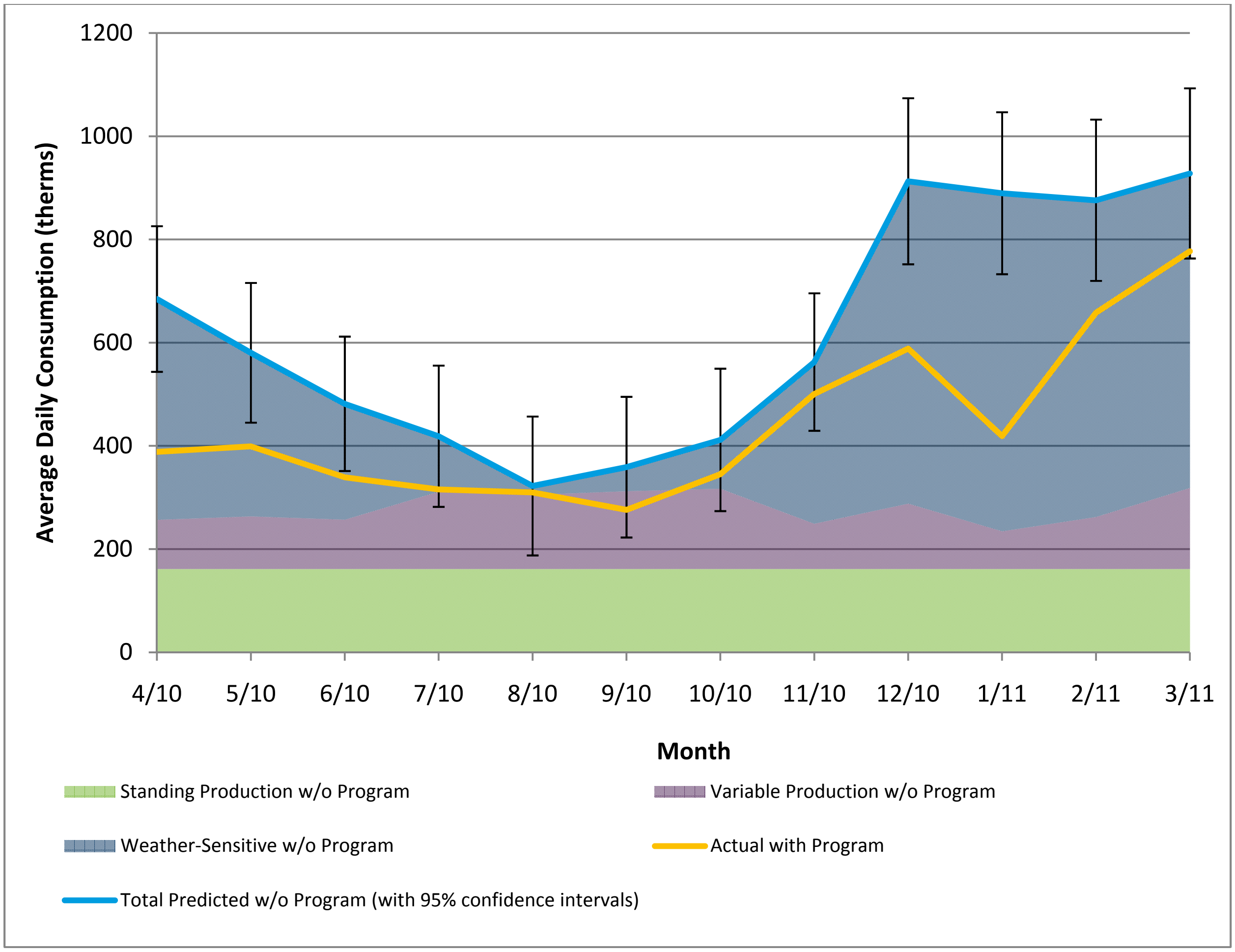
These model coefficients indicate that there was a net decrease of 78.8 therms per day on average following the installation of the new steam pipes, insulation, and control valves. In addition, the installation of the condensing economizers resulted in a decrease of 5.8 therms per HDD on average. Table C10 shows the calculations for the counterfactual load for the past 12 billing cycles, broken out by each consumption type.

Table C10. Site #17739130 Predicted Load by Consumption Type for Past 12 Billing Cycles

Billing Period End Date	Days	Standing Load	Production	Variable Production Load	HDD	Weather Sensitive	Total Predicted Load
4/1/2010	29	4,675	1,026	2,770	697	12,407	19,852
5/3/2010	32	5,158	1,210	3,266	570	10,147	18,571
6/3/2010	31	4,997	1,099	2,967	391	6,960	14,924
7/2/2010	29	4,675	1,612	4,352	175	3,115	12,141
8/6/2010	35	5,642	1,864	5,032	34	605	11,279
9/7/2010	32	5,158	1,788	4,827	84	1,495	11,480
10/6/2010	29	4,675	1,674	4,519	154	2,741	11,935
11/5/2010	30	4,836	977	2,637	528	9,399	16,872
12/8/2010	33	5,319	1,551	4,187	1,158	20,613	30,120
1/7/2011	30	4,836	814	2,197	1,104	19,652	26,685
2/3/2011	27	4,352	1,009	2,724	931	16,573	23,649
3/4/2011	29	4,675	1,689	4,560	993	17,676	26,910
Total	366	58,998	16,313	44,038	6,819	121,383	224,418

As shown in Table C10, the model estimates that weather sensitive consumption would have been 121,383 therms. There would have been a standing production load of 58,998 therms. In addition, this site produced 16,313 cubic yards in the past year, which was responsible for approximately 44,038 therms of consumption. This would lead to a total consumption of 224,418 therms. Actual total consumption over this period was 160,679 therms. We therefore estimate gross savings for the past 12 billing periods at 63,739 therms. The relationship between the actual consumption, estimated consumption, and HDD is shown in Figure C11.

Figure C11. Site #17739130 Reference vs. Actual Load for Past 12 Billing Cycles



In sum, given the results of our billing analysis, we conclude that the retrofits resulted in substantial savings. Using TMY3 HDDs, we estimate that this project will result in an average annual gross savings of 66,015 therms. This value comes from using TMY3 HDDs and the five-year average production of 23,708 cubic yards per year.

Table C11. Site #17739130 Normalized Annual Gross Savings

Estimate	Units	Pre-Retrofit	Post-Retrofit	Difference	Normalized Units/Day	Daily Savings	Normalized Units/Year	Annual Savings
Standing Production	Days	161.2	86.4	-74.8	1.0	74.8	365.25	27,334
Weather Sensitive	HDD	17.8	12.0	-5.8	18.4	105.9	6,712	38,681
Variable Production	Yds.³/ day	2.7	2.7	0.0	64.9	0.0	23,708	-
Total						180.7		66,015

Case Study - Site # 18524903

Site #18524903 is a linen supply company located in Lewiston, Idaho. The project (application #33831) involved installing steam traps in the facility. Installation was completed by May 2010. The claimed savings for this project were 39,706 therms/year.

Site Review

The facility is quite large (between 28,000 and 33,000 sq.ft.), with 102 employees working on site and 12 delivery drivers. Production has varied substantially over the last few years, though by what amount is unclear, as production data was only provided for 15 of the months that we have billing data for.

A 150 HP boiler at 90 to 125 psig was recently repaired after losing a couple of tubes. Condensate is returned to the boiler at roughly 190°F, and we measured exhaust from the boiler at between 345 and 365°F.

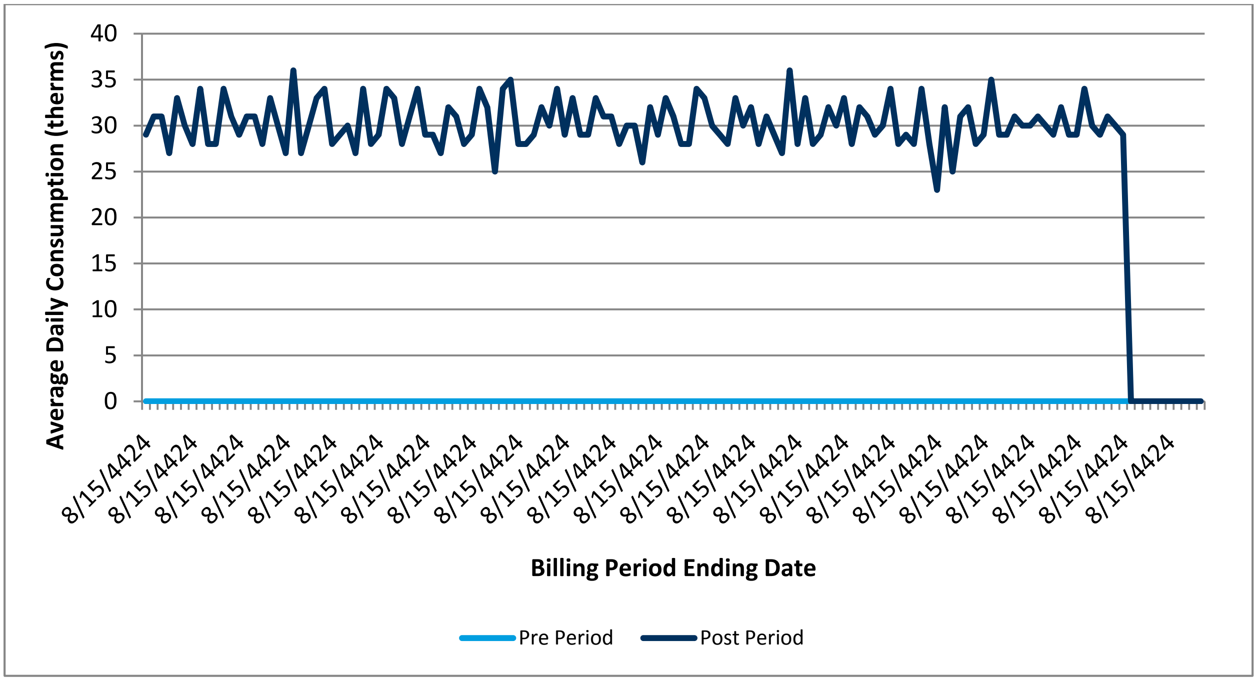
Insulation is falling off in many places throughout the plant. Staff we interviewed mentioned that they plan to reinsulate the building. They also plan to insulate the hot water storage tank. Hot water is maintained at 160°F. Both boiler and wash water are softened.

Steam is only used for production to heat water to 152°F when the gas fired water heater is down and to provide dry steam to production machines. The staff will now clean out the installed steam traps integral strainers on an annual basis. Some of the drip legs could benefit from being a bit longer. The plant turns the boiler on and purges the steam lines with low-pressure steam at 5:00 a.m., and is ready for production at 5:45 a.m. The steam lines are 2-inches in diameter, and most takeoffs are 1-1/4-inches from the machines.

The staff on site noted that the ironing machines have been easier to use since the installation of the steam traps. Much of that is related to a substantial decrease in the amount of moisture in many areas of the plant, and a decrease in water hammer. Pressures have also been reduced by the regulators.

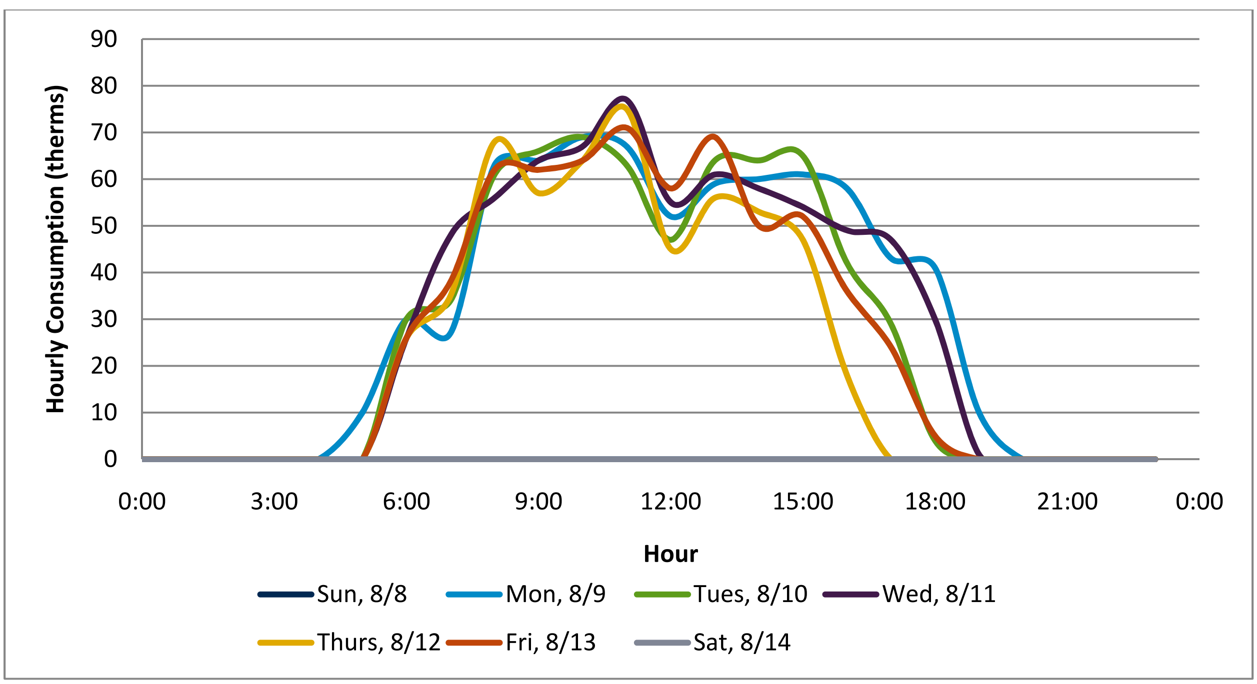
Production has been quite variable over the last few years. This is evident from the gas consumption at the site over the past 11 years (as shown in Figure C12). Per staff we interviewed on site, production is picking up. In 2007, the company was producing 5.0 million pounds in linen; in 2010 it produced 5.6 million pounds. Dry loads increased by 15 percent this year due to a hospital being added in January 2011.

Figure C12. Site #18524903 Average Daily Consumption for Past 11 Years



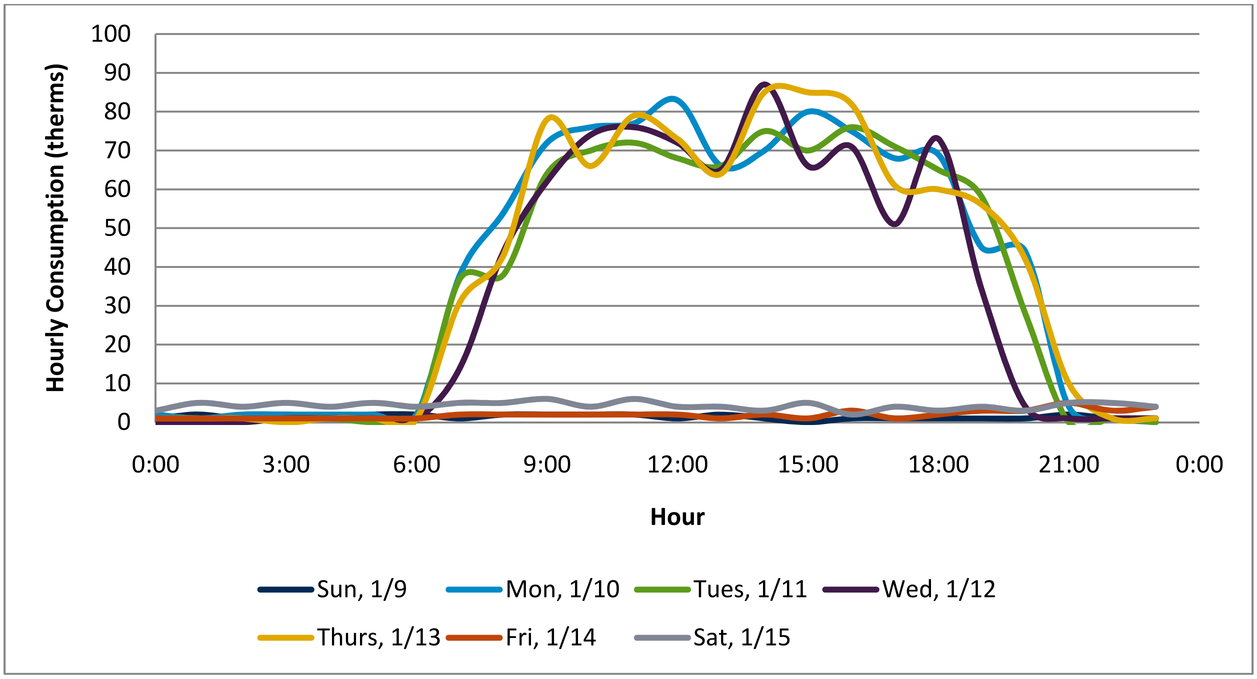
We were also provided with hourly consumption data from the past year. These data confirmed that little space or water heating takes place outside of production hours. Figure C13 and Figure C14 show this pattern for two sample weeks, one in the summer and one in the winter.

Figure C13. Site #18524903 Hourly Consumption (8/8/10 – 8/14/10)



Note that there appears to be a very low level of heating in the winter months. This most likely reflects water heating, as the consumption is not nearly large enough to be reflecting space heaters.

Figure C14. Site #18524903 Hourly Consumption (1/9/11 – 1/15/11)



Billing Analysis

We obtained Lewiston weather data from WBAN #24149, located at the Nez Perce County airport. There were 5,242 HDDs in the 12 billing cycle beginning March 3, 2010 and ending March 4, 2011. There are 5,515 TMY3 HDDs for this weather station, implying that this past winter season was slightly warmer than average.

Given that production data were only available for the previous 15 months (only five of which were pre-period), we were unable to model consumption as a function of both production and weather. However, as previously shown in Figure C12, changes in production clearly have a significant impact on consumption. As production is on the rise, failing to account for the related increase in consumption could create a significant negative bias in savings estimates. This is evident when modeling consumption merely as a function of the retrofit and HDDs, where the model estimates negative savings as a result of the program retrofits.

We attempted several strategies to mitigate this issue. We estimated models using a variety of instrumental variables to account for the unobserved production in the pre-period. We included explanatory variables for HDDs and treatment dummy variables in all the models. We also tested interactions between HDDs and treatment to determine if there is an interactive effect from heat spillage, but found that the effect did not differ significantly from zero in any of the model iterations we ran.

To account for production, we estimated the following models:

- As a function of individual dummy variables controlling for each year and month to account for both year-on-year business cycles and seasonal variations in production;
- As a function of statewide macroeconomic indicators;
- As a function of a polynomial time-trend; and
- Various hybrid models combining the explanatory variables outlined above.

In the end, we decided that the most appropriate model was one that used a simple polynomial time trend. We opted for this model for several reasons. First, this model makes no presuppositions about the drivers of production over time, which is important for determining the change in demand given previous trends. Second, this model was the most parsimonious and well fitting. That is, we achieved the desired significance and expected signs for model coefficients while optimizing both the total and adjusted r-squares.

Models that included a complex dummy structure approximated the time trend model, but lacked the parsimony and ease of interpreting the time trend models. We found macroeconomic models to have only weak signals; largely because most data were only available at the annual and statewide levels. Despite our preference for our final model, savings from comparable models did not differ dramatically from our final estimates. We estimated the model as follows:

$$therms_t = \beta_0 + \beta_1 HDD_t + \beta_2 time_t + \beta_3 time_t^2 + \beta_4 time_t^3 + \beta_5 post_t + e_t$$

Where:

$therms_t$	=	average daily therms for billing period 't'
HDD_t	=	average HDDs for billing period 't'
$time_t$	=	a variable which equals 1 in the first billing period of the sample and increases by 1 in each subsequent period
$post_t$	=	a dummy variable which equals 1 if 't' is after replacement and insulation of outdoor steam lines and equals 0 otherwise

Findings

The estimated coefficients from the model supports the hypothesis that consumption decreased substantially as a result of the retrofits. Table C12 shows the estimated coefficients for the model and its respective fit indices.

Table C12. Site #18524903 Model Fit and Parameters

n	R^2	Coefficients			
		Variable	Estimate	Standard Error	p-value
137	0.77	Intercept	537.31	12.607	<.0001
		HDD	2.18	0.259	<.0001
		Dummy: Steam Traps	-78.54	18.850	<.0001
		Time	-2.20	0.813	0.008
		Time2	-0.023	0.015	0.114
		Time3	0.0003	0.0001	<.0001

These model coefficients indicate that there was a net decrease of 78.5 therms per day on average following installation of the steam traps, holding the past consumption trends constant. Though this model controls for these trends, it is unclear under what conditions this trend analysis will remain stable in the future. For this reason, we present these daily savings as a best estimate, as more production data is necessary to better understand the interaction between production and heating consumption.

Table C13. Site #18524903 Annual Gross Savings

Daily Savings	Annual Savings
78.5	28,686