REPORT

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Impact Evaluation of Washington Electric 2014-2015 Energy Efficiency Programs

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1 Executive Summary

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

- Nonresidential Prescriptive
- Nonresidential Site Specific
- Small Business
- Residential Appliance Recycling
- Residential Heating, Ventilation and Air Conditioning (HVAC)
- Residential Water Heat
- Residential ENERGY STAR® Homes
- Residential Fuel Efficiency
- Residential Lighting
- Residential Shell
- Residential Opower Behavioral
- 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 525 document audits, approximately 360 customer surveys, and nearly 250 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 five 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				
Residential Appliance Recycling	70	72	0	
HVAC Program	68	68	0	√
Water Heat Program	24	13	0	
ENERGY STAR Homes	19	16	0	
Fuel Efficiency	26	25	0	√
Residential Lighting Program	0	0	75	
Shell Program	28	28	0	√
Opower Behavioral Program	0	0	0	√
Low Income	24	0	0	√
Nonresidential				
Prescriptive Lighting	68	22	22	
Prescriptive EnergySmart Grocer	44	20	20	
Prescriptive Non-Lighting Other	24	15	15	
Site Specific	101	84	84	as applicable
Small Business	31		31	
TOTAL	**527**	**363**	**247**	

1.2 Summary of Impact Evaluation Results

Avista's Washington electric 2014 and 2015 programs achieved more than 80 GWh of savings over the two year period (Table 1-2). Table 1-3 and Table 1-4 summarize Avista's 2014 and 2015 impact evaluation results by sector and program.

Table 1-2: Washington Electric Portfolio Evaluation Results

Sector	Reported Savings (kWh)	Realization Rate (%)	Gross Verified Savings (kWh)
Residential	40,595,987	108%	43,849,339
Nonresidential	37,043,299	95%	35,330,436
Low Income	885,598	168%	1,488,180
Portfolio	**78,524,884**	**103%**	**80,667,955**

Table 1-3: Washington Electric Nonresidential Program Evaluation Results

Program	2014-2015 Reported Savings (kWh)	Realization Rate	2014-2015 Verified Gross Savings (kWh)
EnergySmart Grocer	3,512,149	90%	3,144,958
Food Service Equipment	214,937	54%	116,494
Green Motors	25,607	54%	13,879
Motor Controls HVAC	1,374,268	54%	744,838
Commercial Water Heaters	138	54%	75
Prescriptive Lighting	8,145,753	99%	8,046,872
Prescriptive Shell	494,230	54%	267,867
Fleet Heat	8,668	54%	4,698
Site Specific	22,236,575	99%	21,936,984
Small Business	1,030,975	102%	1,053,771
TOTAL NONRESIDENTIAL	**37,043,300**	**95%**	**35,330,436**

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

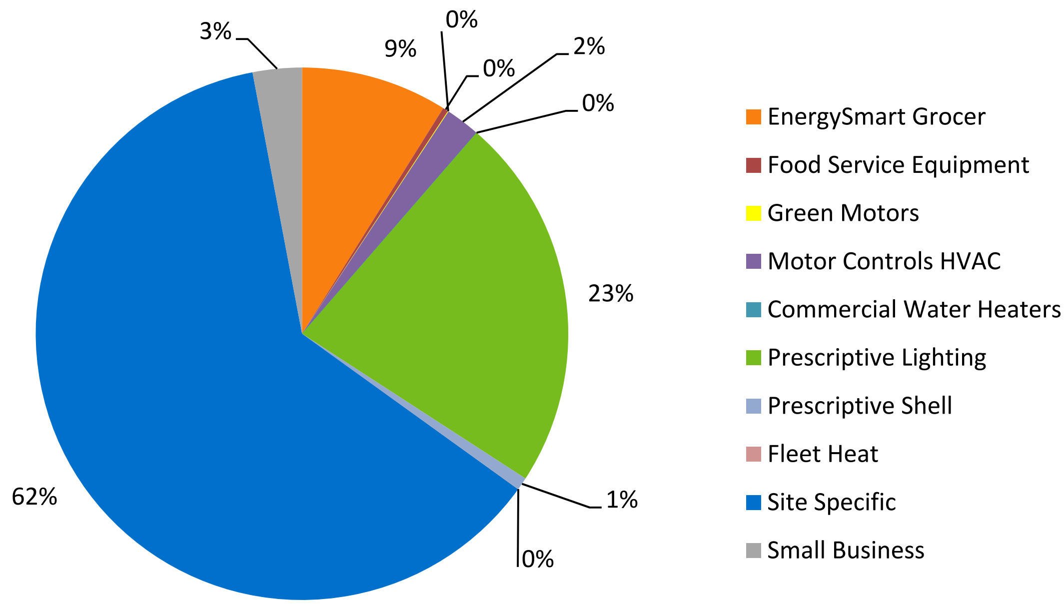
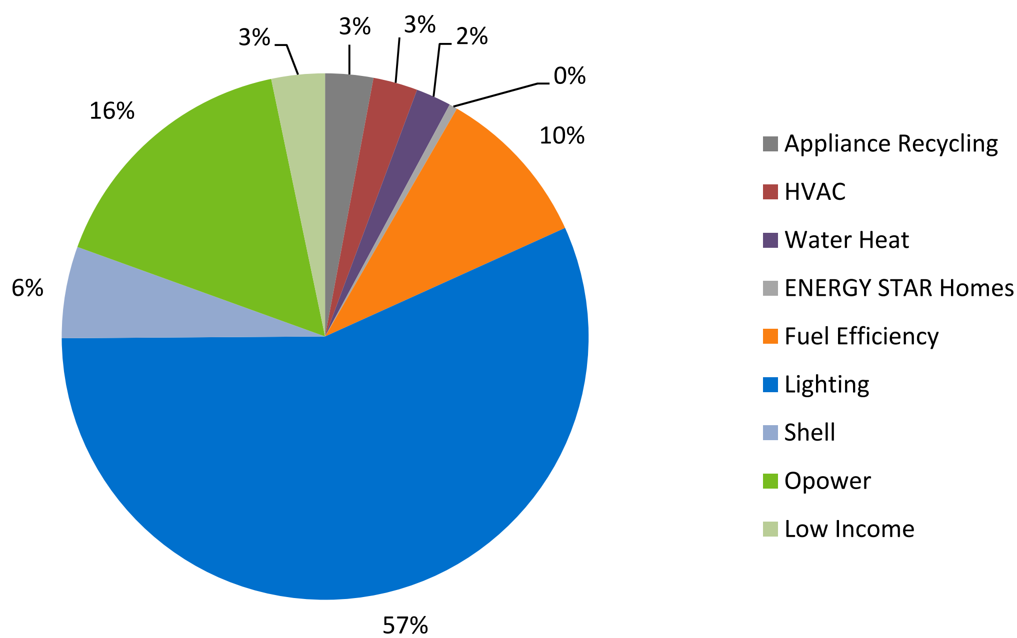


Table 1-4: Washington Electric Residential Program Evaluation Results

Program	2014-2015 Adjusted Reported Savings (kWh)	Realization Rate	2014-2015 Gross Verified Savings
Appliance Recycling	810,072	165%	1,332,668
HVAC	1,597,373	78%	1,238,974
Water Heat	833,720	118%	981,190
ENERGY STAR Homes	180,807	126%	228,387
Fuel Efficiency	7,176,499	62%	4,483,925
Lighting	19,606,228	131%	25,689,564
Shell	4,276,288	60%	2,552,254
Opower	6,115,000	120%	7,342,378
Low Income	885,598	168%	1,488,180
TOTAL RESIDENTIAL	**41,481,585**	**109%**	**45,337,519**

Figure 1-2: Washington Electric Residential Sector Program Gross Saving Shares



1.3 Conclusions and Recommendations

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

1.3.1 Nonresidential Programs

The overall realization rate for the nonresidential portfolio is 95%. The realization rates ranged from 102% for the Small Business program down to 54% for the “Prescriptive Non-Lighting Other” program. The largest program in the nonresidential portfolio, Site Specific, had a realization rate of 99%. The evaluation team found that the processes Avista is utilizing for estimating and reporting energy savings for the nonresidential programs are predominantly sound and reasonable. The following subsections outline specific key conclusions and recommendations for several of the nonresidential programs.

Conclusion: The Site Specific program constitutes more than 60% of the program energy shares. Within the last 2 years, Avista has increased their level of quality assurance and review on projects that participate through the program. The evaluation team’s analysis resulted in a 99% realization rate for the Site Specific program. The high realization rate indicates that Avista’s internal process for project review, savings estimation, and installation verification are working to produce high quality estimates of project impacts.

> **Recommendation**: The evaluation team recommends that Avista continue to operate this program with the current level of rigor. For interior lighting projects, Avista should consider applying the interactive factors deemed by the Regional Technical Forum (RTF) to quantify the interactive effects between lighting retrofits and their associated HVAC systems.

Conclusion: Avista’s EnergySmart Grocer program is successfully providing retail and restaurant customers with an avenue to upgrade their refrigeration equipment. Participation in the program includes both prescriptive and custom projects. The evaluation team’s review of projects in the program resulted in a realization rate of 90%. For prescriptive projects, the evaluation team determined that RTF deemed savings values were being appropriately applied in most cases. However, low project-level realization rates for custom projects, which tend to be larger in size than prescriptive projects, are driving the program realization rate downward.

> **Recommendation**: Avista should consider more internal review of energy savings estimates submitted by vendors for custom projects under this program. Alternatively, Avista could consider tracking custom projects under the Site Specific program with other projects of similar size and complexity.

Conclusion: Avista reported 2014-2015 participation in six other prescriptive programs. Of these, the HVAC Motor Controls program is the largest, constituting 65% of the energy savings for this group. The evaluation team's review of projects in these programs resulted in a 54% realization rate. Cases of ineligible VFD projects receiving incentives were cause of the low realization rate for these programs.

> **Recommendation**: Avista should revise the HVAC Motor Controls program to include more verification of motor eligibility status. More emphasis should be placed on confirming motor application and duty status to ensure compliance with the program's existing eligibility requirements. More specifically, Avista should place specific emphasis on ensuring VFDs are installed in a manner that saves energy (i.e. not just as "soft starters") and that incentivized VFDs serve primary-duty motors.

Conclusion: The Small Business reported savings for faucet aerators were found to be conservatively low based upon the evaluation team's secondary research. The realization rates for faucet aerators were 126% for electric savings and 204% for natural gas savings.

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

1.3.2 Residential Programs

The overall realization rate for the residential portfolio is 109%. The realization rates varied significantly across the various programs evaluated with the Shell and Fuel Efficiency programs having the lowest realization rate (60% and 62% respectively). The evaluation team found that the reported savings for the majority of the programs were understating the actual impacts found from the evaluation activities. The following subsections outline specific conclusions and recommendations for several of the residential programs.

Conclusion: The evaluation team found that the reported deemed savings value (per recycled unit) for the program was lower than estimated gross savings valued from prior studies. Avista may have aligned their deemed savings values close to the RTF deemed savings values, but it is important to understand that the RTF is reporting a value that accounts for net market effects (i.e. free ridership).

> **Recommendation**: If Avista choses to offer an appliance recycling program in the future, it is recommended that a clear distinction between gross and net savings values is noted if Avista reports the most current RTF values.

Conclusion: The evaluation team found, through billing regression analysis, a relatively low realization rate for the Air Source Heat Pump (ASHP) measures (RR of 49%).

> **Recommendation:** The evaluation team recommends Avista reexamine the assumptions relating to annual per-home consumption and savings estimates in homes receiving ASHP installations. In addition, to help better understand the baseline for the ASHP replacement, Avista could consider requesting that contractors and customers provide a better description of the replaced unit

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

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

Conclusion: The evaluation team conducted a billing regression analysis for the Fuel Efficiency participants and found realization rates of 60-70% for rebate projects that included the conversion of a home's heating system from electricity to natural gas. When regression coefficients were examined in detail, the evaluation team noted that the estimated reduction in electric heating load was being offset by an increase in estimated base load within participating homes.

> **Recommendation**: Because the rebate amounts and per-home savings from Fuel Efficiency are so large and the number of participants is relatively low, the evaluation team recommends Avista ask participating customers for details on any additional home renovations that were completed in parallel with the fuel conversion. Home improvement projects such as an addition, finishing a basement, or adding air conditioning can drastically change the consumption patterns within a home and render the assumed baseline inaccurate.

Conclusion: The evaluation team found that over half the homes receiving Fuel Efficiency rebates in 2014-2015 did not have a gas billing history with Avista prior to the conversion. These homes realized savings at a higher rate than homes that did have previous gas service.

> **Recommendation**: The evaluation team recommends that Avista consider adding a field to the program tracking database that indicates the gas meter installation date or service start date of participating homes. This would more clearly delineate homes that were previously all electric and became dual-fuel around the same time as the Fuel Efficiency project, from homes that had been dual-fuel historically. Avista may also want to consider assuming a more conservative electric savings estimate for homes that had prior gas service because it's possible that the home was not 100% electrically heated prior to program participation.

Conclusion: Avista's deemed savings estimates, which were generally the same for all similar product types and not correlated to the bulb wattage, understated the savings found by the evaluation team. This was especially the case for Avista's CFL giveaway program.

> **Recommendation:** The evaluation team recommends that Avsita consider more detailed product type deemed values in an effort to be more closely aligned with the actual participating lamps. Simple Steps has shifted its program tracking to specific product types by lumen bins in accordance with the most current BPA UES measure list.

Avista should consider using these higher resolution deemed values for internal reporting with the Simple Steps program and for use with internal residential lighting programs.

Recommendation: An overarching recommendation related to the Residential Lighting, is that Avista monitor the LED lamp market for technology cost changes and customer preferences, and consider increasing LED lamp options from the 2014-2015 portfolio in future DSM planning. Currently, LED prices are dramatically decreasing and customer preferences are shifting from CFL to LEDs as a preferred choice as an energy efficient technology. Consequently, CFLs shelf space share is declining as an abandoned technology, despite its better cost effectiveness compared to LED lamps.

Conclusion: The evaluation team found a low realization rate (38%) for shell rebate measures (windows and insulation). This finding indicates that reported savings values were too aggressive on average. The evaluation team compared the end-use shares estimated via regression analysis and found that only approximately 5,500 of the 13,000 kWh of average annual consumption in residential homes in Avista's service territory was assigned to heating and cooling load. Given this end-use share, the reported savings values claimed by Avista equate to a 25% reduction in HVAC loads.

Recommendation: The evaluation team recommends Avista examine planning assumptions about per-home consumption, end-use load shares, and percent reductions in heating and cooling loads from shell improvements. It may be that the percent reduction assumptions are sound, but they are being applied to an overstated assumption of the average electric HVAC consumption per home. Conversely, the assumed end-use shares may be accurate, but the end-use reduction percentage is inflated. This investigation should be conducted separately for electrically heated homes and dual fuel homes as the heating electric end-use share will be different.

Conclusion: The evaluation team found that savings held fairly consistent during the 6 month interruption in Home Energy Report delivery. The finding reinforces Avista's decision to assume a multi-year measure life when calculating the cost-effectiveness of the Opower program.

Recommendation: The evaluation team recommends Avista examine the program delivery model in the 2016-2017 cycle. Given the fixed and volumetric nature of program costs, measure life assumptions, and mechanisms by which measured savings are counted toward goal achievement the evaluation team believes there are alternatives to the traditional delivery model that optimize program achievements relative to costs.

Conclusion: The evaluation team found a high realization rate for the fuel conversion measures implemented through the Low Income program. One reason for the high realization rate could be due to the fact that Avista caps the reported savings value to 20% of the contractor estimated savings. In addition, the evaluation team found that the verified savings for these fuel conversion measures aligned closely with the verified savings found through the regular-income Fuel Conversion program.

> **Recommendation:** The evaluation team recommends re-evaluating the current savings cap for fuel conversion projects. In addition, we recommend that Avista align assumptions for fuel switching savings for the Low Income and Fuel Efficiency programs.

2 Introduction

2.1 Purpose of Evaluation

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

2.2 Program Summary

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

2.2.1 Nonresidential

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

2.2.1.1 Site Specific

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

Customers or their representative are required to contact Avista for a Site Specific analysis prior to any equipment being purchased or installed. Based on the post-verification process, incentives may not be offered after the installation of energy efficiency equipment or process under this program design. Table 2-1 shows the incentive levels associated with designated ranges of project simple payback periods. To be eligible for incentive, lighting measures must have a simple payback period less than 8 years and all other measures must have a simple payback period less than 13 years. Simple payback is calculated as the incremental cost of a measure divided by the annual energy savings of the measure, calculated using the customer's Avista electric and/or gas rate. Incremental costs are only those projects costs necessary for the energy efficiency improvement.

Table 2-1: Site Specific Program Measures

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

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

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

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

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

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

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

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

2.2.1.2 Prescriptive Lighting

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

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

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

Table 2-2: Prescriptive Lighting Program Measures

Measure	$ Incentive/ Unit
250 watt HID Fixture to 4-Lamp High Performance (HP) T8 Fixture HO or 2-Lamp T5HO Fixture	$ 90
250 watt HID Fixture to 4-Lamp HP T8 Fixture HO or 2-Lamp T5HO 5-foot Fixture with occupancy sensor	$120
400 watt HID Fixture to 4-Lamp T5 Fixture	$120
400 watt HID Fixture to 4-Lamp T5 Fixture with oc sensor	$150
400 watt HID Fixture to 6-Lamp HP T8 Fixture	$120
400 watt HID Fixture to 6-Lamp HP T8 with oc sensor	$150
400 watt HID Fixture to 8-Lamp HP T8 Fixture (4-Foot Lamps)	$125
400 watt HID Fixture to 8-Lamp HP T8 Fixture (4-Foot Lamps) with oc sensor	$155
40 watt Incandescent to 6-10 watt LED*	$10
60 watt Incandescent to 9-13 watt LED*	$12
75-100 watt Incandescent to 12-20 watt LED*	$15
Over 150 watt Incandescent to 2L HP F32T8 Fixture	$40
20 watt MR16 (GU10 Base) to MR16 LED* 2-4 watt	$10
35 watt MR16 (GU10 Base) to MR16 LED* 4-6 watt	$11
50 watt MR16 (GU10 Base) to MR16 LED* 6-9 watt	$12
75-100 watt Incandescent to LED* Can Light Kit	$30
Fixture with no occupancy sensor to build in to with relays for room control (no switch sensors)	$30
4-Foot 4-Lamp T12/8 to 4-Foot 3-Lamp HP T8 Ballast with 25 or 28 watt Lamps	$32
4-Foot 4-Lamp T12/8 to 4-Foot 2-Lamp HP T8 Ballast with 25 or 28 watt Lamps	$35
4-Foot 3-Lamp T12/8 to 2X4 LED* Fixture	$60
4-Foot 3-Lamp T12/8 to 4-Foot 2-Lamp HP T8 Ballast with 25-28 watt Lamps	$15
4-Foot 2-Lamp T12/8 to 4-Foot 1-Lamp HP T8 Ballast with 25-28 watt Lamps	$13
4-Foot 1-Lamp T12/8 to 1-Lamp HP T8 Ballast with 25-28 watt Lamps	$13
8-Foot 4-Lamp T12/8 to 8-Foot 4-Lamp (8') or 8-Lamp (4') HP T8 Ballast with 25 or 28 watt Lamps	$54
8-Foot 2-Lamp T12/8 to LED* 2X4 Fixture	$80
8-Foot 1-Lamp T12/8 to LED* 1X4 Fixture	$40
T12 Sign Lighting to LED Retrofit	$17 / FT²
Exterior-1000 watt HID to 400-575 watt DHID	$225
Exterior-400 watt HID to 250 watt DHD MH	$150
Exterior-400 watt HID to 122-175 watt LED*	$255
Exterior-320 watt to 122-160 watt LED*	$180

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

2.2.1.3 EnergySmart Grocer

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

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

Table 2-3: EnergySmart Program Measures

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

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

2.2.1.4 Food Service Equipment

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

Table 2-4: Food Service Equipment Program Measures

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

2.2.1.5 Green Motor Rewind

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

Table 2-5: Green Motor Rewinds Program Measures

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

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2.2.1.6 Commercial HVAC Variable Frequency Drive (VFD) Program

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

Table 2-6: Motor Controls HVAC Program Measures

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

2.2.1.7 Commercial Clothes Washers

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

Table 2-7: Motor Controls HVAC Program Measures

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

2.2.1.8 Power Management for Personal Computer Networks

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

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

Measure	Incentive
PC Power Management Software	$5 / license

2.2.1.9 Commercial Windows & Insulation

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

Table 2-9: Commercial Windows & Insulation Measures

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

2.2.1.10 Commercial Water Heaters

The Commercial Water Heaters program provides incentive to electric (Schedule 11, 12, 21, 25) or natural gas (Schedule 101, 111, 121) customers for the purchase and installation of an energy efficient commercial water heater. Water heaters must be commercial grade units and must be served by an Avista fuel source. An incentive of $20 per unit is provided for qualified water heaters. Water heater eligibility guidelines are outlined in Table 2-10. Avista implements this program in a prescriptive manner, and incentives are issued to the participating customer after the measure is installed.

Table 2-10: Commercial Water Heater Measures

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

2.2.1.11 Standby Generator Block Heater

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

Table 2-11: Fleet Heat Measures

Measure	Incentive
Standby Generator Block Heater	$400 / unit

2.2.2 Small Business

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

Direct-install measures include faucet aerators, showerheads, pre-rinse spray valves, screw-in LEDs, smart strips, CoolerMisers, and VendingMisers (Table 2-12). The evaluation team conducted onsite verification, documentation audits, and engineering analysis to determine verified gross savings for each measure in the program.

Table 2-12: Small Business Program Measure Overview

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

2.2.3 Residential

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

Throughout 2014 and 2015, Avista provided incentives and services for its residential electric and gas customers in its Washington service territory and for residential electric customers throughout its Idaho service territory. The evaluation team examined nine core programs in Washington that constituted the bulk of Avista's residential energy-efficiency offerings in 2014 and 2015. Table 2-13 provides a summary of those programs, and the sections below detail each program.

Table 2-13: Residential Program Type and Description

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

2.2.3.1 Appliance Recycling

The appliance recycling program, administered by JACO Environmental Inc, provided a pick-up and recycling service for operational refrigerators or freezers manufactured before 1995. JACO provided the pick-up service free to customers and the $30 rebate was provided for each operational refrigerator and/or freezer, up to two per household (Table 2-14). JACO provided the following data points to Avista on a monthly basis: date of pick-up, customer name, address, city state zip, type of unit collected and number of units collected. The appliance recycling program ceased operation in June 2015 as a result of revised RTF values that became effective in July of 2015 causing the program to cease to be cost-effective.

Table 2-14 Appliance Recycling Measures and Incentives

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

2.2.3.2 HVAC Program

Avista internally manages the HVAC program which encourages the implementation of high efficiency HVAC equipment and smart thermostats through direct incentives issued to the customer after the measure has been installed (Table 2-15). This program is available to all residential electric or natural gas customers with a winter heating season usage of 4,000 or more kilowatt hours, or at least 160 therms of space heating the prior year. Existing or new construction homes are eligible.

Table 2-15 HVAC Measure Overview

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

2.2.3.3 Water Heat

Customers replacing their existing electric or natural gas water heater are eligible to receive a rebate for selecting a high efficiency option. This program also includes discounted showerheads available at participating retailers throughout Avista’s WA and ID service territory under the Simple Steps, Smart Savings program. In 2014 this program included direct installs of low-flow showerheads implemented by UCONS. Table 2-16 outlines the measures offered and rebate per unit.

Table 2-16 Water Heat Program Measure Overview

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

2.2.3.4 ENERGY STAR® Homes

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

Table 2-17 describes eligible measures available for the program.

Table 2-17 ENERGY STAR® Homes Measure Overview

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

2.2.3.5 Fuel Efficiency Program

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

Table 2-18 Fuel Efficiency Measure Overview

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

2.2.3.6 Residential Lighting

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

2.2.3.7 Shell Program

Avista's internally managed shell program incentivizes measures that improve the integrity of the home's envelope (Table 2-19). For insulation and windows: rebates are issued to the customer after measure has been installed. Eligibility guidelines for participation include but may not be limited to: confirmation of electric or natural gas heating usage, itemized invoices including insulation levels or window values and square footage. Pre and/or post-inspection of insulation and windows may occur as necessary throughout the year. Customer must demonstrate a winter heating season electricity usage of 4,000 kilowatt hours or 160 therms to be eligible for insulation and window program participation. Addition of insulation that increases the R-value by R-10 or greater for both fitted/batt type and blow-in products are eligible. Windows with a U-factor of 0.30 or less that replace single or double pane windows are eligible. In 2014, this program included free manufactured home duct-sealing component implemented by UCONS. The manufactured home duct sealing component was conducted in partnership with the Community Energy Efficiency Program funded by WSU-Energy.

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

Table 2-19 Shell Measure Overview

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

2.2.3.8 Home Energy Reports

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

2.2.3.9 Low Income

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

Six CAP agencies serve Avista's Washington service territory and receive a total annual funding about of $2 million (Table 2-20). 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 2-20 Low Income CAP Agencies

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

Avista provides CAP agencies with an "approved measure list", the items on this list are reimbursed 100% (Table 2-21). Avista also provides a "rebate list" of additional energy saving measures the CAP agencies are able to utilize (Table 2-22).

Table 2-21 Low Income Approved Measure List (100% of costs offset by Avista)

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

Table 2-22 Low Income Rebate List

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

2.3 Program Participation Summary

Reported participation and savings for Avista's 2014 and 2015 programs is outlined in Table 2-23 and Table 2-24.

Table 2-23 Avista Nonresidential Reported Participation and Savings

Program	2014-2015 Project Count	2014-2015 Reported Savings (kWh)
EnergySmart Grocer	155	3,512,149
Food Service Equipment	52	214,937
Green Motors	5	25,607
Motor Controls HVAC	18	1,374,268
Commercial Water Heaters	2	138
Prescriptive Lighting	689	8,145,753
Prescriptive Shell	49	494,230
Fleet Heat	4	8,668
Site Specific	286	22,236,575
Small Business	2,354	1,030,975
TOTAL	**3,614**	**37,043,300**

Table 2-24 Avista Residential Reported Participation and Savings

Program	2014-2015 Participation Count	2014-2015 Reported Savings (kWh)
Appliance Recycling	1,335	822,810
HVAC	5,019	1,598,690
Water Heat*	8,589	833,720
ENERGY STAR Homes	28	176,470
Fuel Efficiency	613	7,165,449
Lighting**	1,122,011	19,606,228
Shell	4,016	5,657,633
Opower***	37,703	6,115,000
Low Income****	10,985	885,598
TOTAL		**42,861,597**

*Includes counts for both projects and showerheads
**Denotes bulb count and includes Simple Steps, UCONS and Giveaway
***Number of participants in the Treatment in January, 2015
****Includes both projects and counts of bulbs

2.4 Evaluation Goals and Objectives

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

> *Evaluation is the process of determining and documenting the results, benefits, and lessons learned from an energy-efficiency program. Evaluation results can be used in planning future programs and determining the value and potential of a portfolio of energy-efficiency programs in an integrated resource planning process. It can also be used in retrospectively determining the performance (and resulting payments, incentives, or penalties) of contractors and administrators responsible for implementing efficiency programs.*
>
> *Evaluation has two key objectives:*
>
> *1. To document and measure the effects of a program and determine whether it met its goals with respect to being a reliable energy resource.*
>
> *2. To help understand why those effects occurred and identify ways to improve.*

Avista has identified the following objectives for the evaluation:

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

3 Impact Evaluation Methodology

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

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

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

3.1 Understanding the Program Context

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

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

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

3.2 Designing the Sample

Sample development enabled the evaluation team to deliver meaningful, defensible results to Avista. The sampling methodology used for the impact evaluation was guided by a value of information (VOI) framework, which allowed the team to target activities and respondents with expected high impact and yield, while representing the entire population of interest. In general, VOI focuses budgets and rigor towards the programs/projects with high uncertainty and high impact[3].

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

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

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

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

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

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

Table 3-1 and Table 3-2 show the anticipated confidence/precision level, planned sample sizes, and level of rigor, by program, for the Washington/Idaho electric residential and nonresidential portfolios. The samples are drawn to meet the specified confidence/precision for each program and to meet 90% confidence and 10% precision at the portfolio level[4]. Because programs do not differ between the Washington and Idaho service 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.

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

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

Table 3-1: Planned Sampling and Evaluation Rigor for Washington/Idaho Electric Residential Programs

Electric Residential Program	Target C/P	Document Audit	Surveys	Onsite Inspections	Billing Analysis
Residential Appliance Recycling	90/10		70		
HVAC Program	90/10	67	67		
Water Heat Program[1]	80/20	11	11		
ENERGY STAR Homes	85/15	15	15		census
Fuel Efficiency	85/15	24	24		census
Residential Lighting Program[2]	90/10			70[3]	
Shell Program	85/15	24	24		census
Opower Behavioral Program	census				census
Low Income	85/15	24			census
TOTAL		**165**	**211**	**70**	

[1]Includes Simple Steps, Smart Savings upstream showerhead component
[2]Includes Simple Steps, Smart Savings upstream lighting program and CFL giveaway events
[3]Denotes sample size for residential lighting program logger study

Table 3-2: Sampling and Evaluation Rigor for Washington/Idaho Electric Nonresidential Programs

Electric Nonresidential Program	Target C/P	Document Audit	Surveys	Onsite Inspections	Billing Analysis
Prescriptive Lighting	90/10	68	16	16	
Prescriptive EnergySmart Grocer	95/15	44	15	15	
Prescriptive Non-Lighting Other	90/15	24	9	9	
Cascade Energy Pilot	80/20	5	5		
Site Specific	90/10	84	84	84	based on IPMVP[5]
Small Business	90/15	31	31	31	
TOTAL		**225**	**129**	**124**	

For the purposes of the evaluation sampling, the evaluation team has bundled the following nonresidential electric programs into one program titled "Prescriptive Non-Lighting":

-

[5] International Performance Measurement and Verification Protocol

- Food Service Equipment
- Green Motors Rewind
- HVAC Variable Frequency Drive
- Clothes Washers
- Power Management for PC Networks
- Windows & Insulation
- Standby Generator Block Heater

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

Electric Residential Program	Achieved C/P	Document Audit	Surveys	Onsite Inspections
Residential Appliance Recycling	N/A	70	72	
HVAC Program	90/31	68	68	
Water Heat Program[1]	90/13	24	13	
ENERGY STAR Homes	90/14	19	16	
Fuel Efficiency	90/7	26	25	
Residential Lighting Program[2]	90/15.3			75
Shell Program	90/33	28	28	
Opower Behavioral Program	90/8			
Low Income	90/13	24		
TOTAL	**90/9**	**259**	**222**	**75**

Table 3-4: Achieved Sampling and Evaluation Rigor for Washington/Idaho Electric Nonresidential Programs

Electric Nonresidential Program	Achieved C/P	Document Audit	Surveys	Onsite Inspections
Prescriptive Lighting	90/13	68	22	22
Prescriptive EnergySmart Grocer	95/14	44	20	20
Prescriptive Non-Lighting Other	90/228	24	15	15
Site Specific	90/7	101	84	84
TOTAL	**90/7**	**237**	**141**	**141**
Small Business	90/25	31		31
TOTAL INCLUDING SMALL BUSINESS:		**268**	**141**	**172**

3.3 Database Review

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

3.4 Verifying the Sample – Gross Verified Savings

The next step in the impact evaluation process was to determine the gross impacts, which are the energy savings that are found at a customer site as the direct result of a program's operation; net impacts are the result of customer and market behavior that can add to or subtract from a program's direct results.

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

Total program gross savings were adjusted using the following equation:

$$kWh_{adj} = kWh_{rep} \cdot Realization\,Rate$$

Where:

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

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

3.4.1 Document Audit

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

- Were the data files of the sampled projects complete, well documented, and adequate for calculating and reporting the savings?

- Were the calculation methods correctly applied, appropriate, and accurate?
- Were all the necessary fields properly populated?

3.4.2 Telephone Survey

A second level of evaluation rigor was through stand-alone telephone surveys with program participants. Telephone surveys were conducted in conjunction with the process evaluation activities and were used to gather information on the energy-efficiency measure implemented, the key parameters needed to verify the assumptions used 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 built from the document-audit task discussed earlier. For all onsite inspections, a telephone survey served as an introduction to the evaluation activities and was used to confirm that the customer participated in the program, to confirm the appropriate contact, and to verify basic information such as building type and building size. All onsite activities were conducted by evaluation team field engineers.

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

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

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

Normalized Savings =

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

The broad categories of the IPMVP are as follows:

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

- Option 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.

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

3.4.4 Billing Analysis

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

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

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

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

In addition to program participation records and customer billing histories, the evaluation team collected daily temperature records and normal weather conditions (TMY3) from three weather stations located in Avista's service territory. Observed temperature records were used to calculate the number of heating degree days (HDD) 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 of the March 2016 timing of billing data collection, homes who implemented the fuel conversion measure in the summer of 2015 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 3-5 defines the terms and coefficients shown in the two equations that follow. Equation 3-1 shows the general regression model specification used for electric measures, Equation 3-2 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 3-1: Regression Model Specification for Electric Measures

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

Equation 3-2: Regression Model Specification for Gas Measures

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

Table 3-5: 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
$\beta_{1\text{-}5}$	Coefficients determined via regression describing impacts associated with independent variables
ϵ_{it}	Customer-level random error

The model specifications shown in Table 3-5 defines the terms and coefficients shown in the two equations that follow. Equation 3-1 shows the general regression model specification used for electric measures, Equation 3-2 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 3-1 and Equation 3-2 were used to determine the coefficients describing the relationship between consumption and weather. That relationship was then applied to normal weather conditions to estimate average annual consumption in the pre-installation and post-installation periods to calculate weather normalized savings.

The evaluation team used a multi-faceted approach to estimate savings for many of Avista's programs. The evaluation team used the fixed-effects regression models summarized above, together with a pooled approach, which combined all participants and billing periods into a single regression analysis to estimate weather normalized savings at the program or measure level. In some cases, the team then ran individual customer regressions to obtain weather normalized savings estimates for each customer, allowing for a more granular assessment of how savings magnitudes were distributed across the program or measure population. In addition, for measures with relatively small impact estimates, we included a control group constructed from homes in the Opower program, to achieve a more stable baseline comparison. For these measures, estimates were based on a difference-in-differences regression analysis of billing data from customers in the treatment and comparison groups.

4 Nonresidential Impact Evaluation

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

4.1 Overview

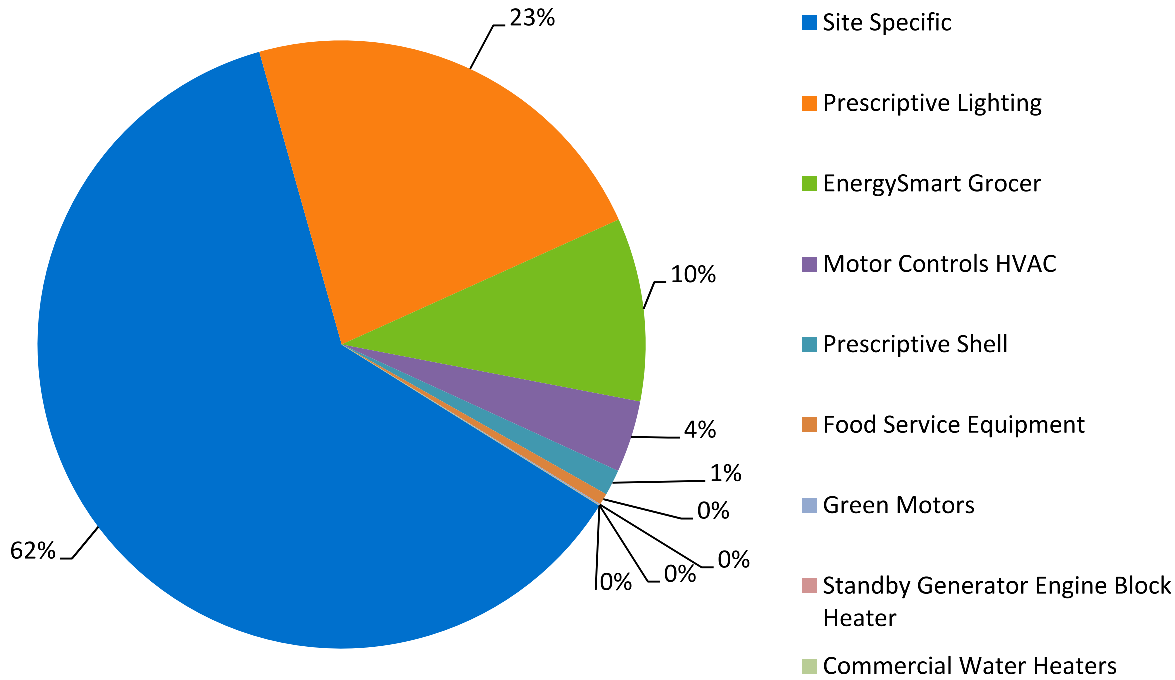
Avista offered 13 nonresidential programs in their Washington service territory in 2014 and 2015, plus the Small Business program which is described in Section 5. The reported savings for the 13 nonresidential programs are summarized in Table 4-1.

Table 4-1: Nonresidential Program Reported Savings

Washington Electric Nonresidential Program	2014-2015 Reported Savings (kWh)
EnergySmart Grocer	3,512,149
Food Service Equipment	214,937
Green Motors	25,607
Motor Controls HVAC	1,374,268
Commercial Water Heaters	138
Commercial Clothes Washers	--
Prescriptive Lighting	8,145,753
Power Mgmt for PC Networks	--
Prescriptive Shell	494,230
Standby Generator Block Heater	8,668
AirGuardian	--
Site Specific	22,236,575
Cascade Strategic Energy Management	--
TOTAL NONRESIDENTIAL	**36,012,324**

No participation was reported in four programs; Commercial Clothes Washers, Power Management for PC Networks, AirGuardian, and Cascade Strategic Energy Management. The Site Specific program contributes the largest share of the reported savings, 62% as shown in Figure 4-1. Prescriptive Lighting is the next largest contributor at 23%.

Figure 4-1: Nonresidential Program Reported Energy Savings Shares



The evaluation team designed a sampling strategy for these programs placing the most emphasis on the Site Specific program because of its large share of savings. The Site Specific program was divided into two strata based on reported savings. As part of the evaluation activities, a total of 237 document audits were conducted, and onsite inspections were conducted on a sub-sample of 141 projects, as shown in Table 4-2. Engineering activities included review of savings calculation methodology and assumptions, verification of operating hours through participant surveys and included use of data loggers in some cases, utility bill analysis, review of energy management system trend data, and energy savings analysis.

Table 4-2: Nonresidential Program Achieved Evaluation Sample

Program/Group	Achieved C/P	Document Audit	Survey	OnSite Inspections
Prescriptive Lighting	90/13	68	22	22
EnergySmart Grocer	90/14	44	20	20
Prescriptive Non-Lighting Other	90/228	24	15	15
Site Specific Large (> 275,000 kWh)	90/7	17	17	17
Site Specific Small (< 275,000 kWh)		84	67	67
TOTAL	**90/7**	**237**	**141**	**141**

4.2 Prescriptive Lighting

4.2.1 Overview

The Prescriptive Lighting program encourages commercial customers and vendors to make lighting improvements to their businesses. The program provides many common retrofits to receive a pre-determined incentive based on baseline and replacement lamp wattages. The program is internally implemented by Avista.

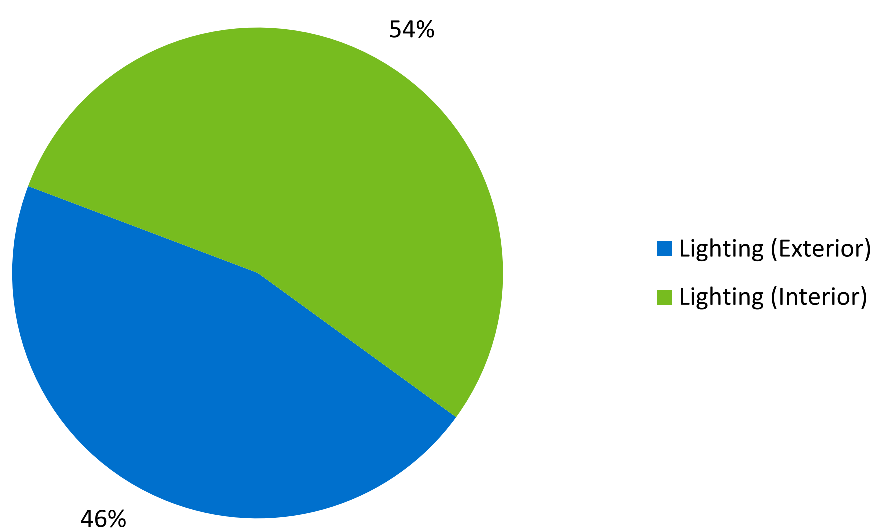
4.2.2 Program Achievements and Participation Summary

A total of 669 prescriptive lighting projects at 528 unique premises were installed in Washington across the 2014 and 2015 program years. Table 4-3 and Figure 4-2 summarize Avista's 2014-2015 Prescriptive Lighting Program energy impacts by measure.

Table 4-3: Prescriptive Lighting Reported Energy Savings by Measure

Measure Type	Energy Savings (kWh)	% Electric Savings
Lighting (Exterior)	3,727,387	46%
Lighting (Interior)	4,418,366	54%
Total	**8,145,753**	**100%**

Figure 4-2: Prescriptive Lighting Reported Energy Savings Shares



4.2.3 Methodology

The impact evaluation for this program followed the RTF's Nonresidential Lighting Retrofit Standard Protocol, IPMVP Option A (Retrofit Isolation: Key Parameter Measurement), and DOE Uniform Methods Commercial and Industrial Lighting Evaluation Protocol[7]. Engineering activities

[7] http://energy.gov/sites/prod/files/2013/11/f5/53827-2.pdf

included installation verification, determination of operational hours including spot-metering in for a sub-sample of projects, and engineering savings calculations.

4.2.3.1 Sampling

The evaluation team conducted document audits for 68 projects. Customer surveys and onsite inspections were completed on a sub-sample of 22 of these projects (Table 4-4). Because of the installation of multiple projects at some sites, the achieved sample size for onsite inspections and surveys was slightly higher than the original sample design of 16 surveys and onsite inspections as noted in Table 3-2.

Table 4-4: Prescriptive Lighting Achieved Sample

Program	Document Audit	Survey	OnSite Inspections
Prescriptive Lighting	68	22	22

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

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

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

Table 4-5: Prescriptive Lighting Onsite Data Collection

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

Where feasible and appropriate, the evaluation team also used standalone data loggers to minimize uncertainty in the estimation of lighting operating hours. Evaluation team engineers installed HOBO® U9-002 light on/off loggers for a minimum of four months. This collected measured data was supplemented by lighting operating characterization as determined through onsite interviews and surveys of control strategies (dimmers, timers, etc.) to inform the balance of the yearly operating hours.

The data collected over the logging duration was tabulated per hour per week to create an average weekly operation schedule for each measured space with energy efficiency measures. The weekly hourly profile includes 24 hours of each of eight distinct day types (Sunday, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, and holiday). Annual operating hours were created by extrapolating measured values to a calendar year, adjusted as needed per the interviews with onsite personnel.

4.2.3.4 Impact Analysis Methods

To calculate the gross verified energy savings of a lighting retrofit, the evaluation utilized the calculation outlined in Equation 4-1:

Equation 4-1: Prescriptive Lighting Energy Savings Calculation

$$\Delta kWh = \left(\#\, fixtures_{base} * kW_{base} - \#\, fixtures_{retrofit} * kW_{retrofit}\right) * \ Hours * IF$$

Where:

$\# \, fixtures_{base \, or \, retrofit}$ = Quantity of fixtures installed in baseline or retrofit of a project

Hours = Annual hours of fixture operation

IF = the ratio of heating and cooling electricity reduction per unit of lighting energy reduction resulting from the reduction in lighting waste heat removed by an electric HVAC system

Equation 4-1 is based on per fixture energy savings as calculated in Equation 4-2 and Equation 4-3:

Equation 4-2: Prescriptive Lighting Base Case Demand Savings Calculation

$$kW_{base} = \frac{\# \, lamps_{base} * \, Watts_{base} * BF_{base}}{1000}$$

Equation 4-3: Prescriptive Retrofit Case Demand Savings Calculation

$$kW_{retrofit} = \frac{\# \, lamps_{retrofit} * \, Watts_{retrofit} * BF_{retrofit}}{1000}$$

Where:

$\# \, lamps_{base \, or \, retrofit}$ = Quantity of lamps installed in a baseline or retrofit fixture

$Watts_{base \, or \, retrofit}$ = Wattage of baseline or retrofit lamp

$BF_{base \, or \, retrofit}$ = Ballast factor of baseline or retrofit light fixture

The analysis utilized a T8 baseline for linear fluorescent replacements, since T12 lamps are no longer compliant under federal regulations (EISA 2007 and EPact 2005).

Interactive Equipment Energy Changes for Lighting Retrofits

The energy consumption of lighting equipment within an enclosed space is not viewed in isolation. Building systems interact with one another and a change in one system will often affect the energy consumption of another. This interaction is important to consider when calculating the benefits provided by lighting equipment because it adopts a comprehensive view of premise-level energy changes rather than limiting the analysis to the energy change directly related to the modified equipment. The evaluation team utilized the interactive factors designated in the RTF's Non-residential Lighting Retrofits protocol[8] and included in Appendix B. Engineers gathered heating and cooling system types serving each space affected by a lighting retrofit project during the site visit in order to appropriately apply the RTF's factors. For desk reviews without an accompanying site visit, the evaluation team assumed electric cooling with gas heating in absence of better information.

[8] http://rtf.nwcouncil.org/measures/measure.asp?id=213

4.2.4 Findings and Recommendations

The data collected as a result of the desk reviews and onsite data measurement and verification activities were utilized to estimate the gross verified savings. The evaluation team's gross verified savings values for the sample of reviewed projects were very close to Avista's reported values, resulting in realization rates near 100% for both measures. Individual project realization rates varied both above and below 100% due to differences in operating hours, baseline and retrofit fixture wattage, and application of interactive effects; these differences averaged out to realization rates near 100%. Table 4-6 summarizes the findings of the realization rate for energy benefits for each measure in the Prescriptive Lighting program.

Table 4-6: Prescriptive Lighting Realization Rate Results

Measure	Sample Unique Projects	Realization Rate	Relative Precision (90% Confidence)
Lighting (Exterior)	36	104%	N/A
Lighting (Interior)	32	97%	
Total	68	99%	13%

The baseline fixture types for the projects in the evaluated sample for Interior Lighting are summarized in Table 4-7. Projects with multiple fixture types are counted multiple times. The majority of evaluated projects were retrofits of incandescent and HID technologies. Linear fluorescent participation was low, only 4 projects in the evaluation sample.

Table 4-7: Baseline Fixture Types for Prescriptive Lighting (Interior)

Baseline Fixture Type	Project Count
T8	1[1]
T12[2]	3
HID	11
Incandescent	21
Halogen	2
Sensor only project	1

[1]Baseline fixture type may have been T12. Project documentation does not specify. All T12s are analyzes using an analogous T8 baseline.

[2]Both Avista and the evaluation team estimated savings for these projects using the analogous T8 technology as the baseline.

Table 4-8 shows the total gross verified savings for the Prescriptive Lighting program.

Table 4-8: Prescriptive Lighting Gross Verified Savings

Program	Reported Savings (kWh)	Energy Realization Rate	Gross Verified Savings (kWh)
Prescriptive Lighting	8,145,753	99%	8,046,872

4.3 Prescriptive EnergySmart Grocer

4.3.1 Overview

The EnergySmart 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. Energy savings are primarily achieved through installation of high efficiency case lighting and other refrigeration system efficiency improvements. Some custom projects identified by CLEAResult are also included in the EnergySmart Grocer program.

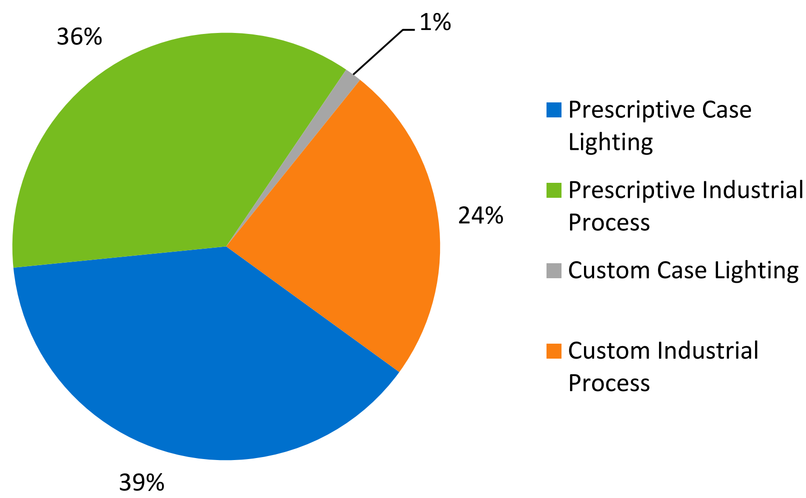
4.3.2 Program Achievements and Participation Summary

A total of 170 unique Prescriptive EnergySmart Grocer measures were installed at 94 premises in Washington in 2014 and 2015. Table 4-9 and Figure 4-3 summarize Avista's 2014-2015 EnergySmart Grocer Program energy impacts by measure. Avista tracks all non-Case Lighting measures as 'Industrial Process', both prescriptive and custom. Examples include ECMs in display cases, floating head pressure controls, etc.

Table 4-9: EnergySmart Grocer Reported Energy Savings by Measure

Measure Type	Energy Savings (kWh)	% Electric Savings
Prescriptive Case Lighting	1,349,424	38%
Prescriptive Industrial Process	1,266,368	36%
Custom Case Lighting	45,054	1%
Custom Industrial Process	851,303	24%
Total	**3,512,149**	**100%**

Figure 4-3: EnergySmart Grocer Reported Energy Savings Shares



4.3.3 Methodology

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

4.3.3.1 Sampling Approach

The evaluation team conducted document audits on 44 projects implemented through the EnergySmart Grocer program. Surveys and onsite inspections were conducted for a sub-sample of 20 of these projects (Table 4-10). Because of the installation of multiple projects at some sites, the achieved sample size for onsite inspections and surveys was slightly higher than the original sample design of 15 surveys and onsite inspections as noted in Table 3-2.

Table 4-10: EnergySmart Grocer Achieved Sample

Program	Document Audit	Survey	OnSite Inspections
EnergySmart Grocer	44	20	20

4.3.3.2 Document Audits

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

4.3.3.3 Field Inspections

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

Table 4-11 summarizes the information that was collected for each project during the onsite inspection. All parameters needed to support the savings analysis of a project were collected, including fixture counts, baseline and post-retrofit wattages, hours of operation, and HVAC system information to inform calculation of interactive effects.

Table 4-11: EnergySmart Grocer Onsite Data Collection

End Use Category	Baseline	Retrofit
All Facilities	Business Type Operating Hours, posted or otherwise Total conditioned square footage Heating system type/age/efficiency/size/condition Cooling system type/age/efficiency/size/condition	
Case Lighting	Case Temperature Lamp Type (e.g., T8, T12) Ballast Type (mag. or elec.) Lamp Size (linear ft.) Quantity of Lamps per Fixture Wattage per Lamp Fixture Quantity Operating Hours Control Type	Case Temperature Lamp Type Confirm Electronic Ballast and Factor Lamp Size (linear ft.) Quantity of Lamps per Fixture Wattage per Lamp Fixture Quantity Operating Hours Control Type Confirm ENERGY STAR© rating
Industrial Process	Type of Equipment (e.g., open reach-in refrigerated case, closed freezer) Operating Temperatures Capacity Efficiency Operating Hours Other Parameters (e.g., motor kW or hp, linear feet of gaskets, thickness of suction line insulation)	Type of Equipment Operating Temperatures Capacity Efficiency Operating Hours Other Parameters

4.3.3.4 Impact Analysis Methods

The evaluation team applied deemed energy savings values as published by the Regional Technical Forum (RTF) where appropriate. Custom analyses were generated for measures not listed with the RTF.

Active RTF-listed Measures

A majority of the measures installed under the EnergySmart Grocer program are active measures with deemed energy savings values published by the RTF. For these measures, the evaluation team reviewed the relevant RTF workbooks[9] and the reported measure savings, verifying eligibility and appropriate application of RTF savings values for each project in the sample.

Non-RTF Measures

For measures not listed with the RTF, the evaluation team analyzed the energy savings using custom project-specific methods.

4.3.4 Findings and Recommendations

The data collected as a result of the desk reviews and onsite measurement and 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 90% for the EnergySmart Grocer program (Table 4-12).

Table 4-12: EnergySmart Grocer Impact Energy Realization Rate Results

Program	Sample Unique Projects	Energy Realization Rate	Relative Precision (90% Confidence)
EnergySmart Grocer	44	90%	14%

In the following subsections, the evaluation team notes observed reasons for the gross verified values for this program.

Application of RTF Deemed Savings Values

The RTF's deemed savings values for specific measures are periodically reviewed and updated based on further research and input from RTF members. For each revision, the RTF publishes a new workbook, and the current workbook as well as all prior versions are available on the RTF website. In some cases, different deemed savings values were observed to be used in the program tracking database for the same measure. The different deemed savings values appear to have been taken from different versions of the RTF workbooks. The program implementer appears to be updating its internal measure savings assumptions within the same program year.

Onsite Inspection Case Lighting Findings

The evaluation team found inconsistencies between onsite conditions and the applied RTF deemed savings values in a few cases. Fewer linear feet of case lighting was noted in one project of the 12 case lighting projects visited. In three cases, it was observed that projects

[9] Grocery - Display Case LEDs (Open Cases) v1.0, 1.1, 1.2, and 1.3. Grocery - Display Case LEDs (Reach-In Cases) v2.0, 2.2, 3.0, 3.1, and 3.2. Grocery – ECMs for Display Cases v2.0, 2.1, 2.2, and 3.0. Grocery – ECMs for Walk-ins. V1.1, 1.2, 2.0, and 2.1. Grocery – Floating Heat Pressure Controls for Single Compressor Systems v1.0, 1.1, 1.2, and 1.3. Available from http://rtf.nwcouncil.org/measures/Default.asp.

reported as occurring in low-temperature cases (i.e. freezers) were actually medium-temperature cases (i.e. refrigerators). Lighting retrofits in medium-temperature cases result in lower energy savings because there is less interactive effect with the case refrigeration system due to the higher temperature. Overall, these finds play a relatively small role in the program realization rate.

Custom Project Findings

Custom projects incentivized under this program have significantly larger reported savings on average than the prescriptive projects. The reported energy savings for custom projects were generally determined using eQuest energy simulation modeling. The evaluation team found discrepancies in the energy model for one large project – a big box retail store with overestimated sales floor lighting hours of operation. Because of the size of the project, this one finding is a primary driver in reducing the program realization rate to 90%. The evaluation team recommends tracking atypical custom projects such as this one through the Site Specific program. This would allow such larger projects access to the QA/QC processes consistent with the Site Specific program.

Table 4-13 presents the 2014-2015 gross verified savings for the EnergySmart Grocer program.

Table 4-13: EnergySmart Grocer Gross Verified Savings

Program	Reported Savings (kWh)	Energy Realization Rate	Gross Verified Savings (kWh)
EnergySmart Grocer	3,512,149	90%	3,144,958

4.4 Prescriptive Non-Lighting Other Programs

4.4.1 Overview

For evaluation purposes, the evaluation team analyzed several of Avista's smaller prescriptive electric programs together under a "Prescriptive Non-Lighting Other" category. Table 4-14 lists brief summaries of the programs included in this group. All are implemented internally by Avista except Green Motors, which is implemented by the Green Motors Initiative.

Table 4-14: Prescriptive Non-Lighting Other Program Summaries

Electric Programs	Description
Food Service Equipment	This program offers incentives for commercial customers who purchase or replace food service equipment with Energy Star or higher equipment (prescriptive).
Green Motors	The Green Motors Initiative is to organize, identify, educate, and promote member motor service centers to commit to energy saving shop rewind practices, continuous energy improvement and motor driven system efficiency.
HVAC Motor Controls	This program is intended to prompt the customer to increase the energy efficiency of their fan or pump applications with variable frequency drives through direct financial incentives.
Commercial Clothes Washers	This program encourages nonresidential customers to improve the efficiency of their clothes washing equipment.
Power Management for PC Networks	This program is designed to encourage implementation of power management software in networked PC's to obtain energy efficiency.
Commercial Windows & Insulation	This program encourages nonresidential customers to improve the envelope of their building by adding insulation and replacing windows.
Commercial Water Heaters	This program encourages nonresidential customers to improve the efficiency of their water heating equipment.
Standby Generator Block Heater	Installation of technology that reduces standby losses of vehicle engine blocks by fleet operators by adding the ability to energize block heaters only when Outside Air Temperature drops below a temperature set-point and the engine mounted thermostat is calling for heat.

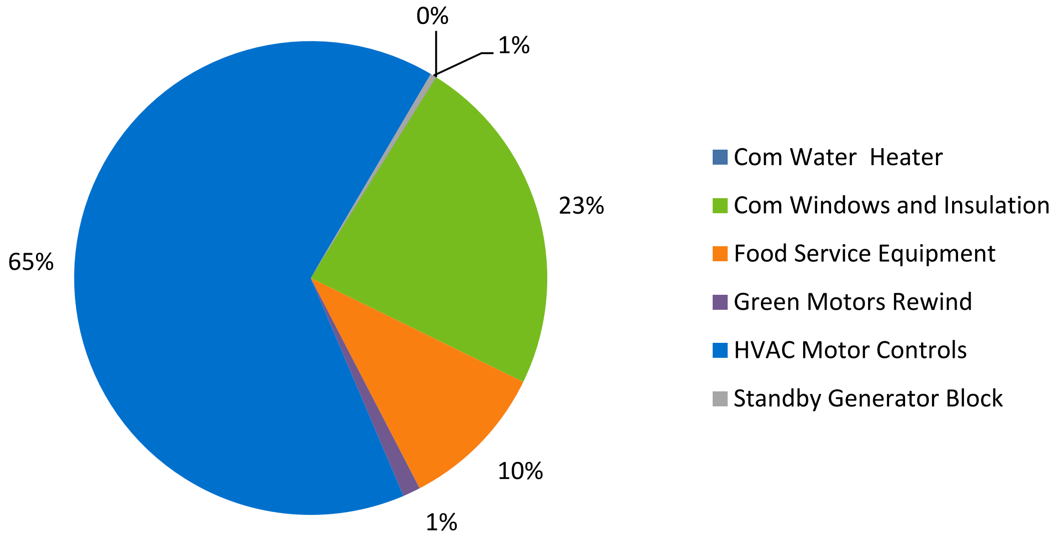
4.4.2 Program Achievements and Participation Study

A total of 132 unique measures were installed at 124 premises in Washington through these "Prescriptive Non-Lighting Other" programs in 2014 and 2015. Table 4-15 and Figure 4-4 summarize Avista's 2014-2015 reported energy impacts by measure for these programs in Washington.

Table 4-15: Prescriptive Non-Lighting Other Reported Energy Savings by Measure

Program	Energy Savings (kWh)	% Electric Savings
Com Water Heater	138	0%
Com Windows and Insulation	494,230	23%
Food Service Equipment	214,937	10%
Green Motors Rewind	25,607	1%
HVAC Motor Controls	1,374,268	65%
Standby Generator Block	8,668	0%
TOTAL	**2,117,848**	**100%**

Figure 4-4: Prescriptive Non-Lighting Other Reported Energy Savings Shares



4.4.3 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.

4.4.3.1 Sampling

The evaluation team conducted document audits for 24 projects that were grouped under the "Prescriptive Non-Lighting Other" category. Surveys and onsite inspections were conducted for a sub-sample of 15 of these projects (Table 4-16). Because of the installation of multiple projects at some sites, the achieved sample size for onsite inspections and surveys was slightly higher than the original sample design of 9 surveys and onsite inspections as noted in Table 3-2. The breakdown by program for the 24 document audits is provided in Table 4-17.

Table 4-16: Prescriptive Non-Lighting Other Achieved Sample

	Document Audit	Survey	OnSite Inspections
Prescriptive Non-Lighting Other	24	15	15

Table 4-17: Prescriptive Non-Lighting Other Achieved Sample by Program

Measure	Sample Size
Com Water Heater	0
Commercial Windows and Insul	17
Food Service Equipment	2
Green Motors Rewind	1
Motor Controls HVAC	4
Standby Generator Block Heater	0

4.4.3.2 Document Audits

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

4.4.3.3 Field Inspections

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

Table 4-18 summarizes the types of information that were collected for each project during the onsite inspection.

Table 4-18: Prescriptive Non-Lighting Other 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
Motors	Motor size (hp) Motor Efficiency Age Condition Operating Hours	Motor size (hp) Motor Efficiency Age Condition Operating Hours VFD Speed (current settings and load profile)
Building Envelope	Insulation Type Insulation Thickness Window Type (no. of panes, type of glass)	Insulation Type Insulation Thickness Window Type (no. of panes, type of glass) Affected Window / Wall / Attic Area (sq ft)
Appliances		Manufacturer Model Number Efficiency

Onsite data collection for HVAC Motor Control (Variable Frequency Drive or VFD) measures included equipment inspection, interviews with site personnel, and collection of energy management system (EMS) trend data if available. Topics covered in the interview included:

- Fan operation prior to the installation of the VFD including baseline fan control capability:
  - On/Off

  - Inlet Guide Vanes
  - Discharge Damper
- Control programming associated with the VFD such as (1) facility operations schedule, (2) temperature setpoints, (3) differential pressure control
- Minimum and maximum observed operating speeds and associated facility and weather conditions
- Typical operating speed
- Annual equipment operation schedule and variation on a daily, weekly, and annual basis
  - After-hours usage in evenings
  - Weekend usage
  - Summer shut down
  - Night setback
- Availability of trended VFD operating data via building EMS or other control system.

Field engineers gathered the following information from equipment nameplates or as-built drawings:

- Motor make and model
- Motor size (hp)
- Motor efficiency
- Motor speed (RPM)
- Motor type
- Fan type
- VFD make and model

Field engineers also collected operating parameters from the VFD drive's user interface control panel (if present). To facilitate this data collection, the field engineers were provided with model-specific guidance for accessing relevant parameters from the control panel. Although the availability of these operating parameters varies between different VFDs, common operating parameters collected include:

- Instantaneous operating parameters:
  - Frequency (Hz)
  - % speed
  - Motor power (W)
  - Motor amperage (A)
- Cumulative kWh and associated time interval

4.4.3.4 Impact Analysis Methods

Food Service Equipment

The Food Service Equipment projects included in the evaluation sample were for ENERGY STAR-rated ice makers. The evaluation team evaluated the energy savings of each ice maker using the Commercial Kitchen Equipment calculator published by ENERGY STAR[10]

Green Motor Rewinds

The energy savings for Green Motor Rewind projects were evaluated using the deemed savings values published by the RTF for this measure[11].

HVAC Motor Controls

The evaluation team assessed the HVAC Motor Control projects by modeling each affected motor's input power based on motor size, efficiency, and performance curves published by ASHRAE for various baseline motor control techniques (e.g. inlet guide vanes) as well as VFD control. The general form of the algorithm used presented in Equation 4-4.

Equation 4-4: HVAC Motor Controls Energy Savings Calculation

$$\Delta kWh = \sum_{cap=5\%}^{100\%} \left[kW_{baseline,cap} - kW_{efficient,cap}\right] \times hours_{cap}$$

Where:

Cap = operating capacity of the motor, ranging from 5% of full capacity to 100%

$kW_{baseline,cap}$ = Baseline motor power consumption at a specific capacity, based on ASHRAE performance curves for baseline motor control capability

$kW_{efficient,cap}$ = *Post-retrofit motor power consumption at a specific capacity, based on ASHRAE performance curve for VFDs*

$hours_{cap}$ = Number of annual hours operating at each % capacity

Commercial Windows and Insulation

For measures affecting building envelope (attic insulation, wall insulation, and window replacements), an industry-standard relationship for insulation improvements was applied. Energy savings during the cooling season were calculated using the algorithm in Equation 4-5

Equation 4-5: Commercial Windows and Insulation Cooling Savings Calculation

$$\Delta kWh_{cooling} = \frac{\left(\frac{1}{R_{pre}} - \frac{1}{R_{post}}\right) \times Area \times 24 \times CDD}{1000 \times \eta_{cool}}$$

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

[11] http://rtf.nwcouncil.org/measures/measure.asp?id=115

Where:

$R_{pre\ and\ post}$	= *Pre- and Post-improvement R-values of insulation or windows*
A_{attic}	= *Affected area (sq ft).*
CDD	= *Annual cooling degree days*
η_{cool}	= Cooling system efficiency, EER or SEER

For buildings with electric heat sources, including both electric resistance furnaces and heat pumps, the calculated savings during the heating season using the following algorithm (Equation 4-6):

Equation 4-6: Commercial Windows and Insulation Heating Savings Calculation

$$\Delta kWh_{heating} = \frac{\left(\frac{1}{R_{pre}} - \frac{1}{R_{post}}\right) \times Area \times 24 \times HDD}{\eta_{heat} \times 3412}$$

Where:

HDD	= *Annual cooling degree days*
η_{heat}	= Heating system efficiency

4.4.4 Findings and Recommendations

Table 4-19 presents the realization rate based on the gross verified savings values for the sample of reviewed projects in the Prescriptive Non-Lighting Other category

Table 4-19: Prescriptive Non-Lighting Other Realization Rate Results

Program/Category	Sample Unique Projects	Energy Realization Rate	Relative Precision (90% Confidence)
Prescriptive Non-Lighting Other	24	54%	228%

HVAC Motor Control Findings

The evaluation sample included four prescriptive HVAC Motor Control projects. Of these, a project for two VFDs was found to have a 50% project-level realization rate because the two VFDs were found to be serving a pair of motors operating in “Duty / Standby” configuration where only one of the two operates at a time. A second project for a single VFD was found to be installed in a non-typical VFD application (workshop dust collection system) and only being used as a soft-starter, with the motor continuing to operate at 100% speed during occupied hours and then switched off at night. Thus, this project was found to have zero energy savings. These findings are the major drivers in the low stratum-level realization rate as well as the high relative precision of 228% for this stratum. Without these two projects, the stratum's relative precision improves to 20% at the 90% confidence interval.

To improve the realization rate, Avista should consider adding additional review processes to the program to check motor eligibility more stringently. More emphasis should be placed on verifying each motor's application, confirming the VFD is controlling the speed of the motor in a variable manner relative to load conditions, and checking that VFDs are not serving standby motors.

Food Service Equipment Findings

The evaluation team did not find any significant discrepancies in the evaluated sample of Food Service Equipment findings. Avista's reported energy savings are similar to what the evaluation team calculated using the ENERGY STAR calculator.

Green Motor Rewind Findings

The evaluation team found that Avista is appropriately applying the deemed values published by the RTF for Green Motor Rewind projects. No discrepancies were found.

Commercial Window and Insulation Findings

The algorithm the evaluation team utilized for verifying heating savings (both electric and gas) resulting from window replacements is very similar to what is used by Avista. Both algorithms estimate the effect of reduced thermal conduction loads on a building's heating system. For cooling savings, the program utilizes an algorithm that estimates savings based on reduced solar radiation loads. The evaluation team reviewed the SEEM model outputs included in the RTF's workbook for Small Commercial Weatherization for Avista's service territory and determined the program's radiation-based algorithm may be overstating savings. The evaluation team opted to apply only the conduction-based algorithm, similar to the heating savings algorithm, because the results aligned more closely with the SEEM values. Table 4-20 summarizes the program-reported and gross verified savings for window replacement cooling season savings, compared with SEEM results for Heating Zones 1 and 2.

Table 4-20: Cooling Season Savings for Window Replacements

	Cooling Season Savings (kWh/sqft)
Reported Savings	5.95
Gross Verified Savings	0.20
SEEM Results, Heating Zone 1*	-0.9 – 0.1
SEEM Results, Heating Zone 2*	0.02 – 0.68

*Values from Small Commercial Weatherization Workbook: SmallCommWx_ProCost_V2_0.xls

The evaluation team's algorithm resulted in very low realization rates for some projects, but the average savings for this type of project is small on average, so the overall impact on the program realization rate is minimal.

The evaluation team recommends that Avista consider alternate algorithms for the cooling season or investigate other ways to support the program's current algorithm using energy modeling, billing analysis, or other third-party sources.

Table 4-21 shows the total gross verified savings for the programs evaluated under the "Prescriptive Non-Lighting Other" stratum.

Table 4-21: Prescriptive Non-Lighting Other Gross Verified Savings

Program	Reported Savings (kWh)	Realization Rate	Gross Verified Savings (kWh)
Com Water Heater	138	54%	75
Com Windows and Insulation	494,230		267,867
Food Service Equipment	214,937		116,494
Green Motors Rewind	25,607		13,879
HVAC Motor Controls	1,374,268		744,838
Standby Generator Block	8,668		4,698
TOTAL	**2,117,848**		**1,147,850**

4.5 Site Specific

4.5.1 Overview

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

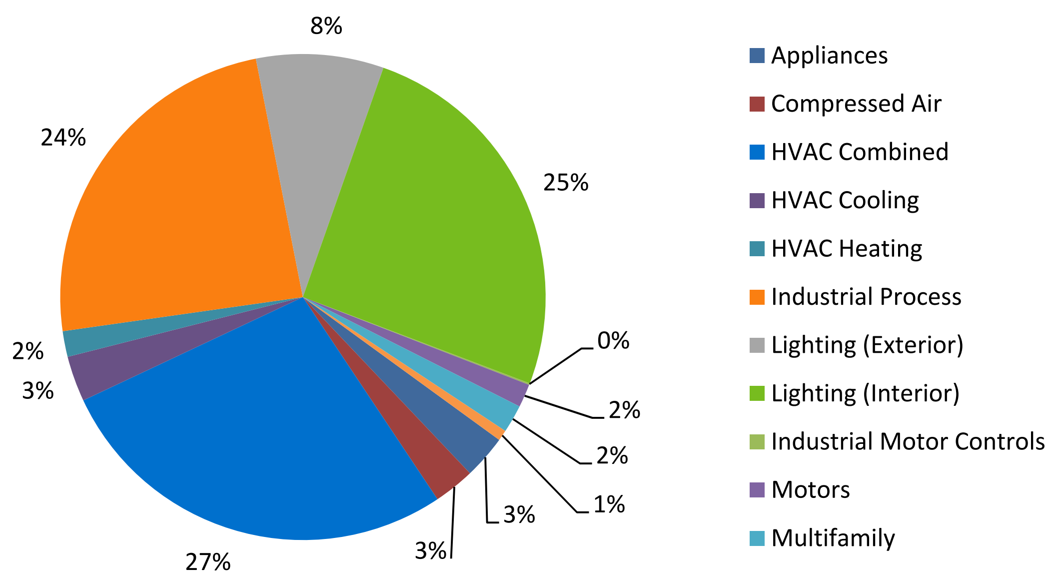
4.5.2 Program Achievements and Participation Summary

A total of 270 unique measures were installed through the Site Specific program at 216 premises in Washington throughout 2014 and 2015. Table 4-22 and Figure 4-5 summarize Avista's reported energy impacts by measure for the Site Specific program.

Table 4-22: Site Specific Reported Energy Savings by Measure

Measure Type	Reported Energy Savings (kWh)	% Electric Savings
Appliances	647,108	3%
Compressed Air	606,774	3%
HVAC Combined	6,087,109	27%
HVAC Cooling	675,075	3%
HVAC Heating	380,291	2%
Industrial Process	5,367,133	24%
Lighting (Exterior)	1,887,074	8%
Lighting (Interior)	5,648,204	25%
Industrial Motor Controls	21,635	0%
Motors	346,480	2%
Multifamily	412,378	2%
Shell	157,314	1%
Total	22,236,575	100%

Figure 4-5: Site Specific Reported Participation Energy Savings Shares



4.5.3 Methodology

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

4.5.3.1 Sampling

The evaluation team conducted 101 document audits on participating projects through the Site Specific program. Customer surveys and onsite inspections were conducted on a subset of these projects. Because of sample overlap with the Site Specific gas program, the achieved sample size for document audits was higher than planned. Within the Site Specific program, the evaluation team designated projects into two strata based on reported savings. Projects with a reported savings over 275,000 kWh were designated as Large projects, with all others designated as Small. This stratified sampling strategy was selected in order to ensure that the relative impacts of large projects were fairly represented in the program-level results. Table 4-23 outlines the achieved sample for the Site Specific Program.

Table 4-23: Site Specific Achieved Sample

Program Strata	Document Audit	Survey	OnSite Inspections
Large (> 275,000 kWh)	17	17	17
Small (< 275,000 kWh)	84	67	67
TOTAL	**101**	**84**	**84**

4.5.3.2 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.

4.5.3.3 Field Inspections

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

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

Table 4-18 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 4-24: 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
Motors	Motor size (hp) Motor Efficiency Age Condition Operating Hours	Motor size (hp) Motor Efficiency Age Condition Operating Hours VFD Speed (current settings and load profile)
Building Envelope	Insulation Type Insulation Thickness Window Type (no. of panes, type of glass)	Insulation Type Insulation Thickness Window Type (no. of panes, type of glass) Affected Window / Wall / Attic Area (sq ft)
Appliances		Manufacturer Model Number Efficiency

Onsite data collection for HVAC Motor Control (Variable Frequency Drive or VFD) measures included equipment inspection, interviews with site personnel, and collection of energy management system (EMS) trend data if available. Topics covered in the interview included:

- Fan operation prior to the installation of the VFD including baseline fan control capability:
    - On/Off
    - Inlet Guide Vanes
    - Discharge Damper
- Control programming associated with the VFD such as (1) facility operations schedule, (2) temperature setpoints, (3) differential pressure control
- Minimum and maximum observed operating speeds and associated facility and weather conditions
- Typical operating speed
- Annual equipment operation schedule and variation on a daily, weekly, and annual basis
    - After-hours usage in evenings
    - Weekend usage
    - Summer shut down.
    - Night setback
- Availability of trended VFD operating data via building EMS or other control system.

Field engineers gathered the following information from equipment nameplates or as-built drawings:

- Motor make and model
- Motor size (hp)
- Motor efficiency
- Motor speed (RPM)
- Motor type
- Fan type
- VFD make and model

Field engineers also collected operating parameters from the VFD drive’s user interface control panel (if present). To facilitate this data collection, the field engineers were provided with model-specific guidance for accessing relevant parameters from the control panel. Although the availability of these operating parameters varies between different VFDs, common operating parameters collected include:

- Instantaneous operating parameters:
    - Frequency (Hz)
    - % speed
    - Motor power (W)

   - Motor amperage (A)
- Cumulative kWh and associated time interval

4.5.3.4 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.

4.5.3.5 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. 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 applied key algorithms for multiple projects, as described in the following sections.

Lighting Projects

The evaluation team utilized the same approach for the lighting projects as described in the methodology section for the Prescriptive Lighting Program (Section 4.2.3.4)

Variable Frequency Drives

Projects involving variable frequency drives (VFDs) were evaluated by modeling each affected motor's input power based on motor size, efficiency, and performance curves published by ASHRAE for various baseline motor control techniques (e.g. inlet guide vanes) as well as VFD control. The general form of the algorithm used is shown in Equation 4-7:

Equation 4-7: VFD Energy Savings Calculation

$$\Delta kWh = \sum_{cap=5\%}^{100\%} \left[kW_{baseline,cap} - kW_{efficient,cap}\right] \times hours_{cap}$$

Where:

cap = operating capacity of the motor, ranging from 5% of full capacity to 100%

$kW_{baseline,cap}$ = Baseline motor power consumption at a specific capacity, based on ASHRAE performance curves for baseline motor control capability

$kW_{efficient,cap}$ = Post-retrofit motor power consumption at a specific capacity, based on ASHRAE performance curve for VFDs

$hours_{cap}$ = Number of annual hours operating at each % capacity

HVAC Replacements

For HVAC projects various permutations of Equation 4-8 were utilized to calculate savings, as applicable:

Equation 4-8: HVAC Replacement Energy Savings Calculation

$$\Delta kWh = EFLH \times kBtuH \times \left(\frac{1}{IEER_{base}} - \frac{1}{IEER_{ee}}\right)$$

Commercial Windows and Insulation

The evaluation team utilized the same approach for the commercial windows and insulation projects as described in the methodology section for the Prescriptive Non-Lighting Other Programs (Section 4.4.3.4)

Conservation Voltage Reduction Project

The largest Site Specific project, 5% of the total program reported savings, was a conservation voltage reduction (CVR) project installed by WSU-Pullman. Because of the size of the project and the uncertainty of the energy savings attributable to the measure, the evaluation team conducted an in-depth analysis of the project. CVR technology allows for more precise control of power system supply voltages and achieves energy savings when the supply voltages at substation feeders can be reduced and still meet applicable ANSI standards. The CVR project at WSU-Pullman was part of a larger CVR project within Avista's territory, and the larger project was studied shortly after installation[12]. For the evaluation of the WSU-Pullman project specifically, Avista was able to provide several updated datasets for analysis. Table 4-25 describes the data sources the evaluation team incorporated into the evaluation of this project.

[12] "2013 Annual Report Demand-Side Management Washington." Avista Utilities. June 1, 2014. Appendix 5.

Table 4-25: Data Sources for CVR Project Evaluation

Data Source	Description	Start Date	End Date
MV90 Load Data	hourly kW, kVAR, and KVA	July 1, 2012	August 25, 2015
CVR System Data	5-minute interval voltage readings and system status	January 1, 2014	August 25, 2015
Weather Data	Hourly readings for Pullman	July 1, 2012	August 25, 2015

The evaluation team conducted a linear regression analysis on the received datasets to analyze the impact of the CVR system operation on each affected WSU-Pullman feeder's kW consumption. This analysis controlled for the effects of weather conditions as well as the hourly, daily, and monthly load variations experiences in these feeders.

4.5.4 Findings and Recommendations

The evaluation team found that the 2014-2015 Site Specific program achieved energy savings very close to its reported performance, with a program-level realization rate of 99% (Table 4-26). Although individual project realization rates within the evaluation team's sample vary both above and below 100%, the high overall average for the program of 99% reflects the high level of review and scrutiny that Avista places on the projects that participate in the Site Specific program.

Table 4-26: Site Specific Program Realization Rate Results

Strata	Sample Unique Projects	Energy Realization Rate	Relative Precision (90% Confidence)
Large (> 275,000 kWh)	17	96%	5%
Small (< 275,000 kWh)	84	101%	12%
TOTAL	**101**	**99%**	**7%**

Measure-level realization rates for measures where more than one project was included in the evaluation sample are presented in Table 4-27.

Table 4-27: Site Specific Measure-Level Gross Verified Savings

Measure	Sample Unique Projects	Energy Realization Rate
Appliances	3	100%
HVAC Combined	31	95%
Industrial Process	4	87%
Lighting (Exterior)	15	102%
Lighting (Interior)	38	112%
Multifamily	3	86%
Shell	5	35%

Lighting Project Findings

The review of lighting projects in the evaluation sample for the Site Specific program showed that Avista is generating high quality savings estimates for these projects, with measure-level realization rates of 102% for Exterior Lighting and 112% for Interior Lighting. The primary factor driving up the realization rate for Interior Lighting is the calculation of interactive effects. The program uses a 7.7% interactive factor for air conditioned spaces with gas heat, the most prevalent HVAC system type in the program, regardless of building type. The evaluation team applied the interactive factors listed by the RTF, which range from 94% to 116% for that HVAC system type (Appendix B). However many of the evaluated projects were in building types at the higher end of the RTF's range, such as Big Box Retail, Anchor Store Retail, and College/University.

The baseline fixture types for the projects in the evaluated sample are summarized in Table 4-28. Projects with multiple fixture types are counted multiple times. The evaluation team observed a distributed participation across several baseline fixture types in the sample.

Table 4-28: Baseline Fixture Types for Site Specific Interior Lighting

Baseline Fixture Type	Project Count
T8	9
T12*	7
T5	5
HID	8
Incandescent	3
CFL	1
New construction	1
Sensor only project	9

*Both Avista and the evaluation team estimated savings for these projects using the analogous T8 technology as the baseline.

Window and Insulation Findings

As similarly described for prescriptive window replacements in Section 4.4.3.4, the algorithm applied for cooling season savings is more conservative than what Avista is using. The program utilizes an algorithm that estimates savings based on reduced solar radiation loads. The evaluation team reviewed the SEEM model outputs included in the RTF's workbook for Small Commercial Weatherization for Avista's service territory and determined the program's radiation-based algorithm may be overstating savings. We opted to apply only a conduction-based algorithm, similar to the heating savings algorithm, because the results aligned more closely with the SEEM values. This difference of approach is the primary driver in the 35% realization rate for Shell measures. However, since this measure makes up only 1% of the total program savings, the impact on the program realization rate is minimal.

WSU-Pullman CVR Findings

The project-level realization rate for the CVR project at WSU-Pullman was 84%. Although the evaluation team's methodology for analyzing savings was different than the original Navigant evaluation[13] and was based on an expanded dataset, the two methods produced similar results for feeder average energy savings. The primary factor lowering the realization rate for this project was the effective CVR system operating hours. The evaluation team's review of the CVR system data showed that the CVR system is only activated 88% of the time on average.

Table 4-29 shows the total gross verified savings for the Site Specific program.

Table 4-29: Site Specific Gross Verified Savings

Program	Reported Savings (kWh)	Energy Realization Rate	Gross Verified Savings (kWh)
Site Specific	22,236,575	99%	21,936,984

The high realization rate for this program indicates that Avista's internal process for project review, savings estimation, and installation verification are working to produce high quality estimates of project impacts. The evaluation team recommends that Avista continue to operate this program with the current level of rigor.

4.6 Nonresidential Sector Results Summary

Table 4-30 lists the gross verified savings for each of Avista's nonresidential programs in Washington in 2014-2015. The Washington electric nonresidential sector achieved a 95% realization rate and the relative precision of the program-level electric realization rate was ±7% at the 90% confidence level

Table 4-30: Nonresidential Program Gross Impact Evaluation Results

Washington Electric Nonresidential Program	2014-2015 Reported Savings (kWh)	Realization Rate	2014-2015 Verified Gross Savings (kWh)
EnergySmart Grocer	3,512,149	90%	3,144,958
Food Service Equipment	214,937	54%	116,494
Green Motors	25,607	54%	13,879
Motor Controls HVAC	1,374,268	54%	744,838
Commercial Water Heaters	138	54%	75
Prescriptive Lighting	8,145,753	99%	8,046,872
Prescriptive Shell	494,230	54%	267,867
Fleet Heat	8,668	54%	4,698
Site Specific	22,236,575	99%	21,936,984
NONRESIDENTIAL TOTAL	**36,012,324**	**95%**	**34,276,665**

[13] "2013 Annual Report Demand-Side Management Washington." Avista Utilities. June 1, 2014. Appendix 5.

5 Small Business Impact Evaluation

5.1 Overview

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

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

Direct-install measures include:

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

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

5.2 Program Achievements and Participation Summary

Table 5-1 provides a comparison of reported participation and the adjusted participation determined through evaluation activities. The differences between the evaluation team’s adjusted participation and Avista’s reported participation were minimal amounting to a total of 24 duplicate audit entries in the program tracking database and a handful of decommissioned faucet aerators, Tier 1 smart power strips, and LED lamps identified during onsite inspections.

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

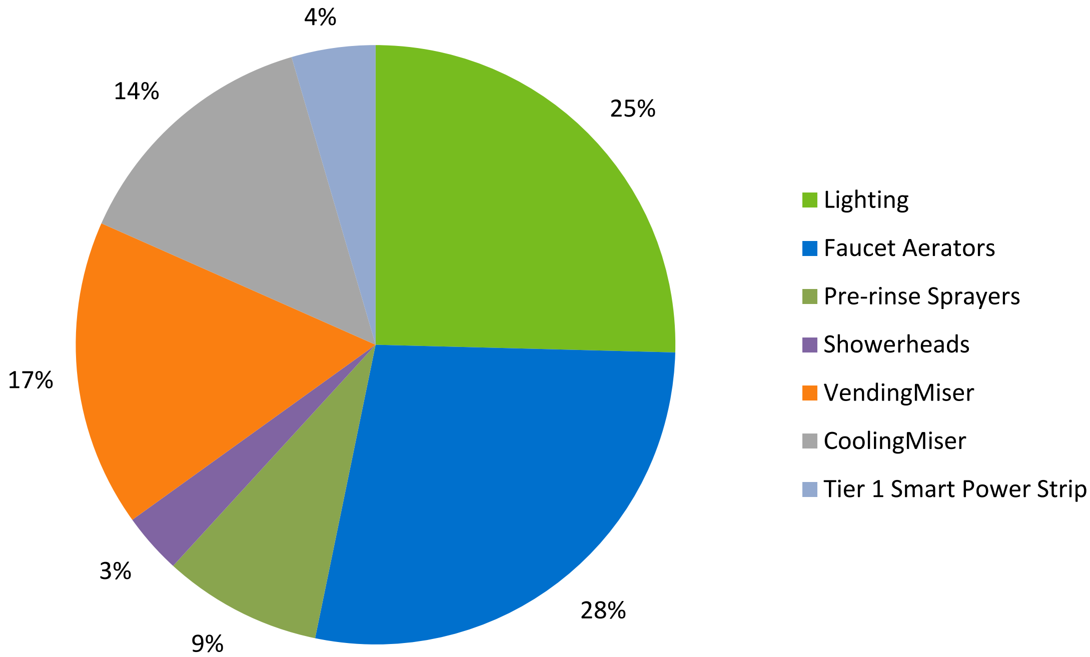
Measure Type	2015 Reported	2015 Adjusted Reported
Water Saving Measures	2,851	2,844
Plug Load Devices	778	775
Lighting	2,781	2,773
Audits	3,543	3,543

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

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

Measure	Electric Savings (kWh)	% Electric Savings
LED Lighting	261,978	25%
Faucet Aerators	286,800	28%
Pre-rinse Sprayers	88,308	9%
Showerheads	33,752	3%
VendingMiser	170,872	17%
CoolingMiser	142,655	14%
Tier 1 Smart Power Strip	46,610	5%
TOTAL	**1,030,975**	**100%**

Figure 5-1: SMB Program Reported Energy Savings Shares



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

5.1.1.1 Sampling

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

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

Program	On-Site Verification	Document Audit
Small Business	31	31

5.1.2 Document Audits

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

5.1.3 Onsite Inspections

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

The onsite inspections were used to determine whether:

- The measure tracking database correctly represented the work that was done at each site
- The measures remained installed and were operational
- There were any opportunities for measure installation that were missed
- There were assumptions embedded in the deemed savings estimates for each installed measure (e.g. 3,000 lighting hours of use) applicable to the site.

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

Table 5-4: Small Business Program Onsite Data Collection

Measure Type	Key Parameters
All Facilities	Number of occupants Business Type Operating Hours, posted or otherwise Water Heater Type (Tank or Tankless) Water Heater Fuel Type (Natural Gas or Electric)
Lighting	Quantity of Lamps Installed Quantity of Lamps Decommissioned Lighting Hours of Use Pre- and Post-retrofit Lamp Wattage
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
VendingMIser CoolingMiser	Quantity Installed Quantity Decommissioned Vending Machine Type Occupancy Hours Frequency of Use
Tier 1 Smart Power Strips	Quantity Installed Quantity Decommissioned Connected Plug Loads Baseline Conditions

5.1.4 Impact Analysis Methods

The evaluation team estimated gross verified savings using the field verified quantities and the program-specified deemed savings value for each measure. The deemed savings values used by the program originate from a variety of sources including (UES) measures from the Regional Technical Forum (RTF), California DEER database[14], and Puget Sound Energy 2014-2015 unit energy savings values. Verified energy savings were generally calculated for each measure using Equation 5-1:

Equation 5-1: Small Business Program Energy Savings Calculation

$$\Delta kWh = Quantity\ Verified\ x\ kWh\ Saved/Unit$$

Where:

Quantity Verified = Quantity of devices/fixtures/lamps verified onsite

14 http://www.deeresources.com/

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

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

5.2 Findings and Recommendations

The gross verified electric energy savings for the sample of reviewed projects for the Small Business program resulted in a realization rate of 102% (Table 5-5).

Table 5-5: Small Business Program Realization Rate Summary

Measure Category	Sampled Measures	Electric Energy Realization Rate	Relative Precision (90% Confidence)
Lighting	62	91%	
Faucet Aerators	59	126%	
Pre-rinse Sprayers	2	85%	
Showerheads	0	100%	
VendingMiser	9	100%	
CoolerMiser	18	95%	
Tier 1 Smart Power Strip	41	89%	
OVERALL	**191**	**102%**	**25%**

5.2.1.1 Deemed Savings for Faucet Aerators

The evaluation team developed new electric (kWh) and natural gas (therms) deemed savings values for both 0.5 GPM and 1.0 GPM faucet aerators installed through the program. The newly developed values were applied on a per device installed basis. They were developed based upon a comprehensive review of five statewide technical reference manuals[15], assumptions for similar measures offered in other jurisdictions[16], and assumptions from applicable RTF UES measures. During the research process, the evaluation team not only compiled the deemed energy savings values used by each source, but also some of the underlying assumptions such

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

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

as baseline and efficient device flow rates (GPM), frequency of use, hot water temperature, and inlet water temperature. A summary of key findings and recommendations are provided in Table 5-6.

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

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

5.2.1.2 Deemed Savings for Pre-Rinse Spray Valves

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

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

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

5.2.1.3 Lighting

The evaluated realization rate for lighting measures was 91%. Downward savings adjustments are attributable to lamps that were removed (decommissioned) by program participants. Table 5-8 summarizes the verified distribution of LED lamps within the evaluated sample along with the number of decommissioned units discovered during onsite inspections.

Table 5-8: Small Business Evaluation Sample Summary for Lighting Measures

Measure Name	Reported Lamps	Quantity Decommissioned	Verified Lamps
Screw-in LED lamp (A-line 40W)	6	0	6
Screw-in LED lamp (A-line 60W)	11	0	11
Screw-in LED lamp (A-line 75W)	0	0	0
Screw-in LED lamp (A-line 100QW)	7	0	7
Screw-in LED lamp (BR30)	31	3	28
Screw-in LED lamp (BR40)	5	1	4
Screw-in LED lamp (PAR30)	3	0	3
Screw-in LED lamp (PAR38)	7	4	3
OVERALL	**70**	**8**	**62**

5.2.1.4 Summary of Decommissioned Non-lighting Measures

The evaluation team made downward savings adjustments for several of the non-lighting measures in the sample where the verified quantity installed did not match the reported quantity due to measures being decommissioned. A summary of all identified decommissioned measures is provided in Table 5-9.

Table 5-9: Small Business Decommissioned Non-lighting Measure Summary

Measure Name	Reported Measures	Quantity Decommissioned	Verified Measures
Faucet Aerator (0.5 GPM)	80	10	72
Faucet Aerator (1.0 GPM)	29	5	24
Pre-rinse Spray Valve	6	2	5
Showerhead	2	0	2
Showerhead (Fitness Center)	4	0	4
CoolerMiser	19	1	18
VendingMiser	9	0	9
Tier 1 Smart Power Strip	44	3	41
OVERALL	**193**	**21**	**175**

Table 5-10 shows the total gross verified savings for each measure and for the Small Business Program in total.

Table 5-10: Small Business Program Gross Impact Evaluation Results

Strata	2015 Reported Savings (kWh)	Realization Rate	2015 Gross Verified Savings (kWh)
Lighting	261,978	91%	237,721
Water-Heating	408,860	115%	468,488
Plug Load	360,137	97%	347,562
SMALL BUSINESS TOTAL	**1,030,975**	**102%**	**1,053,771**

6 Residential Impact Evaluation

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

6.1 Overview

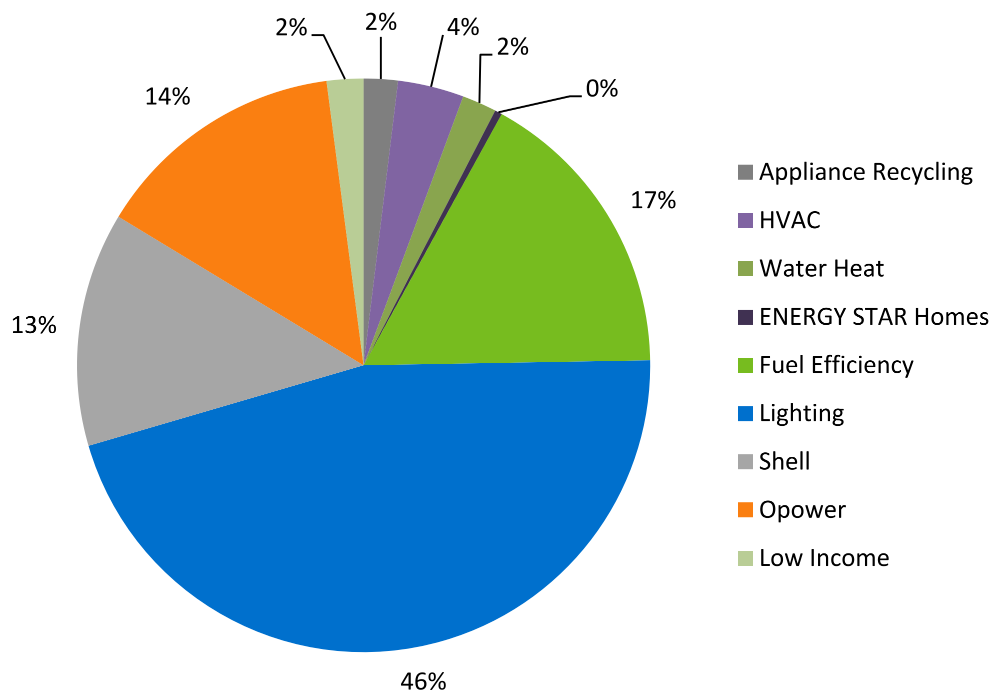
Avista offered seven electric incentive-based residential programs, one residential behavioral program (Opower), and the low income program in their Washington service territory in 2014 and 2015. The reported savings for these residential programs are summarized in Table 6-1.

Table 6-1: Residential Program Reported Savings

Washington Electric Program	2014–2015 Reported Savings (kWh)
Appliance Recycling	822,810
HVAC	1,598,690
Water Heat	833,720
ENERGY STAR Homes	176,470
Fuel Efficiency	7,165,449
Lighting	19,606,228
Shell	5,657,633
Opower (Home Energy Reports)	6,115,000
Low Income	885,598
TOTAL PORTFOLIO	**42,861,597**

The Lighting program contributes the largest share of the reported savings, 46% as shown in Figure 6-1. Fuel Efficiency is the next largest contributor at 17%.

Figure 6-1: Residential Program Reported Energy Savings Shares



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 259 document audits and 222 telephone surveys were conducted, and onsite inspections were conducted on 75 homes in support of the Lighting Hours of Use study, as shown in Table 6-2. Engineering activities included review of savings calculation methodology and assumptions, utility bill analysis and energy savings analysis.

Table 6-2: Residential Program Achieved Evaluation Sample

Electric Residential Program	Achieved C/P	Document Audit	Surveys	Onsite Inspections
Residential Appliance Recycling	N/A	70	72	
HVAC Program	90/31	68	68	
Water Heat Program[1]	90/13	24	13	
ENERGY STAR Homes	90/14	19	16	
Fuel Efficiency	90/7	26	25	
Residential Lighting Program[2]	90/15.3			75
Shell Program	90/33	28	28	
Opower Behavioral Program	90/8			
Low Income	90/13	24		
TOTAL	**90/9**	**259**	**222**	**75**

6.2 Residential Appliance Recycling

6.2.1 Overview

The appliance recycling program, administered by JACO Environmental Inc, provided a pick-up and recycling service for operational refrigerators or freezers manufactured before 1995. The pick-up service was free to customers and a $30 rebate was provided for each operational refrigerator and/or freezer, up to two per household. JACO provided the following data points to Avista on a monthly basis: date of pick-up, customer name, address, city state zip, type of unit collected and number of units collected. The appliance recycling program ceased operation in June 2015 as a result of revised RTF values that became effective in July of 2015 causing the program to cease to be cost-effective.

6.2.2 Program Achievements and Participation Summary

The Appliance Recycling Program's reported participation and savings across the 2014–2015 program cycle is presented in Table 6-3.

Table 6-3 Appliance Program Reported Participation and Savings

Measure	2014–2015 Reported Participation	2014–2015 Reported Savings (kWh)
Refrigerator	965	580,368
Freezer	370	242,442
Total	**1,335**	**822,810**

6.2.3 Methodology

The evaluation team conducted telephone surveys and document audits for 72 program participants.

To record participation, Avista totals participation on a monthly basis from data provided directly by the implementer, JACO. JACO also provided the evaluation team with a total database of all units recycled in 2014 and 2015 under the Avista program. The evaluation team checked this database for duplicates (zero found), and cleaned the database of refrigerators and freezers collected that did not meet the program criteria of being manufactured before 1995 (125 records). The evaluation team then compared these results to Avista's reported values. The final cleaned database reported 1,288 appliances recycled in WA over 2014 and 2015 (Table 6-4).

Table 6-4 2014-2015 Appliance Recycling Participation Counts

Measure	Avista Reported Participation	Implementer Reported Participation	Adjusted Reported Participation
Refrigerators	965	968	909
Freezers	370	386	379
TOTAL	**1,335**	**1,354**	**1,288**

Avista's deemed savings values reported per recycled freezer and refrigerator are based on RTF unit energy savings which include the effects of freeridership. For purposes of estimating a gross savings value for the measures, the evaluation team reviewed the findings from the 2012-2013 WA Impact Evaluation[17]. The evaluation team then applied the gross verified savings values reported in the prior evaluation study to the adjusted reported participation values identified by the evaluation team. Table 6-5 outlines the Avista reported and evaluated savings per unit for the Appliance Recycling program.

Table 6-5 Appliance Recycling Reported and Evaluated Savings

Measure	Avista Reported Savings Value (kWh/unit)	2012-2013 Evaluated Savings (kWh/unit)
Refrigerators	636	1,090
Freezers	612	902

6.2.4 Findings and Recommendations

While this program has been cancelled, there are a few findings that may assist Avista in planning purposes should they implement a similar program in the future.

[17] Avista 2012-2013 Washington Electric Impact Evaluation Report, The Cadmus Group, Inc. May 15, 2014

- The implementer JACO provided each customer with an OrderID, and collects data points for reporting to Avista including: name, account number, address, the type unit recycled, make and model, as well as the year. Due to common place errors in alternate spelling of names and addresses, it is important for the implementer to record accurate account numbers. This will assist tracking of participants across programs and tracking to billing data should that be necessary.
- The roll-up of Avista's reported appliance recycling values included only count of appliance type per month, which is then applied to the deemed savings values to estimate the reported program savings. This makes it difficult to determine where any discrepancies may have occurred between the master implementer database and the summarized Avista database. Maintaining as many variables as possible would allow for improved error checking. For example, based on the fact that the JACO database total counts and Avista reported total counts per appliance are different, it appears some errors in data transfer may have occurred, and/or some appliances may have been rebated by Avista that were manufactured after 1994. The cause of the discrepancy is difficult to determine, however, with the variables reported in Avista's summary.

Table 6-6 outlines the Avista reported savings and the evaluation team's gross verified savings based on the methodology described above. The program achieved a 165% realization rate over the 2014 –2015 program cycle, as compared to the adjusted reported savings.

Table 6-6 Appliance Recycling Gross Verified Savings

Measure	2014–2015 Adjusted Reported Participation Count	2014-2015 Reported Savings (kWh)	2014–2015 Adjusted Reported Savings (kWh)	Realization Rate	2014-2015 Gross Verified Savings
Refrigerator	909	580,368	578,124	171%	990,810
Freezer	379	242,442	231,948	147%	341,858
TOTAL	**1,288**	**822,810**	**810,072**	**165%**	**1,332,668**

6.3 HVAC Program

6.3.1 Overview

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

6.3.2 Program Achievements and Participation Summary

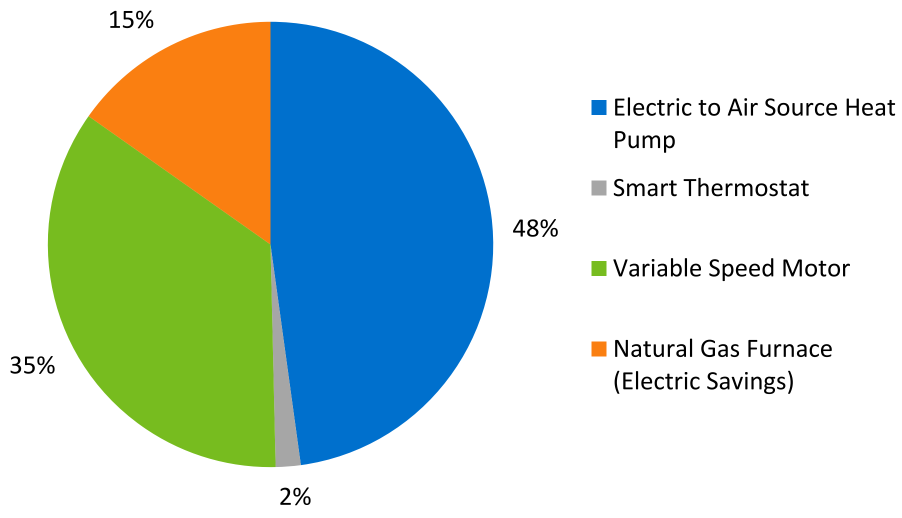
Participation in the 2014–2015 HVAC program totaled 5,019 measures. Table 6-7 and Figure 6-2 summarize Avista's 2014–2015 HVAC program participation and energy impacts.

Table 6-7: HVAC Program Reported Participation and Savings

Measure	2014–2015 Reported Participation Count	2014–2015 Reported Savings (kWh)
Electric to Air Source Heat Pump	171	764,583
Smart Thermostat	30	28,830
Variable Speed Motor	1,258	561,920
Natural Gas Furnace (Electric Savings)*	3,560	243,357
TOTAL	**5,019**	**1,598,690**

*Avista reports savings associated with dual fuel customers

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



6.3.3 Methodology

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

- Air Source Heat Pump (ASHP)
- Natural Gas Furnace
- Electric Variable Speed Motor
- Smart Thermostat

The evaluation team conducted 68 telephone surveys and document audits with program participants and a billing analysis was conducted on all of the measures evaluated as well. As discussed in Section 3.3, these surveys and document audits were conducted to confirm participation in the program, confirm efficiency levels of installed equipment as applicable, check that Avista reported data matched project files and that Avista is reporting the correct savings value for each applicable measure. The evaluation team also conducted a review of Avista's complete 2014 and 2015 program databases to check for errors in measure-level reporting.

The subsections below outline the specific evaluation methodology for estimating the gross verified impacts for the ASHP, Electric Variable Speed Motor and the Smart Thermostat measures. The methodology utilized for the natural gas furnaces is presented in the WA Natural Gas Impact Evaluation Report[18]

6.3.3.1 Air Source Heat Pump

To estimate electric savings resulting from participants' installation of air source heat pumps, the evaluation team utilized the fixed-effects panel regression approach described in Section 3.4.4 Billing Analysis. 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.

Utility billing data for participating homes were merged with observed temperature data (HDD and CDD) and program tracking data was used to identify the measure installation dates and designate the pre-retrofit and post-retrofit periods for each customer. In order to estimate impacts directly attributable to the heat pumps, the evaluation team isolated the customers who received an air source heat pump and no additional measures. An indicator variable was generated to designate billing periods that occurred prior to the measure installation (i.e. "pre" period) and billing periods that occurred after the measure installation (i.e. "post" period). The evaluation team required participants to have at least 12 months of "pre" billing data and at least six months of "post" billing data to be included in the analysis. We then estimated fixed-effects panel regression models to estimate the relationship between electric consumption and weather during the "pre" and "post" retrofit periods. Equation 6-1 shows the model specification used to estimate the relationship.

Equation 6-1: ASHP Fixed-Effects Panel Regression Model Specification

$$\mathrm{kWh}_{\mathrm{it}} = \beta_{\mathrm{i}} + \beta_1 \times \mathrm{Post}_{\mathrm{it}} + \beta_2 \times \mathrm{HDD}_{\mathrm{it}} + \beta_3 (\mathrm{Post} \times \mathrm{HDD})_{\mathrm{it}} + \epsilon_{\mathrm{it}}$$

Table 6-8 provides additional information about the terms and coefficients in Equation 6-1.

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[18] *WA 2014-2015 Natural Gas Impact Evaluation Report – M, 2016*

Table 6-8: ASHP Fixed-Effects Regression Model Definition of Terms

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

The β_1 and β_3 terms in Equation 6-1 describe the average change in daily base kWh and daily kWh per HDD, respectively, in the post-retrofit period. The evaluation team applied these coefficients to the TMY3 normal weather conditions to estimate weather normalized annual electric savings resulting from ASHP installation.

6.3.3.2 Variable Speed Fan Motor

A similar approach was used to estimate electric savings associated with variable speed fan motors. Similar to the ASHP analysis, the evaluation team first isolated the program participants who received a new variable speed motor and no other measures in order to pinpoint the savings directly attributable to the motors. Customers' utility billing data was merged with historic weather records and the pre-installation and post-installation billing periods we designated using the measure installation date from program tracking data. A fixed-effects panel regression model was then estimated to develop the relationship between weather and electric load before and after the variable speed fan improvement was installed.

The model specification used to estimate variable speed motor impacts is slightly different than the model specification used for ASHP. Because the motor is active during both heating and cooling seasons, CDD terms were included in the model specification in addition to the HDD terms. Equation 6-2 shows the model specification used to estimate the impacts of variable speed fan motors.

Equation 6-2: Variable Speed Motor Fixed-Effects Regression Model Specification

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

Table 6-9 provides additional information about the terms and coefficients in Equation 6-2.

Table 6-9: Variable-Speed Motor Fixed-Effects Regression Model Definition of Terms

Variable	Definition
kWh_{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

The β_1, β_3 and β_5 terms in Equation 6-2 represent the average change in daily base load, daily kWh per CDD and daily kWh per HDD, respectively, in the post-installation period. These terms were then applied to the normal weather conditions (TMY3) to estimate average weather normalized annual savings associated with variable speed fan motors.

6.3.3.3 Smart Thermostat

Avista offers rebates for the installation of qualified smart thermostat products. These devices have advance features such as occupancy detection, auxiliary heat lockout, economizer capability, and “learning” algorithms to adapt to resident behavior. Avista claims savings based on the heating fuel of the home so electric savings are only claimed for homes that have electric heating systems. The majority of the smart thermostats rebated in 2014–2015 were in homes with natural gas heating systems. The other challenge for evaluation was that uptake of the smart thermostat offering was highest in the fourth quarter of 2015. This meant that participating only had a few months of post-installation billing data at the time of this evaluation. Further complicating the analysis was the fact that a subset of the smart thermostat rebate recipient also installed other HVAC measures such as variable speed fans and high efficiency furnaces at the same time as the smart thermostat.

The evaluation team used propensity score matching to develop a comparison group of homes from the Opower program to serve as a baseline for savings estimates. Only five homes had sufficient post-retrofit billing data to estimate savings. The sample size wasn’t sufficient to develop a statistically significant per-home verified savings estimate, but two of the five homes produced savings annual estimates below Avista’s per-unit savings value of 961 kWh and three of the five homes produces savings estimates above the reported savings value. Absent any information supporting an adjustment of savings, the evaluation team set the gross verified electric savings equal to reported savings for this measure.

6.3.4 Findings and Recommendations

6.3.4.1 Air Source Heat Pump

The findings from the telephone surveys, document audit and database review found that all records matched between the Avista reported database and the project documentation. Therefore, the reported savings and the adjusted-reported savings for program count and savings match.

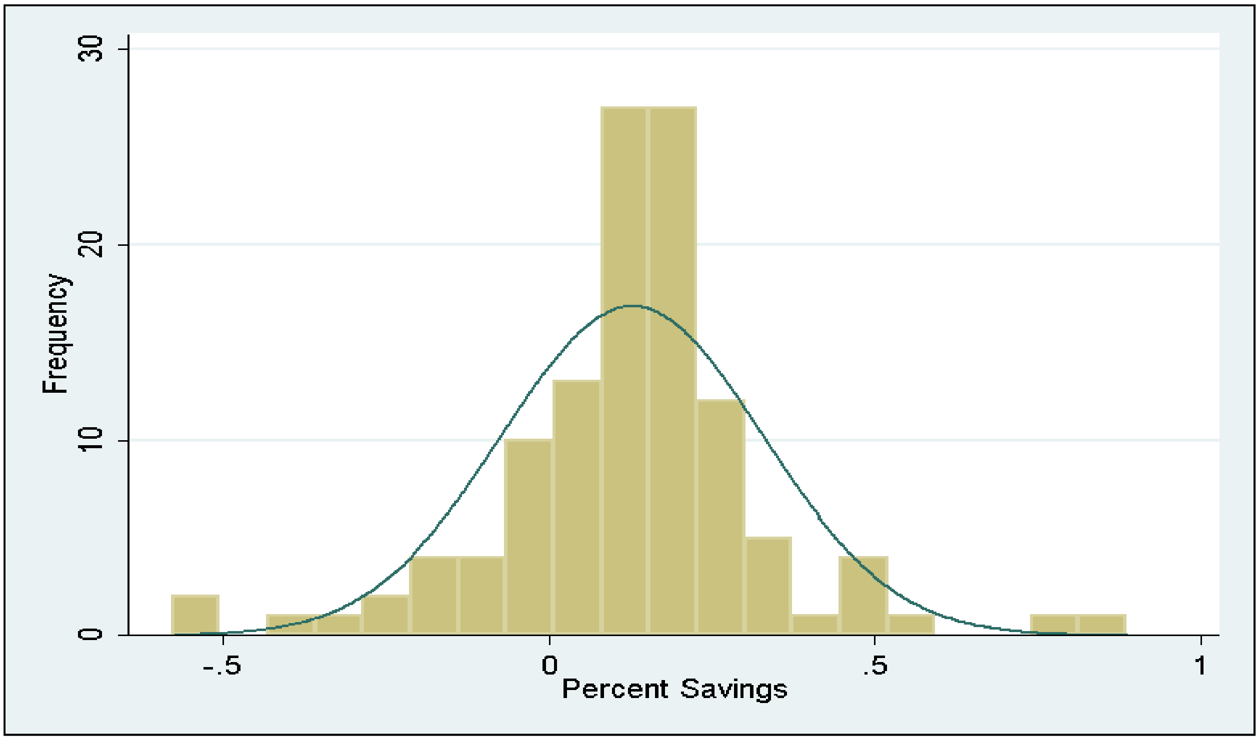
The fixed-effects regression analysis described in Section 6.3.3.1 produced statistically significant reductions in heating loads in homes where air source heat pumps were installed and rebated. Table C- 1 in Appendix C shows the fixed-effects regression output for ASHP rebates. Despite showing statistically significant heating impacts, the gross verified annual savings estimated by the regression approach are well below the deemed savings reported by Avista prior to the analysis. Whereas the average reported ex ante savings for ASHPs was 4,925 kWh, the annual savings estimated by the analysis was 2,390 kWh, resulting in a 48.5% realization rate. The relative precision of the savings estimate for ASHPs was ±19.0% at the 90% confidence level (Table 6-10).

Table 6-10: Air Source Heat Pump Impact Summary

n Homes	Ex Ante kWh	Annual kWh Pre	Annual kWh Post	Delta	RR	Precision at 90% Confidence
109	4,925	20,574	18,183	2,390	48.5%	±19.0%

The evaluation team also ran individual customer regressions using the model specification shown in Equation 6-1 in order to assess the distribution of savings at a more granular level across the measure's participant population. The analysis resulted in an average 12.7% reduction in electric consumption in the "post" period as a result of ASHP installation. Figure 6-3 shows a histogram of the distribution of percent savings across the 109 participants receiving ASHPs.

Figure 6-3: ASHP Distribution of Percent Savings



The evaluation team recommends Avista reexamine the assumptions relating to annual per-home consumption and savings estimates in homes receiving ASHP installations.

6.3.4.2 Variable Speed Fan Motor

The findings from the telephone surveys, document audit and database review found a few errors in the program database, resulting in a slight variance between the program reported and adjusted reported values.

The regression approach produced statistically significant impact estimates in both the heating and cooling loads of homes who installed a variable speed fan motor in their homes. Table C-2 in Appendix C provides the full regression output. In addition, annual savings estimated by the regression were nearly at a level consistent with the deemed savings reported by Avista for the program cycle. Table 6-11 summarizes the impacts and realization rate for variable speed fan motor installations. On average, homes achieved 414 kWh annual savings compared to 439 kWh annual savings reported by Avista, resulting in a realization rate of 94.4%.

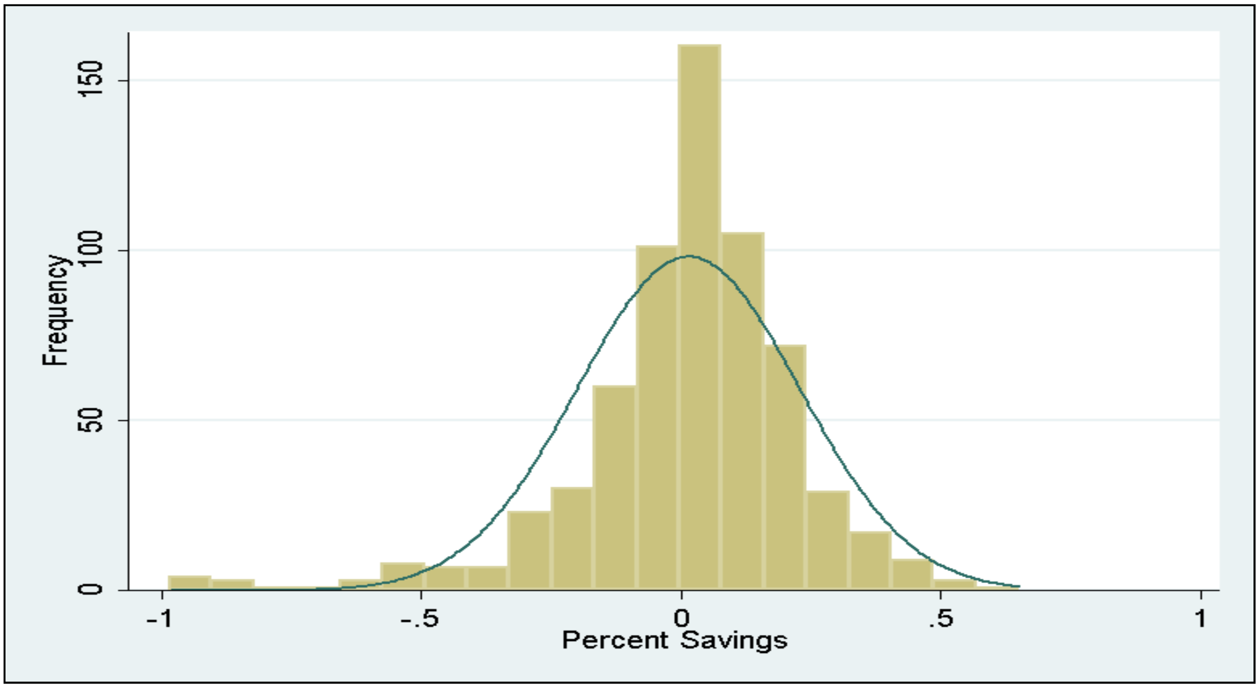
Table 6-11: Variable Speed Motor Impact Summary

n Homes	Ex Ante kWh	Annual kWh Pre	Annual kWh Post	Delta	RR
592	439	12,111	11,696	414	94.4%

The model specification shown in Equation 6-2 was also used to run separate regressions on each individual customer receiving a variable speed motor. On average, customers receiving a variable speed motor installation achieved a 1.4% reduction in annual electric consumption. Figure 6-4 shows the distribution of percent savings for program participants receiving a variable speed motor rebate.

Figure 6-4 shows a histogram of the distribution of percent savings across the 592 participants receiving variable speed fan motors.

Figure 6-4: Variable Speed Motor Distribution of Percent Savings



6.3.4.3 Smart Thermostat

Given the inconclusive analysis results for this measure driven by data limitations, the evaluation team recommends that Avista revisit the analysis of this measure in late 2016 or early 2017, when a full year of post-installation billing data is available for several hundred rebate recipients. Table 6-12 compares findings from smart thermostat impact evaluation across the country. These studies vary in:

- Location (e.g. weather)
- Sample sizes
- Thermostat product installed and type of thermostat replaced
- Robustness of methodology
- Type of installation (utility direct install, professional, self-install).

The impact estimates of these studies also vary considerably. In general, programs that offer direct replacement of manual thermostats have the highest savings estimates and mass market offerings where the replaced thermostat population includes a mix of conventional programmable and manual devices produce lower savings.

Table 6-12: Comparison of Smart Thermostat Evaluation Results

Study Name	State	Baseline Tstat	Installed Tstat	Sample Size	Control Group, If Any	% Savings Whole House	% Savings Cooling	% Savings Heating
MA PAs: Wi-Fi Programmable Controllable Thermostat Pilot Program Evaluation (9/12)	MA	Manual & Programmable	Ecobee Smart	66 (Gas) 11 (Elec)	23		16%	8%
National Grid: Evaluation of 2013–2014 Smart Thermostat Pilots: Home Energy Monitoring, Automatic Temperature Control, Demand Response (7/15)	MA	Manual	Ecobee Smart	9 (Gas), 15 (Elec)			10%	
National Grid: Evaluation of 2013–2014 Smart Thermostat Pilots: Home Energy Monitoring, Automatic Temperature Control, Demand Response (7/15)	MA	Programmable	Ecobee Smart	26 (gas), 48 (elec)			7.4%	
NIPSCO: Evaluation of the 2013–2014 Programmable and Smart Thermostat Program (9/14)	IN	Manual	Nest	238	469 (Gas) 522 (Elec)	3.9%	16%	13.4%
NIPSCO: Evaluation of the 2013–2014 Programmable and Smart Thermostat Program (9/14)	IN	Manual	Conventional Programmable	217 (Gas) 212 (Elec)	469 (Gas) 522 (Elec)	3.9%	15%	8.0%
Vectren: Evaluation of 2013–2014 Programmable and Smart Thermostat Program (1/14)	IN	Manual	Nest	197 (Gas) 191 (Elec)	2611 (Gas) 2714 (Elec)	4.0%	13.9%	12.5%
Vectren: Evaluation of 2013–2014 Programmable and Smart Thermostat Program (1/14)	IN	Manual	Conventional Programmable	184 (Gas) 205 (Elec)	2611 (Gas) 2714 (Elec)	3.7%	13.1%	5.0%
Xcel: In-Home Smart Device Pilot. Public Service Company of	CO	Not specified	Other Smart or PCT	1,100	N/A	3.3%	4.6%	

Study Name	State	Baseline Tstat	Installed Tstat	Sample Size	Control Group, If Any	% Savings Whole House	% Savings Cooling	% Savings Heating
Colorado (4/14)								
PG&E: Findings from the Opower/Honeywell Smart Thermostat Field Assessment (7/14)	CA	conventional programmable & manual mix	Other Smart or PCT	423	695	1.0%		
Puget Sound Energy: 2014 Impact Evaluation of PSE's Web-Enabled Thermostat (WET) Program 8/15)	WA	Not specified	Other Smart or PCT	1,000	1,000	- 0.2%		
Energy Trust of Oregon Nest Thermostat Heat Pump Control Pilot Evaluation	OR	75% programmable, 25% manual	Nest	185	211	4.7%	NA	12.0%
NV Energy 2013 DR Program Evaluation+A27:R27	NV	not clear	Eco-Factor	2477 (T) 2478 (C)	2,478	5.4%		
ComEd Smart 2016 Thermostat-Annual and Seasonal	IL	most likely blended	Smart (mostly Nest)	1791 (T) 1887 (C)	1,887	1.5%	4.8%	6.7%

6.3.5 Program Results

Table 6-13 outlines the program reported, adjusted, and gross verified savings value for each measure in the HVAC program. The evaluation team found a 78% realization rate across the entire HVAC program. The relative precision of the program level electric realization rate is ±30.5% at the 90% confidence level.

Table 6-13: HVAC Program Gross Verified Savings

Measure	2014–2015 Reported Participation Count	2014–2015 Reported Savings (kWh)	2014–2015 Adjusted Reported Savings (kWh)	Realization Rate	Gross Verified Savings (kWh)
Electric to Air Source Heat Pump	171	764,583	764,583	49%	374,205
Smart Thermostat	30	28,830	28,830	100%	28,830
Variable Speed Motor	1258	561,920	560,603	94%	528,975
Natural Gas Furnace (Electric Savings)	3560	243,357	243,357	126%	306,964
TOTAL	**5019**	**1,598,690**	**1,597,373**	**78%**	**1,238,974**

6.4 Water Heat Program

6.4.1 Overview

The evaluation team's assessment of the Water Heat program included analysis and verification of electric water heating-related measures offered by Avista including clothes washers, electric water heaters, and low flow showerheads. Both clothes washers and showerhead incentives were offered through the Simple Steps upstream program. Additionally, Avista provided showerheads through its manufactured home duct sealing program as a direct install measure.

6.4.2 Program Achievements and Participation Summary

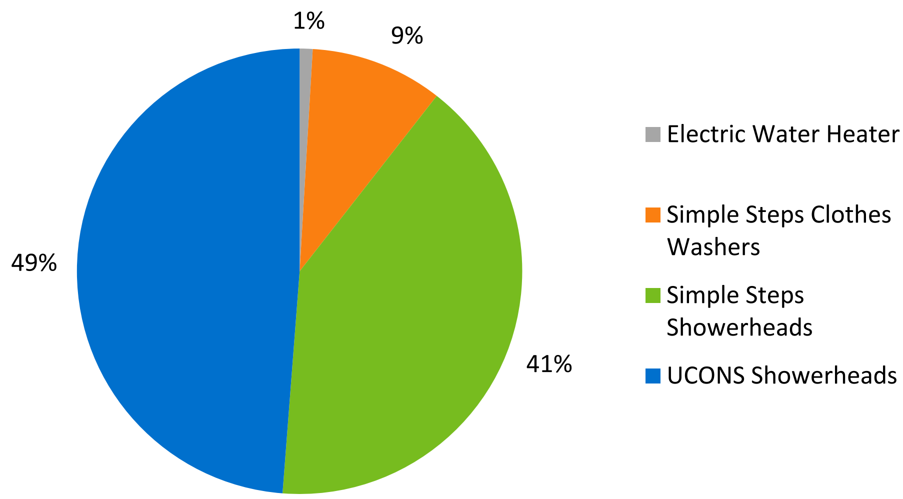
Participation in the 2014–2015 Water Heat program totaled 8,589 measures (includes distinct measure and bulb counts). Table 6-14 and Figure 6-5 summarize Avista's 2014–2015 Water Heat program participation and energy impacts.

Table 6-14: 2014–2015 Water Heat Reported Participation and Savings

Measure	2014–2015 Reported Participation Count	2014–2015 Reported Savings (kWh)
E Electric Water Heater	71	7,846
Simple Steps Clothes washers	608	80,256
Simple Steps Showerheads*	6,598	338,898
UCONS Showerheads	1,312	406,720
TOTAL	**8,589**	**833,720**

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

Figure 6-5: 2014–2015 Water Heat Program Reported Participation Energy Saving Shares



6.4.3 Methodology

The evaluation team performed verification of the program measures through a review of sampled project documentation and phone survey responses with program participants. Our review was designed to confirm the program tracking database was aligned with both project documentation and survey data.

Table 6-15 below presents the sampling completed for the Water Heat evaluation. The evaluation team collected information on fuel types and baseline equipment data from participant surveys and compared these data with project applications and supporting invoices. The evaluation team used this information to assess if the data recorded in the program tracking database was accurate.

Because we designed and drew our sample in 2014, clothes washers were not included in the sample as this measure was not offered until 2015.

Table 6-15: Water Heat Program Achieved Sample

Strata	Document Audit	Phone Survey
Clothes Washers	0	0
Electric Water Heater	13	13
Showerheads[1]	11	11
TOTAL	**24**	**24**

[1]Sample from manufactured homes duct sealing direct install program.

In addition to the participation verification activities described above, the evaluation team also conducted an engineering analysis to estimate per unit savings for showerheads for each efficiency level. The evaluation team estimated savings from low flow showerheads following Equation 6-3 and the parameters and source for each identified in Table 6-16

Equation 6-3: Low Flow Showerhead Energy Savings Calculation

$$Energy\ Savings\ (kWh/Year) = \frac{People \times Shower\ Time \times Days \times \%Days \times \Delta GPM \times (T_{SHOWER} - T_{IN}) \times C_P \times Den}{3{,}413 \times RE \times Showerheads}$$

Where:

People	= the number of people taking showers (ppl/household)
Shower Time	= the average shower length (min/shower)
Days	= the number of days per year (day/yr)
%Days	= the number of showers per day, per person (shower/day-ppl)
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)
3,413	= the conversion rate between BTU and kWh
RE	= the water heater’s energy factor
Total # of Showerheads	= the number of showerheads per home
High-Efficiency Showerheads	= the number of high-efficiency showerheads installed by the program

Table 6-16: Low-Flow Showerhead Parameters and Data Sources

Term	Value	Source
People	2.51	U.S. 2010 Census
Shower Time	8.06	Regional Technical Form
Days	365	Conversion Factor (day/yr)
%Days	0.68	Regional Technical Form
ΔGPM	0.3, 0.55, 0.7, 0.8	Program data (efficient case); Regional Technical Form (baseline case)
TSHOWER	105	Secondary source[19]
TIN	52	Secondary source[20]
EFelectric	100%	Regional Technical Form
CP	1	Constant (BTU/lb-oF)
Den	8.33	Constant (lb/gal)
Number of Showerheads	1.91	U.S. 2010 Census; Regional Technical Form

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

Per unit savings were estimated based on these parameter inputs and extrapolated total savings from showerheads based on the measure counts reported by the program implementers. The Simple Steps database provided the overall number of showerheads sold through the program in Washington; however, no program data was available to determine the proportion of showerheads installed in homes with electric water heating. In order to determine the proportion of homes with electric water heating, the evaluation team leveraged data collected through the 2011 Single Family Regional Building Stock Assessment[21]. We used data specific to Washington to assign the proportion of Simple Steps showerheads that contributed to electric savings. This issue was not present for showerheads installed by UCONS under the manufactured home duct sealing program, as UCONS contractors reported the water heater fuel type for each home that received showerheads.

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

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

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

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

team based the portion assigned to Washington on Avista's Washington residential customer base relative to its entire customer base.

6.4.4 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 assessed and agreed with the savings value being reported for the Simple Steps clothes washer and electric water heater measures. Therefore, these measures were assigned a 100% realization rate.

The analysis conducted for the low flow showerheads, as described above, resulted in a blended realization rate across the 2.0, 1.75, 1.6 and 1.50 GPM Simple Steps showerheads of 157%. The UCONS program reported a higher per unit savings value than the Simple Steps program reported, resulting in the realization rate for the UCONS showerheads of 88%.

The main reasons for the large realization rate for the Simple Steps showerheads include:

- The per unit savings are lower than the evaluation team's calculated values most likely due to a difference in some of the parameters discussed in Table 6-16 above.
- The evaluation team assumed that approximately 60% of the showerhead installations savings are tied to an electric water heater, whereas Avista reports 50% toward electric water heater savings.

The total program realization rate and savings are presented in Table 6-17. The relative precision of the program level electric realization rate is ±13.4% at the 90% confidence level.

Table 6-17: Water Heat Program Gross Verified Savings

Measure	2014–2015 Participation Count	2014–2015 Reported Savings (kWh)	2014–2015 Adjusted Reported Savings (kWh)	Realization Rate (%)	Gross Verified Savings (kWh)
Electric Water Heater	71	7,846	7,846	100%	7,846
Simple Steps Clothes Washers	608	80,256	80,256	100%	80,256
Simple Steps Showerheads	6,598	338,898	338,898	157%	533,754
UCONS Showerheads	1,312	406,720	406,720	88%	359,334
TOTAL	**8,589**	**833,720**	**833,720**	**118%**	**981,190**

6.5 ENERGY STAR® Homes

6.5.1 Overview

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

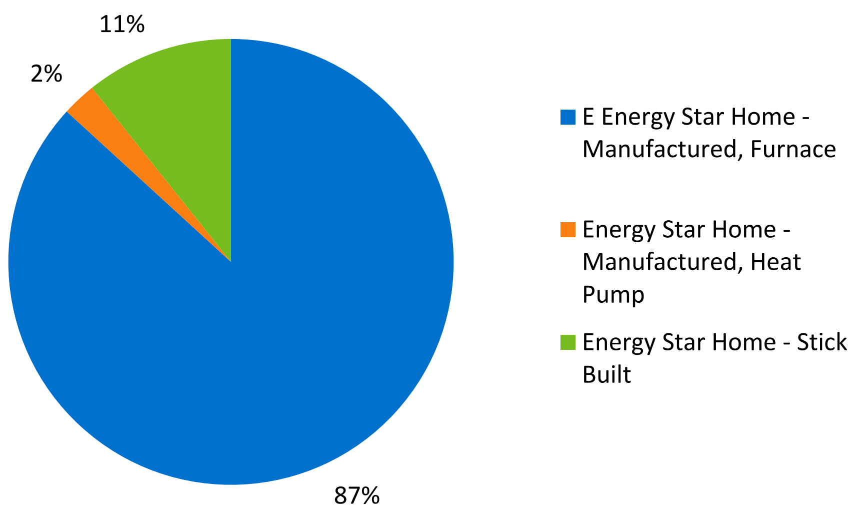
6.5.2 Program Achievements and Participation Summary

Participation in the 2014-2015 ENERGY STAR® Homes program totaled 28 homes. Table 6-18 and Figure 6-6 summarize Avista's 2014 and 2015 ENERGY STAR® Homes program participation and energy impacts.

Table 6-18: 2014–2015 ENERGY STAR® Homes Reported Participation and Savings

Measure	2014–2015 Reported Participation Count	2014–2015 Reported Savings (kWh)
E Energy Star Home - Manufactured, Furnace	23	153,144
E ESTAR HOME - MANUF, HEAT PUMP	1	4,390
E ENERGY STAR HOME–STICK BUILT, WA	4	18,936
TOTAL	**28**	**176,470**

Figure 6-6: 2014–2015 ENERGY STAR® Homes Program Reported Energy Saving Shares



6.5.3 Methodology

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

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

The evaluation team estimated weather normalized annual consumption for ENERGY STAR® Homes using the same basic model specification shown in Equation 3-1and Equation 3-2. Because these newly built homes do not have a pre-retrofit period, only “post-retrofit” consumption was estimated by the model (in this case, the “retrofit” occurs upon completion of the home or at the time of occupancy).

To estimate what the home’s consumption would have been, absent the ENERGY STAR® program, each home’s weather normalized annual consumption estimates was scaled up by a weighting factor calculated as the quotient of the base HERS Index score 80 and the home’s HERS Index score. Equation 6-4 shows the calculation of estimated consumption absent the program. Note that Equation 6-4 denotes electric consumption for ENERGY STAR® Homes; estimated natural gas consumption absent the program was calculated in exactly the same manner, replacing therms for kWh in Equation 6-4 and Table 6-19 below.

Equation 6-4: Calculation of Consumption Absent Program

$$\mathrm{kWh_{NP}} = \mathrm{kWh_{P}} \times \frac{\mathrm{HERS_{Base}}}{\mathrm{HERS_{Home}}}$$

Table 6-19 provides additional information about the terms in Equation 6-4.

Table 6-19: Calculation of Consumption Absent Program Definition of Terms

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

Estimated savings for the 15 ENERGY STAR Natural Gas Homes (therms) and four ENERGY STAR® Stick Built, WA Homes (kWh) were calculated individually using each home's specific HERS Index score and averaged for each cohort. HERS Index scores for the remaining ENERGY STAR® Homes were not available, so the evaluation team applied the mean HERS Index score from among the 19 ENERGY STAR® Homes with HERS Index scores and estimated annual consumption absent the program in the same way for these homes, using Equation 6-4.

6.5.4 Findings and Recommendations

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

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

Table 6-20 shows calculations for electric savings and realization rate for ENERGY STAR® Stick Built homes in Washington. Two of these homes did not have adequate billing data to produce reliable weather normalized consumption estimates and consequently were dropped from the analysis. Analysis on these homes estimated approximately 6,861 annual kWh used under program conditions. The HERS Index weight of 1.7 estimated 11,694 kWh annually under non-program conditions, resulting in 4,833 kWh estimated savings.

Table 6-20: ENERGY STAR Home: Results for Stick Built homes in Washington

n Homes	Ex Ante kWh	Annual kWh	Base kWh	Delta kWh	Weight	Realization Rate
2	4,734	6,861	11,694	4,833	1.7	102%

The evaluation team calculated an average HERS Index score for the 19 homes having individual HERS Index scores. The average score of 49.3 was applied to the remaining subset of ENERGY STAR® - Manufactured, Furnace homes that do not have individual HERS Index scores. Annual consumption and realization rate for these homes are summarized in Table 6-21. Because of the small participation for the ENERGY STAR® Manufactured, Heat Pump homes (one home participated in 2014), the evaluation team applied the same realization to this one participant.

Table 6-21: ENERGY STAR Home: Results for Furnaces in Manufactured Homes

n Homes	Ex Ante kWh	Annual kWh	Base kWh	Delta kWh	Weight	Realization Rate
17	6,847	14,173	23,016	8,843	1.6	129%

6.5.5 Program Results

Table 6-22 outlines the program reported, adjusted, and gross verified savings value for each measure in the ENERGY STAR® homes program. The evaluation team found a 126% realization rate across the entire program. The relative precision of the program level electric realization rate is ±14.4% at the 90% confidence level.

Table 6-22: ENERGY STAR® Homes Program Gross Verified Savings

Measure	2014–2015 Reported Participation Count	2014–2015 Reported Savings (kWh)	2014–2015 Adjusted Reported Savings (kWh)	Realization Rate	Gross Verified Savings (kWh)
E Energy Star Home: Manufactured, Furnace	23	153,144	157,481	129%	203,385
Energy Star Home: Manufactured, Heat Pump	1	4,390	4,390	129%	5,670
Energy Star Home: Stick Built	4	18,936	18,936	102%	19,332
TOTAL	**28**	**176,470**	**180,807**	**126%**	**228,387**

6.6 Fuel Efficiency

6.6.1 Overview

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 evaluation team conducted a document review, database review, telephone surveys, and a billing analysis on a sample of the population in order to estimate the gross verified savings for the program.

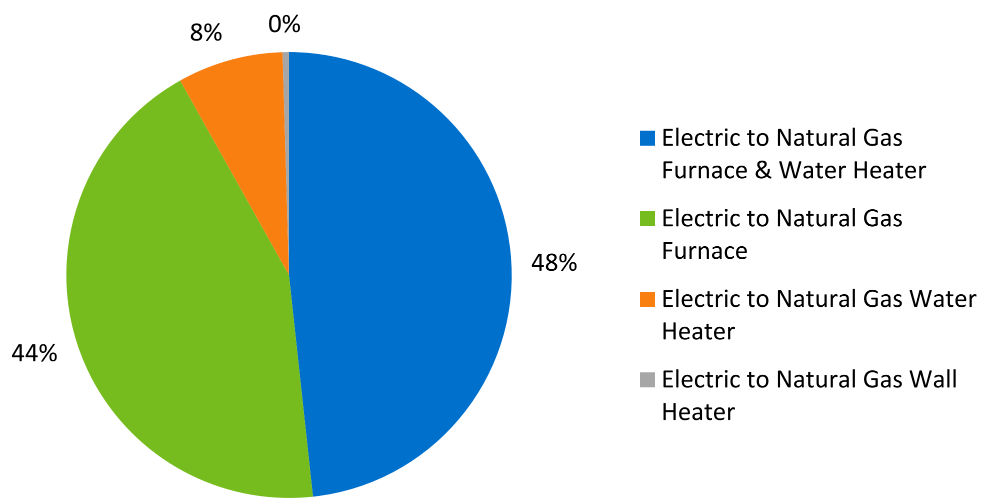
6.6.2 Program Achievements and Participation Summary

Participation in the 2014-2015 Fuel Efficiency program totaled 613 conversions. Table 6-23 and Figure 6-7 summarize Avista's 2014-2015 Fuel Efficiency program participation and energy impacts.

Table 6-23: 2014-2015 Fuel Efficiency Reported Participation and Savings

Measure	2014–2015 Reported Participation Count	2014–2015 Reported Savings (kWh)
Electric to Natural Gas Furnace & Water Heater	210	3,460,081
Electric to Natural Gas Furnace	258	3,123,120
Electric to Natural Gas Water Heater	142	549,452
Electric to Natural Gas Wall Heater	3	32,796
TOTAL	**613**	**7,165,449**

Figure 6-7: 2014–2015 Fuel Efficiency Program Reported Energy Saving Shares



6.6.3 Methodology

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

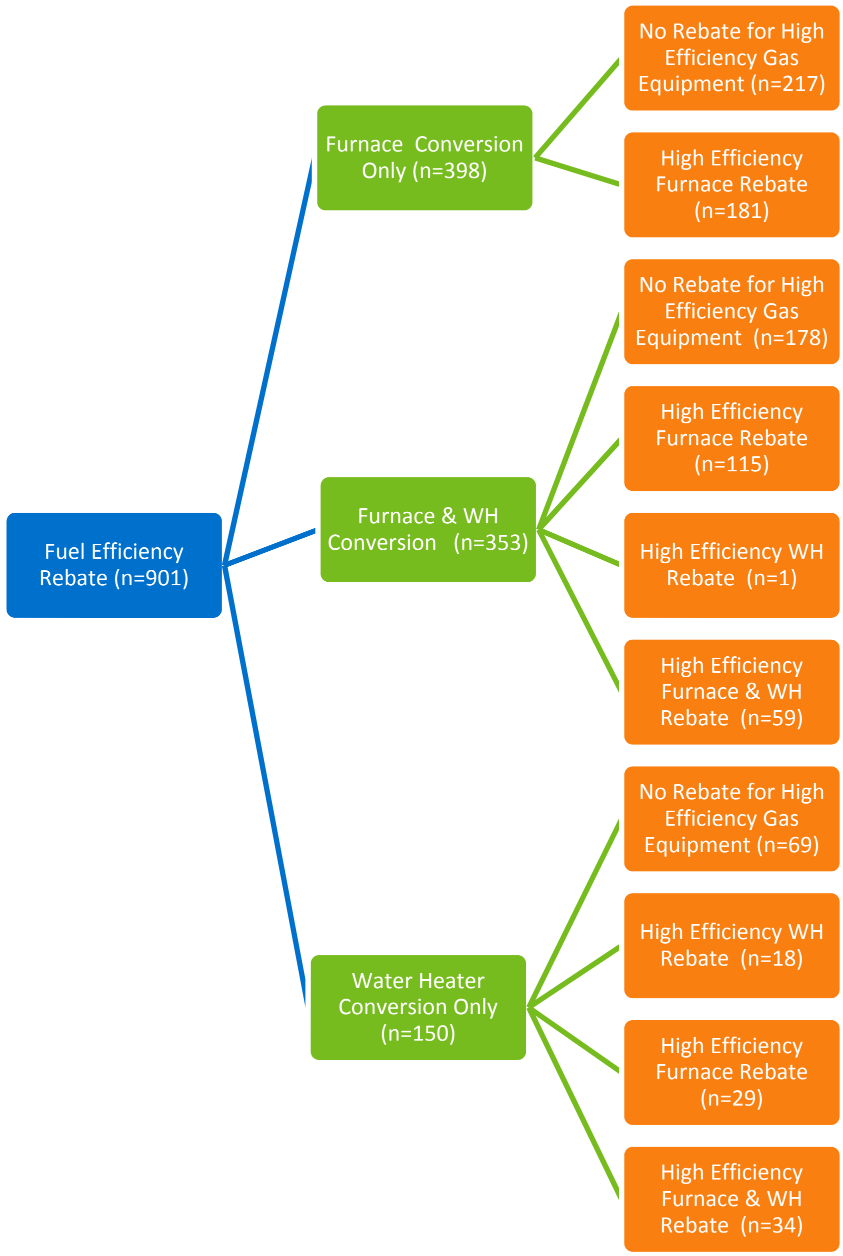
1) Over half of homes that received Fuel Efficiency rebates did not have natural gas service with Avista prior to participation[22]. This means the gas furnace or water heater was installed shortly after gas service was added to the residence. It also makes the gas usage in the home pre-retrofit intuitive—zero therms per year.

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

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

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

Figure 6-8: Diagram of Fuel Switching Participation

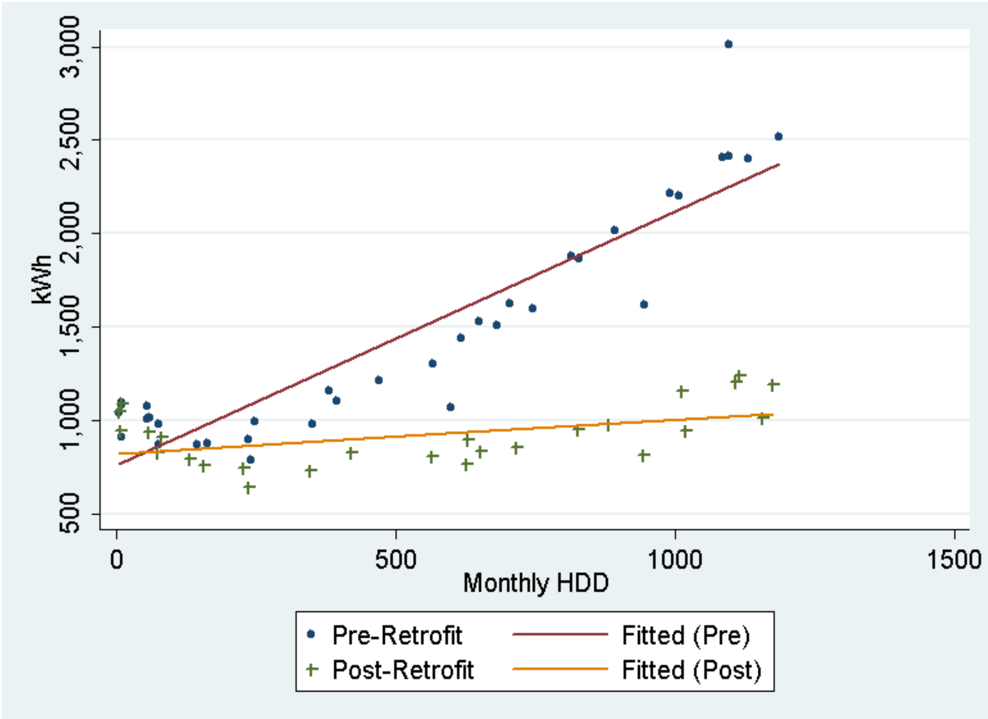


The complexities around secondary rebates for installation of high efficiency rebates were not a major concern for the electric savings analysis because the high efficiency water heater and furnace don't significantly affect the electric usage of the home. The evaluation team did exclude any homes that participated in the Shell rebate program in order to isolate the electric savings from Fuel Efficiency as much as possible. A small number of homes that converted from electric heat to natural gas furnaces also received rebates for installation of a variable speed electric furnace fan, but because the expected fan savings were minimal when compared to the fuel conversion the evaluation team elected not to exclude them from the analysis.

The evaluation team estimated three separate electric regression models, one for each of the conversion types shown in Figure 6-8. The general form of the electric regression model is shown in Section 3.4.4 of this report and the detailed regression output is presented in Appendix C . In order to maximize the number of homes analyzed the evaluation team relaxed the required number of months for inclusion in the analysis. Homes with at least nine months of pre-retrofit electric billing history and six months of post-retrofit billing history were included in the electric analysis.

Figure 6-9 presents a simplified example of the utility bill regression analysis used to estimate electric savings following receipt of Fuel Efficiency rebates. This example uses a single customer and relies on only heating degree days (HDD) to explain the variation in monthly electric usage. During pre-retrofit period electric consumption rises sharply as weather conditions get colder. In the post-retrofit period the slope of the line is still positive, likely due to increased use of the furnace fan or lighting within the home during cold winter months, but the relationship is much less dramatic than the pre-retrofit period. When the slopes of these lines are applied to an identical expected number of annual HDD, the difference in expected kWh is interpreted as savings attributable to the program. The evaluation team’s regression analysis to estimate gross verified savings utilized many homes and also incorporated cooling degree days (CDD) as an independent variable, but the underlying principle is the same.

Figure 6-9: Fuel Efficiency Regression Analysis, Example Home



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

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

6.6.4 Findings and Recommendations

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

Table 6-24 provides detail on the electric billing analyses for the three different fuel conversion paths incented by Avista.

Table 6-24: Fuel Efficiency Electric Billing Analysis Summary Statistics

Rebate Type	Water Heater	Furnace	Furnace & Water Heater
Number of Homes Analyzed	71	173	102
Average Reported kWh	3,864	12,168	16,211
Average Annual kWh Pre	13,403	19,623	19,355
Average Annual kWh Post	9,647	12,100	10,083
Average Weather Normalized Annual kWh Savings per Home	3,756	7,524	9,272
Electric Realization Rate	97%	62%	57%

The “Water Heater” column in Table 6-24 includes both tank and wall heaters. These homes used significantly less electricity prior to the conversion than the homes who converted heating systems—likely because a majority of the homes already used fossil fuel heating systems. The regression coefficients in Table C-8 in Appendix C show an expected pattern of savings. The coefficients for the change in heating and cooling loads within the homes are small and not statistically significant. However the coefficient representing the change in daily baseload (1.treatment) is highly significant and estimates an 8.5 kWh per day reduction in non-weather dependent electric load.

The homes that converted heating fuel from electricity to natural gas showed similarly large weather-normalized annual electric pre-retrofit. The furnace-only homes used 19,623 kWh, on average, and the furnace-and-water heater homes used 19,355 kWh annually. The realization rates for the two groups were similar, with the group that converted both systems showing a lower realization rate than the groups that converted just one system.

Appendix C contains the full regression output for these two fuel conversion groups, but the evaluation team also estimated a combined model using both the furnace and furnace-and-water heater homes. The regression coefficients from this analysis are presented in Table 6-25.

Table 6-25: Regression Coefficients from Combined Furnace Conversion Model

Model Term	Coefficient	Lower Bound of 90% CI	Upper Bound of 90% CI
Intercept	14.69	12.59	16.79
Treatment	8.48	6.65	10.31
hdd_ave	2.01	1.89	2.13
treatment*hdd_ave	-1.63	-1.75	-1.51
cdd_ave	2.57	2.33	2.81
Treatment*cdd_ave	-1.16	-1.37	-0.95

As expected, this model estimates a dramatic reduction in the electric heating consumption of homes who replaced their electric heating system with a natural gas furnace. On average homes go from using 2.01 kWh per HDD (base 65 F) to 0.38 kWh per HDD. Interestingly, the model also estimates a reduction in cooling usage of 1.16 kWh per CDD from 2.57 to 1.41. Another noteworthy result in Table 6-25 is the estimated *increase* in base load from 14.69 kWh per day to 23.17 kWh per day. This 3,000 kWh annual increase could be an artifact of the model fit statistics, either because of small sample size or the 65 (F) degree day base is not accurately disaggregating loads within all homes. However, another possibility is that participating homes are undergoing some other fundamental change at the same time as the fuel conversion. Major home improvement projects such as a home addition or finishing a basement, or a change in occupancy within the home could drastically alter the consumption patterns within a home. The evaluation team recommends Avista consider asking participants to indicate on their rebate application if major home renovations are being completed in parallel with the heating system fuel conversion. We believe excluding any such homes from future billing analysis would be justified and limit the possibility of home improvement projects confounding the electric savings estimates from Fuel Efficiency rebates.

6.6.5 Program Results

The electric realization rate for the Fuel Efficiency program was 62%. This program level realization rate was developed by taking a weighted average of the realization rates of the Fuel Efficiency rebate types shown in Table 6-26. The relative precision of the program level electric realization rate was ±6.9% at the 90% confidence level.

Table 6-26: Fuel Efficiency Program Reported and Gross Verified Savings

Measure	2014–2015 Reported Participation Count	2014-2015 Reported Savings (kWh)	2014–2015 Adjusted Reported Savings (kWh)	Realization Rate	Gross Verified Savings (kWh)
Electric to Natural Gas Furnace & WH	210	3,460,081	3,466,881	57%	1,982,878
Electric to Natural Gas Furnace	258	3,123,120	3,123,120	62%	1,931,062
Electric to Natural Gas Water Heater	142	549,452	553,702	97%	538,113
Electric to Natural Gas Wall Heater	3	32,796	32,796	97%	31,873
TOTAL	**613**	**7,165,449**	**7,176,499**	**62%**	**4,483,925**

6.7 Residential Lighting Program

6.7.1 Overview

In 2014 and 2015, the Avista residential lighting program was comprised of three delivery streams: Simple Steps, UCONS, and the Avista Bulb Giveaway.

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 may select which reduced-price items to include in their territory. Avista's offerings included a selection of general and special CFLs, LED light fixtures, and LED bulbs that were clearly identified with a sticker indicating they were part of the Simple Steps, Smart Savings program. Retailers—big-box stores, regional chains, and national chains—were the primary recipients of the products and typically selected from Avista's approved options for each store location. Additionally, Simple Steps program provided Avista with an allocation of additional residential lighting savings from non-participating utilities; this subprogram is called "Simple Steps – NP." In 2014, the Avista residential lighting program included direct installs of CFLs, implemented by UCONS. Finally, Avista gave its customers free, energy-efficient lighting products, specifically CFL and LED lamps, at corporate and regional events.

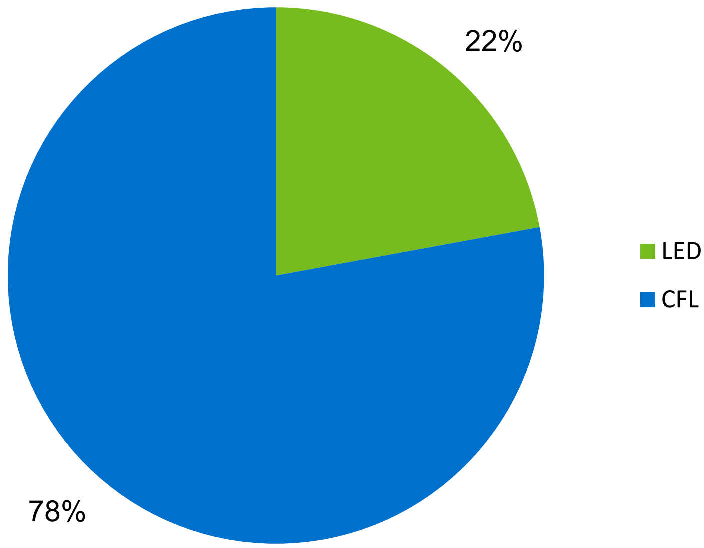
6.7.2 Program Achievements and Participation Summary

Table 6-27 and Figure 6-7 summarize Avista's 2014 and 2015 residential lighting program participation and energy impacts.

Table 6-27: 2014–2015 Residential Lighting Reported Participation and Savings

Measure	2014–2015 Reported Participation Count (Bulbs)	2014–2015 Reported Savings (kWh)
Simple Steps—LED	207,956	4,308,734
Simple Steps—CFL	868,529	14,866,096
Simple Steps – NP—LED	1,391	14,877
Simple Steps – NP—CFL	15,484	165,598
Giveaway—CFL	244	3,660
Giveaway—LED	1,815	9,995
UCONS	10,316	237,268
TOTAL	**1,105,735**	**19,606,228**

Figure 6-10: Distribution of Lighting Energy Savings by Technology Type



Reported energy savings are based on a per-lamp basis, using a deemed value for each lamp product type and delivery approach (i.e. retail, direct installation, giveaway) based on legacy regional technical forum values.

6.7.3 Methodology

The lighting program gross impact analysis involved three distinct program components, although each component ultimately depended on the same calculation and parameters to estimate gross impacts. The underlying values for the input parameters were the only differentiation across program components. Therefore, to simplify the approach and methodology for the program, the evaluation team included a review of each of the key parameters associated with energy savings. The team relied on savings protocols as specified in the DOE-UMP. The UMP includes a full chapter on residential lighting evaluation protocols.[23]

The annual kWh savings for the lighting program are dependent on several key parameters. The annual energy savings produced when a CFL or LED bulb replaces an incandescent bulb is calculated as shown in Equation 6-5 :

Equation 6-5: Calculation of Consumption Absent Program

$$Annual\ kWh\ Savings = Total\ bulbs \times \Delta Watts \times 365.25 \times HOU_{Daily} \times ISR \times IE$$

[23] Residential Lighting Chapter (21) in the UMP: http://energy.gov/sites/prod/files/2013/11/f5/53827-6.pdf. [

Where:

$Annual\ kWh\ Savings$ = *The average annual energy savings from replacing the incandescent bulb with a more efficient bulb*

$Total\ bulbs$ = *The total number of verified program incentivized bulbs*

$\Delta Watts$ = *The change in connected load (baseline minus efficient wattage)*

HOU_{Daily} = *The average operating hours per day the light is turned on*

365.25 = *Average number of days per year (to annualize daily HOU)*

ISR = *The in-service rate*

IE = *The interactive effects (loss of inefficient bulb waste heat).*

Table 6-28 shows each of the key parameters and the inputs for each parameter for the gross savings analysis. More detail about the data sources/collection activities and parameter estimates is presented in the remainder of this section.

Table 6-28: Lighting Program Parameters and Sources

Parameter	CFL Retail	LED Retail	CFL Giveaway
Number of Bulbs	Tracking Database	Tracking Database	Tracking Database
Hours of Use	2015 Light Metering Study—Evaluation	2015 Light Metering Study—Evaluation	2015 Light Metering Study—Evaluation
Delta Watts	Tracking Database, EISA Mapping	Tracking Database, EISA Mapping	Participant Survey
In-Service Rate	Regional Technical Forum; UMP	Regional Technical Forum	Regional Technical Forum; UMP
Cross Sector Leakage	Retailer Interviews	Retailer Interviews	Not applicable
Interactive Effects	Regional Technical Forum	Regional Technical Forum	Regional Technical Forum

6.7.3.1 Total Program Bulbs

The evaluation team verified the number of CFL and LED lamps, product type, location, and the bulb wattage distributed via the Simple Steps program via a database review for the State of Washington. For internal reporting, Avista uses a 70%/30% split to separate the total Simple Steps units between its Washington and Idaho service territories, respectively. During the review of the program database, the evaluation team found that 70.2% of the total units were actually in the Washington service territory. Because of this 0.2% difference between Avista's internal reporting method and the numbers in the database, a slight difference appears between the total units shown in Table 6-27 and in Table 6-29. The actual lamp unit counts in Table 6-29 were used in the evaluation analysis.

Table 6-29: Verified Residential Lighting Unit Counts by Lamp Type and Delivery Stream

Program Delivery Stream	Lamp Type	Unit Counts
Simple Steps	CFL General Purpose	762,002
	CFL Specialty: Reflector	101,476
	CFL Specialty: Globe	736
	CFL Specialty: Candelabra	1,475
	CFL Specialty: 3-way	1,283
	CFL Fixture	4,746
	CFL Subtotal	**871,718**
	LED General Purpose	188,674
	LED Specialty: Reflector	17,355
	LED Specialty: Globe	2,174
	LED Specialty: Candelabra	5,639
	LED Specialty: 3-way	391
	LED Fixture	11,866
	LED Subtotal	**226,099**
Simple Steps - NP	CFL General Purpose	9,886
	CFL Specialty: Reflector	609
	CFL Specialty: Globe	29
	CFL Specialty: Candelabra	137
	CFL Specialty: 3-way	7
	CFL Fixture	170
	CFL Subtotal	**10,839**
	LED General Purpose	620
	LED Specialty: Reflector	229
	LED Specialty: Globe	15
	LED Specialty: Candelabra	48
	LED Specialty: 3-way	1
	LED Fixture	62
	LED Subtotal	**980**
Giveaway	LED General Purpose	244
	CFL General Purpose	1,815
UCONS	CFL General Purpose	10,316
TOTAL		**1,111,092**

6.7.3.2 Hours of Use

As part of the evaluation of residential lighting, the team conducted a large-scale residential lighting hours-of-use (HOU) study by collecting usage data from onsite metering of lighting fixtures in the homes of Avista customers. The study methodology aligns with the Department of Energy (DOE) Uniform Measure Project (UMP) for residential lighting. The research team measured how many hours per day various lighting fixtures were illuminated during a six-month study period beginning July 2015 and lasting through January 2016, at the residences of 74 Avista customers. An average of seven lamps per home were metered across a random sample of fixture and room types, with 522 lighting meters deployed across Avista’s service territory. Collecting data for an average of seven lamps per residence enabled the team to gather a large dataset for analysis across multiple delivery streams, residence, and room types. Metered lamps included both efficient lamps (CFLs and LEDs) and inefficient lamps (incandescents and halogens). A full inventory of lighting (fixture, socket, lamp type, etc.) was also performed while onsite. Chapter 8 details the residential lighting hours-of-use study.

As a study outcome, the measured hours of use for residential lighting bulbs appear in Table 6-30.

Table 6-30: Verified Hours of Use for Residential Lighting

Room (Logger level, weighted by event type)	Annualized Room-Based HOU/day
Kitchen	3.75
Dining	2.48
Living/Great/Family	2.41
Foyer/Hall/Stair	1.25
Bedroom	1.25
Toilet/Bathroom	1.82
Other	1.52
TOTAL WEIGHTED AVERAGE	**1.94**

Because the room type and previous bulb technology of the installed residential lamp is unknown, the total weighted average hours of use of 1.94 hours per day was applied for all residential premises. This value is identical to the Regional Technical Forum value for 60W-equivalent screw-in lamps delivered through a retail markdown channel in the most current UES assumptions.

6.7.3.3 Delta Watts

Delta watts represent the difference between the wattage of the assumed baseline product and the wattage of the CFL or LED. For the CFL and LED markdown programs, the evaluation team first assessed Energy and Independence Security Act (EISA) eligibility for each program bulb product type, segmenting the bulbs into a few groups: EISA-qualified general service lamps (GSL), EISA-qualified reflectors, decorative lamps, and globes. These categories were assigned baselines considering lumen equivalency and “bin mapping,”[24] as summarized Table 6-31 and Table 6-32

Table 6-31: Standard Lamp Baseline Wattage for Equivalences

Minimum Lumens	Maximum Lumens	Incandescent Equivalent Wattage	
		Baseline (Exempt Bulbs)	Baseline (Post-EISA)
2,000	2,600	150	72
1,600	1,999	100	72
1,100	1,599	75	53
8000	1,099	60	43
450	799	40	29
310	449	25	15

Table 6-32: Decorative and Globe Lamp Baseline Wattage for Equivalences

Lumen Bins		Incandescent Equivalent Wattage	
Decorative Shape	Globe Shape	Baseline (Exempt Bulbs)	Baseline (Post-EISA)
	1,100–1,300	150	72
	650–1,099	100	72
	575–649	75	53
500–699	500–574	60	43
300–499	350–499	40	29
150–299	250–349	25	15
90–149		15	15
70–89		10	10

For some product type, the lumen bin is documented by Simple Steps and is easy to map to these EISA bins. For other products, only the efficient case wattage of the product type is known; the evaluation team correlated the wattage to the equivalent lumen bin for each lighting technology (i.e. CFL or LED) through market research.

For the assessment of gross verified energy savings, the post-EISA baseline was used for each product type and wattage. Additionally, the evaluation team calculated a market baseline considering the composition of lamp types found from onsite inspections in the lighting study; respective EISA equivalent baselines; and efficient case wattage to determine the free-ridership

[24] “Bin mapping” refers to the assignment (or “mapping”) of lumen-based equivalent bulbs based on ranges (or “bins”) to determine baseline watts.

market effects, in which a customer likely replaced an expired efficient technology with a like technology. Refer to the description in Appendix E for additional information.

6.7.3.4 Interactive Effects

The team considered heating and cooling interactive effects associated with replacing standard incandescent light bulbs with higher efficiency lighting technology. CFLs and LEDs release substantially less heat into the room, leading to increased heating and decreased cooling loads for a home.

The evaluation team used a single, deemed value of 93.4% to estimate the impacts of the heating, ventilating, and air conditioning (HVAC) system based on assumptions from the most recent RTF residential lighting UES calculation model. Stated differently, the electric energy savings of the efficient lamp were effectively reduced by 6.6% because of the necessary increase in electric heating. However, the evaluation team believes that this reduction factor is likely high for Avista's service territory, because gas-heated homes are more prevalent there than in the Pacific Northwest at-large.

6.7.3.5 Installation Rate

The installation rate, also commonly referred to as the in-service rate (ISR), represents the percentage of program bulbs purchased that are ultimately installed by program participants. This rate quantifies customers' common practice of waiting to replace a bulb until it has burned out, which can lead to product storage and deferred installation. Retail and giveaway programs distribute the bulbs but do not guarantee that customers actually install the bulbs.

For the CFLs distributed as part of the Simple Steps retail program and Avista giveaway delivery channels, the evaluation team used first-year installation rates of 76% from the most recent RTF residential lighting UES calculation model and RBSA[25]. This installation rate only considers the first-year installation rate; it is well understood that stored lamps will eventually be installed by the customer[26]. Because Avista reports program savings on a first-year, annualized basis, the evaluation discounted the future savings of stored lamps back to present value. The RTF UES calculation model recognizes that stored lamps will be installed in the future, but elects to only apply a 109% savings factor in the future and does not provide a present value that can be used in evaluations with first-year savings values.

The evaluation team followed industry-standard DOE-UMP protocols to forecast the future installation trajectory for both program components. Trajectory refers to the installation rates to account for installations that occur in the years following the program year in which the bulb was purchased. The UMP trajectory leverages a comprehensive multi-year study that tracked installations for the same group of participants. A review of the trajectory calculations is included

[25] 24% Storage Rate; Ecotope Inc., "2011 Residential Building Stock Assessment: Single-Family Characteristics and Energy Use", prepared for the Northwest Energy Efficiency Alliance, September 2012.

[26] Section 4.12 Residential Lighting Chapter (21) in the UMP: http://energy.gov/sites/prod/files/2013/11/f5/53827-6.pdf.

in Table 6-33 below. The team used 20-year Treasury bill rates, currently 2.3%, as the rate to discount future installation savings. Using the 2.3% discount rate and accounting for years two through four for installations per the UMP, the final estimated CFL markdown installation rate was 97.5%.

Table 6-33: In-Service Rate Trajectory for Markdown and Giveaway CFL based on UMP

Year	Incremental % Installed	Total % Installed	ISR Calculation	Retail/ Giveaway
Year 1	NA	NA	Researched Value	76%
Year 2	41%	41%	(Storage %Y1 * 41%)+ISR Y1	85.8%
Year 3	28%	69%	(Storage %Y1 * 69%)+ISR Y1	92.6%
Year 4	NA	NA	Default to 97%	97.0%
OVERALL ISR	**NA**	**NA**	**NPV Y1->Y4**	**97.5%**

Consistent with the RTF assumption, the team chose to apply a 100% installation rate for LEDs because:

- Limited or no applicable or equivalent research has been completed for LED bulbs
- The LEDs were purchased as single packs; the CFLs were purchased as multipacks, encouraging customers to place them in storage
- The higher prices of LEDs would likely lead to limited, if any, stockpiling.

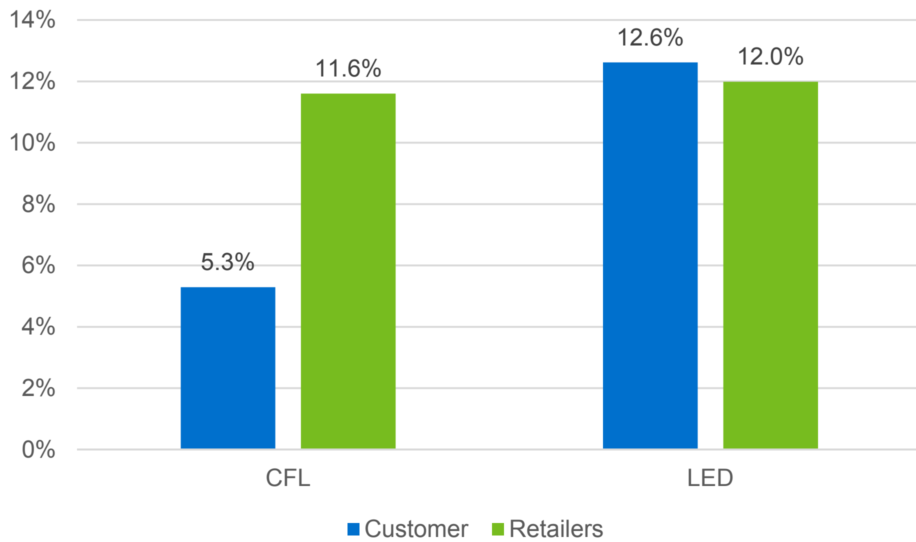
Additionally, consistent with the RTF assumptions, the team chose to apply a 100% installation rate for direct-installation lamps performed by UCONS because the program will not place lamps in storage

Finally, consistent with the RTF assumption, the evaluation team applied a 2% removal rate for all lamps removed before expiration.

6.7.3.6 Cross-Sector Sales Leakage

The Simple Steps, Smart Savings program promotes the sales of CFL and LEDs to residential customers. Avista currently only reports savings for this offering through their residential lighting program. However, because of the delivery mechanism of the program via in-store, buy-down promotions, the evaluation team sought to understand if nonresidential customers were purchasing bulbs discounted through the program and, if so, what percentage of Simple Steps bulbs were “leaking” into the nonresidential sector. The evaluation team estimated this “leakage” into the commercial sector using the responses of customers (participants and nonparticipants), as well as by conducting a survey of large retailers that sell Simple Steps items. The evaluation team’s activities are outlined in the process evaluation report of Avista Utilities 2014 and 2015 energy efficiency programs. Figure 6-11 summarizes the evaluation team findings from surveys of customers and retailers for CFL and LED lamps.

Figure 6-11: Estimates of Percentage of Products in Commercial Sector



Additionally, the evaluation team used the RTF nonresidential operating characteristics to inform the nonresidential HOU: 8 hours per day as a weighted average across the business types[27]. The commercial parameter assumptions, including operating hours and in-service rates, are included in Table 6-34.

Table 6-34: Nonresidential Lighting Input Parameter Assumptions

Parameter	CFL bulbs	LED bulbs
Hours of Use	8.0	8.0
Cross Sector Sales Shares	8.4%	12.3%

6.7.4 Findings and Recommendations

The verified unit counts, verified energy savings, and average savings per lamp are summarized in Table 6-36 for each product type in the residential lighting program.

[27] This value is from market research Nexant conducted for the State of Pennsylvania as the Statewide Evaluator (SWE). http://www.puc.pa.gov/pcdocs/1340978.pdf

Table 6-35: Verified Residential Lighting Energy Savings by Lamp Type and Delivery Stream (2014-2015)

Program Delivery Stream	Lamp Type	Unit Counts	Verified Energy Savings (kWh)	Average kWh/bulb
Simple Steps	CFL General Purpose	762,002	16,988,297	22.3
	CFL Specialty: Reflector	101,476	2,386,163	23.5
	CFL Specialty: Globe	736	21,671	29.4
	CFL Specialty: Candelabra	1,475	39,378	26.7
	CFL Specialty: 3-way	1,283	48,465	37.8
	CFL Fixture	4,746	217,877	45.9
	CFL Subtotal	**871,718**	**19,701,850**	
	LED General Purpose	188,674	4,310,120	22.8
	LED Specialty: Reflector	17,355	563,250	32.5
	LED Specialty: Globe	2,174	44,110	20.3
	LED Specialty: Candelabra	5,639	102,264	18.1
	LED Specialty: 3-way	391	17,633	45.1
	LED Fixture	11,866	356,877	30.1
	LED Subtotal	**226,099**	**5,394,253**	
Simple Steps – NP	CFL General Purpose	9,886	237,051	24.0
	CFL Specialty: Reflector	609	15,494	25.4
	CFL Specialty: Globe	29	832	28.7
	CFL Specialty: Candelabra	137	3,073	22.4
	CFL Specialty: 3-way	7	224	32.0
	CFL Fixture	170	7,804	45.9
	CFL Subtotal	**10,839**	**264,478**	
	LED General Purpose	620	18,647	30.1
	LED Specialty: Reflector	229	7,812	34.1
	LED Specialty: Globe	15	304	20.3
	LED Specialty: Candelabra	48	974	20.3
	LED Specialty: 3-way	1	42	41.8

Program Delivery Stream	Lamp Type	Unit Counts	Verified Energy Savings (kWh)	Average kWh/bulb
	LED Fixture	62	1,865	30.1
	LED Subtotal	**980**	**29,644**	
Giveaway	LED General Purpose	244	7,338	30.1
	CFL General Purpose	1,815	44,637	24.6
UCONS	CFL General Purpose	10,316	247,362	24.0
TOTAL		**1,111,092**	**25,983,686**	

The electric realization rate for the residential lighting program is 131%, as shown in Table 6-36. The relative precision of the program-level electric realization rate is ±13.5% at the 90% confidence level, largely based on the residential lighting hours-of-use study.

Table 6-36: Residential Lighting Realization Rates and Gross Verified Savings

Delivery Stream	2014-2015 Participation (unit counts)	2014-2015 Reported Savings (kWh)	Realization Rate	2014-2015 Gross Verified Savings (kWh)
Simple Steps—LED	226,099.00	4,308,734	125.2%	5,394,253
Simple Steps—CFL	871,718.00	14,866,096	132.5%	19,701,850
Simple Steps – NP—LED	980	14,877	199.3%	29,644
Simple Steps – NP—CFL	10,839	165,598	159.7%	264,478
Giveaway —CFL	244	3,660	200.5%	7,338
Giveaway—LED	1,815	9,995	446.6%	44,637
UCONS	10,316	237,268	104.3%	247,362
TOTAL	**1,122,011**	**19,606,228**	**131.0%**	**25,689,564**

The key factors for the realization rates that were greater than 100% are summarized below:

- Avista's deemed savings estimates, which were generally the same for all similar product types, and not correlated to the bulb wattage, understated the savings, in particular for the giveaway program; improved data illuminated the actual savings
- For product types where Simple Steps and Avista reported a weighted-average energy savings value for multiple lamp wattages, the actual weighted-average, verified-lumen bin was greater than the assumed value, resulting in higher savings
- Verified cross-sector nonresidential sales and the corresponding increase in hours of use meant realization rates over 100%.

6.8 Shell Program

6.8.1 Overview

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

6.8.2 Program Achievements and Participation Summary

Participation in the 2014 and 2015 Shell program totaled 4,016 projects. Table 6-37 and Figure 6-12 summarize Avista's 2014 and 2015 Shell program participation and energy impacts. The evaluation team did find a large outlier in the Window Replacement from Double Pane measure which misrepresented the portion of the program savings across the measures. Figure 6-13 shows the adjusted reported energy savings shares per measure, resulting in a reduction of the window measures representation from 62% (Figure 6-12) to 50% (Figure 6-13).

Table 6-37: 2014–2015 Shell Program Reported Participation and Savings

Measure	2014-2015 Reported Participation Count	2014-2015 Reported Savings (kWh)
Attic Insulation*	398	64,364
Floor Insulation	16	16,038
Wall Insulation	28	52,717
Window Replacement from Single Pane*	2,193	2,436,707
Window Replacement from Double Pane	238	1,090,605
UCONS Manufactured Home Duct Sealing	1,143	1,997,202
TOTAL	**4,016**	**5,657,633**

*Includes projects and savings for gas measures that reported electricity savings

Figure 6-12: 2014–2015 Shell Program Reported Energy Saving Shares

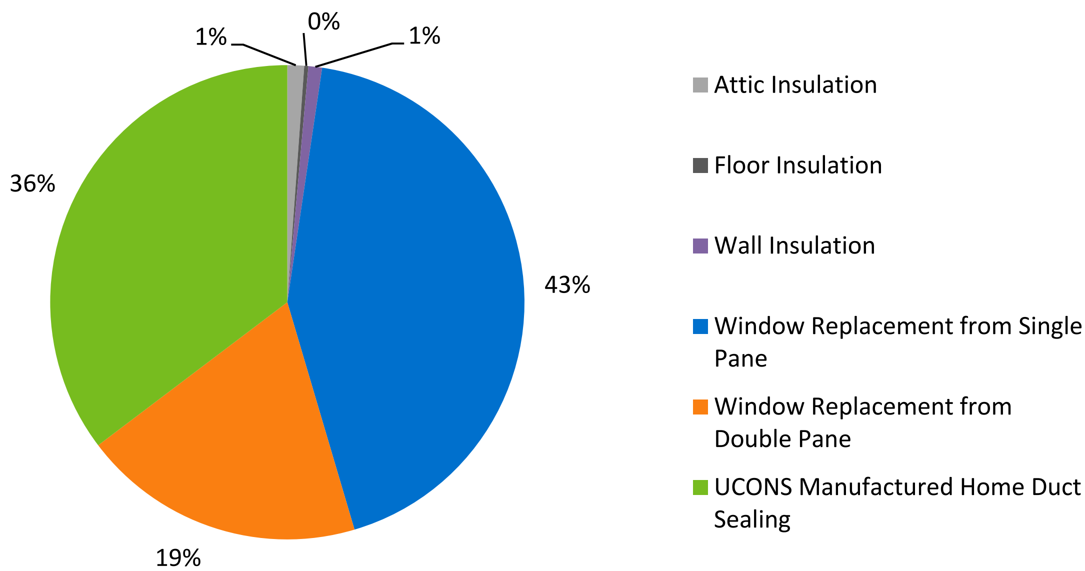
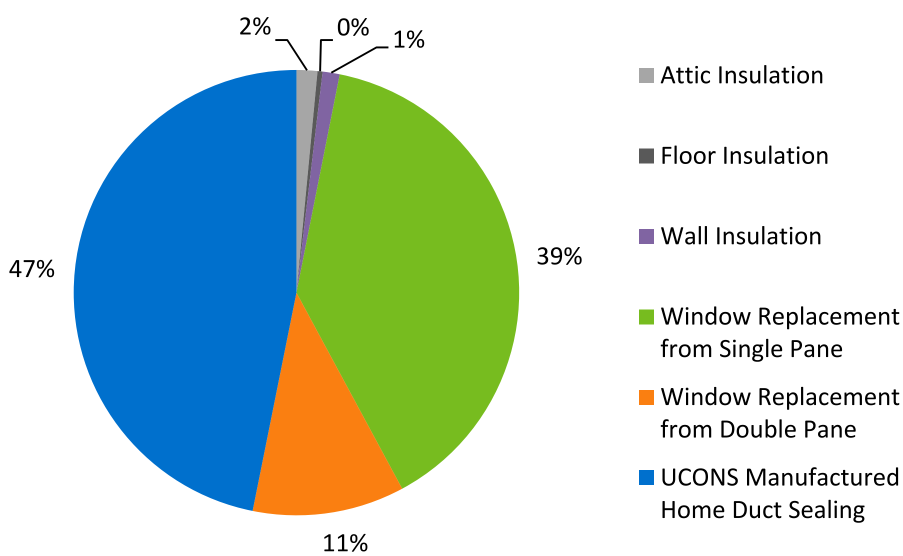


Figure 6-13: 2014–2015 Shell Program Adjusted Reported Energy Saving Shares



6.8.3 Methodology

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

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

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

Where:

kWh_{it}	= Estimated energy usage (dependent variable) in home *i* during period *t*
$Post_{it}$	= Dummy variable indicating whether period *t* was pre- or post-retrofit
CDD_{it}	= Average cooling degree days (base 65 F) during period *t* at home *i*
HDD_{it}	= Average heating degree days (base 65 F) during period *t* at home *i*
ε	= Customer-level random error
β_i	= The model intercept for home *i*
β_{1-5}	= Coefficients determined via regression

The β_1, β_3, and β_5 terms in Equation 6-6 represent the average change in daily baseload, daily kWh per CDD, and daily kWh per HDD respectively. The evaluation team used these coefficients and normal weather conditions (TMY3) for the three chosen weather stations to estimate the average weather normalized annual savings.

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

- Identify the homes that participated in the Shell program and had billing data provided by Avista to the evaluation team **(2,724)**
- Exclude homes that also participated in other Rebate programs to ensure Shell impact estimates are not confounded with impacts from the Fuel Efficiency, HVAC, or other programs. **(2,514)**
- Limit the data set to homes with reported kWh savings and electric billing data **(1,991)**
- Exclude homes with fewer than 12 months of pre-retrofit billing history **(908)**
- Exclude homes with fewer than 12 months of post-retrofit billing history **(767).**

For the evaluation of the UCONS Manufacture Home Duct Sealing component, a similar series of filters was applied to the program participants and their billing data, resulting in 1,179 homes remaining for analysis. As noted in Section 2.2.3, the UCONS initiative installed measures that roll up under the Lighting, Water Heating, and Shell program. For the Shell program analysis, the evaluation team sought to isolate the performance of the duct improvement measure. In order to isolate the duct sealing measure, the evaluation team further trimmed the 1,179 homes that passed each billing analysis screen to only include homes that received duct improvements. Table 6-38 shows the breakdown of installed measures for the 1,179 homes that passed the billing analysis screening steps. Homes that received CFLs only generally had natural gas heating and water heating as evidence by the low average weather normalized consumption. Homes claiming electric savings from showerheads had electric water heating and slightly higher average consumption levels. The homes that received duct improvements were electrically heated and had much higher average reported savings values as well as pre-retrofit consumption.

Table 6-38: 2014 UCONS Electric Participation

Installed Measures	# Homes	Average Reported kWh	Average Pre-Retrofit Usage (Annual kWh)
CFLs only	384	125	8,237
CFLs and showerheads	120	435	11,798
Duct Improvements (with CFLs and showerhead)	675	2,158 total 1,748 from duct repair	17,771

Although many of the homes that received duct sealing measures also received CFLs or showerheads, the "Average Reported kWh" column in Table 6-38 illustrates that the kWh savings from duct improvements represented the majority of the reported savings within the 675 participating homes. In order to isolate the duct sealing savings from the CFL and showerhead savings, the evaluation team assumed that changes in weather dependent consumption (β_3 and β_5 in Equation 6-6) were attributable to duct improvements and used these coefficients to estimate weather normalized savings from duct improvements.

In addition to the billing analysis activities noted above, the evaluation team performed verification of the program tracking database and conducted 28 document audits of participating projects.

6.8.4 Findings and Recommendations

6.8.4.1 Shell Rebate Measures

The evaluation team's regression analysis produced statistically significant reductions in both the cooling and heating loads of homes that implemented the Shell Rebate measures (attic, floor and wall insulation, and window replacements). Appendix C presents the full regression output for the Shell Rebate measures, and the key outputs are summarized in Table 6-39. On average, homes were savings 0.14 kWh per CDD and 0.05 kWh per HDD in addition to 0.39 kWh per day reduction in non-weather dependent electric usage.

Table 6-39: Shell Rebate Model Coefficients

Model Term	Pre-Retrofit	Post-Retrofit	Savings
Base Load	20.04	19.65	0.39
Daily kWh per CDD	1.77	1.63	0.14
Daily kWh per HDD	0.75	0.70	0.05

Although the electric reductions from Shell Rebate measures are statistically significant in both the heating and cooling season, the gross verified savings estimate is well below the reported savings values for the analyzed homes. The average reported savings per home was 1,406 kWh and the average verified savings was 537 kWh. This result equates to a realization rate of 38.2% (Table 6-40) and a 4.1% average reduction in total weather normalized electric consumption (Table 6-41).

Table 6-40: Shell Rebate Gross Verified Savings Summary – per Home

# Homes	Average Reported kWh	Annual kWh Pre	Annual kWh Post	Gross Verified kWh Savings	Realization Rate
767	1,406	13,021	12,484	537	38.2%

The relative precision of the savings estimate is ± 24.8% at the 90% confidence level. Although the per-home margin of error is actually reasonably tight at ± 133 kWh/year, the precision suffers when considered on a relative basis because of the lower than expected impacts. Table 6-41 provides some additional relevant measurements of the estimated gross verified energy savings along with the upper and lower bound of the 90% confidence interval.

Table 6-41: Shell Rebate Precision of Findings

Impact Statistic	Point Estimate	Lower Bound of 90% Confidence Interval	Upper Bound of 90% Confidence Interval
Gross Verified kWh per Home	537	404	670
Realization Rate	38.2%	28.7%	47.6%
Percent Reduction in Whole House Electric Usage	4.1%	3.1%	5.1%
Percent Reduction in Cooling Usage	7.9%	1.8%	14.0%
Percent Reduction in Electric Heating Usage	6.8%	3.0%	10.5%

The evaluation team also examined the performance of Shell Rebate measure categories (window upgrade and insulation) to investigate if the low realization was being driven by a particular measure. Table 6-42 shows the results of this more granular analysis. Savings for homes that received rebates for insulation and windows, both, were not examined.

Table 6-42: Shell Rebate Performance by Measure Category

Parameter	Window Upgrade (Electric Heat)	Window Upgrade (Gas Heat)	Insulation Upgrade (Electric Heat)
Number of Homes Analyzed	209	503	27
Average Reported kWh	2,539	737	1,319
Annual kWh Pre	18,762	10,351	18,516
Annual kWh Post	17,993	9,925	18,254
kWh Savings	769	426	262
Realization Rate	30%	58%	20%

Avista claims a modest electric savings from gas heated homes that install efficient windows – on average 737 kWh per home as shown in Table 6-42. This group's verified savings estimates were closest to the reported values of the three categories analyzed, although none of the differences between groups are statistically significant.

The regression coefficients summarized in Table 6-43 may also help explain the low realization rate for Shell Rebate measures. The evaluation team's regression analysis estimates that prior to retrofit, participating homes were using slightly more than 13,000 kWh annually, but only approximately 5,500 kWh of this consumption was weather dependent HVAC load.

Table 6-43: Shell Rebate Measure Average Annual Usage

Model Term	Pre-Retrofit Coefficient	Multiplier	Annual Usage (kWh)
Base Load (kWh/day)	20.04	365 (days)	7,513 (57.7%)
Daily kWh per CDD	1.77	379 (Spokane CDD)	700 (5.4%)
Daily kWh per HDD	0.75	6,707 (Spokane HDD)	4,808 (36.9%)
Average Annual kWh per Shell Rebate Participant			**13,021**

Savings from shell improvements should be realized almost exclusively through reductions in heating and cooling usage within participating homes. When the average reported savings claim of 1,406 kWh across the 767 homes analyzed is compared to this estimate of end-use load shares, we see that the program is claiming a (1,406/5,508) = 25.5% reduction in HVAC loads. The evaluation team recommends Avista examine planning assumptions about per-home consumption, end-use load shares, and percent reductions in heating and cooling loads from shell improvements. It may be that the percent reduction assumptions are sound, but they are being applied to an overstated assumption of the average electric HVAC consumption per home.

6.8.4.2 UCONS Duct Improvements

Appendix C provides the full regression output for the regression analysis of the 675 homes that received duct sealing from UCONS in 2014. The key coefficients are the average kWh savings per CDD (0.7554) and the average kWh savings per HDD (0.17435). These regression coefficients were applied to a weighted average value of the three Avista weather stations to calculated gross verified savings from duct improvements (Table 6-44).

Table 6-44: UCONS Duct Sealing Analysis Results

Weather Station	Weight	HDD (Base 65 F)	CDD (Base 65 F)	Heating kWh Savings	Cooling kWh Savings	Total kWh
Coeur d'Alene	5.7%	6,915	376	1,206	284	1,490
Lewiston	6.4%	5,511	907	961	685	1,646
Spokane	87.9%	6,707	379	1,169	286	1,456
Weighted Average		**6,641**	**413**	**1,158**	**312**	**1,470**

The ratio of the weather dependent savings (1,470 kWh) to the reported savings from duct repair (1,748 kWh) among the 675 homes analyzed was 84.1% (Table 6-45).

Table 6-45: Shell Rebate Gross Verified Savings Summary

# Homes	Average Reported kWh	Gross Verified kWh Savings	Realization Rate
675	1,748	1,470	84.1%

6.8.5 Program Results

As noted in section 6.8.2, the evaluation team found several significant outliers in Avista's reported data during the database review for the Shell program. In addition, during the document audit activities, the evaluation team also found that reported savings values did not match the project documentation for the majority of the sampled homes that had window replacement from single pane measures (such as size of window installed and baseline measure). In addition, the document audit activities found several discrepancies in the heating fuel type reported for the home and the associated fuel type that the measure is savings. For example, in a few instances, both the customer survey and the project application state wood and natural gas as the primary heating source, but the window and attic insulation incentives were paid based on electric heating. Based on these findings, the evaluation team recommends that Avista work with local contractors to confirm that the measure savings is tied to the correct heating fuel source, perhaps conducting verification activities on a percent of applications received would also help improve the reporting accuracy.

The electric realization rate for the Shell program is 60%. This program level realization rate was developed by taking a weighted average of the realization rates of the program measures shown in Table 6-46. The relative precision of the program level electric realization rate is ±33.1% at the 90% confidence level.

Table 6-46: Shell Program Gross Verified Savings

Measure	2014–2015 Reported Participation Count	2014–2015 Reported Savings (kWh)	2014–2015 Adjusted Reported Savings (kWh)	Realization Rate	2014-2015 Gross Verified Savings (kWh)
Attic Insulation	398	64,364	64,364	38%	24,576
Floor Insulation	16	16,038	16,038	38%	6,124
Wall Insulation	28	52,717	52,717	38%	20,129
Window Replacement from Single Pane	2193	2,436,707	1,668,255	38%	636,994
Window Replacement from Double Pane	238	1,090,605	471,512	38%	180,038
UCONS Manufactured Home Duct Sealing	1143	1,997,202	2,003,402	84%	1,684,392
TOTAL	**4016**	**5,657,633**	**4,276,288**	**60%**	**2,552,254**

6.9 Opower Behavioral Program

6.9.1 Overview

Home Energy Report (HER) programs have been widely shown to obtain savings through reduced energy consumption among households that receive them. Avista's Behavioral program relies on normative comparisons of energy usage to similar homes to increase awareness of energy consumption levels and stimulate recipients to alter their behavior and consume less energy. The evaluation approach relies on a combination of large sample sizes and random assignment to enable straightforward quantification of associated energy savings.

HERs provide residential customers with detailed information about how their home uses energy and includes charts that compare their energy use to that of similar homes. Participants receive up to eight home energy reports annually.

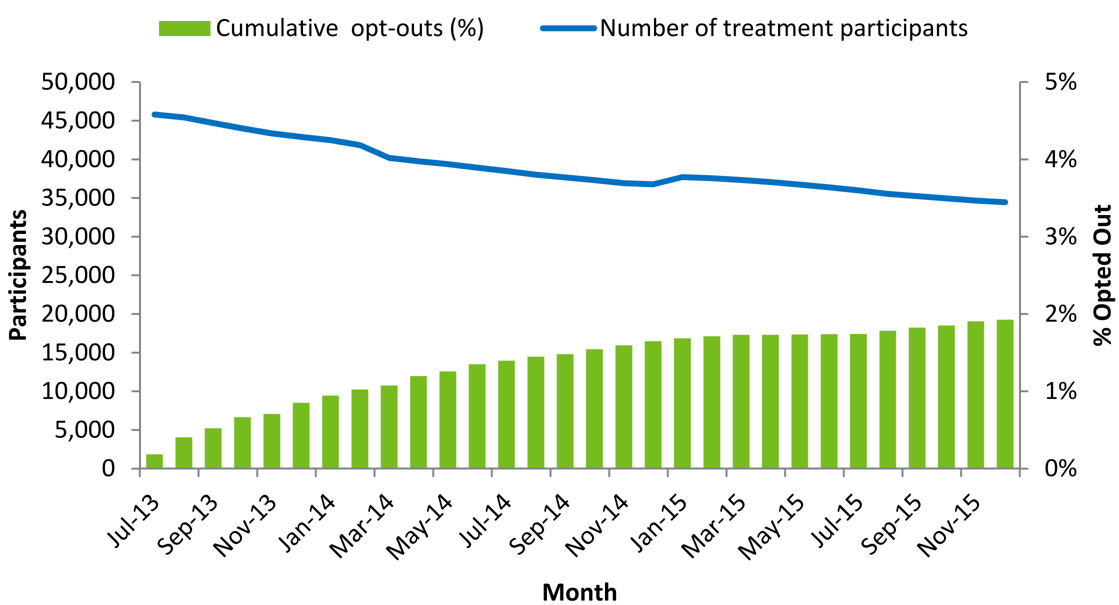
The program launched in June 2013 towards the end of the previous biennium. Avista assumed a three year measure life for savings reported in the 2012 and 2013 biennium so all program achievements in the 2014 and 2015 biennium were incremental to the 6,283,477 kWh reported by the program in the previous biennium. Because of a change in billing system, reports were suspended and none were sent out from February to August of 2015. Reports were reinstated in September 2015; however there was concern about how the gap in reports may affect savings given the incremental accounting of savings net of the previous biennium's achievements.

The Opower Behavioral program is operated as an "electric only" program with the HER messaging designed to stimulate electric conservation among recipient homes. Because of this, Opower calculated reported savings only on electricity (kWh usage), and not on gas (therm) usage. The evaluation team also requested and analyzed the gas consumption records of treatment and control group homes who receive natural gas service from Avista to assess whether the program produced statistically significant reductions in gas usage.

6.9.2 Program Achievements and Participation Summary

In Washington, approximately 48,300 treatment and 13,000 control participants were randomly enrolled in the Behavioral Program. The Opower program is set up as an "opt-out" program, not an "opt-in" program, meaning that while households are randomly selected to receive the home energy report, they can also choose to opt out. Figure 6-14 presents the number of treatment participants and the opt-outs as a cumulative percentage by month in the post-period. The dip in participants observed in 2015 is most likely a legacy of Avista switching its billing system around that time. Approximately 2%[28] of homes opted out of the program.

Figure 6-14: Participation and Cumulative Opt-outs by Month



6.9.3 Methodology

6.9.3.1 Data Sources and Management

To develop estimates of the electric savings attributable to Avista's Behavioral Program, the evaluation team requested data covering two core components:

1) Participation Record: A list of all billing accounts that are part of the initiative, treatment\control designation, date assigned, service zip code, and any demographic or rate code status information available in Avista's customer information system.

[28] 920 opt-outs from a total of 48,299 treatment group homes

2) Consumption History: Monthly electric and gas billing records for each account in the treatment and control group including the meter read date and number of days in the billing period. Billing history was requested back to February 2012 to ensure adequate pre-treatment data for the analysis.

In preparation for the impact analysis, the evaluation team combined and cleaned the billing data provided by Avista. The dataset included 61,285 distinct accounts, 48,289 of which were assigned to the treatment group and 12,996 of which were assigned to the control group. The billing history dataset included 2,400,966 monthly billing records.

The evaluation team removed the following data points and customers from the analysis:

- 12 accounts with duplicate billing data
- 3,121 accounts that had no billing data after program launch
- 5,161 accounts that lacked 12 months of billing data in the pre-period (March 2012 to June 2013). Less than 12 months of pre-treatment data is insufficient for the analysis.

For the participation numbers used to calculate the aggregate impacts for each program month, the number of treatment participants was the number of unique treatment accounts with billing data that month, before accounts with no post data and accounts with insufficient pre-data were removed. Treatment group homes that opted out of the program were not removed from the impact analysis or the participation counts. Although this may seem counterintuitive, it is necessary to preserve the integrity of the RCT design because control group homes do not have the option to opt-out and there is no way to determine which control group homes would opt-out if there were assigned to treatment. This approach dilutes the per-home impacts to some extent because only ~ 98% of the participants were actively receiving HERs at a given time, but this is negated by including all active accounts in the estimation of aggregate impacts.

Like most utilities, Avista does not bill its customers for usage within a standard calendar month interval. Instead, billing cycles are a function of meter read dates and vary across accounts. Since the interval between meter reads vary by customer and by month, the evaluation team “calendarized” the usage data to reflect each calendar month, so that all accounts represent usage on a uniform basis. The calendarization process includes expanding usage data to daily usage, splitting the bill month’s usage uniformly among the days between reads. The average daily usage for each calendar month is then calculated, by taking the average of usage within the calendar month.

A similar calendarization process was performed on the gas billing data. However, instead of cleaning individual accounts with bad data, we matched up the accounts with valid electric billing data to the accounts in the gas billing data and only used those accounts that were also in the cleaned electric data.

6.9.3.2 Equivalence Testing

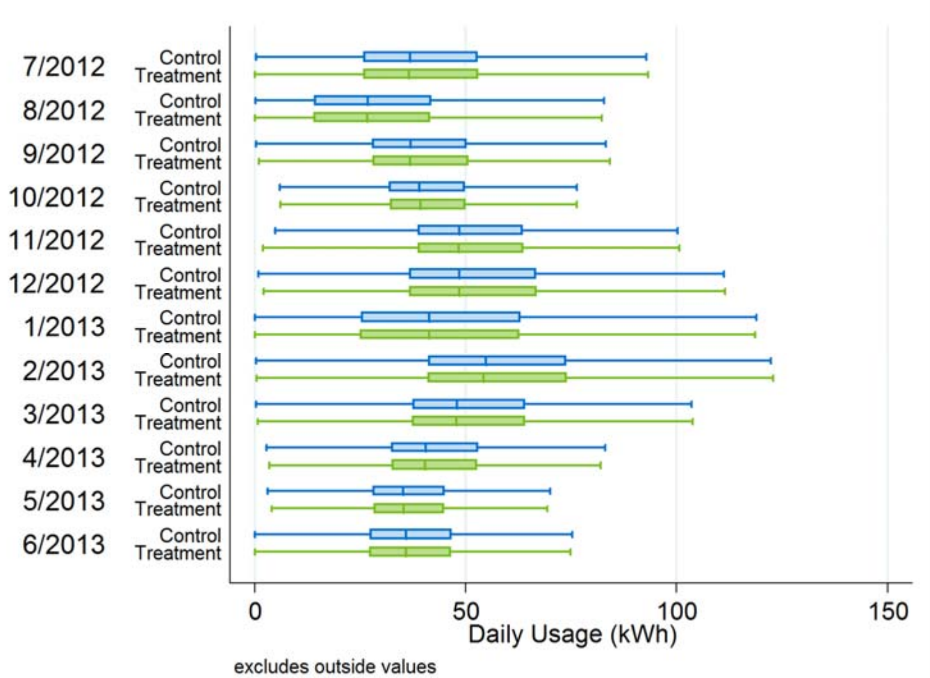
The next step in the evaluation team's analysis approach was to perform a detailed review of the assignment randomization by comparing consumption patterns for the treatment and control group for the months in the pre-period (March 2012 to June 2013). The purpose of this analysis is to determine if structural differences in electricity consumption existed between the treatment and control group before HER exposure. Pre-treatment differences can take the form of total annual consumption or variation in the seasonality of consumption. The findings of this step are of critical importance because they will determine the appropriate model specification to estimate savings. Table 6-47 displays the results of a difference in means two-sided t-test to validate the randomization and confirms that there is no significant difference in usage between the treatment and control groups in the pre-period. The results confirm that the randomization is robust and that there is no real difference in the energy consumption of the two groups.

Table 6-47: Difference in Means t-test Values

Control Average Daily Usage: Pre period	Treatment Average Daily Usage: Pre period	Critical Value (t)	P-value (95%)
45.45	45.53	-1.24	0.21

Figure 6-15 examines usage in the pre-treatment visually and echoes the results of the statistical test.

Figure 6-15: Treatment and Control Energy Usage in the Pre-Period



6.9.3.3 Regression Analysis

The evaluation team used a lagged dependent variable (LDV) model to estimate savings. The LDV model is the preferred analysis approach to use when the randomization of homes to treatment and control is sound and results in groups with equivalent usage prior to HER exposure, as presented in the section above. If pre-assignment differences in electric consumption are present, a linear fixed effects regression model (LFER) would have been the more appropriate model.

The LDV model is a category of specifications in which the dependent variable in the equation is restricted to the post-test period. The customers' usage prior to the onset of treatment for the same period (i.e., usage in the same monthly period in the prior year) is entered into the regression model as an independent variable – thus the name lagged dependent variable model – and the coefficient for the treatment variable is interpreted as the change in consumption due to treatment. The specification used is shown in Equation 6-7, and the corresponding variables are defined in

Table 6-48.

Equation 6-7: Lagged Dependent Variable Model Specification

$$kWh_{ity} = \beta_0 + \sum_{t=1}^{12}\sum_{y=1}^{n} I_{ty} * \beta_{ty} + kWh_{i,t,y-n} * \beta_{t,y-n} + \tau * treatment_i * I_{ty} + \varepsilon_{it}$$

Table 6-48: Lagged Dependent Variable Model Definition of Terms

Variable	Definition
β_0	The intercept, or the coefficient on the billing month t, post-period year indicator variable that is left out due to collinearity
kWh_{ity}	Customer i's average daily energy usage in billing month t of the post-period y
I_{ty}	Indicator variable that equals one for each monthly billing period t, post-period y and zero otherwise.
β_{ty}	The coefficient on the billing month t, post-period year indicator variable
$kWh_{i,t,y-n}$	The lagged usage of customer i in the corresponding billing month t, in the pre-period y-n
$\beta_{t,y-n}$	The coefficient for the corresponding billing month t, in the pre-period y-n
$treatment_i$	Treatment variable, equal to one if customer i is in the treatment group and zero if control
τ	Estimated average daily energy reduction of the treatment group in bill month t for the post-period y
ε_{it}	Error term for customer i for bill month t

The average daily treatment effect (τ) for each billing period of the study is multiplied by the number of active customers in the treatment group times the number of days in that month to estimate the monthly aggregate savings (MWh). The monthly savings impacts are summed over the study horizon to produce the total change in energy consumption in treated homes over the period under study. The results of an overlap analysis discussed below are then subtracted from this total change in consumption to arrive at the net ex post energy savings attributable to the Behavioral Program.

6.9.3.4 Overlap Analysis

The ability to serve as a marketing tool for other energy efficiency initiatives is an important part of what makes normative comparison reports so attractive to utilities and agencies. The billing analysis methodology captures all savings at the meter, even those claimed by other programs. To the extent that the treatment and control group participate in other Avista programs at a different rate, the difference in kWh needs to be netted off of the Behavioral Program impact to prevent any double-counting or under-statement of savings. For measures promoted by Avista and tracked at the customer level, the amount of savings overlap was estimated by matching the treatment and control group customers to the energy efficiency program participation data. Next, the difference between treatment and control groups in rebated savings per home is calculated and the difference multiplied by the number of treatment group homes.

6.9.4 Findings and Recommendations

6.9.4.1 Per-Home kWh and Percent Impacts

The evaluation team estimates the average home in the Opower Behavioral Program saved over 760 kWh of electricity from January 2014 through December 2015. This represents a 2.13% reduction in total electric consumption compared to the control group over the same period. The 760 kWh and 2.13% impact estimates include HER savings net of savings from incremental participation in other Avista Energy Efficiency (EE) programs. As explained in Section 6.9.3.4, an overlap analysis was performed to prevent double-counting of savings that have already been attributed to another energy-saving program. The overlap analysis found that treatment group homes participated in energy efficiency programs at a greater rate than the control group, necessitating a downward adjustment of the impacts. This means a net decrease in usage for the Opower Behavioral Program when comparing the treatment to the control. Therefore, a downward adjustment was applied to each monthly savings estimate based on differential energy efficiency participation and the greater per-home EE savings for the treatment group. The dual participation adjustment totaled 18 kWh over the 24-month period of analysis.

Table 6-49 shows the impact estimates in each month for the average treatment household. The table also shows the subsequent adjustment for savings attributed the energy efficiency overlap, totaling 742 kWh annually per household.

Table 6-49: Opower Behavioral Program Impact Estimates with EE Adjustments

Month	Treatment Participants	kWh Impact per Customer	kWh Impact from EE Overlap	kWh Savings per Treated Home	MWh Savings
January 2014	42,487	38.89	0.43	38.45	1,634
February 2014	41,842	37.76	0.40	37.37	1,564
March 2014	40,195	36.84	0.42	36.42	1,464
April 2014	39,750	28.25	0.37	27.88	1,108
May 2014	39,375	24.66	0.47	24.20	953
June 2014	38,933	20.87	0.51	20.35	792
July 2014	38,492	22.91	0.61	22.30	858
August 2014	38,018	24.39	0.72	23.67	900
September 2014	37,655	23.21	0.70	22.51	848
October 2014	37,306	26.81	0.67	26.14	975
November 2014	36,928	37.01	0.63	36.38	1,343
December 2014	36,780	50.13	0.87	49.25	1,811
January 2015	37,703	46.97	0.93	46.04	1,736
February 2015	37,551	34.19	0.75	33.45	1,256
March 2015	37,336	36.06	1.02	35.04	1,308
April 2015	37,057	28.94	1.07	27.87	1,033
May 2015	36,725	27.30	1.23	26.06	957
June 2015	36,376	25.21	1.08	24.13	878
July 2015	35,983	24.40	1.34	23.05	830
August 2015	35,538	23.26	1.24	22.02	782
September 2015	35,246	21.41	0.56	20.86	735
October 2015	34,949	25.63	0.71	24.92	871
November 2015	34,666	38.56	0.70	37.86	1,312
December 2015	34,454	56.66	0.72	55.94	1,927
BIENNIUM TOTAL		**760.31**	**18.16**	**742.15**	**27,876**

6.9.4.2 Aggregate Impacts

The total impact of the Opower Behavioral Program is calculated by multiplying the per-home impacts (adjusted for incremental EE participation) for each calendar month by the number of treatment group homes in that month. Over the twenty-four month period examined by the evaluation team in this evaluation, participants saved 27,876 MWh of electricity. The monthly and annualized aggregate savings are shown in Table 6-49.

Because some of the savings observed in the 2014-2015 biennium were already claimed in the previous biennium because of the assumed measure life of 3 years, these previous achievements must be netted out to calculate incremental achievements and prevent double-counting. The 2015 incremental impacts were the calculated net of the 2014 results and actually produced a small reduction in the biennium savings total. Table 6-50 displays the aggregate savings in 2014 and 2015, respectively, net of savings counted in the previous year.

Table 6-50: 2014-2015 Opower Program Incremental Annual MWh Savings

Year	Reported MWh impact (cumulative)	Verified MWh impact (cumulative)	Incremental MWh
2013	6,075	6,283	0
2014	13,852	14,250	7,967
2015	12,190	13,625	(625)
BIENNIUM TOTAL			**7,342**

6.9.4.3 Precision of Findings

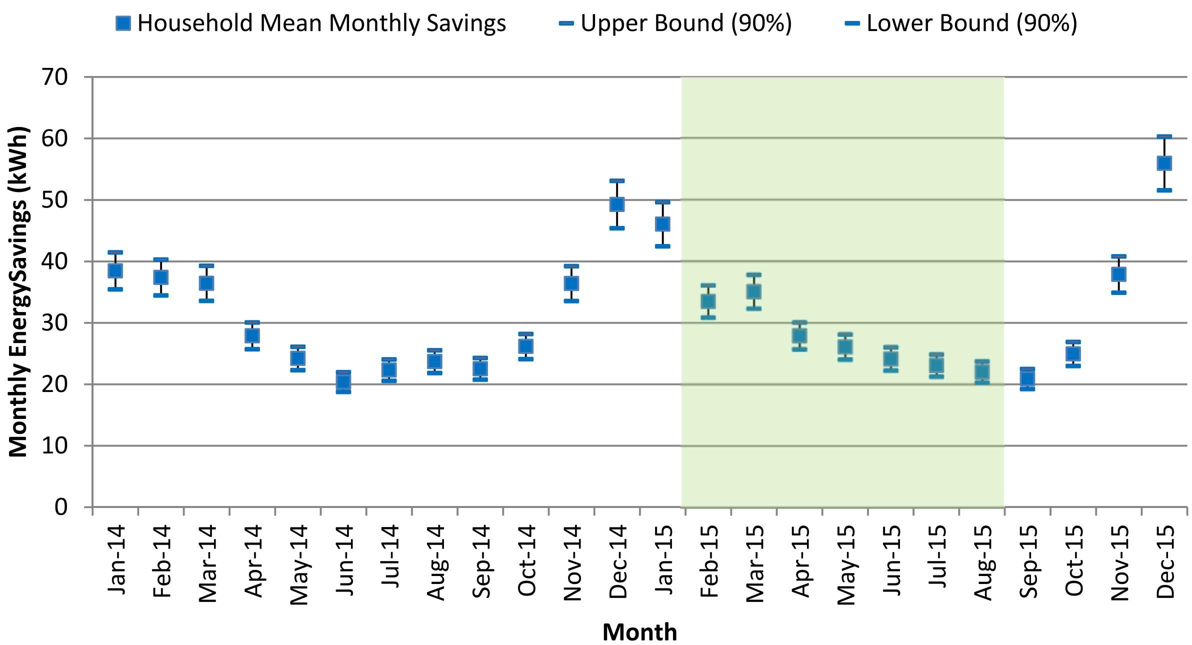
The margin of error of the impact estimates are also important to consider. If margin of error is wide, the true savings value could actually differ from the point estimates by a large amount. The margin of error for the per-home biennium impact estimate is ± 58 kWh at the 90% confidence level. Table 6-51 presents the upper and lower bounds of the 90% confidence interval for biennium per-home kWh savings, percent reduction, and aggregate impact estimates.

Table 6-51: Confidence Intervals Associated with Behavioral Program Impact Estimates

Parameter	Lower Bound (90%)	Point Estimate	Upper Bound (90%)
2014–2015 Program Savings per Home	684 kWh	742 kWh	800 kWh
Percent Reduction	1.97%	2.13%	2.30%
Aggregate Impact	25,697 MWh	27,876 MWh	30,055 MWh

The impact estimate has an absolute precision of ± 0.17% and a relative precision of ± 7.8% at the 90% confidence interval. The estimates are statistically significant, as the confidence interval does not include zero. Figure 6-16 shows the monthly savings estimates with relative precision upper and lower bounds. The shaded box denotes the period between February and August 2015 where reports were not being sent out.

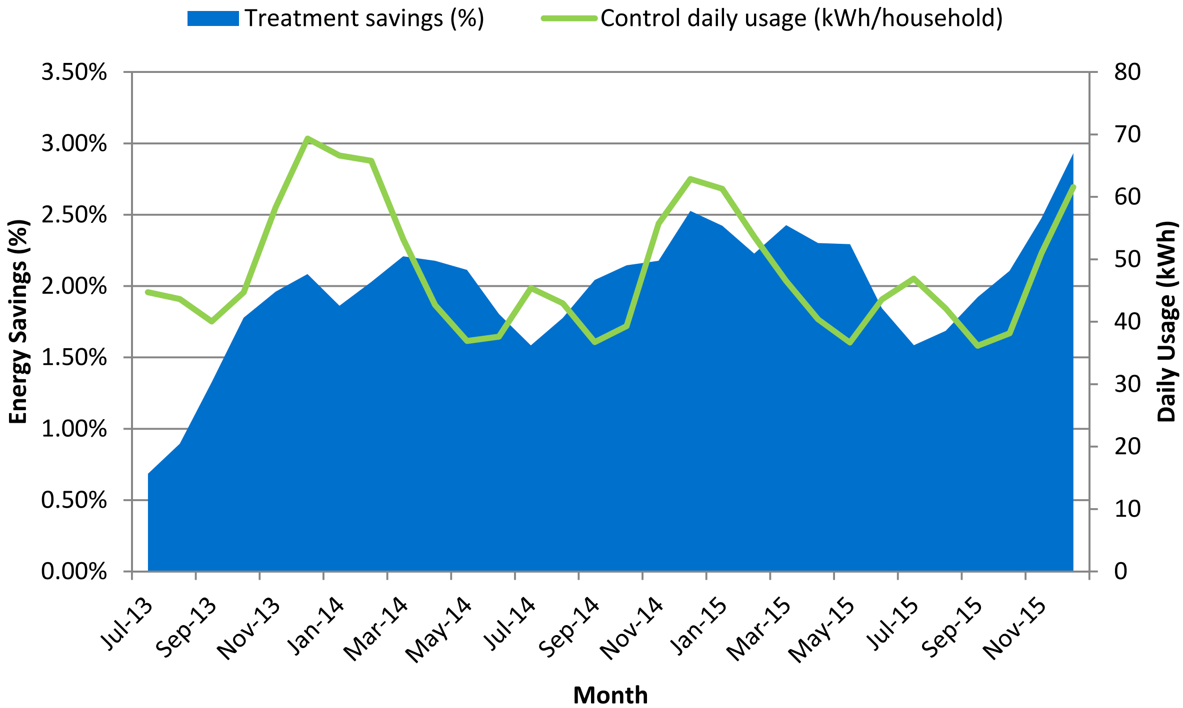
Figure 6-16: Average Monthly Savings per Household with Relative Precision Bounds



6.9.4.4 Savings Patterns

Avista currently mails out reports to the treatment group on a varying cycle, with participants receiving 8 reports annually. The blue series in Figure 6-17 depicts the estimated percent reduction for each month of the treatment period, July 2013 through December 2015. Figure 6-17 also shows the average daily kWh usage of the control group with a green line. The control group's average daily usage shows highest electricity usage in the winter months.

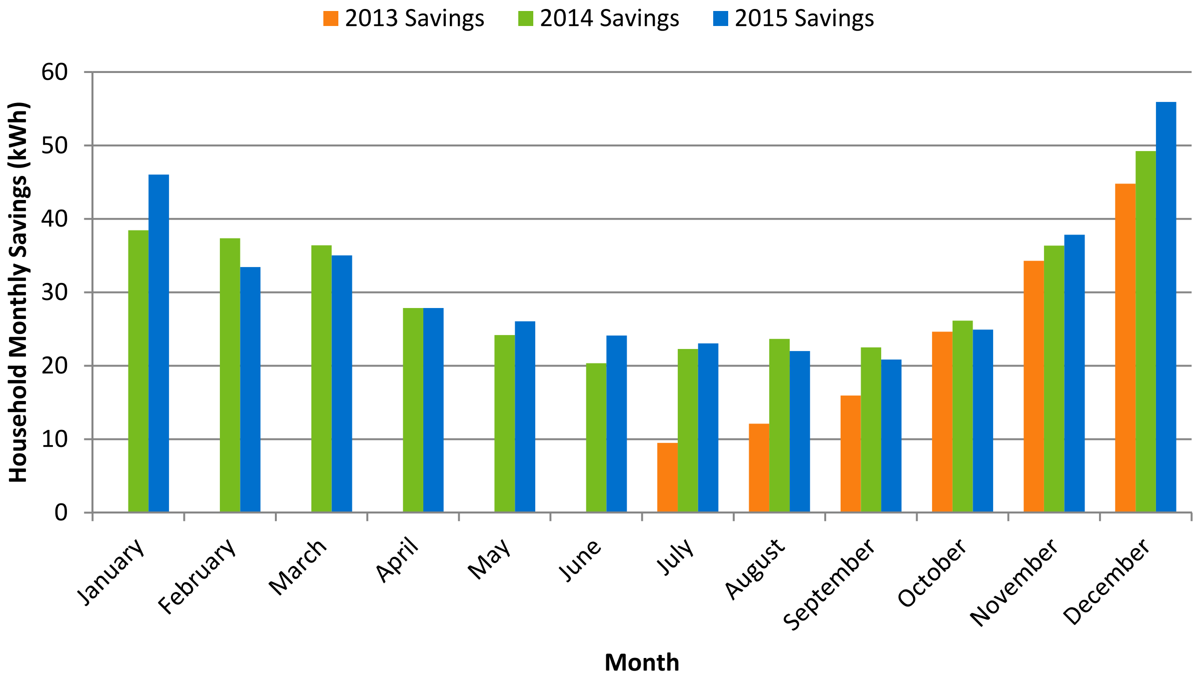
Figure 6-17: Average Percent Savings and Control Daily Usage by Month



There is a seasonal pattern to the savings, where the greatest savings are experienced during the winter months. It is unusual to see the highest savings on a percent basis when usage is also peaking. However, we can see the same pattern on an absolute basis in Figure 6-16. Additionally, the significant gas savings during the winter months, which are discussed in more depth in Section 6.9.4.5, mean that the decrease in electricity usage is not due to customers shifting their usage to gas. The Opower reports can encourage fuel switching as a way of reducing electricity usage.

It is important to note what is happening during the period of February to August of 2015, when home energy reports were not being sent out to customers. The monthly savings by year are shown in Figure 6-18. In 2014 each month contains a growth in savings from what was observed in 2013. While we do not observe any noticeable growth in savings during the February to August 2015 period, it is important to note that the savings hold fairly consistent with what was observed in the year before, meaning they do not diminish significantly either. Additionally, once reports resume in September 2015, monthly savings begin to surpass what they were in the years previous again.

Figure 6-18: Household Monthly Savings by Year



6.9.4.5 Gas Savings

Although the Behavioral Program set up by Avista and Opower is an electricity-saving program, Avista is a gas and electric utility, and approximately 49% of the homes assigned to the program also receive natural gas service from Avista. The evaluation team used the LDV model to examine any gas usage differences created by the program. In addition to general conservation messaging, the Behavioral Program provided information on the benefits of fuel switching (electric to gas). Although fuel switching impacts would be captured by the overlap analysis if the switch was rebated by Avista, these interventions would have opposite effects, so we entered the analysis without a hypothesis about whether gas reductions, increases, or no effect at all would be found.

The results of the gas impact analysis with overlap analysis adjustments are summarized by month in Table 6-52. While in certain months, a net increase in usage is observed in the program participants, over the two year program period a net savings of 6.33 therms per household is estimated. Program-wide, gas savings during the 2014 and 2015 biennium totaled 117,520 therms. Figure 6-19 displays the monthly gas savings estimates with relative precision bounds. The shaded box represents the period between February and August 2015 when no reports were sent out.

Table 6-52: 2014-2015 Opower Program Gas Impact Estimates with EE Adjustments

Average Number of Participants in Biennium	Biennium Gas Savings per Customer	Therms Impact from EE Overlap	Biennium Gas Savings per Treated Home (with EE Overlap)	Aggregate Therms Savings
18,682	5.84	-0.49	6.33	117,520

The margin of error for the per-home biennium impact estimate is ± 3.6 therms at the 90% confidence level. Table 6-53 displays the point estimates and the 90% confidence interval upper and lower bounds for the biennial per home, percent, and aggregate gas savings estimates. The impact estimate has an absolute precision of ± 0.23% and a relative precision of ± 56% at the 90% confidence interval.

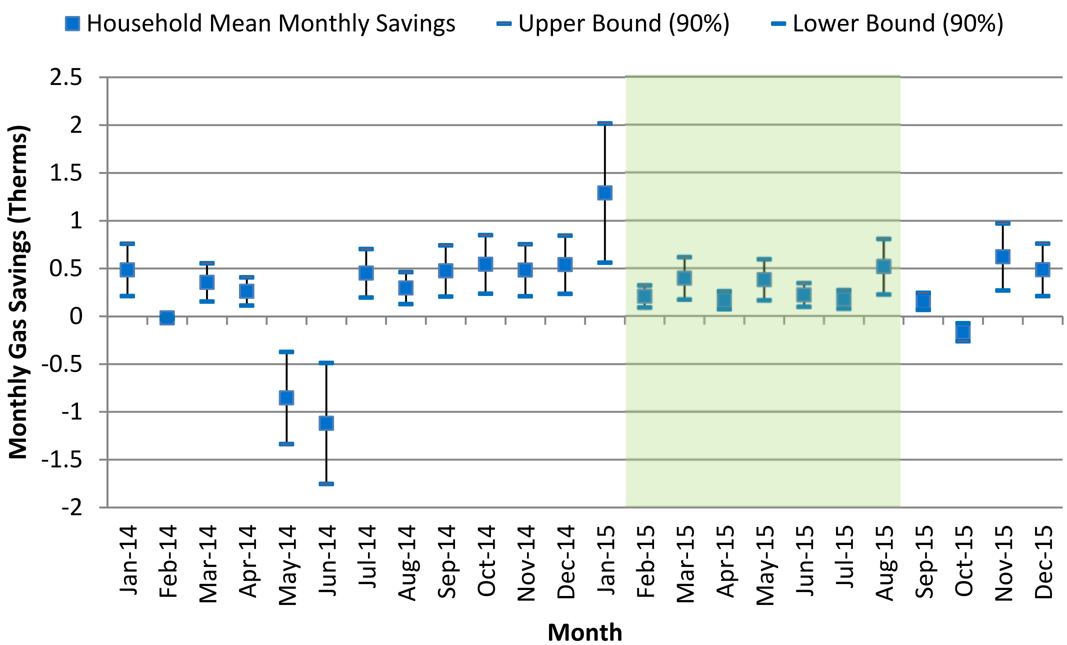
Table 6-53: Confidence Intervals Associated with Program Gas Impact Estimates

Parameter	Lower Bound (90%)	Point Estimate	Upper Bound (90%)
Biannium Savings per Home	3 therms	6 therms	10 therms
Percent Reduction	0.18%	0.40%	0.63%
Aggregate Impact	51,174 therms	117,520 therms	183,867 therms

In May and June 2014, a net increase in household gas usage of about 1 therm per month was observed. However, it is important to note that despite the fluctuations in gas savings illustrated in Figure 6-19, the estimated gas savings are statistically significant over the biennium[29].

[29] t = -2.91, P-value = 0.004

Figure 6-19: Average Monthly Gas Savings per Household with Relative Precision Bounds



6.10 Low Income

6.10.1 Overview

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

6.10.2 Program Achievements and Participation Summary

Participation in the 2014-2015 Low Income program totaled close to 11,000 conservation and fuel conversion projects. Table 6-54 summarizes the reported participation counts and energy savings for the measures that make-up the Low Income program. Figure 6-20 presents the energy savings for non-lighting conservation measures, lighting conservation measures, and the fuel conversion measures. Non-lighting conservation measures account for 50% of the program savings, with insulation measures accounting for 63% of this category, as shown in Figure 6-21.

Table 6-54: 2014–2015 Low-Income Program Reported Participation and Savings

Measure Category	Measure	2014–2015 Reported Participation Count	2014–2015 Reported Savings (kWh)
Non-Lighting Conservation	Insulation	267	183,040
Non-Lighting Conservation	ENERGY STAR Windows	127	8,832
Non-Lighting Conservation	ENERGY STAR Doors	34	10,908
Non-Lighting Conservation	Air Infiltration	229	53,176
Non-Lighting Conservation	Duct Sealing	30	25,488
Non-Lighting Conservation	ENERGY STAR Refrigerator	14	9,771
Non-Lighting Conservation	Water Heater	2	153
Non-Lighting Conservation	Gas Furnace	21	(3,717)
Fuel Conversion	E to G Furnace Conversion	120	295,309
Fuel Conversion	E to G Water Heat Conversion	116	143,440
Fuel Conversion	E to G Heatpump Conversion	3	7,977
Lighting Conservation	LI Giveaway CFL bulbs	7,154	115,237
Lighting Conservation	LI Giveaway LED bulbs	2,868	35,984
	TOTAL	**10,985**	**885,598**

Figure 6-20: 2014-2015 Low Income Program Reported Energy Saving Shares: Measure Category

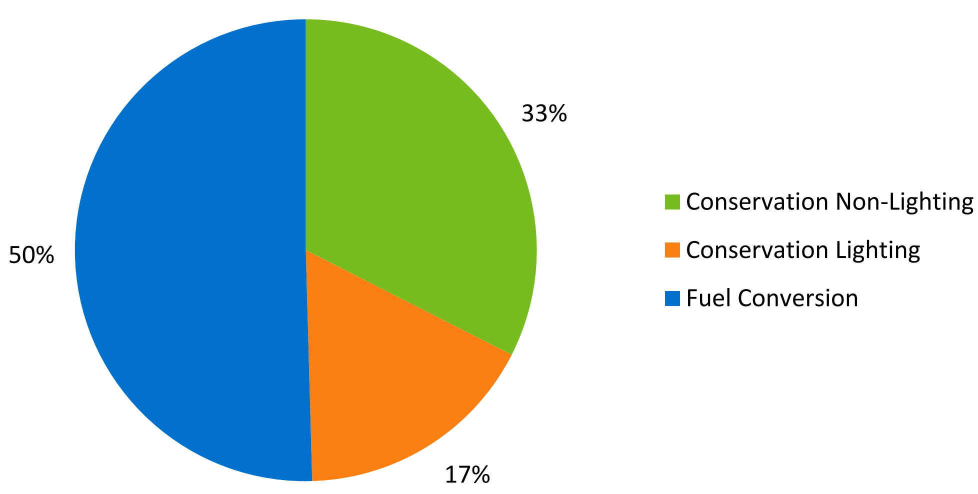
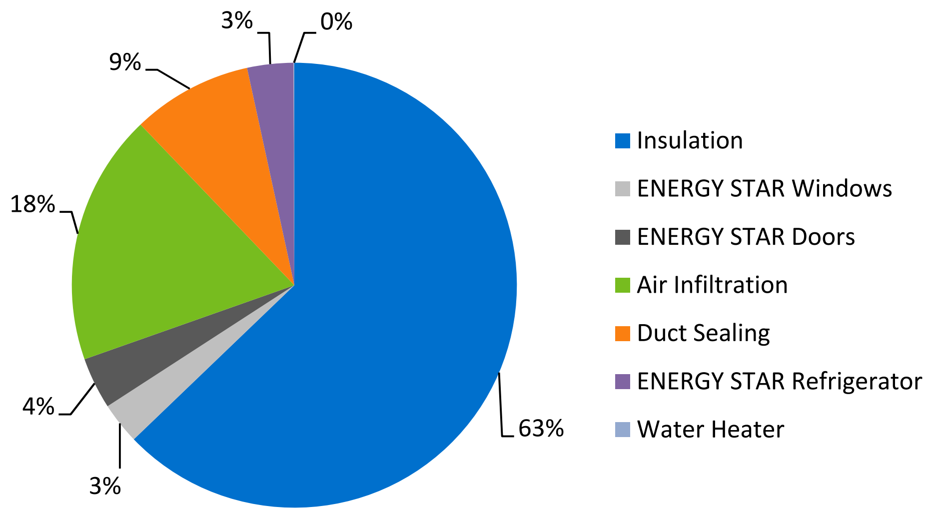


Figure 6-21: 2014-2015 Low-Income Program Reported Energy Saving Shares: Non-Lighting Conservation



6.10.3 Methodology

The evaluation team organized the analysis for the Low Income Program based on the measures categories noted in Table 6-54 above. For the non-lighting conservation and fuel conversion measures, the evaluation team employed a regression analysis. For the lighting conservation measures, the evaluation team followed the same methodology as outlined in the Residential Lighting Section (Section 6.7.3). The remainder of this section outlines the methodology for the non-lighting conservation and fuel conversion measures.

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 electric savings analysis, the evaluation team first filtered the program population to include only those homes with claimed electric 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 electric savings. Billing analysis was determined to be an appropriate method because the average annual electric savings claimed per participating home was almost 2,300 kWh across the 323 treated homes.

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

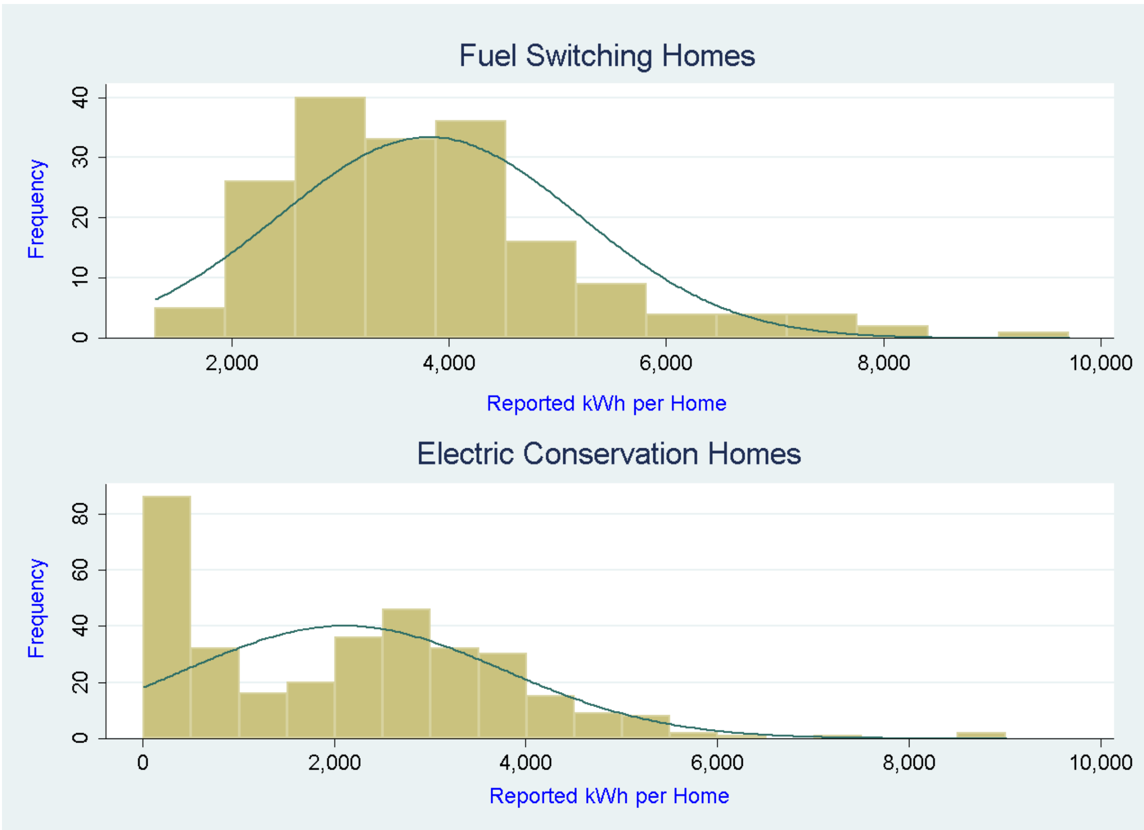
1) **Electric Conservation Homes** – these homes had reported electric savings and either zero reported therm savings or a positive reported therms value.

2) **Fuel Conversion Homes** – these homes had reported electric savings and a *negative* reported therm savings. This net gas penalty (and a large share of the electric savings)

resulted from a conversion of the homes heating or water heating system from electricity to natural gas.

Figure 6-22 shows the distribution of per-home reported electric savings for the two groups. Reported electric Impacts for the fuel switching homes were generally larger. Within the Electric Conservation Homes there was a subset of residences that reported limited electric savings because the primary improvements affected the gas heating system.

Figure 6-22: Distribution of Reported kWh Values by Home Type



As described in Section 3.4.4, each home was matched to 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 homes and electric conservation homes and both Idaho and Washington homes 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 Appendix B.

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

6.10.4 Findings and Recommendations

6.10.4.1 Non-Lighting Conservation and Fuel Conversion Homes

Table 6-55 summarizes the key inputs and outputs of the regression analysis. As expected the fuel switching homes saved significantly more electricity on average than homes that did not have a primary mechanical system converted from electricity to natural gas. The average percent reduction in electric consumption for the 67 fuel switching homes analyzed was 55.7%, meaning the post-retrofit electric consumption was less than half of what it was pre-retrofit. Electric conservation homes used less electricity on average pre-retrofit than fuel switching homes (13,278 kWh vs. 17,722 kWh). This group saved less on both an absolute and percent basis.

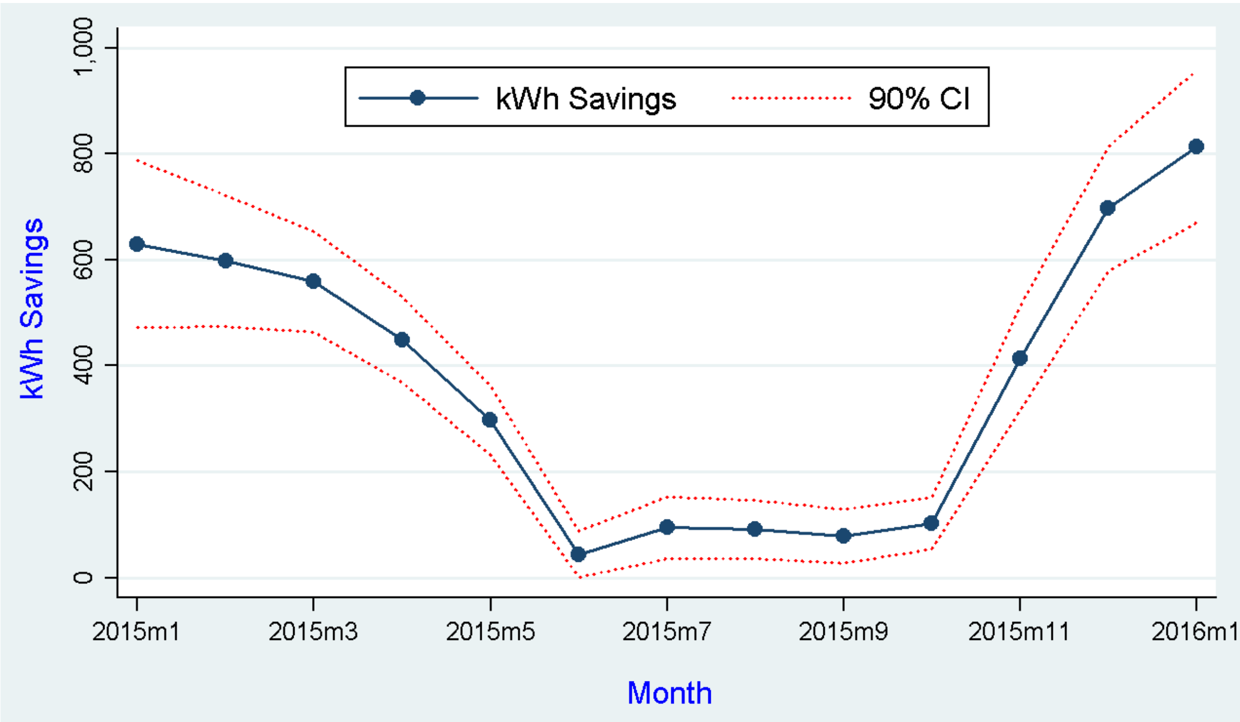
Table 6-55: Low Income Billing Analysis Findings

Stratum	Fuel Conversion Homes	Electric Conservation Homes
Number of Homes Analyzed	67	165
Average Reported kWh per Home	3,909	1,233
Weather Normalized Annual kWh Pre-Retrofit	17,722	13,278
Weather Normalized Annual kWh Post-Retrofit	7,846	12,575
Average kWh Savings per Home	9,876	702
Realization Rate	253%	57%
Relative Precision (90% confidence level)	± 9.2%	± 60.9%
Average Percent Reduction in Annual Electric Consumption	55.7%	5.3%

The realization rate for Fuel Conversion Homes was 253%, with homes saving an average of almost 10,000 kWh annually. It is worth noting that the reported savings assumptions for electric to gas conversion of heating and water heating in Low Income program were far more conservative than the Fuel Efficiency program, which assumed 12,012 kWh for furnace conversions and 4,031 kWh for water heater conversions. Evaluation results actually found a higher per home impact from fuel switching in the Low Income program than in Fuel Efficiency program although the difference was not statistically significant. Moving forward, the evaluation team recommends that Avista align assumptions for fuel switching savings for the Low Income and Fuel Efficiency programs.

Figure 6-23 shows the evaluation teams estimates of the average Low Income home savings by month for the last 13 months. Savings from the Low Income program are occurring primarily during winter months when electric heating loads are highest. Figure 6-23 was created by comparing the actual metered loads of homes (both fuel conversion and electric conservation) to the regression estimates of what consumption would have been during the pre-retrofit period using the actual weather conditions in place January 2015 through January 2016.

Figure 6-23: Low-Income Program Impacts by Month



6.10.4.2 Lighting Conservation

The 2014 and 2015 Low Income programs CAP agencies conducted multiple “giveaway” events throughout the program cycle and reported bulb type (CFL/LED) and bulb count for each of the events and the location of the event so that Avista could allocate the savings attributable to their Washington and Idaho service territories. Based on the program reported data, the average kWh savings attributed to the CFL bulbs was 16.1 kWh and 12.5 kWh for LEDs. Based on the methodology outlined in Section 6.7.3 above, the evaluation team estimates the average savings for the giveaway CFLs to be 18.7 kWhs and 20.9 kWhs for LEDs (assuming a 60w equivalent). Table 6-56 presents the realization rate and per-unit gross verified savings.

Table 6-56: Low-Income Lighting Conservation Measures Gross Verified Savings

Bulb Type	Average Reported Savings (kWh/bulb)	Realization Rate	Gross Verified Savings (kWh/bulb)
CFL Giveway	16.1	116%	18.7
LED Giveaway	12.5	167%	20.9

6.10.5 Program Results

The database review and document audit activities conducted by the evaluation team did not result in any adjustments to the reported Avista savings values. The overall electric realization rate for the Low Income program was 168%. This program level realization rate was developed by taking a weighted average of the realization rates of the measure types shown in Table 6-57. The relative precision of the program level electric realization rate was ±12.6% at the 90% confidence level.

Table 6-57: Low-Income Program Gross Verified Savings

Measure Category	2014–2015 Reported Participation Count	2014–2015 Adjusted Reported Savings (kWh)	Realization Rate	Gross Verified Savings (kWh)
Conservation Non-Lighting	724	287,651	57%	163,961
Conservation Lighting	10,022	151,221	128%	194,002
Fuel Conversion	239	446,726	253%	1,130,217
TOTAL	**10,985**	**885,598**	**168%**	**1,488,180**

6.11 Residential Sector Results Summary

Table 6-58 lists the gross verified savings for each of Avista's residential programs in Washington in 2014 and 2015 and for the overall portfolio. The Washington electric residential sector achieved a 109% realization rate and the relative precision of the program-level electric realization rate was ±9.05% at the 90% confidence level

Table 6-58: Residential Program Gross Impact Evaluation Results

Program	2014–2015 Reported Savings (kWh)	2014–2015 Adjusted Reported Savings (kWh)	Realization Rate	2014-2015 Gross Verified Savings (kWh)
Appliance Recycling	822,810	810,072	165%	1,332,668
HVAC	1,598,690	1,597,373	78%	1,238,974
Water Heat	833,720	833,720	118%	981,190
ENERGY STAR Homes	176,470	180,807	126%	228,387
Fuel Efficiency	7,165,449	7,176,499	62%	4,483,925
Lighting	19,606,228	19,606,228	131%	25,689,564
Shell	5,657,633	4,276,288	60%	2,552,254
Opower	6,115,000	6,115,000	120%	7,342,378
Low Income	885,598	885,598	168%	1,488,180
RESIDENTIAL TOTAL	**42,861,597**	**41,481,585**	**109%**	**45,337,519**

7 Conclusions and Recommendations

7.1 Summary

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

7.2 Impact Findings

The evaluation team performed the impact evaluation for Avista's 2014 and 2015 Washington electric program 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 103% realization rate across Avista's 2014-2015 portfolio of programs (Table 7-1). Table 7-3 and Table 7-2 summarize Avista's 2014 and 2015 impact evaluation results by sector and program.

Table 7-1: 2014-2015 Washington Electric Portfolio Evaluation Results

Sector	Reported Savings (kWh)	Realization Rate (%)	Gross Verified Savings (kWh)
Residential	40,595,987	108%	43,849,339
Nonresidential	37,043,299	95%	35,330,436
Low Income	885,598	168%	1,488,180
PORTFOLIO	**78,524,884**	**103%**	**80,667,955**

Table 7-2: Washington Electric Nonresidential Program Evaluation Results

Program	2014-2015 Reported Savings (kWh)	Realization Rate	2014-2015 Verified Gross Savings (kWh)
EnergySmart Grocer	3,512,149	90%	3,144,958
Food Service Equipment	214,937	54%	116,494
Green Motors	25,607	54%	13,879
Motor Controls HVAC	1,374,268	54%	744,838
Commercial Water Heaters	138	54%	75
Prescriptive Lighting	8,145,753	99%	8,046,872
Prescriptive Shell	494,230	54%	267,867
Fleet Heat	8,668	54%	4,698
Site Specific	22,236,575	99%	21,936,984
Small Business	1,030,975	102%	1,053,771
TOTAL NONRESIDENTIAL	**37,043,300**	**95%**	**35,330,436**

Table 7-3: Washington Electric Residential Program Evaluation Results

Program	2014-2015 Adjusted Reported Savings (kWh)	Realization Rate	2014-2015 Gross Verified Savings (kWh)
Appliance Recycling	810,072	165%	1,332,668
HVAC	1,597,373	78%	1,238,974
Water Heat	833,720	118%	981,190
ENERGY STAR Homes	180,807	126%	228,387
Fuel Efficiency	7,176,499	62%	4,483,925
Lighting	19,606,228	131%	25,689,564
Shell	4,276,288	60%	2,552,254
Opower	6,115,000	120%	7,342,378
Low Income	885,598	168%	1,488,180
TOTAL RESIDENTIAL	**41,481,585**	**109%**	**45,337,519**

7.3 Conclusions and Recommendations

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

7.3.1 Nonresidential Programs

The overall realization rate for the nonresidential portfolio is 95%. The realization rates ranged from 102% for the Small Business program down to 54% for the “Prescriptive Non-Lighting Other” program. The largest program in the nonresidential portfolio, Site Specific, had a realization rate of 99%. The evaluation team found that the processes Avista is utilizing for estimating and reporting energy savings for the nonresidential programs are predominantly sound and reasonable. The following subsections outline specific conclusions and recommendations for several of the nonresidential programs.

7.3.1.1 Site Specific Program

Conclusion: The Site Specific program constitutes more than 60% of the program energy shares. Within the last 2 years, Avista has increased their level of quality assurance and review on projects that participate through the program. The evaluation team’s analysis resulted in a 99% realization rate for the Site Specific program. The strong realization rate indicates that Avista’s internal process for project review, savings estimation, and installation verification are working to produce high quality estimates of project impacts.

> **Recommendation**: The evaluation team recommends that Avista continue to operate this program with the current level of rigor. For interior lighting projects, Avista should consider applying the interactive factors deemed by the RTF to quantify the interactive effects between lighting retrofits and their associated HVAC systems. More specifically, for interior lighting projects, Avista assumes a standard interactive factor of 7.7% for buildings with air conditioning. The RTF’s values for interactive factors vary depending on heating and cooling system types and building type. For some building types, especially those that tend to participate in the Site Specific program, the RTF’s interactive factors are higher than Avista’s factor

> **Recommendation**: While the impact from the Commercial Windows and Insulation measures under the Site Specific program are minimal, Avista should further review its algorithm for cooling season savings achieved by window replacements. The algorithm that Avista currently uses may be overstating the impacts of these replacements on air condition energy consumption.

7.3.1.2 Prescriptive Lighting Program

Conclusion: The Prescriptive Lighting program is the second largest program in Avista’s nonresidential portfolio, constituting more than 20% of the energy savings. The evaluation team’s analysis resulted in a 99% realization rate for the Prescriptive Lighting program, indicating that Avista’s reported energy savings for this program are accurate.

> **Recommendation**: The evaluation team recommends that Avista continue to operate this program with the current level of rigor. Avista should consider applying the interactive factors deemed by the RTF to quantify the interactive effects between interior lighting retrofits and their associated HVAC systems. More specifically, for interior

lighting projects, Avista assumes a standard interactive factor of 7.7% for buildings with air conditioning. The RTF's values for interactive factors vary depending on heating and cooling system types and building type. For some building types, especially those that tend to participate in the Site Specific program, the RTF's interactive factors are higher than Avista's factor

7.3.1.3 EnergySmart Grocer Program

Conclusion: Avista's EnergySmart Grocer program is successfully providing retail and restaurant customers with an avenue to upgrade their refrigeration equipment. Participation in the program includes both prescriptive and custom projects. The evaluation team's review of projects in the program resulted in a realization rate of 90%. For prescriptive projects, the evaluation team determined that RTF deemed savings values were being appropriately applied in most cases. However, low project-level realization rates for custom projects, which tend to be larger in size than prescriptive projects, are driving the program realization rate downward.

Recommendation: Avista should consider more internal review of energy savings estimates submitted by vendors for custom projects under this program. Alternatively, Avista could consider tracking custom projects under the Site Specific program with other projects of similar size and complexity.

7.3.1.4 Prescriptive Non-Lighting Other Programs

Conclusion: Avista reported 2014-2015 participation in six other prescriptive programs. Of these, the HVAC Motor Controls program is the largest, constituting 65% of the energy savings for this group. The evaluation team's review of projects in these programs resulted in a 54% realization rate. Cases of ineligible VFD projects receiving incentives were cause of the low realization rate for these programs.

Recommendation: Avista should revise the HVAC Motor Controls program to include more verification of motor eligibility status. More emphasis should be placed on confirming motor application and duty status to ensure compliance with the program's existing eligibility requirements. More specifically, Avista should place specific emphasis on ensuring VFDs are installed in a manner that saves energy (i.e. not just as "soft starters") and that incentivized VFDs serve primary-duty motors.

7.3.1.5 Small Business Program

Conclusion: Reported savings for faucet aerators were found to be conservatively low based upon the evaluation team's secondary research. The realization rates for faucet aerators were 126% for electric savings and 204% for natural gas savings.

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

Conclusion: The reported deemed savings value for pre-rinse spray valves associated with electric water heat was found to be slightly higher than the average determined through secondary research. The program is currently using a reported electric energy savings value of 1,338 kWh. The average saving values recommended by the evaluation team is approximately 1,229 kWh.

> **Recommendation:** It is recommended that the electric deemed savings value reported by the evaluation team for the pre-rinse spray valve measure be utilized for future reporting purposes. No modifications are recommended for the deemed therm savings value currently being used by the program.

7.3.2 Residential Programs

The overall realization rate for the residential portfolio is 109%. The realization rates varied significantly across the various programs evaluated with the Shell and Fuel Efficiency programs having the lowest realization rate (60% and 62% respectively). The evaluation team found that the reported savings for the majority of the programs were understating the actual impacts found from the evaluation activities. The following subsections outline specific conclusions and recommendations for several of the residential programs.

7.3.2.1 Appliance Recycling

Conclusion: The evaluation team found that the reported deemed savings value (per recycled unit) for the program was lower than estimated gross savings valued from prior studies. Avista may have aligned their deemed savings values close to the RTF deemed savings values, but it is important to understand that the RTF is reporting a value that accounts for net market effects (i.e. free ridership).

> **Recommendation**: If Avista choses to offer an appliance recycling program in the future, it is recommended that a clear distinction between gross and net savings values is noted if Avista reports the most current RTF values.

Conclusion: The evaluation team found discrepancies when comparing Avista's reported participation counts against the implementer reported values. The evaluation team believes that one reason for the discrepancies could be due to overlapping reporting periods and the way participants are reported and tracked.

> **Recommendation**: Avista should consider tracking the customer account number in addition to the name/address. It would be easier to track account numbers back to billing database records than the name /address fields, which are easier misspelled, and often formatted differently.

7.3.2.2 HVAC Program

Conclusion: The evaluation team found, through billing regression analysis, a relatively low realization rate for the Air Source Heat Pump measures (RR of 48.5%).

> **Recommendation:** The evaluation team recommends Avista reexamine the assumptions relating to annual per-home consumption and savings estimates in homes

receiving ASHP installations. In addition, to help better understand the baseline for the ASHP replacement, Avista could consider requesting that contractors and customers provide a better description of the replaced unit

Conclusion: For the analysis of the Smart Thermostat measure, only five homes had sufficient post-retrofit billing data to estimate savings. Therefore, the evaluation team applied a 100% realization rate to the reported savings due to the small population.

Recommendation: Given the inconclusive analysis results for this measure driven by data limitations, the evaluation team recommends Avista revisit the analysis of this measure in late 2016 - early 2017 when a full year of post-installation billing data is available for several hundred rebate recipients.

7.3.2.3 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.

7.3.2.4 ENERGY STAR® Homes

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

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

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

7.3.2.5 Fuel Efficiency

Conclusion: The evaluation team conducted a billing regression analysis for the Fuel Efficiency participants and found realization rates of 60-70% for rebate projects that included the conversion of a home's heating system from electricity to natural gas. When regression coefficients were examined in detail, the evaluation team noted that the estimated reduction in electric heating load was being offset by an increase in estimated base load within participating homes.

> **Recommendation**: Because the rebate amounts and per-home savings from Fuel Efficiency are so large and the number of participants is relatively low, the evaluation team recommends Avista ask participating customers for details on any additional home renovations that were completed in parallel with the fuel conversion. Home improvement projects such as an addition, finishing a basement, or adding air conditioning can drastically change the consumption patterns within a home and render the assumed baseline inaccurate.

Conclusion: The evaluation team found that over half the homes receiving Fuel Efficiency rebates in 2014-2015 did not have a gas billing history with Avista prior to the conversion. These homes realized savings at a higher rate than homes that did have previous gas service.

> **Recommendation**: The evaluation team recommends that Avista consider adding a field to the program tracking database that indicates the gas meter installation date or service start date of participating homes. This would more clearly delineate homes that were previously all electric and became dual-fuel around the same time as the Fuel Efficiency project, from homes that had been dual-fuel historically. Avista may also want to consider assuming a more conservative electric savings estimate for homes that had prior gas service because it's possible that the home was not 100% electrically heated prior to program participation.

Conclusion: The evaluation team found that almost half of all (ID and WA) Fuel Efficiency participants also received rebates for the installation of high efficiency natural gas equipment. This trend was limited to Washington as Idaho does not have rebates for high efficiency natural gas furnaces and water heaters.

> **Recommendation**: Separating the upgrade of a home's heating system from electric resistance heat to a high efficiency natural gas furnace creates some accounting challenges that Avista way want to streamline in the future. The fuel conversion measure assumes the home installs a standard efficiency natural gas furnace and savings are calculated accordingly. The high efficiency furnace measure offered through Avista's HVAC program uses a standard efficiency furnace as the baseline and the installed high efficiency furnace as the efficient case. This creates challenges for analysis of energy savings because the standard efficiency furnace never existed in over half of Washington homes. A possible solution would be to require that homes install a high

efficiency furnace in order to receive a Fuel Efficiency rebate and consider the upgrade a single transaction rather than two. Specifically, instead of claiming a 500 therm penalty for the Fuel Efficiency measure and 100 therms of savings from the high efficiency furnace measure, Avista could claim the electric savings and a 400 therm penalty for an electric -> HE furnace measure.

7.3.2.6 Residential Lighting

Conclusion: Avista's deemed savings estimates, which were generally the same for all similar product types and not correlated to the bulb wattage, understated the savings found by the evaluation team. This was especially the case for Avista's CFL giveaway program.

Recommendation: The evaluation team recommends that Avsita consider more detailed product type deemed values in an effort to be more closely aligned with the actual participating lamps. Simple Steps has shifted its program tracking to specific product types by lumen bins in accordance with the most current BPA UES measure list. Avista should consider using these higher resolution deemed value for internal reporting with the Simple Steps program and for use with internal residential lighting programs.

An overarching recommendation is also for Avista to monitor the LED lamp market for technology cost changes and customer preferences, and consider increasing LED lamp options from the 2014-2015 portfolio in future DSM planning. Currently, LED prices are dramatically decreasing and customer preferences are shifting from CFL to LEDs as a preferred choice as an energy efficient technology. Consequently, CFLs shelf space share is declining as an abandoned technology, despite its better cost effectiveness compared to LED lamps.

7.3.2.7 Shell Program

Conclusion: The evaluation team found a low realization rate (38%) for shell rebate measures (windows and insulation). This findings indicates that reported savings values were too aggressive on average. The evaluation team compared the end-use shares estimated via regression analysis and found that only approximately 5,500 of the 13,000 kWh of average annual consumption in residential homes in Avista's service territory was assigned to heating and cooling load. Given this end-use share, the reported savings values claimed by Avista equate to a 25% reduction in HVAC loads.

Recommendation: The evaluation team recommends Avista examine planning assumptions about per-home consumption, end-use load shares, and percent reductions in heating and cooling loads from shell improvements. It may be that the percent reduction assumptions are sound, but they are being applied to an overstated assumption of the average electric HVAC consumption per home. Conversely, the assumed end-use shares may be accurate, but the end-use reduction percentage is inflated. This investigation should be conducted separately for electrically heated homes and dual fuel homes as the heating electric end-use share will be different.

7.3.2.8 Opower Program

Conclusion: The evaluation team found that savings held fairly consistent during the 6 month interruption in Home Energy Report delivery. The finding reinforces Avista's decision to assume a multi-year measure life when calculating the cost-effectiveness of the Opower program.

Recommendation: The evaluation team recommends Avista examine the program delivery model in the 2016-2017 cycle. Given the fixed and volumetric nature of program costs, measure life assumptions, and mechanisms by which measured savings are counted toward goal achievement the evaluation team believes there are alternatives to the traditional delivery model that optimize program achievements relative to costs. As an example, Avista should consider not running the program during the second year of a biennium given the constraints currently in place. Per the hypothetical example below, the acquisition cost greatly increases in 2017 when a 2 year measure life with no decay is assumed.

Table 7-4: Opower Acquisition Cost Example

Year	kWh per Home	Annual Program Cost per Home	Tx Homes	MWh	Cost	Incremental MWh	Acquisition Cost ($/kWh)
2016	250	$15	50,000	12,500	$750,000	12,500	$0.06
2017	300	$15	46,000	13,800	$690,000	1,300	$0.53

7.3.2.9 Low Income Program

Conclusion: The evaluation team found a high realization rate for the fuel conversion measures implemented through the Low Income program. One reason for the high RR could be due to the fact that Avista caps the reported savings value to 20% of the contractor estimated savings. In addition, the evaluation team found that the verified savings for these fuel conversion measures aligned closely with the verified savings found through the regular-income Fuel Conversion program.

Recommendation: The evaluation team recommends re-evaluating the current savings cap for fuel conversion projects. In addition, we recommend that Avista align assumptions for fuel switching savings for the Low Income and Fuel Efficiency programs.

8 Residential Lighting Study

In order to meet the objectives of the evaluation, the evaluation team collected data in the form of onsite metering of lighting fixtures in the homes of Avista customers. The study methodology chosen aligns with the Department of Energy (DOE) Uniform Measure Project (UMP) for residential lighting . The research team measured how many hours per day various lighting fixtures were illuminated during a six (6) month study period beginning July 2015 and lasting through January 2016, at the residences of 74 Avista customers.

An average of seven (7) lamps per home were metered across a random sample of fixture and room types, with 522 lighting meters deployed across Avista's service territory. Collecting data for an average of seven lamps per residence allowed for a large dataset to be gathered for analysis across multiple delivery streams, residence, and room types. Metered lamps included both efficient lamps (CFLs and LEDs) and inefficient lamps (e.g. incandescents and halogens). A full inventory of lighting (fixture, socket, lamp type, etc.) was also performed while onsite.

All recovered logger data was compiled into a dataset, analyzed, and summarized for hours of use and peak coincidence estimation. Total hours per day was calculated from the measurement results, which included ten-minute time intervals and the associated percent on for that metered fixture. The hours of use was estimated for each logger across every day of the metering period. This data was then weighted (by room type) to the inventory population and regressed against a sinusoidal curve to develop an annualized estimate. This sinusoidal based regression corrects for (annualizes) the metering period which spanned from July 2015 through January 2016.

8.1 Methodology

8.1.1 Household Sampling Approach

To develop the sample frame, the evaluation team drew a stratified random sample of potential participants from Avista Utilities' customer list. This list was used to recruit participants. The sample was stratified by a proportional share of customer energy load in each state. Customers consuming less than 2,000 kWh/ year were removed from the list of potential study candidates[30]. The sample frame was further stratified based on geographic region (ID-North, ID-South, WA-North, WA-Central, and WA-South) and premise type (single family vs. multifamily). The sample structure was designed to be representative of program participation and the population at large, as practical. The representativeness controls the research team established when recruiting participants in the study include:

Participation by geographic region (ID-North, ID-South, WA-North, WA-Central, and WA-South)

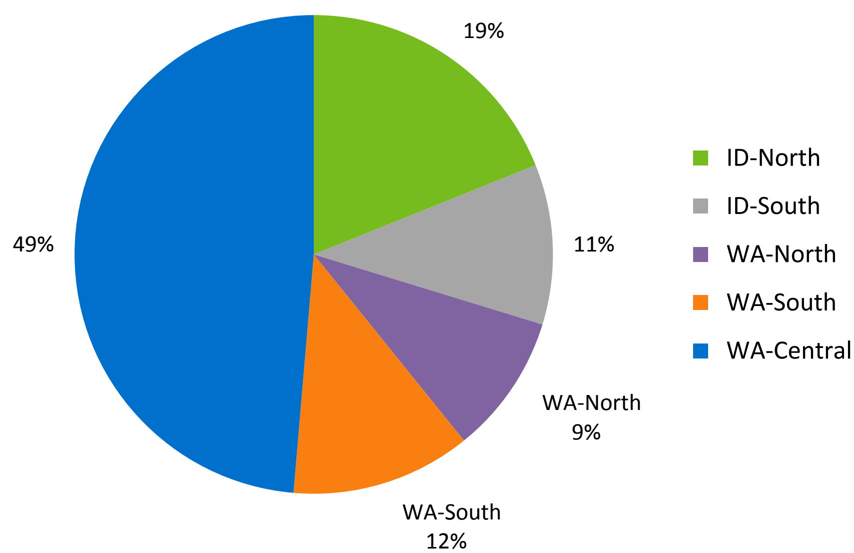
[30] It is assumed that a typical customer home consumes at least 2,000 kWh per year. This control, therefore, will remove non-home premises from the sample.

- Participation by dwelling type (single family vs. multifamily)
- Participation by household income level (low income vs. non-low income)
- Participation by geographic type (rural vs. urban)
- Participation by age of head of household

As outlined in the figures below, the evaluation team believes that the controls have been met to ensure that the sample is representative of the population.

The evaluation team targeted 33% Idaho region (21% ID-North and 12% ID-South) and 67% Washington region (9% WA-North, 11% WA-South, and 47% WA-Central) participation in the study. This split was based on the share of energy consumption by region. Figure 8-1 shows that the actual split of participants was a representative 30% Idaho (19% ID-North and 11% ID-South) and 70% Washington (9% WA-North, 12% WA-South, and 49% WA-Central).

Figure 8-1: Actual Customer Participation by Region

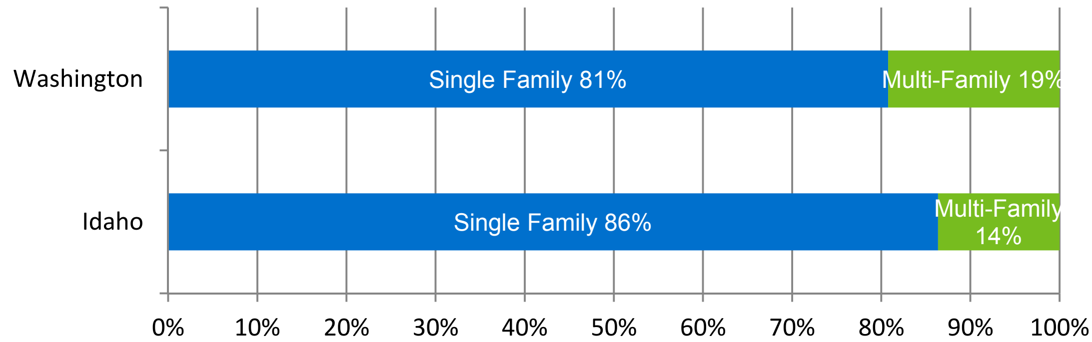


Another important check to ensure a representative sample was to control for housing type (single family vs. multi-family). We researched the current split of residents in the State of Washington for these two housing types at 26% multi-family and 74% single family[31]; with the State of Idaho researched to be 15% multi-family and 85% single family[32]. Figure 8-2 shows that the research team achieved a representative sample with 81% single family and 19% multi-family participants in Washington and 86% single family and 14% multi-family participants in Idaho.

[31] Based on 2015 U.S. Census data for the State of Washington - http://quickfacts.census.gov/qfd/states/53000.html

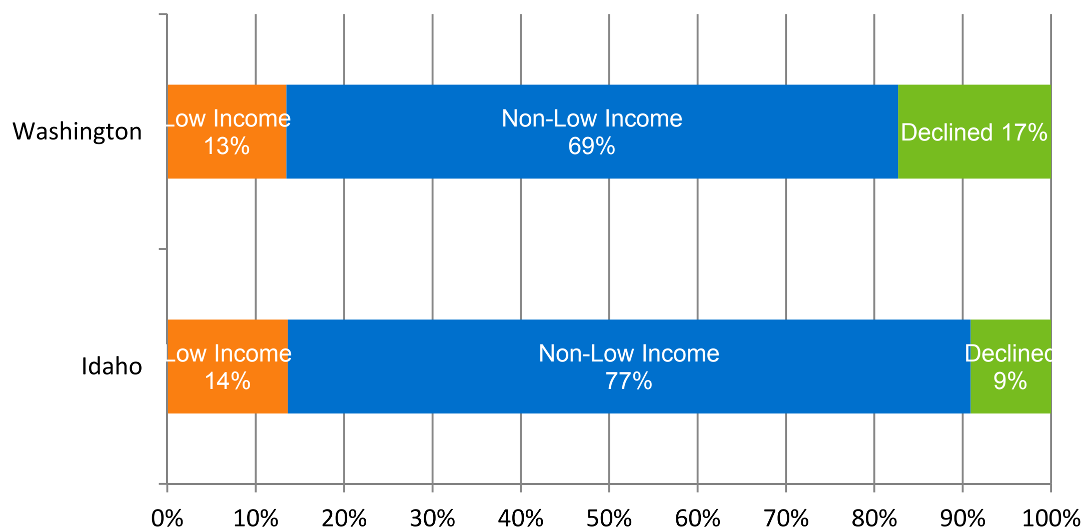
[32] Based on 2015 U.S. Census data for the State of Idaho - http://quickfacts.census.gov/qfd/states/16000.html

Figure 8-2: Actual Participation by Dwelling Type



A third important factor we took into consideration, and monitored to ensure a proper representative sample, was the household income level (low income vs. non-low income).The State of Washington listed 13% within the low income range and 87% non-low income[33]. Similarly, the state of Idaho listed 16% within the low income range and 84% non-low income[34]. Figure 8-3 shows that the research team achieved a representative sample with 13% low income and 69% non-low income participants in Washington (17% of participants declined to answer the survey question) and 14% low income and 77% non-low income participants in Idaho, with 9% declining.

Figure 8-3: Actual Participation by Household Income



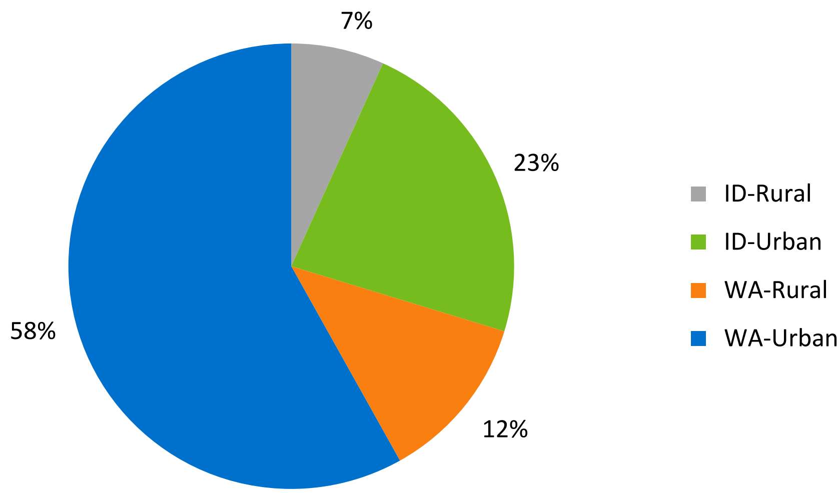
Additionally, the evaluation team reviewed and incorporated the delineation of geographical areas (urban vs. rural) into the sampled homes to further ensure a proper general population representation. The customer counts within Avista's territory showed 53.6% of the population is

[33] Based on 2015 U.S. Census data for the State of Washington - http://quickfacts.census.gov/qfd/states/53000.html

[34] Based on 2015 U.S. Census data for the State of Idaho - http://quickfacts.census.gov/qfd/states/16000.html

considered WA-Urban, while 12.6% is WA-Rural, 23.2% is ID-Urban, and 10.6% is ID-Rural. Figure 8-4 shows that the research team achieved a representative sample with 58.1% WA-Urban, 12.2% WA-Rural, 23.0% ID-Urban, and 6.8% ID-Rural.

Figure 8-4: Actual Participation by Geographical Area



Finally, evaluation team also conducted representativeness checks to ensure participants were from a cross-section of age demographics. The age of the head of household (HOH) was collected for each home visited. The distribution of study participants is provided in Table 8-1 and is reasonably representative of the age demographics for the States of Washington and Idaho. 8.1% of the homes visited declined to provide the age of their head of household, but confirmed it was over the age of 18.

Table 8-1: Head of Household Age Participant Share

HOH Age	Target Participation by Age[35]	Actual Participation by Age
18 to 24	12.0%	1.4%
25 to 44	36.0%	23.0%
45 to 64	36.0%	41.9%
>65	16.0%	25.7%
Declined	0.0%	8.1%

8.1.2 Logger Deployment Sampling Approach

Because the upstream and giveaway components of the Avista lighting program do not target specific fixtures or high-usage areas in the home, the study metered an average of seven (7) lamps per home across a random sample of fixture and room types in the homes of 74 Avista

[35] Based on combined 2012 U.S. Census data for the State of Washington and the State of Idaho

customers. Metered lamps included CFLs, LEDs, halogens, incandescent lamps and other misc. lamps. The lighting study targeted annual operating hour results with 9% precision at the 90% confidence level for the 522 loggers successfully deployed in metered homes.

In addition to the controls mentioned above, the research team also sought to achieve statistically meaningful results for multiple room types, as well as CFL/LED versus incandescent operating hours. The study intended to place a higher proportion of loggers in high-use room types (such as family/living room) to provide higher levels of statistical confidence for those room types. The targeted sample frame of logger deployment by room type is illustrated in below.

Table 8-2: Sample Frame of Logger Deployment by Room Type, by Bulb Type

Room Type	# of Loggers		
	CFL/LED	Incandescent	Total
Bathroom	20	19	39
Bedroom	45	45	90
Dining Room	35	34	69
Foyer/Hallway	20	20	40
Kitchen	35	34	69
Family/Living Room	45	45	90
Garage/Attic/Other	35	34	69
Other	35	34	69
TOTAL	**270**	**265**	**535**

8.1.3 Primary Data Collection

To accurately meet the objectives of this study the evaluation team designed an approach which utilized a primary data collection approach in the form of onsite surveys & metering of customer homes. Onsite surveys and metering provides highly accurate data because information is collected and loggers deployed by trained engineers with experience identifying and properly deploying metering equipment on lighting fixtures. The methods used to collect data through onsite visits are detailed below.

8.1.3.1 Recruitment & Participant Criteria

1,500 general population Avista customers were contacted via a mailed letter (Appendix B) to ask for their participation in the study. Recruitment letters (Appendix C) were mailed to the sample frame customers. The letter introduced them to the study, and requested they call a toll-free phone number to speak with an evaluation team representative if they were interested in participating in the study, or had further questions. Participants were provided a $75 incentive to participate in the study ($25 at the time of logger installation and $50 when the loggers were collected) to participate in the study.

8.1.3.2 Lighting Inventory

An inventory of all the lighting fixtures and lamps was performed while at each participant's home. The purpose was not only to provide insightful saturation data on CFL, LEDs and other lamps, but provided the necessary information to properly weight the hours of use data by room type. Upon arrival at the home, the field engineer inspected each room and took a full inventory of all the lighting circuits, fixtures and lamps. Data collected include:

- Circuit Type
- Room Type & Description
- Fixture type and quantity
- Socket type and socket quantity per fixture
- Lamp type, lamp shape, and lamp quantity per fixture
- Watts per lamp (when available)

The categorization utilized to identify fixture, socket and lamp types can be found in the Lighting Inventory Form in Appendix C.

8.1.3.3 Measurement Activities

An average of seven (7) HOBO® on/off and light intensity data loggers were placed in each of the 74 customer homes that participated. The data loggers utilized for this study include:

- HOBO UX90-002 Light On/Off
- HOBO U9-002 - Light On/Off
- HOBO U12-012 Temp/RH/Light Intensity

The light on/off loggers simply measure on-off luminosity events that exceed a pre-set threshold, while the intensity logger measures incremental changes in luminosity. While all loggers can be calibrated to accurately record data in any setting, the on/off loggers were targeted for deployment in low ambient lighting settings, while the intensity loggers were targeted for deployment in high ambient lighting settings. HOBO UX-90 light pipes were also deployed to help ensure the logger sensors were more effectively recording lamp luminosity, and not ambient light changes.

The location of loggers placed on the various fixtures and rooms in each home was determined by a random sampling methodology that was programmed into a smart phone randomizer application ("app") developed by the evaluation team that deterred the field engineer from introducing any bias into the where the loggers were deployed. The randomizer app required the field engineer to enter in the number of lighting circuits[36] in a home and identify which ones

[36] For the purposes of this study, a circuit is defined as the series of one or more lights controlled by a single switch (e.g. wall switch). By using circuits as the selection criteria, as opposed to fixtures, the research team was able to collect unique data sets (as logging data for more than one fixture on a single circuit would provide duplicate results).

had a CFL or LED installed on it; at which point a random sample of lighting circuits would be provided to the engineer. The field engineer then installed the lighting loggers on one fixture for the identified circuits. In order to obtain as much data as possible on CFLs and LEDs, the randomizer app was programmed to automatically include up to four (4) circuits that had CFL/LED lamp fixtures. The remaining circuits were then randomly selected for the remaining loggers. Additionally, the sampling algorithm confirmed compliance with the overall target sample frame to ensure representativeness of the general population with respect to room type. When room type quotas were reached, the evaluation team engineers refrained from installing any additional loggers in that room type.

In order to fully estimate the changes in daily operating schedules, the research team sought to have loggers deployed at least one month in each season (summer, fall and winter). Based on the delivery schedule of this study, the evaluation team began its six-month metering duration in July/August 2015 and retrieved all the loggers in January 2016.

8.1.4 Data Analysis

8.1.4.1 Data Cleaning

After removal of the loggers in January 2016, analysts downloaded logger data using HOBOware software and imported the data into STATA for generating summary statistics, data cleaning, hours of use and peak coincidence factor estimation. The research team also reviewed logger notes documented by the removal team to determine whether to include or exclude each logger from the HOU analysis. Based on these removal notes, analysts determined loggers to be excluded from the HOU analysis based on the following circumstances:

- Participants prematurely removed loggers from metered fixtures
- Participants didn’t respond to repeated requests by research team to pick up loggers
- Loggers were damaged at the customer home
- Logger malfunction (e.g. battery) led to incomplete dataset
- Field Engineer didn’t correctly “launch” logger during installation
- High ambient light conditions resulted in poor data quality

Initial review of the logger data for viability and outlier behavior was a two-step process based on the logger type: for intensity loggers the data was exported into histograms for review while event loggers (on/off events) were reviewed by STATA code. Analysts reviewed all raw intensity logger data using histograms exported into Excel, specifically targeting minimum thresholds for what would qualify as a light-on event specific to each logger. Loggers with very low or very high intensity readings or reading that appeared suspect were reviewed further; ultimately nine loggers were removed from the analysis due to questionable intensity readings.

Loggers flagged as questionable by the removal team (e.g., the participant removed the logger, the logger fell off the fixture, poor installation, etc.) were carefully reviewed to ensure that data represented *in situ* observations. As poor logger installation did not always result in bad data, some data from improperly installed loggers were included in the analysis. Some loggers were immediately coded as “remove” if they recorded data for only a small fraction of metering period (less than one month of data points), the loggers were damaged, and other anomalies.

To provide a general quality control check, analysts wrote the STATA program to “trim” data points occurring before or on the day of the install date or on the day or after the removal date. This check prevented analysis from including events occurring prior to installation, in case a technician did not reset the logger at the time of installation. The check also prevented the analysis from including events occurring after the removal date, if logger data were downloaded on a day other than the removal date.

Once the light logger data was completely cleaned, the data was merged with the household lighting audit data collected during logger installations. Table 8-3 shows the distribution of total loggers retained for final analysis (loggers with viable data) by room type. After data cleaning, a total of 459 loggers were available for the hours of use and coincident factor analysis.

Table 8-3: Distribution of Loggers Installed by Room with Viable Data

Room	Loggers with Viable Data[37]
Kitchen	61
Dining	33
Living/Great/Family	79
Foyer/Hall/Stair	42
Bedroom	77
Toilet/Bathroom	48
Other	119
TOTAL	**459**

8.1.4.2 Development of Weights

The total number of lamps metered with a data logger was weighted back to the inventory population based on two primary criteria: 1) the data was weighted to match the entire inventory sample population’s distribution of total lamps by room type, and 2) the entire inventory sample populations’ distribution of total lamps by source of efficient light bulbs (delivery stream). Population weights were developed by calculating the inverse of a lamp’s probability of being metered with a data logger. This resulted in a different weight for each combination of room type and source of efficient light bulb, and renders the logger-based lamp sample frame equivalent to a simple random sample. Table 8-4 shows the population weights calculated using the inventory-based, and logger-based, lamp counts.

[37] This represents the number of loggers included in the analysis after data cleaning.

Table 8-4: Population Weights Applied to Sample Frame

Room	Lamp	Inventory-based Lamp Count	Logger-based Lamp Count	Population Weight
		(A)	(B)	(A / B)
Kitchen	CFL	93	54	1.7
	Incandescent	316	95	3.3
	LED	94	31	3.0
Dining	CFL	23	18	1.3
	Incandescent	190	89	2.1
	LED	25	22	1.1
Living/Great/Family	CFL	155	53	2.9
	Incandescent	326	70	4.7
	LED	49	11	4.5
Foyer/Hall/Stair	CFL	55	21	2.6
	Incandescent	223	33	6.8
	LED	13	8	1.6
Bedroom	CFL	182	50	3.6
	Incandescent	432	77	5.6
	LED	42	4	10.5
Toilet/Bathroom	CFL	144	55	2.6
	Incandescent	461	73	6.3
	LED	24	3	8.0
Other	CFL	276	83	3.3
	Incandescent	753	108	7.0
	LED	26	4	6.5

8.1.4.3 Hours of Use Modeling

Estimates of HOU were developed by first annualizing the logger data, and then applying a hierarchical linear model. The logger data was annualized to simulate a full year of data for loggers that were installed for part of the year. The hierarchical linear model was applied, with the population weights, to estimate HOU with standard errors that reflect the structure of the sample.

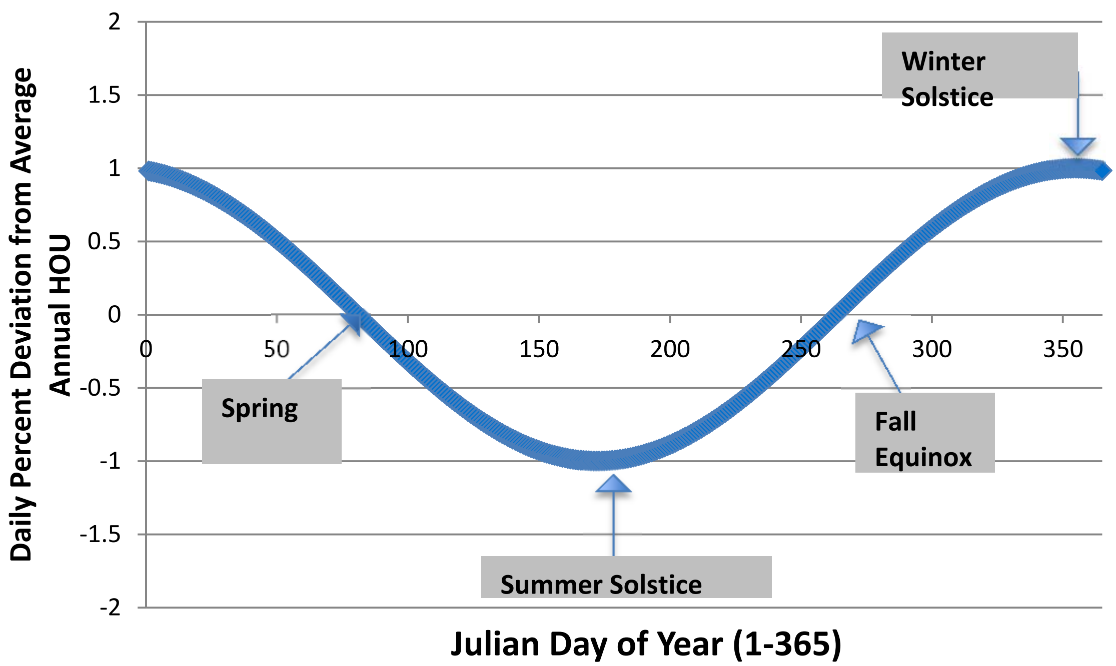
8.1.4.4 Development of Annualized HOU

Residential lighting usage, both frequency and duration-based, is partly a function of ambient daylight. Lamps used in rooms without access to daylight (closets, basements, and other windowless rooms), along with lamps with usage independent of daylight (lights on timers or lights turned on when home from work), can be classified as “base load” lights. Overall, HOU for homes is based on this base load usage, combined with usage dependent on hours of daylight.

Overall usage, therefore, fluctuates over the course of a year given fluctuations in daylight hours.

The average HOU for all lamps during the summer solstice (beginning June 21) is expected to be the lowest of the year, while HOU usage during winter solstice (beginning December 21) to be the highest of the year. Average annual use is assumed to be coincident with the spring and fall equinox, occurring on March 20 and September 22, respectively. For example, the fraction of the daily percent difference from the average annual daylight hours across one year is represented as a sinusoid curve. This curve can be represented by the equation *sin(-2π(284+d)/365),* where d is the Julian date of the year (January 1 = 1, December 31 = 365). Figure 8-5, the peak and trough (at 1 and -1, respectively) represent the winter and summer solstices, and 0 represents the spring and fall equinoxes (effectively the annual average daylight hours).

Figure 8-5: Percent Deviation from Average Annual Daylight Hours



Light logger data were collected during a six-month period starting July 2015 and removed from the homes in January 2016. Basing HOU on these data alone would result in a low estimate, as lighting HOU and daylight hours are inversely related. In other words, HOU should increase with decreasing daylight. Annualization of the spring and summer-only HOU estimate was required to adjust this HOU to an annual value.

The basis for the HOU annualization is the UMP Chapter 6: Residential Lighting Evaluation Protocol[38]. According to the UMP: "Due to the seasonality of lighting usage, logging should be

[38] *The Uniform Methods Project Methods for Determining Energy Efficiency Savings for Specific Measures*, Scott Dimetrosky, Apex Analytics LLC. April, 2013. https://www1.eere.energy.gov/wip/pdfs/53827-6.pdf

conducted in total for at least six months and capture summer, winter, and at least one shoulder season — fall or spring. At a minimum, loggers should be left in each home for at least three months (that is, two waves of three months each to attain six months of data). All data should be annualized using techniques such as sinusoidal modeling to reflect a full year of usage." The UMP goes on to discuss the sinusoid regression: "Sinusoidal modeling assumes that hours of use will vary inversely with hours of daylight over the course of a year. Sinusoid modeling shows that (1) hours of use change by season, reflective of changes in the number of daylight hours and weather and (2) these patterns will be consistent year to year, in the pattern of a sine wave. An example of this approach is provided in the evaluation of the 2006 - 2008 California Upstream Lighting Program evaluation."

A sinusoid curve, best representing annual changes in daylight hours, was then statistically fit to weekend and weekday logger data using the following equation:

Equation 8-1: Sinusoidal Model Specification

$$HOU_d = \beta_0 + \beta_1 \sin\theta_d + \varepsilon_d$$

Where:

HOU = hours of use;

θ = angle, in radians, representing the amount of sunlight on the day. Theta is – for the spring and autumnal equinoxes, pi / 2 for the winter solstice, and –pi / 2 for the summer solstice;

d = the day of the year;

β_0 = the intercept, representing the annual average HOU estimate (which coincides with the spring and fall equinox);

β_1 = coefficient representing the difference between the HOU on the solstice and the average HOU (maximum amplitude of the curve); and

ε = error term.

For the Avista HOU lighting analysis, the evaluation team leveraged this sinusoid model to calculate the adjusted average annual HOU, based on the available logger data. We used separate models for weekday and weekend data, and regressed mean daily use for the relevant days in the metering period on the sin(θd) associated with those days. Drawing on methodology used in the Pennsylvania 2014 Commercial & Residential Light Metering Study[39], a sinusoidal model was deemed to have a poor fit if one of the following criteria was met:

4) β_1 has an absolute value greater than 10;

5) The standard error for $\beta_1$is greater than 1;

6) β_0 is less than or equal to 0; and

7) β_0 is greater than 24.

[39] Pennsylvania Statewide Act 129 2014 Commercial & Residential Light Metering Study. Prepared by the Pa Statewide Evaluation Team; GDS Associates, Nexant, Research Into Action, Apex Analytics. January 13, 2014.

Based on the above criteria, 37 of 916 sinusoidal models were identified as poorly fit. Those 37 represented 30 loggers (because weekend and weekday data was modeled separately, a single logger had two sinusoidal models associated with it). Rather than using the fitted values for those 37 models, the average HOU from the logger data was used to estimate annual HOU.

8.1.4.5 Hierarchical Model

A weighted hierarchical (or multilevel) model was developed to estimate average HOU for the home.[40] The key advantage of the hierarchical approach is that the model takes into account in-home lighting usage covariance in estimating coefficients. This is important as lighting across multiple loggers in the same home are likely to have some covariance associated with the usage behavioral patterns of the home's occupants. For instance, during an extended vacation, nearly all of the lights in the home may be off, and all of those loggers would record zero usage during those same dates.

The model includes random effects for the intercept at the household level, which accounts for correlation among loggers within a home. To estimate HOU for various categories such as room type, lamp usage category and fixture type, fixed effects variables were included in the model. The specification shown in equation 2 below features fixed effects for room type, but the model takes a similar form for other categories.

Equation 8-2: Hierarchical Linear Model for HOU

$$HOU_{h,i} = (\beta_0 + b_{0,h}) + \sum_r \beta_r I_r + \epsilon_{h,i}$$

Where:

HOU = hours of use;
$b_{0,h} \sim N(b_h, \sigma^2_{b_h})$;
h = index for home;
i = index for logger;
r = index for room type;
I_r = indicator variable for room type;
β_x = fixed effects coefficients;
$b_{0,h}$ = random effects coefficients; and
ε = error term.

8.1.4.6 Coincidence Factor Modeling

Avista has three peaks for which coincidence factors were calculated: a summer peak from 5 to 6.30 PM, a winter peak from 7 to 8 AM, and a winter peak from 5 to 6 PM. For each peak, the coincidence factor is average percent of the hour lights are on during the defined peak period of non-holiday weekdays.

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[40] Hierarchical models are described very briefly here. For further details, refer to the following: Woltman, Feldstain, MacKay, and Rocchi, *An introduction to hierarchical linear modeling;* Goldstein, Harvey, *Multilevel Statistical Models;* and Sullivan, Dukes, and Losina, *Tutorial in Biostatistics: An Introduction to Hierarchical Linear Modeling.*

Since loggers were in place for nearly an entire summer period (July through September), and nearly an entire winter period (November through January and, in many cases, some part of February), sinusoidal model estimates were not used in the estimated CF. Average CF was computed for each peak period for each logger and then a hierarchical model was developed to estimate CF. The model has a similar form to that used to estimate HOU, featuring random effects for the intercept at the household level, which accounts for correlation among loggers within a home. To estimate CF for various categories such as room type, lamp usage category and fixture type, fixed effects variables were included in the model. The specification shown in equation 3 below features fixed effects for room type, but the model takes a similar form for other categories. The CF during each of the three peak periods was estimated separately using the same specification.

Equation 8-3: Hierarchical Linear Model for HOU

$$CF_{h,i} = (\beta_0 + b_{0,h}) + \sum_r \beta_r I_r + \epsilon_{h,i}$$

Where:

CF = coincidence factor during a particular peak period;

$b_{0,h} \sim N(b_h, \sigma^2_{b_h})$;

h = index for home;

i = index for logger;

r = index for room type;

I_r = indicator variable for room type;

β_x = fixed effects coefficients;

$b_{0,h}$ = random effects coefficients; and

ε = error term.

8.2 Lighting Inventory Findings

An important part of the residential HOU study is the collection of bulb saturation data across the homes that participated in the study. Saturation studies are useful tools to help gauge the market penetration of efficient lighting products to assess past program effectiveness and to determine future potential for continued lighting program efforts. Additionally, collecting supplemental information about each user and home of where the bulbs were installed allows segmenting the analysis to frame and design future programs to target these areas of highest potential.

There were a total of 3,902 lighting sockets reviewed based on the 74 homes surveyed (or an average of 53 sockets per home). The evaluation team found CFL socket saturation to be 23.8% and LED saturation at 7.0%. The combined less efficient (non CFL/LED) 69.2% bulb saturation can be viewed as the maximum available potential for future CFL and/or LED installations.

Table 8-5: Lighting Inventory Summary Saturation by Lamp Type

Lamp Type	Total Bulbs	Lamp Distribution %
CFL	928	23.8%
Empty Socket	71	1.8%
Halogen/Quartz	152	3.9%
Incandescent	2102	53.9%
LED	273	7.0%
Linear Fluorescent	353	9.0%
Other	6	0.2%
N/A	17	0.4%
TOTAL	**3,902**	**100%**

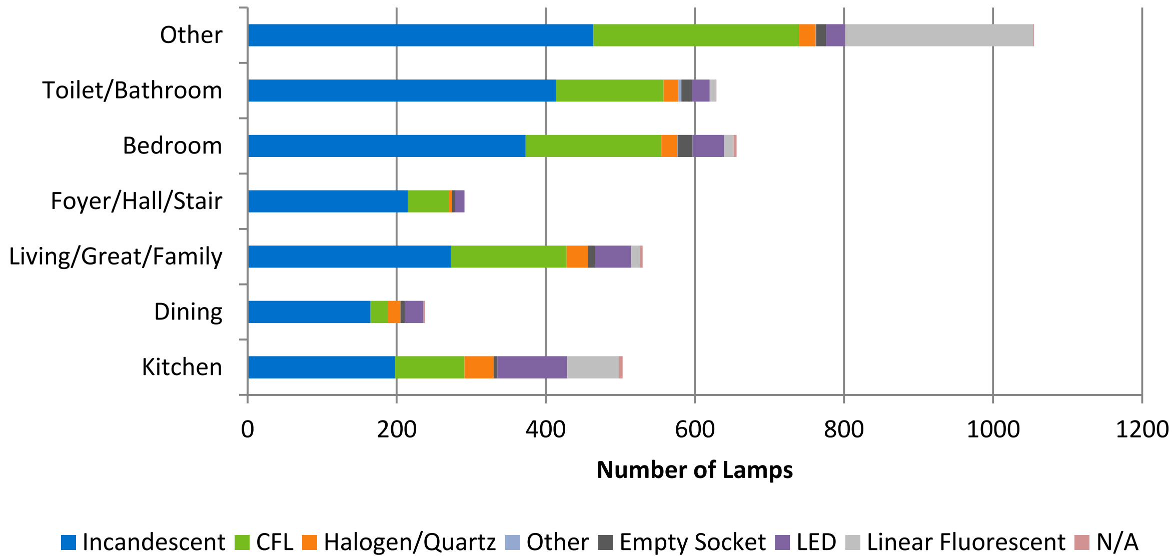
8.2.1 CFL & LED Saturation by Room Type

Knowing which rooms have the most CFL and LED lamps installed helps to understand how consumers are using and installing energy efficient bulbs. Table 8-6 shows the CFL and LED saturation by room type, with living/great/family room type having the highest CFL saturation (29.2% CFL saturation), whereas dining rooms have the lowest CFL saturation (9.7%). Kitchens had the highest LED saturation (18.7%) and "Other" rooms had the lowest LED saturation (2.5%). Figure 8-6: Lighting Inventory Summary of Room and Lamp Type shows the complete lighting inventory represented by room and lamp type.

Table 8-6: Lighting Inventory Summary CFL Saturation by Room Type

Room Type	Total Bulbs	CFLs	CFL Saturation	LED	LED Saturation
Kitchen	503	93	18.5%	94	18.7%
Dining	238	23	9.7%	25	10.5%
Living/Great/Family	530	155	29.2%	49	9.2%
Foyer/Hall/Stair	291	55	18.9%	13	4.5%
Bedroom	656	182	27.7%	42	6.4%
Toilet/Bathroom	629	144	22.9%	24	3.8%
Other	1055	276	26.2%	26	2.5%
TOTAL	**3,902**	**928**	**23.8%**	**273**	**7.0%**

Figure 8-6: Lighting Inventory Summary of Room and Lamp Type



8.2.2 CFL & LED Saturation by Socket and Circuit Type

As shown in Table 8-7 the majority (76.8%) of the sockets are medium screw based bulbs, followed by pin based bulbs (10.4%). CFL saturation is highest for the medium screw based fixtures (30.2%) and LED saturation is highest for the “Other” socket type at 40.8%. Also shown below in Table 8-8 is the majority (86.7%) of circuits are represented by the standard on/off switch. If remote control and other circuits are excluded (since there were only 4 total circuits represented in this study) circuits with dimmer capabilities have the lowest CFL saturation (7.6%) and timers have the lowest LED saturation (2.6%).

Table 8-7: Lighting Inventory CFL Saturation by Socket Type

Socket Type	Total Sockets	Socket Type Distribution	CFL Saturation %	LED Saturation %
Medium Screw Base (standard)	2,998	76.8%	30.2%	5.8%
Small Screw Base (candelabra)	353	9.0%	2.0%	1.1%
Pin Base	404	10.4%	2.5%	8.4%
Other	147	3.8%	4.1%	40.8%
TOTAL	**3,902**	**100.0%**	**23.8%**	**7.0%**

Table 8-8: Lighting Inventory CFL Saturation by Circuit Type

Circuit Type	Total Circuits	Total Sockets per Circuit Group	Circuit Type Distribution	CFL Saturation %	LED Saturation %
3-way	59	198	3.5%	8.1%	12.1%
Dimmer	76	302	4.5%	7.6%	4.3%
Motion/Photo Sensor	26	42	1.5%	19.0%	4.8%
On/Off (switch, plug, string)	1460	3238	86.7%	26.4%	7.2%
Other	1	2	0.1%	0.0%	0.0%
Remote Control	3	6	0.2%	0.0%	0.0%
Timer	23	38	1.4%	31.6%	2.6%
N/A	36	76	2.1%	19.7%	0.0%
TOTAL	**1,684**	**3,902**	**100.0%**	**23.8%**	**7.0%**

8.2.3 CFL & LED Saturation by Housing Type and Ownership Status

Multi-Family homes have the highest CFL saturation (close to 33%) while mobile homes had the highest LED saturation at 14.2% (though the level of confidence in this estimate is low since there were only 5 mobile homes in the sample). Interestingly, CFL saturation was the highest in rental households (38.3%) while LED saturation was highest in owner-occupied households (7.7%).

Table 8-9: Lighting Inventory CFL Saturation by Building Type

Building Type	Number of Homes in Sample	Number of Sockets	CFL Saturation %	LED Saturation %
Mobile Home	5	218	25.2%	14.2%
Multi-Family (3+ Units)	10	167	32.9%	0.6%
Single Family (1 unit)	57	3,450	23.3%	7.0%
Single Family Attached (2 units)	2	67	19.4%	0.0%
TOTAL	**74**	**3,902**	**23.8%**	**7.0%**

Table 8-10: Lighting Inventory CFL Saturation by Ownership Type

Ownership Status	Number of Homes in Sample	Number of Sockets	CFL Saturation %	LED Saturation %
Own	56	3,460	21.9%	7.66%
Rent	16	376	38.3%	1.06%
N/A	2	66	37.9%	6.06%
TOTAL	**74**	**3,902**	**23.8%**	**7.00%**

8.2.4 CFL & LED Saturation by Region

Table 8-11 shows the CFL and LED saturation by region. The Avista region with the highest CFL and LED saturation was WA-Central with 30.3% and 10.7% respectively. The region with the lowest CFL saturation was WA-North (10.1%), while WA-South had the lowest LED saturation (1.2%).

Table 8-11: Lighting Inventory CFL Saturation by Region

Region	Homes in Sample	Number of Sockets	CFL Saturation %	LED Saturation %
Idaho	**22**	**1,231**	**18.8%**	**4.8%**
ID-North	14	648	18.4%	5.1%
ID-South	8	583	19.2%	4.5%
Washington	**52**	**2,671**	**26.1%**	**8.0%**
WA-North	7	317	10.1%	3.5%
WA-South	9	514	20.8%	1.2%
WA-Central	36	1840	30.3%	10.7%
TOTAL	**74**	**3,902**	**23.8%**	**7.0%**

8.2.4.1 Program Participation & Misc. Saturation Findings

While onsite, evaluation team engineers asked homeowners if they recall receiving free light bulbs from Avista from the Avista light bulb give-away program. Table 8-12 shows that percentage of participants that recall receiving the free light bulbs. We also found that of those customers that recall receiving a free light bulb, 100% of them installed the free light bulb.

Table 8-12: Free CFL Program Participation Findings

Building Type	Total Homes Visited	% of homes that recall receiving free lights
Mobile Home	5	80.0%
Multi-Family (3+ Units)	10	40.0%
Single Family (1 unit)	57	56.1%
Single Family Attached (2 units)	2	50.0%
TOTAL	**74**	**55.4%**

Engineers also recorded information on household space heating and space cooling equipment, as well as asked them about the number of portable electronics in the household. The research team found that 81% of households have a furnace to provide their space heating needs, while 54% of households use a central A/C systems for space cooling (Table 8-13 and Table 8-14). 5.4% of households were found to have no space cooling equipment present.

Table 8-13: Space Heating Equipment Saturation

Space Heating Equipment Type	Households	Equipment Count	Saturation
Baseboard	8	8	10.8%
Furnace	60	60	81.1%
Other	4	4	5.4%
N/A	2	2	2.7%
TOTAL	**74**	**74**	**100.0%**

Table 8-14: Space Cooling Equipment Saturation

Space Cooling Equipment Type	Households	Equipment Count	Fuel Share %
Central A/C	40	40	54.1%
Fan	3	3	4.1%
Other	4	4	5.4%
Window A/C	23	23	31.1%
None	4	4	5.4%
TOTAL	**74**	**74**	**100.0%**

The share of households that use natural gas as their primary space heating fuel was estimated at 68.9%, while the share of households that utilize electricity as their primary space heating fuel was estimates at 24.3% (Table 8-15). The research team also asked the participants to estimate the number of portable electronics in their household – and found the average number of portable electronics per household to be 3.7.

Table 8-15: Space Heating Fuel Share

Space Heating Fuel Type	Households	Fuel Share %
Electric	18	24.3%
Gas	51	68.9%
Oil	2	2.7%
Pellets	1	1.4%
Wood	1	1.4%
N/A	1	1.4%
Total	74	100%

8.3 Lighting Hours of Use Findings

8.3.1 Aggregate Hours of Use

The overall daily lighting hours of use (HOU) annualized across the entire year is estimated to be 1.94. This value is estimated with a 90% confidence and 15.3% precision. Given a calculated

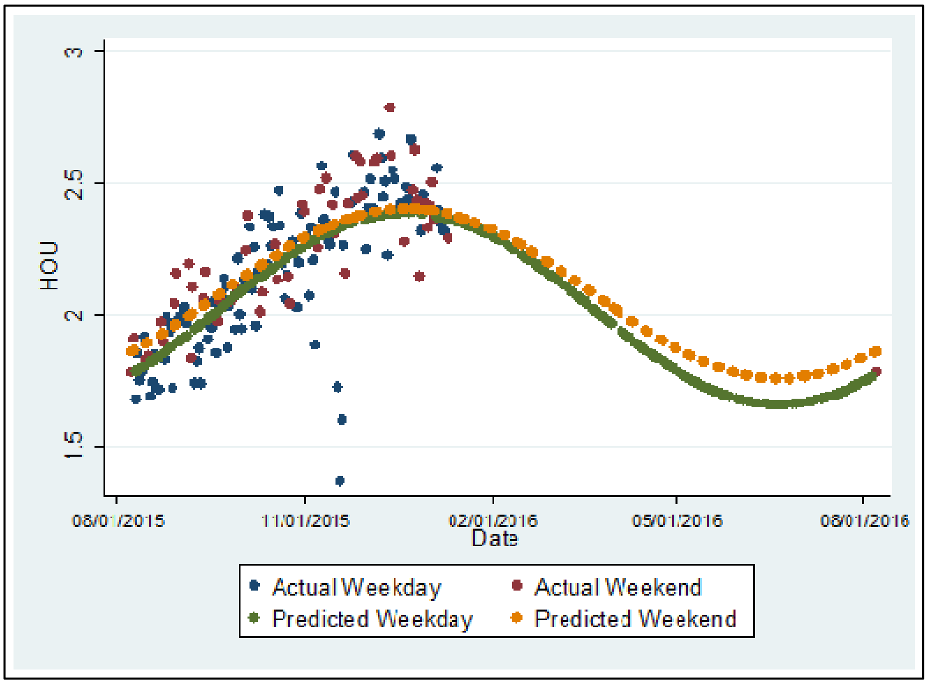
0.18 standard error, the research team estimates this annualized daily HOU value could be as low as 1.64 hours/day or as high as 2.23 hours/day.

Table 8-16: Aggregate Lighting Socket Hours of Use

HOU Estimation	Mean HOU	Standard Error	Precision (90% confidence)	Lower Limit	Upper Limit
Hierarchical Estimate, Clustered SE	1.94	0.18	15.3%	1.64	2.23

The predicted and actual aggregated hours of use from August 8th, 2015 through January 10th, 2016 is displayed in Figure 8-7 below.

Figure 8-7: Aggregate Hours of Use Actual and Annualized Estimate



8.3.2 Hours of Use by Lamp Type

The evaluation team also investigated the differences between bulb types within the homes metered. Higher efficiency bulbs such as CFLs and LEDs showed considerably higher overall hours of use (2.21 and 3.37, respectively) relative to inefficient bulbs such as incandescents (1.69). The results are statistically significant as found in Table 8-17.

Table 8-17: Hours of Use by Lamp Type

Lamp Type (Logger Level)	Mean HOU	Standard Error	Precision (90% confidence)	Lower Limit	Upper Limit
CFL	2.21	0.22	16.8%	1.84	2.58
Incandescent	1.69	0.18	17.7%	1.40	1.99
LED	3.37	0.77	37.7%	2.10	4.64

8.3.3 Hours of Use by Room Type

Finally, the team investigated the differences in lighting hours of use across various room types. Kitchens were the highest HOU, with well above 3 hours/day, relative to bedrooms and foyer/hall/stairways, which are lower-use rooms (just over 1 hour/day). The research team also calculated the estimated hours of use by high/moderate and low usage room types. The results are and presented in Table 8-18 and Table 8-19 respectively.

Table 8-18: Hours of Use by Room Type

Room (Logger level, weighted by event type)	Annualized Room-Based HOU	Standard Error	Precision (90% confidence)	Lower Limit	Upper Limit
Kitchen	3.75	0.45	19.57%	3.02	4.48
Dining	2.48	0.55	36.43%	1.57	3.38
Living/Great/Family	2.41	0.31	21.31%	1.90	2.93
Foyer/Hall/Stair	1.25	0.37	49.09%	0.63	1.86
Bedroom	1.25	0.18	23.08%	0.97	1.54
Toilet/Bathroom	1.82	0.30	27.46%	1.32	2.32
Other	1.52	0.25	26.53%	1.12	1.92

Table 8-19: Hours of Use by Room Usage Type

Room Usage Type (Logger level)	N	HOU	Standard Error	Precision (90% confidence)	Lower Limit	Upper Limit
High Use	314	3.03	0.31	16.58%	2.53	3.53
Moderate Use	606	1.66	0.20	19.68%	1.33	1.98
Low Use	42	0.36	0.36	166.90%	-0.24	0.95

8.3.4 Peak Coincidence

To calculate the peak coincidence factor (CF), the team used the same clean light logger dataset used for HOU estimates. Analysts calculated the peak coincidence factors based on the peak period: a summer peak from 5 to 6.30 PM, a winter peak from 7 to 8 AM, and a winter peak from 5 to 6 PM. Average CF was computed for each peak period for each logger and then a hierarchical model was developed to estimate CF.

The weighted peak coincidence factor for Avista's peak period is 10.2% (Table 8-20). The CF for the winter 7-8am was calculated at 8.0%, while the 5-6pm winter peak CF was calculated at 14.4% and the 5-6:30pm summer peak CF is estimated at 9.1%.

Table 8-20: Lighting Coincident Factor by Peak Period

Peak	CF Estimation	N	CF	Standard Error	Precision (90% confidence)	Lower Limit	Upper Limit
Winter, 7-8 AM	Hierarchical Estimate, Robust SE	962	8.0%	0.01	22.74%	6.2%	9.8%
Winter, 5-6 PM	Hierarchical Estimate, Robust SE	962	14.4%	0.01	14.91%	12.3%	16.6%
Summer. 5- 6.30 PM	Hierarchical Estimate, Robust SE	962	9.1%	0.01	18.73%	7.4%	10.8%
Weighted Average	Hierarchical Estimate, Robust SE	962	10.2%	0.01	15.14%		

The evaluation team also estimated coincident factor by lamp type and room type. Findings are presented in Table 8-21 and Table 8-22, but it should be noted that the number of sample points among some variables is quite low (e.g. metered lamps in hallways), which lead to low confidence/precision estimates. The reader should be mindful of this uncertainty when interpreting the results.

Table 8-21: Coincident Factor by Peak Period by Lamp Type

Peak	Lamp Type (Logger Level)	N	CF	Standard Error	Precision (90% confidence)	Lower Limit	Upper Limit
Winter, 7-8 AM	CFL	334	0.10	0.02	33.54%	0.06	0.13
	Incandescent	545	0.07	0.01	27.07%	0.05	0.08
	LED	83	0.16	0.06	60.40%	0.06	0.26
Winter, 5-6 PM	CFL	334	0.17	0.02	19.71%	0.13	0.20
	Incandescent	545	0.13	0.02	19.49%	0.10	0.15
	LED	83	0.22	0.04	29.24%	0.15	0.28
Summer, 5-6.30 PM	CFL	334	0.10	0.01	21.47%	0.08	0.12
	Incandescent	545	0.08	0.01	23.22%	0.06	0.10
	LED	83	0.13	0.03	32.78%	0.08	0.17

Table 8-22: Coincident Factor by Peak Period by Room Type

Peak	Room Type (Logger level)	N	CF	Standard Error	Precision (90% confidence)	Lower Limit	Upper Limit
Winter, 7-8 AM	Kitchen	180	0.16	0.04	37.49%	0.10	0.23
	Dining	129	0.06	0.02	53.25%	0.03	0.10
	Living/Great/Family	134	0.09	0.02	31.31%	0.06	0.12
	Foyer/Hall/Stair	62	0.09	0.03	55.36%	0.04	0.14
	Bedroom	131	0.06	0.02	47.75%	0.03	0.09
	Toilet/Bathroom	131	0.10	0.03	42.21%	0.06	0.14
	Other	195	0.04	0.02	73.21%	0.01	0.06
Winter, 5-6 PM	Kitchen	180	0.31	0.04	21.03%	0.24	0.38
	Dining	129	0.22	0.04	31.27%	0.15	0.29
	Living/Great/Family	134	0.24	0.03	18.93%	0.20	0.29
	Foyer/Hall/Stair	62	0.12	0.03	42.75%	0.07	0.17
	Bedroom	131	0.08	0.02	33.77%	0.05	0.10
	Toilet/Bathroom	131	0.07	0.02	40.35%	0.04	0.09
	Other	195	0.11	0.02	30.02%	0.08	0.14
Summer, 5-6.30 PM	Kitchen	180	0.16	0.02	24.68%	0.12	0.20
	Dining	129	0.13	0.03	44.49%	0.07	0.18
	Living/Great/Family	134	0.09	0.02	32.93%	0.06	0.11
	Foyer/Hall/Stair	62	0.06	0.02	69.16%	0.02	0.10
	Bedroom	131	0.04	0.01	43.46%	0.02	0.06
	Toilet/Bathroom	131	0.11	0.02	30.86%	0.07	0.14
	Other	195	0.09	0.02	34.97%	0.06	0.12

Appendix A Sampling and Estimation

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

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

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

1) **Mean-Per-Unit** (or estimation in the absence of auxiliary information): This technique was used to analyze samples drawn from populations that are similar in size and scope. This approach was used primarily for residential programs that include a large number of rebates for similar equipment types where the evaluation objective is to determine an average kWh savings per rebated piece of equipment. With mean-per-unit estimation the average kWh 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

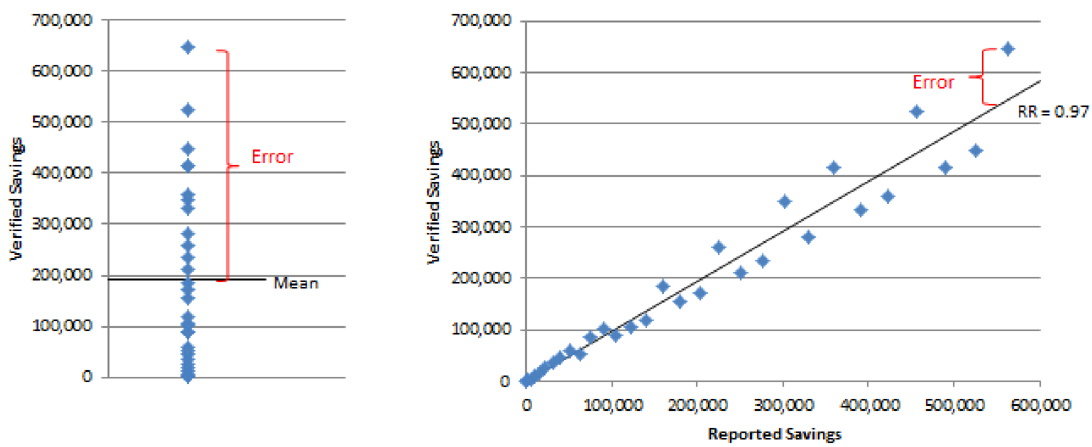
representative of the program as a whole. This ratio is referred to as the *realization rate*, or *ratio estimator*, and is calculated as follows:

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



For a measure such as the variable speed house fan, where each of the nearly 1,300 rebated units claimed an identical savings value of 439 kWh/year ratio estimation would offer no advantage over mean-per-unit estimation because there is no variability along the x-axis to leverage.

A.1 Stratification

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

Table A- 1: Case Weights Example

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

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

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

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

A.2 Presentation of Uncertainty

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

Equation A- 2: Coefficient of Variation

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

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

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

Equation A- 3: Error Ratio

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

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

Equation A- 4: Required Sample Size

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

Where:

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

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

Equation A- 5: Finite Population Correction Factor

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

Where:

N = Size of the population

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

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

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

$$n = n_0 * fpc$$

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

Equation A- 7: Error Bound of the Savings Estimate

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

Where:

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

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

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

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

Equation A- 8: Relative Precision of the Savings Estimate

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

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

Table A- 2: Relative Precision Example

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

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

Equation A- 9: Combining Error Bounds across Strata

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

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 Lighting Interactive Factors

Table B- 1: Lighting Interactive Factors by Building Type and HVAC System Type

Building Type	Electric Resistance w/ Cooling	Electric Resistance w/o Cooling	Heat Pump w/ Cooling	Heat Pump w/o Cooling
Assembly	93%	82%	102%	91%
Automotive Repair	61%	61%	81%	81%
College or University	72%	53%	96%	77%
Exterior 24 Hour Operation	100%	100%	100%	100%
Hospital	29%	28%	65%	64%
Industrial Plant with One Shift	69%	61%	89%	81%
Industrial Plant with Three Shifts	69%	61%	89%	81%
Industrial Plant with Two Shifts	69%	61%	89%	81%
Library	72%	53%	96%	77%
Lodging	70%	60%	90%	80%
Manufacturing	69%	61%	89%	81%
Office <20,000 sf	72%	53%	96%	77%
Office >100,000 sf	93%	82%	102%	91%
Office 20,000 to 100,000 sf	93%	82%	102%	91%
Other Health, Nursing, Medical Clinic	93%	82%	102%	91%
Parking Garage	100%	100%	100%	100%
Restaurant	43%	41%	73%	71%
Retail 5,000 to 50,000 sf	73%	61%	93%	81%
Retail Anchor Store >50,000 sf Multistory	75%	57%	97%	79%
Retail Big Box >50,000 sf One-Story	86%	67%	103%	84%
Retail Boutique <5,000 sf	82%	69%	98%	85%
Retail Mini Mart	75%	61%	95%	81%
Retail Supermarket	86%	78%	97%	89%
School K-12	62%	52%	86%	76%
Street & Area Lighting (Photo Sensor Controlled)	100%	100%	100%	100%
Warehouse	61%	61%	81%	81%
Other	93%	82%	102%	91%

Table B- 2: Lighting Interactive Factors by Building Type and HVAC System Type Cont.

Building Type	Gas, Oil, or Biomass w/o Cooling	Cooling w/o Heat	Refrigerated Space	None/ Exterior	Gas Heating Penalty Interaction (Therms/kWh saved)
Assembly	98%	111%	130%	100%	-0.0082
Automotive Repair	96%	100%	130%	100%	-0.0177
College or University	96%	119%	130%	100%	-0.0214
Exterior 24 Hour Operation	100%	100%	130%	100%	0
Hospital	93%	101%	130%	100%	-0.0328
Industrial Plant with One Shift	96%	108%	130%	100%	-0.0177
Industrial Plant with Three Shifts	96%	108%	130%	100%	-0.0177
Industrial Plant with Two Shifts	96%	108%	130%	100%	-0.0177
Library	96%	119%	130%	100%	-0.0214
Lodging	96%	110%	130%	100%	-0.0182
Manufacturing	96%	108%	130%	100%	-0.0177
Office <20,000 sf	96%	119%	130%	100%	-0.0214
Office >100,000 sf	98%	111%	130%	100%	-0.0082
Office 20,000 to 100,000 sf	98%	111%	130%	100%	-0.0082
Other Health, Nursing, Medical Clinic	98%	111%	130%	100%	-0.0082
Parking Garage	100%	100%	130%	100%	0
Restaurant	94%	102%	130%	100%	-0.0268
Retail 5,000 to 50,000 sf	96%	112%	130%	100%	-0.0177
Retail Anchor Store >50,000 sf Multistory	96%	118%	130%	100%	-0.0196
Retail Big Box >50,000 sf One-Story	97%	119%	130%	100%	-0.0150
Retail Boutique <5,000 sf	97%	113%	130%	100%	-0.0141
Retail Mini Mart	96%	114%	130%	100%	-0.0177
Retail Supermarket	98%	108%	130%	100%	-0.0100
School K-12	96%	110%	130%	100%	-0.0218
Street & Area Lighting (Photo Sensor Controlled)	100%	100%	130%	100%	0
Warehouse	96%	100%	130%	100%	-0.0177
Other	98%	111%	130%	100%	-0.0082

Appendix C Billing Analysis Regression Outputs

C.1 HVAC Program

Table C- 1: ASHP Fixed-Effects Regression Output

```
Fixed-effects (within) regression               Number of obs      =      3826
Group variable: new_acct                        Number of groups   =       109

R-sq:  within  = 0.6350                         Obs per group: min =        20
       between = 0.0705                                        avg =      35.1
       overall = 0.4841                                        max =        37

                                                F(3,108)           =    193.04
corr(u_i, Xb)  = 0.0078                         Prob > F           =    0.0000

                                    (Std. Err. adjusted for 109 clusters in new_acct)
```

daily_kwh	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
treatment	2.953907	1.051504	2.81	0.006	.8696451	5.03817
hdd_ave	1.813402	.078876	22.99	0.000	1.657056	1.969747
c.hdd_ave#c.treatment	-.5409008	.0624757	-8.66	0.000	-.6647383	-.4170632
_cons	24.4846	1.284606	19.06	0.000	21.93829	27.03091
sigma_u	15.473174					
sigma_e	16.184346					
rho	.47754676	(fraction of variance due to u_i)				

Table C- 2: Variable Speed Fan Motor Fixed-Effects Regression Output

```
Fixed-effects (within) regression               Number of obs      =     21036
Group variable: new_acct                        Number of groups   =       592

R-sq:  within  = 0.1426                         Obs per group: min =        19
       between = 0.0007                                        avg =      35.5
       overall = 0.0492                                        max =        37

                                                F(5,591)           =    168.92
corr(u_i, Xb)  = -0.0002                        Prob > F           =    0.0000

                                        (Std. Err. adjusted for 592 clusters in new_acct)
```

daily_kwh	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
cdd_ave	2.240237	.1093027	20.50	0.000	2.025568	2.454906
treatment	.7268809	.4911327	1.48	0.139	-.2376969	1.691459
c.cdd_ave#c.treatment	-.377199	.088024	-4.29	0.000	-.550077	-.204321
hdd_ave	.448729	.031888	14.07	0.000	.3861013	.5113567
treatment	0	(omitted)				
c.hdd_ave#c.treatment	-.0784601	.0243396	-3.22	0.001	-.1262627	-.0306575
_cons	22.42068	.6604954	33.95	0.000	21.12348	23.71788
sigma_u	17.550959					
sigma_e	11.904935					
rho	.68488454	(fraction of variance due to u_i)				

C.2 Low Income Program

Table C- 3: Low Income Fuel Switching

```
Fixed-effects (within) regression               Number of obs      =      2226
Group variable: account                         Number of groups   =        67

R-sq:  within  = 0.6476                         Obs per group: min =        25
       between = 0.0081                                        avg =      33.2
       overall = 0.5357                                        max =        60

                                                F(5,66)            =    107.35
corr(u_i, Xb)  = -0.0104                        Prob > F           =    0.0000

                                (Std. Err. adjusted for 67 clusters in account)
```

daily_kwh	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
treatment	-.2237355	1.204884	-0.19	0.853	-2.629364	2.181893
cdd_ave	1.744057	.1989493	8.77	0.000	1.346842	2.141272
hdd_ave	1.71593	.0943928	18.18	0.000	1.527469	1.904392
c.cdd_ave#c.treatment	-.4636856	.1449925	-3.20	0.002	-.7531725	-.1741987
c.hdd_ave#c.treatment	-1.479525	.0896845	-16.50	0.000	-1.658586	-1.300464
_cons	15.72763	1.486092	10.58	0.000	12.76056	18.69471
sigma_u	11.082831					
sigma_e	14.797874					
rho	.35935317	(fraction of variance due to u_i)				

Table C- 4: Low Income Electric Conservation

```
Fixed-effects (within) regression               Number of obs      =      5758
Group variable: account                         Number of groups   =       165

R-sq:  within  = 0.2724                         Obs per group: min =        26
       between = 0.0021                                        avg =      34.9
       overall = 0.1512                                        max =        70

                                                F(5,164)           =     52.86
corr(u_i, Xb)  = -0.0079                        Prob > F           =    0.0000

                                       (Std. Err. adjusted for 165 clusters in account)
```

daily_kwh	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
treatment	.0369547	1.036704	0.04	0.972	-2.010053	2.083963
cdd_ave	1.413486	.1614987	8.75	0.000	1.094601	1.732371
hdd_ave	1.000256	.083218	12.02	0.000	.8359395	1.164573
c.cdd_ave#c.treatment	-.0717039	.1136132	-0.63	0.529	-.296037	.1526293
c.hdd_ave#c.treatment	-.1048216	.0577246	-1.82	0.071	-.218801	.0091577
_cons	16.68617	1.478321	11.29	0.000	13.76717	19.60517
sigma_u	17.502397					
sigma_e	17.046712					
rho	.5131872	(fraction of variance due to u_i)				

C.3 Shell Program

Table C- 5: Shell Rebate Measures

```
Fixed-effects (within) regression               Number of obs      =     26568
Group variable: new_acct                        Number of groups   =       767

R-sq:  within  = 0.2066                         Obs per group: min =        24
       between = 0.0197                                        avg =      34.6
       overall = 0.0908                                        max =        36

                                                F(5,766)           =    145.62
corr(u_i, Xb)  = -0.0086                        Prob > F           =    0.0000

                                  (Std. Err. adjusted for 767 clusters in new_acct)
```

daily_kwh	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
treatment	-.3911459	.4069751	-0.96	0.337	-1.190065	.407773
cdd_ave	1.767326	.1030673	17.15	0.000	1.564998	1.969654
hdd_ave	.7466587	.0368662	20.25	0.000	.674288	.8190294
c.hdd_ave#c.treatment	-.0504493	.0170151	-2.96	0.003	-.0838509	-.0170476
c.cdd_ave#c.treatment	-.1390177	.0656922	-2.12	0.035	-.2679758	-.0100595
_cons	20.04061	.727349	27.55	0.000	18.61277	21.46844
sigma_u	17.860391					
sigma_e	14.751276					
rho	.59447877	(fraction of variance due to u_i)				

Table C- 6: UCONS Duct Improvement Regression

```
Fixed-effects (within) regression               Number of obs      =     24784
Group variable: new_acct                        Number of groups   =       675

R-sq:  within  = 0.6109                         Obs per group: min =        24
       between = 0.0427                                        avg =      36.7
       overall = 0.3855                                        max =        72

                                                F(5,674)           =    536.13
corr(u_i, Xb)  = 0.0075                         Prob > F           =    0.0000

                                    (Std. Err. adjusted for 675 clusters in new_acct)
```

daily_kwh	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
treatment	2.981132	.4299599	6.93	0.000	2.13691	3.825354
cdd_ave	3.092761	.0841326	36.76	0.000	2.927568	3.257955
hdd_ave	1.765495	.0369863	47.73	0.000	1.692872	1.838117
c.hdd_ave#c.treatment	-.1743508	.0224545	-7.76	0.000	-.2184401	-.1302616
c.cdd_ave#c.treatment	-.7554313	.0596619	-12.66	0.000	-.8725768	-.6382857
_cons	13.02932	.7531098	17.30	0.000	11.5506	14.50804
sigma_u	18.294083					
sigma_e	14.817764					
rho	.60384258	(fraction of variance due to u_i)				

C.4 Fuel Efficiency Program

Table C- 7: Electric to Gas Furnace Conversion

```
Fixed-effects (within) regression               Number of obs      =      5792
Group variable: id                              Number of groups   =       173

R-sq:  within  = 0.5869                         Obs per group: min =        15
       between = 0.0952                                        avg =      33.5
       overall = 0.4080                                        max =        37

                                                F(5,172)           =    114.59
corr(u_i, Xb)  = 0.0217                         Prob > F           =    0.0000

                                    (Std. Err. adjusted for 173 clusters in id)
```

daily_kwh	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
hdd_ave	2.063256	.1090112	18.93	0.000	1.848084	2.278428
1.treatment	10.75073	1.607743	6.69	0.000	7.577283	13.92418
treatment#c.hdd_ave						
1	-1.687934	.1106144	-15.26	0.000	-1.906271	-1.469598
cdd_ave	2.511148	.2011141	12.49	0.000	2.114179	2.908117
treatment#c.cdd_ave						
1	-1.154795	.1769566	-6.53	0.000	-1.504081	-.8055084
_cons	13.8264	1.902086	7.27	0.000	10.07197	17.58084
sigma_u	18.416175					
sigma_e	17.166024					
rho	.53509083	(fraction of variance due to u_i)				

Table C- 8: Electric to Gas Water Heater Conversion

```
Fixed-effects (within) regression               Number of obs      =      2495
Group variable: id                              Number of groups   =        71

R-sq:  within  = 0.2691                         Obs per group: min =        21
       between = 0.0034                                        avg =      35.1
       overall = 0.1216                                        max =        37

                                                F(5,70)            =     26.87
corr(u_i, Xb)  = -0.0141                        Prob > F           =    0.0000

                                   (Std. Err. adjusted for 71 clusters in id)
```

daily_kwh	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
hdd_ave	.4577346	.0671164	6.82	0.000	.3238751	.5915941
1.treatment	-8.485181	1.34192	-6.32	0.000	-11.16156	-5.808806
treatment#c.hdd_ave						
1	-.1015656	.0723047	-1.40	0.165	-.2457728	.0426416
cdd_ave	1.617465	.3369514	4.80	0.000	.9454364	2.289493
treatment#c.cdd_ave						
1	.0304397	.210502	0.14	0.885	-.3893933	.4502726
_cons	26.45666	1.361088	19.44	0.000	23.74206	29.17127
sigma_u	14.212811					
sigma_e	11.201992					
rho	.61682752	(fraction of variance due to u_i)				

Table C- 9: Electric to Gas Furnace and Water Heater Conversion

```
Fixed-effects (within) regression               Number of obs      =      3475
Group variable: id                              Number of groups   =       102

R-sq:  within  = 0.6718                         Obs per group: min =        15
       between = 0.0034                                        avg =      34.1
       overall = 0.4474                                        max =        37

                                                F(5,101)           =    120.37
corr(u_i, Xb)  = -0.0355                        Prob > F           =    0.0000

                                     (Std. Err. adjusted for 102 clusters in id)
```

daily_kwh	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
hdd_ave	1.952949	.0842092	23.19	0.000	1.785901	2.119998
1.treatment	6.088577	1.855304	3.28	0.001	2.408154	9.769001
treatment#c.hdd_ave						
1	-1.627161	.0935052	-17.40	0.000	-1.81265	-1.441672
cdd_ave	2.659406	.1870938	14.21	0.000	2.288262	3.03055
treatment#c.cdd_ave						
1	-1.310611	.1920518	-6.82	0.000	-1.69159	-.9296322
_cons	14.03094	1.437596	9.76	0.000	11.17914	16.88275
sigma_u	18.025111					
sigma_e	15.327112					
rho	.58036822	(fraction of variance due to u_i)				

Appendix D Net to Gross Methodology and Findings

The evaluation team calculated net-to-gross (NTG) ratios for each program, using data collected from participant surveys. NTG takes into consideration the levels of both free ridership (FR) and spillover (SO). Free ridership refers to the portion of energy savings that participants would have achieved in the absence of the program through their own initiatives and expenditures (EPA, 2007).[41] Spillover refers to the program-induced adoption of measures by non-participants and participants who did not receive financial incentives or technical assistance for installations of measures supported by the program (EPA, 2007). The evaluation team used the following formula to calculate a NTG ratio for each program:

$$NTG = 1 - FR + SO$$

D.1 Free Ridership

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

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

$$FR = FRC + FRI$$

Free Ridership Change (FRC)

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

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

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

[SINGLE RESPONSE]

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

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

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

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

Table D- 1: Free Ridership Change Values

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

Free Ridership Influence (FRI)

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

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

[MATRIX QUESTION: SCALE]

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

Anything else, please specify:_____________ _								

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

Table D- 2: Free Ridership Influence Values

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

Program-Level Free Ridership

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

Appliance Recycling Free Ridership

The evaluation team developed an approach to calculating net savings for the Appliance Recycling Program by applying the Department of Energy Uniform Methods Project's (UMP) methodology. The UMP methodology differs from the NTG methodology for other program types. Rather than first calculating a NTG value from survey responses and then applying that to gross savings to yield net savings, the UMP methodology first calculates net savings using jurisdiction-specific data on the energy consumption of new and recycled appliances, together with survey data on the participants' decision-making.[42]

Adding estimated spillover to the net savings and dividing that sum by the program-reported gross savings yields the NTG ratio.[43] The evaluation team developed a modified approach that

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

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

did not require estimates of the average consumption of new and recycled appliances. Surveyed participants reported what they would have done absent the program, and the evaluation team assigned a free ridership value to each respondent based on the latter information (Table D- 3).[44]

Table D- 3: Appliance Recycling Modified FR Values

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

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

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

D.2 Spillover

Spillover estimates the energy savings from non-rebated energy improvements made outside of the program that are influenced by the program, and can be used to adjust gross savings by the additional energy savings garnered and the level of attribution the program is able to claim for these non-rebated measures. A spillover value of 0 equates to no spillover and values greater than 0 demonstrate the existence and magnitude of spillover.[45] The evaluation team used participant survey data to estimate spillover.

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

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

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

Table D- 4: Participant Spillover Program Influence Values

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

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

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

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

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

D.3 Residential Lighting Net to Gross

The estimated free ridership impacts of the residential lighting program—in which a customer likely replaced an expired, efficient technology with a like technology—was calculated by constructing a market baseline. The evaluation team developed this baseline by examining the composition of lamp types found from onsite inspections in the lighting study, respective EISA equivalent baselines, and efficient case wattage to determine the free ridership market effects. The evaluation team's methodology is consistent with the RTF, but values are based on primary data collection from Avista's service territory.

The market share for each lamp technology was determined from the Avista residential lighting hours–of-use study, in which the existing shares of installed lamps by technology type were inventoried during onsite inspections; see Table 8-5. For the purposes of assessing the market baseline for the residential lighting program, the market shares needed to be normalized for screw-in sockets only. For example, the market share for CFL lamps increased from 23.8% to 26.9% once only screw-in sockets were included. The CFL market share from onsite inspections is supported by the data from the NEEA 2014–2015 Northwest Residential Lighting Long-Term Market Tracking Study[46], which listed the estimated CFL market share as 28%.

To determine the adjusted market baseline for screw-in lamps, the evaluation team multiplied the market share by the typical technology wattage for each type. To illustrate the approach, Table D- 5 provides a summary of the calculation to estimate the market baseline for a 60-watt equivalent A-lamp.

Table D- 5: Example Market Baseline 60-watt Equivalent Lamp

Technology Type	Market Share of Screw-in Sockets	Typical Technology Wattage	Contribution to Market Baseline Wattage
CFL	26.9%	13	3.5
Incandescent	60.8%	43[1]	26.1
Halogen	4.4%	43[1]	1.9
LED	7.9%	9.5	0.8
Total	**100%**		**32.3**

1 The technology wattage for incandescent and halogen lamps was set to the applicable lumen bin EISA standard.

In this example, the market baseline reduced the savings baseline from the EISA standard wattage of 43, to the market baseline of 32.3W—a 24.9% reduction of the baseline wattage. This in turn reduced the gross energy savings impacts by the same percentage reduction. The evaluation team followed this approach to uniquely calculate and aggregate each lumen bin and product type.

The net to gross ratio for the residential lighting program was 64.5% as shown in Table D- 6.

Table D- 6: Residential Lighting Net to Gross Ratios and Net Verified Impacts

	Reported Savings (kWh)	Realization Rate	Gross Verified Savings (kWh)	Net to Gross Ratios	Net Verified Savings (kWh)
Simple Steps—LED	4,308,734	125.2%	5,394,253	65.9%	3,557,152
Simple Steps—CFL	14,866,096	132.5%	19,701,850	64.1%	12,623,297
Simple Steps – NP—LED	14,877	199.3%	29,644	65.9%	19,548
Simple Steps – N—CFL	165,598	159.7%	264,478	64.1%	169,456
Giveaway—CFL	3,660	200.5%	7,338	65.9%	4,839
Giveaway—LED	9,995	446.6%	44,637	64.1%	28,600
UCONS	237,268	104.3%	247,362	64.1%	158,489
TOTAL	**19,606,228**	**131.0%**	**25,689,564**	**64.5%**	**16,561,380**

[46] https://neea.org/docs/default-source/reports/northwest-residential-lighting-long-term-market-tracking-study.pdf?sfvrsn=4

D.4 Net to Gross Findings

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

Table D- 7: Nonresidential Program Net To Gross Ratios

Program	FR (savings weighted)	Spillover	NTG
Nonresidential Electric			
Site Specific	58%	0.4%	58%
Prescriptive Lighting	37%	3%	66%
EnergySmart Grocer	NA	0%	NA
Prescriptive Non-Lighting Other	24%	6%	82%
Nonresidential Natural Gas			
Site Specific	70%	0.04%	70%
Com Water Heaters	100%	0%	0%
Com Windows & Insulation	44%	1%	57%
Prescriptive HVAC	55%	0%	45%
Food Service Equipment	51%	0%	49%

Table D- 8: Residential Program Net To Gross Ratios

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

Appendix E Residential Lighting Logger Study Forms

E.1 Lighting Inventory Form

AVISTA

RESIDENTIAL LIGHTING HOURS OF USE STUDY: ON-SITE SURVEY FORM

Customer ID: ______________________

Customer Name: ______________________ Visa Card #: ______________________

Contact Phone: ______________________ Email: ______________________

Address: ______________________

City, State, Zip: ______________________

Engineer: ______________________

Site Visit Date/Time: ______________________

Notes: ______________________

Survey Key

N/A = Not Applicable

NX = Not Available

Site Information

1. Premise Type: ______________________
   (Single-family detached: 1 unit, Single-family attached: 2 units, Multi-family: 3+ units, Mobile Home, Other – specify)
2. Ownership Status: ______________________
   (Own, Rent, Other – specify)
3. How heating fuel: ______________________
   (electric, gas, oil, pellets, wood)
4. Home heating equipment type: ______________________
   (Furnace, Baseboard, Heat Pump, Other – specify)
5. Home Air Conditioning Equipment Type: ______________________
   (Central Air, Window A/C, Fan, Other – specify, None)
6. Estimated number of portable electronic devices used in the house (e.g. iPhone, Tablet computers, Kindles, etc.)?: ______________
7. Home Square Feet (approx.): __________
8. Year Home Constructed: __________

Program Participant Info

9. Does the customer recall receiving a free box of lights from Avista in 2012? (Y/N/DK):__________
10. If so, did the customer install those lights (Y/N/DK)?: ______________

Room Type ID Table

Room #	Room Type	Room Description
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		

Room Type:		
1= Kitchen	6= Utility/Laundry Room	12= Garage
2= Dining Room	7 = Master Bedroom	13= Mech/Electrical Room
3= Living/Family/Great Room	8 = Bedroom	14= Closet/Storage
4= Office	9 = Toilet/Bathroom	15=Exterior
5= Foyer/Hallway/Stairway	10= Basement	16= Other, specify
	11= Attic	

Lighting Inventory & Logger Placement Customer ID:

Room Number: **Room Type:** **Room Description (e.g Master Bath):** **Circuit Type:**

Fixture #1 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	
Fixture #2 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	
Fixture #3 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	
Fixture #4 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	
Fixture #5 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	

Logger Type: Time Logger Placed: Notes on Location:
Logger Serial #: (Be detailed)
Ambient Light (Y/N)? Window Orient (E, W, N, S):

Room Number: **Room Type:** **Room Description (e.g Master Bath):** **Circuit Type:**

Fixture #1 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	
Fixture #2 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	
Fixture #3 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	
Fixture #4 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	
Fixture #5 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	

Logger Type: Time Logger Placed: Notes on Location:
Logger Serial #: (Be detailed)
Ambient Light (Y/N)? Window Orient (E, W, N, S):

Room Number: **Room Type:** **Room Description (e.g Master Bath):** **Circuit Type:**

Fixture #1 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	
Fixture #2 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	
Fixture #3 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	
Fixture #4 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	
Fixture #5 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	

Logger Type: Time Logger Placed: Notes on Location:
Logger Serial #: (Be detailed)
Ambient Light (Y/N)? Window Orient (E, W, N, S):

Room Number: **Room Type:** **Room Description (e.g Master Bath):** **Circuit Type:**

Fixture #1 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	
Fixture #2 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	
Fixture #3 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	
Fixture #4 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	
Fixture #5 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	

Logger Type: Time Logger Placed: Notes on Location:
Logger Serial #: (Be detailed)
Ambient Light (Y/N)? Window Orient (E, W, N, S):

Room Number: **Room Type:** **Room Description (e.g Master Bath):** **Circuit Type:**

Fixture #1 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	
Fixture #2 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	
Fixture #3 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	
Fixture #4 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	
Fixture #5 Type:		Fixture Qty		Socket Type		Sockets/Fixture		Lamp Type		Lamp Shape		Lamp Qty/Fixture		Watts/lamp		# Burnout		Logger Placed?	

Logger Type: Time Logger Placed: Notes on Location:
Logger Serial #: (Be detailed)
Ambient Light (Y/N)? Window Orient (E, W, N, S):

Lamp Shape Lookup Table

Bulb Style	Code	Image	Bulb Style	Code	Image
1. Standard/ Pear/candelabra (A-lamp)	1		5. Spot/ reflector/ Flood light (typical in can lights)	5	
2. Twist/ spiral	2		6. Circline	6	
3. Globe (typical for bathroom vanity)	3		7. Bullet/torpedo	7	
4. =Bug light (yellow/blue/red color)	4		8. Tube	8	

Room Type:			
1= Kitchen	5= Foyer/Hallway/Stairway	9 = Toilet/Bathroom	13= Mech/Electrical Room
2= Dining Room	6= Utility/Laundry Room	10= Basement	14= Closet/Storage
3= Living/Family/Great Room	7 = Master Bedroom	11= Attic	15=Exterior
4= Office	8 = Bedroom	12= Garage	16= Other, specify

Circuit Type:	
1= On/Off (switch, plug, pull string, etc.)	5= Timer
2= Dimmer	6= 3-way
3= Motion/Photo Sensor	7= Other, specify
4 = Remote Control	

Socket Type:	
1= Medium Screw Base (standard)	4= Pin Base
2= Small Screw Base (candelabra)	5= GU Base
3= Large Screw Base (mogule)	6= Other, specify

Fixture Type:		
1= Lamp (floor/table downlight)	5= Ceiling surface mounted	9= Under cabinet
2= Torchiere (floor uplight)	6= Track Lighting	10= Garage Door light
3= Wall-mounted (sconce, vanity)	7= Suspended (chandelier)	11= Other, specify
4= Ceiling Fan Light	8= Recessed (can light)	

Lamp Type:	
1= Incandescent	5= Linear fluorescent
2- CFL	6= Other, specify
3= LED	7=Empty socket
4= Halogen/Quartz	

Lamp Shape		
1=Standard/Pear/Candelabra/A-lamp	5=Spot/Reflector/Flood	9=Other, specify
2=Twist/Sprial	6=Circline	
3=Globe	7=Bullet/Torpedo	
4=Bug light	8=Tube	

Logger Type:	
1= U9-002 Light On/Off	3= U12-012 Temp/RH/Light Int.
2= UX90-002 Light On/Off (w/Display)	4 =UX90-002 w/Light Pipe

E.2 Recruitment Materials

June 30, 2015

Dear <customer>,

Avista Utilities is conducting a residential lighting study in the homes of our customers. You have randomly been selected as a potential participant. In order to better understand how our customers use energy and improve our lighting rebates programs for customers like you, Avista Utilities has retained Nexant, an expert in the energy efficiency evaluation field, to conduct a lighting study on our behalf to measure how many hours per day customers are using lights in various areas of their homes.

We would like to offer you the opportunity to participate in this study. Participation is voluntary and participants of the study will receive **$75 in pre-paid Visa gift cards**. If you are interested in participating, or would like more information, please call **1-855-828-7745** to speak to a Nexant representative. Please reference your Study ID: **<study id>**.

Availability is limited, so participants will be admitted on a first-come, first-serve basis. If you decide to participate in the study, an appointment will be scheduled at your earliest convenience for a Nexant evaluator to visit your home and install 4 to 8 small light measuring devices ("loggers") which measure only the amount of time the lights are turned on. A follow-up appointment will be scheduled in approximately six months for the loggers to be collected.

The results of this study will help us understand how our customers use their lights so that we can improve our energy efficiency programs in the future. If you have any questions about the study, please give me a call.

In addition, Avista Utilities offers several Residential rebates including;

- High Efficiency Equipment (Furnace, Boiler, Variable Speed Motors, Smart Thermostats)
- Insulation (Attic, Wall, Floor)
- Windows
- Space & Water Heat conversions from Electric

For a complete list of rebates and requirements, application forms or to submit an online application go to www.avistautilities.com/resrebates. Or you can contact rebates@avistautilities.com or 800-227-9187 with questions.

Thank you again for your willingness to participate.

Sincerely,

David Schafer -DSM Program Manager
Avista Utilities – P: 509-495-4688 E: David.Schafer@avistacorp.com