REPORT

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Impact Evaluation of Washington Natural Gas 2014-2015 Energy Efficiency Programs

Submitted to Avista Utilities

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Principal Authors:

Lynn Roy, Mary-Hall Johnson, Patrick Burns, Jesse Smith, Wyley Hodgson, Cherlyn Seruto, Nathanael Benton, Greg Sidorov, Shannon Hees; Nexant, Inc.

Ryan Bliss, Paul Schwartz; Research Into Action

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1 Executive Summary

Nexant Inc. and Research Into Action (collectively the evaluation team) conducted an impact and process evaluation of Avista's 2014 and 2015 residential and nonresidential energy efficiency programs. This report documents findings from the impact evaluation activities for Avista's Washington natural gas programs. The primary goal of this evaluation was to provide an accurate summary of the gross energy savings attributable to the following Avista programs offered in 2014 and/or 2015:

- Nonresidential Prescriptive
- Nonresidential Site Specific
- Small Business
- Residential Heating, Ventilation and Air Conditioning (HVAC)
- Residential Water Heat
- Residential ENERGY STAR® Homes
- Residential Fuel Efficiency
- Residential Shell
- Low Income

1.1 Evaluation Methodology and Activities

The evaluation team performed the impact evaluation through a combination of document audits, customer surveys, engineering analysis and onsite measurement and verification (M&V) of completed program projects. Because it is not cost-effective to complete analysis and onsite inspection on a census of the implemented projects, the evaluation team verified energy savings for a representative sample of projects to draw statistically-measurable results. The gross verified program savings were adjusted by a realization rate (RR), which is the ratio of evaluation verified savings to the program-reported savings within the sample.

The evaluation team conducted more than 300 document audits, approximately 210 customer surveys, and 69 onsite inspections across the residential and nonresidential programs being evaluated (Table 1-1). In addition, the evaluation team conducted billing regression analysis to estimate the impacts of three residential programs and on a case-by-case basis for the nonresidential projects. The samples were designed to meet a 90% confidence and 10% precision level at the portfolio and sector level and were based upon the expected and actual significance (or magnitude) of program participation, the level of certainty of savings, and the variety of measures.

Table 1-1: Summary of Impact Evaluation Activities

Program	Document Audit	Surveys	Onsite M&V	Billing Analysis
Residential				
HVAC Program	46	48	0	
Water Heat Program	12	11	0	
ENERGY STAR Homes	11	11	0	
Fuel Efficiency	26	25	0	√
Shell Program	47	47	0	√
Low Income	24	0	0	√
Nonresidential				
Commercial Water Heaters	2	1	1	
Commercial Windows & Insulation	24	11	11	
Natural Gas HVAC	24	0	0	
Food Service Equipment	11	0	0	
Site Specific	45	26	26	as applicable
Small Business	31	31	31	
TOTAL	**303**	**211**	**69**	

1.2 Summary of Impact Evaluation Results

Avista's Washington natural gas 2014 and 2015 programs achieved 1,240,266 therm savings over the two year period Table 1-2, Table 1-3 and Table 1-4 summarize Avista's 2014 and 2015 impact evaluation results by sector and program.

Table 1-2: Washington Natural Gas Portfolio Evaluation Results

Sector	2014-2015 Reported Savings (therms)	Realization Rate (%)	2014-2015 Gross Verified Savings (therms)
Residential	848,225	83%	705,191
Residential – Fuel Conversion	(314,247)	75%	(235,535)
Nonresidential	867,194	92%	797,083
Low Income	27,968	101%	28,248
Low Income – Fuel Conversion	(13,249)	413%	(54,720)
Portfolio	**1,415,890**	**88%**	**1,240,266**

Table 1-3: Washington Gas Nonresidential Program Evaluation Results

Program	2014-2015 Reported Savings (therms)	Realization Rate	2014-2015 Verified Gross Savings (therms)
Commercial Water Heaters	5	127%	6
Commercial Windows & Insulation	32,930	137%	45,265
Natural Gas HVAC	43,434	104%	45,079
Food Service Equipment	55,687	124%	68,889
Site Specific	717,544	86%	615,852
Small Commercial	14,503	125%	21,992
TOTAL NONRESIDENTIAL	**864,103**	**92%**	**797,083**

Figure 1-1: Washington Gas Nonresidential Sector Program Gross Saving Shares

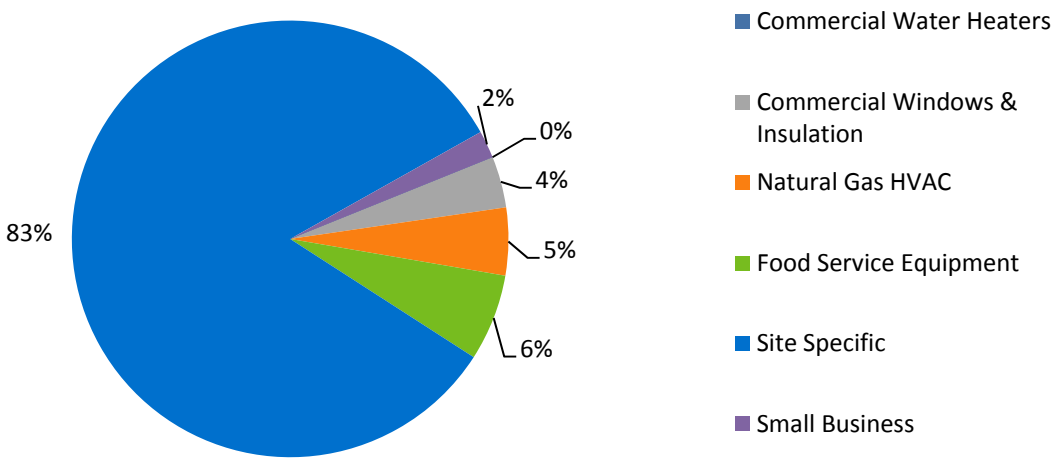
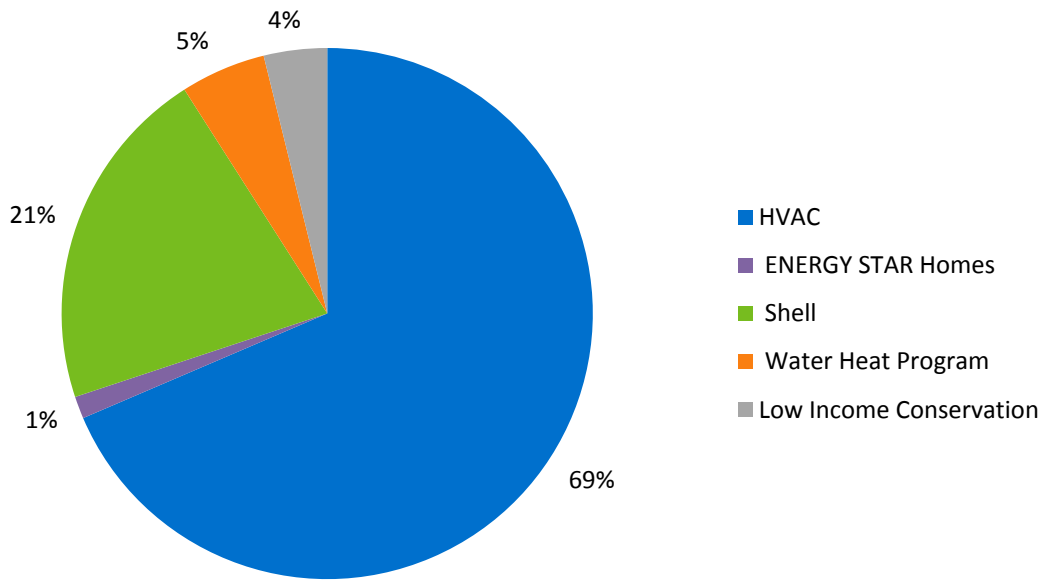


Table 1-4: Washington Natural Gas Residential Program Evaluation Results

Program	2014-2015 Adjusted Reported Savings (therms)	Realization Rate	2014-2015 Verified Gross Savings (therms)
HVAC	402,163	125%	502,820
ENERGY STAR Homes	4,669	212%	9,920
Shell	411,239	38%	154,404
Water Heat Program	30,153	126%	38,046
Low Income Conservation	27,968	101%	28,248
Conservation Total	876,193	84%	733,439
Fuel Efficiency (Fuel Conversion)	(314,805)	75%	(235,535)
Low Income Fuel Conversion	(13,249)	413%	(54,720)
Fuel Conversion Total	(328,055)	88%	(290,256)
TOTAL RESIDENTIAL	**548,138**	**81%**	**443,183**

Figure 1-2: Washington Natural Gas Residential Sector Program Gross Saving Shares (Conservation Only)



1.3 Conclusions and Recommendations

The following outlines the key conclusions and recommendations as a result of the evaluation activities. Specific details regarding the conclusions and recommendations outlined here, along with additional conclusions and recommendations can be found in the program-specific sections of this report and in Section 7.

1.3.1 Nonresidential Programs

The overall realization rate for the nonresidential portfolio is 92%. The realization rates ranged from 137% for the Commercial Windows & Insulation program down to 86% for the Site Specific program, the largest program in the nonresidential portfolio. The evaluation team found that the processes Avista is utilizing for estimating and reporting energy savings for the nonresidential programs are predominantly sound and reasonable.

Conclusion: The Site Specific program constitutes more than 80% of the program energy shares. Within the last 2 years, Avista has increased their level of quality assurance and review on projects that participate through the program. The evaluation team's analysis resulted in a 86% realization rate for the Site Specific program.

> **Recommendation**: The evaluation team recommends that Avista incentivize more of the larger, high impact natural gas projects under its 'performance path' processes. Natural gas projects are more often suited to performance verification via utility billing analysis than their electric counterparts because fewer building end uses are served by natural gas. Incentivizing projects based on proven performance would mitigate the inherent uncertainty in savings estimates generated prior to project installation and improve Avista's realization rate for this program.

Conclusion: Reported savings for Small Business program faucet aerators were found to be conservatively low based upon our secondary research. The realization rate for faucet aerators was 204% for natural gas savings.

> **Recommendation:** It is recommended that the modified deemed savings values utilized by the evaluation team in the verified savings analysis be adopted by the program for future reporting purposes.

1.3.2 Residential Programs

The overall realization rate for the residential portfolio is 81%. The realization rates varied significantly across the programs evaluated with the Low Income – Fuel Conversion program component having the highest realization rate at 413% and the Shell program having the lowest realization rate at 38%.

Conclusion: During the desk review process, the evaluation team found that the installed efficiency for the majority of the furnace replacements was higher than the program minimum-required efficiency level, which resulted in a greater than 100% realization rate. The evaluation

team was unable to determine a conclusive value for the baseline efficiency of the replaced furnaces based on project documentation review and the participant surveys.

> **Recommendation**: The evaluation team recommends that Avista conduct a more in-depth study in order to better understand the baseline for the furnace replacement measure.

Conclusion: The evaluation team found a realization of 85% for the Smart Thermostat measure. The findings are based on the analysis of 34 homes, which resulted in a wide margin of error in the results.

> **Recommendation:** Given that the realization rate is relatively close to 100% with a wide margin of error, the evaluation team does not recommend any changes to Avista's default savings assumption of 41 therms per device. The evaluation team recommends Avista revisit the smart thermostat analysis in 2017 once several hundred participants have a full year of post-installation billing data available and the billing analysis is capable of producing a more precise estimate.

Conclusion: Currently Avista is providing incentives for both tankless and storage gas water heaters at the federal minimum efficiency level.

> **Recommendation:** It is recommended that Avista revisit program requirements for water heaters to ensure that incentives are based on efficiency levels that are greater than the federal minimum.

Conclusion: For showerheads distributed through the Simple Steps program, Avista allocates 50% of its reported savings to electric savings and 50% to natural gas savings to account for homes that have different water heating fuel types.

> **Recommendation:** The evaluation team recommends Avista update this allocation assumption to be based on representative water heater fuel type saturation. These data are available through the Regional Building Stock Assessment study; however, we recommend Avista base the allocation on data specific to its territory.

Conclusion: For the Fuel Efficiency program, the evaluation team found that the 30 homes analyzed that converted from electric heat to a natural gas furnace showed an average weather normalized gas consumption of 332 therms per year pre-retrofit. This is relatively high gas consumption for homes with exclusively electric space heating. These homes also didn't increase their consumption that significantly after the conversion. It's possible that some of these homes had a mix of heating fuels prior to participation and the electric heating system converted was only a supplemental system.

> **Recommendation** The evaluation team recommends Avista carefully screen participants to ensure that homes are exclusively electrically heated to qualify for Fuel

Efficiency rebates or develop a more conservative savings claim for homes that convert a home with dual-fuel heating to all natural gas heat.

Conclusion: The evaluation team found a low realization rate (38%) for Shell rebate measures (windows and insulation). This finding indicates that reported savings values were too aggressive on average. In addition, the evaluation team found an increase in the base load in the customers participating through the Shell Program. The increase in estimated base load is puzzling because the shell improvements should have only limited effect on non-weather dependent end-uses such as cooking and water heating. This result could be an artifact of the regression fitting noisy data with limited sample size. However, other possibilities include homes performing fuel conversion outside of the Avista Fuel Efficiency program or a general shift in gas consumption for non-heating end-uses.

Recommendation: The evaluation team recommends Avista examine planning assumptions about per-home consumption, end-use load shares, and percent reductions in heating loads from shell improvements. It may be that the percent reduction assumptions are sound, but they are being applied to an overstated assumption of the average heating consumption per home. Conversely, the assumed end-use shares may be accurate, but the end-use reduction percentage is inflated.

Recommendation: The evaluation team recommends Avista look at any recent saturation studies or end-use load research findings to see if there is a general shift in base load gas use that could potentially harm the savings from the Shell improvements when analyzed at the whole house level.

2 Introduction

2.1 Purpose of Evaluation

The purpose of the impact evaluation was to verify the savings attributed to Avista's 2014–2015 rebate programs and to identify areas for future program opportunities. The evaluation team estimated gross program energy impacts through a combination of documentation audits, and telephone surveys, as well as engineering analysis and site inspections of completed program projects.

2.2 Program Summary

The following section provides a description of each program we evaluated in Washington. Although the program descriptions outline electric and gas measures, as applicable, the remainder of this report provides the methodology and findings for the natural gas-only measures and programs.

2.2.1 Nonresidential

The nonresidential energy efficiency market is delivered through a combination of prescriptive and site-specific offerings. Any measure not offered through a prescriptive program is automatically eligible for treatment through the site-specific program, subject to the criteria for participation in that program. Prescriptive paths for the nonresidential market are preferred for measures that are relatively small and uniform in their energy efficiency characteristics. The following subsections provide a summary of Avista's Site Specific and Prescriptive programs, including a description of program offerings, measures, and incentive amounts.

2.2.1.1 Site Specific

Avista's Site Specific program offers nonresidential customers the opportunity to propose any energy efficiency project outside the realm of Avista's other programs. Any project with documentable energy savings (kilowatt-hours and/or therms) and a minimum ten year measure life can be submitted for a technical review and potential incentive through the Site Specific program. The majority of projects that participate in this program are appliance upgrades, compressed air, HVAC, industrial process, motors, shell improvements, custom lighting, and natural gas multifamily market transformation projects. Multi-family residential developments may also be treated through the Site Specific program when the majority of the units and common areas are receiving the efficiency improvement. The determination of incentive eligibility is based upon the project's individual characteristics as they apply to the Company's electric Schedule 90 or natural gas Schedule 190 tariffs.

Customers or their representative are required to contact Avista for a Site Specific analysis prior to any equipment being purchased or installed. Based on the post-verification process, incentives may not be offered after the installation of energy efficiency equipment or process under this program design. Table 2-1 shows the incentive levels associated with designated

ranges of project simple payback periods. To be eligible for incentive, lighting measures must have a simple payback period less than 8 years and all other measures must have a simple payback period less than 13 years. Simple payback is calculated as the incremental cost of a measure divided by the annual energy savings of the measure, calculated using the customer's Avista electric and/or gas rate. Incremental costs are only those projects costs necessary for the energy efficiency improvement.

Table 2-1: Site Specific Program Measures

Category	Required Payback Period	Incentive Level ($ / Saved kWh)
All Measures	Between 1 and 2 years	$0.08
	Between 2 and 4 years	$0.12
	Between 4 and 6 years	$0.16
Most Lighting Measures1	Between 6 and 8 years	$0.20
	Greater than 8 years	Not eligible
All Other Measures	Between 6 and 13 years	$0.20
	Greater than 13 years	Not eligible

[1]Lighting measures with independently verified lives of less than 40,000 hours.

Avista internally implements the Site Specific program following a multi-stage internal process outlined in Figure 2-1. To be considered for incentives, Avista must receive notification of a potential project during the planning stage. Avista engineers generate energy analyses and savings estimates for each project.

These energy savings estimates are subjected to a rigorous internal review process, with the level of review dependent on the potential incentive level for the project. Avista's current internal review guidelines are as follows:

- Measures that have an incentive of $0 and an energy based simple payback of over 20 years require no report and no review, just a form letter to the customer.
- Measures that have incentives between $1 and $2,000 will be processed by the reporting engineer without any other review.
- Measures that have incentives between $2001 and $25,000 will be reviewed before going to the customer by another qualified engineer.
- Measures over $25,000 will be reviewed by another qualified engineer with an additional technical management review prior to releasing to the customer.
- Measures over $40,000 will be reviewed by another qualified engineer, a technical manager, and an additional director review prior to releasing to the customer.

Avista employs the use of a "Technical Review Top Sheet" at each stage of the review process. The Top Sheet is a checklist intended to ensure that all program processes and policies have been followed and that project documentation is complete.

An "Energy Efficiency Evaluation Report" is generated for each project that includes a summary of the project's scope of work, estimated energy savings and incentives. Following project installation, Avista program staff members perform installation verification on nearly 100% of projects with limited exceptions. Program staff follows an "Incentive Payment Top Sheet" prior to incentive payment, which is another checklist to ensure that the project has been appropriately documented, tracked, and finalized.

Figure 2-1: Site Specific Program Process[1]

2.2.1.2 Prescriptive Lighting

The Prescriptive Lighting program is designed to make lighting improvement projects more accessible for Avista's nonresidential customers. This program is implemented internally by Avista, and existing commercial or industrial facilities with electric service provided by Avista with rate schedules 11 or above are eligible to participate. The program provides a pre-determined incentive amount for many common lighting retrofits, as shown in Table 2-2. Installed LED lighting must comply with nationally recognized specifications set forth by ENERGY STAR and Design Lights Consortium (DLC) and the Seattle Lighting Design Lab.

[1] Washington Demand Side Management Standard Operation Procedures. Avista Utilities. 2015.

Avista's regionally-based Account Executives (AEs) are a key part of delivering the Prescriptive Lighting program along with area vendors and contractors.

Table 2-2: Prescriptive Lighting Program Measures

Measure	$ Incentive/ Unit
250 watt HID Fixture to 4-Lamp High Performance (HP) T8 Fixture HO or 2-Lamp T5HO Fixture	$ 90
250 watt HID Fixture to 4-Lamp HP T8 Fixture HO or 2-Lamp T5HO 5-foot Fixture with occupancy sensor	$120
400 watt HID Fixture to 4-Lamp T5 Fixture	$120
400 watt HID Fixture to 4-Lamp T5 Fixture with oc sensor	$150
400 watt HID Fixture to 6-Lamp HP T8 Fixture	$120
400 watt HID Fixture to 6-Lamp HP T8 with oc sensor	$150
400 watt HID Fixture to 8-Lamp HP T8 Fixture (4-Foot Lamps)	$125
400 watt HID Fixture to 8-Lamp HP T8 Fixture (4-Foot Lamps) with oc sensor	$155
40 watt Incandescent to 6-10 watt LED*	$10
60 watt Incandescent to 9-13 watt LED*	$12
75-100 watt Incandescent to 12-20 watt LED*	$15
Over 150 watt Incandescent to 2L HP F32T8 Fixture	$40
20 watt MR16 (GU10 Base) to MR16 LED* 2-4 watt	$10
35 watt MR16 (GU10 Base) to MR16 LED* 4-6 watt	$11
50 watt MR16 (GU10 Base) to MR16 LED* 6-9 watt	$12
75-100 watt Incandescent to LED* Can Light Kit	$30
Fixture with no occupancy sensor to built in to with relays for room control (no switch sensors)	$30
4-Foot 4-Lamp T12/8 to 4-Foot 3-Lamp HP T8 Ballast with 25 or 28 watt Lamps	$32
4-Foot 4-Lamp T12/8 to 4-Foot 2-Lamp HP T8 Ballast with 25 or 28 watt Lamps	$35
4-Foot 3-Lamp T12/8 to 2X4 LED* Fixture	$60
4-Foot 3-Lamp T12/8 to 4-Foot 2-Lamp HP T8 Ballast with 25-28 watt Lamps	$15
4-Foot 2-Lamp T12/8 to 4-Foot 1-Lamp HP T8 Ballast with 25-28 watt Lamps	$13
4-Foot 1-Lamp T12/8 to 1-Lamp HP T8 Ballast with 25-28 watt Lamps	$13
8-Foot 4-Lamp T12/8 to 8-Foot 4-Lamp (8') or 8-Lamp (4') HP T8 Ballast with 25 or 28 watt Lamps	$54
8-Foot 2-Lamp T12/8 to LED* 2X4 Fixture	$80
8-Foot 1-Lamp T12/8 to LED* 1X4 Fixture	$40
T12 Sign Lighting to LED Retrofit	$17 / FT^2
Exterior-1000 watt HID to 400-575 watt DHID	$225
Exterior-400 watt HID to 250 watt DHD MH	$150
Exterior-400 watt HID to 122-175 watt LED*	$255
Exterior-320 watt to 122-160 watt LED*	$180

Measure	$ Incentive/ Unit
Exterior- 250 watt HID to 85-140 watt LED* & 250 watt HID to New Construction 85-121 watt LED*	$145
Exterior-175 watt HID to 35-85 watt LED* & 175 watt HID to New Construction 35-85 watt LED*	$135
Exterior-150 watt HID to 35-50 watt LED*	$130
Exterior-90-100 watt HID to 25-50 watt LED*	$75
Exterior-70-90 watt HID to 15-35 watt LED	$55
Exterior-320 & 400 watt HID to New Construction 122-175 watt LED*	$180
Exterior-400 watt Canopy HID to 122-175 watt LED* Canopy Fixture	$325
Exterior-325 watt Canopy HID to 122-160 watt LED* Canopy Fixture	$250
Exterior-250 watt Canopy HID to 85-140 watt LED* Canopy Fixture	$155

2.2.1.3 EnergySmart Grocer

The EnergySmart Grocer program offers a range of proven energy-saving solutions for grocery stores and other customers with commercial refrigeration. The program was designed to offer personalized facility assessments to identify efficiency opportunities and incentives to offset the upfront costs of efficiency projects, making it easy and affordable for participating businesses to achieve significant savings on their utility bills. EnergySmart Grocer is administered by CLEAResult with Avista oversight.

The EnergySmart Grocer program is available to electric (Schedule 11, 12, 21, 25) or natural gas (Schedule 101, 111, 121) customers. The list of measures incentivized by this program is fluid and may change at any point in the year. Table 2-3 lists the measures offered at one point in 2015.

Table 2-3: EnergySmart Program Measures

Measure	Incentive $/unit	Units
Cases		
Low Temp Open Case to Reach-in Case	$150	ln ft of case
Medium Temp Open Case to Reach-in Case	$20	ln ft of case
Low Temp Reach-in to High Efficiency Reach-in Case	$150	ln ft of case
Low Temp Coffin to High Efficiency Reach-in	$55	ln ft of case
Medium Temp Open Case to High Efficiency Open Case	$20	ln ft of case
Special Doors with Low/No ASH for Low Temperature Reach-in	$200	door
Add doors to Open Medium Case	$85	ln ft of case
Case Lighting		
Reach-in Case Light: T12 to Low Power LED, Retrofit	$21	ln ft of LED
Reach-in Case Light: T8 to Low Power LED, Retrofit	$12	ln ft of LED
Reach-in Case Light: T8 to Low Power LED, New Case	$12	ln ft of LED
Reach-in Case Light: Add Motion Sensor to Low Power LED	$1.00	ln ft of LED
Reach-in Case Light: Add Motion Sensor to High Power LED	$2.00	ln ft of LED
Controls		
Anti-Sweat Heat – with Energy Management System	$14	ln ft of case
Anti-Sweat Heat – without Energy Management System – Med Temp	$40	ln ft of case
Anti-Sweat Heat – without Energy Management System – Low Temp	$40	ln ft of case
Evaporated Fan - Walk-In ECM Controller - Low Temp - 1/10-1/20 HP	$35	Motor controlled
Evaporated Fan - Walk-In ECM Controller - Medium Temp - 1/10-1/20 HP	$35	Motor controlled
Strip Curtains, Gaskets & Auto-Closers		
Strip Curtains for Supermarket Walk-in Cooler	$5	sq ft
Strip Curtains for Supermarket Walk-in Freezer	$5	sq ft
Strip Curtains for Convenience Store Walk-in Freezer	$5	sq ft
Strip Curtains for Restaurant Walk-in Freezer	$5	sq ft
Gaskets for Walk-in Cooler – Main	$25	door
Gaskets for Walk-in Freezer – Main Door	$65	door
Gaskets for Reach-in Glass Doors, Medium Temp	$ 25	door
Gaskets for Reach-in Glass Doors, Low Temp	$ 40	door
Auto-Closers for Walk-in Freezers	$170	Closer
Auto-Closers for Walk-in Coolers	$25	Closer
Auto-Closers for Glass Reach-in Doors - Freezers	$35	Closer

Measure	Incentive $/unit	Units
Auto-Closers for Glass Reach-in Doors - Coolers	$35	Closer
Motors		
Evaporator Motors - Shaded Pole to ECM in Display cases	$55	motor
Evaporator Motors - Shaded Pole To ECM in Walk-in ≤ 23 watts	$140	motor
Evaporator Motors - Shaded Pole To ECM in Walk-in > 23 watts	$140	motor
Floating Head Pressure on Singles, LT Condensing Unit	$100	hp
Floating Head Pressure on Singles, MT Condensing Unit	$100	hp
Floating Head Pressure on Singles, LT Remote Condenser	$100	hp
Floating Head Pressure on Singles, MT Remote Condenser	$100	hp

2.2.1.4 Food Service Equipment

The Food Service Equipment Program provides incentives for the purchase and installation of energy efficient commercial food service equipment to Avista's electric (Schedule 11, 12, 21, 25) and natural gas (Schedule 101, 111, 121) customers. Equipment must be commercial grade and must meet Energy Star or Fishnick specifications. Certified equipment is 10-70% more efficient than standard equipment, depending on product type. Types of rebated equipment include fryers, steam cookers, hot food holding cabinets, commercial convection ovens, dish washers, commercial ice machines, pre-rinse sprayers, and commercial rack ovens. Table 2-4 summarizes the incentives available under the Food Service Equipment program. Avista implements this program in a prescriptive manner, and incentives are issued to the participating customer after the measure is installed.

Table 2-4: Food Service Equipment Program Measures

Equipment	Incentive
Commercial Convection Ovens	
Commercial Convection Oven, Natural Gas	$700/ Each
Commercial Convection Oven, Electric	$225/ Each
Commercial Combination Oven, Natural Gas	$1,000/ Each
Commercial Combination Oven, Electric	$1,000/ Each
Dish Washers	
Commercial Low Temp Electric Hot Water	$600/ Each
Commercial High Temp Electric Hot Water	$650/ Each
Commercial Low Temp Natural Gas Hot Water	$300/ Each
Commercial High Temp Natural Gas Hot Water	$350/ Each
Commercial Ice Machines	
Under 200 LBS/Day Capacity	$40/Each
200-399 LBS/Day Capacity	$60/Each
400-599 LBS/Day Capacity	$80/Each
600-799 LBS/Day Capacity	$100/Each
800-999 LBS/Day Capacity	$120/Each
1000-1199 LBS/Day Capacity	$140/Each
1200-1399 LBS/Day Capacity	$160/Each
1400-1599 LBS/Day Capacity	$180/Each
1600-> LBS/Day Capacity	$200/Each
Pre Rinse Sprayers	
1 to 1.00 GPM Electric	$25
.61 to .80 GPM Electric	$25
.81 to 1.00 GPM Natural Gas	$25
.61 to .80 GPM Natural Gas	$25
Commercial Rack Ovens	
Commercial Rack Ovens, Natural Gas	$235

2.2.1.5 Green Motor Rewind

The Green Motors Rewind program is implemented by the Green Motors Practice Group with Avista oversight. This program is available to electric (Schedule 11, 12, 21, 25, 31) customers who receive a green motor rewind at a participating service center. To participate, customers must take an existing motor to a participating service center to have a green rewind done. Customers receive an automatic rebate applied at the service center of $1 per hp based on the size of the motor. Motors ranging from 15 to 5,000 hp are eligible to participate. Motor service centers must meet specific criteria to be qualified for the program.

Table 2-5: Green Motor Rewinds Program Measures

Measure	Eligible Motor Size	Rebate
Green Motor Rewind	15 – 5,000 hp	$1 / hp

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2.2.1.6 Commercial HVAC Variable Frequency Drive (VFD) Program

This program encourages customers to increase HVAC pump and fan system efficiency through the installation of variable frequency drives (VFDs). Incentives are issued after measure installation. To be eligible for an incentive, a VFD must be installed on commercial heating, ventilation, and air conditioning equipment that is served by an Avista electric non-residential rate schedule (Schedule 11, 12, 21, 25). New construction projects are not eligible to participate. Additionally, only VFDs installed on primary pumps and fans are qualified. Secondary or spare pumps and fans do not qualify. Incentives are paid on a per-horsepower basis, depending on the application of the VFD, as shown in Table 2-6. Avista implements this program in a prescriptive manner, and incentives are issued to the participating customer after the measure is installed.

Table 2-6: Motor Controls HVAC Program Measures

Measure	Incentive per HP
VFD Fans	$80
VFD Cooling Pump Only	$85
VFD Heat Pump only or Combined Heating & Cooling Pump	$140

2.2.1.7 Commercial Clothes Washers

The Commercial Clothes Washer Program provides incentives to Avista's electric (Schedule 11, 12, 21, 25) or natural gas (Schedule 101, 111, 121) customers for the purchase and installation of an energy efficient commercial clothes washers. Clothes washers must be commercial grade units and must meet ENERGY STAR™ commercial clothes washer specifications. To be eligible for incentive, the clothes washer must be served by hot water that is generated using an Avista fuel source (e.g. a natural gas hot water heater on Avista natural gas service). The types of equipment eligible to participate in this program are listed in Table 2-7. Avista implements this program in a prescriptive manner, and incentives are issued to the participating customer after the measure is installed.

Table 2-7: Motor Controls HVAC Program Measures

Equipment	Rebate/ unit
ES Washer electric hot water and dryer	$75
ES Washer electric hot water and natural gas dryer	$75
ES Washer natural gas hot water and natural gas dryer	$75
ES Washer – natural gas hot water and electric dryer	$75

2.2.1.8 Power Management for Personal Computer Networks

This program encourages implementation of power management software to obtain energy efficiency. Power management software saves energy by shifting personal computers to a low-power operating state after a specified period of inactivity. When deployed on a network serving multiple personal computers, this type of software can achieve significant energy savings. Eligibility for participation in this program includes confirmation of electric usage, and submission of pre- and post-install usage data. Post-installation reporting may be required for a period of three years. The incentive available for this program is $5 per license. Avista implements this program in a prescriptive manner, and incentives are issued to the participating customer after the measure is installed.

Table 2-8: Power Management for PC Networks Program Measures

Measure	Incentive
PC Power Management Software	$5 / license

2.2.1.9 Commercial Windows & Insulation

The Commercial Windows & Insulation program offers incentives to Avista's non-residential electric (Schedule 11, 12, 21, 25) or natural gas (Schedule 101, 111, 121) customers for improvements to building envelopes through window upgrades and adding insulation. To participate in this prescriptive rebate program, customers must submit documentation of the project that includes post-installation R-values and affected square footage for insulation, and documentation of U-value, solar heat gain coefficient, and size for window replacements. The incentive levels for insulation project are dependent on the pre-and post-retrofit level of insulation. Avista implements this program in a prescriptive manner, and incentives are issued to the participating customer after the measure is installed.

Table 2-9: Commercial Windows & Insulation Measures

Measure	Incentive ($ / sf)
Less than R4 Wall Insulation to R-11-R18 Retrofit	$0.30
Less than R4 Wall Insulation to R19 or above Retrofit	$0.35
Less than R11 Attic Insulation to R30-R44 Retrofit	$0.20
Less than R11 Attic Insulation to R45 or above Retrofit	$0.25
Less than R11 Roof Insulation to R30 or above Retrofit	$0.25
Windows U-Factor of .35 or less and SHGC .35 or Less (New Construction)	$0.50
Windows U-Factor of .35 or less and SHGC .35 or Less (Retrofit)	$0.50

2.2.1.10 Commercial Water Heaters

The Commercial Water Heaters program provides incentive to electric (Schedule 11, 12, 21, 25) or natural gas (Schedule 101, 111, 121) customers for the purchase and installation of an energy efficient commercial water heater. Water heaters must be commercial grade units and must be served by an Avista fuel source. An incentive of $20 per unit is provided for qualified

water heaters. Water heater eligibility guidelines are outlined in Table 2-10. Avista implements this program in a prescriptive manner, and incentives are issued to the participating customer after the measure is installed.

Table 2-10: Commercial Water Heater Measures

Tank Size (gal)	Electric Energy Factor	Natural Gas Energy Factor	Incentive
Greater than or equal to 25 gallons but less than 35 gallons	0.90	0.70	$20
Greater than or equal to 35 gallons but less than 45 gallons	0.90	0.70	
Greater than or equal to 45 gallons but less than 55 gallons	0.90	0.70	
Greater than or equal to 55 gallons but less than 75 gallons	0.87	0.68	
Greater than or equal to 75 gallons but less than 100 gallons	0.87	0.68	
Greater than or equal to 100 gallons but less than 120 gallons	0.86	0.68	

2.2.1.11 Standby Generator Block Heater

This program provides an incentive to Avista's nonresidential electric customers (Schedule 11, 12, 21, 25) for the purchase and installation of a more efficient style of engine block heater. Traditional block heating technology employs a thermosiphon to drive circulation in an engine block. A more efficient option uses pump driven circulation and results in less wasted heat flow between the engine block and the ambient environment. This rebate is available for a retrofit only and requires pre-approval from Avista to do pre and post logging. The available incentive is $400 per heater.

Table 2-11: Fleet Heat Measures

Measure	Incentive
Standby Generator Block Heater	$400 / unit

2.2.1.12 Natural Gas HVAC

This program offers direct incentives to Avista's nonresidential gas customers (Schedule 101, 111, 121) for installing high efficiency natural gas HVAC equipment. The Natural Gas HVAC program encourages customers to select a high efficiency solution when making upgrades to the heating systems serving their businesses. Equipment eligibility guidelines are outlined in Table 2-12. Avista implements this program in a prescriptive manner, and incentives are issued to the participating customer after the measure is installed.

Table 2-12: Natural Gas HVAC Measures

Equipment	Efficiency	Incentive per input kBtu
Natural Gas Single Stage Furnace <225 kBtu/hr	90%–94.9% AFUE	$6.00
	95% AFUE or greater	$7.00
Natural Gas Multi Stage Furnace <225 kBtu/hr	90%–94.9%	$7.00
	95% AFUE or greater	$10.00
Natural Gas Boiler <300 kBtu/hr	85%–89.9%	$4.00
	90% AFUE or greater	$7.00

2.2.2 Small Business

The Small Business (SB) program is administered by SBW consulting and is a direct installation/audit program providing customer energy-efficiency opportunities by: (1) directly installing appropriate energy-saving measures at each target site, (2) conducting a brief onsite audit to identify customer opportunities and interest in existing Avista programs, and (3) providing materials and contact information so that customers are able to follow up with additional energy efficiency measures under existing programs. This program is only available to customers who receive electric service under Rate Schedule 11 in Washington and Idaho, and to customers who receive natural gas service under Rate Schedule 101 in Washington. Schedule 11 customers typically use less than 250,000 kWh per year.

Direct-install measures include faucet aerators, showerheads, pre-rinse spray valves, screw-in LEDs, smart strips, CoolerMisers, and VendingMisers (Table 2-13). The evaluation team conducted onsite verification, documentation audits, and engineering analysis to determine verified gross savings for each measure in the program.

Table 2-13: Small Business Program Measure Overview

Category	Measure Description	Cost
Lighting	Screw in LED Lamp (40W Equivalent)	$17 /lamp
	Screw in LED Lamp (60W Equivalent)	$17 /lamp
	Screw in LED Lamp (100W Equivalent)	$31 /lamp
	Screw in LED BR30	$22 /lamp
	Screw in LED BR40	$28 /lamp
	Screw in LED PAR30	$28 /lamp
	Screw in LEDPAR38	$32 /lamp
Hot Water	Low-flow faucet aerator (0.5 gpm) Electric Water Heat	$8 /unit
	Low-flow faucet aerator (1.0 gpm) Electric Water Heat	$8 /unit
	Low-flow faucet aerator (0.5 gpm) Gas Water Heat	$8 /unit
	Low-flow faucet aerator (1.0 gpm) Gas Water Heat	$8 /unit
	Pre-Rinse Spray Valve Electric Heat	$129 /unit
	Pre-Rinse Spray Valve Gas Heat	$129 /unit
	Shower Head Fitness Electric	$41 /unit
	Shower Head Fitness Gas	$41 /unit
	Shower Head Electric	$41 /unit
	Shower Head Gas	$41 /unit
Cooler Miser	Control for glass-front cooler that uses passive infrared (PIR) sensor to power down machine when surrounding area is vacant	$225 /unit
Vending Miser	Control for refrigerated beverage machine that uses passive infrared (PIR) sensor to power down machine when surrounding area is vacant	$225 /unit
Tier 1 Smart Power Strip	Eliminate standby power draw of peripheral devices while continuing to power devices in “hot” outlets	$39 /unit

2.2.3 Residential

Avista’s residential portfolio is composed of several approaches to engage and encourage customers to consider energy-efficiency improvements in their homes. Prescriptive rebate programs are the main component of the portfolio, together with a variety of other interventions. These include upstream buy-down of low-cost lighting and water-saving measures; select distribution of low-cost lighting and weatherization materials; an appliance recycling program; a low-interest loan program; direct-install programs; and a multi-faceted, multichannel outreach and customer engagement effort.

Throughout 2014 and 2015, Avista provided incentives and services for its residential electric and gas customers in its Washington service territory and for residential electric customers

throughout its Idaho service territory. The evaluation team examined nine core programs in Washington that constituted the bulk of Avista's residential energy-efficiency offerings in 2014 and 2015. Table 2-14 provides a summary of those programs, and the sections below detail each program.

Table 2-14: Residential Program Type and Description

Type	Programs	Implementer	Description
Rebate	Appliance Recycling	JACO	Rebate for recycling fridge or freezer older than 1995. This program was discontinued in June 2015.
	ENERGY STAR® Homes	Avista	Rebate for purchase of ENERGY STAR® home
	Fuel Efficiency	Avista	Rebate for conversion of electric to natural gas furnace and/or water heater
	HVAC Program	Avista	Rebate for purchase of energy efficient and high efficiency HVAC equipment, including variable speed motors, air source heat pump, natural gas furnace and boiler, and smart thermostat
	Shell	Avista	Rebate for adding insulation to attic, walls, and floor, as well as adding energy efficient windows. Rebate for the UCONS duct sealing program measure discontinued at end of 2014.
	Water Heater	Avista	Rebate for installation of high efficiency gas or electric water heater, natural gas water heater, and Smart Savings showerhead. Rebate for the UCONS showerhead program measure discontinued at end of 2014.
Midstream	Residential Lighting: Simple Steps, Smart Savings	CLEAResult	Direct manufacture discount for purchase of approved CFLs, LEDs (bulbs and fixtures), and low-flow showerheads. Rebate for the UCONS lighting program measures discontinued at end of 2014.
Behavior	Home Energy Reports	Opower	The Opower program generates behavioral savings from a treatment group, which receives Home Energy Reports, which compares the customers energy usage to similar homes in Avista's service territory.
Low-income	Low-income Programs	Community Action Partners (CAPs)	CAPs within Avista's Washington and Idaho service territories implement the projects. CAPs determine energy-efficiency measure installations based on the results of a home energy audit.

2.2.3.1 Appliance Recycling

The appliance recycling program, administered by JACO Environmental Inc., provided a pick-up and recycling service for operational refrigerators or freezers manufactured before 1995. JACO provided the pick-up service free to customers and the $30 rebate was provided for each

operational refrigerator and/or freezer, up to two per household (Table 2-15). JACO provided the following data points to Avista on a monthly basis: date of pick-up, customer name, address, city state zip, type of unit collected and number of units collected. The appliance recycling program ceased operation in June 2015 as a result of revised RTF values that became effective in July of 2015 causing the program to cease to be cost-effective.

Table 2-15 Appliance Recycling Measures and Incentives

Measure	Rebate
Pre-1995 Freezer	$30
Pre-1995 Refrigerator	$30

2.2.3.2 HVAC Program

Avista internally manages the HVAC program which encourages the implementation of high efficiency HVAC equipment and smart thermostats through direct incentives issued to the customer after the measure has been installed (Table 2-16). This program is available to all residential electric or natural gas customers with a winter heating season usage of 4,000 or more kilowatt hours, or at least 160 therms of space heating the prior year. Existing or new construction homes are eligible.

Table 2-16 HVAC Measure Overview

Fuel Efficiency Measures	Rebate
Variable speed motor	$100
Electric to air source heat pump	$900
High efficiency natural gas furnace	$250
High efficiency natural gas boiler	$250
Smart thermostat	$50 or $100

2.2.3.3 Water Heat

Customers replacing their existing electric or natural gas water heater are eligible to receive a rebate for selecting a high efficiency option. This program also includes discounted showerheads available at participating retailers throughout Avista's WA and ID service territory under the Simple Steps, Smart Savings program. In 2014 this program included direct installs of low-flow showerheads implemented by UCONS. Table 2-17 outlines the measures offered and rebate per unit.

Table 2-17 Water Heat Program Measure Overview

Water Heat Measure	Rebate
Electric; 35-55 gallon with 0.94 EF or higher	$20
Natural Gas; 40 gallon with 0.62 EF or higher	$20
Natural Gas; 50 gallon with 0.60 EF or higher	$20
Natural Gas: Tankless with 0.82 EF or higher	$130
Simple Steps, Smart Savings Low-flow Showerheads: 1.5-2 GPM	buydown
UCONS Low-Flow Showerheads	Direct install

2.2.3.4 ENERGY STAR® Homes

ENERGY STAR® certified home construction is administered by a Northwest Energy Efficiency Alliance (NEEA) regional program. Avista provides a rebate for homes within their service territory that successfully make it through this ENERGY STAR® certification process. In addition to NEEA's program, the manufactured homes industry has established a labeling program for Energy Star certified manufactured homes, which Avista also incentivizes. New home buyers can apply for an $800 rebate for an ENERGY STAR® ECO-rated new manufactured home or $1,000 for an ENERGY STAR® stick-built home. The purchaser must submit the application and certification paperwork to Avista within 90 days of occupying the residence. The ENERGY STAR® home rebate may not be combined with other Avista individual measure rebates (e.g. high efficiency water heaters).

Table 2-18 describes eligible measures available for the program.

Table 2-18 ENERGY STAR® Homes Measure Overview

Energy Star Home Measure	Rebate
Stick built – electric	$1,000
Stick built or manufactured w/ gas only	$650
Manufactured w/ furnace	$800
Manufactured w/ heat pump	$800

2.2.3.5 Fuel Efficiency Program

The fuel efficiency program offers a rebate for the conversion of electric straight resistance heat to natural gas, as well as the conversion of electric hot water heaters to natural gas models. The home must have used 4,000 or more kWh of electric space heat during the previous winter season to be eligible for flat-rate rebates. If natural gas is not available or is not suitable for the home, the installation of an air source heat pump as a replacement unit is accepted (see electric to air source heat pump measure under 2.2.3.2 HVAC Program.

Table 2-19 Fuel Efficiency Measure Overview

Fuel Efficiency Measures	Savings (kWh)	Rebate
Electric to natural gas conversion – space heat	12,012	$2,300
Electric to natural gas conversion – water heat	4,031	$600
Electric to natural furnace and water heat – combo	16,043	$3,200
Electric to natural gas wall heaters – space heat	10,932	$1,300

2.2.3.6 Residential Lighting

The Simple Steps, Smart Savings program provides discounts to manufacturers to lower the price of efficient light bulbs, light fixtures, showerheads, and appliances. This program, launched by Bonneville Power Administration (BPA) and administered by CLEAResult, operates across the Pacific Northwest. Utilities are able to select which reduced price items to include in their territory. Avista's offerings include a selection of general and special CFLs, LED light fixtures, and LED bulbs[2]. Retailers such a big box stores and regional and national chains are the primary recipient of the product and typically select from Avista's approved options what they will carry at their store location. These products are clearly identified with a sticker indicating they are part of the Simple Steps, Smart Savings program. Avista also encourages the use of the LightRecycle CFL recycling locations throughout their Washington service territory, to further support the utilization of CFL's. In 2014 this program included direct installs of CFL's implemented by UCONS.

2.2.3.7 Shell Program

Avista's internally managed shell program incentivizes measures that improve the integrity of the home's envelope (Table 2-20). For insulation and windows: rebates are issued to the customer after measure has been installed. Eligibility guidelines for participation include but may not be limited to: confirmation of electric or natural gas heating usage, itemized invoices including insulation levels or window values and square footage. Pre and/or post-inspection of insulation and windows may occur as necessary throughout the year. Customer must demonstrate a winter heating season electricity usage of 4,000 kilowatt hours or 160 therms to be eligible for insulation and window program participation. Addition of insulation that increases the R-value by R-10 or greater for both fitted/batt type and blow-in products are eligible. Windows with a U-factor of 0.30 or less that replace single or double pane windows are eligible. In 2014, this program included free manufactured home duct-sealing component implemented by UCONS. The manufactured home duct sealing component was conducted in partnership with the Community Energy Efficiency Program funded by WSU-Energy.

[2] Avista offered LED bulbs in 2014 and the last half of 2015.

Table 2-20 Shell Measure Overview

Fuel Efficiency Measures	Existing Equipment Efficiency	Rebate ($/sf)
Attic insulation	R-19 or less	$0.15
Wall insulation	R-5 or less	$0.25
Floor insulation	R-5 or less	$0.20
Window insulation	0.30 u-factor or lower	$4.00
Manufactured Home Duct Sealing (UCONS, 2014 only, Level1-3)	N/A	No cost to customer

2.2.3.8 Home Energy Reports

Avista provides peer comparison reports of home energy consumption, termed Home Energy Reports (HER), through Opower. This is an opt-out program aimed to encourage customers to save energy. 73,500 customers were initially mailed HERs in June of 2013: 48,300 to WA customers and 25,200 to ID customers. The cadence of reports began by sending out a report every month for the first three months followed by a bi-monthly mailing of reports thereafter, continuing until June 2016. Customers must be a recipient of Avista electricity to qualify. Reports do not have a gas or dual fuel focus, though approximately 42% of recipients also have a gas meter.

2.2.3.9 Low Income

Avista leverages Community Action Program (CAP) agencies to deliver energy efficiency programs to low-income customers. CAP agencies have resources to income qualify, prioritize and treat homes based upon a number of characteristics. In addition to the Company's annual funding, the Agencies have other monetary resources that they can usually leverage when treating a home with weatherization and other energy efficiency measures. The Agencies either have in-house or contractor crews to install many of the efficiency measures of the program.

Six CAP agencies serve Avista's Washington service territory and receive a total annual funding about of $2 million (Table 2-21). Included in this amount is a permissible 15% reimbursement for administrative costs. Each agency may allocate an additional 15% of funds for expenditure on non-energy health and safety measures that may support the energy efficiency measures installed or help improve the home's habitability.

Table 2-21 Low Income CAP Agencies

CAP Agency	Serving Counties
Spokane Neighborhood Action Program	Spokane
Rural Resources	Stevens, Pend Oreille, Ferry and Lincoln
Whitman County Community Action Center	Whitman
Opportunities Industrialization Council	Grant, Adams
Community Action Partnership – Lewiston	Asotin
Washington Gorge Action Programs	Skamania, Klickitat

Avista provides CAP agencies with an “approved measure list”, the items on this list are reimbursed 100% (Table 2-22). Avista also provides a “rebate list” of additional energy saving measures the CAP agencies are able to utilize (Table 2-23).

Table 2-22 Low Income Approved Measure List (100% of costs offset by Avista)

Measures
Electric to Gas Furnace Conversion
Electric to Gas Water Heater Conversion
Insulation (ceiling / attic, floors and walls)
Insulation (duct) / Duct sealing
Air Infiltration
Energy Star® Doors
Energy Star® Windows (gas heat)

Table 2-23 Low Income Rebate List

Measures
Electric to air source heat pump (when natural gas not viable)
Electric to natural gas water heater
Electric Water Heater (0.93 EF)
Gas Water Heater (0.62 EF)
Air Source Heat Pump
Gas Furnace (>90% AFUE)
Duct insulation (electric heat)
Duct insulation (gas heat)
Energy Star® Windows
Energy Star® Refrigerators
Energy Star® Windows (electric heat)

2.3 Program Participation Summary

Reported participation and savings for Avista's 2014 and 2015 programs is outlined in Table 2-24 and Table 2-25.

Table 2-24 Avista Nonresidential Reported Participation and Savings

Program	2014-2015 Project Count	2014-2015 Reported Savings (therms)
Commercial Water Heaters	2	5
Commercial Windows & Insulation	54	32,930
Natural Gas HVAC	79	43,434
Food Service Equipment	68	55,687
Site Specific	106	717,544
Small Commercial	2,851*	14,503
TOTAL NONRESIDENTIAL	**3,160**	**864,103**

*Unique measures, not businesses

Table 2-25 Avista Residential Reported Participation and Savings

Program	2014-2015 Participation Count	2014-2015 Reported Savings (therms)
HVAC	3,851	401,855
ENERGY STAR Homes	22	4,669
Shell	3,119	411,239
Water Heat Program*	7,686	30,154
Low Income Conservation	1,084	14,719
Conservation Total	15,762	862,636
Fuel Efficiency (Fuel Conversion)	613	(314,247)
Low Income Fuel Conversion	373	(13,249)
Fuel Conversion Total	986	(327,497)
TOTAL RESIDENTIAL		**535,139**

*Includes counts for both projects and showerheads

2.4 Evaluation Goals and Objectives

"Model Energy-Efficiency Program Impact Evaluation Guide – A Resource of the National Action Plan for Energy Efficiency," published in November 2007. The report states:

> *Evaluation is the process of determining and documenting the results, benefits, and lessons learned from an energy-efficiency program. Evaluation results can be used in planning future programs and determining the value and potential of a portfolio of energy-efficiency programs in an integrated resource planning*

process. It can also be used in retrospectively determining the performance (and resulting payments, incentives, or penalties) of contractors and administrators responsible for implementing efficiency programs.

Evaluation has two key objectives:

1. To document and measure the effects of a program and determine whether it met its goals with respect to being a reliable energy resource.

2. To help understand why those effects occurred and identify ways to improve.

Avista has identified the following objectives for the evaluation:

- Independently verify, measure and document energy savings impacts from Avista's electric and natural gas energy efficiency programs, or for program categories representing consolidated small scale program offerings, by Avista in 2014 and 2015
- Analytically substantiate the measurement of those savings
- Calculate the cost effectiveness of the portfolio and component programs
- Identify program improvements, if any,
- Identify possible future programs.

3 Impact Evaluation Methodology

The impact evaluation evaluated the gross savings attributable to Avista's 2014 and 2015 energy-efficiency programs. Impact evaluations generally seek to quantify the energy and, when possible, the non-energy savings that have resulted from DSM program operations. These savings may be expressed as all of the changes resulting from the program (gross savings), or only those changes that would not have occurred absent the program (net savings).

The evaluation team verified the gross energy savings of Avista's 2014 and 2015 programs by:

- Understanding the program context
- Designing the impact evaluation sample
- Verifying the project and program savings through document review, telephone surveys, onsite measurement and verification, and billing analysis
- Comparing Avista-reported savings to savings verified during project-level evaluations to determine verified gross savings.

3.1 Understanding the Program Context

The first significant step of the evaluation activities was to gain a comprehensive understanding of the programs and measures being evaluated. Specifically, the team explored the following documents and data records:

- Avista's 2014 and 2015 Demand Side Management (DSM) Business Plans which detail processes and energy savings justifications
- Program tracking databases/spreadsheets and participation through December 2014
- Project documents from external sources, such as documents from customers, program consultants, or implementation contractors.

Based on the initial review, the evaluation team outlined the distribution of program contributions to the overall portfolio of programs. In addition, the review allowed the evaluation team to understand the sources for unit energy savings for each measure offered in the programs, along with the sources for energy-savings algorithms and the internal quality assurance and quality control (QA/QC) processes for large nonresidential projects. Following this review, the evaluation team designed the sample strategy for the impact evaluation activities, as discussed in the following section.

3.2 Designing the Sample

Sample development enabled the evaluation team to deliver meaningful, defensible results to Avista. The sampling methodology used for the impact evaluation was guided by a value of information (VOI) framework, which allowed the team to target activities and respondents with expected high impact and yield, while representing the entire population of interest. In general,

VOI focuses budgets and rigor towards the programs/projects with high uncertainty and high impact[3].

For the sample design, the evaluation team organized the programs into evaluation "bins," segmenting the programs based on two metrics:

- **Program Uncertainty:** The risks associated with a program's reported savings were broken into three categories: high, medium, and low. Risks included custom vs. deemed vs. Regional Technical Forum status, delivery mechanism, performance goals, etc.
- **Program Size:** A determination of size—either large or small—was based on projected energy savings and planned budget allocations.

Bins were created for: (1) residential and nonresidential programs and (2) electric (Washington/Idaho) and natural gas (Washington) programs.

In parallel, the evaluation team calculated a "level of rigor" value for each program; based on assumed measure complexity and Regional Technical Forum (RTF) influence, the team identified an appropriate level of sampling and evaluation rigor.

- **Level of Sampling:** Defined as confidence/precision (C/P) for calculating sample sizes, the evaluation team used three levels for sampling: 90/10, 85/15, or 80/20 C/P.
- **Evaluation Rigor:** Defined as the level of detail used for the evaluation activities, the team identified four levels of increasing evaluation rigor: document audit, surveys, onsite inspections, and billing analysis. In many cases, a combination of these four approaches was used to both validate savings and provide insights into any identified discrepancies between reported and verified savings values.

The evaluation bin identified for each program was one factor in determining the sample size and level of rigor for the evaluation activities. Additional factors that influenced the sample size and level of rigor included evaluation costs, RTF influence, and findings and recommendations from previous evaluations.

Table 3-1 and Table 3-2 show the anticipated confidence/precision level, planned sample sizes, and level of rigor, by program, for the Washington natural gas residential and nonresidential portfolios. The samples are drawn to meet the specified confidence/precision for each program and to meet 90% confidence and 10% precision at the portfolio level[4].

[3] See Appendix A for detailed discussion on sampling and estimation.

[4] See Appendix A for detailed information on the presentation of uncertainty.

Table 3-1: Planned Sampling and Evaluation Rigor for Washington Gas Residential Programs

Gas Residential Program	Target C/P	Document Audit	Surveys	Billing Analysis
Water Heat Program*	80/20	11	11	
ENERGY STAR Homes	85/15	13	13	census
HVAC Program	95/15	46	46	census
Fuel Efficiency Program	85/15	24	24	census
Shell Program	95/15	46	46	census**
Low Income	85/15	24		census
TOTAL		**164**	**140**	

*Includes Simple Steps, Smart Savings upstream showerhead component
**Focus on manufactured homes

Table 3-2: Planned Sampling and Evaluation Rigor for Washington Gas Nonresidential Programs

Gas Nonresidential Program	Target C/P	Document Audit	Surveys	Onsite Inspections	Billing Analysis
Commercial Water Heaters	80/20	11			
Commercial Windows & Insulation	80/20	24	11	11	
Natural Gas HVAC	85/15	24			
Food Service Equipment	80/20	11			
Site Specific	90/10	43	24	24	based on IPMVP[5]
Small Business	90/15	31	31	31	
TOTAL		**144**	**66**	**66**	

Table 3-3 and Table 3-4 show the achieved sample sizes and confidence/precision levels for the Washington natural gas residential and nonresidential portfolios.

[5] International Performance Measurement and Verification Protocol

Table 3-3: Achieved Sampling and Confidence/Precision for Washington Gas Residential Programs

Natural Gas Residential Program	Achieved C/P	Document Audit	Surveys	Billing Analysis
Water Heat Program	90/13	12	11	
ENERGY STAR Homes	90/44	11	11	
HVAC Program	90/5	46	48	
Fuel Efficiency Program	90/27	26	25	√
Shell Program	90/18	47	47	√
Low Income	90/25*	24	0	√
TOTAL	**90/5***	**166**	**142**	

*Conservation projects only, does not include fuel conversion projects

Table 3-4: Achieved Sampling and Evaluation Rigor for Washington Gas Nonresidential Programs

Gas Nonresidential Program	Achieved C/P	Document Audit	Surveys	Onsite Inspections
Commercial Water Heaters	90/0	2	1	1
Commercial Windows & Insulation	90/15	24	11	11
Natural Gas HVAC	90/5	24		
Food Service Equipment	90/14	11		
Site Specific	90/22	45	26	26
TOTAL	**90/14**	**106**	**38**	**38**
Small Business	90/59	31	31	31
TOTAL INCLUDING SMALL BUSINESS:		**137**	**69**	**69**

3.3 Database Review

For the Small Business and Residential programs, the evaluation team conducted a review of the program databases as provided by Avista and its third-party implementers. The purpose of the review was to look for large outliers in program-reported data and to remove any duplicate entries found in the databases. The outcome of the database review was an “adjusted reported” participation count and savings value for each measure and program. The realization rate that the evaluation team calculated as part of the gross verified savings activities, described in the following section, was then applied to the adjusted reported savings value.

3.4 Verifying the Sample – Gross Verified Savings

The next step in the impact evaluation process was to determine the gross impacts, which are the energy savings that are found at a customer site as the direct result of a program’s

operation; net impacts are the result of customer and market behavior that can add to or subtract from a program's direct results.

The impact evaluation activities resulted in realization rates, which were applied to the adjusted/ reported savings. The ratio of the savings determined from the site inspections, measurement and verification (M&V) activities, or engineering calculations to the program-reported savings was the project realization rate; the program realization rate was the weighted average for all projects in the sample. The savings obtained by multiplying the program realization rates by the program-adjusted/reported savings were termed the gross verified savings. These gross verified savings reflect the direct energy and demand impact of the program's operations.

Total program gross savings were adjusted using the following equation:

$$Therms_{adj} = Therms_{rep} * Realization\ Rate$$

Where:

$Therms_{adj}$	=	Therms calculated by the evaluation team for the program, the gross impact
$Therms_{rep}$	=	Therms reported/adjusted for the program
Realization rate	=	weighted average $Therms_{adj} / Therms_{rep}$ for the research sample

The estimate of gross verified energy savings occurred through one or more levels of evaluation rigor, as detailed in the following sections.

3.4.1 Document Audit

The first level of rigor that the evaluation team used was a document audit of all sampled projects for which documentation existed. Document audits were also a critical precursor for conducting telephone surveys and onsite inspections and, more specifically, for determining project-specific variables to be collected during these activities. The document audit for each sampled project sought to answer three questions:

- Were the data files of the sampled projects complete, well documented, and adequate for calculating and reporting the savings?
- Were the calculation methods correctly applied, appropriate, and accurate?
- Were all the necessary fields properly populated?

3.4.2 Telephone Survey

A second level of evaluation rigor was through stand-alone telephone surveys with program participants. Telephone surveys were conducted in conjunction with the process evaluation activities and were used to gather information on the energy-efficiency measure implemented, the key parameters needed to verify the assumptions used to estimate verified energy savings, and any baseline data that may be available from the participant.

3.4.3 Onsite Measurement and Verification

A sample of projects in the nonresidential sector was selected for onsite measurement and verification activities. Before conducting site inspections, it was important for field engineers to understand the project that they were verifying. This understanding built from the document-audit task discussed earlier. For all onsite inspections, a telephone survey served as an introduction to the evaluation activities and was used to confirm that the customer participated in the program, to confirm the appropriate contact, and to verify basic information such as building type and building size. All onsite activities were conducted by evaluation team field engineers.

The evaluation team conducted two levels of rigor associated with the onsite inspections – measurement and verification (M&V) and verification-only (V). Upon review of the project documents, the evaluation team decided which level of rigor was appropriate for each sampled project/measure. In cases where the measure had an approved RTF UES value, the evaluation team's effort focused on verifying the quality and quantity of installation to apply the RTF UES values to.

An M&V plan was developed for each M&V-designated project. The team based these plans on a review of the available calculation methods and assumptions used for determining measure-level energy savings. These plans aided in understanding what data to collect during onsite visits and telephone surveys to calculate gross verified savings for each sampled project.

M&V methods were developed with adherence to the IPMVP. As defined by IMPVP, the general equation for energy savings is defined as: [6]

Normalized Savings =

(Baseline Energy ± Routine Adjustments to fixed conditions ± Non-Routine Adjustments to fixed conditions) - (Reporting Period Energy ± Routine Adjustments to fixed conditions ± Non-Routine Adjustments to fixed conditions)

The broad categories of the IPMVP are as follows:

- Option A, Retrofit Isolation: Key Parameter Measurement – This method uses engineering calculations, along with partial site measurements, to verify the savings resulting from specific measures.
- Option B, Retrofit Isolation: All Parameter Measurement – This method uses engineering calculations, along with ongoing site measurements, to verify the savings resulting from specific measures.
- Option C, Whole Facility: This method uses whole-facility energy usage information, most often focusing on a utility bill analysis, to evaluate savings.

[6] Efficiency Valuation Organization (EVO) "International Performance Measurement and Verification Protocol (IMPVP) Concepts and Options for Determining Energy and Water Savings Volume 1", April 2007, page 19.

- Option D, Calibrated Simulation: Computer energy models are employed to calculate savings as a function of the important independent variables. The models must include verified inputs that accurately characterize the project and must be calibrated to match actual energy usage.

In addition, the evaluation team conducted metering tasks on a subset of the onsite inspection sample chosen for the M&V level of rigor. Projects were selected for metering activities based on the measure type, project complexity, and the level of information needed to estimate gross savings for the project.

3.4.4 Billing Analysis

Participants received an assortment of efficiency measures through Avista's residential rebate programs. Billing analyses are generally considered a best practice for calculating energy savings resulting from "whole-house" efficiency retrofits. Thus, because of the diverse and interactive savings profiles associated with the improvements, the evaluation team determined that a utility bill regression analysis (IPMVP Option C) was the best method for quantifying energy savings resulting from the programs' treatment measures.

The utility billing analysis used data from participating customers who had sufficient utility-billed consumption records before and after the measure installation. Specifically, the evaluation team used a billing analysis approach for estimating gross verified savings for some or all measures in the Shell and Low Income programs. The remainder of this section outlines the general approach that the team followed for conducting the billing analysis. More specific details related to each program and measure evaluation are provided in Section 6.

The evaluation team requested program tracking data and complete billing histories for Avista's residential rebate program participants. IPMVP Option C utility bill analysis works best when at least one full year of utility billing data before and after the measure installation are available for comparison. This ensures that seasonal effects of the improvements are captured in the savings estimates. However, because of the timing of measure installations and the nature of certain programs, some customers had a limited amount of pre-retrofit and/or post-retrofit billing data. For example, accounts under the ENERGY STAR® Homes program do not have any "pre" billing data and, as a result, alternative methods were applied.

Before performing the analysis, utility billing records were assessed for quality and completeness. Duplicate observations were removed from the billing data. Billing periods of more than 35 days or less than 26 days were also excluded from the dataset because these observations are not representative of a typical billing cycle.

In addition to program participation records and customer billing histories, the evaluation team collected daily temperature records and normal weather conditions (TMY3) from three weather stations located in Avista's service territory. Observed temperature records were used to calculate the number of heating degree days (HDD) in each customer's monthly billing period. Weather stations used by the evaluation team include Coeur d'Alene, Idaho; Lewiston, Idaho;

and Spokane, Washington. Each participant was matched to the nearest weather station based on service address.

Gross verified energy savings were calculated by comparing billed consumption in months prior to the measure installations to the billed consumption in months after the measure installations. For most programs the evaluation team required homes to have 12 months of pre-retrofit consumption and 12-months of post-retrofit consumption for inclusion in the billing analysis. In cases in which participation was limited, this requirement was relaxed to increase sample sizes, provided that the participating homes had data from the key seasons.

Table 3-5 defines the terms and coefficients shown in Equation 3-1, which shows the general model specification used for gas measures.

Equation 3-1: Regression Model Specification for Gas Measures

$$\text{Therms}_{it} = \beta_i + \beta_1 \times \text{Post}_{it} + \beta_2 \times \text{HDD}_{it} + \beta_3(\text{Post} \times \text{HDD})_{it} + \epsilon_{it}$$

Table 3-5: Fixed Effects Regression Model Definition of Terms

Variable	Definition
Therms_{it}	Estimated consumption in home i during period t (dependent variable)
Post_{it}	Indicator variable denoting pre-installation period vs. post-installation period
HDD_{it}	Average heating degree days during period t at home i
β_i	Customer specific model intercept representing baseline consumption
$\beta_{1\text{-}3}$	Coefficients determined via regression describing impacts associated with independent variables
ϵ_{it}	Customer-level random error

Equation 3-1 was used to determine the coefficients describing the relationship between gas consumption and weather. That relationship was then applied to normal weather conditions to estimate average annual consumption in the pre-installation and post-installation periods to calculate weather normalized savings.

The evaluation team used a multi-faceted approach to estimate savings for many of Avista's programs. The evaluation team used the fixed-effects regression models summarized above, together with a pooled approach, which combined all participants and billing periods into a single regression analysis to estimate weather normalized savings at the program or measure level. In some cases, the team then ran individual customer regressions to obtain weather normalized savings estimates for each customer, allowing for a more granular assessment of how savings magnitudes were distributed across the program or measure population.

4 Nonresidential Impact Evaluation

This section outlines the impact evaluation methodology and findings for each of the evaluated nonresidential programs.

4.1 Overview

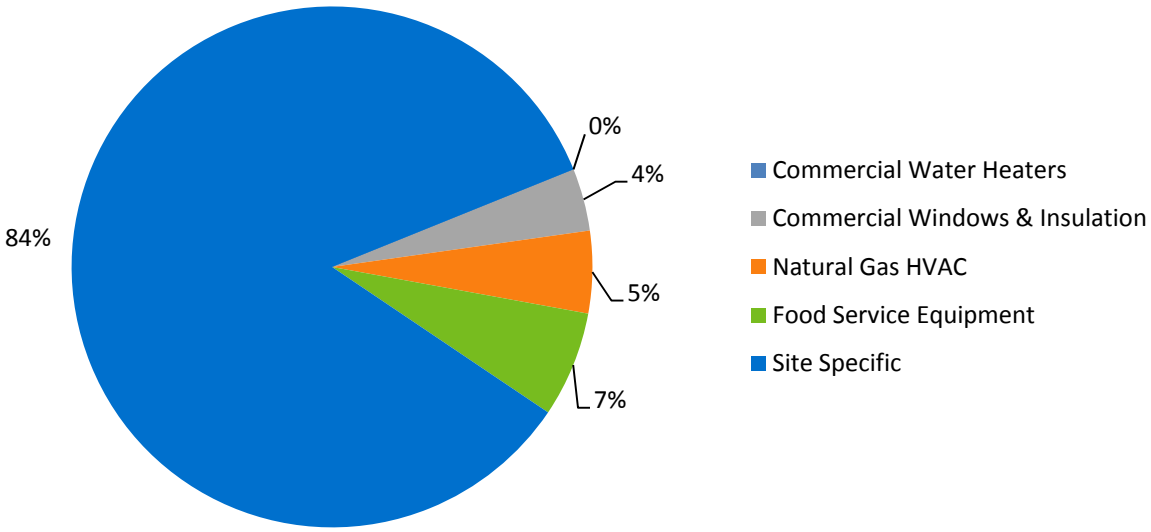
Avista reported natural gas savings in five nonresidential programs in their Washington service territory in 2014 and 2015, plus the Small Business program which is described in Section 5. No participation was reported for the Commercial Clothes Washers program. The reported natural gas savings (therms) for the six nonresidential programs are summarized in Table 4-1.

Table 4-1: Nonresidential Program Reported Savings

Washington Gas Nonresidential Program	2014-2015 Reported Savings (therms)
Commercial Water Heaters	5
Commercial Windows & Insulation	32,930
Commercial Clothes Washers	0
Natural Gas HVAC	43,434
Food Service Equipment	55,687
Site Specific	717,544
Portfolio Total	**849,600**

The Site Specific program contributes the largest share of the reported savings, 84% as shown in Figure 4-1. The Food Service Equipment program contributes the second largest share, 7%.

Figure 4-1: Nonresidential Program Reported Energy Savings Shares



The evaluation team designed a sampling strategy for these programs placing the most emphasis on the Site Specific program because of its large share of savings. The Site Specific program was divided into two strata based on reported savings. As part of the evaluation activities, a total of 109 document audits were conducted, and onsite inspections were conducted on a sub-sample of 41 projects, as shown in Table 4-2. Engineering activities included review of savings calculation methodology and assumptions, verification of operating hours through participant surveys and included use of data loggers in some cases, utility bill analysis, review of energy management system trend data, and energy savings analysis.

Table 4-2: Nonresidential Program Achieved Evaluation Sample

Program	Achieved C/P	Document Audit	Survey	OnSite Inspections
Commercial Water Heaters	90/0	2	1	1
Commercial Windows & Insulation	90/15	24	11	11
Natural Gas HVAC	90/5	24		
Food Service Equipment	90/14	11		
Site Specific Large (> 40,000 therms)	90/22	4	4	4
Site Specific Small (< 40,000 therms)		41	22	22
TOTAL	**90/14**	**106**	**38**	**38**

4.2 Commercial Water Heaters

4.2.1 Overview

The Commercial Water Heaters program encourages nonresidential customers to improve the efficiency of their water heating equipment. The program is internally implemented by Avista.

4.2.2 Program Achievements and Participation Summary

A total of 2 Commercial Water Heater projects were installed in Washington across the 2014 and 2015 program years. Table 4-3 summarizes Avista's 2014-2015 Commercial Water Heaters Program energy impacts.

Table 4-3: Commercial Water Heaters Reported Energy Savings by Measure

Measure Type	Reported Energy Savings (therms)	% Gas Savings
Com Water Heater	5	100%

4.2.3 Methodology

The impact evaluation included the following engineering activities: desk reviews of project documentation, review of Avista's savings methodology, and engineering savings calculations.

4.2.3.1 Sampling

The evaluation team conducted document audits for both projects, and customer surveys and onsite inspections were completed at one of these projects (Table 4-4). Low program participation prevented Nexant from achieving the original sample design of 11 projects..

Table 4-4: Commercial Water Heaters Achieved Sample

Program	Document Audit	Survey	OnSite Inspections
Commercial Water Heaters	2	1	1

4.2.3.2 Document Audits

Project documentation was requested for each sampled project, including invoices, savings calculations, work order forms, equipment specification sheets, and any other project records that may exist. Thorough review of this documentation was the first crucial step in evaluation of each project.

4.2.3.3 Field Inspections

Field inspections were not originally planned for this program. However, one of the participating sites was recruited for field inspection for another program, so Nexant engineers performed field verification of the water heater retrofit while on-site.

Table 4-5 summarizes the information that was collected for each project during the onsite inspection. All parameters needed to support the savings analysis of a project were collected, including fixture counts, baseline and post-retrofit wattages, hours of operation, and HVAC

system information (to inform calculation of interactive effects).

Table 4-5: Prescriptive Lighting Onsite Data Collection

End Use Category	Baseline	Retrofit
All Facilities	Year facility was built Number of occupants Number of stories Business Type Operating Hours, posted or otherwise Total conditioned square footage Heating system type/age/efficiency/size/condition Cooling system type/age/efficiency/size/condition	
Lighting	Lamp Type (e.g., T8, T12) Ballast Type (mag. or elec.) Lamp Size (4 ft. or 8 ft.) Quantity of Lamps per Fixture Wattage per Lamp Fixture Quantity Operating Hours Control Type	Lamp Type Confirm Electronic Ballast and Factor Lamp Size Quantity of Lamps per Fixture Wattage per Lamp Fixture Quantity Operating Hours Control Type Confirm ENERGY STAR© rating

4.2.3.4 Impact Analysis Methods

For these measures, the evaluation team reviewed the RTF workbooks for electric water heater replacements[7] and updated the savings calculation to apply to gas water heaters instead of electric water heaters. Avista uses a similar methodology for this program.

[7] Commercial DWH: Efficient Tanks. v3.0. Available from: http://rtf.nwcouncil.org/measures/measure.asp?id=102#

4.2.4 Findings and Recommendations

The evaluation team's gross verified savings values for these projects resulted in a realization rate of 127% for this program. Nexant and Avista used a similar methodology for this program, but Nexant's analysis was based on a more recent RTF workbook. Table 4-6 summarizes the findings of the realization rate for energy benefits for the Commercial Water Heaters program.

Table 4-6: Commercial Water Heater Realization Rate Results

Program	Sample Unique Projects	Energy Realization Rate	Relative Precision (90% Confidence)
Commercial Water Heaters	2	127%	0%

The relative precision for this analysis is 0% because Nexant's sample included a census of program participants.

Table 4-7 shows the total gross verified savings for the Commercial Water Heaters program.

Table 4-7: Commercial Water Heaters Gross Verified Savings

Program	Reported Savings (therms)	Energy Realization Rate	Gross Verified Savings (therms)
Commercial Water Heaters	5	127%	6

4.3 Commercial Windows & Insulation

4.3.1 Overview

This program offers incentives to Avista's nonresidential customers to improve the envelope of their building by adding additional insulation and/or replacing windows with high efficiency designs. The program is implemented internally by Avista.

4.3.2 Program Achievements and Participation Summary

A total of 54 unique Commercial Windows & Insulation measures were installed at 46 premises in Washington in 2014 and 2015. Table 4-8 summarizes Avista's 2014-2015 Commercial Windows & Insulation Program reported energy impacts.

Table 4-8: Commercial Windows & Insulation Reported Energy Savings by Measure

Measure Type	2014-2015 Participation	2014-2015 Reported Energy Savings (therms)
Commercial Windows & Insulation	54	32,930

4.3.3 Methodology

Engineering activities for the evaluation of this program included review of project documentation, installation verification, determination of operational hours, and savings calculations.

4.3.3.1 Sampling Approach

The evaluation team conducted document audits on 24 projects implemented through the Commercial Windows & Insulation program. Surveys and onsite inspections were conducted for a sub-sample of 11 of these projects (Table 4-9).

Table 4-9: Commercial Windows & Insulation Achieved Sample

Program	Document Audit	Survey	OnSite Inspections
Commercial Windows & Insulation	24	11	11

4.3.3.2 Document Audits

Project documentation was requested for each sampled project, including invoices, savings calculations, work order forms, equipment specification sheets, and any other project records that may exist. Thorough review of this documentation was the first crucial step in evaluation of each project.

4.3.3.3 Field Inspections

The telephone surveys conducted as part of the process evaluation were used to recruit projects for onsite inspection verification. These onsite inspections provide a more rigorous way to verify energy savings, and allowed the evaluation team to note any discrepancies between onsite findings regarding actual measure and equipment performance and the information gathered through the telephone surveys and project documentation review. A survey instrument specific to this program was created in advance of the site inspections to ensure that the correct information was gathered.

Table 1-1 summarizes the information that was collected for each project during the onsite inspection. All parameters needed to support the savings analysis of a project were collected, including the square footage of wall, attic, or window areas affected by the project and the associated HVAC system characteristics.

Table 4-10: EnergySmart Grocer Onsite Data Collection

End Use Category	Baseline	Retrofit
All Facilities	Year of construction Business Type Number of occupants Number of floors Operating Hours, posted or otherwise Total conditioned square footage	
HVAC	Type (e.g., DX, heat pump) Age Heating & Cooling Capacity Efficiency Operating Hours Operating Temperatures (space, supply, return, including info on setbacks) Control Capability / Strategy Other Features (e.g. economizer)	Type Age Capacity Efficiency Operating Hours Operating Temperatures Control Capability / Strategy Features
Building Envelope	Insulation Type Insulation Thickness Window Type (no. of panes, type of glass)	Insulation Type Insulation Thickness Window Type (no. of panes, type of glass) Affected Window / Wall / Attic Area (sq ft)

4.3.3.4 Impact Analysis Methods

An industry-standard relationship for insulation improvements was applied to analyze all projects in the evaluated sample for this program. Natural gas savings occur during the heating season only for these measures, and savings were calculated using Equation 4-1.

Equation 4-1: Commercial Windows and Insulation Heating Savings Calculation

$$\Delta therms_{heating} = \frac{\left(\frac{1}{R_{pre}} - \frac{1}{R_{post}}\right) \times Area \times 24 \times HDD}{\eta_{heat} \times 100{,}000}$$

Where:

$R_{pre\ and\ post}$ = *Pre- and Post-improvement R-values of insulation or windows*

A_{attic} = *Affected area (sq ft).*

HDD = *Annual cooling degree days*

η_{heat} = Heating system efficiency

4.3.4 Findings and Recommendations

The data collected as a result of the desk reviews and onsite verification activities were utilized to estimate the gross verified energy savings for each sampled project. The gross verified savings values for the sample of projects resulted in a realization rate of 137% for the Commercial Windows & Insulation program (Table 4-11).

Table 4-11: Commercial Windows & Insulation Impact Energy Realization Rate Results

Program	Sample Unique Projects	Energy Realization Rate	Relative Precision (90% Confidence)
Commercial Windows & Insulation	24	137%	15%

Avista's savings values for the measures in this program are generated using the same algorithm as Nexant. However, Avista's baseline R-values for both windows and insulation measures are more conservative in many cases. Avista's baseline values reflect minimum R-values as stipulated by energy codes. Nexant also applied code-based minimum R-values where the project was part of a major renovation, new construction, or building addition. For standalone projects installed separate from other major renovations, Nexant calculated savings based on the actual pre-retrofit insulation R-values. Thus, the verified savings for most standalone projects were higher than what Avista reported, resulting in the program realization rate of 137%.

Table 4-12 presents the 2014-2015 gross verified savings for the Commercial Windows & Insulation program.

Table 4-12: Commercial Windows & Insulation Gross Verified Savings

Program	2014-2015 Reported Savings (therms)	Energy Realization Rate	2014-2015 Gross Verified Savings (therms)
Commercial Windows & Insulation	32,930	137%	45,265

4.4 Natural Gas HVAC

4.4.1 Overview

This program offers incentives to Avista's nonresidential customers to improve the efficiency of their buildings' heating systems by upgrading to new high-efficiency gas equipment. The program is implemented internally by Avista.

4.4.2 Program Achievements and Participation Study

A total of 79 unique Natural Gas HVAC measures were installed at 72 premises in Washington in 2014 and 2015. Table 4-13 summarizes Avista's 2014-2015 Natural Gas HVAC Program reported energy impacts.

Table 4-13: Natural Gas HVAC Reported Energy Savings by Measure

Measure Type	2014-2015 Participation	Reported Energy Savings (therms)
Natural Gas HVAC	79	43,434

4.4.3 Methodology

Engineering activities for the evaluation of this program included review of project documentation, installation verification, determination of operational hours, and savings calculations.

4.4.3.1 Sampling

The evaluation team conducted document audits on 24 projects implemented through the Natural Gas HVAC program (Table 4-14). Surveys and on-site inspections were not conducted for this program.

Table 4-14: Natural Gas HVAC Achieved Sample

Program	Document Audit	Survey	OnSite Inspections
Natural Gas HVAC	24	0	0

4.4.3.2 Document Audits

Project documentation was requested for each sampled project, including invoices, savings calculations, work order forms, equipment specification sheets, and any other project records that may exist. Thorough review of this documentation was the first crucial step in evaluation of each project.

4.4.3.3 Impact Analysis Methods

Nexant applied an industry-standard relationship[8] for heating system efficiency improvements to all projects in the evaluated sample for this program, as listed in Equation 4-2.

Equation 4-2: Natural Gas HVAC Savings Calculation

$$\Delta therms_{heating} = Capacity_{input-e} \times EFLH_{e-installed} \times \left[\frac{AFUE_e}{AFUE_b} - 1\right]$$

Where:

[8] Uniform Methods Protocol – Residential Furnaces and Boilers Evaluation Protocol. Available from http://energy.gov/sites/prod/files/2013/11/f5/53827-5.pdf.

$Capacity_{input\text{-}e}$ = *peak heating input capacity of both the baseline and installed unit*

$EFLH_{e\text{-}installed}$ = *effective full-load hours of the installed high efficiency unit*

$AFUE_e$ = *annual fuel utilization efficiency of the high efficiency unit*

$AFUE_b$ = *annual fuel utilization efficiency of the baseline or code-compliant standard efficiency unit*

4.4.4 Findings and Recommendations

The data collected as a result of the desk reviews were utilized to estimate the gross verified energy savings for each sampled project. The gross verified savings values for the sample of projects resulted in a realization rate of 104% for the Natural Gas HVAC program (Table 4-15).

Table 4-15: Natural Gas HVAC Impact Energy Realization Rate Results

Program	Sample Unique Projects	Energy Realization Rate	Relative Precision (90% Confidence)
Natural Gas HVAC	24	104%	5%

Table 4-16 presents the 2014-2015 gross verified savings for the Natural Gas HVAC program.

Table 4-16: Commercial Windows & Insulation Gross Verified Savings

Program	2014-2015 Reported Savings (therms)	Energy Realization Rate	2014-2015 Gross Verified Savings (therms)
Natural Gas HVAC	43,434	104%	45,079

4.5 Food Service Equipment

4.5.1 Overview

This program offers incentives for commercial customers who purchase or replace food service equipment with Energy Star or higher equipment (prescriptive).

4.5.2 Program Achievements and Participation Summary

A total of 68 unique measures were installed at 63 premises in Washington through the Food Service Equipment program in 2014 and 2015. Table 4-17A total of 79 unique Natural Gas HVAC measures were installed at 72 premises in Washington in 2014 and 2015. Table 4-13 summarizes Avista's 2014-2015 Natural Gas HVAC Program reported energy impacts.

summarizes Avista's 2014-2015 reported energy impacts for this program.

Table 4-17: Food Service Equipment Reported Energy Savings

Measure Type	2014-2015 Participation	Reported Energy Savings (therms)

Food Service Equipment	68	55,687

4.5.3 Methodology

Engineering activities for the evaluation of these projects varied by measure and included review of project documentation, review of relevant RTF deemed savings values and workbooks, installation verification, determination of operational hours, and savings calculations.

4.5.3.1 Sampling

The evaluation team conducted document audits for 11 Food Service Equipment projects (Table 4-18). Surveys and onsite inspections were not conducted for this program.

Table 4-18: Food Service Equipment Achieved Sample

Program	Document Audit	Survey	OnSite Inspections
Food Service Equipment	11	0	0

4.5.3.2 Document Audits

Project documentation was requested for each sampled project, including invoices, savings calculations, work order forms, equipment specification sheets, and any other project records that may exist. Thorough review of this documentation was the first crucial step in evaluation of each project.

4.5.3.3 Impact Analysis Methods

For ENERGY STAR-rated kitchen equipment, Nexant evaluated the energy savings for each project in the evaluation sample using ENERGY STAR's Commercial Kitchen Equipment calculator[9]. For categories of kitchen equipment not covered by ENERGY STAR, Nexant used other third-party sources and studies to evaluate energy impacts.

4.5.4 Findings and Recommendations

Table 4-19 presents the realization rate based on the gross verified savings values for the sample of reviewed projects in the Food Service Equipment program.

Table 4-19: Food Service Equipment Realization Rate Results

Program	Sample Unique Projects	Energy Realization Rate	Relative Precision (90% Confidence)
Food Service Equipment	11	124%	14%

Avista's deemed energy savings for this program are also derived from ENERGY STAR's published calculator. However, Nexant customized the inputs to the calculator for the specific

[9] https://www.energystar.gov/sites/default/files/asset/document/commercial_kitchen_equipment_calculator%2003-15-2016.xlsx

rates of the equipment in the evaluation sample. This customization resulted in a realization rate greater than 100% for many projects in the sample and yielded a program-wide realization rate of 124%.

Table 4-20 shows the total gross verified savings for the Food Service Equipment program.

Table 4-20: Food Service Equipment Gross Verified Savings

Program	Reported Savings (therms)	Energy Realization Rate	Gross Verified Savings (therms)
Food Service Equipment	55,687	124%	68,889

4.6 Site Specific

4.6.1 Overview

Avista's Site Specific program offers commercial customers the opportunity to propose any energy efficiency project with documentable energy savings (kilowatt-hours and/or therms) for an incentive. The majority of projects in this program are appliance upgrades, compressed air, HVAC, industrial process, motors, shell measures, custom lighting projects, and natural gas multifamily market transformation. The Site Specific program is implemented internally by Avista, and program staff develop custom energy savings estimates for each project with input from the customer. Projects must have a simple payback period between one and eight years for lighting projects and between one and thirteen years for all other projects to be eligible for incentive.

4.6.2 Program Achievements and Participation Summary

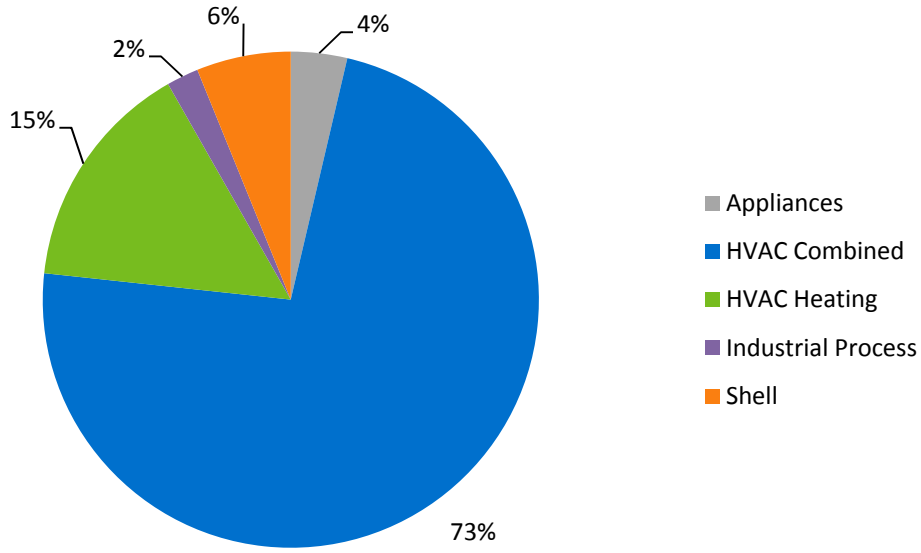
A total of 106 unique measures were installed through the Site Specific program at 87 premises in Washington throughout 2014 and 2015. Table 4-21 and Figure 4-2 summarize Avista's reported energy impacts by measure for the Site Specific program. The 'HVAC Combined' and 'HVAC Heating' measures make up 90% of the reported energy impacts for this program. Most projects under both of these measure types are building heating system efficiency improvements.

Table 4-21: Site Specific Reported Energy Savings by Measure

Measure Type	Reported Energy Savings (therms)	% Gas Savings
Appliances	26,955	4%
HVAC Combined	537,589	75%
HVAC Heating	110,789	15%
Industrial Process	15,415	2%
Shell	45,256	6%
Multifamily	-18,460	-3%

Total	**717,544**	**100%**

Figure 4-2: Site Specific Reported Participation Energy Savings Shares



4.6.3 Methodology

The impact evaluation for this program followed IPMVP guidance as well as the DOE Uniform Method Protocol(s). The RTF's Non-Residential Lighting Retrofit Standard Protocol was followed for lighting projects and IPMVP Option C was used to guide billing analysis for select projects. Engineering activities included thorough review of the program savings methodology for each project, installation verification, determination of operational hours including spot-metering in some cases, collection of energy management system (EMS) trend data, and associated energy savings calculations.

4.6.3.1 Sampling

The evaluation team conducted 45 document audits on participating projects through the Site Specific program. Customer surveys and onsite inspections were conducted on a subset of these projects. Because of sample overlap with the Site Specific gas program, the achieved sample size for document audits was higher than planned. Within the Site Specific program, the evaluation team designated projects into two strata based on reported savings. Projects with a reported savings over 40,000 therms were designated as 'Large' projects, with all others designated as 'Small'. This stratified sampling strategy was selected in order to ensure that the relative impacts of large projects were fairly represented in the program-level results. Table 4-22 outlines the achieved sample for the Site Specific Program.

Table 4-22: Site Specific Achieved Sample

Program Strata	Document Audit	Survey	On Site Inspections
Large (> 40,000 therms)	4	4	4
Small (< 40,000 therms)	41	22	22
TOTAL	45	26	26

4.6.3.2 Document Audits

Project documentation was requested for each sampled project, including Avista's 'Top Sheets', invoices, savings calculations, work order forms, equipment specification sheets, and any other project records that may exist. The evaluation team's desk review process for Site Specific projects included tracking the history of each project through the various stages of the program as documented in the "Top Sheets". Thorough review of this documentation was the first crucial step in evaluation of each project.

For projects where Avista estimated savings using energy modeling software such as eQuest, the evaluation team requested and reviewed the energy models.

4.6.3.3 Field Inspections

The telephone surveys conducted as part of the process evaluation were primarily used to recruit a sample for onsite inspection verification. Some additional recruitment for this activity was done by phone separate from the process telephone survey.

The onsite inspections provide a more rigorous way to verify energy savings, and allowed the evaluation team to note any discrepancies between onsite findings regarding actual measure and equipment performance and the information gathered through the telephone surveys and project documentation review. Because of the wide variety of measures included in this evaluation, project-specific survey instruments were generated in advance of each onsite inspection to ensure that sufficient information was gathered to support the analysis of each measure.

Table 4-23 summarizes the types of information that were collected for each project during the onsite inspection. All parameters needed to support the savings analysis of a project were collected.

Table 4-23: Site Specific Onsite Data Collection

End Use Category	Baseline	Retrofit

End Use Category	Baseline	Retrofit
All Facilities	Year of construction Business Type Number of occupants Number of floors Operating Hours, posted or otherwise Total conditioned square footage	
HVAC	Type (e.g., DX, heat pump) Age Heating & Cooling Capacity Efficiency Operating Hours Operating Temperatures (space, supply, return, including info on setbacks) Control Capability / Strategy Other Features (e.g. economizer)	Type Age Capacity Efficiency Operating Hours Operating Temperatures Control Capability / Strategy Features
Building Envelope	Insulation Type Insulation Thickness Window Type (no. of panes, type of glass)	Insulation Type Insulation Thickness Window Type (no. of panes, type of glass) Affected Window / Wall / Attic Area (sq ft)
Appliances		Manufacturer Model Number Efficiency

4.6.3.4 Project-Specific Billing Analysis

The evaluation team reviewed utility bill histories for several projects where appropriate. To be a good candidate for savings estimation using utility bill analysis approach, a project must provide energy savings equal to at least 10% of the facility's annual consumption. Secondly, at least 9 months but preferably 12 months of post-project utility bill data must be available at the time of the analysis. Thirdly, conditions at the facility should be relatively static, except for the project of interest. The installation of other energy efficiency measures or other major changes at the facility makes billing analysis inappropriate for project-specific savings estimation. If a project was deemed to be a good candidate for utility bill analysis, then the evaluation team employed IPMVP Option C to estimate energy savings, normalizing for monthly variation in weather conditions.

4.6.3.5 Project-Specific Energy Modeling Analysis

Avista used eQuest energy modeling to generate savings estimates for the majority of the Site Specific natural gas projects in the evaluation sample. For these projects, Nexant reviewed the

baseline- and efficient-case eQuest models and outputs for several criteria:

- Appropriateness of baseline model assumptions
- Calibration of baseline model output with pre-project utility bill data, if appropriate
- Consistency between efficient model assumptions and observed on-site conditions
- Agreement between efficient model output and post-project utility bill data, if possible

Based on this review process, Nexant updated the provided eQuest models as necessary to generate verified savings values.

4.6.3.6 Algorithm-Based Impact Analysis Methods

Because of the custom nature of the projects that participated in the Site Specific program, a wide array of custom analysis methods were utilized and tailored to each individual project. Most projects in the evaluated sample were analyzed using utility bill analysis, energy modeling, or a custom savings analysis. In many cases, if the evaluation team agreed with the program team's savings methodology, then the evaluation team used the same methodology for the project evaluation, updating only the input values and assumptions based on the results of onsite inspections or other data collection. In some cases, the evaluation team used a different methodology, especially where billing data or trend data allowed for savings to be calculated from measured data.

The evaluation team utilized an algorithm-based analysis for some Site Specific Shell projects, as described in the methodology section for the Commercial Windows & Insulation Program (Section 4.3.3.4)

4.6.4 Findings and Recommendations

The evaluation team found that the 2014-2015 Site Specific program achieved a program-level realization rate of 86% (Table 4-24). Avista's internal processes for this program include a high level of review and scrutiny of measure savings estimates. The program-level realization rate of 86% reflects the high level of complexity and uncertainty inherent to many natural gas projects.

Table 4-24: Site Specific Program Realization Rate Results

Strata	Sample Unique Projects	Energy Realization Rate	Relative Precision (90% Confidence)
Large (> 40,000 therms)	4	93%	0%
Small (< 40,000 therms)	41	80%	51%
TOTAL	**45**	**86%**	**22%**

Measure-level realization rates for measures where more than one project was included in the evaluation sample are presented in Table 4-25.

Table 4-25: Site Specific Measure-Level Gross Verified Savings

Measure	Sample Unique Projects	Energy Realization Rate
Appliances	3	100%
Shell	7	102%
HVAC Heating	9	89%
HVAC Combined (Small Stratum)	21	71%
HVAC Combined (Large Stratum)	4	93%

Appliance Findings

The evaluation team did not find any significant discrepancies in the evaluated sample of Appliance projects. Avista is using accurate and defensible data sources to estimate the energy savings for these measures.

Shell Findings

The evaluation team did not find any significant discrepancies in the evaluated sample of Shell projects. Nexant and Avista applied similar algorithms for these projects. The project-level realization rates for all projects in the evaluated sample were near 100%.

HVAC Heating and HVAC Combined Findings

The evaluation team found that the energy saving for several projects were overestimated, resulting in project realization rates well below 100%. Nexant also found a few cases of very high project realization rates. Avista's energy savings estimates for these measures were primarily developed using eQuest energy modeling. Nexant reviewed the eQuest models for consistency with project documentation, observed on-site conditions, and pre- and post-project utility billing data whenever possible.

Nexant observed several instances where assumptions included in the 'efficient' eQuest model were not in alignment with conditions observed on-site. For example, savings for one project were based on aggressive nighttime setback scheduling that was found to be only partially implemented.

Table 4-26 shows the total gross verified savings for the Site Specific program.

Table 4-26: Site Specific Gross Verified Savings

Strata	Reported Savings (therms)	Energy Realization Rate	Gross Verified Savings (therms)
Site Specific	717,544	86%	615,852

To improve realization rates, the evaluation team recommends that Avista shift more of the Site Specific gas projects, especially larger projects and projects where the estimated energy savings will be more than 10% of annual natural gas usage, to a performance path for M&V. Natural gas measures are often easier to verify using utility bills than electric measures because buildings tend to have fewer natural gas end uses. Using proven project performance to report energy savings will eliminate the uncertainty surrounding ex-ante savings estimates of complex

natural gas projects.

4.7 Nonresidential Sector Results Summary

Table 4-27 lists the gross verified savings for each of Avista's nonresidential programs in Washington in 2014-2015. The Washington gas nonresidential sector achieved a 91% realization rate and the relative precision of the program-level natural gas realization rate was ±14% at the 90% confidence level.

Table 4-27: Nonresidential Program Gross Impact Evaluation Results

Washington Gas Nonresidential Program	2014-2015 Reported Savings (therms)	Realization Rate	2014-2015 Verified Gross Savings (therms)
Commercial Water Heaters	5	127%	6
Commercial Windows & Insulation	32,930	137%	45,265
Natural Gas HVAC	43,434	104%	45,079
Food Service Equipment	55,687	124%	68,889
Site Specific	717,544	86%	615,852
NONRESIDENTIAL TOTAL	**849,600**	91%	**775,091**

5 Small Business Impact Evaluation

5.1 Overview

The Small Business (SB) program is a third-party-administered (SBW Consulting), direct installation/audit program, providing customer energy efficiency opportunities by:

1) Directly installing appropriate energy-saving measures at each target site
2) Conducting a brief onsite audit to identify customer opportunities and interest in existing Avista programs
3) Providing materials and contact information so that customers are able to follow up with additional energy efficiency measures under existing programs.

Direct-install measures include:

- Faucet aerators
- Showerheads
- Pre-rinse spray valves
- Screw-in LEDs
- Smart power strips
- CoolerMisers
- VendingMisers

The evaluation team conducted onsite verification, documentation audits, and engineering analysis to determine verified gross savings for each measure in the program. Another key objective for this evaluation was to develop new deemed savings values for faucet aerators and pre-rinse spray valves based upon secondary research of statewide technical reference manuals (TRMs) and published third-party data.

5.2 Program Achievements and Participation Summary

Table 5-1 provides a comparison of reported participation and the adjusted participation determined through evaluation activities. The differences between the evaluation team's adjusted participation and Avista's reported participation were minimal amounting to a total of 7 duplicate entries in the program tracking database.

Table 5-1: Small Business Program Reported and Adjusted Participation

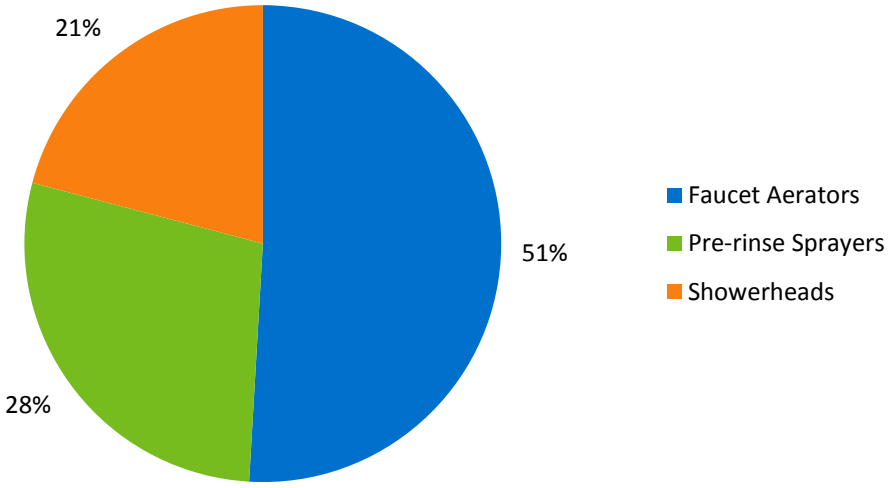
Measure Type	2015 Reported	2015 Adjusted Reported
Water Saving Measures	2,851	2,844
Audits	3,543	3,543

Table 5-2 and Figure 5-1 summarize Avista's 2015 Small Business Program reported natural gas energy impacts by measure type.

Table 5-2: 2015 Small Business Program Reported Energy Savings by Measure

Measure	Reported Gas Savings (therms)	% Savings
Faucet Aerators	7,385	55%
Pre-rinse Sprayers	4,088	31%
Showerheads	3,030	14%
Total	**14,503**	**100%**

Figure 5-1: SMB Program Reported Energy Savings Shares



The gross program energy impacts for the Small Business program were evaluated through a combination of documentation audits and onsite inspections of a representative sample of completed program projects.

5.1.1.1 Sampling

The evaluation team selected a simple random sample of 31 projects for the impact evaluation of the Small Business Program. Onsite verification was performed for all 31 sites. The 31 sampled project sites collectively accounted for a total of 191 electric and 46 natural gas saving measures. Table 5-3 summarizes the achieved sample size.

Table 5-3: Small Business Program Impact Evaluation Achieved Sample

Program	On-Site Verification	Document Audit
Small Business	31	31

5.1.2 Document Audits

The evaluation team conducted a review of the project documentation for each sampled project, including invoices, savings calculations, work order forms, equipment specification sheets, and any other project records that may exist. Thorough review of this documentation was the first crucial step in evaluation of each project.

5.1.3 Onsite Inspections

The impact evaluation activities included telephone surveys, documentation audits, and onsite inspections for the entire sample. A telephone survey served as an introduction to the evaluation activities and was used to confirm that the customer participated in the program, confirm the appropriate contact, and to verify basic information such as building type and building size. Arrangements for onsite inspections were then made during the telephone survey.

The onsite inspections were used to determine whether:

- The measure tracking database correctly represented the work that was done at each site
- The measures remained installed and were operational
- There were any opportunities for measure installation that were missed
- There were assumptions embedded in the deemed savings estimates for each installed measure applicable to the site.

Field engineers were equipped with a custom field data collection tool designed to capture the relevant data points for each measure included in the SB program. Table 5-4 summarizes the information that was collected for each measure type during the onsite inspection. All parameters needed to support the savings analysis of a project were collected, including, but not limited to, fixture counts, hours of operation, and water heater fuel type.

Table 5-4: Small Business Program Onsite Data Collection

Measure Type	Key Parameters
All Facilities	Number of occupants Business Type Operating Hours, posted or otherwise Water Heater Type (Tank or Tankless) Water Heater Fuel Type (Natural Gas or Electric)
Faucet Aerators Pre-rinse Sprayers Showerheads	Quantity of Efficient Fixtures/Aerators Installed Quantity of Efficient Fixtures/Aerators Decommissioned Device Flow Rate Water Heater Type Facility Hot Water Load

5.1.4 Impact Analysis Methods

The evaluation team estimated gross verified savings using the field verified quantities and the program-specified deemed savings value for each measure. The deemed savings values used by the program originate from a variety of sources including (UES) measures from the Regional Technical Forum (RTF), California DEER database[10], and Puget Sound Energy 2014-2015 unit energy savings values. Verified energy savings were generally calculated for each measure using Equation 5-1:

Equation 5-1: Small Business Program Energy Savings Calculation

$$\Delta Therms = Quantity\ Verified\ x\ Therm\ Saved/Unit$$

Where:

Quantity Verified = Quantity of devices/fixtures verified onsite

Therm Saved = Program-stipulated electric energy (Therms) saved per unit installed

In addition to estimating program-level savings, the evaluation team also conducted a deemed savings review for each direct-install measure offered by the Small Business Program. This review process consisted of comparing deemed savings values used by Avista with those used by similar programs in other jurisdictions and in other statewide TRMs. Recommended updates to the deemed savings values were developed by the evaluation team for the faucet aerator and pre-rinse spray valve measure offerings. The deemed savings assumptions used for the remainder of the measures were deemed appropriate and therefore, were not modified in the analysis. Additional details on the research conducted and measure-specific findings determined for faucet aerators and pre-rinse spray valves are discussed in the Findings and Recommendations section below.

[10] http://www.deeresources.com/

5.2 Findings and Recommendations

The gross verified electric energy savings for the sample of reviewed projects for the Small Business program resulted in a realization rate of 125% (Table 5-5).

Table 5-5: Small Business Program Realization Rate Summary

Measure Category	Sampled Measures	Gas Energy Realization Rate	Relative Precision (90% Confidence)
Faucet Aerators	37	204%	83%
Pre-rinse Sprayers	3	96%	11%
Showerheads	2	100%	0%
Showerheads (Fitness)	4	100%	0%
Total	46	125%	59%

5.2.1.1 Deemed Savings for Faucet Aerators

The evaluation team developed new gas (kWh) and natural gas (therms) deemed savings values for both 0.5 GPM and 1.0 GPM faucet aerators installed through the program. The newly developed values were applied on a per device installed basis. They were developed based upon a comprehensive review of five statewide technical reference manuals[11], assumptions for similar measures offered in other jurisdictions[12], and assumptions from applicable RTF UES measures. During the research process, the evaluation team not only compiled the deemed energy savings values used by each source, but also some of the underlying assumptions such as baseline and efficient device flow rates (GPM), frequency of use, hot water temperature, and inlet water temperature. A summary of key findings and recommendations are provided in Table 5-6.

Table 5-6: Recommended Deemed Savings Values for Faucet Aerator Measures

Measure	Avg Base GPM	Avg Reduced GPM	Avg Gal Reduced/yr	Hot H2O Temp (°F)	Inlet H2O Temp (°F)	Avg Deemed kWh Savings	Avg Deemed therms Savings
Faucet Aerator (1.0)	2.1	1.2	5,460	105	52	176	12
Faucet Aerator (0.5)	2.1	0.5	4,500	105	52	300	21

5.2.1.2 Deemed Savings for Pre-Rinse Spray Valves

The evaluation team also developed verified per-device energy savings estimates for pre-rinse spray valves using the same approach and data sources described for faucet aerators. Key findings from this research are provided in Table 5-7.

[11] Statewide TRMs reviewed as part of our research included Massachusetts, Pennsylvania, Wisconsin, Minnesota, and Michigan.

[12] Programs from other jurisdictions included the ComEd Small Business Energy Savings (SBES) Program and a program offered by Questar Gas.

Table 5-7: Recommended Deemed Savings Values for Pre-Rinse Spray Valve Measures

Measure	Avg Base GPM	Avg Reduced GPM	Avg Gal Reduced/yr	Hot H2O Temp (°F)	Inlet H2O Temp (°F)	Avg Deemed kWh Savings	Avg Deemed therms Savings
Pre-Rinse Sprayer	1.8	1.1	23,617	105	52	1,130	72

5.2.1.3 Summary of Decommissioned Measures

The evaluation team made downward savings adjustments for several of the measures in the sample where the verified quantity installed did not match the reported quantity due to measures being decommissioned. A summary of the gas-specific identified decommissioned measures is provided in Table 5-8.

Table 5-8: Small Business Decommissioned Measure Summary

Measure Name	Reported Measures	Quantity Decommissioned	Verified Measures
Faucet Aerator (0.5 GPM)	80	8	72
Faucet Aerator (1.0 GPM)	29	5	24
Pre-rinse Spray Valve	6	1	5
Showerhead	2	0	2
Showerhead (Fitness Center)	4	0	4
OVERALL	**121**	**14**	**107**

Table 5-9 shows the total gross verified savings for each gas-specific measure and for the Small Business Program in total.

Table 5-9: Small Business Program Gross Impact Evaluation Results

Measure	Reported Savings (therms)	Energy Realization Rate	Gross Verified Savings (therms)
Faucet Aerators	7,385	204%	15,047
Pre-rinse Sprayers	4,088	96%	3,915
Showerheads	1,890	100%	1,890
Showerheads (Fitness)	1,140	100%	1,140
Total	**14,503**	**125%**	**21,992**

6 Residential Impact Evaluation

The following sections outline the impact evaluation methodology and findings for each of the evaluated residential programs and the low income program.

6.1 Overview

Avista offered four natural gas incentive-based residential programs and the low income program in their Washington service territory in 2014 and 2015. The reported savings for these residential programs are summarized in Table 6-1.

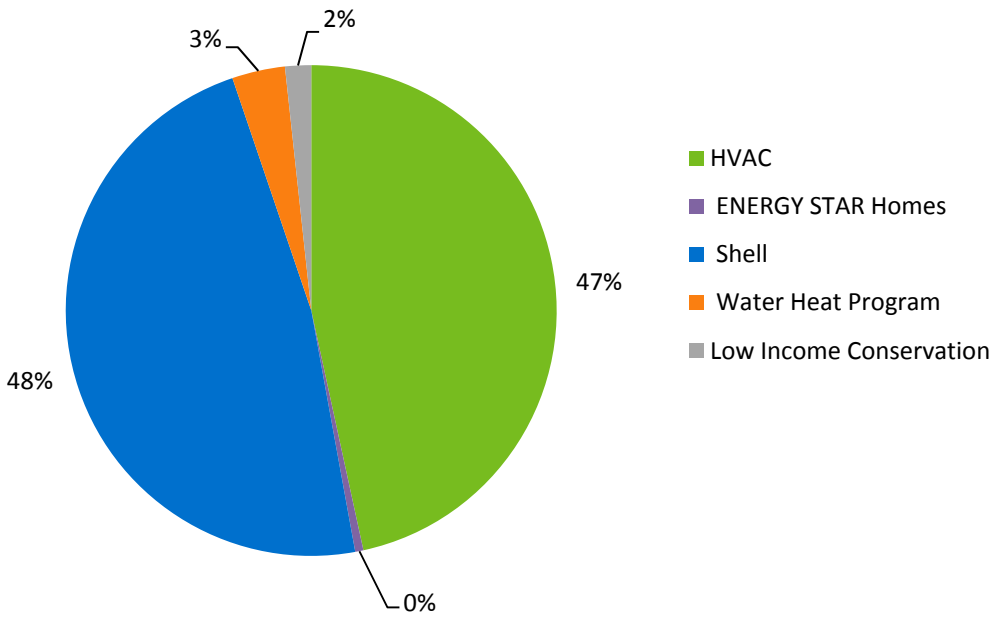
Table 6-1: Residential Program Reported Savings

Program	2014-2015 Reported Savings (therms)
HVAC	401,855
ENERGY STAR Homes	4,669
Shell	411,239
Water Heat Program*	30,154
Low Income Conservation	14,719
Conservation Total	862,636
Fuel Efficiency (Fuel Conversion)	(314,247)
Low Income Fuel Conversion	(13,249)
Fuel Conversion Total	(327,497)
TOTAL RESIDENTIAL	**535,139**

*Includes counts for both projects and showerheads

The Shell and HVAC programs collectively contributed 95% of the reported savings, as shown in Figure 6-1.

Figure 6-1: Residential Program Reported Energy Savings Shares (Conservation Only)



The evaluation team designed a sampling strategy for these programs placing the most emphasis on the programs with the highest projected savings and the highest level of uncertainty. As part of the evaluation activities, a total of 166 document audits and 142 telephone surveys were conducted, as shown in Table 6-2. Engineering activities included review of savings calculation methodology and assumptions, utility bill analysis and energy savings analysis.

Table 6-2: Residential Program Achieved Evaluation Sample

Natural Gas Residential Program	Achieved C/P	Document Audit	Surveys	Billing Analysis
Water Heat Program	90/13	12	11	
ENERGY STAR Homes	90/44	11	11	
HVAC Program	90/5	46	48	
Fuel Efficiency	90/27	26	25	√
Shell Program	90/18	47	47	√
Low Income	90/25*	24	0	√
TOTAL	**90/5***	**166**	**142**	

*Conservation projects only, fuel conversion projects not included in precision calculation

6.2 HVAC Program

6.2.1 Overview

Avista internally manages the HVAC program which encourages the implementation of high efficiency HVAC equipment and smart thermostats through direct incentives issued to the customer after the measure has been installed. The evaluation team used a combination of desk reviews, customer telephone surveys and billing analysis to estimate the gross-verified savings for the applicable measures and the program as a whole.

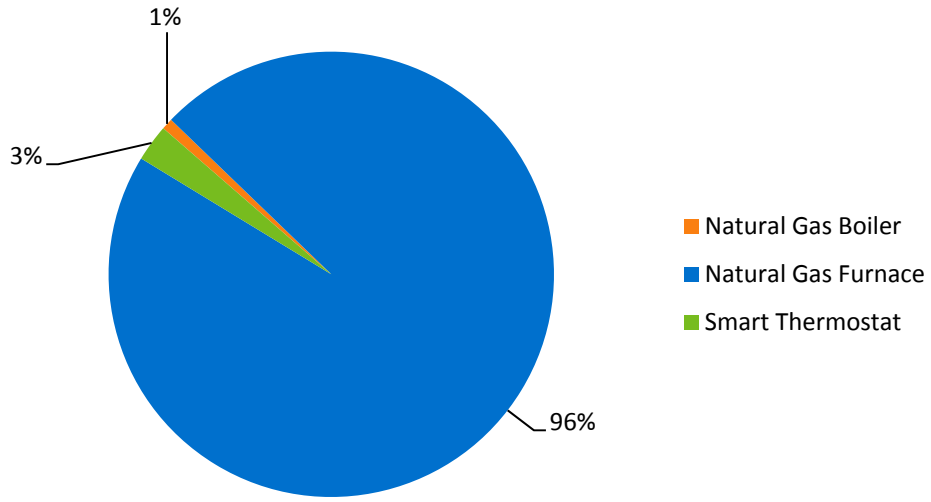
6.2.2 Program Achievements and Participation Summary

Participation in the 2014–2015 HVAC program totaled 3,851 measures. Table 6-3 and Figure 6-2 summarize Avista's reported 2014–2015 HVAC program participation and energy impacts.

Table 6-3: HVAC Program Reported Participation and Savings

Measure	2014–2015 Reported Participation Count	2014–2015 Reported Savings (Therms)
Natural Gas Boiler	35	3,303
Natural Gas Furnace	3,560	387,769
Smart Thermostat	256	10,783
TOTAL	**3,851**	**401,855**

Figure 6-2: 2014–2015 HVAC Program Reported Participation Energy Saving Shares



6.2.3 Methodology

The evaluation team investigated measures under the residential HVAC program separately, but utilized similar methods across multiple measures. The following two measure categories were analyzed:

- High Efficiency Natural Gas Furnace and Boilers
- Smart Thermostat

The evaluation team conducted approximately 46 document audits and telephone surveys with HVAC program participants and a billing analysis was conducted for the Smart Thermostat measure. As discussed in Section 3.3, telephone surveys and document audits were conducted to confirm participation in the program, confirm efficiency levels of installed equipment as applicable, check that Avista reported data matched project files and that Avista is reporting the correct savings value for each applicable measure. The evaluation team also conducted a review of Avista's complete 2014 and 2015 program databases to check for errors in measure-level reporting.

The subsections below outline the specific evaluation methodology for estimating the gross verified impacts for the high efficiency heating equipment and smart thermostat measures.

6.2.3.1 High Efficiency Furnaces and Boilers

To estimate verified savings, the evaluation team focused on the natural gas furnace measure due to the low participation of boiler measures. To estimate these gas savings, the evaluation team utilized document audits to verify efficiency and capacity. Based on the verified efficiency and capacity, we calculated effective full load hours (EFLH) by using the average billed consumption in months after the measure was installed. The combination of these processes determined the variables used in Equation 6-1 below to calculate total gross verified savings.

Equation 6-1: Natural Gas Furnace Energy Savings Equation

$$\Delta\text{Therms} = \text{EFLH} \times \text{Cap} \times (((AFUE_{in} - AFUE_{base})/AFUE_{base})/100{,}000)$$

Table 6-4 provides additional information about the terms and coefficients in Equation 6-1.

Table 6-4: Natural Gas Furnace Variable Definitions

Variable	Definition
ΔTherms	Change in therm consumption
Cap	Capacity of Furnace
$AFUE_{in}$	Efficiency of installed furnace
$AFUE_{base}$	Efficiency of previous furnace
100,000	Conversion of Btu to Therm

The evaluation team merged the utility billing data for participating homes with observed temperature data (HDD) and program tracking data was used to identify the measure installation dates and designate the pre-retrofit and post-retrofit periods for each customer. In order to estimate impacts directly attributable to the natural gas, the evaluation team isolated the customers who received a natural gas furnace and no additional measures. These homes often used natural gas for additional appliances such as a range, therefore post usage was found by only counting consumption directly related to heating the home, which was estimated using the average HDD for the WA service territory (6500). This was used to determine the average therms usage for heating which was found to be 648.5 therms for post installation customers. The average furnace efficiency (95%) and capacity (72,550 Btu) which were verified from the document audit process were applied to back-out an EFLH value. The EFLH were found to be 941. This EFLH and the individually verified capacities and efficiencies were entered into Equation 6-1 above to calculate a total gross verified savings per participant and subsequently realization rates per customer and the measure overall.

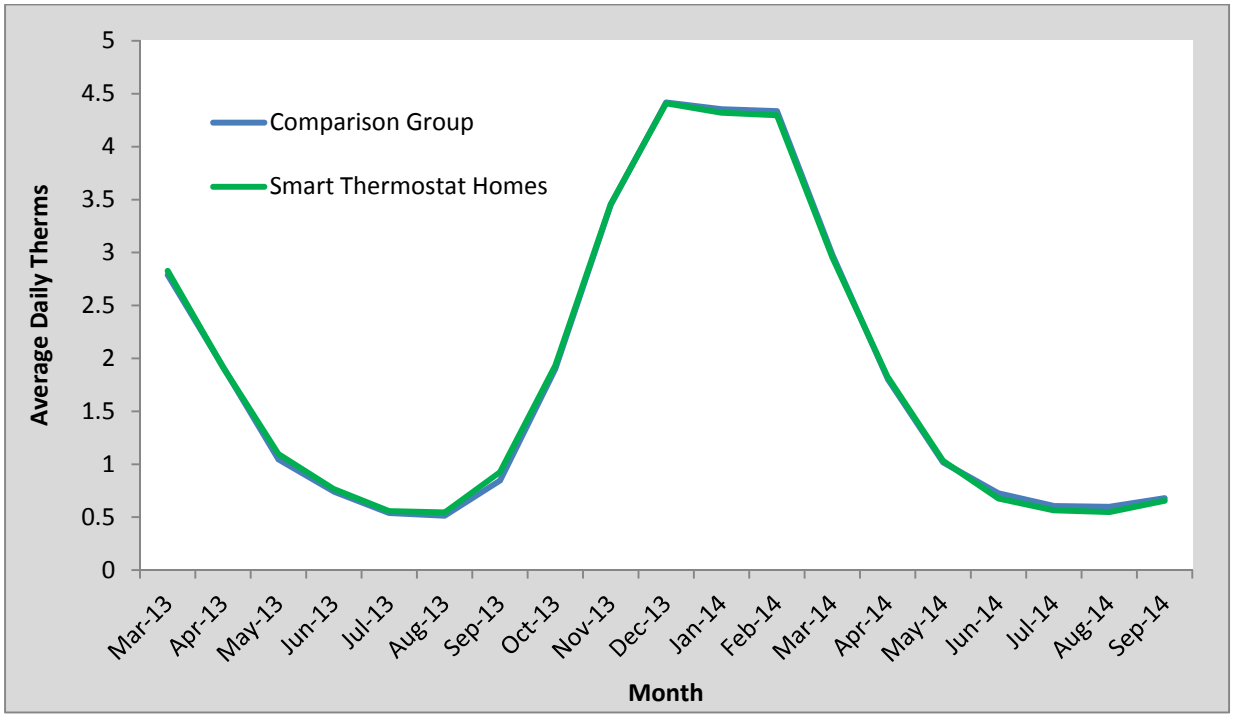
6.2.3.2 Smart Thermostat

Avista offers rebates for the installation of qualified smart thermostat products. These devices have advance features such as occupancy detection, auxiliary heat lockout, economizer capability, and “learning” algorithms to adapt to resident behavior. Avista claims savings based on the heating fuel of the home so natural gas savings are only claimed for homes that have gas heating systems. The majority of the smart thermostats rebated in 2014–2015 were in homes with natural gas heating systems. One challenge for the evaluation was that uptake of the smart thermostat offering was highest in the fourth quarter of 2015. This meant that participating homes had a limited number of months of post-installation billing data at the time of this evaluation. Although the number of months was less than ideal, the timing of the installations proved advantageous because the available months were from the winter of 2015-2016 when gas heating loads were highest. In order to maximize the number of participating homes analyzed, the evaluation team included homes with at 8 months of pre-installation billing data and four months of post-installation billing data in the analysis. The billing period when the thermostat was installed was omitted from the analysis.

Another complicating factor was that a subset of the smart thermostat rebate recipients also installed other HVAC measures such as high efficiency furnaces at the same time as the smart thermostat. After applying these filters to the participant list, the evaluation team was left with 34 homes for analysis.

The evaluation team used propensity score matching to develop a comparison group of homes from the Opower program to serve as a baseline for savings estimates. For each of the 34 homes that installed a smart thermostat, the evaluation team selected five homes from the Opower program that used natural gas most similarly between March 2013 and September 2014 (the first smart thermostat rebate was issued in October 2014). Figure 6-3 compares the average daily therm usage of the 34 smart thermostat homes with the 170 comparison group homes over the 19 month matching period. This equivalence check shows that the two groups used natural gas virtually identically before the smart thermostat installations began and provides confidence that any observed differences in gas usage after installation are because of the smart thermostat.

Figure 6-3: Equivalence Check – Smart Thermostat Comparison Group



The evaluation team used a fixed-effects panel regression to estimate the gas savings attributable to smart thermostat installations. Equation 6-2 provides the detailed model specification.

Equation 6-2: Smart Thermostat Regression Model Specification

$$\text{Therms}_{it} = \beta_i + \beta_1 \times \text{Post}_{it} + \beta_2 \times \text{HDD}_{it} + \beta_3(\text{Post} \times \text{HDD})_{it} + \beta_4 \times \text{treatpost}_{it} + \beta_5(\text{treatpost} \times \text{HDD})_{it} + \epsilon_{it}$$

Table 6-5 provides additional information about the terms and coefficients in Equation 6-2.

Table 6-5: Smart Thermostat Regression Model Definition of Terms

Variable	Definition
$Therms_{it}$	Metered gas consumption in home i during period t (dependent variable)
$Post_{it}$	Indicator variable denoting pre-installation period vs. post-installation period. For the comparison group homes, the pre->post conversion was set equal to the installation date of the matched participant home
HDD_{it}	Average heating degree days during period t at home i.
$Treatpost_{it}$	Interaction of a treatment indicator variable and the post term. Equal to 1 for smart thermostat recipients in the post-installation period, zero otherwise
β_i	Customer specific model intercept representing baseline consumption
β_{1-5}	Coefficients determined via regression describing impacts associated with independent variables
ϵ_{it}	Customer level random error

The β_4 and β_5 terms in Equation 6-2 represent the average change in daily base load and change in daily therms per HDD, respectively, in the post-installation period. These terms were then applied to the normal weather conditions (TMY3) to estimate average weather normalized annual savings from smart thermostat installations.

6.2.4 Findings and Recommendations

6.2.4.1 Natural Gas Furnace

The findings from the telephone surveys, document audit and database review found that most records matched between the Avista reported database and the project documentation. There was a minor discrepancy found for three participants that did not report therm savings in the Avista database. This accounts for the minor difference (308 therms) between the reported savings and the adjusted-reported savings. Based on the adjusted-reported savings, the measure achieved a 126% realization rate.

Table 6-6 outlines the program reported, adjusted, and gross verified savings value for natural gas furnaces in the HVAC program.

Table 6-6: Natural Gas Furnace Results Summary

Measure	2014–2015 Reported Participation Count	2014–2015 Reported Savings (Therms)	2014–2015 Adjusted Reported Savings (Therms)	Realization Rate	2014-2015 Gross Verified Savings (Therms)
Natural Gas Furnace	3560	387,769	388,077	126%	489,508

6.2.4.2 Smart Thermostat

The evaluation team's regression analysis produced a verified savings estimate of 34.8 therms per homes that installed a smart thermostat. This result is fairly consistent with Avista's default savings value of 41 therms per thermostat and equates to a realization rate of 85%. Table 6-7 presents the key results and the detailed regression output for the smart thermostat regression is included in Appendix B.1.

Table 6-7: Smart Thermostat Results Summary

# Homes	Average Reported Therms	Annual Therms Pre-Installation	Annual Therms Post-Installation	Annual Therm Savings	RR	% Savings
34	41	737.8	703.0	34.8	85%	4.71%

The regression model shows a small savings in gas base load (~ 3 therms annually) and a reduction in weather dependent gas usage of 0.00474 therms per heating degree day. In an average year, Spokane faces approximately 6,700 HDD (base 65F) so this result means homes are saving close to 32 therms of heating usage annually. Neither the base load nor heating load term in the regression model is statistically significant. The lack of statistical significance is a likely a function of sample size. If smart thermostats do indeed produce a 5% reduction in total home gas consumption, the evaluation team estimates a sample size of at least 250 to 350 homes will be needed to produce an impact estimate that is statistically significant at the 90% confidence level.

6.2.5 Program Results

Table 6-8 outlines the program reported, adjusted, and gross verified savings value for each measure in the HVAC program. The evaluation team found a 125% realization rate across the entire HVAC program. The relative precision of the program level gas realization rate is ±4% at the 90% confidence level.

Table 6-8: HVAC Program Gross Verified Savings

Measure	2014-2015 Participation	2014–2015 Reported Savings (Therms)	2014–2015 Adjusted Reported Savings (Therms)	Realization Rate	2014-2015 Gross Verified Savings (Therms)
Natural Gas Boiler	35	3,303	3,303	126%	4,166
Natural Gas Furnace	3,560	387,769	388,077	126%	489,508
Smart Thermostat	256	10,783	10,783	85%	9,145
TOTAL	**3,851**	**401,855**	**402,163**	**125%**	**502,820**

6.3 Water Heat Program

6.3.1 Overview

The evaluation team's assessment of the Water Heat program included analysis and verification of gas water heating-related measures offered by Avista including gas water heaters (storage and tankless) and low flow showerheads. The water heater measures were rebated through Avista's Water Heat program. Showerhead incentives were offered through the Simple Steps upstream program and provided as direct install measures through Avista's manufactured home duct sealing program.

6.3.2 Program Achievements and Participation Summary

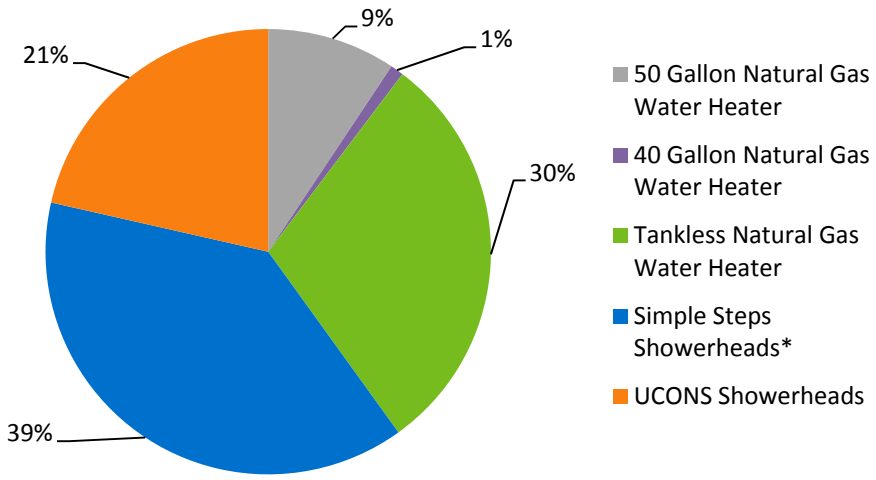
Participation in the 2014–2015 Water Heat program totaled 7,686 measures (includes distinct measure counts). Table 6-9 and Figure 6-4 summarize Avista's 2014–2015 Water Heat program participation and energy impacts.

Table 6-9: 2014–2015 Water Heat Reported Participation and Savings

Measure	2014–2015 Reported Participation Count	2014–2015 Reported Savings (Therms)
50 Gallon Natural Gas Water Heater	314	2,815
40 Gallon Natural Gas Water Heater	33	291
Tankless Natural Gas Water Heater	153	8,973
Simple Steps Showerheads*	6,598	11,607
Ucons Showerheads	588	6,468
TOTAL	**7,686**	**30,154**

*Inclusive of 1.5, 1.6, 1.75, and 2.0 gpm low flow showerheads and includes nonparticipant savings

Figure 6-4: 2014–2015 Water Heat Program Reported Participation Energy Saving Shares



*Includes non-participants counts and savings

6.3.3 Methodology

The evaluation team performed verification of the program measures through a review of sampled project documentation and phone survey responses with program participants. Our review was designed to confirm the program tracking database was aligned with both project documentation and survey data. The following subsections outline the methodology for the water heaters and low flow showerheads.

6.3.3.1 Water Heaters

The evaluation team leveraged the data collected from the project documentation and phone surveys along with parameter assumptions sourced from other Technical Reference Manuals to conduct an engineering analysis to estimate savings for storage and tankless water heaters. Specifically, the following data was reviewed from these sources:

- Energy factor of the replaced and new water heater
- Average daily hot water usage per person
- Number of household occupants
- Water heater set points

The evaluation team used the reported age of the replaced water heater to estimate the baseline energy factor. The participant responses reported an average age 13.7 years for gas water heaters. Based on this average age, we applied the 2004 federal standard as the baseline energy factor.We adjusted the energy factor based on the size (40 gallon versus 50 gallon) or type (storage versus tankless) based on the data presented in Figure 6-5 and Figure 6-6 below.

Figure 6-5: Federal Standards for Natural Gas Storage Water Heaters

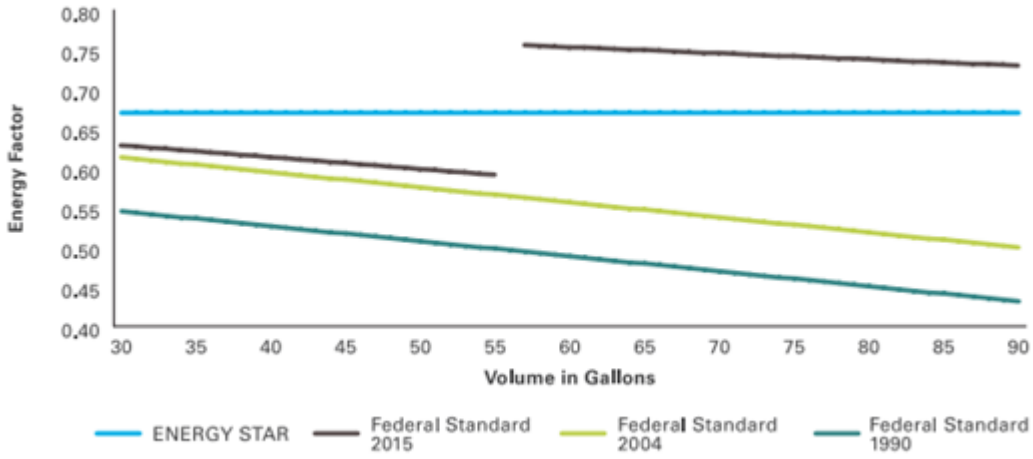


Figure 6-6: 2004 Federal Standards for Natural Gas Tankless Water Heaters

Instantaneous Gas-fired Water Heater	<2 gallons	0.62−(0.0019 × Rated Storage Volume in gallons)	EF = 0.82−(0.0019 × Rated Storage Volume in gallons).

The evaluation team estimated savings for water heaters using Equation 6-3. The parameters and source for each parameter is identified in Table 6-10:

Equation 6-3: Water Heater Energy Savings Calculation

$$\Delta Therms = \frac{\left(\frac{1}{EF_{baseline}} - \frac{1}{EF_{retrofit}}\right) \times \left(GPD \times 365.25 \times Den \times C_p \times (Temp_{outlet} - Temp/_{inlet})\right)}{100{,}000}$$

Table 6-10: Water Heater Parameters and Data Sources

Parameter	Value	Source
People	2.43	Participant survey data[1]
Hot water usage per day per person (GPD)	25.1	Secondary Source
Days	365.25	Conversion Factor (day/yr)
Outlet water temperature (F˚)	135	Secondary source[13]
Inlet water temperature (F˚)	52	Secondary source[14]
$EF_{baseline}$	0.52	Participant survey data
$EF_{retrofit\text{-}storage}$	0.62	Program documentation[1]
$EF_{retrofit\text{-}tankless}$	0.91	Program documentation[1]
CP	1	Constant (BTU/lb)
Den	8.33	Constant (lb/gal)

[1]Average for sampled participants.

We calculated verified energy savings for each sampled project. Due to the small sample size, we calculated a single realization rate for all the water heater measures offered by the program.

6.3.3.2 Low Flow Showerheads

The evaluation team estimated savings from low flow showerheads following Equation 6-4 and the parameters and source for each identified in Table 6-11:

Equation 6-4: Low Flow Showerhead Energy Savings Calculation

$$\Delta Therms = \frac{People \times Shower\ Time \times Days \times \%Days \times \Delta GPM \times (T_{shower} - T_{in}) \times Den \times C_p}{EF \times 100{,}000 \times Showerheads}$$

Where:

People = the number of people taking showers (ppl/household)

Shower Time = the average shower length (min/shower)

Days = the number of days per year (day/yr)

%Days = the number of showers per day, per person (shower/day-ppl)

[13] DeOreo, William, P. Mayer, L. Martien, M. Hayden, A. Funk, M. Kramer-Duffield, and R. Davis (2011). "California Single-Family Water Use

[14] https://www3.epa.gov/ceampubl/learn2model/part-two/onsite/ex/jne_henrys_map.html

ΔGPM = the difference in gallons per minute for the base showerhead and the new showerhead (gal/min)

TSHOWER = the average water temperature at the showerhead (oF)

TIN = the average inlet water temperature (oF)

CP = the specific water heat (BTU/lb-oF)

Den = the water density (lb/gal)

100,000 = the conversion rate between BTU and therm

EF = the water heater's energy factor

Total # of Showerheads = the number of showerheads per home

Table 6-11: Low Flow Showerhead Parameters and Data Sources

Term	Value	Source
People	2.51	U.S. 2010 Census
Gallons per Day (GPD)	25.1	Secondary source
Shower Time	8.06	Regional Technical Form
Days	365	Conversion Factor (day/yr)
%Days	0.68	Regional Technical Form
ΔGPM	0.3, 0.55, 0.7, 0.8	Program data (efficient case); Regional Technical Form (baseline case)
Outlet water temperature (F˚)	135	Secondary source[15]
Inlet water temperature (F˚)	52	Secondary source[16]
$EF_{baseline}$	0.52	Participant survey data
$EF_{retrofit\text{-}storage}$	0.62	Program documentation
$EF_{retrofit\text{-}tankless}$	0.91	Program documentation
CP	1	Constant (BTU/lb-oF)
Den	8.33	Constant (lb/gal)
Number of Showerheads	1.91	U.S. 2010 Census; Regional Technical Form

[15] DeOreo, William, P. Mayer, L. Martien, M. Hayden, A. Funk, M. Kramer-Duffield, and R. Davis (2011). "California Single-Family Water Use

[16] https://www3.epa.gov/ceampubl/learn2model/part-two/onsite/ex/jne_henrys_map.html

Because the showerheads were either distributed via an upstream or direct install program, the evaluation team assumed an installation rate of 1.0.

Per unit savings were estimated based on these parameter inputs and the extrapolated total savings from showerheads based on the measure counts reported by the program implementers. The Simple Steps database provided the overall number of showerheads sold through the program in Washington; however, no program data was available to determine the proportion of showerheads installed in homes with natural gas water heating. In order to determine the proportion of homes with natural gas water heating, the evaluation team leveraged data collected through the 2011 Single Family Regional Building Stock Assessment[17]. We used data specific to Washington to assign the proportion of Simple Steps showerheads that contributed to natural gas savings. This issue was not present for showerheads installed by UCONS under the manufactured home duct sealing program, as UCONS contractors reported the water heater fuel type for each home that received showerheads.

Additionally, the Bonneville Power Authority (BPA) reported additional non-participant savings from showerheads under the Simple Steps program. The evaluation team allocated these additional savings based on the same assumed natural gas water heating saturation for Washington. We also assigned only a portion of these savings to Washington as the BPA non-participant savings represented both Avista's Washington and Idaho territories. The evaluation team based the portion assigned to Washington on Avista's Washington residential customer base relative to its entire customer base.

6.3.4 Findings and Recommendations

Based on the review of sampled project documentation and phone survey data, the evaluation team did not identify any errors or corrections needed to the program tracking database.

The evaluation team's analysis for the water heater measures resulted in a realization rate of 118%. The primary driver for the high realization rate is because in the gross savings calculation, the evaluation team used the actual baseline EF's found in the participant surveys, resulting in a lower efficiency baseline than what Avista is currently assuming in their energy savings calculations.

The analysis conducted for the low flow showerheads, as described above, resulted in a blended realization rate across the 2.0, 1.75, 1.6 and 1.50 GPM Simple Steps showerheads of 142%. The UCONS program reported a higher per unit savings value than the Simple Steps program reported, resulting in a lower realization rate for the UCONS showerheads of 113%.

The total program realization rate and savings are presented in Table 6-12. The relative precision of the program level natural gas realization rate is ±13% at the 90% confidence level.

[17] http://neea.org/docs/reports/residential-building-stock-assessment-single-family-characteristics-and-energy-use.pdf?sfvrsn=8

Table 6-12: Water Heat Program Gross Verified Savings

Measure	2014–2015 Participation Count	2014–2015 Reported Savings (Therms)	2014–2015 Adjusted Reported Savings (Therms)	Realization Rate (%)	2014-2015 Gross Verified Savings (Therms)
50 Gallon Natural Gas Water Heater	314	2,815	2,815	118%	3,312
40 Gallon Natural Gas Water Heater	33	291	291	118%	342
Tankless Natural Gas Water Heater	153	8,973	8,972	118%	10,556
Simple Steps Showerheads*	6,598	11,607	11,607	142%	16,512
Ucons Showerheads	588	6,468	6,468	113%	7,324
TOTAL	**7,686**	**30,154**	**30,153**	**126%**	**38,046**

6.4 ENERGY STAR® Homes

6.4.1 Overview

The ENERGY STAR® Homes program provides new home buyers with an $800 rebate for an ENERGY STAR® ECO-rated new manufactured home or $1,000 for an ENERGY STAR® stick-built home. The evaluation team conducted a document review and engineering analysis for a sample of the participating homes and attempted to conduct a billing analysis to estimate gross verified impacts for the program.

6.4.2 Program Achievements and Participation Summary

Participation in the 2014-2015 ENERGY STAR® Homes program totaled 22 homes. Table 6-13 summarize Avista's reported 2014 and 2015 ENERGY STAR® Homes program participation and energy impacts.

Table 6-13: 2014–2015 ENERGY STAR® Homes Reported Participation and Savings

Measure	2014–2015 Reported Participation Count	2014–2015 Reported Savings (Therms)
G Energy Star Home – Natural Gas Only	22	4,669
TOTAL	**22**	**4,669**

6.4.3 Methodology

The evaluation team initially attempted to use a difference-in-means approach to estimate savings for the ENERGY STAR® Homes program. Utility billing data was used to compare average weather normalized annual consumption of newly built ENERGY STAR® Homes to the weather normalized annual consumption of non-program new meter hookups in Avista service territory, allowing for an estimate of program-related savings. However, due to the small number of ENERGY STAR® Homes participants and absent any detailed characteristics of the homes (e.g. square footage, single- vs. multi-family, etc.) a reliable non-program comparison group could not be attained.

Instead, the evaluation team collected Home Energy Rating System (HERS) Index scores for participating ENERGY STAR® Homes wherever available. A total of 19 HERS scores were found, including four ENERGY STAR® Stick Built, WA homes and 15 ENERGY STAR Natural Gas homes. A baseline HERS Index score of 80 was assumed as standard for non-program new meter hookups, determined by the 2012 IECC HERS Index Score for climate zone 5.

The evaluation team estimated weather normalized annual consumption for ENERGY STAR® Homes using the same basic model specification shown in Equation 3-1. Because these newly built homes do not have a pre-retrofit period, only “post-retrofit” consumption was estimated by the model (in this case, the “retrofit” occurs upon completion of the home or at the time of occupancy).

To estimate what the home’s consumption would have been, absent the ENERGY STAR® program, each home’s weather normalized annual consumption estimates was scaled up by a weighting factor calculated as the quotient of the base HERS Index score 80 and the home’s HERS Index score. Equation 6-5 shows the calculation of estimated consumption absent the program.

Equation 6-5: Calculation of Consumption Absent Program

$$\text{Therms}_{\text{NP}} = \text{Therms}_{\text{P}} \times \frac{\text{HERS}_{\text{Base}}}{\text{HERS}_{\text{Home}}}$$

Table 6-14 provides additional information about the terms in Equation 6-5.

Table 6-14: Calculation of Consumption Absent Program Definition of Terms

Variable	Definition
$Therms_{NP}$	Estimated gas consumption in home absent the program
$Therms_{P}$	Weather normalized annual gas consumption of the home
$HERS_{Base}$	2012 IECC HERS Index Score for climate zone 5 = 80
$HERS_{Home}$	HERS Index Score for the home

Estimated gas savings for the 15 ENERGY STAR Natural Gas Homes (therms) were calculated individually using each home's specific HERS Index score. HERS Index scores for the remaining ENERGY STAR® Homes were not available, so the evaluation team applied the mean HERS Index score from among the ENERGY STAR® Homes with HERS Index scores and estimated annual consumption absent the program in the same way for these homes, using Equation 6-5.

6.4.4 Findings and Recommendations

The findings of the HERS Index score approach produced savings estimates exceeding the deemed ex ante savings reported by Avista for the ENERGY STAR® Homes measures. Realization rates were calculated at greater than 100% of reported savings across all measures.

While the results of the HERS Index score approach shows positive savings results, a billing analysis approach with a non-program comparison group would have been the preferred approach. For future evaluations, the evaluation team recommends that Avista track more detailed characteristics of the ENERGY STAR® program homes and non-program homes to allow for a reliable non-participant comparison group billing analysis approach.

Table 6-15 shows calculations for gas savings and realization rate for ENERGY STAR® Natural Gas Homes. Analysis on these homes estimated approximately 631 annual therms used under program conditions. The HERS Index weight of 1.6 estimated 1,062 therms annually under non-program conditions, resulting in 431 therms estimated savings.

Table 6-15: ENERGY STAR Home: Results for Natural Gas Homes

n Homes	Ex Ante Therms	Annual Therms	Base Therms	Delta Therms	Weight	Realization Rate
15	203	631	1,062	431	1.6	212%

Table 6-16 outlines the program reported, adjusted, and gross verified savings value for the gas-specific homes in the ENERGY STAR® homes program. The evaluation team found a

212% realization rate across the entire program. The relative precision of the program level electric realization rate is ±43.8% at the 90% confidence level.

Table 6-16: ENERGY STAR® Homes Program Gross Verified Savings

Measure	2014–2015 Reported Participation Count	2014–2015 Reported Savings (Therms)	2014–2015 Adjusted Reported Savings (Therms)	Realization Rate	2014-2015 Gross Verified Savings (Therms)
G Energy Star Home – Natural Gas Only	22	4,669	4,669	212%	9,920
TOTAL	**22**	**4,669**	**4,669**	**212%**	**9,920**

6.5 Fuel Efficiency

6.5.1 Overview

The fuel efficiency program offers a rebate for the conversion of electric resistance heat to natural gas, as well as the conversion of electric hot water heaters to natural gas models. The evaluation team conducted a document review, database review, telephone surveys, and a billing analysis on a sample of the population in order to estimate the gross verified savings for the program.

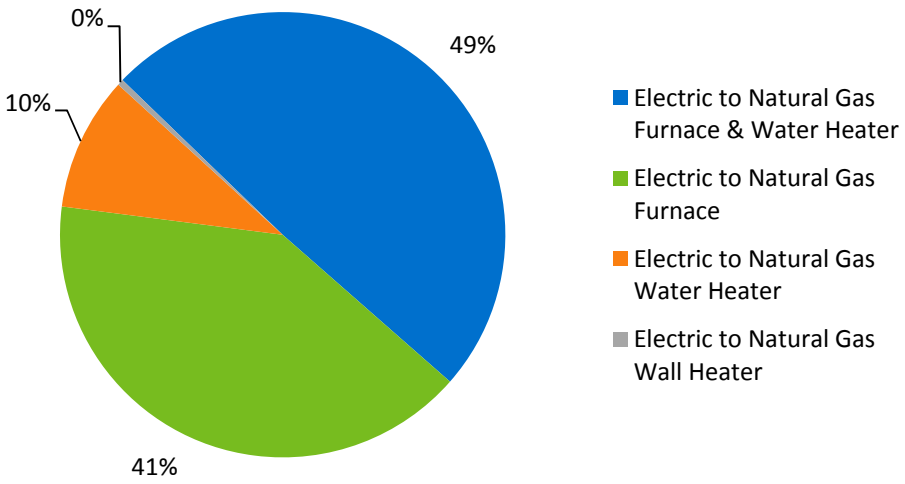
6.5.2 Program Achievements and Participation Summary

Participation in the 2014-2015 Fuel Efficiency program totaled 613 conversions. Table 6-17 and Figure 6-7 summarize Avista's 2014-2015 Fuel Efficiency program participation and energy impacts.

Table 6-17: 2014-2015 Fuel Efficiency Reported Participation and Savings

Measure	2014–2015 Reported Participation Count	2014–2015 Reported Savings (Therms)
Electric to Natural Gas Furnace & Water Heater	210	-154,761
Electric to Natural Gas Furnace	258	-128,013
Electric to Natural Gas Water Heater	142	-30,634
Electric to Natural Gas Wall Heater	3	-1,398
TOTAL	**613**	**-314,247**

Figure 6-7: 2014–2015 Fuel Efficiency Program Reported Gas Penalty Shares



6.5.3 Methodology

The Fuel Efficiency program is a dynamic offering because participants modify the fuel source used for space heating and/or water heating within their residences. These measures produce a large reduction in electric consumption, which is offset to some extent by increased consumption of natural gas. The evaluation team examined both the electric savings and associated gas penalty using an Option C regression analysis of billing data provided by Avista. There are two key factors that affect gas penalty analysis – the first simplifies matters, while the second complicates the analysis and accounting of the gas penalty.

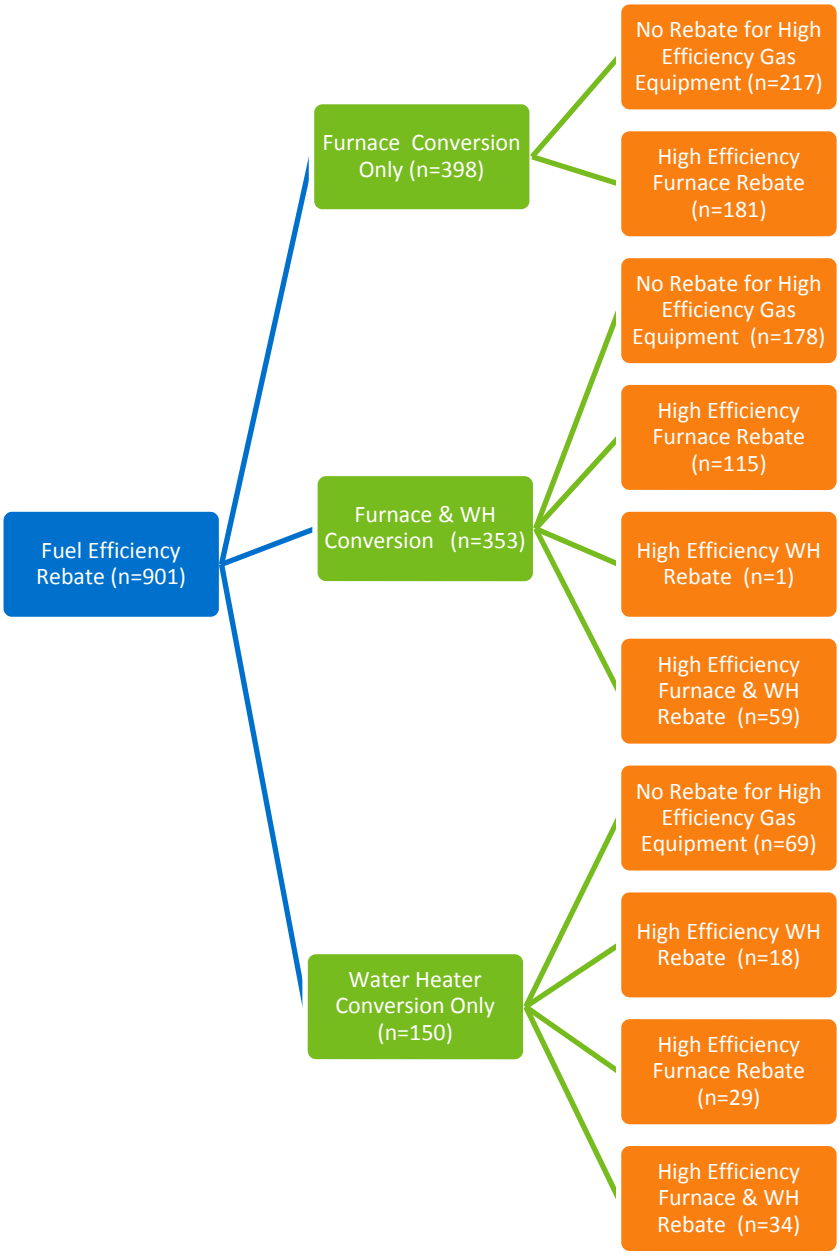
1) Over half of homes that received Fuel Efficiency rebates did not have natural gas service with Avista prior to participation[18]. This means the gas furnace or water heater was installed shortly after gas service was added to the residence. It also makes the gas usage in the home pre-retrofit intuitive—zero therms per year.

2) Approximately 49% of homes that received fuel efficiency incentives from Avista also received rebates for the installation of a high efficiency furnace or water heater. For these homes the observed increase in gas consumption actually overstates the appropriate gas penalty because the gas meter records the consumption of the rebated efficient appliance rather than the code minimum furnace or water heater required of the homeowner to receive a Fuel Efficiency rebate. The difference in consumption between the code minimum appliance that was not installed and high efficiency appliance that was installed are credited as savings in the Gas HVAC and Gas Water Heating programs.

[18] The evaluation team used homes with two of fewer months of gas billing history and more than two months of electric billing history as a proxy for the absence of gas service.

The evaluation team requested monthly consumption records for each account that received a Fuel Efficiency rebate (both Washington and Idaho) from Avista in 2014 and 2015. Billing records were requested for January 2013 through February 2016 to maximize the quantity of pre- and post-retrofit data available. The team excluded accounts where the meter number changed during the period as this indicates the customer had moved and the consumption data was from two different physical residences. Figure 6-8 provides of breakdown of the remaining 901 homes that received Fuel Efficiency rebates. Note that while there were 613 reported participants in the Washington Gas Fuel Efficiency program, the analysis conducted by the evaluation team is based on homes in both Idaho and Washington.

Figure 6-8: Diagram of Fuel Switching Participation



The prevalence of rebates for high efficiency natural gas water heaters and furnaces limited the sample sizes for the gas penalty analysis compared to the electric savings because the evaluation limited the analysis data set to homes that did not receive a rebate for high efficiency gas equipment.

The general form of the regression model is shown in Section 3.4.4 of this report and the detailed regression output is presented in Appendix B . In order to maximize the number of homes analyzed the evaluation team relaxed the required number of months for inclusion in the analysis. Homes with at least nine months of pre-retrofit electric billing history and six months of post-retrofit billing history were included in the electric analysis.

Gas impacts (negative savings or increased consumption) were estimated separately for homes with and without prior natural gas service and weighted average realization rate for the two groups was calculated and applied to all reported therm penalties from furnace conversions. Table 6-18 shows the results of the calculation for electric to gas furnace conversions.

Table 6-18: Electric to Gas Furnace Conversion Penalty Calculation

Group	# Homes	Ex Ante Therms	Annual Therms Pre	Annual Therms Post	Annual Gas Impact	Realization Rate
Homes with prior gas service	30	-491	332	576	-243	49.6%
Homes with new gas service	78	-492	0	427	-427	86.8%
Gas Penalty Realization Rate for Electric to Gas Furnace Conversion						76.4%

The same process was repeated for homes that converted both furnace and water heater. Almost all of the homes that converted only the water heating type had previous gas service so the penalty for that group was determined exclusively using a pre\post analysis of gas consumption in those homes.

In addition, the evaluation team performed verification of the program tracking database and conducted 26 document audits and telephone surveys with customers who participated in the program.

6.5.4 Findings and Recommendations

During the document audit and program database review, the evaluation team did find a few reporting errors, which are reflected in the “adjusted reported” savings value found in the Program Results section below.

Table 6-19 provides the primary billing analyses results of interest for the three different fuel conversion paths incented by Avista. Full output tables from the five natural gas fuel efficiency models are provided in Appendix B.4.

Table 6-19: Fuel Efficiency Gas Penalty Impact Summary

Model	n	Ex Ante Therms	Annual Therms Pre	Annual Therms Post	Annual Therm Savings	RR	Weighted Average
Electric to Gas WH - with prior gas service	50	-202	565	763	-198	97.8%	n/a
Electric to Gas Furnace - with prior gas service	30	-491	332	576	-243	49.6%	76.44%
Electric to Gas Furnace - without prior gas service	78	-492	0	427	-427	86.8%	
Electric to Gas Furnace and WH - with prior gas service	9	-713	322	817	-495	69.4%	68.72%
Electric to Gas Furnace and WH - without prior gas service	60	-713	0	489	-489	68.6%	

One noteworthy finding in Table 6-19 is that the 30 homes analyzed that converted from electric heat to a natural gas furnace showed an average weather normalized gas consumption of 332 therms per year pre-retrofit. This is relatively high gas consumption for homes with exclusively electric space heating. These homes also didn't increase their consumption that significantly after the conversion. It's possible that some of these homes had a mix of heating fuels prior to participation and the electric heating system converted was only a supplemental system. The evaluation team recommends Avista carefully screen participants to ensure that homes are exclusively electrically heated to qualify for Fuel Efficiency rebates or develop a more conservative savings claim for homes that convert a home with dual-fuel heating to all natural gas heat.

6.5.5 Program Results

The gas realization rate for the Fuel Efficiency program was 75%. This program level realization rate was developed by taking a weighted average of the realization rates of the Fuel Efficiency rebate types shown in Table 6-20. The relative precision of the program level gas realization rate was ±27.5% at the 90% confidence level.

Table 6-20: Fuel Efficiency Program Reported and Gross Verified Savings

Measure	2014–2015 Reported Participation Count	2014-2015 Reported Savings (Therms)	2014–2015 Adjusted Reported Savings (Therms)	Realization Rate	2014-2015 Gross Verified Savings (Therms)
Electric to Natural Gas Furnace & WH	210	-154,761	-154,761	69%	-106,353
Electric to Natural Gas Furnace	258	-128,013	-128,013	76%	-97,849
Electric to Natural Gas Water Heater	142	-30,634	-30,634	98%	-29,965
Electric to Natural Gas Wall Heater	3	-1,398	-1,398	98%	-1,368
TOTAL	**613**	**-314,247**	**-314,805**	**75%**	**-235,535**

6.6 Shell Program

6.6.1 Overview

Avista's internally managed shell program incentivizes measures that improve the integrity of the home's envelope such as insulation (attic, floor and wall), window replacements and manufacture home duct sealing (part of the UCONS program for 2014 only). The evaluation team conducted a database review, document audits, customer telephone surveys, and a billing analysis to estimate the adjusted reported and gross verified savings for the program.

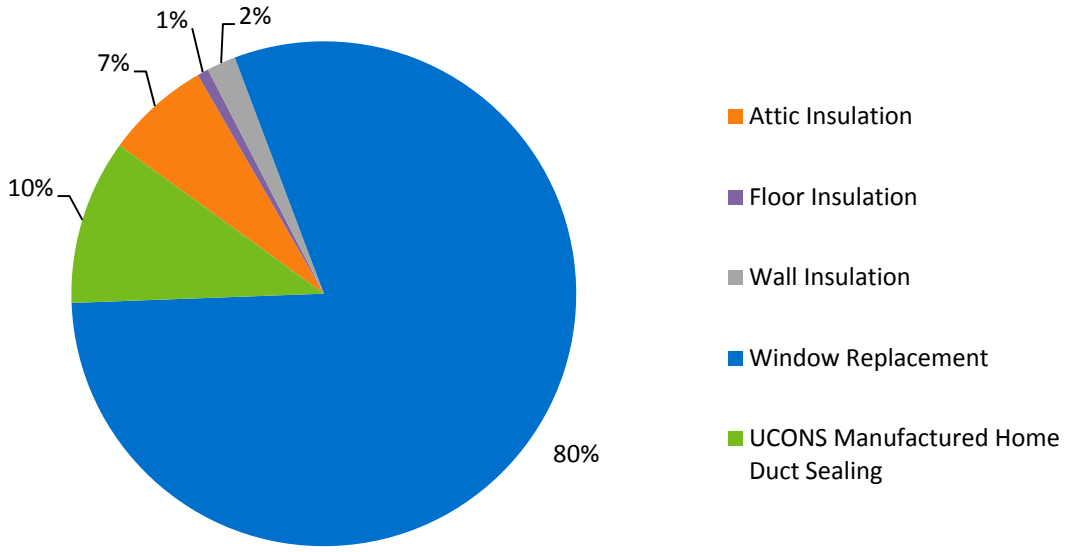
6.6.2 Program Achievements and Participation Summary

Participation in the 2014 and 2015 Shell program totaled 3,119 projects. Table 6-21 and Figure 6-9 summarize Avista's reported 2014 and 2015 Shell program participation and energy impacts.

Table 6-21: 2014–2015 Shell Program Reported Participation and Savings

Measure	2014-2015 Reported Participation Count	2014-2015 Reported Savings (Therms)
Attic Insulation	320	27,460
Floor Insulation	46	2,993
Wall Insulation	110	7,651
Window Replacement from Single Pane	1,919	329,631
UCONS Manufactured Home Duct Sealing	724	43,505
TOTAL	**3,119**	**411,239**

Figure 6-9: 2014–2015 Shell Program Reported Energy Saving Shares



6.6.3 Methodology

The evaluation team investigated the two delivery streams of the Shell program; Rebate Measures (Attic, Floor, Wall Insulation and Window Replacement) and UCONS Manufactured Home Duct Sealing, separately but utilized very similar methods. Natural gas billing data from participating homes was merged with historic weather conditions (HDD) and program tracking data was used to code the pre-retrofit and post-retrofit period for each home. The evaluation team then estimated fixed effects panel regression models to develop a mathematical relationship between weather and gas load before and after the Shell improvements were installed. Equation 6-6 shows the form of the model and the text below defines the model terms.

Equation 6-6: Fixed-Effects Panel Regression Model Specification

$$Therms_{it} = \beta_i + \beta_1(Post)_{it} + \beta_2(HDD)_{it} + \beta_3(Post \times HDD)_{it} + \varepsilon_{it}$$

Where:

$Therms_{it}$ = Metered energy usage (dependent variable) in home *i* during period *t*
$Post_{it}$ = Dummy variable indicating whether period *t* was pre- or post-retrofit
HDD_{it} = Average heating degree days (base 65 F) during period *t* at home *i*
ε = Customer-level random error
β_i = The model intercept for home *i*
$\beta_{1\text{-}3}$ = Coefficients determined via regression

The β_1 and β_3 terms in Equation 6-6 represent the average change in daily baseload and daily therms per HDD respectively. The evaluation team used these coefficients and normal weather

conditions (TMY3) for the three chosen weather stations to estimate the average weather normalized annual savings.

In order to construct the electric Shell Rebate analysis data set, the evaluation team implemented the following data preparation steps. The number of unique homes remaining for analysis after each filter is shown in parentheses.

- Identify the homes that participated in the Shell program and had gas billing data provided by Avista to the evaluation team **(2,724)**
- Exclude homes that also participated in other Rebate programs to ensure Shell impact estimates are not confounded with impacts from the Fuel Efficiency, HVAC, or other programs. **(2,514)**
- Limit the data set to homes with reported therm savings and gas billing data **(1,697)**
- Exclude homes with fewer than 12 months of pre-retrofit billing history **(769)**
- Exclude homes with fewer than 12 months of post-retrofit billing history **(660).**

For the evaluation of the UCONS Manufacture Home Duct Sealing component, a similar series of filters was applied to the program participants and their billing data, resulting in 474 homes remaining for analysis. As noted in Section 2.2.3, the UCONS initiative installed measures that roll up under the Water Heating, and Shell program. For the Shell program analysis, the evaluation team sought to isolate the performance of the duct improvement measure. In order to isolate the duct sealing measure, the evaluation team further trimmed the 474 homes that passed each billing analysis screen to only include homes that received duct improvements and removed 30 homes that received only a low-flow showerhead. The remaining 444 homes either received only duct improvement (n=112) or duct improvement and a showerhead (n=332).

In order to isolate the duct sealing savings from showerhead savings, the evaluation team assumed that changes in weather dependent consumption (β_3 in Equation 6-6) were attributable to duct improvements and used these coefficients to estimate weather normalized savings from duct improvements.

In addition to the billing analysis activities noted above, the evaluation team performed verification of the program tracking database and conducted 47 document audits of participating projects.

6.6.4 Findings and Recommendations

6.6.4.1 Shell Rebate Measures

Table 6-22 presents the key findings from the evaluation team's gas billing analysis for shell rebate measures. On average homes are reducing their total weather normalized annual gas consumption by 4.3% (33 therms). Although a significant reduction in total consumption this result falls short of the average reported savings for these 660 homes of 93 therms.

Table 6-22: Shell Rebate Billing Analysis Findings

# Homes	Average Reported Therms	Annual Therms Pre-Retrofit	Annual Therms Post-Retrofit	Annual Therm Savings	RR
660	93	764	731	33	36.0%

Appendix B.3 contains the full regression output for the shell rebate billing analysis and Table 6-23 presents the coefficients for each term in the model. Notice that the model estimates a significant reduction in gas load per heating degree day (β_3), but a statistically significant increase in base load (β_1).

Table 6-23: Shell Rebate Regression Coefficients

Model Term	Coefficient	Lower Bound of 95% CI	Upper Bound of 95% CI
Post (β_1)	0.075	0.035	0.115
HDD (β_2)	0.113	0.109	0.117
Post*HDD (β_3)	-0.009	-0.011	-0.007
Intercept (β_i)	0.042	-0.030	0.114

Shell improvements such as windows and insulation upgrades are primarily focused on reducing the heating consumption within the home. Using the coefficients in Table 6-23, the evaluation team estimates that the heating consumption within participating homes was reduced by almost 8% from 0.113 therms per HDD to (0.113 - .009 = 0.104) therms per day.

6.6.4.2 UCONS Duct Improvements

Appendix B.3 provides the detailed output for the regression analysis of the gas heated homes that received duct sealing from UCONS in 2014. The key coefficient is the average therm savings per HDD (0.00463). These regression coefficients were applied to a weighted average value of the three Avista weather stations to calculated gross verified savings from duct improvements (Table 6-24).

Table 6-24: UCONS Duct Sealing Analysis Results

Weather Station	Weight	HDD (Base 65 F)	Heating Therm Savings
Coeur d'Alene	5.7%	6,915	32.0
Lewiston	6.4%	5,511	25.5
Spokane	87.9%	6,707	31.1
Weighted Average		6,641	30.8

The ratio of the weather dependent savings (30.8 therms) to the reported savings from homes receiving duct repair (60.5 therms) among the homes analyzed was 50.8% (Table 6-25).

Table 6-25: Shell Rebate Gross Verified Savings Summary

# Homes	Average Reported Therms	Gross Verified Therms Savings	Realization Rate
444	60.5	30.8	50.8%

6.6.5 Program Results

During the document audit activities, the evaluation team found several discrepancies in the heating fuel type reported for the home and the associated fuel type that the measure is saving. For example, in a few instances, both the customer survey and the project application state wood and natural gas as the primary heating source, but the window and attic insulation incentives were paid based on electric heating. Based on these findings, the evaluation team recommends that Avista work with local contractors to confirm that the measure savings is tied to the correct heating fuel source, perhaps conducting verification activities on a percent of applications received would also help improve the reporting accuracy.

The natural gas realization rate for the Shell program is 38%. This program level realization rate was developed by taking a weighted average of the realization rates of the program measures shown in Table 6-26. The relative precision of the program level gas realization rate is ±17.5% at the 90% confidence level.

Table 6-26: Shell Program Gross Verified Savings

Measure	2014–2015 Reported Participation Count	2014–2015 Reported Savings (Therms)	2014–2015 Adjusted Reported Savings (Therms)	Realization Rate	2014-2015 Gross Verified Savings (Therms)
Attic Insulation	320	27,460	27,460	36%	9,878
Floor Insulation	46	2,993	2,993	36%	1,077
Wall Insulation	110	7,651	7,651	36%	2,753
Window Replacement from Single Pane	1,919	329,631	329,631	36%	118,582
UCONS Manufactured Home Duct Sealing	724	43,505	43,505	51%	22,115
TOTAL	**3,119**	**411,239**	**411,239**	**38%**	**154,404**

6.7 Low Income

6.7.1 Overview

Avista's Low Income program offers a variety of conservation and fuel efficiency measures to low income households. Avista leverages Community Action Program (CAP) agencies to deliver energy efficiency programs to the Company's low income customer group. CAP agencies have resources to income qualify, prioritize and treat homes based upon a number of characteristics. In addition to the Company's annual funding, the Agencies have other monetary resources that they can usually leverage when treating a home with weatherization and other energy efficiency measures. The Agencies either have in-house or contractor crews to install many of the efficiency measures of the program. Avista provides CAP agencies with an "Approved Measure List" of energy efficiency measures. Any measure installed on this list by the Agency in an income qualified home will receive 100% reimbursement for the cost for the work.

6.7.2 Program Achievements and Participation Summary

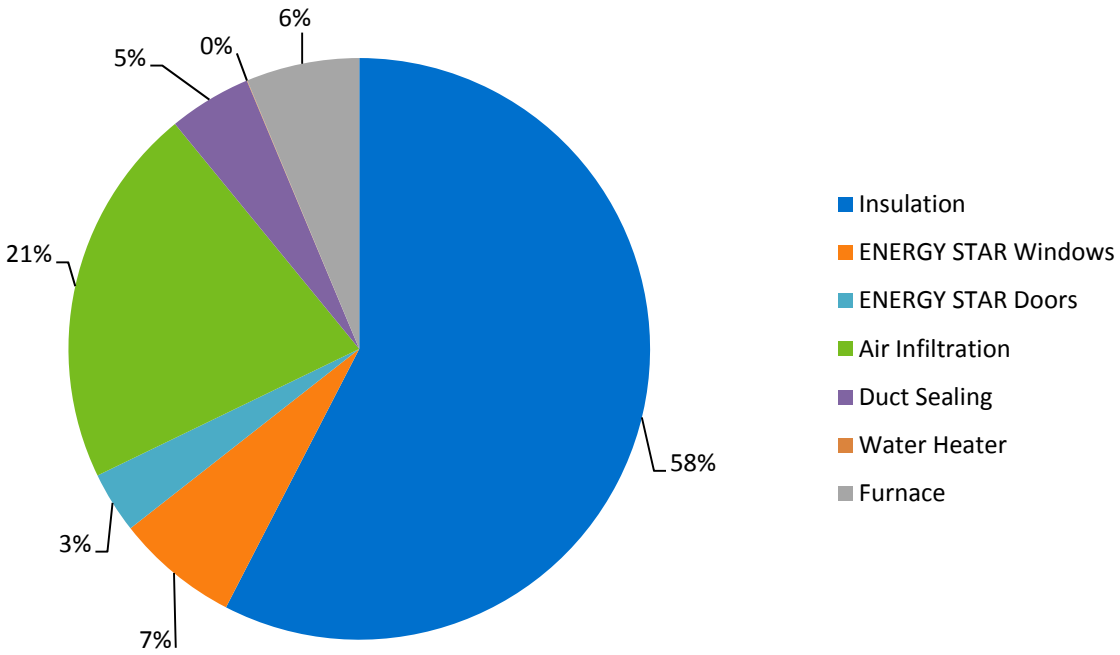
Participation in the 2014-2015 Low Income program totaled 1,457 conservation and fuel conversion projects. Table 6-27 summarizes the reported participation counts and energy savings for the measures that make-up the Low Income program. Insulation measures account for 58% of the program savings, with air infiltration the second largest measure at 21% (Figure 6-10).

Table 6-27: 2014–2015 Low-Income Program Reported Participation and Savings

Measure Category	Measure	2014–2015 Reported Participation Count	2014–2015 Reported Savings (Therms)
Conservation	Insulation	541	16,104
Conservation	ENERGY STAR Windows	119	1,911
Conservation	ENERGY STAR Doors	115	956
Conservation	Air Infiltration	262	5,942
Conservation	Duct Sealing	24	1,288
Conservation	Water Heater	1	7
Conservation	Gas Furnace	22	1,760
Fuel Conversion	E to G Furnace Conversion	197	-9,006
Fuel Conversion	E to G Water Heat Conversion	176	-4,243
	TOTAL	**1,457***	**14,719**

*Unique measures, not individual homes, the evaluation team found 282 homes that implemented conservation measures and 108 fuel conversion homes.

Figure 6-10: 2014-2015 Low-Income Program Reported Energy Saving Shares: Conservation Measures



6.7.3 Methodology

The evaluation team organized the analysis for the Low Income Program based on the measures categories noted in Table 6-27 above. For the conservation and fuel conversion measures, the evaluation team employed a regression analysis.

The Low Income program operates as a dual fuel program in Washington with CAP Agencies targeting both electric and natural gas savings opportunities. Participating homes generally received multiple improvements so the electric and gas savings values from all measures installed within a given home were aggregated to arrive at the total reported savings for each home. For the gas savings analysis, the evaluation team first filtered the program population to include only those homes with claimed therm savings in the program tracking data.

Next, homes were assigned to one of two groups for analysis:

1) **Conservation Homes** – these homes had positive reported therm savings.

2) **Fuel Conversion Homes** – these homes had large reported electric savings and a *negative* reported therm savings. This net gas penalty (and a large share of the electric savings) resulted from a conversion of the homes heating or water heating system from electricity to natural gas.

The evaluation team then relied on a regression analysis of Avista billing data to estimate per-home impacts for homes claiming therm savings. Billing analysis was determined to be an appropriate method because the average annual gas savings claimed per participating home was almost 84 therms across the 282 gas conservation homes and -84 therms for the 108 fuel conversion homes.

As described in Section 3.4.4, each home was matched to the nearest weather station and historical weather records were merged with historical consumption. Homes were required to have at least 12 months of pre-retrofit and 9 months of post-retrofit billing data for inclusion in the analysis. The evaluation team used a fixed effects panel regression model to establish the average relationship between fuel consumption and weather before and after service. Separate models were estimated for fuel conversion homes and conservation homes. Both Idaho and Washington homes were used in the fuel conversion analysis to boost the precision of the results. Regression coefficients were then applied to normal weather conditions (TMY3) for the region to estimate weather-normalized annual gas savings. The regression coefficients and relevant goodness of fit statistics are presented in Appendix B.2.

The evaluation team also conducted a review of Avista's 2014 and 2015 tracking databases and a document audit on 24 projects.

6.7.4 Findings and Recommendations

Table 6-28 summarizes the key inputs and outputs of the regression analysis. The average percent reduction in gas consumption for the 127 gas conservation homes analyzed was 12%.

The verified savings for this group was very consistent with Avista's reported savings with a realization rate of 101%. As expected, the fuel conversion homes showed a drastic increase in gas consumption (a 222% increase). Similar to the electric low-income fuel conversion findings, it appears that Avista's reported estimates of gas penalties from fuel conversion are understated. The realization rate for the 15 homes analyzed was over 400%. Although this result led to a significant adjustment in the low-income program, it is important to note that the verified savings results are similar to Avista's reported gas penalty in the Fuel Efficiency program on a per-home basis.

Table 6-28: Low Income Billing Analysis Findings

Stratum	Gas Conservation Homes	Fuel Conversion Homes
# Homes Analyzed	127	15
Average Reported Therms	77.3	-123.2
Annual Weather-Normalized Therms Pre-Retrofit	642.5	228.8
Annual Weather Normalized Therms Post-Retrofit	564.2	737.3
Average Therm Savings per Home	78.2	-508.5
Realization Rate	101%	413%
Average Percent Reduction	12%	-222%

Figure 6-11 examines the seasonality of gas savings among the 127 low-income gas conservation homes analyzed. These impacts were estimated using the pre-retrofit regression coefficient and applying them to the actual weather conditions in 2015 (post period). The difference between these baseline estimates and the actual metered load during the post-retrofit period are the savings estimate. Unlike the results shown in Table 6-28, the impact estimates in Figure 6-11 are not weather normalized.

As expected, savings are concentrated during winter months when gas heating loads are highest. The surprising trend in Figure 6-11 actually occurs during the summer months when homes show a statistically significant increase in gas consumption (negative savings). Recall from Section 6.6.4.1 that the Shell rebate analysis found a similar trend of increased base load in the post-retrofit period. While this result could certainly just be a result of a regression model with limited sample size 'over-fitting' the data there could also be increased gas consumption in the water heating and cooking end-uses that counteract the heating savings when the data is analyzed at the whole house level.

Figure 6-11: Monthly Gas Savings Trend – Gas Conservation Homes

6.7.5 Program Results

The database review and document audit activities conducted by the evaluation team did not result in any adjustments to the reported Avista savings values. The overall gas realization rate for the Low Income program was -180%. This program level realization rate was developed by taking a weighted average of the realization rates of the measure categories shown in Table 6-29. The relative precision of the program level gas realization rate was ±25% at the 90% confidence level for the conservation measure category.

Table 6-29: Low-Income Program Gross Verified Savings

Measure Category	2014–2015 Reported Participation Count	2014–2015 Adjusted Reported Savings (Therms)	Realization Rate	2014-2015 Gross Verified Savings (Therms)
Conservation	1,084	27,968	101%	28,248
Fuel Conversion	373	-13,249	413%	-54,720
TOTAL	**1,457**	**14,719**	**-180%**	**-26,473**

6.8 Residential Sector Results Summary

Table 6-30 lists the gross verified savings for each of Avista's residential programs in Washington in 2014 and 2015 and for the overall portfolio. The Washington gas residential sector achieved an 81% realization rate and the relative precision of the program-level gas realization rate was ±5.1% at the 90% confidence level.

Table 6-30: Residential Program Gross Impact Evaluation Results

Program	2014-2015 Reported Savings (therms)	2014-2015 Adjusted Reported Savings (therms)	Realization Rate	2014-2015 Gross Verified Savings
HVAC	401,855	402,163	125%	502,820
ENERGY STAR Homes	4,669	4,669	212%	9,920
Shell	411,239	411,239	38%	154,404
Water Heat Program	30,154	30,153	126%	38,046
Low Income Conservation	14,719	27,968	101%	28,248
Conservation Total	862,636	876,193	84%	733,439
Fuel Efficiency (Fuel Conversion)	(314,247)	(314,805)	75%	(235,535)
Low Income Fuel Conversion	(13,249)	(13,249)	413%	(54,720)
Fuel Conversion Total	(327,497)	(328,055)	88%	(290,256)
TOTAL RESIDENTIAL	**535,139**	**548,138**	**81%**	**443,183**

7 Conclusions and Recommendations

7.1 Summary

The following outlines the evaluation team's conclusions and recommendations for Avista to consider for future program processes and reporting. Additional details regarding the conclusions and recommendations outlined here can be found in the program-specific sections of this report.

7.2 Impact Findings

The evaluation team performed the impact evaluation for Avista's 2014 and 2015 Washington gas programs through a combination of document audits, customer surveys, engineering analysis and onsite measurement and verification (M&V) on a sample of participating projects. The impact evaluation activities resulted in an 88% realization rate across Avista's 2014-2015 portfolio of programs (Table 7-1). Table 7-3 and Table 7-2 summarize Avista's 2014 and 2015 impact evaluation results by sector and program.

Table 7-1: 2014-2015 Washington Natural Gas Portfolio Evaluation Results

Sector	2014-2015 Reported Savings (therms)	Realization Rate (%)	2014-2015 Gross Verified Savings (therms)
Residential	848,225	83%	705,191
Residential – Fuel Conversion	(314,247)	75%	(235,535)
Nonresidential	867,194	92%	797,083
Low Income	27,968	101%	28,248
Low Income – Fuel Conversion	(13,249)	413%	(54,720)
Portfolio	**1,415,890**	**88%**	**1,240,266**

Table 7-2: Washington Gas Nonresidential Program Evaluation Results

Program	2014-2015 Reported Savings (therms)	Realization Rate (%)	2014-2015 Verified Gross Savings (therms)
Commercial Water Heaters	5	127%	6
Commercial Windows & Insulation	32,930	137%	45,265
Natural Gas HVAC	43,434	104%	45,079
Food Service Equipment	55,687	124%	68,889
Site Specific	717,544	86%	615,852
Small Commercial	14,503	125%	21,992
TOTAL NONRESIDENTIAL	**864,103**	**92%**	**797,083**

Table 7-3: Washington Gas Residential Program Evaluation Results

Program	2014-2015 Adjusted Reported Savings (kWh)	Realization Rate (%)	2014-2015 Verified Gross Savings (therms)
HVAC	402,163	125%	502,820
ENERGY STAR Homes	4,669	212%	9,920
Shell	411,239	38%	154,404
Water Heat Program	30,153	126%	38,046
Low Income Conservation	27,968	101%	28,248
Conservation Total	876,193	84%	733,439
Fuel Efficiency (Fuel Conversion)	(314,805)	75%	(235,535)
Low Income Fuel Conversion	(13,249)	413%	(54,720)
Fuel Conversion Total	(328,055)	88%	(290,256)
TOTAL RESIDENTIAL	**548,138**	**81%**	**443,183**

7.3 Conclusions and Recommendations

The following outlines the key conclusions and recommendations as a result of the evaluation activities. Specific details regarding the conclusions and recommendations outlined here, along with additional conclusions and recommendations can be found in the program-specific sections of this report.

7.3.1 Nonresidential Programs

The overall realization rate for the nonresidential portfolio is 92%. The realization rates ranged from 137% for the Commercial Windows & Insulation program down to 86% for the Site Specific program, the largest program in the nonresidential portfolio. The evaluation team found that the processes Avista is utilizing for estimating and reporting energy savings for the nonresidential

programs are predominantly sound and reasonable. The following subsections outline specific conclusions and recommendations for several of the nonresidential programs.

7.3.1.1 Site Specific Program

Conclusion: The Site Specific program constitutes more than 80% of the program energy shares. Within the last 2 years, Avista has increased their level of quality assurance and review on projects that participate through the program. The evaluation team's analysis resulted in an 86% realization rate for the Site Specific program.

> **Recommendation**: The evaluation team recommends that Avista incentivize more of the larger, high impact natural gas projects under its 'performance path' processes. Natural gas projects are more often suited to performance verification via utility billing analysis than their electric counterparts because fewer building end uses are served by natural gas. Incentivizing projects based on proven performance would mitigate the inherent uncertainty in savings estimates generated prior to project installation and improve Avista's realization rate for this program.

7.3.1.2 Natural Gas Prescriptive Programs

Conclusion: Avista reported participation in four prescriptive natural gas programs in 2014-2015: Food Service Equipment, Commercial Windows & Insulation, Natural Gas HVAC, and Commercial Water Heaters. Strong realizations rates for each of these programs indicate that the Avista's deemed savings estimates for these measures are accurate and appropriate.

> **Recommendation**: The evaluation team recommends that Avista continue to operate these programs with the current level of rigor.

7.3.1.3 Small Business Program

Conclusion: Reported savings for faucet aerators were found to be conservatively low based upon our secondary research. The realization rate for faucet aerators was 204% for natural gas savings.

> **Recommendation:** It is recommended that the modified deemed savings values utilized by the evaluation team in our adjusted savings analysis be adopted by the program for future reporting purposes.

7.3.2 Residential Programs

The overall realization rate for the residential portfolio is 81%. The realization rates varied significantly across the programs evaluated with the Low Income – Fuel Conversion program component having the highest realization rate at 413% and the Shell program having the lowest realization rate at 38%. The following subsections outline specific conclusions and recommendations for several of the residential programs.

7.3.2.1 HVAC Program

Conclusion: During the desk review process, the evaluation team found that the installed efficiency for the majority of the furnace replacements was higher than the program minimum-required efficiency level, which resulted in a greater than 100% realization rate. The evaluation team was unable to determine a conclusive value for the baseline efficiency of the replaced furnaces based on project documentation review and the participant surveys.

> **Recommendation**: The evaluation team recommends that Avista conduct a more in-depth study in order to better understand the baseline for the furnace replacement measure.

Conclusion: The evaluation team found a realization of 85% for the Smart Thermostat measure. The findings are based on the analysis of 34 homes, which resulted in a wide margin of error in the results.

> **Recommendation:** Given that the realization rate relatively close to 100% with a wide margin of error, the evaluation team does not recommend any changes to Avista's default savings assumption of 41 therms per device. The evaluation team recommends Avista revisit the smart thermostat analysis in 2017 once several hundred participants have a full year of post-installation billing data available and the billing analysis is capable of producing a more precise estimate.

> **Recommendation**: Avista currently rebates smart thermostats from multiple vendors. Nest, Honeywell, and Ecobee are the primary vendors in this space and represented the majority of rebates in 2014-2015. One recent study in the Pacific Northwest[19] have found different levels of savings between thermostat vendors so Avista may want to consider segmenting subsequent analyses by product or even limiting the products that qualify for rebates.

7.3.2.2 Water Heat

Conclusion: Currently Avista is providing incentives for both tankless and storage gas water heaters at the federal minimum efficiency level. It is recommended that Avista set a higher EF as a program qualification.

> **Recommendation:** It is recommended that Avista revisit program requirements for water heaters to ensure that incentives are based on efficiency levels that are greater than the federal minimum.

Conclusion: For showerheads distributed through the Simple Steps program, Avista allocates 50% of its reported savings to electric savings and 50% to natural gas savings to account for homes that have different water heating fuel types.

[19] http://assets.energytrust.org/api/assets/reports/Smart_Thermostat_Pilot_Evaluation-Final_wSR.pdf

Recommendation: The evaluation team recommends Avista update this allocation assumption to be based on representative water heater fuel type saturation. These data are available through the Regional Building Stock Assessment study; however, we recommend Avista base the allocation on data specific to its territory.

7.3.2.3 ENERGY STAR® Homes

Conclusion: The evaluation team initially attempted to use a difference-in-means approach to estimate savings for the ENERGY STAR® Homes program. However, due to the small number of ENERGY STAR® Homes participants and absent any detailed characteristics of the homes (e.g. square footage, single- vs. multi-family, etc.) a reliable non-program comparison group could not be attained. Therefore, the evaluation team collected Home Energy Rating System (HERS) Index scores for participating ENERGY STAR® Homes wherever available to conduct the impact analysis.

Recommendation: As more participants enter the program, the evaluation team recommends again attempting a difference-in-means approach to estimating the savings for the program, if sufficient data is available.

Recommendation: To aid future evaluation efforts, the evaluation team recommends including the HERS scores in the program tracking documents. In addition, for stick-built ENERGY STAR homes, application forms could ask for the RESNET Registry ID, which is now assigned as part of RESNET Archival of all HERS Rated or ENERGY STAR homes. This will ensure that the home has been certified third party and is recognized by RESNET, the certifying agency for ENERGY STAR.

7.3.2.4 Fuel Efficiency

Conclusion: The evaluation team found that the 30 homes analyzed that converted from electric heat to a natural gas furnace showed an average weather normalized gas consumption of 332 therms per year pre-retrofit. This is relatively high gas consumption for homes with exclusively electric space heating. These homes also didn't increase their consumption that significantly after the conversion. It's possible that some of these homes had a mix of heating fuels prior to participation and the electric heating system converted was only a supplemental system.

Recommendation The evaluation team recommends Avista carefully screen participants to ensure that homes are exclusively electrically heated to qualify for Fuel Efficiency rebates or develop a more conservative savings claim for homes that convert a home with dual-fuel heating to all natural gas heat.

Conclusion: The evaluation team found that almost half of all (ID and WA) Fuel Efficiency participants also received rebates for the installation of high efficiency natural gas equipment.

Recommendation: Separating the upgrade of a home's heating system from electric resistance heat to a high efficiency natural gas furnace creates some accounting

challenges that Avista way want to streamline in the future. The fuel conversion measure assumes the home installs a standard efficiency natural gas furnace and savings are calculated accordingly. The high efficiency furnace measure offered through Avista's HVAC program uses a standard efficiency furnace as the baseline and the installed high efficiency furnace as the efficient case. This creates challenges for analysis of energy savings because the standard efficiency furnace never existed in over half of Washington homes. A possible solution would be to require that homes install a high efficiency furnace in order to receive a Fuel Efficiency rebate and consider the upgrade a single transaction rather than two. Specifically, instead of claiming a 500 therm penalty for the Fuel Efficiency measure and 100 therms of savings from the high efficiency furnace measure, Avista could claim the electric savings and a 400 therm penalty for an electric -> HE furnace measure.

7.3.2.5 Shell Program

Conclusion: The evaluation team found a low realization rate (38%) for shell rebate measures (windows and insulation). This finding indicates that reported savings values were too aggressive on average. In addition, the evaluation team found an increase in the baseload in the customers participating through the Shell Program. The increase in estimated baseload is puzzling because the shell improvements should have only limited effect on non-weather dependent end-uses such as cooking and water heating. This result could be an artifact of the regression fitting noisy data with limited sample size. However, other possibilities include homes performing fuel conversion outside of the Avista Fuel Efficiency program or a general shift in gas consumption for non-heating end-uses.

Recommendation: The evaluation team recommends Avista examine planning assumptions about per-home consumption, end-use load shares, and percent reductions in heating loads from shell improvements. It may be that the percent reduction assumptions are sound, but they are being applied to an overstated assumption of the average heating consumption per home. Conversely, the assumed end-use shares may be accurate, but the end-use reduction percentage is inflated.

Recommendation: The evaluation team recommends Avista look at any recent saturation studies or end-use load research findings to see if there is a general shift in base load gas use that could potentially harm the savings from the Shell improvements when analyzed at the whole house level.

7.3.2.6 Low Income Program

Conclusion: The verified savings for the gas conservation homes was very consistent with Avista's reported savings with a realization rate of 101%. Similar to the electric low-income fuel conversion findings, it appears that Avista's reported estimates of gas penalties from fuel conversion are understated, with the realization rate for the fuel conversion participants at over 400%. Although this result led to a significant adjustment in the low-income program, it is

important to note that the verified savings results are similar to Avista's reported gas penalty in the Fuel Efficiency program on a per-home basis.

> **Recommendation:** The evaluation team recommends that Avista align assumptions for fuel switching penalty savings for the Low Income and Fuel Efficiency programs.

Appendix A Sampling and Estimation

The gross verified energy savings estimates presented in this report from Avista's DSM programs were generally determined through the observation of key measure parameters among a sample of program participants. A census evaluation would involve surveying, measuring, or otherwise evaluating the entire population of projects within a population. Although a census approach would eliminate the sampling uncertainty for an entire program, the reality is that M&V takes many resources both on the part of the evaluation team and the program participants who agree to be surveyed or have site inspections conducted in their home or business. When a sample of projects is selected and analyzed, the sample statistics can be extrapolated to provide a reasonable estimate of the population parameters. Therefore, when used effectively, sampling can improve the overall quality of an evaluation study. By limiting resource-intensive data collection and analysis to a random sample of all projects, more attention can be devoted to each project surveyed.

The nuances and tradeoffs considered by the evaluation team when developing sampling approaches varied across the portfolio and are discussed in more detail in Section 3.2. However, several common objectives were shared across sectors and programs. The most important sampling objective was representativeness – that is the projects selected in the evaluation were representative of the population they were selected from and will produce unbiased estimates of population parameters. A second key sampling objective was to consider the value of information being collected and align sample allocations accordingly. This effort generally involves considering the size (contribution to program savings) and uncertainty associated with the area being studied and making a determination about the appropriate level of evaluation resources to allocate.

The evaluation team used two broad classes of probability estimation techniques to make inferences about program or stratum performance based on the observations and measurements collected from the evaluation sample. Auxiliary information refers to the reported savings estimates stored in the program tracking system.

1) **Mean-Per-Unit** (or estimation in the absence of auxiliary information): This technique was used to analyze samples drawn from populations that are similar in size and scope. This approach was used primarily for residential programs that include a large number of rebates for similar equipment types where the evaluation objective is to determine an average therms savings per rebated piece of equipment. With mean-per-unit estimation the average therms savings observed within the sample is applied to all projects in the population.
2) **Ratio Estimation** (or estimation using auxiliary information): This technique was used for nonresidential programs and residential programs with varying savings across projects. This technique assumes that the ratio of the sum of the verified savings estimates to the sum of the reported savings estimates within the sample is

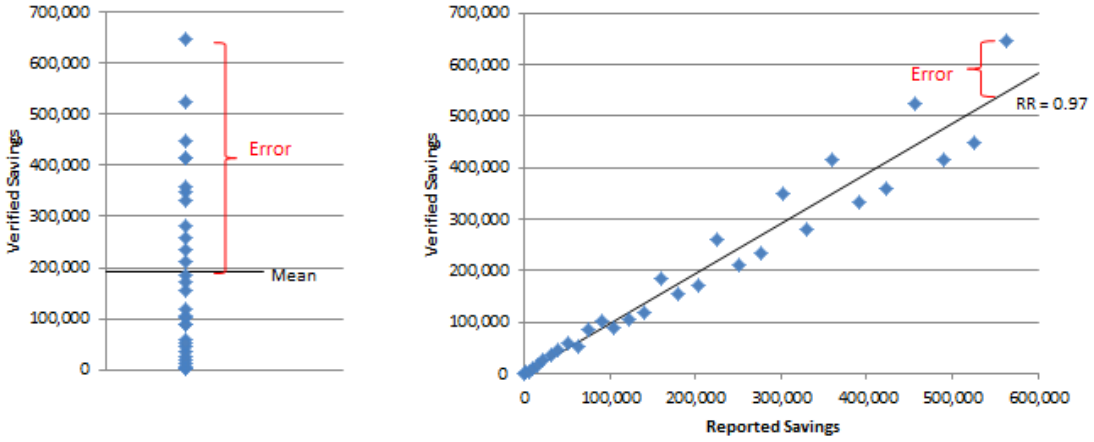
representative of the program as a whole. This ratio is referred to as the *realization rate*, or *ratio estimator*, and is calculated as follows:

Equation A- 1: Coefficient of Variation

$$Realization\ Rate = \frac{\sum_i^n Verified\ Savings}{\sum_i^n Reported\ Savings}$$

Where *n* is the number of projects in the evaluation sample. The realization rate is then applied to the claimed savings of each project in the population to calculate gross verified savings. Figure A- 1 shows the reduction in error that can be achieved through ratio estimation when the sizes of projects within a program population vary considerably. The ratio estimator provides a better estimate of individual project savings than a mean savings value by leveraging the reported savings estimate.

Figure A- 1: Comparison of Mean-Per-Unit and Ratio Estimation



A.1 Stratification

The evaluation team used sample stratification with both classes of estimation techniques. Stratification is a departure from simple random sampling (SRS), where each sampling unit (customer/project/rebate/measure) has an identical likelihood of being selected in the sample. Stratified random sampling refers to the designation of two or more sub-groups (strata) from within a program population prior to the selection process. Whenever stratification was employed the evaluation team took great care to ensure that each sampling unit within the population belonged to one (and only one) stratum. In each program sample design where stratification was used, the probability of selection is different between strata and this difference must be accounted for when calculating results. The inverse of the selection probability is referred to as the *case weight* and is used in estimation of impacts when stratified random samples are utilized. Consider the following simplified example in Table A- 1 based on a fictional program with two measures; refrigerators and clothes washers.

Table A- 1: Case Weights Example

Measure	Population Size	Sample Size	Case Weight
Clothes Washer	15,000	30	500
Refrigerator	6,000	30	200

Because refrigerators are sampled at a higher rate (1-in-200) than clothes washers (1-in-500), each sample point carries less weight in the program results than an individual clothes washer sample point. In general, the evaluation team designed samples so that strata with high case weights had low per-unit impacts or were well-understood measures. Low case weights were reserved for large and complex measures such as the large stratum of the Site Specific program.

The evaluation team felt that stratification was advantageous and utilized it in the sample design for a variety of reasons across the portfolio:

1) Increased precision if the within-stratum variability was expected to be small compared to the variability of the population as a whole. Stratification in this case allows for increased precision or smaller total sample sizes, which lowered evaluation costs.
2) To ensure that a minimum number of units within a particular stratum will be verified. This was relevant for small programs like ENERGY STAR® Homes. Although the program's contribution to portfolio savings was small, the evaluation team felt it was important to sample enough projects to independently estimate program performance.
3) It is easy to implement a value-of-information approach through which the largest projects are sampled at a much higher rate than smaller projects by creating size-based strata.
4) Sampling independently within each stratum allows for comparisons among groups. Avista and the evaluation team find value in comparing results between strata; e.g., comparing the realization rates between measures within a program.

A.2 Presentation of Uncertainty

There is an inherent risk, or uncertainty, that accompanies sampling, because the projects selected in the evaluation sample may not be representative of the program population as a whole with respect to the parameters of interest. As the proportion of projects in the program population that are sampled increases, the amount of sampling uncertainty in the findings decreases. The amount of variability in the sample also affects the amount of uncertainty introduced by sampling. A small sample drawn from a homogeneous population will provide a more reliable estimate of the true population characteristics than a small sample drawn from a heterogeneous population. Variability is expressed using the coefficient of variation (C_v) for programs that use simple random sampling, and an error ratio for programs that use ratio estimation. The C_v of a population is equal to the standard deviation (σ) divided by the mean (μ) as shown in Equation A- 2.

Equation A- 2: Coefficient of Variation

$$C_v = \frac{\sigma}{\mu}$$

When ratio estimation is utilized, standard deviations will vary for each project in the population. The error ratio is an expression of this variability and is analogous to the C_v for simple random sampling.

Equation A- 3 provides the formula for estimating error ratio.

Equation A- 3: Error Ratio

$$Error\ Ratio = \frac{\sum_{i=1}^{N} \sigma_i}{\sum_{i=1}^{N} \mu_i}$$

Equation A- 4 shows the formula used to calculate the required sample size for each evaluation sample, based on the desired level of confidence and precision. Notice that the C_v term is in the numerator, so required sample size will increase as the level of variability increases. For programs that rely on ratio estimation, error ratio replaces the C_v term in Equation A- 4. Results of the 2012-2013 portfolio evaluation were the primary source of error ratio and C_v assumptions for the evaluation.

Equation A- 4: Required Sample Size

$$n_0 = \left(\frac{Z * C_v}{D}\right)^2$$

Where:

n_0 = The required sample size before adjusting for the size of the population
Z = A constant based on the desired level of confidence (equal to 1.645 for 90% confidence two-tailed test)
C_v = Coefficient of variation (error ratio for ratio estimation)
D = Desired relative precision

The sample size formula shown in Equation A- 4 assumes that the population of the program is infinite and that the sample being drawn is reasonably large. In practice, this assumption is not always met. For sampling purposes, any population greater than approximately 7,000 may be considered infinite for the purposes of sampling. For smaller, or finite, populations, the use of a finite population correction factor (FPC) is warranted. This adjustment accounts for the extra precision that is gained when the sampled projects make up more than about 5% of the program savings. Multiplying the results of Equation A- 4 by the FPC formula shown in Equation A- 5 will produce the required sample size for a finite population.

Equation A- 5: Finite Population Correction Factor

$$fpc = \sqrt{\frac{N - n_0}{N - 1}}$$

Where:

N = Size of the population

n_0 = The required sample size before adjusting for the size of the population

The required sample size (*n*) after adjusting for the size of the population is given by Equation A- 6.

Equation A- 6: Application of the Finite Population Correction Factor

$$n = n_0 * fpc$$

Throughout this report gross verified energy savings are reported with the associated margin of error. The margin of error can be introduced by sampling or via estimation error from a billing analysis, or both. Billing analyses rely on consumption data that often contains variability not explained by weather or other independent variables. This inherent variability in the data introduces uncertainty because program savings effects must be separated from underlying noise. The standard errors of coefficients in the regression model quantify this uncertainty and allow a margin of error to be calculated. Verified savings estimates always represent the point estimate of total savings, or the midpoint of the confidence interval around the verified savings estimate for the program. Equation A- 7 shows the formula used to calculate the margin of error for a parameter estimate.

Equation A- 7: Error Bound of the Savings Estimate

$$Error\ Bound = se * (z - statistic)$$

Where:

se = The standard error of the population parameter of interest (proportion of customers installing a measure, realization rate, total energy savings, etc.) This formula will differ according to the sampling technique utilized.

$z - statistic$ = Calculated based on the desired confidence level and the standard normal distribution.

The 90% confidence level is a widely accepted industry standard for reporting uncertainty in evaluation findings. Unless otherwise noted, the confidence levels and precision values presented in this report are at the 90% confidence level. The z-statistic associated with 90% confidence is 1.645.

The evaluation team also reports the relative precision value associated with verified savings estimates. When evaluators or regulators use the term “90/10”, the 10 refers to the relative precision of the estimate. The formula for relative precision shown in Equation A- 8:

Equation A- 8: Relative Precision of the Savings Estimate

$$Relative\ Precision_{Verified\ Savings} = \frac{Error\ Bound_{(kWh\ or\ kW)}}{Verified\ Impact_{(kWh\ or\ kW)}}$$

An important attribute of relative precision to consider when reviewing achieved precision values is that it is “relative” to the impact estimate. Therefore programs with low realization rates are likely to have larger relative precision values because the error bound (in kWh) is being divided by a smaller number. This means two programs with exactly the same reported savings and sampling error in absolute terms, with have very different relative precision values (example in Table A- 2).

Table A- 2: Relative Precision Example

Program	Reported kWh	Realization Rate	Error Bound (kWh)	Verified kWh	Relative Precision (90%)
Program #1	4,000,000	0.5	400,000	2,000,000	± 20%
Program #2	4,000,000	1.0	400,000	4,000,000	± 10%

In many cases a program-level savings estimate requires summation of the verified savings estimates from several strata. In order to calculate the relative precision for these program-level savings estimates, the evaluation team used Equation A- 9 to estimate the error bound for the program as a whole from the stratum-level error bounds.

Equation A- 9: Combining Error Bounds across Strata

$$Error\ Bound_{Program} = \sqrt{Error\ Bound_{Stratum1}^2 + Error\ Bound_{Stratum2}^2 + Error\ Bound_{Stratum3}^2}$$

Using this methodology, the evaluation team developed verified savings estimates for the program and an error bound for that estimate. The relative precision of the verified savings for the program is then calculated by dividing the error bound by the verified savings estimate.

Appendix B Billing Analysis Regression Outputs

B.1 HVAC Program

Table B-1: Smart Thermostat Fixed-Effects Regression Output

daily_therms	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
hdd_ave	.0980248	.0028509	34.38	0.000	.0924022	.1036475
hdd_ave	0	(omitted)				
post	.0264988	.0353165	0.75	0.454	-.0431548	.0961524
c.hdd_ave#c.post	-.0025006	.0020674	-1.21	0.228	-.0065781	.0015769
hdd_ave	0	(omitted)				
treatpost	-.0075493	.1250237	-0.06	0.952	-.2541295	.2390309
c.hdd_ave#c.treatpost	-.0047474	.0076001	-0.62	0.533	-.0197369	.0102421
_cons	.2296749	.0519838	4.42	0.000	.127149	.3322008
sigma_u	.75760128					
sigma_e	.71769006					
rho	.52703333	(fraction of variance due to u_i)				

B.2 Low Income Program

Table B- 2: Gas Penalty for Fuel Conversion

```
Fixed-effects (within) regression               Number of obs      =       493
Group variable: account                         Number of groups   =        15

R-sq:  within  = 0.3991                         Obs per group: min =        26
       between = 0.0006                                        avg =      32.9
       overall = 0.3359                                        max =        36

                                                F(3,14)            =      9.59
corr(u_i, Xb)  = -0.0323                        Prob > F           =    0.0011

                                              (Std. Err. adjusted for 15 clusters in account)
```

daily_therms	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
treatment	.2284104	.128117	1.78	0.096	-.0463731	.503194
hdd_ave	.0317692	.0111892	2.84	0.013	.0077707	.0557678
c.hdd_ave#c.treatment	.0640983	.0252911	2.53	0.024	.0098543	.1183424
_cons	.0497175	.2022054	0.25	0.809	-.3839699	.483405
sigma_u	.67824218					
sigma_e	1.2623138					
rho	.22401948	(fraction of variance due to u_i)				

Table B- 3: Low Income Gas Conservation

```
Fixed-effects (within) regression               Number of obs      =      4312
Group variable: account                         Number of groups   =       127

R-sq:  within  = 0.7964                         Obs per group: min =        23
       between = 0.0138                                        avg =      34.0
       overall = 0.6781                                        max =        36

                                                F(3,126)           =    357.98
corr(u_i, Xb)  = -0.0182                        Prob > F           =    0.0000

                                              (Std. Err. adjusted for 127 clusters in account)
```

daily_therms	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
treatment	.0503026	.0242704	2.07	0.040	.0022721	.0983331
hdd_ave	.0995368	.0033627	29.60	0.000	.092882	.1061915
c.hdd_ave#c.treatment	-.0148549	.0022919	-6.48	0.000	-.0193905	-.0103192
_cons	-.0132711	.0521874	-0.25	0.800	-.1165485	.0900063
sigma_u	.58921168					
sigma_e	.64672348					
rho	.45356751	(fraction of variance due to u_i)				

B.3 Shell Program

Table B-4: Shell Rebate Measures

```
Fixed-effects (within) regression               Number of obs      =     22864
Group variable: new_acct                        Number of groups   =       660

R-sq:  within  = 0.7641                         Obs per group: min =        25
       between = 0.0108                                        avg =      34.6
       overall = 0.6091                                        max =        36

                                                F(3,659)           =   1233.02
corr(u_i, Xb)  = -0.0034                        Prob > F           =    0.0000

                                                (Std. Err. adjusted for 660 clusters in new_acct)
```

daily_therms	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
treatment	.0752274	.02041	3.69	0.000	.0351509	.115304
hdd_ave	.1127962	.0020426	55.22	0.000	.1087854	.116807
c.hdd_ave#c.treatment	-.0091613	.0010401	-8.81	0.000	-.0112036	-.007119
_cons	.0419385	.0367524	1.14	0.254	-.0302274	.1141043
sigma_u	.8507755					
sigma_e	.82733398					
rho	.51396628	(fraction of variance due to u_i)				

Table B- 5: UCONS Duct Improvement Regression

```
Fixed-effects (within) regression               Number of obs      =     12193
Group variable: new_acct                        Number of groups   =       332

R-sq:  within  = 0.8079                         Obs per group: min =        24
       between = 0.0131                                        avg =      36.7
       overall = 0.6751                                        max =        72

                                                F(3,331)           =   1017.95
corr(u_i, Xb)  = 0.0003                         Prob > F           =    0.0000

                                    (Std. Err. adjusted for 332 clusters in new_acct)
```

daily_therms	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
treatment	.0986672	.0209322	4.71	0.000	.0574903	.1398442
hdd_ave	.0840557	.0021292	39.48	0.000	.0798672	.0882443
c.hdd_ave#c.treatment	-.0046327	.0013804	-3.36	0.001	-.0073482	-.0019172
_cons	.0967967	.0387358	2.50	0.013	.0205972	.1729962
sigma_u	.52060443					
sigma_e	.54375233					
rho	.47826203	(fraction of variance due to u_i)				

B.4 Fuel Efficiency Program

Table B- 6: Electric to Gas Furnace Conversion – No Prior Gas Service

```
Fixed-effects (within) regression               Number of obs      =       876
Group variable: id                              Number of groups   =        78

R-sq:  within  = 0.8078                         Obs per group: min =         6
       between = 0.2313                                        avg =      11.2
       overall = 0.7117                                        max =        25

                                                F(1,77)            =    371.24
corr(u_i, Xb)  = 0.0050                         Prob > F           =    0.0000

                                                (Std. Err. adjusted for 78 clusters in id)
```

daily_therms	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
treatment	0	(omitted)				
hdd_ave	.0751861	.0039022	19.27	0.000	.0674158	.0829564
c.hdd_ave#c.treatment	0	(omitted)				
_cons	-.1274667	.0568443	-2.24	0.028	-.2406582	-.0142753
sigma_u	.38976648					
sigma_e	.48070922					
rho	.39665326	(fraction of variance due to u_i)				

Table B- 7: Electric to Gas Furnace and Water Heater Conversion – No Prior Gas Service

```
Fixed-effects (within) regression               Number of obs      =       537
Group variable: id                              Number of groups   =        60

R-sq:  within  = 0.8216                         Obs per group: min =         6
       between = 0.0764                                        avg =       8.9
       overall = 0.6834                                        max =        13

                                                F(1,59)            =    322.57
corr(u_i, Xb)  = 0.0017                         Prob > F           =    0.0000

                                              (Std. Err. adjusted for 60 clusters in id)
```

daily_therms	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
treatment	0	(omitted)				
hdd_ave	.0650354	.0036211	17.96	0.000	.0577897	.0722811
c.hdd_ave#c.treatment	0	(omitted)				
_cons	.1270582	.0495282	2.57	0.013	.0279525	.2261639
sigma_u	.41119618					
sigma_e	.41597802					
rho	.49421926	(fraction of variance due to u_i)				

Table B- 8: Electric to Gas Furnace Conversion – Prior Gas Service

```
Fixed-effects (within) regression               Number of obs      =      1013
Group variable: id                              Number of groups   =        30

R-sq:  within  = 0.5711                         Obs per group: min =        17
       between = 0.3234                                        avg =      33.8
       overall = 0.4704                                        max =        37

                                                F(3,29)            =     40.30
corr(u_i, Xb)  = 0.0658                         Prob > F           =    0.0000

                                                (Std. Err. adjusted for 30 clusters in id)
```

daily_therms	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
treatment	-.3377654	.0561455	-6.02	0.000	-.4525958	-.222935
hdd_ave	.0376786	.0080366	4.69	0.000	.0212419	.0541152
c.hdd_ave#c.treatment	.056042	.0083951	6.68	0.000	.0388721	.073212
_cons	.2340358	.1228196	1.91	0.067	-.0171585	.4852301
sigma_u	.62837493					
sigma_e	.7546757					
rho	.40943483	(fraction of variance due to u_i)				

Table B- 9: Electric to Gas Furnace and WH Conversion – Prior Gas Service

```
Fixed-effects (within) regression               Number of obs      =       292
Group variable: id                              Number of groups   =         9

R-sq:  within  = 0.5746                         Obs per group: min =        24
       between = 0.1485                                        avg =      32.4
       overall = 0.4684                                        max =        36

                                                F(3,8)             =     11.60
corr(u_i, Xb)  = 0.0293                         Prob > F           =    0.0028

                                              (Std. Err. adjusted for 9 clusters in id)
```

daily_therms	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
treatment	.1840315	.1843752	1.00	0.347	-.2411384	.6092014
hdd_ave	.0503383	.0182947	2.75	0.025	.0081508	.0925259
c.hdd_ave#c.treatment	.0682586	.0271139	2.52	0.036	.0057338	.1307833
_cons	.0173263	.2906163	0.06	0.954	-.6528362	.6874888
sigma_u	.79899521					
sigma_e	.98881963					
rho	.39500686	(fraction of variance due to u_i)				

Table B- 10: Electric to Gas Water Heater Conversion – Prior Gas Service

```
Fixed-effects (within) regression               Number of obs      =      1756
Group variable: id                              Number of groups   =        50

R-sq:  within  = 0.7415                         Obs per group: min =        21
       between = 0.0088                                        avg =      35.1
       overall = 0.6115                                        max =        37

                                                F(3,49)            =    145.87
corr(u_i, Xb)  = -0.0279                        Prob > F           =    0.0000

                                                (Std. Err. adjusted for 50 clusters in id)
```

daily_therms	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
treatment	.472594	.0688871	6.86	0.000	.3341601	.6110278
hdd_ave	.0953229	.0062927	15.15	0.000	.0826772	.1079685
c.hdd_ave#c.treatment	.0038856	.0040498	0.96	0.342	-.0042528	.012024
_cons	-.1618602	.104646	-1.55	0.128	-.3721542	.0484338
sigma_u	.68125549					
sigma_e	.76063083					
rho	.44511667	(fraction of variance due to u_i)				

Appendix C Net to Gross Methodology and Findings

The evaluation team calculated net-to-gross (NTG) ratios for each program, using data collected from participant surveys. NTG takes into consideration the levels of both free ridership (FR) and spillover (SO). Free ridership refers to the portion of energy savings that participants would have achieved in the absence of the program through their own initiatives and expenditures (EPA, 2007).[20] Spillover refers to the program-induced adoption of measures by non-participants and participants who did not receive financial incentives or technical assistance for installations of measures supported by the program (EPA, 2007). The evaluation team used the following formula to calculate a NTG ratio for each program:

$$NTG = 1 - FR + SO$$

C.1 Free Ridership

Subtracting free ridership from gross savings produces an estimate of how much the program influenced participants to make the energy saving improvements that the program incents. Free ridership ranges from 0 to 1, with 0 being no free ridership (the program induced all of the reported gross savings), 1 being total free ridership (the program induced none of the savings) and values in between represent varying degrees of partial free ridership. The evaluation team used participant survey data to inform free ridership estimates.

With the exception of appliance recycling (which uses a different approach, explained below), free ridership consists of two components – change (FRC) and influence (FRI) – which both range from 0 to .5.

$$FR = FRC + FRI$$

Free Ridership Change (FRC)

Free ridership change is the participant's self-report of what they likely would have done if the program had not provided an incentive for their energy upgrade. To determine this, the evaluation team asked participant survey respondents FRC questions specific to the measures they installed. The question below exemplifies how the evaluation team collected FRC data.

*I'd like to ask a few questions about what you most likely would have done had you not received assistance from Avista for the **[Measure Type]**.*

Q1. Which of the following three alternatives is most likely: Would you have:

[SINGLE RESPONSE]

1. Put off buying a new **[Measure Type]** for at least one year [Includes repairing old or buying a used one.]
2. Bought a new **[Measure Type]** that was less expensive or less energy efficient.

20 The Environmental Protection Agency (EPA) (2007). Model Energy Efficiency Program Impact Evaluation Guide. Retrieved June 8, 2015 from http://www.epa.gov/cleanenergy/documents/suca/evaluation_guide.pdf.

3. Bought the exact same **[Measure Type]** anyway, and paid the full cost yourself. [*Do not read:*]
-96. 96. Other, please specify: [OPEN-ENDED RESPONSE]
-97. 98. Don't know
-98. 99. Refused

The evaluation team then assigned the following FRC values to each respondent, based on their response to the question above, as shown in the Table C- 1.

Table C- 1: Free Ridership Change Values

Q1 Response	FRC Value
Put off buying a new [Measure Type] for at least one year [Includes repairing old or buying a used one.]	0.00
Bought a new [Measure Type] that was less expensive or less energy efficient.	0.25
Bought the exact same [Measure Type] anyway, and paid the full cost yourself.	0.50
Other	FRC values assigned on a case by case basis, depending on which pre-coded response item they most resemble
Don't know / Refused	0.25

Free Ridership Influence (FRI)

Free ridership influence represents how much influence the program had on a participant's decision to perform the incented energy upgrade. To determine this, the evaluation team asked participant survey respondents the following question:

Q2. Now I would like to ask about the influence that the program played in your decision to purchase the energy efficient **[Measure Type]**. I'm going to read a list of things that may have influenced your decision to buy the **[Measure Type]**. For each one, please indicate how much of an influence it played in your decision, where '1' means it was "not at all influential" and "5" means it was "extremely influential." Let me know if an item doesn't apply to you. *[Interviewer: do not read 97-99]*

[MATRIX QUESTION: SCALE]

[LOGIC] Item	1	2	3	4	5	97 NA	98 DK	99 RF
[IF INCENTIVE = REBATE] The rebate you received								
Information on Avista's website								
Advertising and other information from Avista								
A salesperson or contractor								

Anything else, please specify:_____ _								

The evaluation team then selected the highest rated program-attributable item for each respondent and assigned the following FRI scores, depending on their high score value (Table C- 2).

Table C- 2: Free Ridership Influence Values

Influence Rating	FRI Value
1	0.500
2	0.375
3	0.250
4	0.125
5	0.000
Don't know / Refused	Sector-level measure average

Program-Level Free Ridership

The evaluation team summed FRC and FRI scores for each respondent, yielding participant-level free ridership (FR) scores. The evaluation team used the participant-level FR scores to calculate a savings-weighted average FR score for each program, which serves as the program-level FR score.

Appliance Recycling Free Ridership

The evaluation team developed an approach to calculating net savings for the Appliance Recycling Program by applying the Department of Energy Uniform Methods Project's (UMP) methodology. The UMP methodology differs from the NTG methodology for other program types. Rather than first calculating a NTG value from survey responses and then applying that to gross savings to yield net savings, the UMP methodology first calculates net savings using jurisdiction-specific data on the energy consumption of new and recycled appliances, together with survey data on the participants' decision-making.[21]

Adding estimated spillover to the net savings and dividing that sum by the program-reported gross savings yields the NTG ratio.[22] The evaluation team developed a modified approach that

[21] See *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*, Chapter 7: "Refrigerator Recycling Evaluation Protocols, National Renewable Energy Laboratory," March 2013 (Download available at: http://www1.eere.energy.gov/wip/pdfs/53827-7.pdf).

[22] The rationale for the UMP approach is that the actual gross savings for a particular participant depends on whether or not the participant replaced the recycled unit with a new one. Replacing the recycled unit with a new one yields gross savings equal to the energy consumption of the recycled unit minus the energy consumption of the replacement unit. Recycling without replacement yields gross savings equal to the entire energy consumption of the recycled unit. The net savings thus account for the level of free ridership as well as the mix of replaced and non-replaced appliances.

did not require estimates of the average consumption of new and recycled appliances. Surveyed participants reported what they would have done absent the program, and the evaluation team assigned a free ridership value to each respondent based on the latter information (Table C-3).[23]

Table C-3: Appliance Recycling Modified FR Values

Scenario	FR Value
The participant would not have recycled appliance without the program	0.000
Without the program, the participant would have sold or given away appliance for use in another home. Some of those would have been removed from the grid, some not.*	0.375
Without the program, the participant would have disposed of the appliance in a way that removed it from the grid.	1.000

* The UMP methodology assumes that half the units would have been taken off the grid without replacement, one-quarter of the units would have been taken off the grid with replacement, and one-quarter of the units would not have been taken off the grid. The evaluation team assigned free ridership values of 0, .5, and 1.0 to those three subgroups, respectively.

The evaluation team used the participant-level FR scores to calculate a savings-weighted average FR score for the appliance recycling program, which serves as the program-level FR score.

C.2 Spillover

Spillover estimates the energy savings from non-rebated energy improvements made outside of the program that are influenced by the program, and can be used to adjust gross savings by the additional energy savings garnered and the level of attribution the program is able to claim for these non-rebated measures. A spillover value of 0 equates to no spillover and values greater than 0 demonstrate the existence and magnitude of spillover.[24] The evaluation team used participant survey data to estimate spillover.

The evaluation team asked participant survey respondents to indicate what energy saving measures they had implemented since participating in the program to identify potential spillover. The evaluation team then asked participants to use a 1 to 5 scale, where 1 means “not at all influential” and 5 means “extremely influential,” to indicate how much influence the Avista program had on their decision to purchase these additional energy saving measures. Table C-4 exhibits how much program influence, ranging from 0% to 100%, is associated with each scale response to the spillover influence question.

[23] The surveyed respondents also reported whether they did or did not replace the recycled appliance. However, the information on replacement or non-replacement did not enter the free ridership equation, as that only indicates the amount of gross savings possible.

[24] Spillover values can be interpreted as percentages, where 1=100%. Thus, a spillover value of .5 would mean that spillover savings were 50% of program gross savings.

Table C-4: Participant Spillover Program Influence Values

Reported Avista Program Influence	Influence Value
1	0.0
2	0.0
3	0.5
4	1.0
5	1.0

The evaluation team used the influence value to calculate the participant measure spillover (PMSO) for each spillover measure that each participant reported. Participant measure spillover is calculated as follows, with the deemed measure savings values based on the evaluation teams estimate of the savings for the implemented measure:

$$PMSO = Deemed\ Measure\ Savings * Influence\ Value$$

The evaluation team then summed all PMSO values associated with each program and divided them by the sample's gross program savings to calculate the spillover estimates for each program:

$$Program\ SO = \frac{\sum Program\ PMSO}{\sum Sample's\ Gross\ Program\ Savings}$$

C.3 Net to Gross Findings

The tables below outline the free ridership, spillover, and NTG values estimated for each program.

Table C- 5: Nonresidential Program Net To Gross Ratios

Program	FR (savings weighted)	Spillover	NTG
Nonresidential Electric			
Site Specific	58%	0.4%	58%
Prescriptive Lighting	37%	3%	66%
EnergySmart Grocer	NA	0%	NA
Prescriptive Non-Lighting Other	24%	6%	82%
Nonresidential Natural Gas			
Site Specific	70%	0.04%	70%
Com Water Heaters	100%	0%	0%
Com Windows & Insulation	44%	1%	57%

Prescriptive HVAC	55%	0%	45%
Food Service Equipment	51%	0%	49%

Table C-6: Residential Program Net To Gross Ratios

Program	FR (savings weighted)	Spillover	NTG
Residential Electric			
Appliance Recycling	75%	0%	26%
ENERGY STAR Homes	67%	0%	33%
Fuel Efficiency	27%	0%	73%
HVAC	54%	0%	46%
Shell	45%	0%	55%
Water Heat	74%	0%	26%
Residential Natural Gas			
ENERGY STAR Homes	53%	0%	47%
HVAC	58%	1%	43%
Shell	49%	4%	55%
Water Heat	46%	0%	54%