

Savings Audit of Avista's
2009 Natural Gas Demand-Side
Management Programs



Report

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Executive Summary

This report summarizes the process and results of a detailed first-year verification of natural gas savings claims under Avista's 2009 energy efficiency programs. These programs are designed to support the "Decoupling" order providing rate treatment for energy savings programs in both the states of Idaho and Washington. Ecotope was contracted to review these savings claims by assessing the reported accomplishments in each of the Avista programs. While there are several separate programs, the verification divided the energy efficiency into eight separate verifications, each with a separate sampling and engineering review:

1. **Commercial /Industrial Programs:** The commercial/industrial (C/I) programs were largely based on custom engineering calculations applied to each individual account. Even where prescriptive measures were used, the documentation is assembled for each customer and often includes a mix of custom and prescriptive measures. For this verification the entire C/I program was combined into a single program. The individual measures were then collapsed into the customer accounts where they actually occurred. This process resulted in a total of 288 unique sites. These sites were sampled using a random sample with a stratification design. Each site received a detailed engineering analysis of savings and onsite verification.
2. **Residential Limited-Income:** This program was the result of contracts with social service agencies that provide support to limited-income clients. Avista contracts with these agencies to design and manage the programs. The gas savings claims are reported to the utility and have been used as claimed savings for these programs. A separate sample and audit protocol was developed for this set of programs. In addition, the engineering review applied to these programs was largely consistent with the review developed for the Avista operated residential programs.
3. **Residential Weatherization:** This program was designed and administered by the utility. It is composed of several measures designed to upgrade the thermal integrity of single-family homes in the Avista service territory. The program offers incentives to homeowners who insulate components of their homes and/or install replacement or new windows. Private contractors are hired by the homeowners and provide documentation of their work. The documentation is reviewed by the utility and a standardized rebate is returned to the homeowner. Savings from this program are derived from a standard set of calculations developed by the utility and adapted to the particular measures installed in the home.
4. **Residential Products and Appliances:** The utility offers a rebate to certain energy-efficient appliances and equipment. The rebates focus on clothes washing machines and dishwashers certified under the national Energy Star appliance efficiency ratings. The review of these products was focused on the list of certified products corresponding to the actual receipts submitted by the customers. Also included in this program were several Energy Star domestic hot water (DHW) appliances generally installed by plumbers. These receipts were also reviewed to ensure compliance with the standards.
5. **Residential Heating Equipment:** This program offered rebates to condensing furnaces and boilers used in heating single-family residences. The savings for this program were calculated using an assumed space heating load for all homes in the Avista service territory. The review was designed to assess the actual heating load (derived from billing analysis) and apply the documented efficiency of the equipment rebated to that load.
6. **Multi-Family Shell Measures:** This program was operated by an independent contractor. The contract was similar to the contracts used in the Limited-Income program. The gas savings from this

contract were derived from retrofit insulation and windows applied to multi-family clients. The savings claims were developed by the contractor and approved by the utility. These claims were not consistent with the utility's methodology. The review of this program included both the engineering calculations used and the actual measure verification in a sample of the sites affected by this program.

7. **Ground Source Heat Pumps (GSHP):** This measure is based on the assumption that if an electric GSHP is installed that meets this standard, the savings in gas would be equivalent to the overall gas use for space heating in the home. The verification for this program focused on determining whether the home had, or could have had, gas supplied by the utility. In reviewing a sample of these applications, no conditions were found in which gas heat was offset or could have been offset.
8. **Energy Star New Construction:** This program is operated regionally by the Northwest Energy Efficiency Alliance (NEEA). The verification rate for this program was taken as the ratio between the evaluated savings done for the entire program (adjusted for Spokane climate), and the claimed savings derived from NEEA tables and use by the utility in its savings claims.

The components of the verification were similar across the program groups:

- A sample of each of these major programs was developed using a 90/10 sampling criteria. Only the Energy Star New Construction program did not involve a sample in the final verification ratio.
- An engineering review was conducted on most programs. Only the appliance rebates and the Energy Star program did not get a custom engineering review.
- Most programs received a field review on virtually all the applications in the sample. The field review typically consisted of verification of the installed measures, and in the C/I program, the veracity of the custom engineering applied to each site. The appliance rebate and heating equipment rebate programs did not receive a field verification review.

Verification ratios were calculated from each of the eight programs. These verifications included all of the claimed natural gas savings under the Avista energy efficiency programs. Table 1 summarizes the results of this review for each program. As shown in the table, the overall verification rate was determined to be 83.4% of the utility's overall claim.

Table 1. Summary of Verification Ratios, All Programs

Program	Verification Ratio	T-statistic	Program Claimed Savings	Program Verified Savings
Limited Income Residential	0.676	-2.76	95,251	64,390
UCONS Multi-Family	1.000	0.00	35,290	35,290
Residential Weatherization	0.792	-2.55	545,180	431,544
Residential Products and Appliances	0.908	-2.99	48,666	44,172
Residential Heating Equipment	0.879	-2.62	395,076	347,018
Energy Star New Construction	0.528		18,124	9,569
Ground Source Heat Pumps, Conversions	0.000		15,740	0
All Residential Programs	0.808		1,153,327	931,983
All Commercial/Industrial Programs	0.868	-2.45	890,313	772,659
Total, All Claims	0.834		2,043,640	1,704,642

Table 2 and Table 3 summarize the verification results for the states of Washington and Idaho respectively. These tables use a single overall verification ratio for each separate program. The overall verification ratio is the weighted average of the separate programs. This weighting results in small differences in the verification ratio between the two states due to differences in the individual program claims between the states.

Table 2. Washington Program Verification

Program	Verification Ratio	Program Claimed Savings	Program Verified Savings
Limited Income Residential	0.676	83,178	56,228
UCONS Multi-Family	1	17,548	17,548
Residential Weatherization	0.792	418,529	331,475
Residential Products and Appliances	0.908	24,669	22,399
Residential Heating Equipment	0.879	269,001	236,452
Energy Star New Construction	0.528	13,002	6,865
Ground Source Heat Pumps, Conversions	0	9,444	0
All Residential Programs	0.803	835,371	670,968
All Commercial/Industrial Programs	0.868	608,004	527,747
Total, All Claims	0.830	1,443,375	1,198,715

Table 3. Idaho Program Verification

Program	Verification Ratio	Program Claimed Savings	Program Verified Savings
Limited Income Residential	0.676	12,073	8,161
UCONS Multi-Family	1	17,741	17,741
Residential Weatherization	0.792	126,651	100,308
Residential Products and Appliances	0.908	9,141	8,300
Residential Heating Equipment	0.879	128,075	112,578
Energy Star New Construction	0.528	5,122	2,704
Ground Source Heat Pumps, Conversions	0	6,296	0
All Residential Programs	0.819	305,099	249,792
All Commercial/Industrial Programs	0.868	282,309	245,044
Total, All Claims	0.842	587,408	494,837

1. Introduction

The purpose of this report is to document the procedures and results of Ecotope's independent, third-party verification of the 2009 Avista gas savings claims filed under Avista's "Decoupling Order" for natural gas efficiency measures in the states of Washington and Idaho. This review focused on the programs themselves without regard for the individual state. It was directed instead on the accomplishments and engineering that produced the energy savings claims filed. The programs evaluated were conducted in all major sectors, and for purposes of this report have been divided into two main sections: residential programs, filed under various program categories, and commercial programs, filed largely in "custom savings" categories.

Each of these programs includes an engineering estimate of, or procedure for arriving at, savings; a set of specifications required to implement any particular program measure; and a set of savings that result from such an implementation among individual customers. This verification is divided into individual sections, and refers to each major component of the savings claims made by Avista under its decoupling programs.

1.1. Goals and Objectives

The goal of this verification was to review the Avista programs that generate savings natural gas savings claims. The approach was based on a rigorous sampling methodology, designed to efficiently review the customers and measures in these programs and determine the veracity of the savings claims made.

To accomplish this goal several steps were implemented:

1. Review the claimed datasets. This review included the development of overall claimed savings and the structure of the individual measures within the Avista savings claim. Included in this review was a review of the database to remove duplicates and related anomalies from the sample frame and the future verification.
2. Develop a statistically-valid sample design aimed at efficiently reviewing the individual programs and assessing, on a customer level, the validity of savings claim. Depending on the program, either a simple random sample or a stratified random sample was used.
3. Using customers sampled and Avista's documentation, assess the engineering calculation used to evaluate the savings. This includes both deemed savings calculations and customized engineering calculations.
4. Conduct a field review on each site to establish the validity of the savings calculations and the presence of the measures as claimed. The field review was implemented to check observed measures against a compiled list of claimed measures from the Avista documentation.
5. Combine the engineering review and the field observations to develop an alternative savings calculation.
6. Using this alternative savings calculation, develop a verification ratio for each site. This ratio is the ratio between the savings claimed for all measures on the site to the savings calculated from the observed measures and the engineering adjustments.
7. Combine these ratios with the sample design to arrive at an overall verification ratio for each program evaluated. This ratio was then combined with the original savings claim to develop a final verified savings for the entire program.

2. Methodology

This section presents Ecotope's approach to providing a complete, third-party verification of Avista's 2009 natural-gas DSM programs. The key components of our audit approach include: a representative random sample; file review and engineering analysis of both the program assumptions and the individual site applications and a customized field verification plan.

The purpose of the audit was to verify savings claims and to develop a verification ratio for gas savings that can be presented to the regulators as part of compliance with the decoupling agreements, and for the utility to assess its progress on program implementation.

2.1. Data Collection and Review

The first step in the audit was to collect and review Avista's natural-gas DSM program designs and engineering calculations. Ecotope collected and reviewed Avista's 2009 claimed savings database and the following Avista program documentation.

2.1.1. Residential Measures

This program design documentation included eligibility criteria, participation requirements, and any assumptions, reasoning, or engineering calculations underlying claimed Therm savings values for prescriptive residential measures, where the claimed savings are either a fixed number per occurrence (H&C, PROD, and WH, ESH), or a per-square-foot value (most weatherization measures). Because most of these savings are based on deemed savings values or on deemed savings calculations, this documentation included those values and procedures.

Requested and reviewed residential measures included:

- Energy star homes (all-gas and elec/gas) (ESH)
- High-efficiency ground-source heat pump (H&C)
- High-efficiency gas boiler (H&C)
- High-efficiency gas furnace (H&C)
- Energy star clothes washer (PROD)
- Energy star dish washer (PROD)
- High-efficiency gas water heater (40G, 50G, tankless) (WH)
- Fireplace damper (WZN)
- Insulation (ceiling/attic, floor, wall) (WZN)
- Window replacement (WZN)
- New Window (WZN)

2.1.2. Limited-Income Residential Measures

Program documentation for the prescriptive, limited-income residential measures included the same information and background files as listed under the prescriptive measures presented above.

Requested and reviewed measures included:

- High-efficiency gas furnace (H&C)
- High-efficiency gas water heater (40G) (WH)
- Air infiltration (WZN)

- Energy Star doors (WZN)
- Energy Star windows (WZN)
- Insulation (ceiling, wall, floor, duct) (WZN)

2.1.3. Multi-Family Shell Insulation Measures

For this program both the measures and the engineering were reviewed as they were developed by the contractor, UCONS.

- MF shell (UCONS)

2.1.4. Commercial and Industrial Measures

The commercial and industrial program is based, in large part, on engineering reviews and custom calculations applicable to the particular customer and facility. There are, however, several prescriptive measures in the C/I program which may be assessed using deemed values or calculations. General documentation for this program included program design files for all prescriptive measures as well as any general design guidelines and/or engineering calculations for custom measures. More specifically, Ecotope requested clarification on the methodology used for developing the savings estimates: using deemed value or a deemed calculator.

Requested and reviewed commercial and industrial measures included:

- Appliances (SSA)
- Energy Smart-industrial process (ESG)
- Energy Star dishwasher (ESP)
- HVAC (SSHVAC)
- Industrial process (SSIP)
- Prescriptive comm clothes washer (PCW)
- Prescriptive demand cont. vent. (PDCV)
- Prescriptive food service (PFS)
- Prescriptive refrigerated warehouse (PRW)
- Prescriptive steam trap replacement (PSTR)
- Shell (SSS)

2.2. Sampling Plan

Based on analysis of the claimed savings database and the program documentation, Ecotope developed a sampling plan for performing file and site verification of a subset of program measures and sites included in Avista's 2009 claimed savings numbers. In the list below, the sampling plan methodologies for Avista's natural gas programs are broken out by sector and program.

In this phase measures listed in Section 2.1 were grouped into like measures so that the verification procedure could be adapted to the individual measure types. For example, retrofit insulation was included in all major residential program groups. These were each sampled separately and similar audit and engineering protocols were used to conduct the verification. Similarly, product rebates of all types were grouped to facilitate a file and engineering review only.

Our basic approach was to select a methodology and a verification sample size which would deliver a verification confidence level of at least 90/10 (90% confidence that the estimate is within 10% of the

actual value) at minimum cost in sample points. For most of the verification groupings, this led us to use a size-stratified sample, where “size” was the claimed Therm savings for a particular sample point. Typically, the unit of sampling was the Avista account number, rather than an individual measure. Because much of our verification was field-based the utility account was the sampling unit as it represented a physical location.

For a given sample, the number of strata and the boundaries for individual strata were determined using Dalenius-Hodges methodology, subject to the constraint that the number of strata should not be permitted to grow so large that the Neyman allocation sample plan called for fewer than four sample points in any given stratum. The various programs we sampled had varying degrees of heterogeneity of claimed therm savings. Since the payoff to increasing stratification varies with the degree of such heterogeneity, the number of strata in each of our statistical samples was not constant, varying from five strata in the case of residential weatherization and C/I samples, to just one in the case of the residential furnace and boiler sample (since claimed savings at each installation site were identical).

2.2.1. Residential Sample

The verification included both a field sample that was implemented at individual customer sites and a paper review that addressed the engineering calculations. In programs that are designed as appliance rebates for retail sales of efficient appliances (furnaces, boilers, and fireplace dampers), a large sample of files was reviewed for compliance with eligible products.

Ecotope developed field samples in several programs. A stratified random sample was drawn for field review of the weatherization programs (including limited-income). In addition, a field sample was drawn for the UCONS multi-family program and the ground source heat pump program.

For the Energy Star new construction program, the program operator evaluates the program for the entire region. For the audit, Ecotope used the results of that evaluation for the small savings attributed to Energy Star in the Avista savings claims.

- **Conventional Weatherization Sample.** This program includes several measures that are accounted independently but are applied to homes in various combinations. These are: insulation for the walls, ceilings, floors, replacement windows, and new windows. A stratified random sample of the accounts was drawn (using a 90/10 criteria, stratified by total savings in weatherization). A request for all available documentation of the measures, and savings calculation for that file, was forwarded to the utility. Non-weatherization measures were not part of the sampling criteria these measures were verified separately with the other furnace rebates. .
- **Limited-Income Weatherization Sample.** This program includes several measures that are combined in each account. These measures include: insulation for the walls, ceilings, floors and ducts; replacement doors and windows; and various appliances including high efficiency furnaces. An optimized stratified random sample of the accounts was drawn (using a 90/10 criteria). The individual accounts were sent with a request for all available documentation of the measures, and savings calculation for that file. In the sample, the furnace and appliance rebates were included in the verification of those programs.
- **High Efficiency Furnaces & Gas Boilers Sample.** Each program includes essentially one measure that is an efficiency upgrade of an existing heating system (increase in AFUE). Every measure has identical attributed savings derived from a single engineering calculation. As a result, the sampling plan was based on a simple random sample with an assumed coefficient of

variation, since all entries have the same claimed savings. Prior to drawing this sample elementary cleaning of the database was conducted to remove duplicates and address other data anomalies. This resulted in a small adjustment in the total savings claimed.

- **Appliance Rebate Sample.** These programs include a wide variety of appliances that are offered as rebates through contractors or other retail processes, including domestic water heaters, clothes washers, dishwashers, and fireplace dampers. Each major category received a data review to remove apparent duplicates and other data problems. A simple random sample was then drawn based on compliance with program specifications. A small variance (assuming at least 90% compliance with the program specifications) was assumed in developing the sample.
- **Other Measures Sample.** There are two programs in this category, including the ground source heat pump conversion from gas furnace or other heating equipment, and the UCONS multi family program. Both of these programs serve a limited number of customers. We drew a random sample for each of these programs separately. In the UCONS program the sample was stratified and designed for the program distribution. In the case of the ground source heat pump, the sample was a simple random sample of three to five cases for the small number of such incentives (about 20).

2.2.2. Commercial and Industrial Sample

The goal of this sample was to verify the savings estimates and measures installed under this program in the 2009 program year. The design was based on a stratified random sample developed using the savings claim from the C/I database. The sample was drawn using a statistical criteria of 90/10 (90% significance level, +/-10% confidence interval for sample means) which is standard practice for a field verification of this type.

To optimize the sample, a stratification design was developed. This strategy resulted in a sample that represents a large fraction of the total savings claim. A random verification sample of C/I applications was drawn for the verification.

2.3. Engineering Review

The engineering review was different for the various programs. Each of these programs was verified using a customized analysis and verification approach:

2.3.1. Residential Weatherization/Insulation

The weatherization program delivers savings from retrofit insulation and window measures. The program is delivered by contractors and incentives are paid to the individual customers as a result of receipts or invoices submitted to the utility.

The engineering review for insulation reviewed the original calculations used by Avista for its programs. These calculations were designed to provide an approximate savings estimate without a direct reference to the variety of homes and climates in the service territory. These calculations were revised based on regional calculation procedures used by the Regional Technical Forum (RTF). Individual sites were reviewed and key parameters of these savings calculations were collected and compared to the values in the Avista tracking system. This procedure resulted in adjustments in the savings in virtually all such measures. The same approach was used in evaluating the Limited-Income program and the UCONS

multi-family program. In the later case a multi-family prototype was used to characterize the savings in this program.

2.3.2. Residential Heating Equipment

Avista supports the installation of condensing gas furnaces, either as a replacement for a conventional furnace or as an upgrade beyond code of a furnace installed as part of an overall conversion from electric heating to gas heating. In both cases the savings are taken from conventional furnace efficiency as set by the Washington State Energy Code. Savings are calculated from a deemed heating base that is applied to all installations. The heating equipment represented a change in efficiency of the heating delivered in each home.

For this program no separate field review was performed. A sample of applications was reviewed to ascertain that the equipment installed met the Avista specifications for this program. A simple billing analysis was developed to assess the base-case heating energy use for each building. This allowed a custom assessment of the savings estimate for each home. Saving verification rates were set using the results of this analysis applied to the observed efficiency specifications of the equipment installed and compared to the claimed savings developed at the outset of this program. By this device the single calculation applied to all homes was modified to account for the size, climate, and occupant behavior appropriate to the actual customers that used this rebate.

In general, this method was only applied to homes where the measure replaced an existing gas furnace. The information developed from this billing analysis was used to calibrate the savings for these applications as well as the conversion applications included in this program.

2.3.3. Residential Appliance and Products

There are several efficient appliances that receive a rebate from Avista. These represent about 5% of the residential sector savings claimed. While there are several types of appliances in the program the applications are dominated by clothes washers and dishwashers (86% of the applications). The verification strategy was to use the same list of Energy Star appliances to verify that a sample of the individual applications qualify for the program and savings. This approach was applied to all appliances, including the various DHW measures as they appear in the sample. The verification ratio was calculated from the ratio of complying and non-complying applications. For these applications the Avista savings calculations were checked and used. All adjustments to these programs were the results of products that were not on the EnergyStar lists.

2.3.4. Commercial and Industrial Sector

All engineering reviews in the C/I programs focused on the individual site and evaluated all the assumptions and calculations used to develop the savings claims for that site. This approach included energy simulations and detailed engineering calculations for individual sites. As the review continued questions and clarifications were developed and discussed with the Avista staff responsible for these calculations. Adjustments were made based on these calculations as necessary. Often these reviews included reassessing the engineering simulation used in developing the savings estimates for the individual site.

2.4. File Review and Field Audit

The file reviews were conducted for each sampled application that would allow a field visit. A small amount of over-sample was drawn to allow for attrition in the recruiting process. In every case (commercial or residential) where a field audit was part of the protocol, the file review identified the measures to be reviewed by the auditors. In the case of the residential audits these measures were almost always insulation or weatherization measures. Audits were aimed at verifying the area of each component for which savings were claimed, the insulation value of the resulting installation, and the initial conditions (that could be observed).

The result of this process was to provide estimates of any changes in the measure specification or treated area. This information was combined with the engineering reviews to develop a verified savings that was compared to the savings claimed for that site.

In the case of the commercial sector some of the cases involved more complex engineering reviews that assessed the applicability of engineering assumptions made in either the Avista review or in the verification analysis. These were combined to arrive at final savings for each site. In the case of this program, when the engineering review and the verification review came to substantive agreement, no adjustment was made in the Avista savings claims.

2.5. Verification Ratio Estimation

In most cases the estimator applied to the resulting sample was the ratio estimator with an assumed underlying common verification ratio across all strata. Where the statistical assumptions of the ratio estimator are appropriate, it has desirable statistical properties and usually delivers tight confidence intervals.

In two cases, where the ratio model assumptions were not met, we used different estimators. In the residential furnace/boiler applications, claimed savings did not vary across sites. As a result it was necessary to draw a simple random sample of accounts. We directly estimated program savings, rather than directly estimating the verification ratio. In the case of our simple random sample of rebated appliances, we avoided the ratio estimator because of a suspicion based on sample results that the verification ratio was not constant across different classes of appliances which had significantly different claimed savings attached to them. We did not believe we had sufficient sample points to separately estimate verification ratios for each separate type of appliance. Our response to the situation was to use a post-stratification estimator with two groupings to estimate program savings directly and at the same time separate accounts containing a rebate for high-savings appliances from accounts containing rebates only for low-savings appliances.

Further details of the sampling plans and verification ratios calculated can be found in the following sections.

3. Audit of Residential Sector Programs

In the residential sector all *ex ante* engineering calculations were pre-calculated based on standardized assumptions, and so the savings are only partly the result of the individual components of the actual installation, and are partly an allocation of “average” or deemed practices used in the original engineering review of these programs. Thus the verification consisted of re-calculating these deemed savings and then applying these values to the results of the field audits.

Table 4 summarizes the residential savings claims verified in this effort. These savings include all of the residential-sector claims noted in the filing, but as can be seen, the UCONS program is included in this allocation as well as the “limited-income” program, even though both are reported in separate categories. These programs are unique in that they are operated by independent groups under contract to Avista. The savings calculations and program specifications are potentially different than other programs operated with the same or similar measures. With the addition of these contract programs the overall residential savings claims are somewhat higher than direct Avista filing for the residential sector.

Table 4. Residential Sector Savings Claims

Program	Description	Savings Claimed		Applications	
		Therms	%	N	%
WZN	Residential Weatherization				
	INSULATION - FLOOR	42,711	3.7%	190	1.4%
	INSULATION - WALL	103,011	8.9%	427	3.1%
	INSULATION- CEILING/ATTIC	111,607	9.6%	1,122	8.1%
	REPLACEMENT WINDOWS	287,704	24.8%	3,456	24.8%
	NEW WINDOWS	147	0.0%	3	0.0%
FUR	Heating Equipment				
	HIGH EFF. FURNACE	389,418	33.5%	3,166	22.7%
	HIGH EFF. BOILER	8979	0.8%	73	0.5%
APP	Appliance Rebates				
	ESTAR CLOTHES WASHER	24,336	2.1%	2,704	19.4%
	ESTAR DISHWASHER	8115	0.7%	1,623	11.7%
	ESTAR WATERHEAT TANKLESS	11,700	1.0%	195	1.4%
	ESTAR WATERHEAT 40 Gal	1208	0.1%	151	1.1%
	ESTAR WATERHEAT 50 Gal	3707	0.3%	337	2.4%
	FIREPLACE DAMPER	3724	0.3%	49	0.4%
LI	LIMITED INCOME PROGRAM	95,251	8.2%	268	1.9%
GSHP	NEW GROUND HEAT PUMP	15,740	1.4%	20	0.1%
UCONS	UCONS MULTI-FAMILY Shell	35,290	3.0%	41	0.3%
ESTAR	Energy Star New Construction				
	ESTAR HOME ELEC/GAS	17,336	1.5%	88	0.6%
	ESTAR HOME GAS ONLY	788	0.1%	4	0.0%
TOTAL		1,160,772		13,917	

3.1. Residential Weatherization

The weatherization programs operated under the Avista gas savings program included five major categories: floor insulation, wall insulation, ceiling/attic insulation, replacement windows, and new windows. This represented a total of 47% of all residential savings claimed by Avista. The engineering procedure for this group was developed using an abbreviated engineering calculation of the savings potential of these residential programs. This procedure resulted in relatively indefensible savings methodologies for the program when compared to the regional practices for residential weatherization programs.

For this verification the savings were recalculated using the procedures used by the Northwest Power and Conservation Council (NPCC) and the Regional Technical Forum (RTF) for developing savings from various residential weatherization programs. The approach was designed around two prototypes developed by the NPCC as part of its Sixth Plan for regional electric utility conservation goals. While this required some adaptation for use in estimating the impacts of weatherization on gas savings, the general approach allowed for whole-building simulations to calibrated models as a basis for estimating savings from these programs. The evaluation was done using the SEEM building simulation program used by the NPCC and the RTF as a standard for estimating savings potential from residential programs.

Table 5 shows the definition of the three residential prototypes used to evaluate Avista's residential programs. The insulation levels in these prototypes were varied to account for different measures with different initial conditions. In general, the savings were calculated using the least-insulated home that could be specified within the limits of the physical properties of the materials. The prototypes were evaluated in two climates: Spokane and Lewiston. These climates were averaged together to get a single estimate for the entire program. We used this method to correspond with the Avista claims as much as possible. In these calculations the assumed distribution of climates was 82% for Spokane and 18% for Lewiston. The same analysis was conducted on both the multi-family and single-family prototypes. Only the single-family results were used to assess the savings claims in the residential weatherization program.

Table 5. Residential Prototypes

Component	Prototype 1	Prototype 2	Multi-Family
Areas (ft² unless otherwise noted)			
Heated Area	1,344	2,688	26,400
Attic	1,344	1,344	8,800
Wall (Above Grade)	1,184	1,480	10,512
Wall (Below Grade)		1,036	-
Door	40	40	40
Window	176	376	3,840
Floor	1,344		8,800
Slab Perimeter (Lft)		148	-
Other			
Units	1	1	24
Infiltration	.35 ACH	.35 ACH	.35 ACH
Combustion Eff.	0.78	0.78	0.78
Duct Leakage	25%	16%	-
Duct Insulation	None	None	-

Table 6 shows the changes in measure savings calculated from the prototype analysis for the single-family cases. These are shown in comparison to the savings used in all Avista weatherization programs. We have used these savings estimates to update the savings and generate a new savings estimate for all residential weatherization programs. The ratio between the savings calculated in this analysis and the savings calculated in the Avista deemed calculator are shown in the "Ratio" column of Table 6. These adjustments vary between about 150% and about 20%, and based on this adjustment alone, some reduction in savings claims could be anticipated.

Table 6. Residential Insulation Savings

Measure		Therms Saved / ft ²				Weighted	Avista	Ratio
		Spokane		Lewiston				
Prototype		1,344	2,688	1,344	2,688			
Ceiling	R0-R38	0.302	0.245	0.256	0.210	0.266	0.195	1.366
	R11-R38	0.093	0.075	0.078	0.064	0.081	0.101	0.807
	R19-R38	0.039	0.032	0.033	0.027	0.035	0.073	0.473
Floor	R0-R30	0.111	-	0.098	-	0.109	0.331	0.329
	R11-R30	0.027	-	0.024	-	0.027	0.144	0.184
	R19-R30	0.011	-	0.010	-	0.011	0.037	0.287
Wall	R0-R11	0.236	0.190	0.196	0.158	0.207	0.263	0.786
Window	1.1-0.35	1.338	1.198	1.099	0.986	1.227	0.810	1.515
	0.8-0.35	0.680	0.600	0.550	0.487	0.618	0.810	0.763
	0.55-0.35	0.178	0.145	0.134	0.110	0.154	0.420	0.368

To construct the residential weatherization sample all the individual applications were combined in the individual accounts. This process developed a population of 4,304 homes with an average of 1.2 measures per home. Subsequently a sample was drawn for the residential weatherization program; a savings claim for each site sampled was developed by combining all the measures claimed (as weatherization measures) in the particular home.

An optimum stratified random sample was developed. Further field evaluation was conducted to verify the areas and insulation values in the individual homes in the weatherization program. For the weatherization program, an initial sample of 25 homes was drawn from a five-strata design. Of these sites, 24 were recruited and allowed an auditor to visit the home and inspect the measures claimed in that home. Due to this initial over-sample, this sample easily met the minimum sampling criteria.

At each site the auditor first determined if the weatherization measure claimed was in fact present. The auditor was then asked to assess the measure installed and attempt to discern the initial conditions prior to the installation. In most cases this represented essentially an un-insulated base case, but in some cases the auditor observed some initial insulation and the savings were then calculated using that adjustment (see Table 6). In addition, the Auditor was asked to confirm the area affected by the weatherization measure. As with the insulation levels these areas were used to calculate the savings estimates for each site.

Using the combination of the savings calculated and shown in Table 6 and the observed areas and insulation base case, a new savings value was calculated for each home in the field sample. The results of this combination of verifications are shown in Table 7; here, the individual allocations by stratum are summarized, including the verified savings, adjusted for the engineering analysis.

The overall verification rate used the ratio estimator explained above. This allowed the statistical weighting implied by the sample design to be expanded to the entire residential program and yielded a single point estimation. This procedure also allowed the development of an estimated confidence interval and a significance test against the claimed savings to determine the statistical significance of the estimate.

Table 7. Residential Weatherization Verification

Sample Stratum	Population		Sample			N
	Claimed Savings (Therms)	N	Claimed Savings (Therms)	Sample % (Therms)	Verified Savings (Therms)	
1	54,575	1,496	203	0.37%	225	5
2	143,156	1,481	389	0.27%	375	4
3	155,774	910	1,055	0.68%	726	6
4	115,199	324	1,319	1.14%	1,030	4
5	76,476	93	4,620	6.04%	2,238	5
Totals	545,180	4,304	7,586	1.39%	4,594	24
Verification Statistics				Notes:		
Ratio	95% Conf Interval		T-statistic*	*Statistically significant at 95% confidence level		
	Upper	Lower				
0.792	0.631	0.952	-2.546			

3.1.1. Program Recommendations

In this program there is a serious gap between the standards for calculating *ex ante* savings estimates throughout the region. We would recommend that the prototype analysis used by the RTF be adapted for purposes of developing the savings estimates for this program. Most of the adjustments made in this program were the result of the engineering changes in the savings calculation methodology. There were indications that the inspection of the contractor work was adequate. However, the next largest adjustment in savings came from measures that were improperly credited or where the actual insulation level did not correspond to the savings calculations. This could only be corrected with added inspections and would probably improve the overall program verification

3.2. Heating Equipment

One of the largest programs in the residential sector for Avista was the heating equipment program, resulting in 34.3% of all residential claimed savings. This program offered a rebate to Avista customers who upgraded their furnaces to a condensing-type furnace from a conventional combustion furnace (or boiler). This measure increases the nominal combustion efficiency from .78 (the minimum required by federal standards and Washington State code) to .90 or greater (with added incentives for furnaces with combustion efficiency above .95). The Avista engineering evaluation of the furnace system was based on a single point estimate developed based on a conservative estimate of the total heat-loss rate for typical houses in the Avista service territory. This rate, however, was not justified by any empirical data collected in the service territory or anywhere else.

To verify this program, a simple random sample was drawn of 67 sites; this was meant to be a sufficient sample to get a 90/10 confidence interval. Since every home had the same savings claimed, an assumed standard deviation was constructed to determine the appropriate sample to evaluate this program. An assumed coefficient of variation (standard deviation divided by population mean) was developed from these assumptions of approximately 50% (this represents a large estimated variance in gas heating energy use across the participants in the Avista furnace rebate program).

About 3,200 separate applications were part of this program, each of which include a contractor invoice and documentation of the furnace installed. This invoice allowed a reviewer to determine if the furnace met the efficiency requirements of the Avista program. To complete the engineering verification, a billing analysis was conducted on the sample of homes in which the furnaces were installed. This billing analysis estimated the total space heating used by the homes prior to the installation of the more efficient furnaces. This was used as a substitute for a field review, as we believed that such a review could not assess the heat load adequately within the time constraints of the verification.

The billing analysis was used as a basis for estimating savings based on the documented furnace efficiency from the contractors invoice and the assumed base efficiency. This is probably a conservative estimate since many older furnaces do not meet even current minimum standards. Of the 67 homes, 48 homes had sufficient data with which to assess the heating load prior to the installation of new equipment. For these homes a savings estimate was constructed using the difference in efficiency calculated for each home.

The remaining cases were assumed to be either new construction, or conversions from electric (or some other type of heating) to natural gas. We identified new construction sites either through the use of a new construction rebate form (rather than a replacement rebate form), or because both electric and gas billing records commenced around the installation date recorded on the rebate form. If the electric billing record was present prior to the furnace installation data but no gas bills were recorded (or had no prior heating signature) we assumed the site was a conversion. The conversions could not be evaluated with a billing analysis, so the average of the 48 homes that were evaluated was used to determine the savings. This group included a total of seven homes in the sample. The remaining 12 homes were assigned to new construction. For this group, the savings were decremented by one-third to account for improved insulation. The base furnace efficiency was set at .80 for this group since modern codes require this higher level of efficiency. Table 8 shows the resulting energy savings and verification ratio for this program throughout the service territory.

Table 8. Furnace/Heating System Verification

Population		Sample			
Claimed Savings (Therms)**	N	Claimed Savings (Therms)	Sample % (Therms)	Verified Savings (Therms)	N
395,076	3,212	8,241	2.09%	7248	67
Verification Statistics					
	95% Conf Interval				
Ratio	Upper	Lower	T-statistic*	Notes: *Statistically significant at 95% confidence level	
0.879	0.788	0.969	-2.62		
**An adjustment of 0.8% was made in the Avista savings claim to account for duplicates in the database.					

3.2.1. Program Recommendations

This program appears to be very effective and has received the support of the HVAC contractors. The result is a large apparent savings. The use of a single “calculated” value to assess the savings seems unavoidable but some adjustment in this rate should be expected to be adjusted with evaluation and/or engineering as the program progress. The documented savings calculation for this program predicted a savings of about 87 Therms for each furnace. The claimed savings was about 123 Therms. This verification was about halfway in-between. We would suggest that collecting a small amount of added data such as house size and the age of the replaced furnace might inform future *ex ante* savings calculations and reduce both first-year verification adjustments and improve overall evaluation realization rates.

3.3. Appliance Rebates

Six separate appliance rebates were offered by Avista over the course of the 2009 program. These are mainly for Energy Star appliances purchased either in the retail sector or from contractors. Rebates were granted based on the receipt or invoices associated with the purchase of the appliances. Overall this program accounts for 36% of all savings applications filed by Avista (about 5,059 separate rebates), but only 4.5% of the natural gas savings claimed in the residential sector.

To sample this, a simple random sample was drawn for all 5,059 appliance rebate applications filed. This was not based on the distribution of savings estimates within that program. A total of 90 appliance rebate forms were randomly selected. The sample size was based on a “binomial” sample. Such a sample is based on establishing the fraction of the rebates that in fact received rebates for appliances on the Avista approved Energy Star list. This sample became the verification sample for the appliance sector. Some accounts had more than one rebate application. These applications were separated out. As a result the final sample was increased to 93 cases.

As can be seen by reviewing Table 4, a simple random sample will draw large numbers of dishwashers and clothes washers, since they represent the bulk of both savings and applications in this program. In this group, however, there are a few “tankless” domestic hot water (DHW) heaters. These appliances offer large savings well beyond any of the other products in the sample. Directly estimating a single “Energy Star verification ratio” for the whole sample (an estimated percentage of rebated appliances that are in fact Energy Star), and multiplying this ratio times the aggregate claim to get verified savings, runs the risk that population verification ratios for high-savings coupons differ from the overall average. Verification rates within sampled coupons did in fact suggest that the assumption of uniform verification percentages across appliance categories was not tenable. We responded to this problem by using a post-stratification estimator which separated sampled accounts with rebates for tankless heaters, from all other accounts.

The verification for the remaining products consisted of reviewing the invoices filed by the homeowner or contractor, and checking them against the Energy Star list for these appliances. Since the savings for each individual appliance was deemed and did not vary with the make model or size of the appliance, we reviewed the applications based on the Energy Star calculator. When the sampled application did not include an appliance that was on the Energy Star list the savings were zeroed out for that application. The verification ratio for this set of appliances was calculated as the ratio of the total claimed savings for the sampled group and the total claimed savings when these cases were removed. The tankless DHW products were evaluated separately in the same way. Since none of these products failed the review, that portion of the savings claimed remained as filed.

As with the other residential programs this procedure resulted in a single point estimate of a verification ratio. Given the sample size and the probability of an appliance failing the Energy Star criterion, a significance test was constructed. The results of this verification are shown in Table 9. The resulting verification ratio for the entire product rebate program is statistically significant.

Table 9. Product Verification

Sample stratum	Population		Sample			N
	Claimed Savings (Therms)**	N	Claimed Savings (Therms)	Sample % (Therms)	Verified Savings (Therms)	
0	36,992	4,499	704	1.90%	639	88
1	14,942	234	300	2.01%	300	5
Totals	51,934	4,733	1,004	1.93%	939	93
Verification Statistics				Notes:		
Ratio	95% Conf Interval		T-statistic*	*Statistically significant at 95% confidence level		
	Upper	Lower				
0.899	0.843	0.956	-3.49			
**An adjustment of 1.6% was made in the Avista savings claim to account for duplicates in the database.						

3.3.1. Program Recommendations

This program seems well designed for rebating incentive to customers purchasing efficient equipment as long as there is an agreed standard for such equipment. In general, such a standard exists through the EnergyStar program for almost all of the savings claimed. This made the verification straightforward.

In one case (“Fireplace Dampers”) there is no standard and the engineering associated with this “product” seemed very suspect. Since this measure was combined with the other products, and since it was a very small fraction of the entire appliance program, the sample did not include any of these products. We did not adjust or remove these savings from the overall program, but we believe with a larger sample and more time to review the engineering, this program would have been dramatically reduced. We would recommend that it be dropped as a measure or at least that the engineering estimates used be carefully reviewed before the next verification.

3.4. Limited-Income Program

The limited-income (LI) program is a separate program contracted with individual community action programs (CAP). Avista has contracted with four such programs; however, only two had significant activity in 2009. To develop a sample for the limited-income program a stratified random sample was conducted of the individual accounts; these accounts used a combination of measures from essentially all of the weatherization measures used by Avista in the residential sector. The sampling procedures and technical evaluation paralleled the residential weatherization program discussed above.

The CAPs have typically used the savings calculations from Avista. In some cases they generated their own savings estimates and submitted them to the utility as their savings claims. The claims of the CAPs were adjusted using the same analysis used in the weatherization programs based on the simulation results

summarized in Table 6. A few measures were separately evaluated since they did not appear in the Avista program. In these cases, (infiltration/air sealing, insulated doors, and duct insulation) the savings claims reported by the program were used once the measure itself was verified.

Since this is a stratified random sample some recruitment issues unique to the LI program required added sample points to ensure an adequate final sample. The agencies themselves were crucial in recruiting their individual clients. Even with their help the response rate was only about 50%. Unlike the other programs, a second back-up sample was drawn to allow for this high rate of non-response. A total of 16 homes were audited and field verified as part of the final sample.

In this field protocol the auditors were asked to review the measures claimed in the same manner as for residential weatherization. In addition, they were asked to verify if the home was actually gas-heated. This was thought to be important since no separate verification of heating system was included in the claims made by the CAPs. In addition, two measures were reviewed, infiltration control and duct insulation. This was not directly field verified, but the documented blower door results were reviewed and the standard savings calculations used to evaluate changes in blower door tests was used to recalculate the appropriate savings claim for that measure. Duct insulation was verified and, if observed, the savings claims were accepted as verified.

Once this allocation was complete, a full verification ratio was conducted similar to the weatherization program, in which the stratification was evaluated and a verification rate calculated across all strata. In the LI program a total of 38 homes were sampled for purposes of verification; the actual target developed from the sample design was 19 homes (including some over-sample). No homes were reviewed unless they agreed to a field audit. Finally, 16 of the 19 homes were reviewed. The appendix summarizes the audit results and verification rates for the individually audited sites. Table 10 shows the results of this verification and includes the verification ratio once again calculated by accounting for strata and statistical design.

Table 10. Limited-Income Program Verification

Sample Stratum	Population		Sample			N
	Claimed Savings (Therms)	N	Claimed Savings (Therms)	Sample % (Therms)	Verified Savings (Therms)	
1	18,565	121	756	4.07%	561	4
2	38,794	98	1,253	3.23%	833	4
3	37,892	49	6,352	16.76%	4,097	8
Totals	95,251	268	8,361	8.78%	5,491	16
Verification Statistics				Notes:		
Ratio	95% Conf Interval		T-statistic*	*Statistically significant at 95% confidence level		
	Upper	Lower				
0.676	0.446	0.906	-2.761			

3.4.1. Program Recommendations

The Limited-Income programs are operated by separate CAP agencies who apparently are allowed to calculate their savings estimates. This policy seems to have resulted in large savings estimates which are not easily supported by the engineering analysis done for the weatherization programs. This has resulted in a significant verification adjustment. We recommend that the savings methods used by these agencies be consistent with the Avista procedures or that the *ex ante* savings for the limited-income programs be supplied by Avista as part of its contract with the agencies. It appears that in other respects these programs are well run and that the quality control was effective.

3.5. Ground Source Heat Pump

The ground source heat pump (GSHP) incentive offered by Avista assumed that in developing the ground source heat pump, Avista saved gas heating as a result of removing or otherwise avoiding a gas furnace and replacing it instead with a high-efficiency electric based GSHP. Thus all the heating requirements of the home, which would have been gas, are saved. This is a dubious assumption, and our verification sample included three randomly-selected GSHP cases (out of 20 in the program) in which the auditors were instructed to review the homes primarily for whether gas heating was (or ever could be) a heating source for the home. Thus the verification ratio in effect was the degree to which these homes were likely to ever save gas produced and sold by the Avista utility. From the three sites reviewed, this was not possible in any of these cases. We believe that this is representative of the entire sector, so the verified savings for the program was set to zero and all the claimed savings were removed.

3.5.1. Program Recommendations

It is not clear how this program deliver gas savings for the Avista program. The base case is not gas in any of our sampled cases. If there is to be any savings booked there should be an entry that specifically notes both the existence of gas space heat and/or the existence of a gas service that might be used to provide space heat to these customers. Otherwise this measure, while it may provide electric or other fuel savings, is not a gas efficiency measure.

3.6. UCONS Multi-Family Shell Retrofits

The UCONS program is similar in some respects to the limited-income program, in that a separate contractor was hired to manage the program and to develop program savings claims and implement installation of these measures. The great bulk of the program was focused on developing electric savings from new efficient lighting and hot-water flow restrictors. However, a fraction of the program also was aimed at retrofitting multi-family buildings with various envelope insulation measures. The UCONS program set the savings claims using a set of savings calculations submitted and approved by Avista. These in turn became the basis for the claimed savings.

A two-step verification process was used. The first step was to draw a stratified random sample for the 41 multi-family shell insulation projects claimed under the UCONS program. These were sometimes buildings within the same complex, and sometimes individual buildings operated separately. The overall sample design included 13 such projects and involved 10 separate complexes or buildings. The appendix summarizes the site-by-site verification results for this program. The auditors were asked to review each site and try to discern the measures. They were primarily asked to measure the areas used to assemble the

savings claims and to determine the initial insulation conditions. The saving calculations verified used the same "calculated" savings number (.15 Therms/ft²) for all insulation measures regardless of initial conditions, building component, or amount of insulation installed.

As a result of this abbreviated method, a multi-family prototype was drawn from the NPCC prototypes (see Table 5) and used for the re-evaluation of the initial savings estimates. Table 11 shows the result of this simulation review. This review often increased the nominal savings estimates assigned to the UCONS measures. In all cases the heating efficiency was set using a combination of anticipated gas distribution and combustion efficiencies of .75.

Table 11. Multi-Family Savings by Measure

Measure	Savings Calculated (Th/ft ²)				Ratio
	Spokane	Lewiston	Weighted	UCONS	
Wall R0-R11	0.171	0.142	0.166	0.15	1.11
Attic R0-R38	0.196	0.148	0.187	0.15	1.25
Attic R19-R38	0.015	0.026	0.017	0.15	0.11
Floor R0-R11	0.200	0.152	0.191	0.15	1.28
Floor R0-R19	0.246	0.190	0.236	0.15	1.57
Floor R0-R30	0.273	0.212	0.262	0.15	1.75
Window U=1.0 to U=.35	1.146	0.904	1.102	0.625	1.76
Window U=.55 to U=.35	0.214	0.159	0.204	0.625	0.33

The overall impact of the UCONS program was recalculated based on the same procedures used in the weatherization programs. There were two sources for the adjustments. First, the areas of the component that received the insulation measure were reviewed and altered by the auditor in the field; and, second, the insulation was assessed and, when possible, the initial insulation value was observed. When components were impossible to verify, the UCONS area claims were used in combination with the revised measure savings values in Table 11. Ten separate UCONS' applications were reviewed, representing 13 separate invoices from the program.

The verification ratio was calculated with a combination of the new savings ratios as shown in Table 12 and based on the verified areas and insulation levels observed by our auditors at these sites. Table 12 shows the allocation of savings by stratum for the UCONS program and shows the calculated verification ratio and significance level for this sample.

Table 12. UCONS Program Verifications

Sample Stratum	Population		Sample			N
	Claimed Savings (Therms)	N	Claimed Savings (Therms)	Sample % (Therms)	Verified Savings (Therms)	
1	6,193	21	481	7.77%	370	2
2	16,222	13	7,083	43.66%	8,477	4
3	12,874.8	4	12,874.8	100.00%	9,509	4
Totals	35,289.8	38	20,438.8	57.92%	18,356	10
Verification Statistics				Notes:		
Ratio	Confidence Interval		T-statistic*	*Not statistically significant at 90% confidence level		
	Upper	Lower				
1.000	0.816	1.184	0.00			

3.6.1. Program Recommendations

The UCONS program does not appear to have been reviewed thoroughly during the program set-up and operation. None of the savings claims were justified, although the size of the claim was typically very conservative so the errors actually resulted in increased energy savings estimates. The area documentation was poor and often large adjustments seemed necessary. There were several comments on the quality control of the program by the apartment managers. These comments generally referred to the actual contractors that did the installation but indicated limited accountability. While this verification concluded no savings adjustment was statistically justified, the program itself is very erratic. The program delivered insulation measures in a sector that can use these measures. However, a better designed program operated by the utility through apartment owners or even insulation contractors would serve this sector.

3.7. Energy Star

Avista participated in the regional EnergyStar program for new home construction; this program is managed across the entire region by the Northwest Energy Efficiency Alliance (NEEA). We did not verify those savings directly but rather used the regional evaluation to assign savings to the applications in the Avista program.

This evaluation was completed in July 2010 but did not separately evaluate savings for the climate zones in the Avista service territory. As a result the savings are not calibrated to the same standard that Avista used in its savings claims. The evaluation did not document the climate distinction so we used an upper boundary of their savings estimates, arguing that it was within the confidence interval and was certainly better-suited to the Avista service territory. Even so, the evaluated savings for the Energy Star new construction program documented a savings rate that implied a .528 verification ratio for this program. This ratio was used to calculate savings for the 92 Energy Star applications in the Avista 2009 savings claims.

4. Audit of Commercial and Industrial Sector Programs

The Commercial/Industrial (C/I) program offerings are divided into eleven major categories. Each of these categories has separate program offerings and separate calculation requirements. Table 13 shows both the nominal categories used in this program and the savings filed for each of these categories. As can be seen in Table 13, there are two classes of measures. The first are measures calculated on a custom basis for each application. These include building shells, HVAC equipment, and industrial processes. Prescriptive measures use a deemed savings calculation that is compiled for each particular measure. These measures constitute about 17% of the total Avista savings claim. Measures included here are prescriptive appliances, cooking equipment and other types of specific commercial measures. In all cases, these prescriptive measures' savings are calculated based on an engineering review of the particular measure that could be applied to all such applications.

For the C/I program, given the distribution of savings – especially between the various engineering methods and the overall savings – we elected to sample the program as a whole for purposes of verification. By this device, the verification rate itself is calculated using engineering and deemed savings on the individual sites sampled. The verification rate calculated from this review is designed to apply to the C/I program as a whole.

Table 13. Commercial and Industrial Gas Program Savings Claims

Program	Description	Applications	Savings Claimed	
			Therms	Percent
Custom				
SSA	Appliances	19	11,970	5.0%
ESG	Energy Smart-Industrial Process	2	5,891	0.5%
SSHVAC	HVAC	160	579,237	41.8%
SSS	Shell	132	173,942	34.5%
SSIP	Industrial Process	4	78,829	1.0%
Prescriptive				
PRW	Energy Star Dishwasher	4	1,955	1.0%
PCW	Prescriptive Comm Clothes Washer	11	3,062	2.9%
PDCV	Prescriptive Demand Control Vent.	3	1,056	0.8%
PFS	Prescriptive Food Service	43	22,726	11.2%
PRW	Prescriptive Refrigerated Warehouse	1	1,863	0.3%
PSTR	Prescriptive Steam Trap Replace	4	9,782	1.0%
	Total	383	890,313	

The goal of this sample was to verify the savings estimates and measures installed under this program in the 2009 program year. The design was based on a stratified random sample, using savings claims for the database summarized in Table 13. Prior to sampling all the measures were collapsed into the individual accounts. This had the effect of reducing the number of cases but increasing the number of measures reviewed within the sample. The total number of accounts in the sample frame was 288. While this changed the sample design it had no effect on the savings claim used in developing the verification. The sample was drawn using a statistical criterion of 90% significance level, 10% confidence interval, for verification ratios drawn from the individual customers. This criterion was judged to be standard practice for field verification of a program of this type.

To optimize the sample a stratification design was developed using a Dalenius-Hodges stratification and a Neyman allocation among the various strata. This strategy resulted in a sample that represents a large fraction of the total savings claims, and within each stratum, a random sample was conducted across all CI applications. A total of 25 sample points were drawn using the stratification design developed. These are representative of the sample distribution, and would be the basis of both the engineering review and the field review.

A detailed engineering review was conducted on each of the 25 sites. These sites included both prescriptive or the custom measures as they appeared in the site. Given this approach the engineering analysis and the verification calculations were applicable to the commercial sector as a whole but not necessarily to any particular subset of the sector by either geography or measure.

The engineering review included all engineering worksheets, simulations, and related documentation for every claim within the sample. This review included rerunning the simulation calculations when that was supplied. Errors in these calculations were then applied to the entire account to adjust the total savings claim. In cases where there were prescriptive measures, the deemed savings were generally used, but the actual files were reviewed to ensure that the equipment that was installed met the specifications and certifications required by the deemed savings calculator.

Subsequent to this engineering review, a field review of each sample point was attempted. Because of difficulties with recruiting and scheduling, two sites of the 25 were not reviewed in the field. For these sites only the engineering review is used to arrive at final savings verifications. Appendix A summarizes the engineering review and adjustments made on this sample of projects.

Table 14 details the verification findings and rate for each sample stratum and the program as a whole. A significance test was conducted on the ratio of the verified savings from the engineering/field review compared to the claimed savings developed for the Avista savings claim. This process developed a point estimate of the ratio between the verified savings and the claimed savings, which became the verification ratio for the C/I program.

Table 14. Commercial/Industrial Verifications

Sample stratum	Population		Sample			N
	Claimed Savings (Therms)	N	Claimed Savings (Therms)	Sample % (Therms)	Verified Savings (Therms)	
1	75,160	185	2,970	3.95%	2,678.7	5
2	137,059	59	14,194	10.36%	10,862.7	5
3	209,523	29	34,209	16.33%	33,610	5
4	184,089	9	103,381	56.16%	73,055.71	5
5	284,482	6	237,343	83.43%	223,212.3	5
Totals	890,313	288	392,097	44.04%	343,419.41	25
Verification Statistics				Notes:		
Ratio	95% Conf Interval		T-stat*	*Statistically significant at 95% confidence level		
	Upper	Lower				
0.868	0.762	0.974	-2.451			

This point estimate ratio is applicable to the entire program and thus applicable to each individual state directly. Also included in this verification is a significance test; our criterion was that it must achieve significance at a 90% level. As can be seen, this significance level was met by the sample and verification results. In the C/I programs, this verification rate applies across all applications (prescriptive and custom). The UCONS program, which was included in the original C/I claim, was evaluated separately under the residential program.

4.1.1. Program Recommendations

A review of this program provides evidence that this approach is very effective for the C/I sector. There was good evidence that often the custom engineering review resulted in effective measures installed. There were some cases where issues arose that should be addressed. Primarily the use of a code requirement did not always inform the savings calculations. We would recommend that for any replacement equipment covered by the energy code the savings should be calculated from the base code efficiency.

5. Overall Verification Results

Table 15 summarizes the verification ratios for each Avista program using the 2009 savings claims. Because of the nature of these samples, and the independence of these samples, the overall verification is the arithmetic weighted average of the savings claimed and the verification noted in each of these categories. Table 15 summarizes these results as well as the final total verification.

Table 15. All Programs, Summary of Verification Rates

Program	Verification Ratio	T-statistic	Program Claimed Savings	Program Verified Savings
Limited Income Residential	0.676	-2.76	95,251	64,390
UCONS Multi-Family	1.000	0.00	35,290	35,290
Residential Weatherization	0.792	-2.55	545,180	431,544
Residential Products and Appliances	0.899	-3.49	51,934	46,709
Residential Heating Equipment	0.879	-2.62	395,076	347,018
Energy Star New Construction	0.528		18,124	9,569
Ground Source Heat Pumps, Conversions	0.000		15,740	0
All Residential Programs	0.808		1,156,595	934,519
All Commercial/Industrial Programs	0.868	-2.45	890,313	772,659
Total, All Program Claims	0.834		2,046,908	1,707,178

Table 16 and Table 17 summarize the verification results for the states of Washington and Idaho respectively. The sample design was developed around each of Avista's program offerings. To divide the verification into states the savings claims for each of the programs were separated for each state. Subsequently, the program verification ratio was applied to the claimed savings. The overall verification ratio in each state is a weighted averaged over the actual claims, resulting in a small variation in the verification ratio between the two states.

Table 16. Washington Program Verification

Program	Verification Ratio	Program Claimed Savings	Program Verified Savings
Limited Income Residential	0.676	83,178	56,228
UCONS Multi-Family	1	17,548	17,548
Residential Weatherization	0.792	418,529	331,475
Residential Products and Appliances	0.908	24,669	22,399
Residential Heating Equipment	0.879	269,001	236,452
Energy Star New Construction	0.528	13,002	6,865
Ground Source Heat Pumps, Conversions	0	9,444	0
All Residential Programs	0.803	835,371	670,968
All Commercial/Industrial Programs	0.868	608,004	527,747
Total, All Claims	0.830	1,443,375	1,198,715

Table 17. Idaho Program Verification

Program	Verification Ratio	Program Claimed Savings	Program Verified Savings
Limited Income Residential	0.676	12,073	8,161
UCONS Multi-Family	1	17,741	17,741
Residential Weatherization	0.792	126,651	100,308
Residential Products and Appliances	0.908	9,141	8,300
Residential Heating Equipment	0.879	128,075	112,578
Energy Star New Construction	0.528	5,122	2,704
Ground Source Heat Pumps, Conversions	0	6,296	0
All Residential Programs	0.819	305,099	249,792
All Commercial/Industrial Programs	0.868	282,309	245,044
Total, All Claims	0.842	587,408	494,837

Appendix: Site-by-Site Verification Documentation

Residential Sector Verification by Site

Table 18. UCONS Multi-Family Field and Engineering Review

Application	Measures	Claimed savings	Verified savings	Ratio	Comments
29233	FLOOR INSULATION	6362	5864	0.922	Increased engineering savings
29475	ATTIC INSULATION	346	194	0.561	Reduced Area, increased engineering savings
29477	ATTIC INSULATION	3073	3841	1.250	Increased engineering savings
29913	ATTIC INSULATION	840	740	0.881	Reduced Area
30269	WALL INSULATION	648	834	1.287	Increased area, increased engineering savings
30002	FLOOR INSULATION	2315	3634	1.570	Increased engineering savings
31276	ATTIC INSULATION	4840	839	0.173	Decreased area, R30 initial R-value
29997	ATTIC INSULATION	795	1039	1.307	Increased engineering savings
30258	ATTIC INSULATION	135	176	1.304	Increased engineering savings
32125	WALL INSULATION	2647	1195	0.451	Decreased area, increased engineering savings

Table 19. Residential Weatherization Field and Engineering review

ACCOUNT NO.	Measures	Claimed Savings	Verified Savings	Ratio	Comments
503381	ATTIC, WALL INSUL.	431	450	1.045	Increase in insulated component area
804116	WINDOWS	27	21	0.770	Reduced engineering savings
1403781	ATTIC INSULATION	90	81	0.900	Reduced engineering savings
1810248	WINDOWS	126	150	1.190	Increased engineering savings
2001573	ATTIC INSULATION	78	70	0.897	Reduced engineering savings
2009719	WINDOWS	95	74	0.776	Reduced engineering savings
2210009	WINDOWS	163	253	1.554	increased engineering savings, increased Window area
2300185	WINDOWS	57	44	0.774	Reduced engineering savings
50046808	WINDOWS	32	25	0.768	Reduced engineering savings
90024147	WALL INSULATION	269	186	0.690	Reduced engineering savings
130100807	WINDOWS	34	100	2.928	increased engineering savings, increased Window area
170116853	ATTIC, WALL & WINDOWS	746	713	0.955	Reduced & Increased engineering savings, reduced area
250107787	ATTIC, FLOOR, WALL, WINDOWS	183	121	0.661	Reduced engineering savings
250118107	WINDOWS	53	35	0.666	Reduced engineering savings
530098573	FLOOR INSULATION	1349	173	0.128	Reduced engineering savings, reduced area
530102604	ATTIC, WALL, FLOOR & WINDOWS	799	394	0.493	Reduced engineering savings
570114779	WINDOWS	131	23	0.174	Reduced engineering savings
610106985	ATTIC, WALL & WINDOWS	922	567	0.615	No floor insulation, reduced window areas
730005910	WINDOWS	195	31	0.161	Reduced engineering savings, reduced area
730097409	WINDOWS	200	155	0.775	Reduced engineering savings
770029513	FLOOR, WINDOWS	804	462	0.574	Reduced engineering savings, reduced area

Table 20. Limited-Income Field and Engineering Review

ACCOUNT NO.	Measures	Claimed Savings	Verified Savings	Ratio	Comments
1606749	ceiling, floor	865	305	0.353	Small initial ceiling insulation: reduced savings
50070609	ceiling, wall, infilt	556	340	0.612	Reduction due to reduced engineering savings
90038805	ceiling, floor, door, infilt	1154	873	0.756	Floor not accessible, reduced engineering savings
90084309	floor, window, infilt	547	493	0.902	Reduced floor insulation impact, significant insulation base
130068961	ceiling	290	88	0.305	R19 initial insulation base
170081965	ceiling, door, window, infilt	322	98	0.304	4" initial ceiling insulation
250065380	ceiling, floor, door, infilt	671	268	0.399	R11 base case floor insulation, reduced engineering savings
250117883	floor, window, infilt	240	0	0.000	No Gas heat, Heating with wood stove
290077410	ceiling, wall, floor, infilt	292	326	1.115	Larger floor area
330114573	ceiling, wall, floor, window, infilt	1106	807	0.730	Reduced engineering savings
450080245	wall, infilt	276	298	1.081	Reduced engineering savings, increased treated area
450113230	ceiling, floor, infilt, duct	159	223	1.402	Better insulation, increased area
490052185	ceiling, door, floor, infilt, duct	659	551	0.836	Reduced engineering savings
610054496	ceiling, wall, floor, window, infilt	720	460	0.638	Reduced engineering savings
610094039	floor, infilt, duct	146	241	1.647	Increased area
650054852	ceiling, window, infilt	395	120	0.305	R19 initial ceiling insulation, reduced engineering savings

Commercial and Industrial Program Verification by Site

Account #	Measures
490113297	Building Shell Insulation, Window upgrade, Efficient boiler, Heat Recovery
Proposed Savings (Therms)	Verified Savings (Therms)
58,351	50,351
Comments	
<ol style="list-style-type: none"> 1. Provided model had errors & wouldn't run. 2. After fixing model, EEMS for High Efficiency Windows, Roof Insulation, and Central System were re-run. Savings were adjusted to be consistent with eQuest model. 3. The Avista HRV calculator was assumed to be correct. 	

Account #	Measures
490111094	Building shell insulation
Proposed Savings (Therms)	Verified Savings (Therms)
167.7	167.7
Comments	
Ceiling insulation field verified	

Account #	Measures
490105388	CO2 sensor and outside air control
Proposed Savings (Therms)	Verified Savings (Therms)
550	550
Comments	
CO2 sensor verified in field	

Account #	Measures
450036381	Water heating efficiency upgrade, DDC control and upgraded control settings
Proposed Savings (Therms)	Verified Savings (Therms)
3333	3333
Comments	
Field verified control settings. Control calculation appear adequate	

Account #	Measures
370075982	Prescriptive cooking equipment
Proposed Savings (Therms)	Verified Savings (Therms)
1621.8	813.8
Comments	
1. The model number for the installed Fryers was not on the Avista approved fryer list available on the website. Savings were removed for this measure.	

Account #	Measures
370033015	Efficient boiler and OA temp control
Proposed Savings (Therms)	Verified Savings (Therms)
60,305	60,305
Comments	
<p>1. The UA calculation did not have enough supporting documentation to verify whether or not it was done correctly. Several of the assumptions seemed suspect; for instance, the Heat Load used to calculate the firing rate of the boilers varied exponentially with temperature rather than linearly.</p> <p>2. Hand calcs showed that the estimated savings are probably conservative, so no changes were made to the claimed savings.</p>	

Account #	Measures
290117099	New Construction, High efficient boiler, upgraded window and insulation package, efficient DHW
Proposed Savings (Therms)	Verified Savings (Therms)
13,476	7335.715
Comments	
<p>1. Assumptions for radiant floor modeling are un-likely & over-estimate the gas savings. The majority of the savings are in the fan energy reduction, rather than a change in the gas use for radiant systems. Savings were remodeled with more appropriate assumptions and the savings claim was adjusted accordingly.</p> <p>2. Cooling added to residential & deleted from community.</p> <p>3. Radiant floors require full R-10 underslab insulation.</p>	

Account #	Measures
210011707	Replaced Foam Molding Machine
Proposed Savings (Therms)	Verified Savings (Therms)
22,856	37,128
Comments	
<p>Several small calculation errors were found in the review of the calculation:</p> <ol style="list-style-type: none"> 1. Didn't include g_c (Bernoulli' equation units don't work without an adjustment). 2. Used diameter instead of radius to calculate the cross-sectional area of the opening. 3. Used the wrong density for the steam. 4. On site visit, owners stated that current press produces max 15600 blocks/year <p>The errors actually caused the calc to under predict the savings. A better method for determining the savings would probably be to install a meter on the steam to the original machine. It would add confidence in the predicted savings considering the size of the incentive payment.</p>	

Account #	Measures
130047560	Replaced & upgraded boilers for heat and hot water
Proposed Savings (Therms)	Verified Savings (Therms)
31,173	35,015
Comments	
<ol style="list-style-type: none"> 1. Several small errors in the domestic hot water and heating system eQuest model changed the results (increased the savings slightly). Additionally, the estimate for daily DHW use was very low for a residential building. 	

Account #	Measures
45005940	New controls, upgraded DHW
Proposed Savings (Therms)	Verified Savings (Therms)
25,145	329
Comments	
<ol style="list-style-type: none"> 1. Site Visit determined that set-backs for Outside Air & Temperature during unoccupied hours were not programmed into the schedules. Savings from scheduling removed. 2. The savings for the new DHW heater were not adjusted. 	

Account #	Measures
10121335	New Construction, Designed a HP loop and a high efficiency DHW
Proposed Savings (Therms)	Verified Savings (Therms)
14,880	6690
Comments	
<ol style="list-style-type: none"> 1. Modeled savings for heat pump system not likely for residential project unless there is a mixed use year round cooling load (i.e. retail store). This is confirmed by Ecotope's modeling runs using the provided baseline. Savings were adjusted using eQuest model with more appropriate assumptions. 	

Account #	Measures
2529110	Replaced old boiler steam system and replaced with RTU and add controls and ventilation control (CO2)
Proposed Savings (Therms)	Verified Savings (Therms)
25,810	21,573
Comments	
<ol style="list-style-type: none"> 1. The geometry in the provided eQUEST models don't match the high school building, which is the only part of the school affected by the heating system upgrade. 2. The hot water calc wasn't included in the documentation, so we re-calculated the savings using the eQUEST defaults for a school building. 3. The original building didn't have programmable t-stats with set-backs, so we added that to the model of the proposed building.. 	

Account #	Measures
2427024	Replaced old RTU
Proposed Savings (Therms)	Verified Savings (Therms)
304	0
Comments	
<ol style="list-style-type: none"> 1. Savings estimates unreasonable, new installed equipment is code minimum. 	

Account #	Measures
2416485	Prescriptive Steam trap replacement
Proposed Savings (Therms)	Verified Savings (Therms)
2543	2543
Comments	
Field verified functioning steam traps. Pipe temperature change confirm operation	

Account #	Measures
1221764	Boiler Replacement
Proposed Savings (Therms)	Verified Savings (Therms)
6703	6703
Comments	
<ol style="list-style-type: none"> 1. Boiler efficiency confirmed with documentation and field review. 2. System confirmed as hot water, no cooling 	

Account #	Measures
1216995	Replaced and upgraded steam boiler
Proposed Savings (Therms)	Verified Savings (Therms)
49,990	49,990
Comments	
Confirmed boiler efficiency and operating schedule in the field	

Account #	Measures
1216621	Boiler upgrade at replacement
Proposed Savings (Therms)	Verified Savings (Therms)
3496	1277.9
Comments	
<ol style="list-style-type: none"> 1. Boilers in proposed model set up as steam boilers (88% combustion efficiency generally isn't possible with steam boilers). 2. Site visit determined that the original and updated heating systems are hot water, w/ fan coils rather than steam as modeled. 3. Re-modeled base-line & proposed using a hot water boiler in both models and reduced savings accordingly. 	

Account #	Measures
919170	Boiler replacement, Prescriptive cooking equipment
Proposed Savings (Therms)	Verified Savings (Therms)
5155	5155
Comments	
Boiler and cooking equipment verified in field	

Account #	Measures
770014900	New Construction, HP Loop, upgraded window an insulation specs, efficient DHW
Proposed Savings (Therms)	Verified Savings (Therms)
35,524	27,551.32
Comments	
1. Changed baseline model to match documentation (DX cooling rather than a water cooled heat pump) & adjusted savings accordingly.	

Account #	Measures
770013072	Upgrade boiler at replacement
Proposed Savings (Therms)	Verified Savings (Therms)
5518	5518
Comments	
Confirmed Boiler efficiency in field	

Account #	Measures
730118749	Building shell insulation
Proposed Savings (Therms)	Verified Savings (Therms)
1155	1155
Comments	
Auditor confirmed ceiling insulation levels	

Account #	Measures
730113820	Building shell upgrade, fume hood upgrade, efficient boiler replacement
Proposed Savings (Therms)	Verified Savings (Therms)
7823	7224
Comments	
1. Changed model to account for fume hood exhaust/outside air load and re-modeled boiler, window and roof EEMs & reduced savings to match modeling results.	

Account #	Measures
690022592	Prescriptive steam traps
Proposed Savings (Therms)	Verified Savings (Therms)
2895	2895
Comments	
Steam traps installed and functioning	

Account #	Measures
610018687	Efficient boiler replacement, building controls
Proposed Savings (Therms)	Verified Savings (Therms)
9010	9010
Comments	
<ol style="list-style-type: none">1. The documentation for this project is nearly impossible to decipher, field verification determined that it's likely that the savings have been under-estimated. In the future, records should be kept which identify as-found and as-left conditions before and after the work is performed. Additionally, on projects which include multiple buildings and multiple incentives, records should be kept identifying which energy efficiency measures were pursued and for which building.2. Savings not adjusted.	