Appendix D:

2016-2017 Natural Gas Impact Evaluation

REPORT

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Impact Evaluation of Washington Natural Gas 2016-2017 Energy Efficiency Programs

Submitted to Avista Utilities

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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 2016 and 2017 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 2016 and/or 2017:

- 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 600 document audits, 139 customer surveys, and 52 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	159	44	-	√
Water Heat Program	63	-	-	
ENERGY STAR Homes	15	-	-	
Fuel Efficiency	76	43	-	√
Shell Program	75			
Low Income	133	-	-	√
Nonresidential				
Energy Smart Grocer	12	-	6	As applicable
HVAC	12	6	0	
Food Service Equipment	11	6	6	
Small Business	22	16	22	
Site Specific	27	22	16	As applicable
Commercial Insulation	3	2	2	
Total	**608**	**139**	**52**	

1.2 Summary of Impact Evaluation Results

Avista's Washington natural gas 2016 and 2017 programs achieved 1,669,374 therm savings over the two year period (conservation only measures). Table 1-2, Table 1-3 and Table 1-4 summarize Avista's 2016 and 2017 impact evaluation results by sector and program.

Table 1-2: Washington Natural Gas Portfolio Evaluation Results

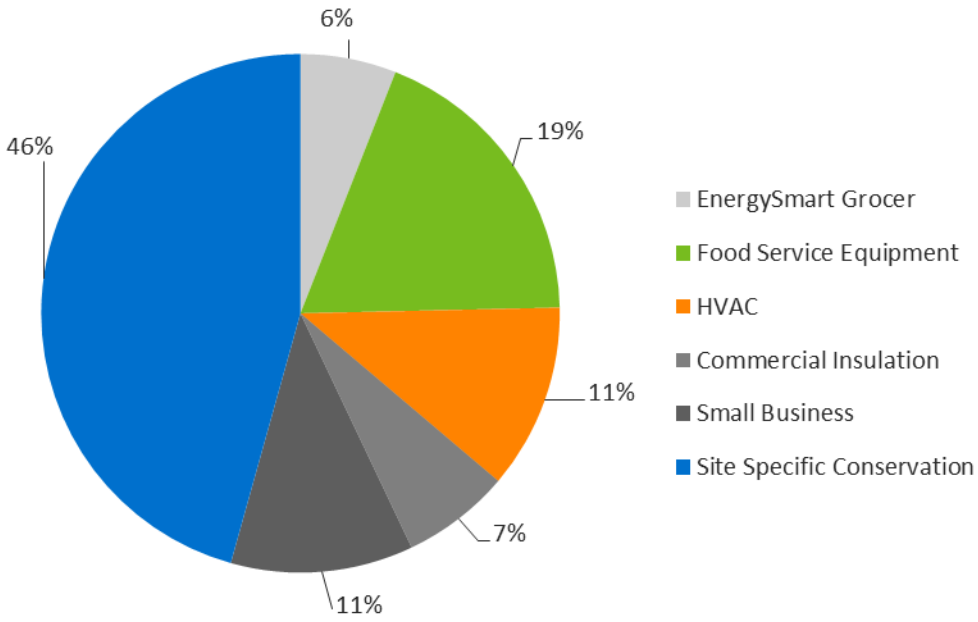
Sector	2016–2017 Reported Savings (therms)	Realization Rate (%)	2016–2017 Gross Verified Savings (therms)
Residential	1,004,240	122%	1,223,358
Nonresidential	425,318	103%	437,875
Low Income	29,473	28%	8,141
Portfolio Total[1]	**1,459,030**	**114%**	**1,669,374**

[1] Fuel conversion measures (measures wherein customers convert from electric to natural gas space and water heating) result in a negative impact and are not included in the total. Impacts of fuel conversion measures can be found in the program specific sections (Sections 4 and 5).

Table 1-3: Washington Gas Nonresidential Program Evaluation Results

Program	2016-2017 Reported Savings (therms)	Realization Rate	2016-2017 Verified Gross Savings (therms)
EnergySmart Grocer	62,433	42%	26,175
Food Service Equipment	77,674	105%	81,748
HVAC	40,725	124%	50,555
Commercial Insulation	20,866	142%	29,566
Small Business	47,180	106%	49,884
Site Specific Conservation	176,440	113%	199,948
Nonresidential Total[2]	**425,318**	**103%**	**437,875**

Figure 1-1: Washington Gas Nonresidential Sector Program Gross Saving Shares (conservation only)

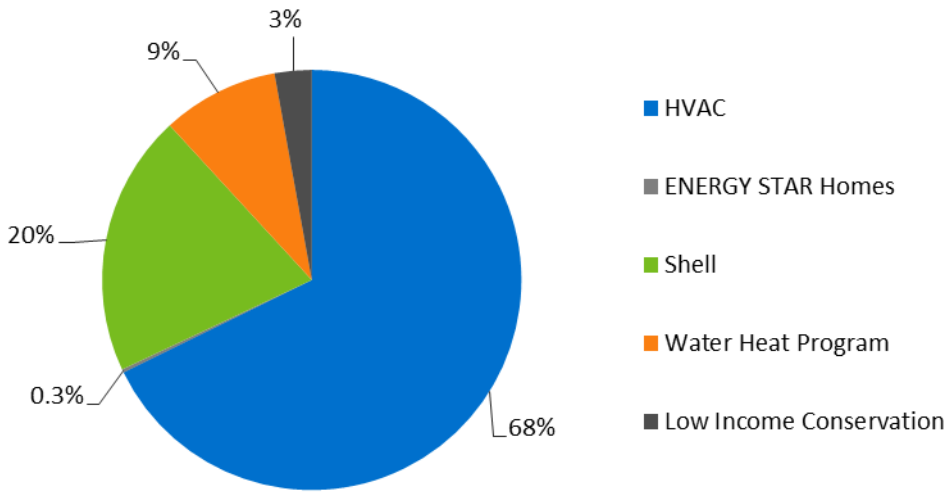


[2] Nonresidential total does not include impacts of Site Specific fuel conversion measures. See Section 4.6 for fuel conversion impacts.

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

Program	2016-2017 Reported Savings (therms)	Realization Rate	2016-2017 Verified Gross Savings (therms)
HVAC	700,257	133%	931,390
ENERGY STAR Homes	2,639	212%	5,607
Shell	208,371	78%	163,260
Water Heat Program	92,972	134%	123,101
Low Income Conservation	29,473	28%	8,141
Residential Total[3]	**1,033,713**	**119%**	**1,231,499**

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. Additional conclusions and recommendations can be found in the program-specific sections of this report and in Section 6.

1.3.1 Nonresidential Programs

The overall realization rate for the nonresidential portfolio is 103%. The realization rates ranged from 142% for the Commercial Insulation program down to 42% for the Energy Smart Grocer

[3] Residential total does not include impacts of residential and low income fuel conversion measures. See Sections 5.5 and 5.7 for fuel conversion impacts.

program. 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 45% of the program energy shares (verified gross savings). Over the last 4 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 133% realization rate for the Site Specific program (conservation measures only).

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

Conclusion: Avista reported participation in four prescriptive natural gas programs in 2016-2017: Food Service Equipment, Commercial Insulation, Natural Gas HVAC, and Energy Smart Grocer. Strong realizations rates for most 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.

Conclusion: The Energy Smart Grocer program constituted about 6% of the nonresidential natural gas portfolio energy shares. The evaluation team found a realization rate of 42% for this program, predominately due to a zero realization rate that was found for a few large projects in the sample, based on utility bill analysis.

> **Recommendation**: The Energy Smart Grocer program is implemented by a third party. It is recommended that for large projects, Avista work more closely with the implementer to ensure accurate reporting.

> **Recommendation**: The evaluation team recommends that Avista consider using performance-based incentives for any measures that are estimated to achieve savings of 10% or more of annual natural gas consumption. For projects where eQuest modeling was utilized by the implementer to estimate savings, Avista should verify that the baseline eQuest model was calibrated on a monthly basis for both gas and electric consumption.

Conclusion: The Small Business program implementer has improved their tracking of decommissioned measures in the 2016-2017 biennium, in comparison to the 2014-2015 biennium, as shown by the evaluation team's calculated persistence rate of 98% for the measures included in the sample in the 2016-2017 biennium.

1.3.2 Residential Programs – including Low Income

The overall realization rate for the residential portfolio's conservation programs was 119% while the conversion programs achieved a 70% realization rate. The conversion programs all

performed well with realization rates above 100% with the exception of the Shell and Low Income programs. The conversion programs low realization rates indicates the forecasted increase gas consumption was not realized.

Conclusion: The evaluation team found a realization of 133% for the HVAC program. This is similar to the findings of the 2014-2015 evaluation which found a 125% realization rate for Washington. The findings are based on the analysis of 802 homes resulting in a relative precision of 6.8%.

> **Recommendation:** Given that the realization rate is substantially higher than 100% and is associated with a low error bound, Avista should consider revising its reported savings values for measures within the program.

Conclusion: The evaluation team found that the homes analyzed that converted from electric heat to a natural gas furnace showed an average weather normalized gas consumption increase of 328 therms per year resulting in a 70% realization rate. This impact and realization rate is very similar to findings from the prior evaluation (384 therms increased consumption with a 70% realization rate).

> **Recommendation** The evaluation team recommends Avista review its forecasted gas penalty for the Fuel Efficiency program. Based on two cycles of evaluation, the program appears to be over-estimating the actual impact.

Conclusion: The evaluation team found a realization rate of 78% for shell program. These findings reflect reported savings are fairly well aligned for the program. However, there may be room for further refinement of savings assumptions for the reported values.

> **Recommendation:** To refine the reported savings assumptions, we recommend Avista examine planning assumptions about per-home consumption, end-use load shares, and percent reductions in heating loads from shell improvements.

2 Introduction

2.1 Purpose of Evaluation

The purpose of the impact evaluation was to verify the savings attributed to Avista's 2016–2017 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 fuel conversion. 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. Electric incentives are offered up to 20 cents per kWh for projects with a simple payback less than 15 years. Incentives are capped at 70% of incremental project

costs. Natural gas incentives are offered up to $3.00 per therm for projects with a simple payback of less than 15 years. Incentives are capped at 70% of incremental project costs. 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. Fuel-conversion incentives are available only for conversion to natural gas with an end-use efficiency of 44% or greater.

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 a "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[4]

2.2.1.2 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. Incentives varied between 2016 and 2017 program years and were offered for the following measure categories:

- Refrigerated Cases
- Case Lighting
- Anti-Sweat Heater Controls
- Evaporated Fan – Walk-in ECM Controller
- Strip Curtains
- Gaskets for Walk-in Coolers, Walk-in Freezers, and Reach-in Glass Doors
- Evaporator Motors
- Floating Head Pressure

[4] Washington Demand Side Management Standard Operation Procedures. Avista Utilities. 2017.

Energy Smart Grocer is administered by CLEAResult with Avista oversight. The program is available to electric (Schedule 11, 12, 21, 25) or natural gas (Schedule 101, 111, 121) customers.

2.2.1.3 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 2-1 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 2-1: 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

Equipment	Incentive
.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
Hot Food Holding Carts	
Hot Food Holding Carts, >15 cubic feet	$165/each
Fryers	
Commercial Fryer, Natural Gas	$1,000/each
Commercial Fryer, Electric	$300/each
Steam Cookers	
Commercial Steam Cooker Natural Gas	$1,300/ 3 pan
Commercial Steam Cooker Natural Gas	$1,700/ 4 pan
Commercial Steam Cooker Natural Gas	$2,200/ 5 pan
Commercial Steam Cooker Natural Gas	$2,600/ 6 pan
Commercial Steam Cooker Natural Gas	$3,200/ 10 pan or >
Commercial Steam Cooker, Electric	$70/ 3 pan
Commercial Steam Cooker, Electric	$100/ 4 pan
Commercial Steam Cooker, Electric	$135/ 5 pan
Commercial Steam Cooker, Electric	$160/ 6 pan
Commercial Steam Cooker, Electric	$180/ 10 pan or >
Commercial Griddles	
Commercial Griddle, Electric	$505/each
Commercial Griddle, Natural Gas	$88/each

2.2.1.4 Commercial Insulation

The Commercial Insulation program offers incentives to Avista's nonresidential electric (Schedule 11, 12, 21, 25) or natural gas (Schedule 101, 111, 121) customers for improvements to building envelopes through 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 installation. 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 2-2: Commercial Insulation Measures

Measure	Incentive ($ / sf)
Less than R4 Wall Insulation to R-11-R18 Retrofit	$0.40
Less than R4 Wall Insulation to R19 or above Retrofit	$0.45
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

2.2.1.5 Natural Gas Commercial 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 Commercial 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 2-3. Avista implements this program in a prescriptive manner, and incentives are issued to the participating customer after the measure is installed.

Table 2-3: Natural Gas HVAC Measures

Equipment	Efficiency	Incentive per input kBtu
Natural Gas Single Stage Furnace <225 kBtu/hr	90%–94.9% AFUE	$4.50
	95% AFUE or greater	$6.00
Natural Gas Multi Stage Furnace <225 kBtu/hr	90%–94.9%	$6.00
	95% AFUE or greater	$7.50
Natural Gas Boiler <300 kBtu/hr	85%–89.9%	$5.00
	90% AFUE or greater	$8.00

2.2.2 Small Business

The Small Business 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 and gas service under Rate Schedule 101 in Washington and Idaho. 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 2-4).

Table 2-4: Small Business Program Measure Overview

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

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 2016 and 2017, 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 2016 and 2017. Table 2-5 provides a summary of those programs, and the sections below detail each program.

Table 2-5: Residential Program Type and Description

Type	Programs	Implementer	Description
	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.
	Water Heater	Avista	Rebate for installation of high efficiency gas or electric water heater, natural gas water heater, and Smart Savings showerhead.
Midstream	Residential Lighting: Simple Steps, Smart Savings	CLEAResult	Direct manufacture discount for purchase of approved CFLs, LEDs (bulbs and fixtures), and low-flow showerheads.
Behavior	Home Energy Reports	Oracle	The Home Energy Reports 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 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 2-6). This program is available to all residential electric (Schedule 1) or natural gas (Schedule 101) customers who heat their homes with Avista electricity or natural gas. To qualify for the air source heat pump conversion or the smart thermostat, the home must demonstrate a winter heating season electricity usage of 8,000 or more kilowatt hours of electric space heat. Natural gas customers must demonstrate a winter heating season gas usage of 340 therms to be eligible for participation. Existing or new construction homes are eligible.

Table 2-6 HVAC Measure Overview

HVAC Measures	2016 Rebate	2017 Rebate
Variable speed motor	$100	$80
Electric to air source heat pump	$900	$700
Electric to ductless heat pump	-	$450
High efficiency natural gas furnace	$300	$300
High efficiency natural gas boiler	$300	$300
Smart thermostat – self install	$35	$75
Smart thermostat – contractor install	$70	$100

2.2.3.2 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. Table 2-7 outlines the measures offered and rebate per unit.

Table 2-7 Water Heat Program Measure Overview

Water Heat Measure	2016 Rebate	2017 Rebate
Heat Pump Water Heater	-	$200
Natural Gas; 40 gallon with 0.62 EF or higher*	-	
Natural Gas; 50 gallon with 0.60 EF or higher*	-	
Natural Gas: Tankless with 0.82 EF or higher	$180	$200
Simple Steps, Smart Savings Low-flow Showerheads: 1.5-2 GPM	buydown	

*While there is no rebate for these measures in 2016 or 2017 there was some participation in Q1 2016 as a result of carryover from the 2015 program year. Savings for these measures is documented in this evaluation.

2.2.3.3 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 2-8 describes eligible measures available for the program.

Table 2-8 ENERGY STAR® Homes Measure Overview

Energy Star Home Measure	2016 Rebate	2017 Rebate
Stick built – electric	$1,000	$1,000
Stick built or manufactured w/ gas only	$650	-
Manufactured w/ furnace	$800	$800
Manufactured w/ heat pump	$800	$800

2.2.3.4 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 2.2.3.1 HVAC Program).

Table 2-9 Fuel Efficiency Measure Overview

Fuel Efficiency Measures	2016 Rebate	2017 Rebate
Electric to natural gas conversion – space heat	$2,300	$1,500
Electric to natural gas conversion – water heat	$600	$750
Electric to natural furnace and water heat – combo	$3,200	$2,250
Electric to natural gas wall heaters – space heat	$1,300	$1300

2.2.3.5 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. 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.

2.2.3.6 Shell Program

Avista's internally managed shell program incentivizes measures that improve the integrity of the home's envelope (Table 2-10). 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 8,000 kilowatt hours or 340 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.

Table 2-10 Shell Measure Overview

Shell Measures	Existing Equipment Efficiency	2016 Rebate ($/sf)	2017 Rebate ($/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	$3.50	$1.50
Storm Windows		-	$1.00

2.2.3.7 Home Energy Reports

Avista provides peer comparison reports of home energy consumption, termed Home Energy Reports (HER), through Oracle. 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. At the start of the 2016-2017 biennium, attrition due to opt outs and account closures reduced the original population of 48,300 treatment customers to about 34,000 customers. At the beginning of the 2016-2017 biennium, Avista 'refilled' the program back to a count of close to 49,000 treatment customers in Washington, who received their first report in April, 2016. Customers must be a recipient of Avista electricity to qualify.

2.2.3.8 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 2-11). Typically some of the annual funding in Washington goes unspent. In 2016 the Spokane Indian Housing Authority was able to identify and serve Avista customers on the reservation while assisting to spend the formerly unspent remainder of the Washington allocation. (Community Action Partnership – Lewiston serves Avista Idaho customers.) 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 2-11 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	Asotin
Washington Gorge Action Programs	Skamania, Klickitat
Spokane Indian Housing Authority (SIHA)*	Stevens (Spokane Tribe Reservation)
Community Action Partnership – Lewiston	Benewah, Bonner, Boundary, Clearwater, Idaho, Kootenai, Latah, Lewis, Nez, Perce, Shoshone

*SIHA funding is part of and not in addition to Washington's $2m allocations

Avista provides CAP agencies with an "approved measure list", the items on this list are reimbursed 100% (Table 2-12 Low Income Approved Measure List (100% of costs offset by Avista)). Avista also provides a "rebate list" of additional energy saving measures the CAP agencies are able to utilize (Table 2-13).

Table 2-12 Low Income Approved Measure List (100% of costs offset by Avista)

Measures	End Use
Electric to Gas Furnace Conversion	Fuel Conversion
Electric to Gas Water Heater Conversion	Fuel Conversion
Electric to Ductless Heat pump	Fuel Conversion
High Efficiency Furnace (90% AFUE) and High Efficiency Water Heater (0.82 EF)	Natural Gas
Insulation (ceiling / attic, floors and walls)	Electric and Natural Gas
Insulation (duct) / Duct sealing	Electric and Natural Gas
Air Infiltration	Electric and Natural Gas
Energy Star® Doors	Natural Gas
Energy Star® Windows (gas heat)	Natural Gas
LED Lighting	Electric

Table 2-13 Low Income Rebate List (WA, all rebate list measures are electric end-use)

Measures
Electric to air source heat pump (when natural gas not viable)
Electric to heat pump water heater
Energy Star® Doors
Energy Star® Windows
Energy Star® Refrigerators

2.3 Program Participation Summary

Reported participation and savings for Avista's 2016 and 2017 programs is outlined in Table 2-14 and Table 2-15.

Table 2-14 Avista Nonresidential Reported Participation and Savings

Program	2016-2017 Project Count	2016-2017 Reported Savings (therms)
EnergySmart Grocer	15	62,433
Food Service Equipment	102	77,674
HVAC	80	40,725
Commercial Insulation	26	20,866
Small Business	1,565*	47,180
Site Specific Conservation	51	176,440
Site Specific Fuel Conversion	14	-88,088
Nonresidential Total - Conservation Only	**1,839**	**425,318**

*Unique measure count

Table 2-15 Avista Residential Reported Participation and Savings

Program	2016-2017 Participation Count	2016-2017 Reported Savings (therms)
HVAC	8,105	700,257
ENERGY STAR Homes	13	2,639
Shell	1,887	208,371
Water Heat Program*	4,481	92,972
Low Income Conservation	1,038	29,473
Conservation Total	**15,524**	**1,033,713**
Fuel Efficiency (Fuel Conversion)	2,677	-1,103,872
Low Income Fuel Conversion	230	-32,710
Fuel Conversion Total	**2,907**	**-1,136,582**

*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 2016 and 2017
- 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 assessed the gross savings attributable to Avista's 2016 and 2017 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 2016 and 2017 programs by:

- Understanding the program context
- Designing the impact evaluation sample
- Verifying the project and program savings through document audits, 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 2016 Demand Side Management (DSM) Business Plans which detail processes and energy savings justifications
- 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 was an important step that enabled the evaluation team to deliver meaningful, defensible results to Avista. The evaluation team used stratified random sampling approaches for much of our data collection activities. Our sampling methodology was guided by a "value of information" (VOI) framework which allowed us to target activities and respondents

with expected high impact and yield, while representing the entire population of interest. VOI focuses budgets and rigor towards the programs/projects with high uncertainty and high impact.

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

- **Program Uncertainty:** The risks associated with a program's reported savings (i.e., custom vs. deemed vs. Regional Technical Forum status), delivery mechanism, and performance goals, etc., broken into three categories: high, medium, and low.
- **Program Size:** Either large, or small; based on projected energy savings, and planned budget allocations.

Bins were created for residential and nonresidential programs separately and for electric (WA/ID) and natural gas (WA) programs separately.

In parallel, we calculate a 'level of rigor' value for each program, and based on assumed measure complexity and RTF influence, we identify an appropriate level of sampling and evaluation rigor.

- **Level of Sampling:** Defined as confidence/precision for calculating sample sizes, the evaluation team is using four levels: 90/10, 80/10, 85/15, or 80/20.
- **Evaluation Rigor:** Defined as the level of detail used for the evaluation activities, including four levels: document audit, surveys, onsite inspections, and billing analysis.

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 influence the sample size and level of rigor include evaluation costs, Regional Technical Forum (RTF) influence, and findings and recommendations from prior evaluations.

The approaches (i.e. level of rigor) for estimating the gross energy savings for the programs evaluated included: document audit, surveys, site inspections, and statistical billing analysis. In many cases, a combination of approaches were used to both validate savings and provide insights into any identified discrepancies between reported and verified savings values. The sampling strategy for the impact evaluation also overlapped, as applicable, with the sample approach used for the process evaluation activities in order to obtain information for both the impact and process evaluations during one single onsite inspection and/or survey. This nested sampling approach helped to minimize costs while still maintaining adequate sample sizes.

Table 3-1and Table 3-2 show the planned sample sizes and level of rigor for WA/ID Electric residential and nonresidential programs. The samples were drawn to meet the specified confidence/precision for each program and to meet 90% confidence and 10% precision at the portfolio level[5]. Because programs do not differ between the Washington and Idaho service

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

territories, the sample approach was combined for both territories, and the findings from the impact evaluation (i.e. realization rates) were applied across both states.

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	68	-	-
ENERGY STAR Homes	census	68	-	census
HVAC Program	census	68	42	census
Shell Program	census	68	42	census
MyHER Behavioral Program	census	NA	-	census
Low Income	census	68	-	census
Residential Total	**90/10**	**340**	**84**	**-**

*Includes Simple Steps, Smart Savings upstream showerhead component

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
HVAC	80/20	11	6	6	
Food Service Equipment	80/20	11	6	6	
Energy Smart Grocer	80/20	11	0	0	
Small Business	85/15	23	16	16	
Site Specific	85/15	24	24	24	based on IPMVP
Nonresidential Total	**90/10**	**80**	**52**	**52**	

*Sample sizes were designed to meet C/P target and are based on known 2016 participation values through July, and 2017 planning values.

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.

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
HVAC	90/7	159	44	
Water Heat	90/13	63	-	
ENERGY STAR Homes	90/44	15	-	
Fuel Efficiency	90/14	76	-	√
Shell	90/11	75	43	√
Low Income*	90/57	133	-	√
Residential Total	**90/6**	**521**	**87**	

*Conservation projects only, does not include fuel conversion projects

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

Natural Gas Nonresidential Program	Achieved C/P	Document Audit	Surveys	Onsite Inspections
HVAC	80/13	12	6	0
Food Service Equipment	80/10	11	6	6
Energy Smart Grocer	80/37	12	0	6
Small Business	90/9	22	16	16
Site Specific	80/4	27	22	22
Commercial Insulation	80/33	3	2	2
Nonresidential Total	**90/5**	**87**	**52**	**52**

3.3 Database Review

For all evaluated 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. If any large discrepancies were found, the evaluation team confirmed with Avista or its third-party implementers that the discrepancies was or was not an error and if it was noted as an error, the discrepancies were fixed and reported savings values were updated accordingly.

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 Equation 3-1:

Equation 3-1: Gross Verified Savings 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, information needed to estimate net-to-gross values, the key parameters needed to verify the assumptions used by RTF for approved values or 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 was 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.

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.
- 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.

[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.

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 was the best method for quantifying energy savings resulting from these 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 all measures in the following residential programs: Shell, Fuel Efficiency, HVAC, Home Energy Reports, and Low Income.

The evaluation team requested program tracking data and complete billing histories for Avista's residential rebate program participants as well as nonparticipants to develop a matched comparison group (see Section 3.4.4.1 below). We aimed to use participant data that contained at least one full year of utility billing data before and after measure installation to ensure 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 participants may have had up to nine months of post-installation data available.

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.

3.4.4.1 Comparison Group Selection

Nexant selected the comparison groups using propensity score matching to find residential Avista customers who are nonparticipants with monthly consumption most similar to those of participants. In this procedure, a probit model is used to estimate a score for each customer based on a set of observable variables that are assumed to affect the decision to participate in a rebate program. A probit model is a regression model designed to estimate probabilities—in this case, the probability that a customer would participate. The score can be interpreted two different ways. First, the propensity score can be thought of as a summary variable that includes all the relevant information in the observable variables about whether a customer would choose to participate in a rebate program. Each participant was matched with a customer in the nonparticipant population that has the closest propensity score. The second way to think of the propensity score is as the probability that a customer will participate in a rebate program based

on the included independent variables. Thinking of it this way, each customer in the comparison group was matched to a treated customer with a similar probability of participating given the observed variables.

Nexant performed the match within each program and state. In other words, the match was conducted separately for customers in Washington and Idaho and for each rebate program. The match was based on a set of variables that characterize energy consumption during the full calendar year prior to treatment (2015). Twenty matches based on various combinations of monthly, seasonal, and annual energy consumption were tested and the final probit model which resulted in the closest match between participant and comparison customer average usage each month of 2015 was selected. One match was found for each participant and the same comparison customer could not be matched to multiple participants.

Figure 3-1 displays the average daily kWh consumption in 2015 for participants in the Electric Shell program and for the matched comparison group. Over the year prior to treatment, consumption was very similar between the two groups, with a difference of approximately 0.5% on average. These differences are taken into account by the difference-in-differences estimation methodology described in the following section.

Figure 3-2 displays the average daily therms consumption for each month in 2015 for the Gas Shell group and the corresponding comparison group. Once again, consumption throughout the pre-treatment year is very similar between the two groups, indicating that the matched comparison group behaves similarly to participants in the absence of treatment.

Figure 3-1: Electric Shell Matched Control Group vs Participants

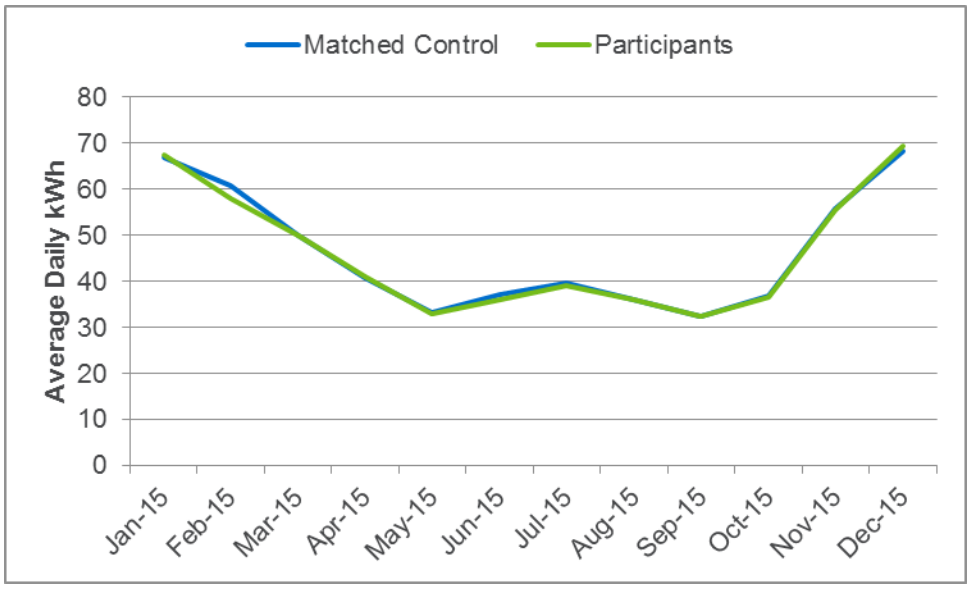
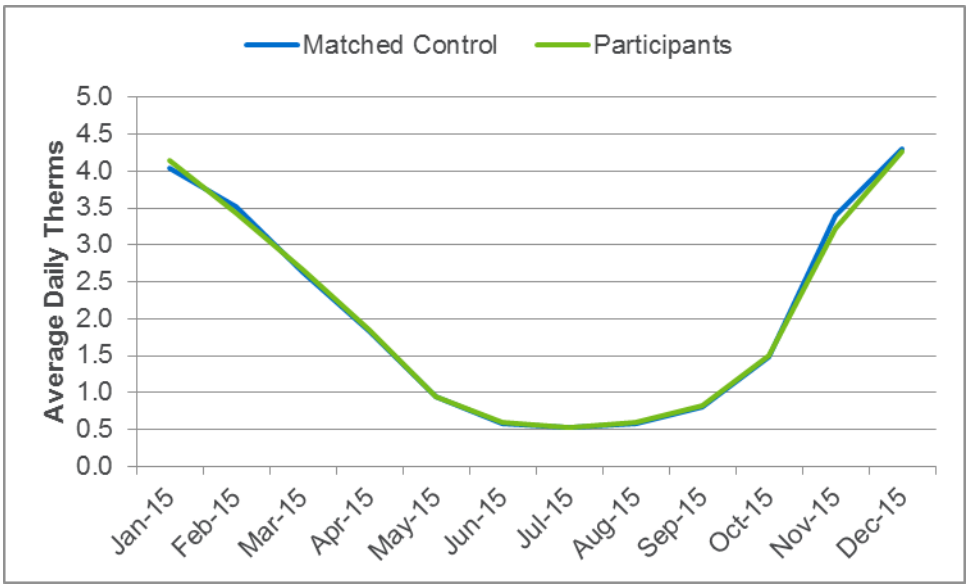


Figure 3-2: Gas Shell Matched Control Group vs Participants



3.4.4.2 Ex Post Estimation Method

After the comparison groups for treatment customers were selected and validated, energy impacts were estimated using a difference-in-differences (DiD) methodology for the Shell, HVAC, Fuel Efficiency, and Home Energy Reports[7] programs (the Low Income program used a participant pre/post billing analysis, see Section 3.4.4.2 below). Impacts are estimated as the difference in average consumption between treatment and comparison customers in each month, with the slight difference between the two groups on the pre-treatment year removed. This calculation controls for residual differences in load between the groups that are not eliminated through the matching process, thus reducing bias.

The DiD analysis can be done by hand using simple averages or by using panel regression analysis. Customer fixed effects regression analysis allows each customer's mean consumption to be modeled separately, which reduces the standard error of the impact estimates without changing their magnitude. Additionally, panel regression easily facilitates calculation of standard errors, confidence intervals, and significance tests for load impact estimates that correctly account for the correlation in customer loads over time.

The model specification for estimating load impacts is shown in Equation 3-2 and Table 3-5 provides detail for each model variable. The model was estimated separately for each hour and event day.

Equation 3-2: Monthly Energy Savings Model Specification

$$daily\_consumption_i = \alpha + \gamma \text{event} + \beta \text{treatXevent}_i + v_i + \varepsilon$$

[7] The Oracle Home Energy Report program is designed as a randomized control trial and therefore a matched comparison group was not selected for the billing analysis.

Table 3-5: Description of Energy Savings Model Regression Variables

Variable	Description
$daily\_consumption_i$	Per customer consumption (kWh or therms) for customer *i*
α	Mean consumption for all customers
γ	The coefficient on the post-treatment indicator variable
post	Equal to 1 for the post-treatment period and 0 for the same month in 2015
β	DiD estimator of the treatment effect (the impact in kWh or therms)
treatXpost	Interaction of treatment and post variables, equal to 1 for the post-treatment period for participants and 0 otherwise
v_i	The customer fixed effects variable for customer *i*
ε	The error term

In Equation 3-2 the variable $daily\_consumption_i$ equals electricity or gas consumption during the time period of interest, which would be each month of the post-treatment period. The index *i* refers to each individual customer. The estimating database contained electricity and gas consumption data during the pre- and post-treatment periods for both treatment and matched comparison group customers. The variable *post* is equal to 1 for months after installation and a value of 0 for the same month in 2015. The *treatXpost* term is the interaction of *treat* and *post* and its coefficient β is a differences-in-differences estimator of the treatment effect that makes use of the pre-treatment data. The primary parameter of interest is β, which provides the estimated energy impact of the rebate programs during the relevant period. The parameter *a* is equal to mean daily consumption for each customer for the relevant time period (e.g., monthly). The v_i term is the customer fixed effects variable that controls for unobserved factors that are time-invariant and unique to each customer.

This was estimated for each month of 2016 and 2017 separately. Impacts are estimated on a per-customer basis. Reference consumption is equal to observed treatment consumption plus the estimated impact.

3.4.4.3 Low Income Pre/Post Billing Ex Post Estimation Method

For the Low Income program, the evaluation team was unable to select a matched comparison group as Avista does not provide information in its billing records to identify low income customers. Therefore, the evaluation team used a pre/post billing analysis based on participant billing data.

The evaluation team reviewed the participant data in the same method used for the other programs by accessing data quality and completeness. In addition to program participation records and customer billing histories, the evaluation team also 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) and cooling degree days (CDD) 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. For example, switching from electric heat to a natural gas furnace will produce the largest savings during winter months. Because the evaluation team received data through February of 2018, homes who implemented the fuel conversion measure in the summer of 2017 might have a full 12 months of pre-retrofit data but only 6 to 8 months of post-retrofit data. However, the post-retrofit period included the heating season and gave the regression model sufficient data upon which to establish a mathematical relationship between weather and consumption.

Table 3-6 defines the terms and coefficients shown in the two equations that follow. Equation 3-3 shows the general regression model specification used for electric measures, Equation 3-4 shows the general model specification used for gas measures. The key difference between them is the absence of cooling degree day (CDD) terms in the gas model. Because residential gas consumption is predominantly associated with heating, the evaluation team opted to exclude the CDD terms from the gas model, resulting in more robust impact estimates.

Equation 3-3: Regression Model Specification for Electric Measures

$$\mathrm{kWh}_{it} = \beta_i + \beta_1 \times \mathrm{Post}_{it} + \beta_2 \times \mathrm{CDD}_{it} + \beta_3(\mathrm{Post} \times \mathrm{CDD})_{it} + \beta_4 \times \mathrm{HDD}_{it} + \beta_5(\mathrm{Post} \times \mathrm{HDD})_{it} + \epsilon_{it}$$

Equation 3-4: Regression Model Specification for Gas Measures

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

Table 3-6: Fixed Effects Regression Model Definition of Terms

Variable	Definition
kWh_{it} / $Therms_{it}$	Estimated consumption in home i during period t (dependent variable)
$Post_{it}$	Indicator variable denoting pre-installation period vs. post-installation period
CDD_{it}	Average cooling degree days during period t at home i
HDD_{it}	Average heating degree days during period t at home i
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

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 six nonresidential programs in their Washington service territory in 2016 and 2017. The reported project count and savings for each of these programs is summarized in Table 4-1.

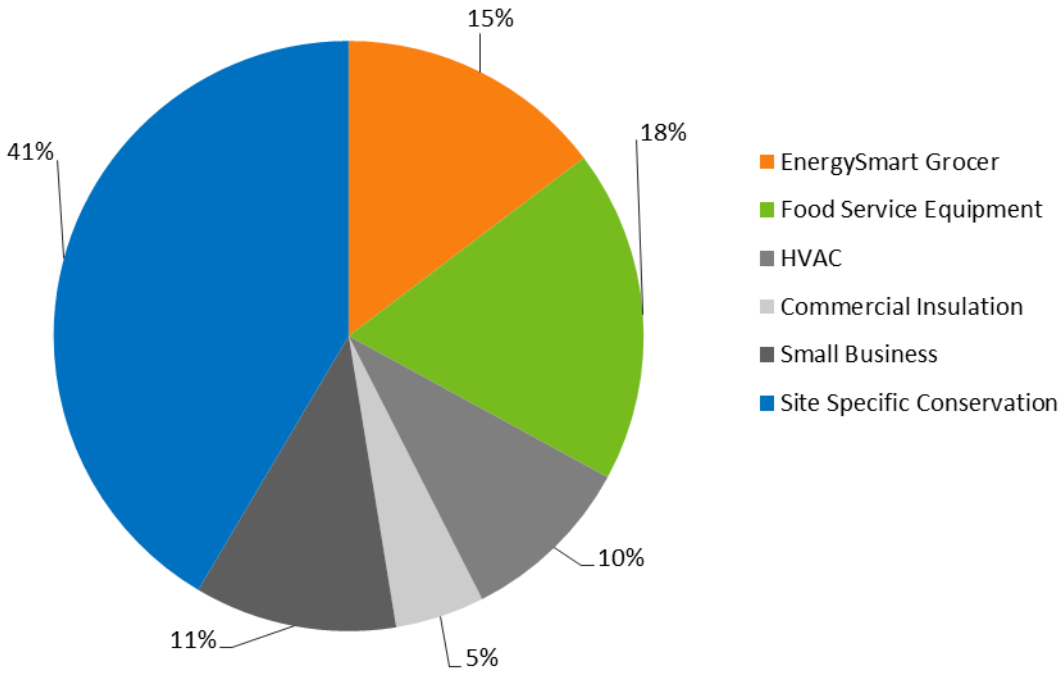
Table 4-1: Nonresidential Program Reported Savings

Washington Gas Nonresidential Program	2016-2017 Reported Project Count	2016-2017 Reported Savings (therms)
EnergySmart Grocer	15	62,433
Food Service Equipment	102	77,674
HVAC	80	40,725
Commercial Insulation	26	20,866
Small Business	1,565*	47,180
Site Specific Conservation	51	176,440
Site Specific Fuel Conversion	14	-88,088
Portfolio Total - Conservation Only	**1,839**	**425,318**

*Unique measure count

The Site Specific program contributes the largest share of the reported savings, 41% as shown in Figure 4-1. The Food Service Equipment program contributes the second largest share, 18%.

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. As part of the evaluation activities, a total of 87 document audits were conducted, and onsite inspections were conducted on a sub-sample of 52 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

Natural Gas Nonresidential Program	Achieved Confidence/Precision	Document Audit	Surveys	Onsite Inspections
HVAC	80/13	12	0	0
Food Service Equipment	80/10	11	23	6
Energy Smart Grocer	80/37	12	0	6
Small Business	90/9	22	44	16
Site Specific	80/4	27	6	22
Commercial Insulation	80/33	3	-	2
Nonresidential Total	**90/5**	**87**	**73**	**52**

4.2 Energy Smart Grocer

4.2.1 Overview

The Energy Smart Grocer program, implemented by CLEAResult, offers a range of proven energy-saving solutions for grocery stores and other customers with commercial refrigeration. This program is intended to prompt the customer to increase the energy efficiency of their refrigerated cases and related grocery equipment through direct financial incentives.

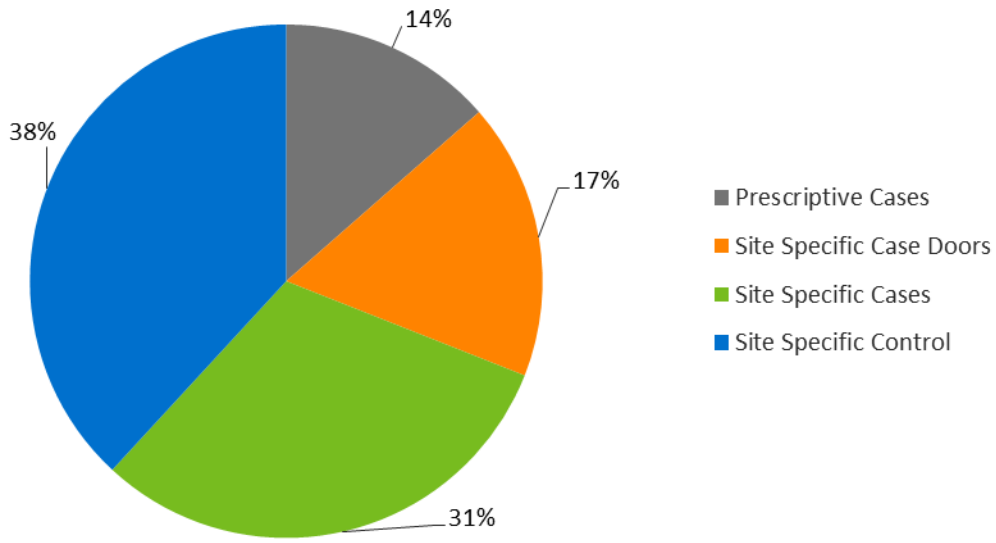
4.2.2 Program Achievements and Participation Summary

A total of 15 unique Energy Smart Grocer measures were installed at 9 premises in Washington in 2016 and 2017. Table 4-3 and Figure 4-2 summarize Avista's 2016-2017 Energy Smart Grocer Program reported energy impacts by measure.

Table 4-3: EnergySmart Grocer Reported Energy Savings by Measure

Measure Type	2016-2017 Reported Project Count	2016-2017 Reported Savings (therms)
Prescriptive Cases	2	8,461
Site Specific Case Doors	3	10,883
Site Specific Cases	8	19,282
Site Specific Controls	2	23,807
Total	**15**	**62,433**

Figure 4-2: EnergySmart Grocer Reported Energy Savings Shares



4.2.3 Methodology

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

4.2.3.1 Sampling Approach

The evaluation team conducted document audits on 12 projects implemented through the Energy Smart Grocer program. Surveys and onsite inspections were conducted for a sub-sample of these projects (Table 4-4).

Table 4-4: Energy Smart Grocer Achieved Sample

Program	Document Audit	OnSite Inspections
Energy Smart Grocer	12	6

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

Participants were recruited for onsite inspection via telephone calls. 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 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.

4.2.3.4 Impact Analysis Methods

The evaluation team reviewed utility bill histories for many of the sampled 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.

In addition, the program implementer used energy modeling to generate savings estimates for most of the sampled Energy Smart Grocer natural gas projects. For these projects, the evaluation team reviewed the baseline- and efficient-case 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, the evaluation team made adjustments as necessary to generate verified savings values.

4.2.4 Findings and Recommendations

The reported energy savings for these measures were generally determined using eQuest energy simulation modeling. The evaluation team used utility billing analysis to calculate verified energy savings values for the majority of the evaluated projects. The majority of the evaluated savings were in-line with the reported savings value, but two projects were found to have achieved no savings and therefore drove the realization rate for this program down significantly. The gross verified savings values for the sample of projects resulted in a realization rate of 42% for the Energy Smart Grocer program (Table 4-5).

Table 4-5: Energy Smart Grocer Impact Energy Realization Rate Results

Program	Sample Unique Projects	Energy Realization Rate	Relative Precision (80% Confidence)
Energy Smart Grocer	12	42%	37%

The Energy Smart Grocer program is implemented by a third party. It is recommended that for large projects (both electric and natural gas) that Avista work more closely with the implementer to ensure accurate reporting. In addition, the evaluation team recommends that Avista consider using performance-based incentives for any measures that are estimated to achieve savings of 10% or more of annual natural gas consumption. For projects where eQuest model were employed by the implementer to estimate savings, Avista should verify that the baseline eQuest model was calibrated on a monthly basis for both gas and electric consumption.

Table 4-6 presents the 2016-2017 gross verified savings for the Energy Smart Grocer program.

Table 4-6: Energy Smart Grocer Gross Verified Savings

Program	Reported Savings (therms)	Energy Realization Rate	Gross Verified Savings (therms)
Energy Smart Grocer	62,433	42%	26,175

4.3 Commercial 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. The program is implemented internally by Avista.

4.3.2 Program Achievements and Participation Summary

A total of 26 unique Commercial Insulation measures were installed at 26 premises in Washington in 2016 and 2017. Table 4-7 summarizes Avista's 2016-2017 Commercial Insulation Program reported energy impacts.

Table 4-7: Commercial Insulation Reported Energy Savings by Measure

Program	2016-2017 Reported Participation	2016-2017 Reported Energy Savings (therms)
Commercial Insulation	26	20,866

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 3 projects implemented through the Commercial Insulation program. Onsite inspections were conducted for 2 of these projects (Table 4-8). It should be noted that in the development of the Evaluation Plan, target document

audits and onsite inspections were not planned for this program and projects were added during the evaluation period as projects with therm savings were reported through the program (projects were dual fuel measures with both electric and natural gas savings).

Table 4-8: Commercial Insulation Achieved Sample

Program	Document Audit	Survey	OnSite Inspections
Commercial Insulation	3	2	2

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.

4.3.3.3 Field Inspections

Telephone surveys were used to recruit projects for onsite inspection verification. 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 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 4-9 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 or attic areas affected by the project and the associated HVAC system characteristics.

Table 4-9: Commercial Insulation 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	

End Use Category	Baseline	Retrofit
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	Insulation Type Insulation Thickness Affected 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 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*

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 142% for the Commercial Insulation program (Table 4-10).

Table 4-10: Commercial Insulation Impact Energy Realization Rate Results

Program	Sample Unique Projects	Energy Realization Rate	Relative Precision (80% Confidence)
Commercial Insulation	3	142%	33%

Avista's savings values for the measures in this program are generated using the same algorithm as the evaluation team. However, Avista's baseline R-values for insulation measures are more conservative in many cases. Avista's baseline values reflect minimum R-values as stipulated by energy codes. The evaluation team 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, the evaluation team 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 142%.

Table 4-11 presents the 2016-2017 gross verified savings for the Commercial Insulation program.

Table 4-11: Commercial Insulation Gross Verified Savings

Program	2016-2017 Reported Savings (therms)	Energy Realization Rate	2016-2017 Gross Verified Savings (therms)
Commercial Insulation	20,866	142%	29,566

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 80 unique Natural Gas HVAC measures were installed at 73 premises in Washington in 2016 and 2017. Table 4-12 summarizes Avista's 2016-2017 Natural Gas HVAC Program reported energy impacts.

Table 4-12: Natural Gas HVAC Reported Energy Savings by Measure

Program	2016-2017 Reported Participation	Reported Energy Savings (therms)
Natural Gas HVAC	80	40,725

4.4.3 Methodology

Engineering activities for the evaluation of this program included review of project documentation and savings calculations.

4.4.3.1 Sampling

The evaluation team conducted document audits on 12 projects implemented through the Natural Gas HVAC program (Table 4-13). Surveys and on-site inspections were not conducted for this program.

Table 4-13: Natural Gas HVAC Achieved Sample

Program	Document Audit	OnSite Inspections
Natural Gas HVAC	12	-

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.

4.4.3.3 Impact Analysis Methods

The evaluation team 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:

$Capacity_{input\text{-}e}$ = *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 124% for the Natural Gas HVAC program (Table 4-14).

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

Table 4-14: Natural Gas HVAC Impact Energy Realization Rate Results

Program	Sample Unique Projects	Energy Realization Rate	Relative Precision (80% Confidence)
Natural Gas HVAC	12	124%	13%

Table 4-15 presents the 2016-2017 gross verified savings for the Natural Gas HVAC program.

Table 4-15: Commercial Windows & Insulation Gross Verified Savings

Program	2016-2017 Reported Savings (therms)	Energy Realization Rate	2016-2017 Gross Verified Savings (therms)
Natural Gas HVAC	40,725	124%	50,555

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 102 unique measures were installed at 98 premises in Washington through the Food Service Equipment program in 2016 and 2017. Table 4-16 summarizes Avista's 2016-2017 reported energy impacts for this program.

Table 4-16: Food Service Equipment Reported Energy Savings

Measure Type	2016-2017 Participation	2016-2017 Reported Energy Savings (therms)
Food Service Equipment	102	77,674

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 4-17). Onsite inspections were conducted for 6 projects.

Table 4-17: Food Service Equipment Achieved Sample

Program	Document Audit	OnSite Inspections
Food Service Equipment	11	6

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

4.5.4 Findings and Recommendations

Table 4-18 presents the realization rate based on the gross verified savings values for the sample of reviewed projects in the Food Service Equipment program.

Table 4-18: Food Service Equipment Realization Rate Results

Program	Sample Unique Projects	Energy Realization Rate	Relative Precision (80% Confidence)
Food Service Equipment	11	105%	10%

Avista's deemed energy savings for this program are also derived from ENERGY STAR's published calculator. However, the evaluation team customized the inputs to the calculator for the specific rates of the equipment in the evaluation sample. This customization resulted yielded a program-wide realization rate of 105%.

Table 4-19 shows the total gross verified savings for the Food Service Equipment program.

Table 4-19: Food Service Equipment Gross Verified Savings

Program	Reported Savings (therms)	Energy Realization Rate	Gross Verified Savings (therms)
Food Service Equipment	77,674	105%	81,748

[9] Found on the following website: https://www.energystar.gov/products/commercial_food_service_equipment

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 natural gas projects in this program are appliance upgrades, HVAC, industrial process, and shell measures. The Site Specific program is implemented internally by Avista, and program staff develops custom energy savings estimates for each project with input from the customer.

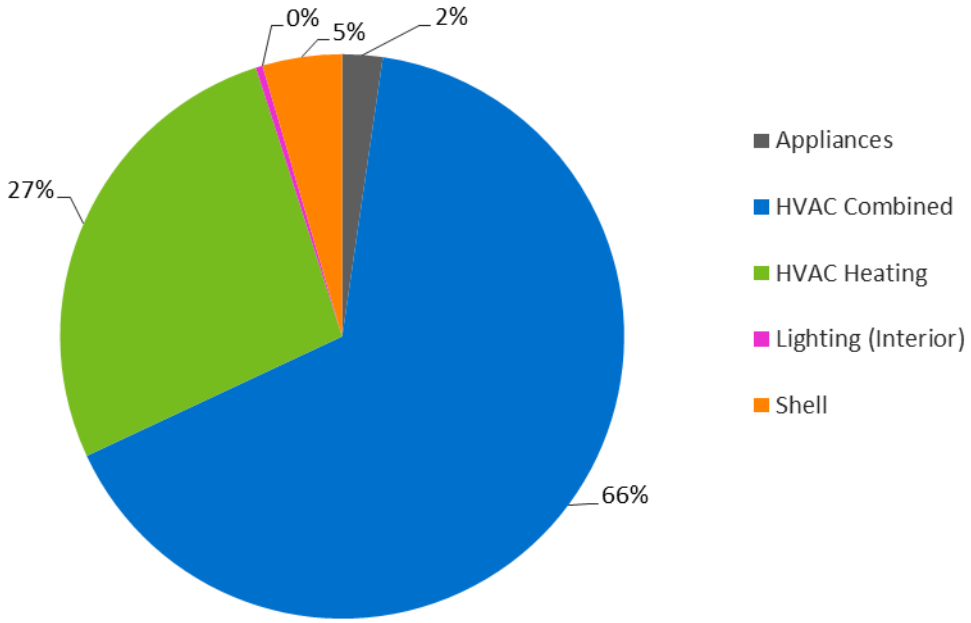
4.6.2 Program Achievements and Participation Summary

A total of 65 unique measures were installed through the Site Specific program in Washington throughout 2016 and 2017. Table 4-20 and Figure 4-3 summarize Avista's reported energy impacts by measure for the Site Specific program. The 'HVAC Combined' and 'HVAC Heating' measures together make up 93% of the reported energy impacts for this program.

Table 4-20: Site Specific Reported Energy Savings by Measure

Measure Type	2016-2017 Reported Project Count	2016-2017 Reported Energy Savings (therms)
Appliances	3	4,178
HVAC Combined	12	118,839
HVAC Heating	15	48,831
Industrial Process	2	-4,361
Lighting (Interior)	1	709
Multifamily	0	0
Multifamily Fuel Conversion	14	-88,088
Shell	18	8,244
Total	**65**	**88,352**
Total without Fuel Conversion	**51**	**176,440**

Figure 4-3: 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). Engineering activities included thorough review of the program savings methodology for each project, installation verification, determination of operational hours, collection of energy management system (EMS) trend data, and associated energy savings calculations.

4.6.3.1 Sampling

The evaluation team conducted 27 document audits on participating projects through the Site Specific program. Customer surveys and onsite inspections were conducted on a subset of these projects. Within the Site Specific program, the evaluation team designated projects into two strata based on conservation-only projects and fuel conversion projects. Table 4-21 outlines the achieved sample for the Site Specific Program.

Table 4-21: Site Specific Achieved Sample

Program –Measure Type	Document Audit	On Site Inspections
Site Specific - Conservation	23	18
Site Specific – Fuel Conversion	4	4
Total	**27**	**22**

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

Participants were recruited for onsite inspection via telephone calls. 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 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 4-22 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 4-22: Site Specific 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	Insulation Type Insulation Thickness Affected Wall / Attic Area (sq ft)

End Use Category	Baseline	Retrofit
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 Trend Data Analysis

The evaluation team incorporated project-specific trend data for some projects in the evaluation sample in accordance with IPMVP Option B. Trend data was collected from building energy management systems or other on-site data collection systems whenever available. The period of data collection varied depending on the type of project being evaluated and ranged from a few weeks to several months as available.

4.6.3.6 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, the evaluation team 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, the evaluation team made adjustments to the provided eQuest models as necessary to generate verified savings values.

4.6.3.7 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 Insulation Program (Section 4.3.3.4)

4.6.4 Findings and Recommendations

The evaluation team found that the 2016-2017 Site Specific program achieved a program-level realization rate of 113% for conversation-only measures and 133% for fuel conversion measures (Table 4-23). These realization rates reflect the high level of review that is conducted through Avista's internal processes.

Table 4-23: Site Specific Program Realization Rate Results

Progra,	Sample Unique Projects	Energy Realization Rate	Relative Precision (80% Confidence)
Site Specific - Conservation	23	113%	4%
Site Specific – Fuel Conversion	4	133%	n/a

Measure-level realization rates for measures where more than one project was included in the evaluation sample are presented in Table 4-24.

Table 4-24: Site Specific Measure-Level Gross Verified Savings

Measure	Sample Unique Projects	Realization Rate
HVAC Combined	4	93%
HVAC Heating	6	172%
Multifamily – fuel conversion	4	133%
Shell	11	108%

HVAC Heating and HVAC Combined Findings

The evaluation team found Avista to be using conservative assumptions in several of the reviewed HVAC Heating and HVAC Combined measures, resulting in high realization rates. Avista's energy savings estimates for these measures were primarily developed using internal calculators or customized eQuest energy modeling. The evaluation team reviewed the assumptions underlying Avista's estimates in comparison to conditions found during on-site visits. The high realization rates for these measures resulted from a variety of different project-specific findings. For example, savings for one radiant heating project were estimated using eQuest. The evaluation team evaluated this project using engineering algorithms because eQuest cannot model radiant heat transfer well. The evaluation team's algorithm approach indicated high savings than the original Avista estimate.

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%.

Table 4-25 shows the total gross verified savings for the Site Specific program.

Table 4-25: Site Specific Gross Verified Savings

Program	2016-2017 Reported Savings (therms)	Energy Realization Rate	2016-2017 Gross Verified Savings (therms)
Site Specific – Conservation Only	176,440	113%	199,948

4.7 Small Business Program

4.7.1 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.

4.7.2 Program Achievements and Participation Summary

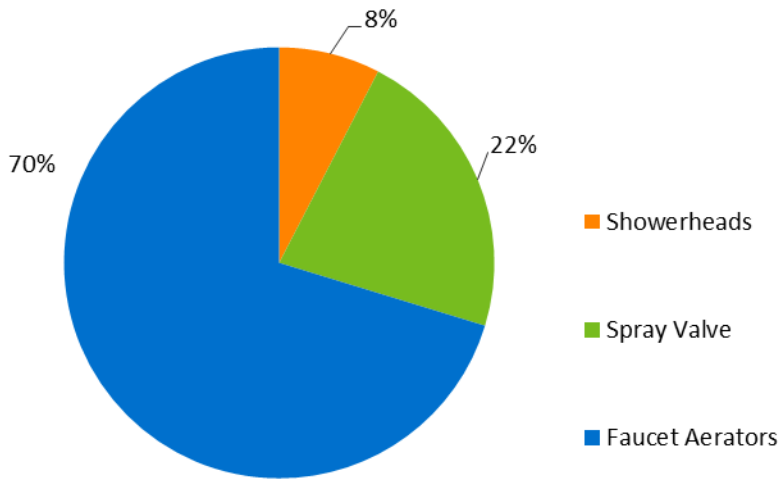
A total of 1,565 unique measures were installed at approximately 500 unique premises through the Small Business program in Washington throughout 2016 and 2017. Table 4-26 and Figure

4-4 summarize Avista's reported energy impacts by measure for the Small Business program.

Table 4-26: Small Business Program Reported Energy Savings by Measure

Measure	2016-2017 Reported Unique Measure Count	2016-2017 Reported Gas Savings (therms)
Showerheads	73	3,590
Spray Valve	173	10,429
Faucet Aerators	1,319	33,160
Total	**1,565**	**47,180**

Figure 4-4: Small Business Program Reported Energy Savings Shares



4.7.3 Methodology

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.

4.7.3.1 Sampling

The evaluation team selected a simple random sample of 22 projects for the impact evaluation of the Small Business Program. Onsite verification was performed for 16 sites. The 22 sampled project sites collectively accounted for a total of 187 unique natural gas saving measures, as reported by the program implementer. Table 4-27 summarizes the achieved sample size.

Table 4-27: Small Business Program Impact Evaluation Achieved Sample

Program	Document Audit	On-Site Verification
Small Business	22	16

4.7.4 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.

4.7.5 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

Field engineers were equipped with a custom field data collection tool designed to capture the relevant data points for each measure included in the program. Table 4-28 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, counts, hours of operation, and water heater fuel type.

Table 4-28: 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

4.7.6 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 the findings of the 2014-2015 evaluation. Verified energy savings were generally calculated for each measure using Equation 4-3:

Equation 4-3: 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

4.7.7 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 106% (Table 4-29).

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

Table 4-29: Small Business Program Realization Rate Summary

Measure Category	Sampled Measures	Gas Energy Realization Rate	Relative Precision (90% Confidence)
Faucet Aerators	157	105%	9%
Showerheads	22	90%	
Spray Valve	8	116%	
Total	**187**	**106%**	**9%**

The evaluation team found a greater than 100% realization rate for the majority of gas measures assessed. The evaluation team understands that the Small Business program implementer applied the realization rates and decommissioned rates from the 2014-2015 evaluation to the deemed savings values noted in Avista's Technical Reference manual. The evaluation team utilized the deemed savings value per measure and applied the persistence rate found during the current evaluation to the TRM value, therefore resulting in a gross verified savings values greater than the reported values. In summary, the Small Business program implementer improved their tracking of decommissioned measures in the 2016-2017 biennium. The following subsection outlines the persistence rates found for the current evaluation.

4.7.7.1 Installation Persistence

The program implementer keeps track of measures that are decommissioned by program participants, when program participants inform the implementer that they have removed measures. The evaluation team evaluated the persistence of measures installed for program participants, or the percent of measures that were removed by participants wherein the implementer was not informed of the removal. Table 4-30 provides a summary of the reported installation quantities, the verified installation quantities, and the persistence rate for all measures where greater than 10 measure quantities were evaluated. Overall, the program had a high persistence rate with 98% of the total quantity of measures still installed at the time of the evaluation activities. Spray valves are not included in the installation persistence calculation due to the low count included in the sample.

Table 4-30: Small Business Installation Persistence

Measure	Sample Reported Quantity*	Sample Verified Quantity	Persistence Rate
Faucet Aerator (0.5 GPM)	120	120	100%
Faucet Aerator (1.0 GPM)	37	34	92%
Showerhead	22	21	95%
Overall	**179**	**175**	**98%**

*Includes measures associated with both gas and electric savings

Table 4-31 shows the total gross verified savings for the Small Business Program in total.

Table 4-31: Small Business Program Gross Impact Evaluation Results

Program	2016-2017 Reported Savings (therms)	Realization Rate	2016-2017 Gross Verified Savings (therms)
Small Business	47,180	106%	49,884

4.8 Nonresidential Sector Results Summary

Table 4-32 lists the gross verified savings for each of Avista's nonresidential programs in Washington in 2016-2017. The Washington gas nonresidential sector achieved a 103% realization rate and the relative precision of the program-level natural gas realization rate was ±5% at the 90% confidence level.

Table 4-32: Nonresidential Program Gross Impact Evaluation Results

Program	2016-2017 Reported Savings (therms)	Realization Rate	2016-2017 Verified Gross Savings (therms)
EnergySmart Grocer	62,433	42%	26,175
Food Service Equipment	77,674	105%	81,748
HVAC	40,725	124%	50,555
Commercial Insulation	20,866	142%	29,566
Small Business	47,180	106%	49,884
Site Specific Conservation	176,440	113%	199,948
Site Specific Fuel Conversion	-88,088	133%	-117,387
Nonresidential Total – Conservation Only	**425,318**	**103%**	**437,875**

1 1
2 Nonresidential Impact Evaluation

5 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.

5.1 Overview

Avista offered four natural gas incentive-based residential programs and the low income program in their Washington service territory in 2016 and 2017. The reported savings for these residential programs are summarized in Table 5-1.

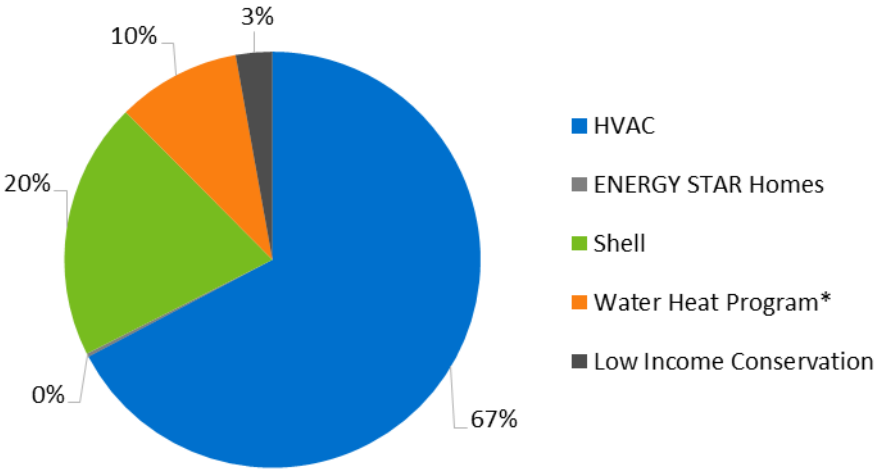
Table 5-1: Residential Program Reported Savings

Program	2016-2017 Reported Savings (therms)
HVAC	700,257
ENERGY STAR Homes	2,639
Shell	208,371
Water Heat Program*	92,972
Low Income Conservation	29,473
Conservation Total	**1,033,713**
Fuel Efficiency (Fuel Conversion)	-1,103,872
Low Income Fuel Conversion	-32,710
Fuel Conversion Total	**-1,136,582**

*Includes counts for both projects and showerheads

The Shell and HVAC programs collectively contributed 87% of the reported savings, as shown in Figure 5-1.

Figure 5-1: 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 521 document audits and 87 telephone surveys were conducted, as shown in Table 5-2. Engineering activities included review of savings calculation methodology and assumptions, utility bill analysis and energy savings analysis.

Table 5-2: Residential Program Achieved Evaluation Sample

Natural Gas Residential Program	Achieved C/P	Document Audit	Surveys	Billing Analysis
HVAC Program	90/7	159	44	
Water Heat Program	90/13	63	-	
ENERGY STAR Homes	90/44	15	-	
Fuel Efficiency	90/14	76	-	√
Shell Program	90/11	75	43	√
Low Income	90/57	133	-	√
Residential Total	**90/6**	**521**	**87**	

5.2 HVAC Program

5.2.1 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.

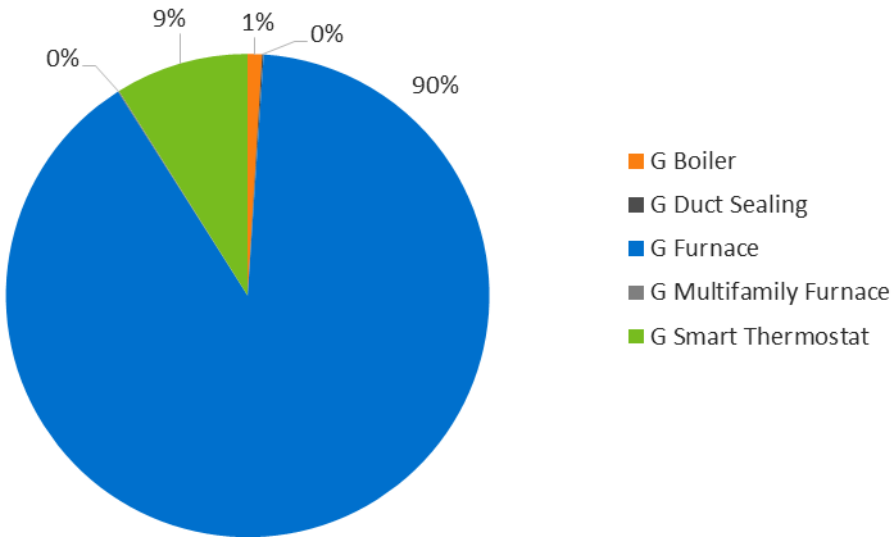
5.2.2 Program Achievements and Participation Summary

Participation and energy impacts as a result of the 2016–2017 HVAC program are summarized in Table 5-3 and Figure 5-2 below.

Table 5-3: HVAC Program Reported Participation and Savings

Measure	2016–2017 Reported Participation Count	2016–2017 Reported Savings (Therms)
G Boiler	65	6,660
G Duct Sealing	10	746
G Furnace	6,129	629,732
G Multifamily Furnace	38	570
G Smart Thermostat	1,863	62,549
TOTAL	**8,105**	**700,257**

Figure 5-2: 2016–2017 HVAC Program Reported Participation Energy Saving Shares



5.2.3 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 159 document audits and telephone surveys with HVAC program participants and a billing analysis was conducted for the Smart Thermostat measure. As discussed in 3.4, 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 as noted in their Technical Reference Manual (TRM). The evaluation team also conducted a review of Avista's complete 2016 and 2017 program databases to check for errors in measure-level reporting.

5.2.3.1 Program billing analysis

As discussed in Section 3.4.4.1, the evaluation team developed a matched comparison group to HVAC participants in order to conduct a difference-in-differences fixed-effects panel regression analysis. Gross verified energy savings are estimated as the difference in average consumption between treatment and comparison customers in each month during the pre- and post-treatment periods. Upon review of the billing data, the evaluation team found participants averaged approximately 831 therms annual consumption during the pre-treatment period. We identified nonparticipants with similar consumption profiles to comprise the matched comparison group used in our analysis. Our final model observed data for 802 participants who only participated in the HVAC program.

5.2.4 Findings and Recommendations

The document audits uncovered two minor discrepancies between details reported in the Avista database and documented in program participant files. Adjusting to the corrected values effectively cancelled each other out and did not affect reported program savings.

Table 5-4 outlines the program reported and gross verified savings value for the HVAC program. The evaluation team found a 133% realization rate across the entire HVAC program. The relative precision of the program level electric realization rate was ±6.8% at the 90% confidence level.

The high realization rate reflects both a vast majority of participation in high efficient gas furnaces, as well as relatively low reported savings per participant. The program saw 8,105 measures rebated to 6,993 customers in 2016 and 2017 which is an average reported savings of 100 therms per participant. However, the results of the billing analysis found an average savings per participant of 133 therms. Figure 5-3 below illustrates program impacts observed in the 2017 program year and, as expected, clearly indicate the heating season as the primary driver of program savings.

Figure 5-3: HVAC post-treatment consumption

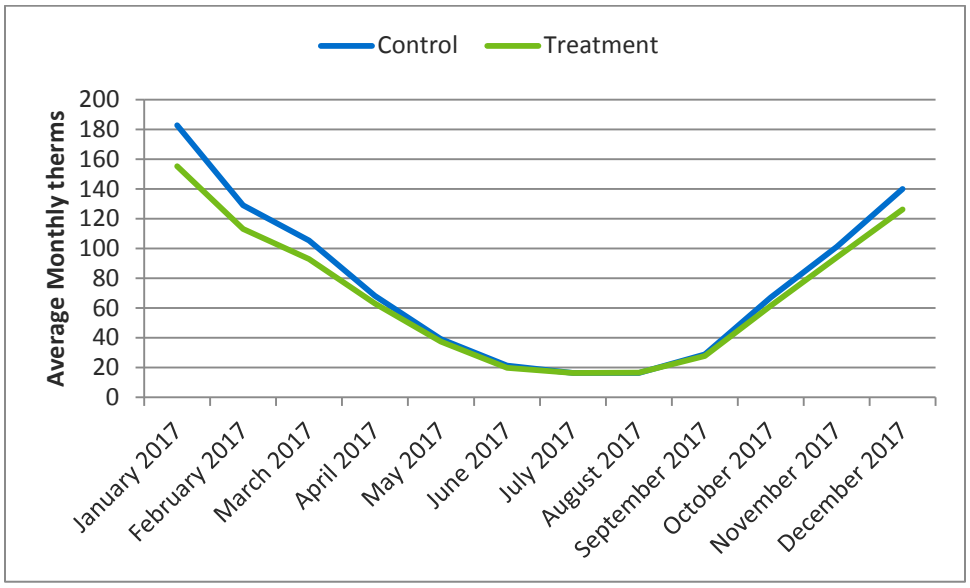


Table 5-4: HVAC Program Gross Verified Savings

2016–2017 Reported Participation Count	2016–2017 Reported Savings (therms)	2016–2017 Reported Average Savings per Participant (therms)	Realization Rate	2016–2017 Gross Verified Average Savings per Participant (therms)	2016-2017 Gross Verified Savings (therms)
6,993	700,257	100	133%	133	931,390

5.3 Water Heat Program

5.3.1 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 showerheads. The water heater measures were rebated[11] through Avista's Water Heat program. Showerhead incentives were offered through the Simple Steps upstream program.

5.3.2 Program Achievements and Participation Summary

A summary of participation and resulting energy impacts from the 2016–2017 Water Heat program is presented below in Table 5-5 and Figure 5-4.

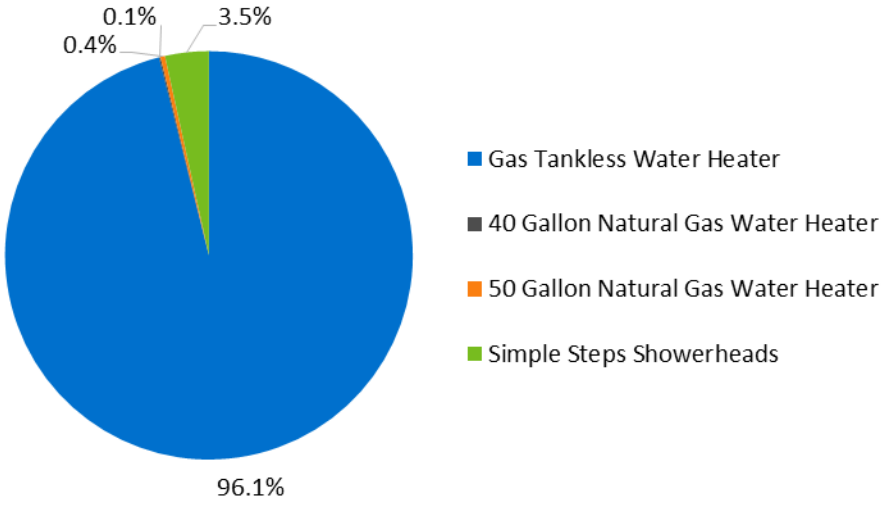
[11] Storage water heaters were not incentivized in the 2016-2017 program cycle, however rebates and savings for storage water heaters occurred in Q1 2016 as spillover from the prior cycle and are accounted for in this evaluation report.

Table 5-5: 2016–2017 Water Heat Reported Participation and Savings

Measure	2016–2017 Reported Participation Count	2016–2017 Reported Savings (Therms)
Gas Tankless Water Heater	1,359	89,308
40 Gallon Natural Gas Water Heater	12	106
50 Gallon Natural Gas Water Heater	37	334
Simple Steps Showerheads*	3,073	3,224
TOTAL	**4,481**	**92,972**

*Inclusive of 1.5, 1.75, and 2.0 gpm low flow showerheads

Figure 5-4: 2016–2017 Water Heat Program Reported Participation Energy Saving Shares



5.3.3 Methodology

The evaluation team performed verification of the program measures through a review of sampled project documentation and phone survey responses with program participants[12]. 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.

5.3.3.1 Water Heaters

The evaluation team leveraged the data collected from the project documentation and phone surveys[12] along with parameter assumptions sourced from Technical Reference Manuals and

[12] The 2016-2017 evaluation's weighted sampling approach did not specifically target water heat participants, however 27 participants targeted for the sample also reported having installed a water heat related measure during the evaluation timeframe.

published reports to conduct an engineering analysis to estimate savings for the 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 from the 2014-2015 impact survey results to estimate the baseline energy factor. The 2014-2015 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 factorWe adjusted the energy factor based on the data presented in Figure 5-5 and Figure 5-6 below.

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

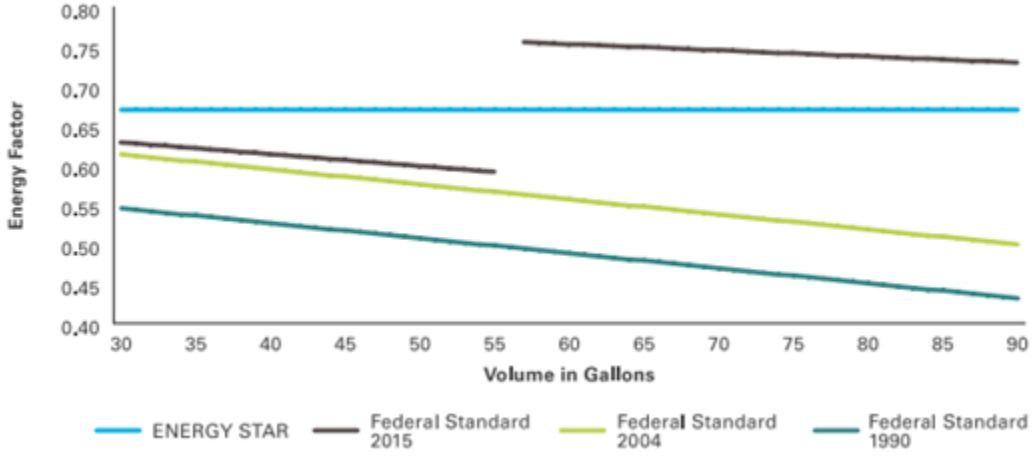


Figure 5-6: 2004 Federal Standards for Natural Gas Tankless Water Heaters

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 5-1. The parameters and source for each parameter is identified in Table 5-6:

Equation 5-1: 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 5-6: Water Heater Parameters and Data Sources

Parameter	Value	Source
People	2.890	Participant survey data[1]
Hot water usage per day per person (GPD)	15.744	Secondary Source[13]
Days	365.25	Conversion Factor (day/yr)
Outlet water temperature (F˚)	135	Secondary source[14]
Inlet water temperature (F˚)	52	Secondary source[15]
$EF_{baseline}$	0.52	Participant survey data[2]
$EF_{retrofit\text{-}tankless}$	Range	0.75-00.91, Calculated per-unit using program documentation
CP	1	Constant (BTU/lb)
Den	8.33	Constant (lb/gal)

[1]Average for 27 sampled participants that had installed a high efficiency water heater.
[2]Sourced from 2014-2015 evaluation cycle water heat impact survey results

The evaluation team calculated verified energy savings for each tankless water heater as this measure type accounts for 96% of program savings. Tank water heaters were assigned the realization rate from the prior evaluation cycle as they were legacy measures from the 2015 program year.

5.3.3.2 Low Flow Showerheads

The evaluation team estimated savings from low flow showerheads following Equation 5-2 and the parameters and source for each identified in Table 5-7:

Equation 5-2: 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)

[13] http://www.waterrf.org/PublicReportLibrary/4309A.pdf

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

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

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

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 5-7: Low Flow Showerhead Parameters and Data Sources

Term	Value	Source
People	2.890	Participant survey data[1]
Baseline Gallons per Minute	2.3	Regional Technical Forum (RTF)
Efficient Gallons per Minute	1.5-1.75	Given per Measure
Shower Time	8.06	RTF
Days	365	Conversion Factor (day/yr)
%Days	0.68	RTF
ΔGPM	0.3, 0.55, 0.7, 0.8	Program data (efficient case); RTF (baseline case)
Outlet water temperature (F˚)	135	Secondary source[16]
Inlet water temperature (F˚)	52	Secondary source[17]
$EF_{baseline}$	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

[1]Average for sampled participants.

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

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

Because the showerheads were either distributed via an upstream 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 Simple Steps. 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[18]. We used data specific to Washington to assign the proportion of Simple Steps showerheads that contributed to natural gas savings.

5.3.4 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 tankless water heater measures resulted in a realization rate of 132%. 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, and 1.50 GPM Simple Steps showerheads of 157%.

The total program realization rate and savings are presented in Table 5-8. The relative precision of the program level natural gas realization rate is ±13% at the 90% confidence level.

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

Table 5-8: Water Heat Program Gross Verified Savings

Measure	2016–2017 Reported Savings (Therms)	Realization Rate (%)	2016-2017 Gross Verified Savings (Therms)
Gas Tankless Water Heater	89,308	132%	117,522
40 Gallon Natural Gas Water Heater	106	118%	125
50 Gallon Natural Gas Water Heater	334	118%	395
Simple Steps Showerheads	3,224	157%	5,060
TOTAL	**92,972**	**132%**	**123,101**

5.4 ENERGY STAR® Homes

5.4.1 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. Reported energy saving assumptions did not change for the ENERGY STAR Homes program between the 2014-2015 and 2016-2017 program years. As the program parameters did not change, the evaluation team conducted a document review and database review for 2016-2017 participants and used the realization rate from the 2014-2015 evaluation cycle to calculate verified savings.

5.4.2 Program Achievements and Participation Summary

Participation and energy impacts from the 2016-2017 ENERGY STAR® Homes program are summarized in Table 5-9 below.

Table 5-9: 2016–2017 ENERGY STAR® Homes Reported Participation and Savings

Measure	2016–2017 Reported Participation Count	2016–2017 Reported Savings (Therms)
G Energy Star Home – Natural Gas Only	13	2,639

5.4.3 Methodology

The evaluation team conducted a document audit of 16[19] Natural Gas ENERGY STAR Homes (WA and ID) application materials along with a participation database review to ensure accurate program savings values were recorded. The document audit and database review did not find any errors in reporting of savings values for Washington Natural Gas 2016-2017 ENERGY

[19] Included projects in both WA and ID

STAR Homes participants. As the ENERGY STAR Homes program qualification and savings parameters did not change between the 2014-2015 and 2016-2017 biennium, the evaluation team utilized the realization rate for ENERGY STAR Homes from the 2014-2015 evaluation cycle to calculate verified savings for the 2016-2017 biennium. For the analysis method used in the prior evaluation, the evaluation team collected Home Energy Rating System (HERS) Index scores for participating ENERGY STAR Homes. A baseline HERS Index score of 80 was assumed as standard for non-program new meter hookups. The evaluation team estimated weather normalized annual consumption for ENERGY STAR Homes using the same basic model specification shown in Equation 3-4. Because these newly built homes do not have a pre-retrofit period, only "post-retrofit" consumption was estimated by the model[20].

Equation 5-3 shows the calculation of estimated consumption absent the program.

Equation 5-3: Calculation of Consumption Absent Program

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

Table 5-10 provides additional information about the terms in Equation 5-3.

Table 5-10: Calculation of Consumption Absent Program Definition of Terms

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

Table 5-11 shows the 2014-2015 calculation for gas savings and realization rate for ENERGY STAR® Natural Gas Homes.

Table 5-11: ENERGY STAR Home: Results for Natural Gas Homes 2014-2015 Evaluation

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

[20] To determine verified energy savings, a recommendation from the 2014-2015 evaluation was 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, which is preferred compared to the HERS index score approach utilized in that evaluation. Avista's response to the recommendation was that the regional program effort leverages regional savings estimates and Avista does not have access to additional data points.

5.4.4 Findings and Recommendations

Table 5-12 outlines the program reported and gross verified savings value for the gas-specific homes in the ENERGY STAR® homes program. The relative precision of the program level natural gas realization rate is ±44% at the 90% confidence level.

Table 5-12: ENERGY STAR® Homes Program Gross Verified Savings

Program	2016–2017 Reported Savings (Therms)	Realization Rate	2016-2017 Gross Verified Savings (Therms)
G Energy Star Home – Natural Gas Only	2,639	212%	5,607

Similar to recommendations in the 2014-2015 evaluation, a billing analysis would be the preferred method to assess savings as a result of ENERGY STAR Homes measures. In order to conduct a reliable billing analysis, a non-program comparison group is needed to allow for a reliable non-participant comparison group billing analysis approach. This data could be made available via the Avista billing database should Avista track the following for new service point ID's: identifying new construction accounts with a flag, and collecting basic home information such as square footage and number of stories.

At a minimum, Avista may find more accurate savings projections by incorporating energy savings values from the prior evaluation cycle into their TRM.

5.5 Fuel Efficiency

5.5.1 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.

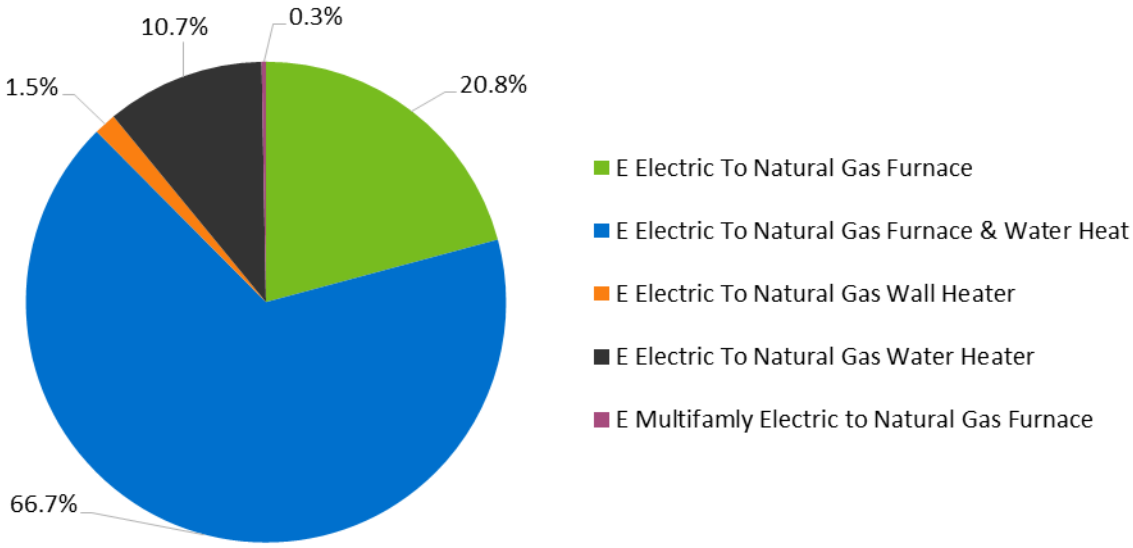
5.5.2 Program Achievements and Participation Summary

Participation in the 2016-2017 Fuel Efficiency program totaled 2,677. Table 5-13 and Figure 5-7 summarize Avista's 2016-2017 Fuel Efficiency program participation and energy impacts.

Table 5-13: 2016-2017 Fuel Efficiency Reported Participation and Savings

Measure	2016–2017 Reported Participation Count	2016–2017 Reported Savings (Therms)
E Electric to Natural Gas Furnace	658	-229,695
E Electric to Natural Gas Furnace & Water Heat	1,340	-736,736
E Electric to Natural Gas Wall Heater	47	-16,506
E Electric to Natural Gas Water Heater	599	-117,767
E Multifamily Electric to Natural Gas Furnace	33	-3,168
Total	**2,677**	**-1,103,872**

Figure 5-7: 2016–2017 Fuel Efficiency Program Reported Gas Penalty Shares



5.5.3 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 a regression analysis of billing data provided by Avista as described in Section 3.4.4.3. The regression output is presented in the Appendix B.

The evaluation team compiled a dataset consisting of 2016-2017 Fuel Efficiency program participants being sure to include only those customers who were not enrolled in any other of Avista's rebate programs during the evaluation period. In addition, the evaluation team requested monthly consumption records for each account that received a Fuel Efficiency rebate (both Washington and Idaho) from Avista in 2016 and 2017. Billing records were requested for January 2015 through March 2018 to maximize the quantity of pre- and post-retrofit data

available. 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 billing history and six months of post-retrofit billing history were included in the analysis.

Of the 216 homes that received rebates through the Fuel Efficiency program only and had adequate pre-retrofit and post-retrofit billing data, 82 homes (approximately 38%) did not have natural gas service with Avista prior to participation[21]. This means gas measures were installed in these homes shortly after gas service was added to the residence. It also presumes that the pre-retrofit gas usage in these homes is intuitively zero therms per year.

It is noteworthy that a large share of customers who received rebates through the Fuel Efficiency program also received rebates for high efficiency natural gas measures through other Avista programs. Because the analysis aimed at isolating the impacts solely attributable to the Fuel Efficiency program, customers enrolled in multiple programs were excluded, which reduced the customer sample size available for analysis.

5.5.4 Findings and Recommendations

Gas impacts (in this case, negative savings or increased consumption) were estimated separately for homes with and without prior natural gas service and a weighted average realization rate for the two groups was calculated. This weighted realization rate was then applied to all reported therm penalties from fuel conversions to estimate verified impacts. Table 5-14 shows the results of the calculation for electric to gas furnace conversions.

Table 5-14: Electric to Gas Conversion Calculation

Group	# Homes	Ex Ante Therms	Annual Therms Pre	Annual Therms Post	Annual Gas Impact	Realization Rate
Homes with prior gas service	134	-463	667	987	-320	65.2%
Homes with new gas service	82	-463	0	629	-629	127.8%
Weighted Gas Realization Rate for Electric to Gas Furnace Conversion						69.8%

The regression model estimated that homes with pre-existing natural gas service consumed an additional 320 therms annually. Homes without prior gas service went from zero therms per year to 629 therms per year. The average estimated reported impact for each of these groups was 463 therms. The resulting weighted realization rate for the electric to gas conversion was 69.8%. The relative precision of the program level gas realization rate was ±14.0% at the 90% confidence level.

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

Table 5-15: Fuel Efficiency Program Reported and Gross Verified Savings

Program	2016-2017 Reported Savings (Therms)	Realization Rate	2016-2017 Gross Verified Savings (Therms)
Fuel Efficiency	-1,103,872	70%	-770,062

5.6 Shell Program

5.6.1 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), and window replacements. 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.

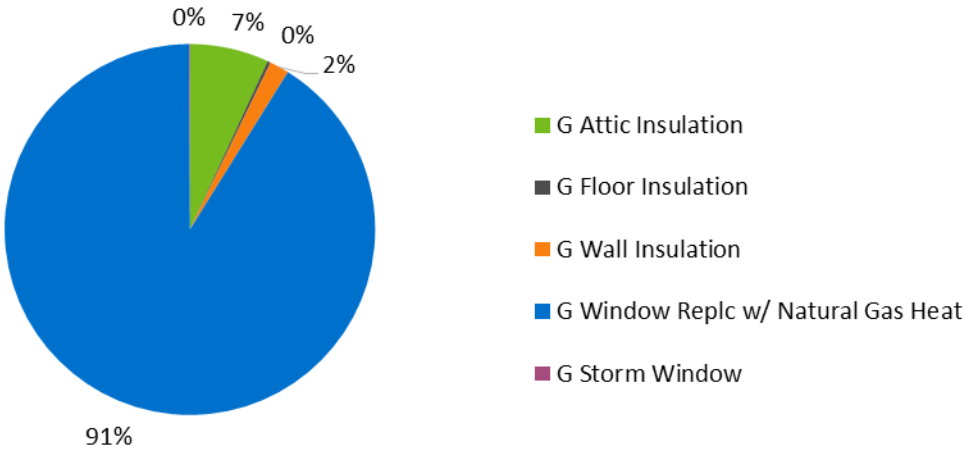
5.6.2 Program Achievements and Participation Summary

Participation and energy impacts for the 2016 and 2017 Shell program is summarized in Table 5-16 and Figure 5-8.

Table 5-16: 2016–2017 Shell Program Reported Participation and Savings

Measure	2016-2017 Reported Participation Count	2016-2017 Reported Savings (Therms)
G Attic Insulation	177	14,380
G Floor Insulation	12	568
G Wall Insulation	57	3,531
G Window Replacement with Natural Gas Heat	1,641	189,744
G Storm Window	3	148
TOTAL	**1,890**	**208,371**

Figure 5-8: 2016–2017 Shell Program Reported Energy Saving Shares



5.6.3 Methodology

The evaluation team conducted 75 document audits as part of our evaluation activities. These 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 savings value for each applicable measure as noted in their Technical Reference Manual (TRM). The evaluation team also conducted a review of Avista's complete 2016 and 2017 program databases to check for errors in measure-level reporting.

Nine shell participant document records reported different values in installed square footage units than the Avista participation database. These data entry errors did not affect reported savings values.

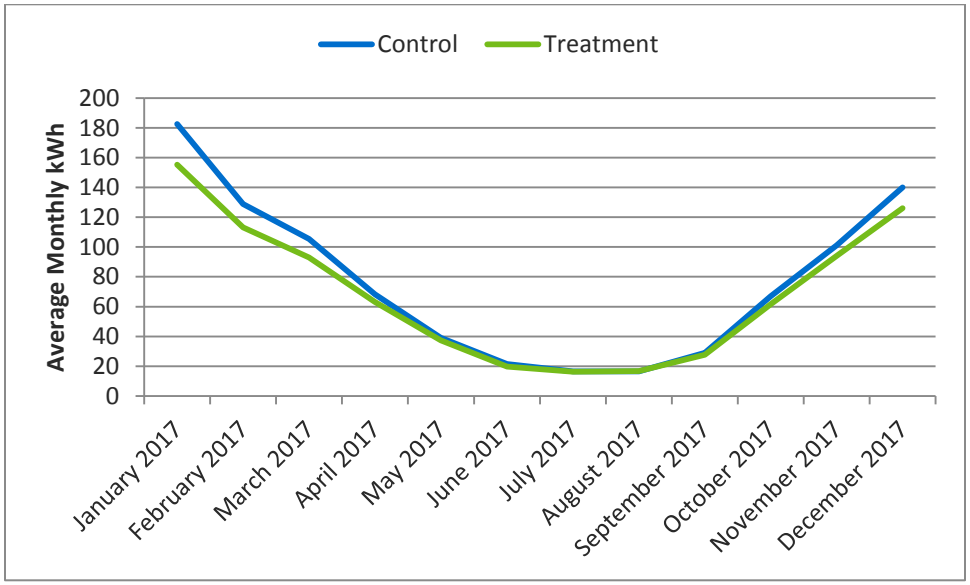
5.6.3.1 Program billing analysis

Following the same method used to estimate impacts for the HVAC program, the evaluation team requested monthly consumption records for each account that received a Shell rebate (both Washington and Idaho) from Avista in 2016 and 2017. Billing records were requested for January 2015 through February 2018 to maximize the quantity of pre- and post-retrofit data available. The evaluation team filtered customers who participated in other Avista programs in order to capture effects of only the Shell program. The evaluation team estimated impacts by selecting a matched comparison group of non-participants to conduct a difference in differences regression model as discussed in Section 3.4.4.1 of this report and the detailed regression outputs are presented in the Appendix.

5.6.4 Findings and Recommendations

Figure 5-9 below illustrates program impacts observed in the 2017 program year. The figure denotes modest savings during the winter months and minimal savings across the summer season.

Figure 5-9: Shell Post-Treatment Impacts



The gas realization rate for the Shell program was estimated at 78% (see Table 5-17). The relative precision of the program level gas realization rate was ±11% at the 90% confidence level.

Table 5-17: Shell Program Gross Verified Savings

2016–2017 Reported Savings (therms)	2016–2017 Reported Average Savings per Participant (therms)	Realization Rate	2016–2017 Gross Verified Average Savings per Participant (therms)	Gross Verified Savings (kWh)
208,371	122	78%	96	163,260

5.7 Low Income

5.7.1 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.

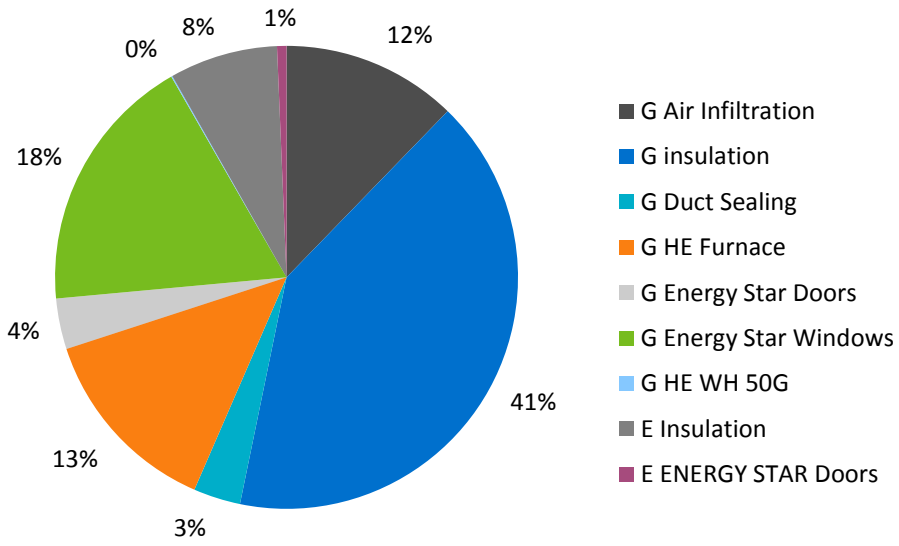
5.7.2 Program Achievements and Participation Summary

Participation in the 2016-2017 Low Income program totaled 1,268 conservation and fuel conversion projects. Table 5-18 summarizes the reported participation counts and energy savings for the measures that make-up the Low Income program. Insulation measures account for 41% of the program savings, with high efficient gas furnace the second largest measure at 13% (Figure 5-10).

Table 5-18: 2016–2017 Low-Income Program Reported Participation and Savings

Measure Category	Measure	2016–2017 Reported Participation Count	2016–2017 Reported Savings (Therms)
Conservation	G Air Infiltration	200	3,613
Conservation	G Insulation	342	12,075
Conservation	G Duct Sealing	29	970
Conservation	G HE Furnace	62	3,970
Conservation	G Energy Star Doors	90	1,046
Conservation	G Energy Star Windows	105	5,354
Conservation	G HE WH 50G	4	24
Conservation	E Insulation	177	2,227
Conservation	E ENERGY STAR Doors	29	194
Low Income Total – Conservation Only		**1,038**	**29,473**
Fuel Conversion	E to G Furnace Conversion	110	-18,424
Fuel Conversion	E to G H2O Conversion	120	-14,287
Low Income Total – Fuel Conversion		**230**	**-32,710**

Figure 5-10: 2016-2017 Low-Income Program Reported Energy Saving Shares: Conservation Measures



5.7.3 Methodology

The evaluation team organized the analysis based on conservation and fuel conversion measures and employed a regression analysis to estimate impacts.

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 gas savings in the program tracking data. We then relied on a regression analysis of Avista billing data to estimate per-home impacts for homes claiming gas savings.

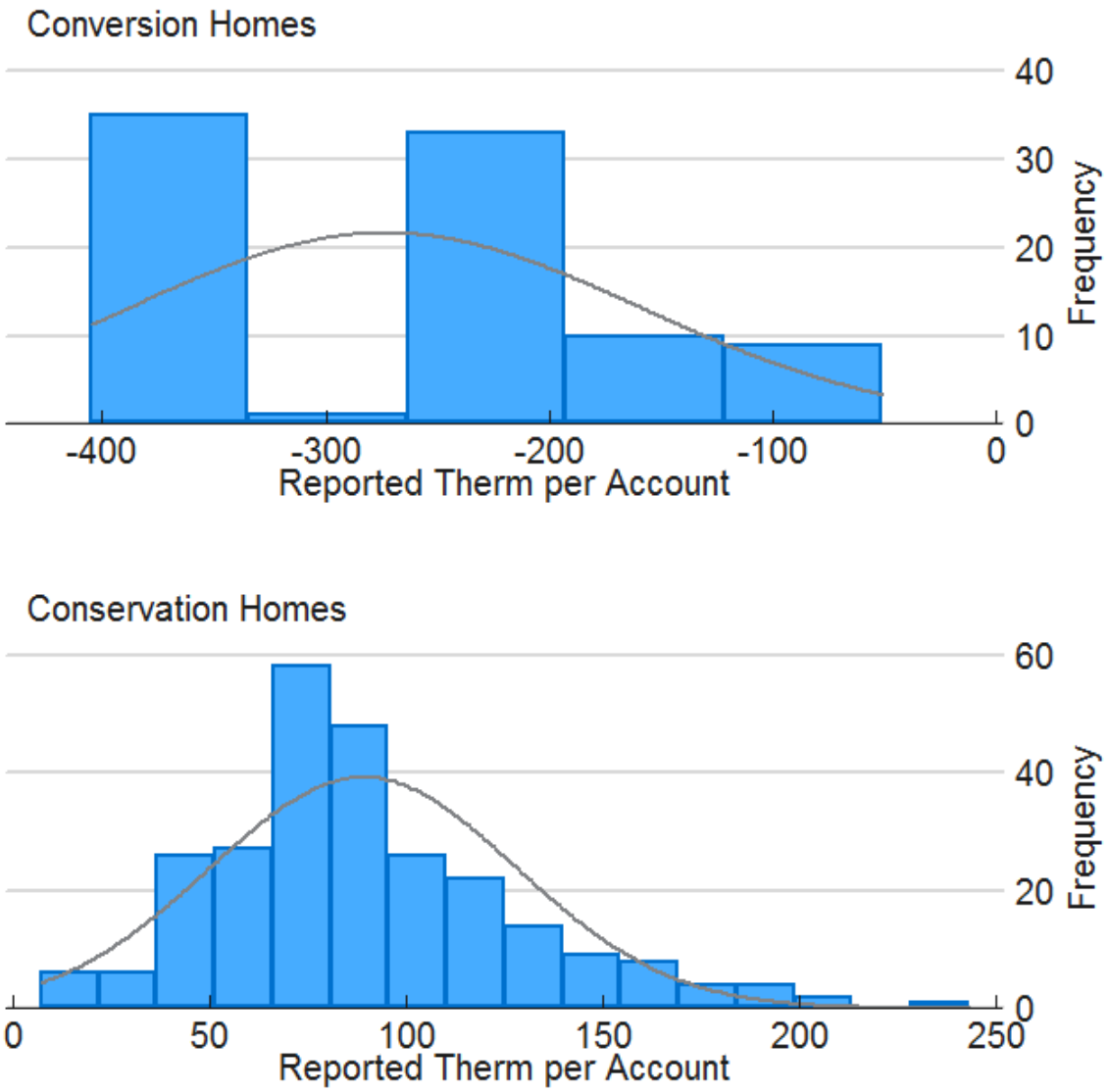
Next, homes were assigned to one of two groups for analysis:

1) **Conservation Participants** – these customers participated only in conservation-related measures in the program.

2) **Conversion Participants** – these customers were unique participants only partaking in conversion measures through the program.

Figure 5-11 shows the distribution of per-home reported electric savings for the two groups. Reported electric impacts for the fuel switching homes were generally larger.

Figure 5-11: Distribution of Reported Therm Values by Home Type



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 12 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 electric consumption and weather before and after service. Separate models were estimated for fuel conversion customers and electric conservation customers and both Idaho and Washington participants were used in the 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 electric savings. The regression coefficients and relevant goodness of fit statistics are presented in the Appendix.

5.7.4 Findings and Recommendations

Table 5-19 summarizes the key inputs and outputs of the regression analysis. As the conversion participants switched from electric to gas heating, this cohort realized a substantial increase in gas consumption of approximately 280%. However, with a realization rate of 75%, the increased gas usage was less than forecasted by Avista. For conservation participants, the average impact was just over 6% reduction in gas consumption which is significantly less than found in the prior 2014-2015 biennium evaluation. Further investigation into consumption patterns revealed an anomaly with the 2016-2017 participants relative to the previous biennium. As Figure 5-12 illustrates, the consumption profile for 2014-2015 participants saw a decrease in consumption by January 2015 due to program treatment. However, 2016-2017 participants saw an increase in consumption by January 2017 and only a decrease to similar 2016 consumption values by the biennium close in December 2017. Therefore, the overall impact on gas consumption was low and ultimately the conservation measures achieved a 28% realization rate.

Figure 5-12: 2014-2015 vs 2016-2017 Low Income Biennium Consumption

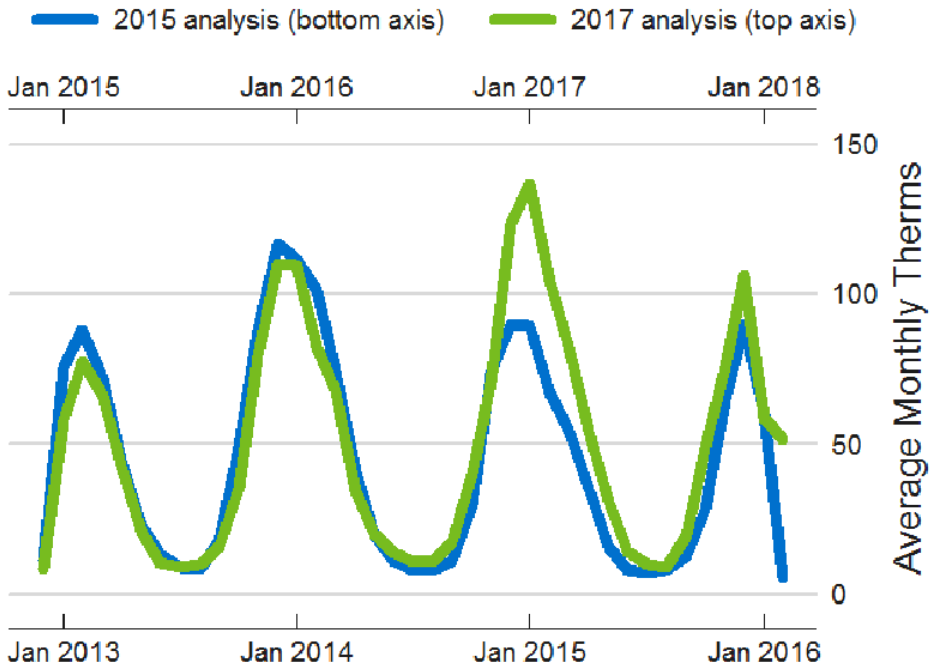


Table 5-19: Low Income Billing Analysis Findings

Stratum	Fuel Conversion Participants	Conservation Participants
Number of Homes Analyzed	42	98
Average Reported therm per Home	-535	146
Weather Normalized Annual therm Pre-Retrofit	143	636
Weather Normalized Annual therm Post-Retrofit	542	595
Average therm Savings per Home	-400	40
Realization Rate	74.7%	27.6%
Relative Precision (90% confidence level)	14.3%	65.7%
Average Percent Reduction in Annual Natural Gas Consumption	-280.1%	6.3%

The conservation and fuel conversion reported and gross verified savings are presented in Table 5-20. The relative precision of the program level gas realization rate was ±57% at the 90% confidence level for the conservation measure category.

Table 5-20: Low-Income Program Gross Verified Savings

Measure Category	2016–2017 Reported Participation Count	2016–2017 Reported Savings (therms)	Realization Rate	Gross Verified Savings (therms)
Conservation	1,038	29,473	28%	8,141
Fuel Conversion	230	-32,710	75%	-24,425

5.8 Residential Sector Results Summary

Table 5-21 lists the gross verified savings for each of Avista's residential programs in Washington in 2016 and 2017 and for the overall portfolio. The Washington gas residential sector achieved a 119% realization rate for conservation measures and a 70% realization rate for conversion measures. The relative precision of the portfolio-level gas realization rate was ±6.4% at the 90% confidence level.

Table 5-21: Residential Program Gross Impact Evaluation Results

Program	2016-2017 Reported Savings (therms)	Realization Rate	2016-2017 Gross Verified Savings
HVAC	700,257	133%	931,390
ENERGY STAR Homes	2,639	212%	5,607
Shell	208,371	78%	163,260
Water Heat Program	92,972	132%	123,101
Low Income Conservation	29,473	28%	8,141
Conservation Total	**1,033,713**	**119%**	**1,231,499**
Fuel Efficiency (Fuel Conversion)	-1,103,872	70%	-770,062
Low Income Fuel Conversion	-32,710	75%	-24,425
Fuel Conversion Total	**-1,136,582**	**70%**	**-794,487**

6 Conclusions and Recommendations

6.1 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.

6.2 Impact Findings

The evaluation team performed the impact evaluation for Avista's 2016 and 2017 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 a 114% realization rate across Avista's 2016-2017 portfolio of programs (Table 6-1). Table 6-2 and Table 6-3 summarize Avista's 2016 and 2017 impact evaluation results by sector and program.

Table 6-1: 2016-2017 Washington Natural Gas Portfolio Evaluation Results

Sector	2016–2017 Reported Savings (therms)	Realization Rate (%)	2016–2017 Gross Verified Savings (therms)
Residential	1,004,240	122%	1,223,358
Nonresidential	425,318	103%	437,875
Low Income	29,473	28%	8,141
Portfolio Total[22]	**1,459,030**	**114%**	**1,669,374**

[22] Fuel conversion measures (measures wherein customers convert from electric to natural gas space and water heating) result in a negative impact and are not included in the total. Impacts of fuel conversion measures can be found in the program specific sections (Sections 4 and 5).

Table 6-2: Washington Gas Nonresidential Program Evaluation Results

Program	2016-2017 Reported Savings (therms)	Realization Rate	2016-2017 Verified Gross Savings (therms)
Energy Smart Grocer	62,433	42%	26,175
Food Service Equipment	77,674	105%	81,748
HVAC	40,725	124%	50,555
Commercial Insulation	20,866	142%	29,566
Small Business	47,180	106%	49,884
Site Specific Conservation	176,440	113%	199,948
Nonresidential Total[23]	**425,318**	**103%**	**437,875**

Table 6-3: Washington Gas Residential Program Evaluation Results

Program	2016-2017 Adjusted Reported Savings (kWh)	Realization Rate (%)	2016-2017 Verified Gross Savings (therms)
HVAC	700,257	133%	931,390
ENERGY STAR Homes	2,639	212%	5,607
Shell	208,371	78%	163,260
Water Heat Program	92,972	132%	123,101
Low Income Conservation	29,473	28%	8,141
Residential Total[24]	**1,033,713**	**119%**	**1,231,499**

6.3 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.

6.3.1 Nonresidential Programs

The overall realization rate for the nonresidential portfolio is 103%. The realization rates ranged from 142% for the Commercial Insulation program down to 42% for the Energy Smart Grocer program. The evaluation team found that the processes Avista is utilizing for estimating and

[23] Nonresidential total does not include impacts of Site Specific fuel conversion measures. See Section 4.6 for fuel conversion impacts.

[24] Residential total does not include impacts of residential and low income fuel conversion measures. See Sections 5.5 and 5.7 for fuel conversion impacts.

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.

6.3.1.1 Site Specific Program

Conclusion: The Site Specific program constitutes more than 45% of the program energy shares (verified gross savings). Over the last 4 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 133% realization rate for the Site Specific program (conservation measures only).

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

6.3.1.2 Natural Gas Prescriptive Programs

Conclusion: Avista reported participation in four prescriptive natural gas programs in 2016-2017: Food Service Equipment, Commercial Insulation, Natural Gas HVAC, and Energy Smart Grocer. Strong realizations rates for most 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.

Conclusion: The Energy Smart Grocer program constituted about 6% of the nonresidential natural gas portfolio energy shares. The evaluation team found a realization rate of 42% for this program, predominately due to a zero realization rate that was found for a few large projects in the sample, based on utility bill analysis.

> **Recommendation**: The Energy Smart Grocer program is implemented by a third party. It is recommended that for large projects, Avista work more closely with the implementer to ensure accurate reporting.

> **Recommendation**: The evaluation team recommends that Avista consider using performance-based incentives for any measures that are estimated to achieve savings of 10% or more of annual natural gas consumption. For projects where eQuest model were employed by the implementer to estimate savings, Avista should verify that the baseline eQuest model was calibrated on a monthly basis for both gas and electric consumption.

6.3.1.3 Small Business Program

Conclusion: The Small Business program in WA constituted approximately 11% of the total savings for the nonresidential portfolio. The evaluation team found a 106% realization for the program.

Conclusion: The Small Business program implementer has improved their tracking of decommissioned measures in the 2016-2017 biennium, in comparison to the 2014-2015 biennium, as shown by the evaluation team's calculated persistence rate of 98% for the measures included in the sample in the 2016-2017 biennium.

6.3.2 Residential Programs

The overall realization rate for the residential portfolio's conservation programs was 119% while the conversion programs achieved a 70% realization rate. The conversion programs all performed well with realization rates above 100% with the exception of the Shell and Low Income programs. The conversion programs low realization rates indicates the forecasted increase gas consumption was not realized. The following subsections outline specific conclusions and recommendations for several of the residential programs.

6.3.2.1 HVAC Program

Conclusion: The evaluation team found a realization of 133% at the program level. This is similar to the findings of the 2014-2015 evaluation which found a 125% realization rate for Washington. The findings are based on the analysis of 802 homes resulting in a relative precision of 6.8%.

> **Recommendation:** Given that the realization rate is substantially higher than 100% and is associated with a low error bound, Avista should consider revising its reported savings values for measures within the program.

6.3.2.2 Water Heat

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.

6.3.2.3 Fuel Efficiency

Conclusion: The evaluation team found that the homes analyzed that converted from electric heat to a natural gas furnace showed an average weather normalized gas consumption increase of 328 therms per year resulting in a 70% realization rate. This impact and realization rate is very similar to findings from the prior evaluation (384 therms increased consumption with a 70% realization rate).

> **Recommendation** The evaluation team recommends Avista review its forecasted gas penalty for the Fuel Efficiency program. Based on two cycles of evaluation, the program appears to be over-estimating the actual impact.

6.3.2.4 Shell Program

Conclusion: The evaluation team found a realization rate of 78% for shell program. These findings reflect reported savings are fairly well aligned for the program. However, there may be room for further refinement of savings assumptions for the reported values.

> **Recommendation:** To refine the reported savings assumptions, we recommend Avista examine planning assumptions about per-home consumption, end-use load shares, and percent reductions in heating loads from shell improvements.

6.3.2.5 Low Income Program

Conclusion: The verified savings for the gas conservation homes was very low relative to Avista's reported savings with a realization rate of 28%. This is a departure from the previous evaluation which found a realization rate of 101%. Moreover, the evaluation observed unexpected increases in consumption on average after the first year of the biennium. The conversion measures achieved a 75% realization rate indicating the program assumed too high of a gas penalty.

> **Recommendation:** The evaluation team recommends that Avista maintain its current assumptions for conservation measures due to the diverging realization rates between the prior and current evaluations that appear to be driven by varying participant consumption profiles.

Appendix A Sampling and Estimation

The gross verified energy savings estimates presented in this report from Avista's natural gas energy efficiency 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 on-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 therm savings per rebated piece of equipment. With mean-per-unit estimation the average therm 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

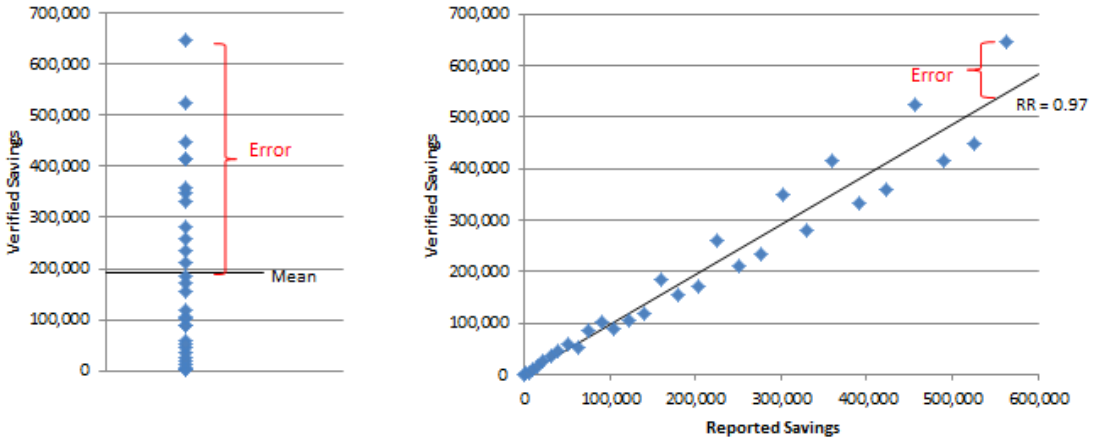
representative of the program as a whole. This ratio is referred to as the *realization rate*, or *ratio estimator*, and is calculated as follows:

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

In a few cases, 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 Dryers	15,000	30	500
Gas Furnaces	6,000	30	200

Because gas furnaces are sampled at a higher rate (1-in-200) than clothes dryers (1-in-500), each sample point carries less weight in the program results than an individual clothes dyer 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.

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. Although a program's contribution to portfolio savings may be 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 2014-2015 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

$$n = n_0 * fpc$$

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

$$Relative\ Precision_{Verified\ Savings} = \frac{Error\ Bound_{(therms)}}{Verified\ Impact_{(therms)}}$$

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 therms) 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 therms	Realization Rate	Error Bound (therms)	Verified therms	Relative Precision (90%)
Program #1	400,000	0.5	40,000	200,000	± 20%
Program #2	400,000	1.0	40,000	400,000	± 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