CADMUS

Washington Biennium (2018–2019) Natural Gas Impact Evaluation Report

May 28, 2020

Table of Contents

Tables

Figure

CADMUS

Portfolio Executive Summary

For several decades, Avista Corporation (Avista) has administered demand-side management (DSM) programs to reduce electricity and natural gas energy use by its customer portfolio. While most of these programs have been implemented in house, a few have had external implementers.

Avista contracted with Cadmus to complete process and impact evaluations of its Program Year (PY) 2018 and PY 2019 natural gas DSM programs in Washington. This report presents the biennium natural gas impact evaluation findings. Cadmus did not apply net-to-gross (NTG) adjustments to savings values, except where deemed energy savings values already incorporated NTG as a function of the market baseline.

Evaluation Methodology and Activities

Table 1 shows the variety of methods and activities Cadmus completed in conducting the Washington natural gas portfolio evaluation.

Table 1. Biennium Natural Gas Program Evaluation Activities

Sector	Program	Document/ Database Review	Verification/ Metering Site Visit	Billing Analysis
Nonresidential	Prescriptive (multiple)	✓	✓	--
	Site Specific	✓	✓	✓
Residential	Simple Steps, Smart Savings™	✓	--	--
	HVAC	✓	--	✓
	Shell	✓	--	✓
	ENERGY STAR® Homes	✓	--	--
	Multifamily Direct Install	✓	--	✓
	Multifamily Direct Install Supplemental Lighting	✓	--	--
Low-Income	Low-Income	✓	--	✓
Fuel Efficiency	Site Specific (Nonresidential)	✓	✓	--
	Residential	✓	--	✓
	Low-Income	✓	--	✓

Summary of Impact Evaluation Results

Overall, the Washington portfolio achieved a 78% realization rate on savings from natural gas measures, acquiring 1,038,227 therms in biennial gross savings, as shown in Table 2. Cadmus collected Avista's reported savings through database extracts from Avista's Customer Care and Billing (Residential), InforCRM and iEnergy (Nonresidential) databases, and third-party implementers' data.

Table 2. Reported and Evaluated Energy Efficiency Natural Gas Savings

Sector	Reported Savings (Therms)	Biennial Evaluated Savings (Therms)	Realization Rate
Nonresidential	208,630	186,966	90%
Residential	1,083,098	816,529	75%
Low-Income[b]	36,216	34,732	96%
Total[a]	**1,327,944**	**1,038,227**	**78%**

[a] This total does not include Fuel Efficiency measures resulting in a negative therms savings impact. Fuel conversion measure impacts can be found in the Fuel Efficiency Impact Evaluation section.

Conclusions and Recommendations

During the course of the biennium evaluation, Cadmus identified the areas addressed below for improvements by sector.

Nonresidential Conclusions and Recommendations

In PY 2018 and PY 2019, the Nonresidential sector achieved total biennial, evaluated, natural gas energy savings of 186,966 therms, with a combined realization rate of 90%. The Nonresidential sector did not meet the combined Prescriptive and Site Specific program paths' natural gas savings goal of 434,166 therms, with the program achieving 43% of this goal.

During PY 2019, Avista made midyear changes to its application tracking database system which presented challenges in evaluating the PY 2019 Nonresidential program. The new iEnergy database stores and reports data in different formats and different aggregation levels than the previous system. As the transition occurred midyear and some applications were entered into both systems, Avista and Cadmus staff had to manually combine and recategorize data from the new database to match up with the format used for the old database. Cadmus found several mistakes in exports from the new database, and underlying errors in how the new system calculated some savings. Avista corrected the issues Cadmus identified, and the new iEnergy database has the potential to facilitate more accurate savings estimates, more detailed project tracking, and more thorough evaluations in the future.

Cadmus offers the following recommendations for improving the Nonresidential sector's natural gas savings:

- Confirm time periods used for pre- and post-installation analysis when employing utility billing regression analysis. Misaligning billing periods can result in variances between reported and biennial evaluated savings—sometimes by a significant amount.

- Normalize utility billing regression analysis to Typical Meteorological Year (TMY3) data rather than normalizing to the actual weather for the post-installation year. Year-to-year variations in weather data can cause significant differences in reported savings, and TMY3 normalization is an accepted practice for addressing this variation.

- Provide more thorough documentation with Avista installation verification (IV) reports. Cadmus recommends that all IV reports include basic information explicitly stating the quantity and type of equipment found as well as clear photos of equipment nameplates.

Residential Conclusions and Recommendations

Biennial evaluated natural gas savings show a 74% realization rate on acquired savings of 816,529 therms for Residential programs, or 84% of the savings goal for the biennium.

The HVAC program accounts for most biennial evaluated Residential natural gas savings (86%), followed by the Shell program with 11% of natural gas savings. Simple Steps, Smart Savings, Multifamily Direct Install (MFDI), and ENERGY STAR Homes account for 1% of combined savings, primarily through water-saving measures.

Billing analysis results for natural gas furnace measures served as the biggest driver of the 74% realization rate for Residential savings, providing a measure-level realization rate of 80%. The Avista TRM unit savings value of 102 therms is based on a 2011 billing analysis of natural gas upgrades, which showed higher natural gas savings largely because roughly 10% of participants in the treatment group installed heat pumps along with a more efficient natural gas furnace; participants who installed a heat pump along with a furnace upgrade showed a sharp reduction natural gas usage, indicating that some heating load shifted to the heat pump. For PY 2018 and PY 2019, Cadmus identified no participants who installed both a high-efficiency natural gas furnace a heat pump. Billing analysis also provided relatively low natural gas savings for replacement windows, partly because the 2018 Avista Technical Reference Manual (TRM) used an especially high savings value per square foot.

Cadmus offers three recommendations regarding Avista's Residential natural gas programs:

- Adjust the Avista TRM to provide lower savings values for natural gas furnaces, replacement windows, and storm windows, based on the billing analysis conducted for this evaluation. Cadmus believes that the billing analysis unit energy savings of 82 therms for the G Natural Gas Furnace measure and 0.34 therms per square foot for G Storm Windows with Natural Gas Heat and G Window Replace with Natural Gas Heat provide more accurate estimates of savings than the current TRM values.

- Continue to encourage installations of high-efficiency natural gas furnaces, which provided 60% of evaluated natural gas savings for Residential programs. The Northwest Energy Efficiency Alliance's *Residential Building Stock Analysis II* estimated that roughly 70% of natural gas furnaces in Washington single-family homes have an annual fuel utilization efficiency under 90%, indicating substantial savings opportunities remain.

- Continue to emphasize installation of Shell measures and smart thermostats, each of which accounted for 11% of natural gas savings for the biennium. Billing analysis showed smart thermostats have a 102% realization rate with natural gas heating equipment.

Nonresidential Impact Evaluation

Through its Nonresidential program portfolio, Avista promotes purchases of high-efficiency equipment for commercial and industrial utility customers. By providing rebates, Avista partially offsets cost differences between high-efficiency and standard equipment. Cadmus conducted Nonresidential impact evaluation activities to determine biennial evaluated savings for most programs; the team also conducted measurement and verification (M&V) of Prescriptive and Site Specific projects across the full biennial sample.

Program Summary

In PY 2018 and PY 2019, Avista offered and completed incentives for 186 Nonresidential natural gas measures in Washington, reporting total natural gas energy savings of 208,630 therms. Through the Nonresidential sector, Avista offers incentives for high-efficiency equipment and controls via three program paths: Prescriptive, Site Specific, and Fuel Efficiency.

The Prescriptive program path serves smaller, straightforward equipment installations that generally include similar operating characteristics (such as simple HVAC systems, food service equipment, and envelope upgrades). The Site Specific program path serves more unique projects, requiring custom savings calculations and technical assistance from Avista's Energy Efficiency Engineers (such as compressed air, process equipment and controls, and comprehensive HVAC retrofits).

Multifamily Market Transformation measures involve a combination of electric savings and natural gas penalties. Typically, these measures include replacing electric space-heating or water-heating systems with natural gas equipment. The *Fuel Efficiency Impact Evaluation* section provides a discussion of the evaluation methodology and the results for Multifamily Market Transformation measures.

Program Participation Summary

This section summarizes Nonresidential sector participation and progress toward biennium goals through the Prescriptive and Site Specific program paths.

Nonresidential Prescriptive Programs

Table 3 shows natural gas energy savings goals assigned to Avista's Nonresidential Prescriptive programs for the biennium as well as reported savings and a comparison between reported savings and goals.

Table 3. Nonresidential Prescriptive Natural Gas Savings

Program Type	Savings Goals (Therms)	Savings Reported (Therms)	Percentage of Goal
HVAC	64,284	39,705	62%
Shell	41,600	51,234	123%
Food Service Equipment	99,127	73,667	74%
Energy Smart Grocer[a]	29,155	0	0%
Total	**234,166**	**164,606**	**70%**

[a] The Energy Smart Grocer savings goal includes Site Specific Energy Smart Grocer measures, with the Site Specific portion constituting approximately 10% of the overall goal.

Table 4 shows participation goals by rebated equipment quantity, as provided by Avista. Though the PY 2018–PY 2019 Nonresidential tracking database extract listed individual projects, it did not include rebated equipment quantities. For reference, Table 5 provides participation by unique application numbers.

Table 4. Nonresidential Prescriptive Participation Goals by Equipment Rebated

Program Type	Participation Goal
HVAC	20,116
Shell[a]	185,000
Food Service Equipment	186
Energy Smart Grocer[b]	9,779

[a] The Shell participation goal includes participants with electric savings.
[b] The Energy Smart Grocer goal includes Site Specific Energy Smart Grocer participants.

Table 5. Nonresidential Prescriptive Participation by Project

Program Type	Participation Reported[a]
HVAC	62
Shell	20
Food Service Equipment	104
Energy Smart Grocer	0
Total	**186**

[a] Participant is defined as a unique application number.

Nonresidential Site Specific Program

Table 6 shows natural gas savings goals assigned to the Site Specific program path for Avista's Nonresidential sector in PY 2018 and PY 2019 as well as reported savings. Note: the table does not include reported natural gas penalties for the Fuel Efficiency sector, such as those associated with the Multifamily Market Transformation program.

Table 6. Nonresidential Site Specific Natural Gas Savings

Program	Savings Goals (Therms)	Savings Reported (Therms)	Percentage of Goal
Site Specific	200,000	44,024	22%

Nonresidential Impact Evaluation Methodology

As the first step in evaluating biennial savings for the Nonresidential sector, Cadmus explored the following documents and data records to gain an understanding of programs and measures slated for evaluation:

- Avista's annual business plans, detailing processes and energy savings justifications
- Project documents from external sources (such as customers, program consultants, or implementation contractors)

Based on the initial review, Cadmus checked the distribution of program contributions with the overall program portfolio. The review provided insight into the sources for unit energy savings (UES) claimed for

each measure offered in the programs, along with sources for energy-savings algorithms, internal quality assurance, and quality control processes for large Nonresidential sector projects.

Following this review, Cadmus designed a sample strategy for impact evaluation activities, with Cadmus performing the following evaluation activities in each of the four waves:

- Selected evaluation sample and requested project documentation from Avista
- Reviewed project documentation
- Prepared on-site M&V plans
- Performed site visits and collected on-site data (such as trend data, photos, and operating schedules)
- Used site visit findings to calculate biennial evaluated savings by measure
- Applied realization rates to the total reported savings population to determine overall biennial evaluated savings

Sample Design

Cadmus created four sample waves for PY 2018 and PY 2019:

- Sample 1 included program data from January 2018 through April 2018
- Sample 2 included program data from May 2018 through December 2018
- Sample 3 included program data from January 2019 through June 2019
- Sample 4 included program data from July 2019 through December 2019

As a guideline, Cadmus used the proposed overall PY 2018 and PY 2019 Nonresidential sample sizes by subprogram, provided in the M&V plan, seeking to complete approximately one-quarter of the sample during each of the first three waves. Cadmus adjusted the final sample to meet the overall confidence and precision targets for the entire biennium.

For each activity wave, Cadmus organized the submitted program applications by path and measure (such as Site Specific Shell Measure, Prescriptive Lighting, Prescriptive Motor Controls), allowing the team to select the highest-savings applications in each category with certainty. For non-certainty applications, Cadmus assigned random numbers and developed a random sample. In some cases, the team sampled another application at the same location or facility previously selected (and where Cadmus could assess both applications with one site visit, a cost-effective verification strategy even if the second application represented minimal claimed savings).

As Avista similarly implements its programs in both states, Cadmus sampled randomly selected sites across both Washington and Idaho. The team pooled results from the randomly selected sites to calculate a realization rate by stratum and applied that realization rate to projects in both states. Cadmus applied evaluated savings for sites selected with certainty only to the state in which they had been implemented.

Table 7 summarizes the Washington Nonresidential Prescriptive program path's natural gas evaluation sample. Overall, Cadmus sampled 24 Prescriptive applications at 20 unique sites. Of the sampled applications, the team selected eight for certainty review, based on the savings scale, measure type, or location, and selected the remaining 16 applications randomly.

Table 7. Washington Nonresidential Prescriptive Natural Gas Evaluation Sample

Program Type	Applications Sampled	Sampled Savings (Therms)	Percentage of Reported Savings
HVAC	8	4,900	12%
Shell	6	17,693	35%
Food Service Equipment	10	10,248	14%
Nonresidential Prescriptive	**24**	**32,841**	**20%**

Table 8 summarizes the Washington Nonresidential Site Specific program path's natural gas evaluation sample. Cadmus sampled six Site Specific applications at six unique sites. Of the sampled applications, the team selected three for certainty reviews based on the savings scale, measure type, or location, and selected the remaining three applications randomly.

Table 8. Washington Nonresidential Site Specific Natural Gas Evaluation Sample

Program	Applications Sampled	Sampled Savings (Therms)	Percentage of Reported Savings
Site Specific	6	27,628	63%

Document Review

Cadmus requested and reviewed project documentation for each sampled application and prepared M&V plans to guide the site visits. Typically, project documentation included incentive applications, calculation tools (usually based on the 2017 Regional Technical Forum [RTF]),[1] invoices, equipment specification sheets, and IV reports.

On-Site Verification

Cadmus performed site visits at 39 unique Nonresidential locations to assess natural gas energy savings for 44 unique Prescriptive and Site Specific measures (not including Fuel Efficiency measures). Site visits involved verifying installed equipment types, make and model numbers, operating schedules, and set points, as applicable. Cadmus used the project documentation review and on-site findings to adjust reported savings calculations, where necessary.

Nonresidential Evaluation Results

This section summarizes natural gas impact evaluation results for the Nonresidential sector's Prescriptive and Site Specific program paths over the 2018–2019 biennium.

---

[1] Regional Technical Forum. 2017. "Standard Protocols." Available online: https://rtf.nwcouncil.org/standard-protocols

Nonresidential Prescriptive Programs

Table 9 shows biennial reported and evaluated natural gas energy savings for Avista's Nonresidential Prescriptive program path as well as realization rates between biennial evaluated and reported savings for PY 2018 and PY 2019. The overall Nonresidential Prescriptive program path achieved an 88% natural gas realization rate.

Table 9. Nonresidential Prescriptive Natural Gas Impact Findings

Program Type	Reported Savings (Therms)	Biennial Evaluated Savings (Therms)	Realization Rate
HVAC	39,705	40,133	101%
Shell	51,234	42,210	82%
Food Service Equipment	73,667	62,257	85%
Nonresidential Prescriptive	**164,606**	**144,600**	**88%**

Of 24 evaluated applications, Cadmus identified discrepancies for 10, based on site visits and project documentation reviews. Table 10 summarizes reasons for discrepancies between reported and biennial evaluated savings.

Table 10. Nonresidential Prescriptive Evaluation Summary of Discrepancies

Project Type	Number of Occurrences	Savings Impact	Reason(s) for Discrepancy
Food Service Equipment	4	⬇	• Cadmus reduced the pounds of food cooked per day for four fryer measures from the savings calculator value, based on the site manager interview.
	2	⬇	• Cadmus decreased the operating hours for two fryer measures from the savings calculator value, based on the site manager interview.
	1	⬇	• Cadmus reduced the pounds of food cooked per day for an oven measure from the savings calculator value, based on the site manager interview. • Cadmus increased the operating hours for oven and fryer measures from the savings calculator value, based on the site manager interview. • Cadmus decreased operating times per day for a pre-rinse spray valve measure from the savings calculator value, based on the site manager interview.
	1	⬇	• Cadmus reduced the pounds of food cooked per day and operating hours for a steam cooker measure from the savings calculator value, based on the site manager interview.
Commercial HVAC	1	⬆	• Cadmus determined from on-site inspection that a furnace reported as 80 kBTU/hr on the application was actually a 100 kBTU/hr unit.
Shell Measure	2	⬇	• Avista reported incorrect savings values for two Shell insulation projects due to an error in their new database software. Cadmus reviewed all prescriptive Shell measures to confirm that only two projects were affected by the bug. The team treated the two affected projects as certainty projects and evaluated savings using the typical savings calculator methodology.

Cadmus staff found that the detail level in IV reports varied. Most IV reports Cadmus reviewed only stated that the reviewer "found the installation to match the application submitted," including projects where Cadmus' inspections found discrepancies between the installation and the application. Avista performed an inspection of the Commercial HVAC project (with a discrepancy listed in Table 10), but the

IV report only contained an overall photo of the unit with no nameplate photo and no text. The inspection did not report the mismatched unit size.

Nonresidential Site Specific Program

Table 11 shows reported and biennial evaluated natural gas energy savings for Avista's Nonresidential sector Site Specific program path, in addition to a comparison between biennial evaluated and reported savings. The overall Site Specific program path achieved a 96% natural gas realization rate. Note: the table does not include reported and biennial evaluated natural gas penalties for measures in the Fuel Efficiency path.

Table 11. Nonresidential Site Specific Natural Gas Impact Findings

Program	Reported Savings (Therms)	Biennial Evaluated Savings (Therms)	Realization Rate
Site Specific	44,024	42,365	96%

Of the six evaluated applications, Cadmus identified discrepancies for three, based on the site visit and on the project documentation review. Table 12 summarizes reasons for discrepancies between reported and biennial evaluated savings.

Table 12. Nonresidential Site Specific Evaluation Summary of Discrepancies

Project Type	Number of Occurrences	Savings Impact	Reason(s) for Discrepancy
HVAC	1	↓	• This project involved implementing demand-controlled ventilation and fan motor variable frequency drives for department store air-handling units. During the document review, Cadmus found reported savings were calculated using natural gas utility data for an incorrect post-installation period and included some baseline system data. For the biennial evaluated savings calculation, Cadmus only used utility data for the installed and fully operational system.
Appliance	1	↑	• Cadmus decreased the pounds of food cooked per day (from that shown in the calculator workbook, "PGE broiler testing report calculator.xlsx") for the broiler measure, based on the site interview.
Industrial Process	1	↓	• Cadmus determined that the submitted calculation files for a steam trap replacement project used several incorrect values. Cadmus corrected the quantity of steam traps, boiler efficiency, and system pressures to determine the evaluated savings.

Cadmus found that Avista used a regression analysis of weather data and utility bills to analyze most Site Specific HVAC projects. In all such applications reviewed, Avista developed a regression model for the baseline period, using actual weather and utility data from before the measure's implementation, applied that model to the actual weather data from the post-installation period to estimate how much energy the site would have used without the efficient equipment, and compared that to the actual utility consumption in the same post-installation period to determine savings. This approach accurately calculated first-year energy savings for the project, but might not accurately represent typical annual savings over the expected lifetime of the measure due to annual variations in weather.

The calculated annual gas savings for HVAC heating projects will be higher if the post-installation period is unusually cold and lower if it is unusually warm. Many programs develop a model for both baseline and post-installation utility usage, then apply both models to National Oceanic and Atmospheric Administration's (NOAA) TMY3 data to normalize savings to a typical year, avoiding year-to-year variations.

Nonresidential Conclusions and Recommendations

In PY 2018 and PY 2019, the Nonresidential sector achieved total biennial evaluated natural gas energy savings of 186,966 therms, with a combined realization rate of 90%. The Nonresidential sector did not meet the combined Prescriptive and Site Specific program paths' natural gas savings goal of 434,166 therms, and achieved 43% of its goal.

Cadmus encountered challenges in evaluating the PY 2019 Nonresidential program due to midyear changes that Avista made to its application tracking database system. The new iEnergy database stores and reports data in different formats and at different aggregation levels than the previous system. Because the transition occurred midyear and some applications were entered into both systems, Avista and Cadmus staff had to manually combine and recategorize data from the new database to match up with the format used for the old database.

Cadmus found several mistakes in exports from the new database as well as underlying errors in how some savings were calculated by the new system. Avista has corrected these issues, and the new iEnergy database has the potential to facilitate more accurate savings estimates, more detailed project tracking, and more thorough evaluations in the future.

Cadmus offers the following recommendations for improving the Nonresidential sector's natural gas savings:

- Confirm time periods used for pre- and post-installation analysis when applying utility billing regression analysis. Misaligning billing periods can result in variances between reported and biennial evaluated savings—sometimes by a significant amount.

- Normalize utility billing regression analysis to TMY3 data rather than normalizing it to actual weather for the post-installation year. Year-to-year variations in weather data can cause significant differences in reported savings, and TMY3 normalization is an accepted practice for addressing this variation.

- Provide more thorough documentation with Avista IV reports. Cadmus recommends that all IV reports include basic information explicitly stating the quantity and type of equipment found and include clear photos of equipment nameplates.

Residential Impact Evaluation

Cadmus designed the Residential sector impact evaluation to verify reported program participation and energy savings. The team used data collected and reported in the tracking database, online application forms, Avista TRM savings review, and analysis of natural gas consumption data to estimate evaluated savings. This approach provided the strongest estimate of achieved savings practical for each program, given its delivery method, magnitude of savings, number of participants, and availability of billing data.

Program Summary

In PY 2018 and PY 2019, Avista reported participation of 434,451 for the Residential natural gas program in Washington, resulting in reported natural gas energy savings of 1,083,098 therms. Participation was defined as installed pieces of equipment (such as a furnace or showerhead) for some measures and square feet of surface for others (such as wall insulation and replacement windows).

The Residential program path includes several programs:

- Simple Steps, Smart Savings, which encourages consumers to purchase and install high-efficiency lighting and showerheads
- Residential HVAC, which offers incentives for high-efficiency heating and cooling equipment
- Residential Shell, which provides rebates to encourage customers to install insulation and high-efficiency windows and storm windows
- ENERGY STAR Homes, which offers 15% to 25% in energy savings relative to the state energy code
- The MFDI, which provides free direct-install measures to multifamily residences (five units or more) and common areas
- MFDI Supplemental Lighting, which revisited multifamily properties served by the MFDI program to install additional common area lighting.

Program Participation Summary

This section summarizes the Residential sector program path's participation and progress toward PY 2018 and PY 2019 goals.

Residential Programs

Table 13 shows savings goals assigned to Avista's Residential sector programs as well as reported savings and the portion of goals achieved. All programs except Simple Steps, Smart Savings and ENERGY STAR Homes exceeded savings goals, based on reported savings, leading to an overall achievement of 111% for Residential programs.

Table 13. Residential Programs Reported Natural Gas Savings

Program	Savings Goals (Therms)	Savings Reported (Therms)	Percentage of Goal
Simple Steps, Smart Savings	26,306	1,188	5%
HVAC	749,535	840,479	112%
Shell	188,700	229,974	122%
ENERGY STAR Homes	3,788	1,293	34%
Multifamily Direct Install	8,120	10,164	125%
Multifamily Direct Install Supplemental Lighting	0	0	-
Residential Programs Total	**976,449**	**1,083,098**	**111%**

Table 14 summarizes participation goals and reported participation in Avista's Residential sector programs for PY 2018 and PY 2019, along with goal percentages achieved.

Table 14. Residential Programs Participation

Program	Participation Goals	Participation Reported	Percentage of Goal
Simple Steps, Smart Savings[a]	5,245	3,410	65%
HVAC[b]	9,795	11,218	115%
Shell[c]	217,750	417,601	192%
ENERGY STAR Homes[b]	20	8	40%
Multifamily Direct Install	133	2,214	1665%
Multifamily Direct Install Supplemental Lighting	0	0	-
Residential Programs Total	**232,943**	**434,451**	**187%**

[a] Participation is defined as the number of purchased units.

[b] Participation is defined as the number of rebates.

[c] Participation is defined as square feet of installed windows or storm windows.

Residential Impact Evaluation Methodology

To determine the Residential sector's biennial evaluated savings for PY 2018 and PY 2019, Cadmus employed a combination of three impact evaluation methods:[2]

- Database review
- Document review
- Billing analysis

First, Cadmus calculated adjusted savings for each program, based on results of a database review. For the HVAC, Shell, and Fuel Efficiency programs, Cadmus also applied realization rates for the document reviews. For these programs, Cadmus calculated prescriptive evaluated savings by multiplying adjusted

---

[2]   With approval from Avista, Cadmus ceased performing a fourth impact activity—verification surveys—in Q3 PY 2018; this eliminated redundancy between verification surveys and document reviews.

savings by the document review realization rate, as shown in Figure 1. With programs without document reviews conducted, adjusted savings were considered Prescriptive evaluated savings.

Figure 1. Residential Prescriptive Impact Process
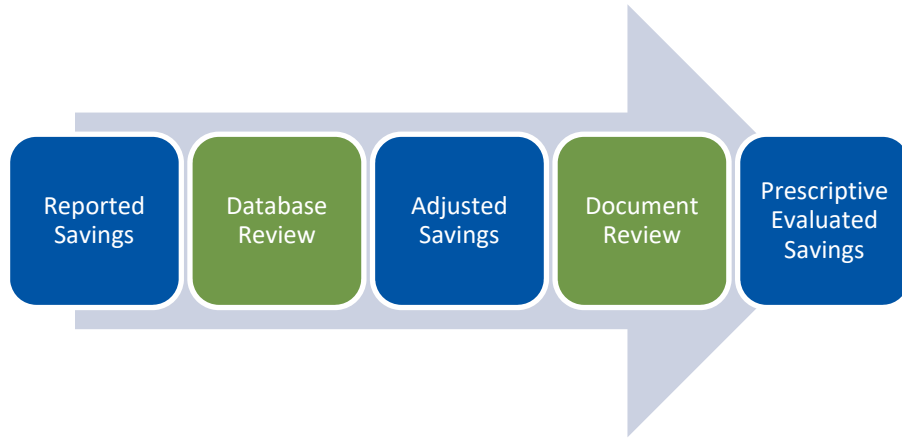
To provide, where practical, the most rigorous evaluation method, Cadmus analyzed consumption data for all available participants of the HVAC, Shell, and Fuel Efficiency programs. As described in more detail in the Billing Analysis section, Cadmus applied billing analysis results to determine evaluated savings only for measures where savings could be isolated (that is, where a sufficient number of participants could be identified who installed only that measure) and where confidence and precision met specific targets. Program-level realization rates for the HVAC, Shell, and Fuel Efficiency programs incorporate billing analysis results for some measures.

Database Review

For the impact evaluation database review, Cadmus used UES values provided in the TRM to calculate savings from measures reported in the measure tracking database. Such impact activity may help identify incorrect UES values used to calculate reported savings. Cadmus defined savings calculated during the database review as *adjusted savings*.

For this biennial evaluation, Cadmus applied 2018 Avista TRM values to PY 2018 measures and 2019 Avista TRM values to PY 2019 measures.

Document Review

To conduct the document review, Cadmus compared information from rebate forms and other supporting documents to measure tracking data for a random sample of projects. This impact activity may identify installed measures that did not meet eligibility requirements, quantities not matching the measure tracking database, and other discrepancies. Following the review of all projects, Cadmus calculated a realization rate for the document review by dividing savings calculated for the sample (using the revised information) by reported savings for the sample. The team multiplied this realization rate by adjusted savings for the entire program to determine *prescriptive evaluated savings* for the biennium.

Cadmus conducted document reviews for the programs shown in Table 15, drawing roughly equal samples from participants in each quarter through the first half of PY 2019. Based on the low variation in document review results, these sample sizes easily met the target of ±10% relative precision at 90% confidence established for this evaluation activity.

Table 15. Residential Sector Natural Gas Impact Document Review

Program	Complete Through 2Q PY 2019
HVAC	51
Shell	51

Billing Analysis

For the Residential sector, Cadmus conducted billing analysis using available natural gas and electricity consumption data from Avista for the HVAC, Shell, and Fuel Efficiency programs. Evaluating Simple Steps, Smart Savings program savings through billing analysis was not practical because participants of the midstream retail program were largely unknown. The ENERGY STAR homes program had too few participants to produce meaningful billing analysis results. With MFDI, Cadmus did not analyze natural gas consumption as would have been impossible to separate lighting interactive effects from savings due to installations of aerators and efficient showerheads.

HVAC, Shell, and Fuel Efficiency Savings Estimates

With the HVAC, Shell, and Fuel Efficiency programs, Cadmus eliminated the effects of multiple energy efficiency measures by only including participants in the analysis who installed one measure. With these programs, the goal was to provide average unit savings values at the measure level to ensure the most accurate values possible were used for evaluated savings and cost-effectiveness.

Cadmus used the unit savings value provided by the billing analysis for a given measure when results for that measure met two requirements: the number of sites in the participant group was at least five, and the relative precision achieved was no greater than ±40% at the 90% confidence level.

If results calculated using only Washington participants met these requirements, the team used those results. If results, based only on Washington participants, failed to meet the requirements, Cadmus checked combined results for Washington and Idaho participants to determine if those results passed. In all cases, billing analysis results for each measure either met requirements with Washington participants or failed to meet requirements with Washington participants and with Washington and Idaho participants.

Data Sources

To conduct the consumption analysis, Cadmus used program measure tracking data provided by Avista, monthly electric and gas consumption data provided by Avista, and weather data, which included actual average daily temperatures for 10 weather stations from NOAA for the billing analysis period. The team used zip codes to match daily heating and cooling degree days to respective monthly bill read dates. Additionally, Cadmus used typical meteorological year (TMY3) 15-year normal weather values from

1991–2005, obtained from NOAA for the same weather stations, in assessing energy use under normal weather conditions.

Participant and Comparison Group Designation

Cadmus gathered data for a participant (treatment) group, composed of all HVAC, Shell, and Fuel Efficiency program participants with measures installed in 2018. This allowed enough pre- and post-consumption data to analyze the various measures' effects.

To isolate the impact of exogenous factors (such as energy rate changes, economic condition changes, and non-programmatic effects) on energy use, Cadmus utilized a quasi-experimental design that involved selection of a comparison group, composed of participants with installation dates in late PY 2019. Through this approach, the team compared the treatment group's pre- and post-change energy use (assumed to capture the program treatment) to the comparison group's change in energy use (reflecting what would have happened absent the program). To ensure similarity between treatment and control groups, the team chose to use future participants as the comparison group because they would have similar qualifications and could be assumed to have not participated in energy efficiency prior to program treatment.

Data Screening

Starting with all HVAC, Shell, and Fuel Efficiency participants and the comparison group, Cadmus cleaned the data and screened for several criteria to identify final analysis samples. Data cleaning included performing account-level reviews of the pre- and post-period monthly consumption of all individual participants to identify anomalies (such as periods of unoccupied units) that could bias the results. The team conducted the consumption analysis using participants who had not moved since participating and who had at least 10 months of pre- and post-period billing data.

The team applied several screens to remove anomalies, incomplete records, and outlier accounts. The following are examples of accounts excluded from the analyses:

- Accounts missing records, prohibiting the team from merging participant program tracking data with consumption data

- Accounts with low annual use in the pre- or post-period, such as less than 1,240 kWh annually

- Customers with incorrect signs on Princeton Scorekeeping Method (PRISM) parameter estimates

- Accounts with other extreme values, including vacancies in billing data (outliers), non-program-related heating or cooling system changes (such as added or removed heating or cooling loads), baseload equipment changes, or changes in occupancy. This included screening for accounts with large gaps in interval data, such as having zero consumption across multiple months.

Analysis

To estimate measure level impacts, the Cadmus team employed a pre- and post-installation savings analysis using household-level PRISM models that accounted for differences in pre- and post-installation

weather conditions. The Cadmus team estimated the heating PRISM model using variable 45- to 65-degree heating bases in both the pre- and post-period for each customer.

Residential Impact Evaluation Results

The following sections summarize findings for each impact evaluation methodology and provide biennial evaluated savings.

Database Review

Table 16 shows database review findings, with adjusted savings slightly higher than reported savings for some programs and considerably lower for others. Adjusted savings differed from reported savings with ENERGY STAR Homes because the Avista TRM provides a value of zero therm savings for dual-fuel ENERGY STAR manufactured homes and a value one-half of the reported value for ENERGY STAR manufactured homes with gas heating. With the MFDI program, Cadmus applied RTF UES values for multifamily direct-install aerators that were much lower than the older values used by the implementer.

Table 16. Residential Programs Database Review Natural Gas Impact Findings

Program	Reported Natural Gas Savings (Therms)	Adjusted Natural Gas Savings (Therms)	Percentage Change
Simple Steps, Smart Savings	1,188	1,188	0%
HVAC	840,479	841,554	0%
Shell	229,974	233,110	1%
ENERGY STAR Homes	1,293	473	(63%)
Multifamily Direct Install	10,164	7,777	(23%)
Multifamily Direct Install Supplemental Lighting	0	0	N/A
Residential Total	**1,083,098**	**1,084,101**	**0%**

During the PY 2018 evaluation, Avista confirmed that the natural gas UES value used in the tracking data for replacement windows (0.48 therms) had not been updated to the 2018 TRM value (1.92 therms), resulting in apparent underreporting of savings. Under Avista's direction, Cadmus adjusted reported savings for the 2018 Shell windows measures to use 2018 TRM values. Cadmus used those same adjusted reported savings values for 2018 Shell windows measures for this biennial evaluation. For PY 2019, the tracking data used the 2019 TRM UES value of 0.60 therms.

Cadmus noted numerous additional discrepancies between the measure-tracking data and TRM values; these balanced each other out or had only a small effect on program-level adjusted savings. The following list shows a few examples of these discrepancies:

- Measure-tracking data reported various unit savings values for smart thermostats other than the 2018 and 2019 TRM values of 26 therms, and, in one case, reported large kWh savings but no therm savings.
- Some window replacement measures reported much lower savings values than provided in the 2018 and 2019 TRMs.

- All PY 2019 high-efficiency natural gas water heater measures reported savings of 25 therms per unit rather than the 20.9 therms value provided in the 2019 TRM.
- For several instances of installed Shell measures, apparent typos for square feet of windows or insulation or incorrect UES values caused discrepancies between reported and adjusted savings.

Document Review

Table 17 summarizes document review findings for measures installed from Q1 PY 2018 through Q2 PY 2019. The HVAC program had a 100% natural gas document review realization rate, and the Shell program had a 105% natural gas document review realization rate.

Table 17. Residential Natural Gas Impact Document Review Realization Rates

Program	Document Audit Count	Sample Reported Savings (Therms)	Sample Biennial Evaluated Savings (Therms)	Biennial Document Audit Realization Rate
HVAC	51	7,306	7,306	100%
Shell	51	3,195	3,360	105%

Cadmus' document review (through Q2 PY 2019) identified several discrepancies:

- For two window measures, documentation showed square footage for installed windows that differed from the reported window area. In one case, the documented area was higher than reported; in the other case, it was lower. Cadmus adjusted savings based on the corrected window area for both measures.
- For three window measures reported for sites with electric heating, project documents identified natural gas as the heating fuel. Cadmus added natural gas savings and removed electricity savings at these sites.

Billing Analysis

Table 18 shows measure-level billing analysis results, used when calculating biennial natural gas savings. The participant count and relative precision for each measure easily met requirements established to ensure meaningful results, which required a participant count of at least five and a relative precision no greater than ±40% at the 90% confidence level.

Table 18. Residential Programs Billing Analysis Results

Measure	2019 Avista TRM Unit Energy Savings (Therms)	n[a]	Pre-Installation Weather Normalized Usage (Therms)	Annual Unit Energy Savings (Therms)	Realization Rate	Relative Precision at 90% Confidence
G Natural Gas Furnace	102.0	824	834	81.664	80%	±10%
G Smart Thermostat DIY with Natural Gas Heat[b]	26.0	470	856	26.642	102%	±30%
G Smart Thermostat Paid Install with Natural Gas Heat[b]	26.0	470	856	26.642	102%	±30%
G Storm Windows with Natural Gas Heat[c]	0.6	40,117	6.949	0.339	56%	±25%

Measure	2019 Avista TRM Unit Energy Savings (Therms)	n[a]	Pre-Installation Weather Normalized Usage (Therms)	Annual Unit Energy Savings (Therms)	Realization Rate	Relative Precision at 90% Confidence
G Window Replc With Natural Gas Heat[c]	0.6	40,117	6.949	0.339	56%	±25%

[a]To provide unit savings values that align with TRM units (sq. ft.), this table presents participant count in sq. ft. of window surface for storm widow and replacement window measures.
[b]Results shown represent combined analysis of smart thermostats for do-it-yourself and contractor installation to maximize relative precision. Separate results for each delivery method appeared similar.
[c]Results shown represent combined analysis of storm window and window-replacement measures, to maximize relative precision. Separate results for each measure appeared similar.

Billing analysis results for natural gas furnace measures had a large impact on the realization rate for the HVAC program and the Residential sector as a whole. The Avista TRM unit savings value of 102 therms is based on a 2011 billing analysis of natural gas upgrades. Cadmus identified three reasons for the reduction in billing analysis results from 102 therms to 82 therms. The difference with the largest impact was that roughly 10% of participants included in the 2011 study installed an air source heat pumps along with a more efficient natural gas furnace. Installation of a heat pump appeared to result in greater natural gas savings by shifting some of the heating load to the heat pump, based on the observed sharp reduction in natural gas consumption for these participants.

Other factors included a shift from normalizing temperature based on TMY2 weather data in 2011 to TMY3 weather data for the current study and using a floating degree day base temperature for the current study rather than the fixed base temperature of 65 degree Fahrenheit in 2011.

Billing analysis also provided relatively low natural gas savings for replacement windows relative to the 2019 TRM value of 0.6 therms per square foot of window area. The billing analysis UES value of 0.34 had an even larger impact on 2018 savings as the 2018 Avista TRM used a UES value of 1.92 therms per square foot.

Smart thermostats achieved strong savings, as estimated by the billing analysis. The billing analysis UES value of 26.6 therms provided a realization of rate of 102% relative to the TRM UES value of 26 therms. To provide participant counts high enough to support statistically significant estimates, Cadmus combined participants for the two measures, which distinguished between do-it-yourself installation and contractor installation. When the two measures were analyzed separately, only the do-it-yourself measure produced statistically significant results, with a relative precision of ±33% and a UES of 25 therms.

Biennial Evaluated Savings

To calculate biennial evaluated savings, Cadmus used unit savings values determined through the billing analysis for the measures shown in Table 18. For the remaining measures, Cadmus applied the results of database review and, where applicable, the document review to evaluate savings for each measure. The analysis then rolled up measure-level evaluated savings to calculate evaluated savings and a realization rate for each program. Table 19 shows the resulting biennial evaluated savings and realization rates.

Table 19. Residential Programs Natural Gas Impact Findings

Program	Reported Savings(Therms)	Biennial Evaluated Savings (Therms)	Realization Rates
Simple Steps, Smart Savings™	1,188	1,188	100%
HVAC	840,479	714,665	85%
Shell	229,974	92,426	40%
ENERGY STAR Homes	1,293	473	37%
Multifamily Direct Install	10,164	7,777	77%
Multifamily Direct Install Supplemental Lighting	0	0	N/A
Residential Programs Total	**1,083,098**	**816,529**	**75%**

Residential Conclusions and Recommendations

Biennial evaluated natural gas savings show a 74% realization rate on acquired savings of 816,529 therms for Residential programs, or 84% of the savings goal for the biennium.

The HVAC program accounts for most biennial evaluated Residential natural gas savings (88%), followed by the Shell program with 11% of natural gas savings. Simple Steps, Smart Savings, MFDI, and ENERGY STAR Homes account for 1% of combined savings, primarily through water-saving measures.

Billing analysis results for natural gas furnace measures served as the biggest driver of the 74% realization rate for Residential savings, providing a measure-level realization rate of 80%. The Avista TRM unit savings value of 102 therms is based on a 2011 billing analysis of natural gas upgrades, which showed higher natural gas savings largely because roughly 10% of participants in the treatment group installed heat pumps along with a more efficient natural gas furnace; participants who installed a heat pump along with a furnace upgrade showed a sharp reduction natural gas usage, indicating that some heating load shifted to the heat pump. For PY 2018 and PY 2019, Cadmus identified no participants who installed both a high-efficiency natural gas furnace a heat pump. Billing analysis also provided relatively low natural gas savings for replacement windows, partly because the 2018 Avista TRM used an especially high savings value per square foot.

Cadmus offers three recommendations regarding Avista's Residential natural gas programs:

- Adjust the Avista TRM to provide lower savings values for natural gas furnaces, replacement windows, and storm windows, based on the billing analysis conducted for this evaluation. The billing analysis showed savings nearly equal to the unit savings value provided by the Avista TRM for natural gas furnace installations, when fuel-switching for secondary heating was not evident, but the billing analysis indicated that effective overall savings will be lower than the current TRM value because of the shifts to greater use of new furnaces in some homes.

- Continue to encourage installations of high-efficiency natural gas furnaces, which provided 65% of evaluated natural gas savings for Residential programs. The Northwest Energy Efficiency Alliance's *Residential Building Stock Analysis II* estimated that roughly 70% of natural gas furnaces in Washington single-family homes have an annual fuel utilization efficiency under 90%, indicating substantial savings opportunities remain.

- Continue to emphasize installation of Shell measures and smart thermostats, each of which accounted for 11% of natural gas savings for the biennium. Billing analysis showed smart thermostats had a realization rate of 102% with natural gas heating equipment.

Low-Income Impact Evaluation

Cadmus designed the Low-Income program impact evaluation to verify reported program participation and energy savings. Evaluation methods included database review and billing analysis.

Program Summary

A group of five Community Action Program agencies and one tribal weatherization organization deliver energy efficiency programs to Avista's low-income Residential customers in the Washington service territory. With annual funding of $2,350,000 available for electric and natural gas, these Community Action Program agencies qualify low-income customers, generate referrals through energy assistance efforts, and make funding resources available to meet customers' home energy needs.

For PY 2018 and PY 2019, the program achieved 39,655 therms in reported natural gas savings for Washington, including 3,439 therms reported from the Communtiy Energy Efficiency Program (CEEP). Cadmus received CEEP reported savings too late to include those savings in the current evaluation, other than noting them as reported savings.

Program Participation Summary

Table 20 shows Avista's savings goals for the Low-Income sector as well as reported savings and goal portions achieved throughout the biennium.

Table 20. Low-Income Reported Savings

Program	Savings Goals (therms)	Reported Savings (therms)ᵃ	Portion Reported
Low-Income	45,100	36,216	80.3%

ᵃ Reported savings do not include Low-Income Fuel Efficiency savings, shown in the *Fuel Efficiency Impact Evaluation* section.

Table 21 summarizes participation goals for the Low-Income programs, along with the participation reported and achieved in PY 2018 and PY 2019.

Table 21. Low-Income Participation

Program	Participation Goalsᵃ	Participation Reportedᵃ	Percentage of Goal
Low-Income	402,755	345,173	86%

ᵃ Participation numbers do not include Low-Income Fuel Efficiency participation, shown in the *Fuel Efficiency Impact Evaluation* section. Participation is defined as the number of installed units or square feet of installed insulation or windows.

Low-Income Impact Evaluation Methodology

Cadmus evaluated Low-Income program measures by conducting a database review (described above in the Database Review section). The team used UES values provided in the TRM to calculate savings for measures reported in the measure-tracking database, Cadmus labeled savings calculated during the database review as *adjusted savings*.

For many measures reported in the tracking database, notes indicated that savings were capped at 20% of consumption. When duplicating savings calculations using TRM values, Cadmus used the newly calculated value if it was less than the capped value, but used the capped value if the TRM value indicated greater savings.

Cadmus also conducted billing analysis for the Low-Income program, using all available natural gas consumption data for PY 2018 and PY 2019 program participants. Because of the relatively small number of Low-Income program participants, Cadmus was unable to isolate measure-level savings for the program (which are necessary for cost-effectiveness calculations). However, the billing analysis did provide savings estimates for the program as a whole that produced a point of comparison for evaluated savings, estimated using Prescriptive methods.

Low-Income Impact Evaluation Results

Table 22 shows reported and adjusted natural gas savings for Low-Income conservation measures. The table does not include savings for Low-Income Fuel Efficiency measures (shown in the *Low-Income Fuel Efficiency Impact Findings* section below).

Table 22. Low-Income Natural Gas Impact Findings

Program	Reported Natural Gas Savings (Therms)	Adjusted Natural Gas Savings (Therms)	Biennial Evaluated Natural Gas Savings (Therms)	Realization Rate
Low-Income	36,216	34,732	34,732	96%

During the database and TRM review, Cadmus noted numerous errors in the measure-tracking data, such as measures with little or no reported savings and unit savings values that did not match TRM values.

The billing analysis estimated a realization rate of 111% for Low-Income natural gas savings, excluding homes that installed Fuel Efficiency measures, but participation was not high enough to allow for isolation from effects of other installed measures. Such isolation is necessary to provide valid measure-level savings, which are necessary to support cost-effectiveness calculations for each measure.

Additionally, with relative precision of ±34% at the 90% confidence level, the estimate has relatively large error bounds. Accordingly, while the 111% realization rate suggests that natural gas savings may be understated for the Low-Income program, Cadmus recommends adopting the more conservative interpretation that the result provides strong support for the 96% realization rate calculated for the Low-Income program.

Low-Income Conclusions and Recommendations

With a 96% realization rate for natural gas savings, the Low-Income program achieved savings of 34,723 therms in PY 2018 and PY 2019, or about 77% of goal.

The Low-Income program measure-tracking data do not include adequate information to determine when savings values are appropriately capped. Cadmus recommends that annual consumption be provided for each measure in the tracking data, so savings evaluation can include verifying that savings have been capped at 20% of consumption for applicable measures.

Fuel Efficiency Impact Evaluation

Cadmus designed the Fuel Efficiency sector impact evaluation to verify reported program participation and natural gas consumption impacts. Evaluation methods included a database review, document review, and billing analysis.

Program Summary

Fuel Efficiency measures replace electric space-heating or water-heating systems with equipment that uses natural gas. These measures are offered within the Nonresidential Site Specific path, Residential programs, and Low-Income program. Across these programs, the Fuel Efficiency measures achieved participation of 1,774 projects in PY 2018 and PY 2019 and reported a natural gas energy penalty of 941,993 therms.

Fuel Efficiency measures provide positive electricity savings and negative natural gas consumption impacts, reflecting negative avoided costs. The *Washington Biennium (2018–2019) Electric Impact Evaluation Report* provides electric energy savings.

Program Participation Summary

This section summarizes Fuel Efficiency sector impact in PY 2018 and PY 2019 for the Nonresidential Site Specific path (includes HVAC Combined, refrigerator case doors, industrial process, and Multifamily Market Transformation measures), Residential programs, and Low-Income programs.

Table 23 shows Avista's combined PY 2018 and PY 2019 participation estimate and reported participation for Residential and Low-Income Fuel Efficiency measures as well as achieved percentages of the estimate. Avista did not estimate Nonresidential sector participation outside of the Multifamily Market Transformation program.

Table 23. Efficiency Reported Participation

Program	Participation Estimate[a]	Participation Reported[a]	Percentage of Estimate
Residential Fuel Efficiency	2,361	1,604	68%
Low-Income Fuel Efficiency	93	142	153%

[a] Participation defined as the number of rebates.

Table 24 shows natural gas consumption impact estimates, reported consumption impacts, and percentage of estimate for Nonresidential Site Specific, Multifamily Market Transformation, Residential, and Low-Income Fuel Efficiency measures.

Table 24. Avista Portfolio Fuel Efficiency Reported Natural Gas Penalties

Fuel Efficiency Measure	Consumption Impacts Estimate (therms)	Consumption Impacts Reported (therms)	Percentage of Estimate
Nonresidential Site Specific	N/A	(31,524)	N/A
Multifamily Market Transformation	(139,836)	(106,211)	76%
Residential Fuel Efficiency	N/A	(593,517)	N/A
Low-Income Fuel Efficiency	N/A	(22,319)	N/A

Fuel Efficiency Impact Evaluation Methodology

This section presents the impact methodology for Fuel Efficiency measures included in the Nonresidential Site Specific path, Residential programs, and Low-Income program.

Nonresidential Site Specific Fuel Efficiency Impact Methodology

For Fuel Efficiency measures, Cadmus followed the same impact evaluation methodology described in the *Nonresidential Impact Evaluation Methodology* section. In evaluating Nonresidential sector Fuel Efficiency, Cadmus sampled seven Multifamily Market Transformation program project measures that together represented 37% of the reported natural gas consumption impacts, shown in Table 25.

Table 25. Nonresidential Fuel Efficiency Evaluation Sample

Fuel Efficiency Measure	Applications Sampled	Sampled Consumption Impacts (therms)	Percentage of Reported Consumption Impacts (therms)
Nonresidential Site Specific	0	0	0%
Multifamily Market Transformation	7	(50,522)	48%
Total	**7**	**(50,522)**	**37%**

Cadmus performed site visits at six unique Nonresidential locations to assess natural gas penalties for the seven Multifamily Market Transformation program applications evaluated. Site visits involved verifying installed equipment types, make and model numbers, operating schedules, and set points, as applicable.

Cadmus did not evaluate any Nonresidential Site Specific applications in the Fuel Efficiency program, but did evaluate various measures in the same measure categories in the electric and gas Site Specific programs. Cadmus found 100% gas realization rates for Site Specific Case Doors and Site Specific HVAC Combined measures in the relevant measure categories, and therefore applied a 100% realization rate to those measure categories in the Fuel Efficiency program.

Residential Fuel Efficiency Impact Methodology

Cadmus applied billing analysis results to evaluate natural gas consumption impacts for all but one Residential Fuel Efficiency measure, using the methodology described previously in Billing *Analysis*. For the remaining measure—four instances of E Multifamily Electric to Natural Gas Water Heater—Cadmus applied the results of the database and document reviews. This approach provided the strongest estimate of achieved natural gas consumption impacts practical for each measure. Cadmus completed document reviews for 50 Fuel Efficiency participants from Q1 PY 2018 through Q2 PY 2019.

Low-Income Fuel Efficiency Impact Methodology

To evaluate natural gas consumption impacts for the Low-Income Fuel Efficiency measures, Cadmus conducted a database review (described in the *Database Review* section) and billing analysis. The relatively low number of participants for the Low-Income program made it impractical for the billing analysis to isolate consumption impacts for specific measures. Using unit savings values provided in the TRM, Cadmus calculated natural gas consumption impacts for measures reported in the measure-

tracking database. For Low-Income program measures in general (including Low-Income Fuel Efficiency measures), the evaluation relied on results from the database review to determine biennial evaluated natural gas consumption impacts.

Fuel Efficiency Impact Evaluation Results

This section summarizes findings for Fuel Efficiency measures in the Nonresidential Site Specific path, Residential program, and Low-Income program. All Fuel Efficiency measures provide positive electricity savings and negative natural gas consumption impacts because the measures replace electric space-heating or water-heating systems with equipment that uses natural gas. Negative natural gas consumption impacts reflect negative avoided costs and are incorporated in the electric cost-effectiveness calculations. Cadmus reported positive electric savings in the *Washington Biennium (2018–2019) Electric Impact Evaluation Report*.

Nonresidential Site Specific Fuel Efficiency Impact Findings

Table 26 shows reported and biennial evaluated natural gas penalties for Avista's Nonresidential sector Fuel Efficiency measures, along with realization rates.

Table 26. Nonresidential Fuel Efficiency Natural Gas Impact Findings

Fuel Efficiency Measure	Reported Consumption Impacts (Therms)	Biennial Evaluated Consumption Impacts (Therms)	Realization Rate
Nonresidential Site Specific	(31,524)	(31,524)	100%
Multifamily Market Transformation	(106,211)	(94,263)	89%
Total	**(137,735)**	**(125,787)**	**91%**

Of the seven Multifamily Market Transformation Fuel Efficiency applications evaluated, Cadmus identified discrepancies in four applications (two of which were installed at the same site), based on the evaluation site visits and project documentation reviews. Table 27 summarizes reasons for discrepancies between reported and biennial evaluated natural gas penalties. One application had a realization rate of 99% due to minor calculation differences and is not included in the table below.

Table 27. Nonresident Fuel Efficiency Summary of Discrepancies

Program	Number of Occurrences	Penalty Impact	Reason(s) for Discrepancy
Multifamily Market Transformation	2	⬇	• The site installed more efficient furnaces than reported, resulting in lower natural gas energy consumption by installed units versus baseline efficiency units and a reduced natural gas energy penalty.
	1	⬆	• The site installed natural gas-fired furnaces with a higher heating capacity (Btu/hr) and a lower AFUE than reported. Based on Cadmus' review of the project documentation, the post-inspection did not confirm installed unit model numbers. Though this update did not affect reported electric savings, it increased the natural gas penalty.

Residential Fuel Efficiency Impact Findings

In reviewing documentation for 50 Residential Fuel Efficiency measures, Cadmus did not find issues affecting natural gas consumption impacts. This led to a 100% document review realization rate for natural gas consumption impacts for the sole measure not receiving a UES from the billing analysis. Table 28 shows natural gas results from the impact document review for Residential Fuel Efficiency measures.

Table 28. Residential Fuel Efficiency Natural Gas Impact Document Review Realization Rate

Fuel Efficiency Measure	Document Audit Count	Sample Reported Consumption Impacts (Therms)	Sample Biennial Evaluated Consumption Impacts (Therms)	Biennial Document Audit Realization Rate
Residential Fuel Efficiency	50	(14,630)	(14,630)	100%

Table 29 shows measure-level billing analysis results used when calculating biennium natural gas consumption impacts. The participant count and relative precision for each measure easily met requirements established to ensure meaningful results, which required a participant count of at least five and relative precision no greater than ±40% at the 90% confidence level. In general, the billing analysis found the additional natural gas usage to be much higher than predicted by the 2019 Avista TRM values. Other than the 90% realization rate for the wall-heater measure, realization rates ranged from a low of 131% to a high of 284%, indicating that 131% to 284% more of natural gas was consumed than the TRM values predicted.

Table 29. Residential Fuel Efficiency Billing Analysis Results

Measure	2019 Avista TRM Unit Energy Savings (Therms)	n	Pre-Installation Weather Normalized Usage (Therms)	Annual Unit Energy Savings (Therms)	Realization Rate	Relative Precision at 90% Confidence
E Electric To Natural Gas Water Heater[a]	(144)	24	240	(408)	284%	23%
E Electric To Natural Gas Furnace	(275)	244	12	(470)	170%	5%
E Electric To Natural Gas Furnace & Water Heat	(420)	268	3	(548)	131%	4%
E Multifamily Electric to Natural Gas Furnace and Water Heat	(199)	20	-	(386)	194%	10%
E Multifamily Electric to Natural Gas Furnace	(96)	7	-	(232)	241%	9%
E Electric To Natural Gas Wall Heater[b]	(466)	20	-	(418)	90%	22%

[a] The 2019 Avista TRM does not include the E Electric to Natural Gas Water Heater measure. The TRM value shown is the difference between TRM values for the E Electric to Natural Gas Furnace & Water Heat and E Electric to Natural Gas Furnace measures.

[b] The 2019 Avista TRM does not include the E Electric to Natural Gas Wall Heater measure. The TRM value shown is taken from the 2018 Avista TRM.

To calculate biennial evaluated natural gas consumption impacts, Cadmus used unit savings values determined through billing analysis for the measures shown in Table 29. For the remaining measure (E Multifamily Electric to Natural Gas Water Heater), Cadmus applied the results of database review to determine evaluated natural gas consumption impacts. The analysis then rolled up measure-level evaluated consumption impacts to calculate the evaluated consumption impacts and realization rate shown in Table 30.

Table 30. Residential Fuel Efficiency Natural Gas Impact Findings

Fuel Efficiency Measure	Reported Consumption Impacts (Therms)	Adjusted Consumption Impacts (Therms)	Biennial Evaluated Consumption Impacts (Therms)	Realization Rate
Residential Fuel Efficiency	(593,517)	(644,312)	(794,417)	134%

Low-Income Fuel Efficiency Impact Findings

Table 31 shows reported, adjusted, and evaluated natural gas impact results for Low-Income Fuel Efficiency measures based on the database review.

Table 31. Low-Income Fuel Efficiency Program Natural Gas Impact Findings

Fuel Efficiency Measure	Reported Consumption Impacts (Therms)	Adjusted Consumption Impacts (Therms)	Biennial Evaluated Consumption Impacts (Therms)	Realization Rate
Low-Income Fuel Efficiency	(22,319)	(21,789)	(21,789)	98%

The billing analysis estimated a realization rate of 221% for Low-Income Fuel Efficiency natural gas consumption impacts, with a relative precision of ±7% at the 90% confidence level. Participation was not high enough to allow for isolating consumption impacts at the measure level, which are necessary for calculating cost-effectiveness, but the results do indicate much greater natural gas fuel penalties for Low-Income Fuel Efficiency measures as a whole than indicated by 2019 Avista TRM values. This finding also supports the electric billing analysis finding that electric savings for Low-Income Fuel Efficiency measures are much higher than estimated by the 2019 Avista TRM (see *Washington Biennium (2018 – 2019) Electric Impact Evaluation Report*). Together, the electric and natural gas billing analysis results suggest a much greater heating load than indicated by TRM values, which is evident as the heating load shifts from electricity to natural gas.

Fuel Efficiency Conclusions

Nonresidential Site Specific and Multifamily Market Transformation Fuel Efficiency measures achieved biennial evaluated natural gas penalties of 125,787 therms, yielding a 91% realization rate. The Multifamily Market Transformation Fuel Efficiency measures achieved 67% of the total Nonresidential natural gas penalty estimate of -139,836 therms.

Cadmus recommends ensuring that the final reported natural gas consumption impacts calculations reflect the most up-to-date project details, including post-IV photos, equipment submittals, and

invoices. During two project verifications, the team found installed equipment performance that differed from that used in the reported consumption impacts calculations.

Residential Fuel Efficiency measures achieved biennial evaluated natural gas impacts consumption increase of 794,417 therms, yielding a 134% realization rate. Low-Income Fuel Efficiency measures contributed a natural gas increase of 21,789 therms, with a 98% realization rate, though billing analysis results suggest that the natural gas consumption increase for these measures is much higher.

Cadmus recommends adjusting Avista TRM values for Residential and Low-Income Fuel Efficiency measures to increase their natural fuel penalties, as indicated by the biennium billing analysis results.