Impact Evaluation

2014 New Buildings Program: Final Report

May 5, 2017

Energy Trust of Oregon

Energy Trust of Oregon

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MichaelsEnergy

Contents

Executive Summary

Energy Trust of Oregon (Energy Trust) delivers a myriad of energy efficiency programs to Oregon customers of PGE, Pacific Power, and Cascade Natural Gas. Energy Trust also provides energy efficiency programs to both Oregon and Washington customers of NW Natural. Beginning in 2017, Energy Trust began providing these services to Avista natural gas customers in Oregon.

One of these programs is the New Buildings program. Since 2003, New Buildings has supported the design, construction, and major renovation of energy efficient commercial buildings from early design to occupancy, utilizing a variety of services and incentives, including early design assistance, technical service incentives, and installation incentives. The New Buildings program supports projects for customers throughout the Oregon service territory[1], including Avista customers beginning in 2017.

The New Buildings program offers incentives through three distinct types of measures; Prescriptive and Calculated, Market Solutions, and Custom Analysis.

- Prescriptive measures offer standardized savings for straightforward technologies through the use of deemed savings.
- Calculated measures where a deemed algorithm is used to calculated savings with sets of operating parameters that vary depending on specific customer characteristics.
- Market Solutions are pre-packaged sets of prescriptive and calculated measures specific to different building types.
- Custom measures include savings developed using custom-built engineering analyses, as well as whole building energy simulations.

Energy Trust contracted with Michaels Energy to evaluate projects and measures recognized through the New Buildings program in the 2014 program year. The first step in the evaluation process was to develop the sample. The sample for the 2014 program year was designed to achieve the primary goals outlined by Energy Trust, which are listed below:

- Verify the electricity savings (kWh) at the 90/10 confidence and precision level
- Verify the natural gas savings (therm) at the 90/10 confidence and precision level
- Provide robust realization rates for each major building type

An additional goal of the evaluation was to report any important observations about New Buildings projects and make recommendations for specific changes that will help Energy Trust improve the accuracy and effectiveness of future program savings estimates and the results of future impact evaluations.

The Michaels team received an extract of program participation data including all projects and measures that had been recognized in 2014. The sampling plan developed provides broad coverage of the total savings claimed through the program, as can be seen in Table 1. In total, 66% of the energy savings (in MMBTU) were evaluated. Only four of the eleven building categories had less than half of their total energy savings included in the sample. Conversely,

[1] The New Buildings Program does not currently serve NW Natural customers in Washington.

the sample included more than 90% of the savings for each of four building types: assisted living, college/university, data center, and K-12 school.

Table 1 | Summary of Final Sample

Group	Projects	Measures	Electricity Savings (kWh)	Gas Savings (therms)
Program Total	358	1,292	34,618,562	653,764
Sample Total	99	493	22,332,783	454,818
Sample Share of Total	28%	38%	65%	70%

The Michaels team verified the gross savings claimed for the program using a combination of onsite data collection, project file reviews, and engineering analysis. The approach used for each project is shown in Figure 1.

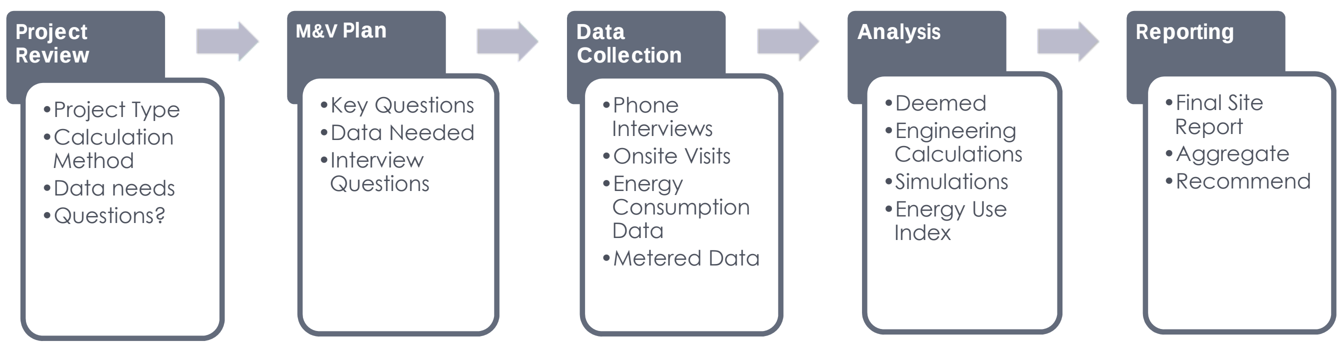

Figure 1 | Impact Evaluation Process

The Michaels team evaluated a total of 99 different projects and 493 individual measures across 11 different building types. The evaluated projects included prescriptive, calculated, market solutions and custom measures for end uses ranging from hot water to lighting and HVAC controls.

The Michaels team completed onsite verification for 71 of the sampled projects and completed project file reviews for the remaining 28. During the onsite visits, Michaels' field engineers verified equipment counts, efficiency levels, and collected metered data from data logger installations or the customers' energy management system.

These collected data were used in conjunction with customer energy usage data to revise engineering savings estimates for each measure in the sample. Prescriptive measure methodologies were not adjusted, but quantities of claimed measures and any other necessary adjustments were made. Operational data collected during the site visits were used to update any calculation templates for custom projects. Finally, energy usage data and operational information were used to update any building simulations that had been used by the program.

The results of the evaluation determined that the program achieved a 96% realization rate for electricity (kWh) savings and a 94% realization rate for natural gas (therm) savings. The final realization rate relative precision values also exceeded the target of 10% at the 90% confidence level.

Table 2 | New Buildings 2014 Electricity and Gas Verified Savings Summary

Fuel	*Ex Ante*	*Ex Post*	Realization Rate	Relative Precision
Electricity (kWh)	34,618,562	33,185,354	96%	3%
Natural Gas (therms)	653,764	614,276	94%	4%

The Michaels team also calculated realization rates for each building type in the sample, which is shown in Table 3. While there wasn't a strict statistical precision requirement around the results reported at the building type level, the stratification strategy provides robust results for each building type, except data centers. The relative precision at the 90% confidence level for each building type ranged from 1% to 30%. However, six out of the eleven different building type categories had a relative precision of 10% or less for both gas and electric fuels. Four of the eleven building types had a relative precision for at least one fuel of 10% or less. Relative precision for data centers was 30%, due to a small sample size and large variance between projects.

Table 3 | Realization Rates and Relative Precision (at the 90% Confidence Level) by Building Type

Building Type	Sampled Projects	Electric (kWh) Realization Rate	Natural Gas (therms) Realization Rate	Electric Relative Precision	Nautral Gas Relative Precision
Assisted Living Property	9	100%	104%	3%	10%
College/University	9	90%	84%	5%	7%
Data Center	4	89%	N/A	30%	N/A
Grocery	5	100%	N/A	3%	N/A
K-12 School	10	97%	103%	11%	1%
MultiFamily < 70,000 Ft2	10	91%	82%	6%	27%
MultiFamily 70,000+ Ft2	8	91%	104%	5%	24%
Office/Retail	11	110%	64%	8%	29%
Other	12	106%	94%	6%	5%
Restaurant/Lodging/Hotel/Motel	10	95%	107%	2%	4%
Warehouse and Storage	11	94%	79%	9%	10%
Total Program	**99**	**96%**	**94%**	**3%**	**4%**

The Michaels team categorized the adjustments made to each measure evaluated. The most common reason for adjustment was that equipment was operated or installed differently. This was found to be true at the program level for both electricity and gas savings, as well as across measure types. Figure 2 shows the savings impact due to each of the adjustment categories. The most significant reason for adjustment for both electric and natural gas measures was that equipment was operated or installed differently. This is as expected for new construction programs since there are no historical data or practices on which to base assumptions for a particular customer.

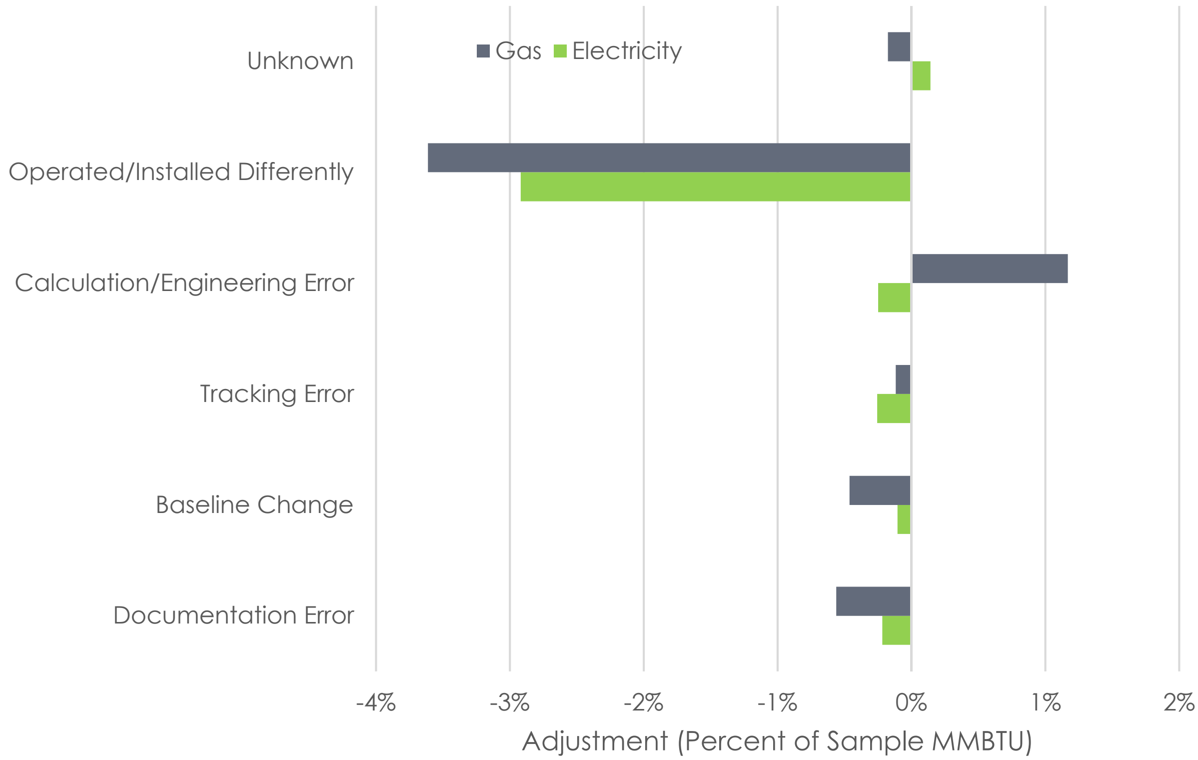

Figure 2 | Savings Impact by Adjustment Type

One important observation from Figure 2 is the minimal impact due to baseline changes. Using the appropriate baseline for new construction measures is second in importance only to the anticipated operation. The small impact that changes to the baseline had on the program savings overall speaks to the careful consideration that takes place for accurately quantifying baselines for custom measures.

Based on the data collected during this evaluation, and the resulting data analysis, the Michaels team found that program implementation staff did an excellent job estimating savings for a majority of projects during the 2014 program year. In order to build on that success and maintain high levels of realized savings, the Michaels team developed several key recommendations for the program to consider:

- **Continue improving documentation of modeling files.** Modeling projects and the associated modeling files can be complex. Projects can undergo multiple design iterations, and program staff are not the ones creating the original model files. The 2012 evaluation noted that modeling files were inconsistent and that the evaluator had difficulty analyzing building simulation savings. During the 2014 evaluation, Michaels did not have notable difficulty with incomplete or inconsistent modeling files. This indicates the program made significant strides since 2012. Not all modeling files followed precise naming conventions. However, baseline, as-built, interactive, and measure level models were included with project files or available via request to PMC staff. Continued work regarding naming conventions will further improve the review process internally by Energy Trust and PMC staff, as well as by evaluators.

- **Connect verification site visit results to the claimed savings.** During the Michaels evaluation, there were several instances where the equipment or specifications needed to be updated based on findings onsite. However, for three of these cases, the same adjustments had already been noted by the PMC's post-construction verification site visits. These notes, and in some instances, photos, were located in the documentation provided to Michaels for the projects. This indicates that there is some missing link in the feedback loop since savings were not adjusted using the findings from the PMC's visits. Michaels recommends that the program makes changes to the verification process. For example, compare the claimed and "verified" savings on the cover sheet of the site visit documentation. This would make any significant difference more visible and help reduce documentation errors.
- **Verify primary or secondary equipment.** One site visited during the evaluation was found to have claimed savings for a condensing boiler that was installed as a backup to a heat pump system. Since the boiler is used only when the heat pump system cannot supply the necessary heat, the operation is significantly less than that of a primary space heating boiler. This project, while small, pointed to a gap in the 2014 verification process, as it does not appear program staff specifically inquired about backup or redundant equipment. The inspection for this project correctly noted that the equipment was installed. However, the savings for this, and many other HVAC measures do not account for backup or redundant equipment. Energy Trust indicated that this practice has been updated since the 2014 program year. Therefore, Michaels recommends that the next evaluation of the New Buildings program include some additional focus on ensuring backup equipment, especially for HVAC equipment and pumping VFDs, are being properly counted.
- **Consider delaying verification of new buildings for as long as possible during the current program year.** The previous (2012) evaluation noted a similar recommendation: having "ramp up" periods for projects. While that recommendation was focused specifically on large projects, a similar process may be helpful for smaller projects. Michaels found that differences in the assumed operation of systems (used to claim savings) and how customers actually operated systems was the most common reason for savings adjustment. One possible way to help mitigate these risks is for the program to complete any onsite verification as late as possible in the program year. This will allow as much time as possible for projects to get "up and running" after completion while still claiming the savings in the current year.
- **Engage customers during late stage project completion about low flow devices.** Low flow faucet aerators, shower wands, and shower heads had a realization rate of 82% for electric savings and 42% for gas savings. This was due in part to customers removing them for satisfaction reasons. Continuing engagement with customers who install these measures could help to keep the customer reminded about their benefits and alert the program to early replacement by the customer.

- **Consider expanding the verification for multifamily buildings.** Similar to the previous recommendation, there were six projects in the evaluation sample (four multifamily and two assisted living) where the claimed quantity of low flow devices and HVAC equipment (PTHPS or ductless mini-splits) did not match the quantities from the project documentation. While onsite verification from program staff is occurring in 10% of the units in a building, there are still discrepancies between the claimed and actual quantities of measures. One way to reduce this is to complete a larger percentage of verifications for each building. However, this can be cost prohibitive and can lay an additional burden on customers. An alternative approach would be to require that a final unit list or map be obtained for each multifamily building and that it be included in the project documentation and project audit file. This would ensure that the final counts of units and the appropriate number of bathrooms are included in the claimed savings.
- **Identify phased projects early and separate them from the "regular" population of projects.** Energy Trust has already begun this process to some extent, as very large industrial customers are already separated from the remainder of the New Buildings Program. There were two large data center projects in the sample for this evaluation that were found to be in various stages of construction. One had finished the third and final phase of the build-out in 2016, so it was included in the evaluation sample. The other was planned to finish the final phase in 2017. This project was ultimately dropped from the sample to ensure the facility was fully operational and to avoid contacting the customer multiple times for each phase evaluation. Energy Trust has recently set up a process for evaluating large and complex new construction projects and is currently soliciting qualifications for a pool of evaluation contractors. Utilizing this process for any significant projects, and identifying these projects early, will aid evaluators considerably, and be more transparent for large customers where "contact fatigue" can be a significant concern.
- **Verify seasonal changes within modeling projects.** One of the modeling projects evaluated, a large university building, had summer and winter schedules for some, but not all, of the equipment. This resulted in a realization rate for the lighting measures of 61%. Most modeling software packages have the ability to apply more than one equipment operating schedule, and more than one internal load schedule (such as people or equipment loads). These seasonal changes can be significant, especially for educational facilities. Model reviewers should take care to validate the equipment and loading schedule to ensure it is consistent with the anticipated operation of the building.
- **Engage and educate data center customers on advanced UPS control functions.** The largest adjustment to the electric realization rate was caused by very low loading for a data center uninterruptible power supply (UPS) system. Data centers will always have some sort of UPS system, and many of the new systems are capable of either variable module management system (VMMS) or energy saving system (ESS) controls. The customer indicated they run their system with the UPS units in parallel to ensure redundancy. This left the UPS units underutilized and operating at low efficiency. Michaels has seen this similar situation for other data centers examined in Energy Trust territory and others. Engaging customers about the benefits of the EES or VMMS controls,

while demonstrating how they do not add operational risk, could help ensure customers are utilizing these controls when available.

- **Consider methodologies for claiming negative measure level interactive savings.** There were several measures identified during the evaluation where negative measure interactions were calculated, but not recorded in Energy Trust tracking system. This is due to current Energy Trust policy which does not allow claiming negative cross fuel savings to avoid penalizing other member utilities unnecessarily. During the 2014 evaluation, these interactions were small, affecting only 2.3% of the measures claimed and 0.5% of the sample kWh savings. However, large dual fuel interactive measures, such as heat recovery chillers, could cause significant discrepancies for future years. Michaels recommends that some additional controls be put in place within the Energy Trust tracking system to verify savings in the tracking system versus the calculated savings at the project level. Energy Trust should check that the total claimed savings at the project level recorded in the tracking system match those provided in the calculation files. This will ensure the savings for the entire project are accurately recorded in the Energy Trust tracking system. Note this only applies when both fuels are provided by member utilities.
- **Consider claiming HVAC interactions for lighting measures.** High efficiency lighting measures, such as LED lighting, have significant interactions with a facility's HVAC systems. These interactions can be both positive and negative. Michaels completed a simplified estimation of the impact of HVAC interactions for lighting measures assuming all customers with lighting were both air conditioned and had natural gas heat. While neither of these assumptions was accurate for the New Buildings Program, it did provide an upper bound on the impact of HVAC interactive effects. Claiming these interactions for lighting would have added approximately 3% in additional electricity savings, but would have penalized the program gas savings by 26%. Michaels recommends that Energy Trust examines methods for tracking and claiming these types of interactions in the future. A possible starting point would be to track the interactive savings at the measure or project level, and then use the evaluation of the program year to "true-up" the negative interactions accumulated during the year. This could be done initially for the New Buildings program on an informational basis. Once the impact is known, further decisions regarding how to implement this change in conjunction with savings goals, payments, and other policy considerations could be made.
- **Set defined criteria for the application of the Technical Guidelines.** During the evaluation, one modeling project was completed during a time frame in which two different versions of the Energy Trust Technical Guidelines (specifically, the modeling requirements in SEED Appendix L) were available. The versions of the Technical Guidelines did not provide clear direction on what versions were applicable to which projects. Michaels recommends that a specific date is used as the effective date for future revisions of the Technical Guidelines. One possible option for this would be the project enrollment date. Using this date would ensure that updated guidelines are in place prior to modeling work beginning on the project. Additionally, this would aid with consistency across the project both from a technical and customer clarity standpoint.

MEMO

Date: December 5, 2017
To: Board of Directors
From: Jessica Iplikci, Commercial Sector Sr. Program Manager
Dan Rubado, Evaluation Project Manager
Subject: Staff Response to 2014 New Buildings Impact Evaluation

The impact evaluation of the 2014 New Buildings program conducted by Michaels Energy demonstrated a strong program that was operating well in 2014 and accurately estimating savings for most projects. In addition to high realization rates, there were no major problems with missing project documentation or simulation modelling files, which have been issues in past evaluations. The evaluator adjusted claimed energy savings based on actual operating conditions. The evaluator identified only minor opportunities for improvement in program operations and savings estimation.

Recommendations mainly focused on incremental improvements to the project verification process, recommendations the program has either already implemented, or which could be incorporated as the program adjusts procedures. Other recommendations targeted specific end uses such as low flow devices in multifamily buildings, and uninterruptible power supply (UPS) controls in data centers.

The evaluator commented on Energy Trust procedures for handling cross-fuel interactive effects at the measure level. Per Energy Trust Commercial Sector program policy, New Buildings does not claim negative interactions for individual custom and calculated measures if the interaction causes savings for a single fuel drop below zero, although these interactions are calculated for measure-level cost-effectiveness screening. In contrast, when both fuels remain above zero, the program does claim the negative interactions. This policy of zeroing-out cross-fuel, measure-level interactions has a small effect on New Buildings program savings (0.5% of electric savings in 2014), but creates an inconsistency between projects with modeled energy savings and those with custom and calculated measures. Energy Trust Planning and Evaluation will investigate this issue further and determine the magnitude of the potential impact on savings across the Commercial and Industrial sectors. If it is determined to be an important issue, Planning and Evaluation will propose a process for tracking these interactions in Energy Trust's systems across programs.

The evaluator identified a related issue, noting that there are significant interactions between lighting measures and HVAC systems that the program does not currently quantify or claim. The program does this in accordance with Energy Trust Commercial Sector program policy, which was intended to ignore these interactions so as not to penalize its gas portfolio for activity in its electric portfolio. The result is that substantial amounts of claimed gas savings may be negated by interactions with efficient lighting systems. However, Energy Trust believes that these interactions are of decreasing importance as the baseline efficiency for building envelopes, lighting, and HVAC systems improves across the board. Planning and Evaluation will investigate this issue further and determine the magnitude of the impact across the Commercial and Industrial sectors. If it is determined to be an important issue, Planning and Evaluation will propose a process for quantifying and tracking the interactions between lighting measures and HVAC energy use across programs.

1. Introduction

Energy Trust of Oregon delivers a myriad of programs to Oregon customers of PGE, Pacific Power, NW Natural, Cascade Natural Gas, and Avista, and customers of NW Natural in southwest Washington. One of these programs is the New Buildings program[2]. Since 2003, New Buildings has supported the design, construction, and major renovation of energy efficient commercial buildings from early design to occupancy, utilizing a variety of services and incentives, including early design assistance, technical service incentives, and installation incentives.

The New Buildings program offers incentives through three distinct types of measures: Prescriptive and Calculated, Market Solutions, and Custom Analysis.

- Prescriptive measures offer standardized savings for straightforward technologies through the use of deemed savings.
- Calculated measures where a deemed algorithm is used to calculated savings with sets of operating parameters that vary depending on specific customer characteristics.
- Market Solutions include pre-packaged sets of prescriptive and calculated measures specific to different building types.
- Custom measures include savings developed using custom built engineering analyses, as well as whole building simulations.

The New Buildings Program is implemented by a third party program management contractor (PMC). CLEAResult has been implementing the New Buildings program since 2009[3] and was the program implementer during the 2014 program year.

As part of the Energy Trust's ongoing efforts to improve program performance, it regularly completes impact and process evaluations of its programs. Energy Trust contracted with Michaels Energy, in partnership with Evergreen Economics and PWP Inc., (collectively the Michaels team or Michaels) to complete the impact evaluation of the 2014 New Buildings program. This summary report provides details regarding the evaluation methodology, analysis, and results, as well as recommendations the program can consider to further improve program performance in the future.

1.1 | Program Summary

The New Buildings program has performed very consistently over the last several years. Electricity savings have ranged between 30 and 80 GWh per year, while natural gas savings have ranged

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[2] New Buildings only serves Oregon customers. NW Natural customers in SW Washington are served by the Existing Buildings program. Avista customers only became eligible to participate in the program in mid-2016, so are not included in this evaluation.

[3] CLEAResult acquired Portland Energy Conservation, Inc. in 2014, which had been implementing the New Buildings program since 2009.

from 450,000 to 700,000 therms. Similarly, the number of incented measures has ranged between 1,100 and 1,300 individual measures per year. A summary of program performance for gas and electric savings over the last four years can be seen in Figure 3[4].

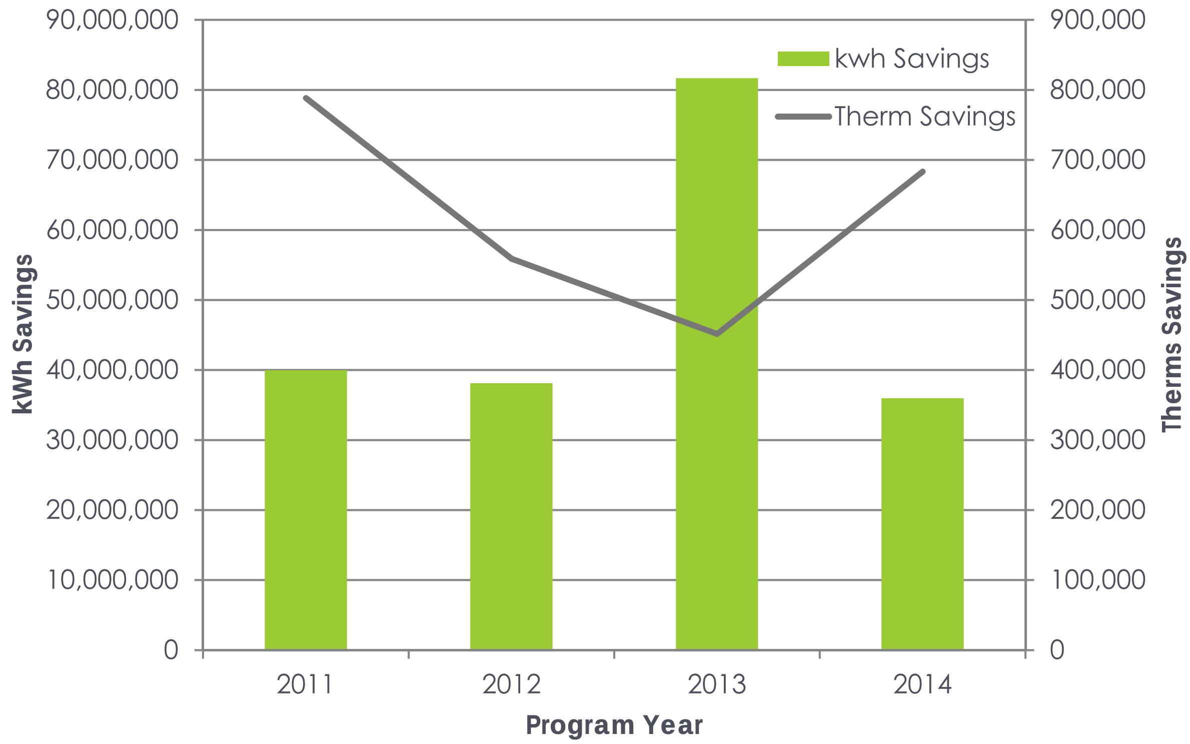

Figure 3 | New Buildings Program Performance Summary

The significant increase in electric savings for the 2013 program year was due to four large projects, and one very large project. These five projects accounted for 48,165,205 kWh of electric savings and 139,306 therms of natural gas savings.

The New Buildings program provided incentives to a wide variety of building types in program year 2014. Grocery and data centers had the highest electric savings in 2014. College and university buildings had the highest levels of gas savings. A summary of the working savings claimed by building type can be seen in Table 4.

[4] The savings shown in Figure 3 are the claimed savings for the entire program year. This includes projects which may have been dropped from evaluations, or were evaluated through supplemental evaluation efforts.

Table 4 | Summary of 2014 Savings Claimed by Building Type[5]

Building Use Type	Projects	Electricity Savings (kWh)	Natural Gas Savings (therms)
Assisted Living Property	11	788,945	85,542
College/University	19	4,042,490	140,737
Data Center	7	6,247,770	-
Grocery	20	6,840,372	9,157
K-12 School	18	511,590	33,820
MultiFamily < 70,000 Ft2	39	1,661,726	56,568
MultiFamily 70,000+ Ft2	19	5,351,611	102,463
Office/Retail	59	2,876,840	14,507
Other	72	3,373,970	76,598
Restaurant/Lodging/Hotel/Motel	75	1,206,737	101,041
Warehousing and Storage	19	1,716,511	33,330
Total	**358**	**34,618,562**	**653,764**

The savings for the 2014 program year were also evenly split between custom and prescriptive (or standard) measures. The measure count is significantly higher for prescriptive measures, which is typical of new construction programs with a mix of custom and prescriptive measures. Market solutions measures were smaller in number and savings and were retained as their own separate category. A summary of the types of custom and prescriptive measures recognized through the program in 2014 can be seen in Table 5.

[5] The savings values presented do not include a datacenter project which was dropped from the evaluation. This is discussed in section 2.1. This was done to provide consistency of stated numbers throughout the report.

Table 5 | Summary of 2014 Savings Claimed by Measure Type

Measure Type	Count of Measures	Electric Savings (kWh)	Natural Gas Savings (therms)
Standard Clothes Washer	41	349,011	5,420
Standard Controls	12	64,055	2,305
Standard Food Service	165	537,864	63,910
Standard HVAC	152	2,371,278	124,799
Standard Lighting	273	10,075,841	-
Standard Motors	18	1,722,802	-
Standard Refrigeration	71	386,321	-
Standard Water Heating	284	2,428,295	151,664
Standard Sub-Total	**1,016**	**17,935,467**	**348,098**
Market Solutions	**25**	**2,043,140**	**61,911**
Custom Controls	4	770,991	42,240
Custom Gas	7	-	15,072
Custom HVAC	121	2,965,449	150,444
Custom Lighting	32	2,364,833	-
Custom Other	50	1,360,106	36,000
Custom Refrigeration	23	852,039	-
Data Center	12	6,247,770	-
LEED	2	78,767	-
Custom Sub-Total	**251**	**14,639,955**	**243,756**
Total	**1,292**	**34,618,562**	**653,764**

1.2 | Evaluation Goals

During the kick-off meeting and evaluation planning phases, Energy Trust and the Michaels team developed goals for the evaluation of the 2014 program. These goals formed the foundation on which we developed our sampling approach, data collection, and data analysis methodologies. The goals for the evaluation were:

1. Verify the electricity savings (kWh) at the 90/10 confidence and precision level
2. Verify the natural gas savings (therm) at the 90/10 confidence and precision level
3. Provide robust realization rates for each major building type
4. Report any important observations about New Buildings projects and make recommendations for specific changes that will help Energy Trust improve the accuracy and effectiveness of future program savings estimates and the results of future impact evaluations.

2. Evaluation Methodology

The Michaels team verified the gross savings claimed for the program using a combination of onsite data collection, project file reviews, and engineering analysis. The approach used for each project is shown in Figure 4.

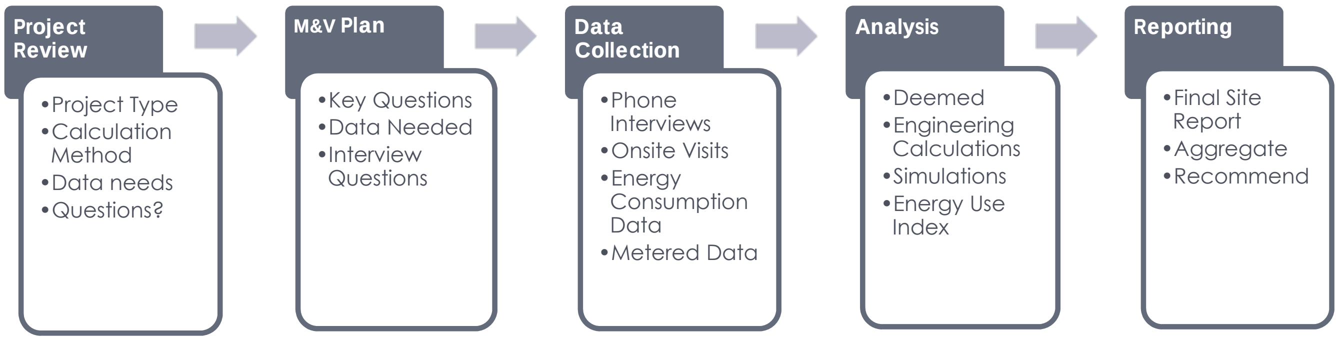

Figure 4 | Impact Evaluation Process

2.1 | Sampling

The first step in the evaluation process was to develop the sample. To determine which projects would be needed, the Michaels team utilized a statistically significant sample of projects. The sample for the 2014 program year was designed to achieve the primary goals outlined by Energy Trust, which are listed below:

- Verify the electricity savings (kWh) at the 90/10 confidence and precision level
- Verify the natural gas savings (therm) at the 90/10 confidence and precision level
- Provide robust realization rates for each major building type

The Michaels team received an extract of program participation data including all projects and measures that had been recognized in 2014. After completing the initial draft of the sampling plan and beginning work, one project, a large data center, was discovered to be only partially completed at the time of the evaluation. Additionally, this project was only one of three build phases at this facility. The Michaels team in conjunction with Energy Trust determined that this project would not represent a reasonable data point for the program. Therefore, this project was dropped from the sample and the population for the 2014 program year. Since this project was in a certainty stratum (large, significant project), it did not necessitate a replacement. This project will undergo evaluation once more phases of the project have been completed.

2.1.1 | Sample Design

The sample design was developed using measure level data provided by Energy Trust for projects completed as part of the New Buildings program during the 2014 program year. The team chose the project ID[6] as the sampling unit. Therefore, the team first aggregated the

[6] The variable "project id" from the tracking data was used to establish project level savings.

measure-level data to the project-level. A summary of the complete sample frame can be seen in Table 6. A detailed list of how the building types map to those in the population can be found in Appendix A.

Table 6 | 2014 New Buildings Sample Frame Summary

Building Use Type	Projects	*Ex Ante* kWh Savings	Share of Total kWh Savings	*Ex Ante* Therm Savings	Share of Total Therm Savings
Assisted Living Property	11	788,945	2%	85,542	13%
College/University	19	4,042,490	12%	140,737	22%
Data Center	7	6,247,770	18%	-	0%
Grocery	20	6,840,372	20%	9,157	1%
K-12 School	18	511,590	1%	33,820	5%
MultiFamily < 70,000 Ft2	39	1,661,726	5%	56,568	9%
MultiFamily 70,000+ Ft2	19	5,351,611	15%	102,463	16%
Office/Retail	59	2,876,840	8%	14,507	2%
Other	72	3,373,970	10%	76,598	12%
Restaurant/Lodging/Hotel/Motel	75	1,206,737	3%	101,041	15%
Warehousing and Storage	19	1,716,511	5%	33,330	5%
Total	**358**	**34,618,562**	**100%**	**653,764**	**100%**

Due to some projects having both gas and electric savings, projects had to be assigned to either the gas or electric strata. The team determined each project's primary fuel type[7] by converting all electric (kWh) and natural gas (therm) savings for each project to a common unit of millions of BTUs (MMBTU)[8], and then the fuel contributing the most site BTU savings was the primary fuel. If the majority of savings in MMBTU came from electric measures, the project was included in the electric project sample. Similarly, projects were included in the natural gas sample if over 50% of savings were natural gas. Over 66% of total program energy savings in MMBTU came from electric measures, and 34% came from gas measures, as shown in Table 7 below.

[7] The primary fuel type is the fuel that results in the greatest energy savings for the project.
[8] MMBTUs were determined using a conversion factor of 100,000 BTU/therm and 3,412 BTU/kWh.

Table 7 | 2014 New Buildings Energy Savings Summary

Building Use Type	Electricity Savings (MMBTU)	Gas Savings (MMBTU)	Total Savings (MMBTU)	Electricity Savings as Share of Total Savings (%)	Gas Savings as Share of Total Savings (%)	Share of Total Savings (%)
Assisted Living Property	2,692	8,554	11,246	1%	5%	6%
College/University	13,793	14,074	27,867	8%	8%	15%
Data Center	21,317	-	21,317	12%	0%	12%
Grocery	23,339	916	24,255	13%	0%	13%
K-12 School	1,746	3,382	5,128	1%	2%	3%
MultiFamily < 70,000 Ft2	5,670	5,657	11,327	3%	3%	6%
MultiFamily 70,000+ Ft2	18,260	10,246	28,506	10%	6%	16%
Office/Retail	9,816	1,451	11,266	5%	1%	6%
Other	11,512	7,660	19,172	6%	4%	10%
Restaurant/Lodging/Hotel/Motel	4,117	10,104	14,222	2%	6%	8%
Warehousing and Storage	5,857	3,333	9,190	3%	2%	5%
Total	**118,119**	**65,376**	**183,495**	**64%**	**36%**	**100%**

Given the goals of this evaluation, the Michaels team combined building use types of a similar nature into a single building use type[9]. For example, “Multifamily Property” contains both “Affordable Multifamily Property” and “Market Rate Multifamily Property”. For all building use types that were very few in number (i.e. less than 10 sites), our team created “Other” building use type strata.

Next, within each building use type, the Michaels team stratified the sample using the Dalenius-Hodges method[10], creating one or two probability-based strata. Within each building use type, the team assigned two strata, “Prob. Large” and “Prob. Small”. Projects with the largest energy savings that summed up to 50% of total building use type energy savings were allocated to the “Prob. Large” strata. The remainder was assigned to the “Prob. Small” strata. Projects within the probability strata were chosen at random. Each probability site was assigned a random number and was chosen in ascending order (smallest to largest). If a project contributed more than 10% of total energy savings for a building-use type, it was marked as a certainty or census site and allocated to a “Certainty” stratum.[11]

We computed the sample size needed to achieve a given level of confidence and precision using the following formulas:

$$n_0 = \left(\frac{z * CV}{e_{rel}}\right)^2 \qquad n = \frac{n_0 * N}{n_0 + (N-1)}$$

Where:

n_0	=	Sample size without considering finite population correction
n	=	Sample size with finite population correction
z	=	z-value for the corresponding level of confidence (90%)
e_{rel}	=	Relative precision (e.g. 10%)
CV	=	Coefficient of variation

[9] More specifically, these variables are labeled “market” and “bu1_deprecated”.
[10] For more information on the Dalenius-Hodges method, see Section 5A.7 of *Sampling Techniques, 3rd Edition*, by William G. Cochran.
[11] All of the sites which were larger than 10% of the savings for the stratum were chosen as census projects.

N = Population size

Since a number of sites were sampled with certainty, thereby reducing the CV and number of eligible sample projects and savings, the team modified the sampling formula as follows:

$$n = \left[\left(\frac{z * CV}{e_{rel}} \right)^2 \Bigg/ \left(1 + \frac{\frac{z * CV}{e_{rel}}}{Projects_p} \right) \right] * (1 - Sav_p)$$

Where:

- n = Sample size
- z = z-value for the corresponding level of confidence (90%)
- e_{rel} = Relative precision (e.g. 10%)
- CV = Coefficient of variation
- $Projects_p$ = Number of probability projects
- Sav_p = Proportion of savings attributable to certainty projects

A similar calculation was conducted for each building use type strata with a relative precision value equal to 20%. Each of the noted sample sizes were determined to achieve 90/20 precision for each building-use type and 90/10 for each fuel type. The resulting sample included 99 total projects, 45 of which were certainty sites, while the remaining 54 were probability sites.

2.1.2 | Sample Summary

Table 8 shows a summary of the final sample compared to the 2014 population. The sample design used by the team represents a large share of electricity and natural gas savings while examining less than 30% of the total number of projects. This is mostly due to there being a substantial number of projects within the sample that have both gas and electric savings. Michaels completed onsite verification at 71 of the 99 sampled projects, with the remaining 28 receiving desk reviews and phone interviews if needed.

Table 8 | Summary of Final Sample

Group	Projects	Measures	Electricity Savings (kWh)	Gas Savings (therms)
Program Total	358	1,292	34,618,562	653,764
Sample Total	99	493	22,332,783	454,818
Sample Share of Total	28%	38%	65%	70%

The sample also provided excellent coverage across the building use type categories used during this evaluation. Table 9 shows the number of sample projects, as well as the *ex ante* electricity (kWh) and natural gas (therms) savings for each building use type.

Table 9 | Sample Summary by Building Use Type

Building Use Type	Projects	*Ex Ante* kWh Savings	Sample Share of kWh Savings	*Ex Ante* Therm Savings	Sample Share of therms Savings
Assisted Living Property	9	699,168	89%	84,170	98%
College/University	9	3,272,930	81%	138,241	98%
Data Center	4	5,948,447	95%	-	N/A
Grocery	5	2,954,640	43%	-	0%
K-12 School	10	434,405	85%	32,218	95%
MultiFamily < 70,000 Ft2	10	790,643	48%	15,779	28%
MultiFamily 70,000+ Ft2	8	2,969,413	55%	53,364	52%
Office/Retail	11	1,498,573	52%	10,998	76%
Other	12	1,726,823	51%	46,522	61%
Restaurant/Lodging/Hotel/Motel	10	721,316	60%	40,804	40%
Warehouse and Storage	11	1,316,425	77%	32,722	98%
Total	**99**	**22,332,783**	**65%**	**454,818**	**70%**

In total, 66% of the energy savings (in MMBTU) were evaluated, representing 65% of the electric (kWh) savings and 70% of the natural gas (therms) savings. Only four of the eleven building categories had less than half of their total energy savings included in the sample. Conversely, the sample covered more than 90% savings for each of four building types: assisted living property, college/university, data center, and K-12 school. Figure 5 shows the relative savings of the sample compared to the population for each of the building use types. Similarly, Figure 6 shows the relative savings at the measure level. A detailed breakdown of measure type mapping can be found in Appendix A.

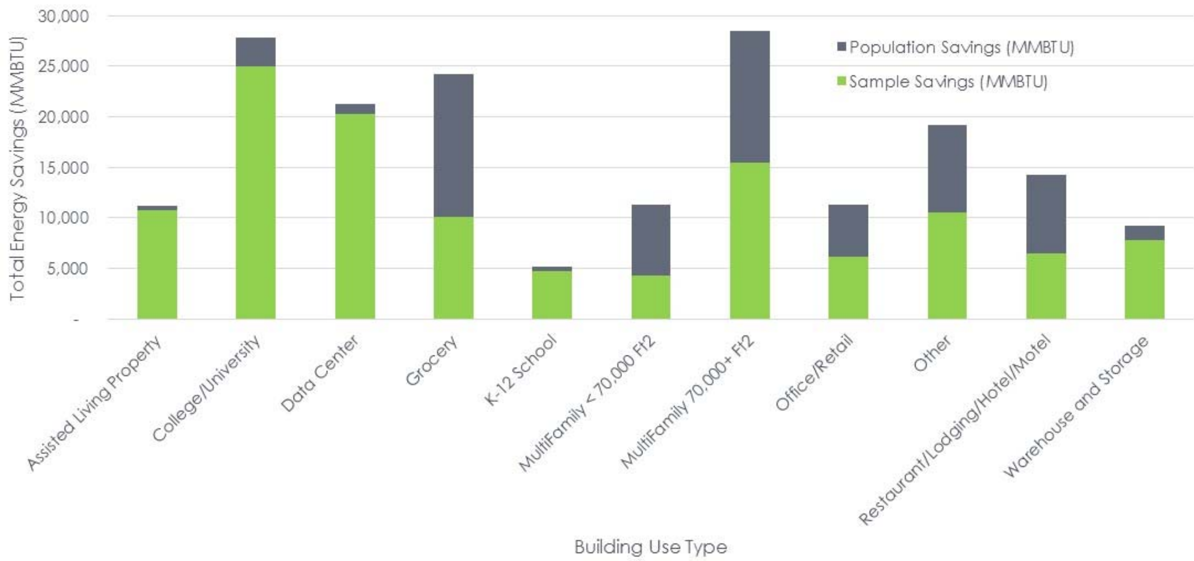

Figure 5 | Sample Savings Overlapping Population Savings by Building Use Type

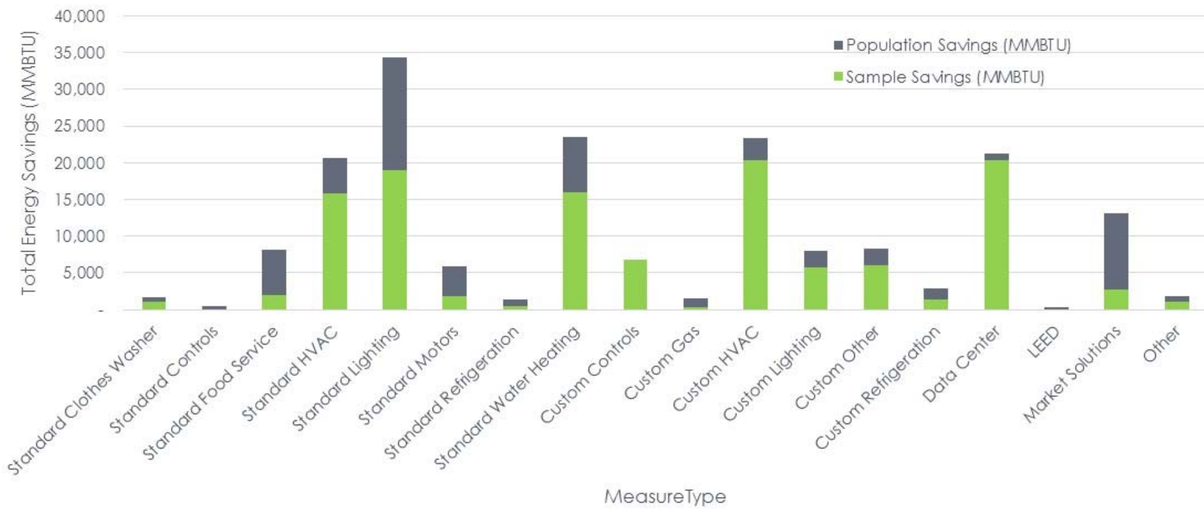

Figure 6 | Sample Savings Overlapping Population Savings by Measure Type

2.2 | Data Collection

After the sampled projects were reviewed and approved by Energy Trust, the Michaels team requested project files to begin data collection. The Michaels team also requested energy usage data for all of the projects to support the gross savings calculations, as well as the program and project level benchmarking. The data received from Energy Trust usually included the following key items:

- **Documentation File:** This was a single PDF that included key pieces of documentation including all the applications, savings summaries, and important eligibility information or discussions. It also contained specifications for all of the installed equipment, images of relevant building plans or schematics, and PDFs of spreadsheet calculations when applicable.
- **Verification Site Visit Summary:** This was another PDF file that contained the program's verification results. This would also specify the measures claimed, occasionally include specifications for pertinent equipment, and verify that equipment was installed.
- **Communications:** A list of relevant emails between the customer, Outreach Manager, Builder, and technical review team.
- **Final Technical Files:** The spreadsheet calculations, deemed savings workbooks, and final modeling files used to determine the savings.
- **Site Visit Photos:** Photos from the program's verification of installed equipment and nameplates.
- Other supporting information as needed.

Michaels also received documentation which provided background and technical support for certain types of measures or for the New Buildings Program as a whole. These documents included:

- 2012 New Buildings Evaluation Report

- Measure Approval Documents (MADs) for the standard and market solutions measures
- Monthly and quarterly program summary reports
- New Buildings Program Technical Guidelines
- 2014 program tracking data
- Model Calibration Summary Info
- New Buildings Project File Structure details

2.2.1 | Review Project Files

Michaels obtained background documentation and calculation files for all of the projects in the sample. Michaels reviewed the background information to develop a more detailed understanding of each project, the important components, equipment and its specifications, and any relevant site specific details.

Deemed, calculated, and Market Solutions measures were reviewed to ensure the quantities and types of equipment claimed were consistent with the project documentation. Additionally, equipment specifications were reviewed to verify the claimed and installed equipment was program qualifying. Calculated savings measures, such as lighting, also had the input assumptions used in the prescribed calculation, such as lighting hours of use, verified against emails, site visit notes, and other program documentation.

Custom engineering and building simulation measures and projects were also reviewed but in greater detail. The savings calculations were reviewed for appropriate baselines and engineering accuracy. Building simulations were run to validate that modeled savings match claimed savings for the project. The background details of the building simulations such as system type, operating schedules, equipment interactions, ventilation rates, lighting schedules, and control settings were also verified. The key parameters from any custom engineering calculation or building simulation were noted and recorded for further investigation during the site visit.

2.2.2 | Develop Site-specific Measurement and Verification Plans

Once the project file had been reviewed, the next step was to develop a site-specific measurement and verification plan (SSMVP) for each site in the sample. These plans were developed with project complexity, savings magnitude, and access to critical parameter measurement in mind. Critical parameters included a combination of those which have a significant impact on the savings and/or have a high level of uncertainty.

The SSMVP details the proposed analysis methodology, as well as the data required to complete that analysis. The team shared the SSMVPs for the 45 certainty sites included in the evaluation sample with Energy Trust and the PMC for review and comment. Any suggested revisions were made to these SSMVPs, as well as the other 54 SSMVPs for the probability sites prior to completing any site work as part of the evaluation. Through drafting the SSMVPs, Michaels was able to determine that 71 sites required a site visit, while the remaining 28 could be evaluated using a desk review and phone interview. The approved SSMVPs are included as part of the site reports found in CONFIDENTIAL Appendix C.

2.2.3 | Complete Onsite Data Collection

Once SSMVPs were completed, Michaels recruited customers for site visits. Michaels was able to successfully recruit and complete site visits for 71 of the 99 projects in the sample. During the site visits, the customer was interviewed in detail regarding the operation of the building systems, setpoints, equipment, and the facilities. Photographs or screenshots of pertinent equipment were taken (when permitted by the customer), and controls settings, schedules, and other operational details were recorded as found during the site visit.

The customers were also interviewed to determine if any significant changes at the facility had happened which would have affected their energy consumption, as well as if any significant changes were going to happen in the near future. This information was used during the calibration process for projects where the savings were calculated using building simulations. Similarly, facility information was used to refine or explain significant differences in operation of custom measure savings (i.e. lighting hours of use, HVAC schedules, etc.).

Many of the customers were able to provide trend data for the systems relevant to each project. Trend data capabilities ranged from one month to one year, depending on the control system, parameter of interest, and customer ability to access the data. In all cases, Michaels obtained the maximum amount of information that was readily available and obtainable by the customer.

Finally, Michaels requested energy usage data for each of the 99 projects in the sample. Energy Trust was able to provide monthly energy (kWh) and natural gas (therms) usage back to 2014 for all customers, and as far back as 2011 for some.

2.2.4 | Desk Reviews

A total of 28 sites were designated as low uncertainty, low impact projects and received desk reviews. These projects included only one or two (typically prescriptive) measures and were in the probability strata. There were two exceptions to this during the 2014 evaluation. One was a certainty site in the large multi-family building strata where the customer was in the process of selling the property and refused the site visit. Michaels made numerous attempts to establish further communication with the customer to obtain permission to work with the new building owner, but was unable to reach the necessary parties.

The second certainty project to receive a desk review was in the warehousing and storage stratum. The customer initially refused the site visit. Michaels engaged the New Buildings Outreach Managers to further explain the evaluation process to this customer and answer any questions. Neither Michaels nor the Outreach Manager were able to reach the customer further.

During the desk reviews, equipment specifications were compared to program qualifications to ensure that all equipment met program requirements. Similarly, the equipment sizes and efficiency levels were verified to have been properly applied to the deemed savings calculations. A total of 18 sites for which a desk review was completed also had a telephone interview completed with the customer. During this interview, the customer was asked to confirm the installation and operation of key pieces of equipment, and discuss the detailed operation of particular systems, such as lighting or HVAC controls. The remaining ten customers could not be reached.

2.3 | Data Analysis

Michaels used the trend data and operational information obtained during the site visits or phone interviews to update the savings calculations for each project. The *ex post* savings were calculated using the same or very similar methodology and calculation tools as the *ex ante* analysis provided with the project files. This process avoids introducing errors into the results simply by changing the analysis approach. The Michaels team reviewed and verified all calculation templates to ensure they were reasonable and consistent with sound engineering fundamentals. None of the calculation templates used during the 2014 year had flaws in this regard.

2.3.1 | Deemed Savings

There were a significant number of prescriptive measures with deemed savings that were used to establish the *ex ante* savings for the program. These types of measures included standard screw-in lighting, appliances, commercial food service equipment, and some HVAC equipment. Energy Trust completed a rigorous review and vetting of all deemed savings measures that are included in the New Buildings program. Many of Energy Trust's measures are based on RTF measures. All Energy Trust measures are reviewed by an internal team of planning engineers. For some measures, where additional data or analysis are required, a third party may be hired to do data collection, analysis, or provide a review of the savings methodology. Since there has been considerable review of prescriptive savings previously, the Michaels team did not duplicate that work during this evaluation. Instead, for prescriptive measures, field engineers verified the measure quantity installed, that measures were still operational, and that the equipment met the program qualifications. The savings for these measures were revised as appropriate by applying the correct quantity of measures, the size of equipment, or efficiency.

2.3.2 | Calculated Savings

Calculated measures use standardized calculation spreadsheets. These spreadsheets have inputs that include the facility type, equipment size, measure type, and in some cases operating hours. Michaels used these same calculation templates to determine the *ex post* savings estimates for calculated measures.

The inputs used in the calculations were verified through the documentation review and site visits. The parameters used in the calculations were either pre-defined or could be specifically inputted to match a particular customer. For example, the savings for lighting occupancy sensors were fixed at 25% for each site indicated to have controls. Lighting hours of use, however, could either use predetermined schedules, or the daily schedule could be custom input for that customer.

Michaels determined the *ex post* savings using the same calculation spreadsheet for calculated measures. The inputs used in the spreadsheet were verified to be consistent with information gathered during the evaluation. Any parameters which were found to be different from actual customer operations were adjusted in the ex post calculation. Parameters which were deemed, such as the occupancy sensor control savings percentage, were treated like deemed savings values. However, if any of the inputs were adjusted from the prescribed values, or were custom in nature, Michaels verified and adjusted them as needed to match the specific customer conditions.

2.3.3 | Building Simulations

Building simulations were updated to reflect operational and controls information obtained during the site visits. In all cases, the existing modeling files were used for these analyses. This removed any differences that could occur from creating and developing different building simulations from scratch.

Each of the building simulations was analyzed using actual historical weather information and the customer's previous 12 months of electric and natural gas energy usage data to ensure it was properly calibrated. All of the detailed operating information, controls setpoints, and equipment sequencing information collected during the site visits were used to fine tune the operation of the final as-built, *ex post* models. The *ex post* savings were determined using TMY3 (typical meteorological year) weather data to ensure the final *ex post* savings were representative of a typical year of operation.

2.3.4 | Custom Engineering Calculations

Similar to the building models, the original calculation files or calculation methodologies were used whenever possible to determine the *ex post* savings. Equipment operational profiles and efficiencies were updated based on the customer supplied information and trend data. All weather sensitive measures were normalized to TMY3 weather data by developing correlations of the actual operation to actual weather conditions (i.e. chiller kW as a function of average outdoor air temperature). These correlations were used in conjunction with TMY3 weather data to predict normalized *ex post* savings estimates.

2.3.5 | Realization Rates

The data collected during the site visits and the calculation methods described previously were used to determine a realization rate for each measure. The realization rate was defined as the *ex post* savings determined by the Michaels Team, divided by the *ex ante* savings from the Energy Trust tracking data. This formula was used for both fuels to determine the electricity and natural gas (if applicable) realization rates for each measure.

$$RR = \frac{Ex\ Post\ Savings}{Ex\ Ante\ Savings}$$

The measure level realization rates were recorded and used to develop the realization rates for the different measure types. The measure *ex ante* and *ex post* savings were also used to determine the realization rate at the project level. The project level realization rate was calculated by taking the sum of the *ex post* savings for each measure in the project and dividing by the sum of the *ex ante* savings for each measure.

$$RR_{Project} = \frac{\sum_{1}^{i} Measure\ Ex\ Post\ Savings_i}{\sum_{1}^{i} Measure\ Ex\ Ante\ Savings_i}$$

Where,

$RR_{Project}$ = Realization Rate for the project

i = Number of measures for a given project

Project level realization rates were also recorded and were used to aggregate all of the evaluated results up to the individual building type results, as well as to the overall realization rates for both electric energy (kWh) savings and natural gas (therms) savings for the 2014 program year.

2.3.6 | Develop Final Site Reports

The final step was to develop final site reports (FSRs) for each project evaluated. These FSRs provide a majority of the detailed technical information and methodologies used to evaluate the sampled projects. Each FSR contains the following sections:

1. Summary of *Ex Ante* Calculations – a summary of how the *ex ante* savings for each measure were determined, along with any key variables and assumptions.
2. Measurement and Verification Plan – the methodology proposed to be completed during the site visit.
3. Description of the Verification – the actual activities completed during the site visit, and a description of any key parameters obtained during the site visit.
4. *Ex Post* Calculation Description – a description of the calculation methodology and findings based on the data collection activities.

A full compendium of the FSRs for this evaluation have been completed and are found in CONFIDENTIAL Appendix C.

2.3.7 | Energy Use Intensity

The energy use intensity (EUI) analysis examined both electricity and gas usage, normalized by square feet of building area, in order to examine the efficacy of participant buildings.

To determine the energy use intensity of each building, the Michaels team requested usage histories for all 99 projects in the sample. Energy Trust was able to provide either electric or natural gas billed histories for 98 of the customers in the sample. The usage histories contained monthly billing data from as far back as possible through August of 2016. Depending on the customer, the earliest data of billing data was 2011, while 82 of the customers had billing data at least as far back as 2013.

Since most of the projects in the sample were finalized during 2014, the Michaels team did not use 2014 as the basis for the EUI analysis. Instead, to ensure that as many of the projects were operating under typical conditions as possible, the calendar year 2015 was used as the basis.

Individual projects were examined on a case by case basis if ramp-up periods at the facility extended into 2015. However, 12 months of data were used for each project included in the analysis. The natural gas and electric usage data from meters attached to each project were weather normalized and annualized using TMY3 weather data. The normalized annual gas and electric usage were then converted to kbtu and summed for each project. The reported square footage was checked against the project documentation and matched to the same spaces as the meter data. Annual kbtu usage was then divided by applicable square footage to calculate EUI.

Once EUI values were calculated for each of the available projects, each was cross-checked against typical values for that building type from the Commercial Building Energy Consumption Survey (CBECS) 2012 database[12]. Individual building EUI's that varied more than 20% from the appropriate building type in the west pacific region from CBECS were reviewed in further detail. During this review, the Michaels team removed an additional 14 projects from the EUI analysis. There were eight (8) buildings where Michaels did not have either electric or natural gas billing data since the customer's utility was not an ETO member utility. The remaining six (6) buildings were removed as outliers because the energy usage data was not consistent with the savings for the project or the building type in general. This was most likely due to missing specific meters that were not properly allocated to the building in the utility billing data.

The resulting sample of buildings included in the EUI analysis totaled 84 different buildings, from each of the 11 strata used in the sample design. The resulting energy intensities were analyzed two different ways. The first was to compare the results against previous program years as well as other regional and national EUI sources. This information provides a useful and high-level look at the performance of 2014 program buildings. The Michaels team examined the differences between program buildings and national or regional benchmark studies and provided insights into where and why differences were occurring.

The second and more detailed approach compared the energy intensities of the same building types within the impact evaluation sample. For example, the energy intensity analysis completed during the 2014 program year impact evaluation had the following ranges of energy intensities (kBtu/sf) by building type:

- School – 19.3 to 63.4
- Multifamily – 5.0 to 103.2
- Grocery – 72.0 to 127.4

Michaels leveraged the data that was collected during the onsite visits and project file reviews to provide further insights into why these variations may be happening. We compared the EUI from sample points within the same building type and determined if any trends in EUI could be determined based on several factors:

- Cooling Fuel
- Primary Cooling Source
- Primary Heating Source

[12] Commercial Building Energy Consumption Survey (CBECS) website. https://www.eia.gov/consumption/commercial/

- Secondary Heating Source
- Secondary Cooling
- Air Handling
- Ventilation
- Energy Recovery

Each of the factors had multiple choices that could be selected for each building. For example, the primary cooling source could be Air Cooled DX, Air Source Heat Pump, Water Cooled DX, Water Source Heat Pump, Air Source VRF, Water Source VRF, Air Cooled Chiller, Water Cooled Chiller, or Geo Heat Pump. A full list of the characteristics used in the EUI analysis can be found in Appendix B.

2.4 | Data Aggregation

One of the evaluation goals was to determine notable trends in the evaluation results at the measure type, building type, or overall program level. The Michaels Team aggregated and extrapolated the results to different levels of program data. Measure type results were used to determine if any particular measure or analysis types were significant drivers of the realization rates. Similarly, project level results were aggregated to the building type level, as well as weighted and extrapolated back to the entire program year participation data.

2.4.1 | Measure Level Aggregation

The savings for each measure were aggregated into similar measure types. There was a total of 125 different measure types in the 2014 program tracking data. The Michaels team rolled these individual measures into higher level categories of similar measures. A full map of how the measures were categorized can be found in Appendix A.

Results at the measure level were determined using a straight average. The sum of *ex post* savings for all measures in that category was divided by the sum *ex ante* savings. The end results were not weighted and extrapolated back up to the program population. Therefore, discussions about program savings by measure type, such as those in section 3.3, were unweighted savings or realization rates.

2.4.2 | Building Type Extrapolation

To estimate the building type-level realization rates, the Michaels team aggregated and weighted the individual project realization rates. We determined the realization rate for each stratum as the weighted average realization rate of projects within that stratum. The weights for each project were the *ex ante* savings of the project relative to the total sampled *ex ante* savings from that stratum.

As part of the sampling process, very large projects that the evaluation team wanted to ensure were included in the sample were selected into a “certainty stratum.” By definition, the evaluation team selected projects within each certainty stratum deterministically, rather than randomly like other projects in the probability strata. Because we selected these projects deterministically, we only applied the realization rates calculated for a “certainty” project to that project; we did not extrapolate the results to other projects within the evaluation population[13].

The total savings and the savings used to weight the certainty and probability strata within each building category are shown in Table 10 and Table 11 for electric and natural gas savings, respectively.

Table 10 | Electric Savings (kWh) Used for Weighting Building Type Results

Building Type	Certainty Electric Savings (kWh)	Probability Electric Savings (kWh)	Program Electric Savings (kWh)
Assisted Living Property	570,037	218,908	788,945
College/University	3,189,689	852,801	4,042,490
Data Center	5,494,668	753,102	6,247,770
Grocery	2,168,888	4,671,484	6,840,372
K-12 School	419,484	92,106	511,590
MultiFamily < 70,000 Ft2	536,538	1,125,188	1,661,726
MultiFamily 70,000+ Ft2	1,584,579	3,767,032	5,351,611
Office/Retail	1,142,751	1,734,089	2,876,840
Other	1,250,975	2,122,995	3,373,970
Restaurant/Lodging/Hotel/Motel	626,215	580,522	1,206,737
Warehousing and Storage	1,249,119	467,392	1,716,511
Total Program	**18,232,943**	**16,385,619**	**34,618,562**

[13] In other words, each building category realization rate is equal to the weighted average of the certainty strata realization rate and the weighted average realization rate for all randomly selected projects. For this calculation, the certainty strata is weighted by the percent of savings that the certainty projects contribute towards building type category savings and the average realization rate among randomly selected sites is weighted by the percent of building type savings contributed by all other sites in the population.

Table 11 | Natural Gas Savings (therms) Used for Weighting Building Type Results

Building Type	Certainty Gas Savings (therms)	Probability Gas Savings (therms)	Program Gas Savings (therms)
Assisted Living Property	70,360	15,183	85,542
College/University	128,579	12,158	140,737
Data Center	-	-	-
Grocery	-	9,157	9,157
K-12 School	32,058	1,762	33,820
MultiFamily < 70,000 Ft2	6,343	50,225	56,568
MultiFamily 70,000+ Ft2	42,706	59,757	102,463
Office/Retail	5,382	9,125	14,507
Other	27,879	48,719	76,598
Restaurant/Lodging/Hotel/Motel	27,068	73,973	101,041
Warehousing and Storage	29,526	3,804	33,330
Total Program	**369,900**	**283,864**	**653,764**

2.4.3 | Program Level Results

The final extrapolation step was to determine program-level realization rates for each fuel. We computed the program level results for each fuel as the weighted average realization rates across all building types for that fuel, again utilizing the total program savings by building type shown in Table 10 and Table 11.

Due to the complexity associated with the on-site sample frame and the wide-ranging variability in *ex ante* energy savings projects, typical parametric methods for computing standard errors and confidence intervals cannot be used. Instead, we developed approximate confidence intervals using the bias-corrected and accelerated (BCa) bootstrap method. The BCa method, developed by Efron[14] (1987), is an improvement over the standard percentile-based method for developing confidence intervals, which involves resampling from the empirical distribution of values and then selecting the alpha/2 and (1-alpha/2) values as the lower and upper values of the confidence interval. When the underlying data are skewed, percentile-based confidence intervals tend to be biased. The BCa bootstrap adjusts for both bias and skewness in the bootstrap distribution. The BCa approach is applicable in a wide variety of analyses, in particular for those analyses where the measure of interest is bounded at one or more specific values, such as the current analysis where realization rates are generally assumed to be bounded by zero.

In situations in which the empirical distribution of data is skewed, BCa confidence intervals have been shown to be asymptotically more accurate than standard percentile-based methods, while retaining the desirable property of robustness. We are therefore confident that the confidence intervals we developed using the BCa method are at least as good (if not superior) in performance to standard percentiles.

[14] Efron, B. (1987). Better bootstrap confidence intervals. Journal of the American Statistical Association, 82, 171-185.

3. Analysis and Results

Following the data collection and project level analysis, the Michaels team compiled the results to provide program level results. Additionally, Michaels completed several other detailed analyses to examine the results at the building type level and measure type level to determine if any trends were present.

3.1 | Program Realization Rates

Based on the sample of 99 projects, the Michaels team developed the following program level estimates of gross electricity (kWh) and natural gas (therms) savings for the 2014 program year. The resulting relative precision at the 90% confidence level exceeds the 90/10 precision target outlined in the sampling plan.

Table 12 | Program Level Results

Fuel	*Ex Ante*	*Ex Post*	Realization Rate	Relative Precision
Electricity (kWh)	34,618,562	33,185,354	96%	3%
Natural Gas (therms)	653,764	614,276	94%	4%

The electric and gas realization rates from the 2014 program year were very similar to the results from 2010 and were higher than both 2011 and 2012. A graph showing the comparison of the realization rates from 2014 to the previous five years can be seen in Figure 7. Note that Program Year 2013 results were not included in this comparison. The program did not receive a comprehensive evaluation in 2013 since previous evaluation results had been very consistent. However, five large 2013 projects, which accounted for more than half[15] of the electric savings and one-third of the gas savings for the entire program year, were evaluated separately. The remaining projects from program year 2013 were not evaluated.

[15] The five large 2013 projects mentioned totaled 48,165,205 kWh of electric savings, which was 59% of the entire 2013 program year electric savings, and 139,306 therms of gas savings, which was 31% of gas savings.

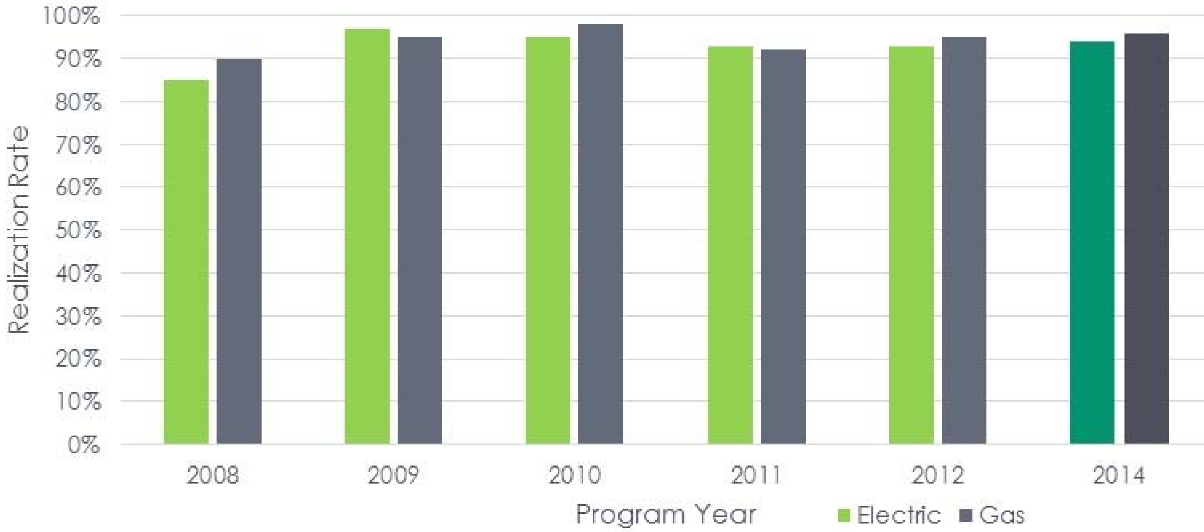

Figure 7 | Recent Historical Program Realization Rates

Overall, both of the gas and electric realization rates were near 100%. They are also consistent with the realization rates seen during the previous five evaluations of this program. Program performance as a whole appears to be good, and consistent over time. This can further be seen when looking at the frequency analysis of the realization rate for each project in the 2014 evaluation sample. Figure 8 shows the realization rate for each project in the sample grouped into realization rate bins. These bins are broken down to within 10% different, between 10% and 25% different, between 25% and 50% different, and more than 50% different.

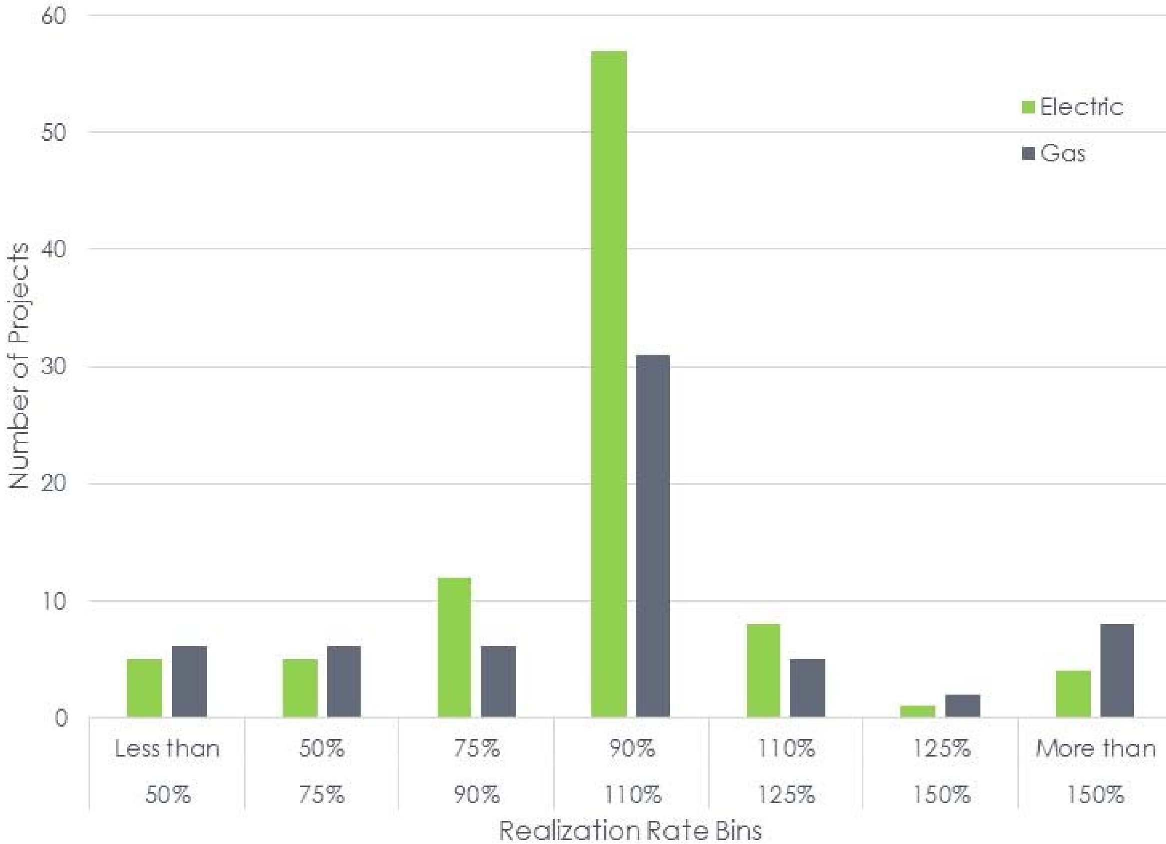

Figure 8 | Frequency Analysis of Project Realization Rates

The results from Figure 8 are consistent with the Michaels team's experience with other new construction programs that have a significant prescriptive component. The high realization rate of the program, as well as the clustering of projects near 100% realization rate for both fuels, shows that program staff are doing an excellent job estimating savings for a majority of projects. The program is accomplishing this through the verification site visits that are completed for each project to confirm the installation of prescriptive and custom measures, and the high rigor of the custom calculations. Similarly, the program is engaged with customers often, which provides detailed and up-to-date operational information that feeds custom calculations and building simulations.

This same type of pattern is visible when the results were examined by overall analysis type, either prescriptive or custom. Prescriptive measures included deemed measures, calculated measures, and market solutions measures. Custom measures included savings determined by custom engineering analyses as well as building simulations. Figure 9 and Figure 10 show the realization rate frequency for prescriptive measures and custom measures, respectively. These charts further demonstrate that the program is accurately estimating savings for a majority of individual measures, as well as entire projects.

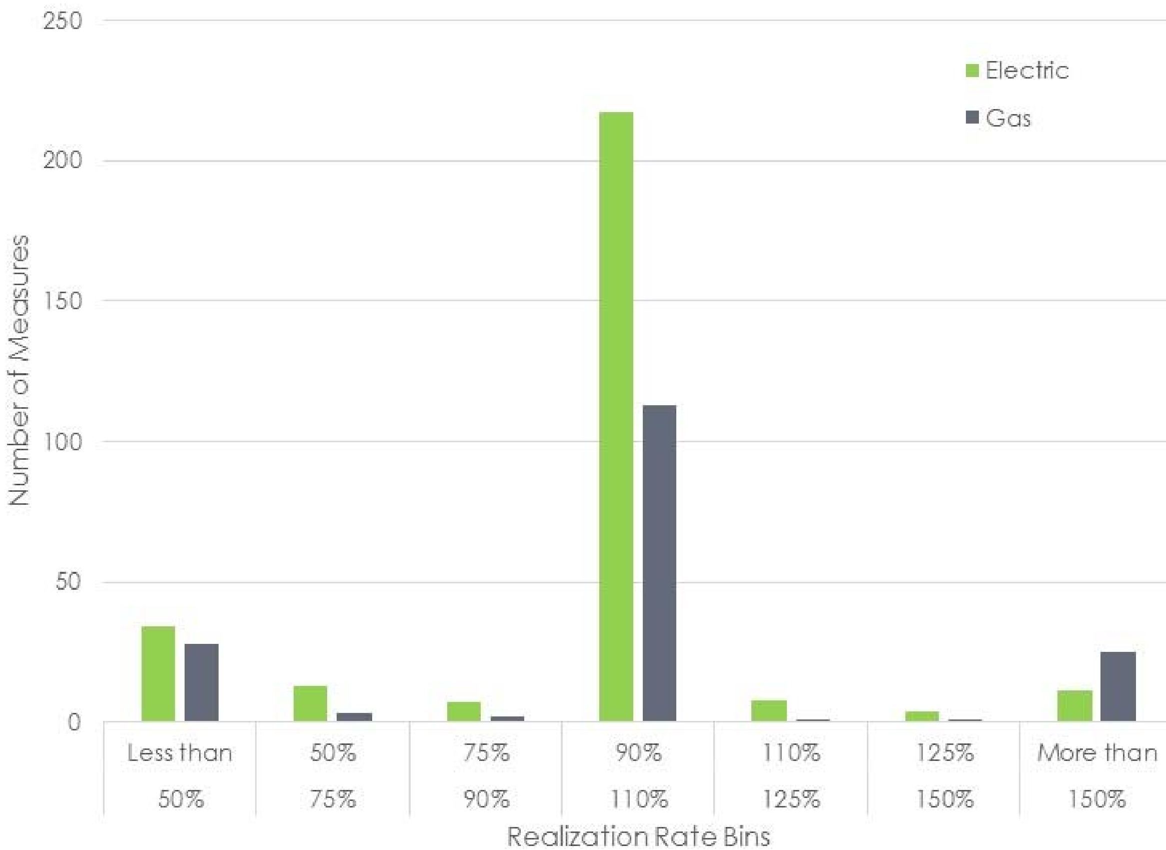

Figure 9 | Prescriptive Measure Realization Rate Frequency Analysis

There was a total of 374 prescriptive measures included in the sample. The unweighted[16] realization rate for standard electric measures was 99%. The unweighted realization rate for gas measures was similarly high at 94%.

[16] Unweighted means that it was not aggregated back to the whole population based on sample weights. It is just the simple total *ex post* savings divided by total *ex ante* savings.

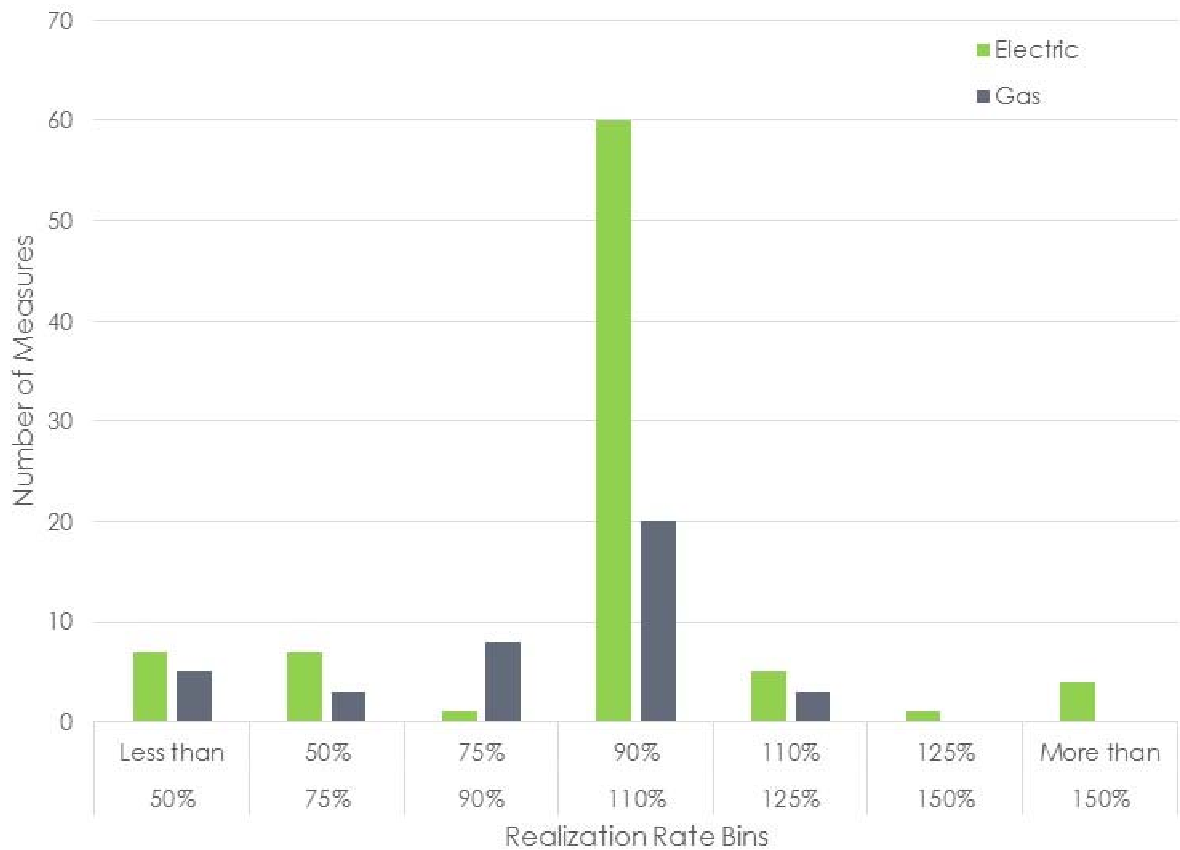

Figure 10 | Custom Measure Realization Rate Frequency Analysis

There was a total of 119 custom measures evaluated in the sample. The unweighted electric realization rate for custom measures was 91%, while the unweighted gas realization rate was lower at 84%.

3.2 | Results by Building Type

The Michaels team also calculated realization rates for each building type in the sample. A summary of the sample savings by building type is shown in Table 13.

Table 13 | Summary of Sample Savings by Building Type

Building Use Type	Projects	*Ex Ante* kWh Savings	Sample Share of kWh Savings	*Ex Ante* Therm Savings	Sample Share of therms Savings
Assisted Living Property	9	699,168	89%	84,170	98%
College/University	9	3,272,930	81%	138,241	98%
Data Center	4	5,948,447	95%	-	N/A
Grocery	5	2,954,640	43%	-	0%
K-12 School	10	434,405	85%	32,218	95%
MultiFamily < 70,000 Ft2	10	790,643	48%	15,779	28%
MultiFamily 70,000+ Ft2	8	2,969,413	55%	53,364	52%
Office/Retail	11	1,498,573	52%	10,998	76%
Other	12	1,726,823	51%	46,522	61%
Restaurant/Lodging/Hotel/Motel	10	721,316	60%	40,804	40%
Warehouse and Storage	11	1,316,425	77%	32,722	98%
Total	**99**	**22,332,783**	**65%**	**454,818**	**70%**

The stratification strategy the team employed provided robust results for each building type. The relative precisions for each building type ranged from 1% to 30%. However, six out of the eleven building type categories had relative precision of 10% or less for both gas and electric fuels. Four of the remaining building types had relative precisions for at least one fuel that met the sampling strategy target of 90/20 confidence and precision. Even though the precision target estimates from the sample design were not met in all cases, the overall program results exceeded the 90/10 precision goal for each fuel.

Table 14 | Realization Rates and Relative Precision (at the 90% Confidence Level) by Building Type

Building Type	Sampled Projects	Electric (kWh) Realization Rate	Natural Gas (therms) Realization Rate	Electric Relative Precision	Nautral Gas Relative Precision
Assisted Living Property	9	100%	104%	3%	10%
College/University	9	90%	84%	5%	7%
Data Center	4	89%	N/A	30%	N/A
Grocery	5	100%	N/A	3%	N/A
K-12 School	10	97%	103%	11%	1%
MultiFamily < 70,000 Ft2	10	91%	82%	6%	27%
MultiFamily 70,000+ Ft2	8	91%	104%	5%	24%
Office/Retail	11	110%	64%	8%	29%
Other	12	106%	94%	6%	5%
Restaurant/Lodging/Hotel/Motel	10	95%	107%	2%	4%
Warehouse and Storage	11	94%	79%	9%	10%
Total Program	**99**	**96%**	**94%**	**3%**	**4%**

The *ex ante* savings of the 99 sampled sites total 22,332,783 kWh and 454,818 therms of natural gas. Below, we describe reasons for major deviations between *ex ante* and *ex post* savings for five building types that had the largest impacts on the overall program realization rates:

college/university, data center, multifamily (both below and above 70,000 square feet), office/retail, and warehouse and storage.

3.2.1 | College/University

There were nine college/university projects included in the sample, totaling 3,272,930 kWh and 138,241 therms of savings. There was one project which constituted the majority of the adjustments made to college/university projects. Excluding that site, the average realization rate for the remaining eight college/university projects was 94% for electric and 117% for gas.

Key Project – NBC23

The majority of the adjustment to the college/university category came from one large project. This facility was a new building that included numerous classroom, office, and laboratory spaces. The customer received incentives for a wide variety of measures including a high efficiency central heating and cooling plant, laboratory air flow reset controls, low flow laboratory fume hoods, demand controlled ventilation, atrium air reclamation, interior lighting, and regenerative elevator systems. The *ex ante* electric savings for this project were 2,449,477 kWh, approximately 11% of the sample kWh. The *ex ante* natural gas savings were 85,644 therms, approximately 19% of the sample natural gas savings.

Based on the site visit, Michaels made several changes to the modeling files that contributed to reductions in the gas and electric savings for this project. The first was that in the baseline model it was found that the minimum flow ratio for a majority of the spaces throughout the facility had been set to 0.4 CFM/ft^2. This was inconsistent with the Energy Trust Technical Guidelines SEED Appendix L, section 4.3.3.11. Michaels adjusted the baseline to 0.2 CFM/ft^2, to be consistent with those guidelines, as well as the customer's actual operation determined during the site visit, in both the baseline and as-built model runs.

One important aspect of this project was that there were multiple versions of the Energy Trust Technical Guidelines which were available during the program's analysis of this project. Each of the versions has different baseline ventilation requirements in Appendix L, section 4.3.3.11. However, the Technical Guidelines did not provide a clear indication which version of the guidelines was the appropriate version to use. Michaels' interpretation was that the version dated October 1, 2010, was the appropriate version, which lists the 0.2 CFM/ft^2 ventilation requirement.

A second adjustment was modifying the lighting and classroom schedules based on the use of the rooms at the facility. During the site visit, Michaels recorded the operating schedules for each of the labs and classrooms, and used the average operating schedule for each type of room in the baseline and proposed models. The operating schedules observed at the site were lower than what was assumed in the original models, causing a reduction in both lighting and equipment operation, and therefore, the savings for these measures.

Finally, the elevator regenerative systems were not observed to be installed on any of the elevators in the building. This was also confirmed by the customer. The savings for the regenerative elevator systems was set to zero.

The aggregate adjustment for this project totaled a decrease of 227,692 kWh and a decrease of 20,721 therms. The *ex post* savings for this project were determined to be 2,221,785 kWh and 64,923 therms, resulting in realization rates of 91% and 76%, respectively.

3.2.2 | Data Center

There were four data center projects included in the sample, totaling 5,948,447 kWh of electricity savings, and there were no natural gas savings. The four data center projects had realization rates ranging from 0% to 210%. Three of the data center projects were adjusted based on the data collected. The largest data center project, NBC15, was verified to be completed as anticipated and had a 100% realization rate.

The key driver for the three data center projects where savings adjustments were made was the actual IT loading. This is true for the projects which had reduced savings and the one project with increased savings. The IT loading for data centers can significantly affect the uninterruptable power supply (UPS) efficiency since the equipment will operate at lower load conditions than anticipated. Lower IT loads also affect the cooling energy required, since internal gains in the data center are not as high.

The lower than expected loads at two of the data center sites could have been negated had the customer enabled the variable module management system (VMMS) or energy saving system (ESS) controls at their facility. These controls are part of the reason the UPS units are expected to operate at such high efficiencies. The benefit of VMMS controls is that they essentially operate like a server sequencer. The VMMS controller matches the current IT load to the minimum required number of UPS units. The process effectively ensures high loads on whichever UPS units are in use, while the remaining units can be run in bypass mode at near 100% efficiency.

The EES controls are similar, but the effect is localized to individual servers instead of systems of servers as with VMMS controls. The benefit of EES controls is that it allows a particular server to bypass double conversion operation, and operate near 99% efficiency. The downside is that this type of control must be engaged on each sever, and is often a manual "switch" on the server itself. This requires facility operators to physically enable or disable this setting. Customers have indicated, both as part of the New Buildings evaluation and other program evaluations the Michaels Team has completed, that they avoid operating the EES controls because they are concerned about the lack of protection outside of double conversion mode.

There were three of the four data center projects which had the savings adjusted during the 2014 New Buildings evaluation. Each of those three projects is described in additional detail below.

Key Project – NBC46

This data center project included savings for installing high efficiency UPS. The *ex ante* savings for this measure were 1,153,922 kWh, approximately 5% of the sample kWh savings. There were no claimed gas savings. During the site visit, it was found that all four of the UPS units installed were operated in parallel, and therefore at very low loading conditions. The customer had installed a UPS system with 100% redundancy, which meant the maximum load on each UPS system could only be 50% of maximum capacity. However, the IT load at the facility was lower than expected, causing each UPS to operate at around 30% of max capacity. The efficiency of UPS units decreases with decreasing utilization, which caused the operating efficiencies to be below that of the appropriate baseline[17].

This is likely because the customer was operating all of the UPS units in parallel instead of in variable module management system (VMMS) or energy saving system (ESS) controls, even though the units were equipped with ESS modes. The customer indicated that the loading of the UPS units is not expected to change significantly in the future. Since the units were operating below baseline, the *ex post* savings for this project were determined to be 0 kWh, resulting in a realization rate of 0%. The total downward adjustment of 1,153,922 kWh was approximately 5% of the sample kWh savings.

Key Project – NBC24

This data center project consisted of five different measures; a high-efficiency UPS system, ECPM motors, high efficiency lighting and controls, harmonic mitigating transformers, and high efficiency HVAC. The *ex ante* savings claimed for this project were 775,707 kWh, approximately 3% of the sample kWh savings. There were no gas savings claimed. During the site visit, the average IT load of each of the two UPS systems was found to be 131 kW. This is lower than the 180 kW for each system assumed in the *ex ante* analysis.

The lower IT load of the facility also had an impact on the anticipated cooling savings for the high efficiency HVAC system. The IT load used to determine the cooling savings was lowered from 360 kW to 263 kW. Reducing the IT load reduced the total cooling needed at the facility nearly proportionally.

The three other measures at the facility were found to operate consistent with the *ex ante* analysis. The aggregate adjustment for this project was a decrease of 204,968 kWh, approximately 1% of the sample kWh savings. The *ex post* savings were determined to be 570,739 kWh, resulting in a realization rate of 74%.

Key Project – NBP4

This data center received incentives for installing a high efficiency cooling system. The *ex ante* savings claimed for this project were 453,779 kWh, approximately 2% of the sample kWh savings. There were no gas savings claimed. The *ex ante* savings for this project were determined using a building model in eQuest. During the site visit, it was found that the IT load was significantly greater than what was specified in the building model (1,492 kW rather than 660 kW). Increasing the internal loads of the facility in the building model caused the cooling savings to increase nearly proportionately.

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[17] The baseline used in the *ex ante* analysis was the efficiencies from the California Public Utility Commission's *Energy Efficiency Baselines for Data Centers, Revision 1.* This is an appropriate baseline for this technology.

The aggregate adjustment to this project was an increase of 497,700 kWh, approximately 2% of the sample kWh savings. The *ex post* savings for this project were determined to be 951,479 kWh, a realization rate of 210%.

3.2.3 | Multifamily (both below and above 70,000 square feet)

There were 18 multifamily projects included in the sample, totaling 3,760,056 kWh and 69,142 therms of savings. The results of both multifamily strata were found to be dependent on the same factors, so both strata are included in this section. Across all multifamily buildings in the evaluation sample, there were two main reasons for adjustments. The first was that the quantities of installed low flow water devices were inconsistent with the claimed quantities from the project documentation. The second was that customers had removed low flow devices after building completion due to tenant complaints.

There were four projects for which the quantities verified during the site visit were not consistent with the claimed quantity of low flow devices. Two projects had adjustments based on the actual number of apartments and bathrooms in the building. In both cases, it appears the number of bathrooms and sinks or showers was confused within the project documentation. The third project was a documentation error where the savings were claimed for a 109 unit apartment when the facility was actually a 26 unit apartment, and the documentation includes photos of the unit count of the building. The fourth documentation error was for a project where the low flow devices were claimed as electric measures, even though the water heater at the facility was natural gas. The combined realization rate for these four projects was 58% for electricity and 90% for gas. The aggregate adjustment for these four projects was a decrease of less than 0.5% of the sample savings for both kWh and therms.

There were four projects where the customer had removed the low flow devices after they were installed. In each case, the customer contact indicated during the site visit that they had done so for tenant satisfaction reasons. The aggregate adjustment to the savings was a decrease of 109,612 kWh and 12,461 therms, less than 1% of the kWh and approximately 3% of the therms sample savings.

3.2.4 | Office/Retail

There were 11 office/retail projects included in the sample, totaling 1,498,573 kWh and 10,998 therms of savings. Electric savings were higher than expected because of two projects, while the gas savings were lower because of one project.

The increase in the electrical (kWh) savings was due to adjustments to lighting and HVAC equipment operating hours for two projects. During the site visit, the exterior lighting for one project was verified to operate from dusk until dawn. The *ex ante* savings assumed that some of the exterior lighting would operate dusk to dawn, but that the lighting near the entrance of the building would turn off at around midnight each day (approximately 6 hours of run time). The second project had tenants occupying two floors of the building which required the lighting to run 24/7. This was a significant increase over the 10 hours per day assumed in the *ex ante* analysis. The increase in occupied hours for this building also increased the savings for half of the heat recovery ventilators installed at the facility. The kWh realization rates for these two projects were 116% and 233%, respectively. The total increase in kWh savings was 103,275 kWh, approximately 0.5% of the sample kWh savings.

The reduction in gas realization rate for the office/retail building type was a result of one project. This customer installed a high efficiency condensing boiler, and the *ex ante* savings were determined using the standard measure methodology. However, during the site visit, the boiler was found to supply supplemental heating for a water loop heat pump system. The customer stated that the condensing boiler is rarely used, and will occasionally turn on when the outdoor air temperature remains below 20°F. Since the savings for the prescriptive measure are calculated assuming the boiler is the primary source of heat, the reduced operation significantly affected the savings. The aggregate adjustment for this project was a decrease of 4,454 therms, approximately 1% of the sample therms savings.

3.2.5 | Warehouse and Storage

The warehouse and storage building type included 11 sampled projects, totaling 1,316,425 kWh and 32,722 therms of savings.

The slightly lower 94% kWh realization rate is due to four projects where the lighting hours of use were adjusted to match the data collected during the site visits. In three of the four cases, the warehouse or storage area of the facility was found to operate consistently with the *ex ante* assumptions. However, each of these buildings had office space which did not operate on the same schedule. Taking the office space schedule into account resulted in decreases to the annual kWh savings. Two cases were especially significant, as the office was found to operate less than 4,000 hours per year, while the *ex ante* assumed it would operate 8760 hours per year similar to the warehouse space.

The decreases in operating hours were nearly entirely offset by one occupancy sensor project. The *ex ante* calculation assumed that the occupancy sensors would save 50% run time hours at the facility. The metered data collected during the site visit showed the average operating hours were 1,433 hours per year, a reduction of 84%. The aggregate savings adjustment for lighting hours of use was a decrease of 33,379 kWh, approximately 0.1% of the sample kWh savings.

The reduced gas realization rate for the warehouse and storage building type is driven by one larger project where the customer built an addition and installed infrared heaters. The savings for this project were reduced as a result of the infrared heater measure calculations being updated based on the operational setpoints obtained during the site visit, as well as some of the building characteristics which were inappropriately modeled within the *ex ante* calculation. The *ex ante* and *ex post* savings were determined using the Energy Trust calculation template for infrared heaters. The *ex ante* savings for the infrared heaters were determined using inputs into the calculation which had lower insulation levels than required by code, different space temperature setpoints than the customer was actually using, and more windows than were actually installed. The appropriate baseline for this measure would have been code compliant insulation levels, proper heating temperature setpoints, and the actual window area installed. The Michaels team made these changes to the baseline model, which reduced the savings. The gas realization rate for this project was 69%. The adjustment was a decrease of 3,775 therms, approximately 1% of the sample therms savings.

3.3 | Results by Measure Type

The Michaels team also estimated realization rates for different measure types. These categories were developed based on the measure classifications in the Energy Trust tracking data, as well as what has been used during previous evaluations. More detail can be found in Appendix A.

Market Solutions packages are pre-determined packages of measures applied to specific building types. The sampling plan the Michaels team employed did not focus specifically on measure types and emphasized larger projects to ensure precision and confidence targets were met for each fuel. This meant very few Market Solutions projects were selected into the sample as there was not a large number in the program, and the projects tended to be small. In total, four different Market Solutions projects, from three different building types were sampled. Due to the low sample sizes for each type, it was not possible to make significant conclusions about this measure type.

3.3.1 | Electric Measures

Table 15 shows the unweighted electric realization rates for the different measure types included in the evaluation.

Table 15 | Unweighted Electric Realization Rates by Measure Type

Measure Type	Measure Count in Sample	*Ex Ante* Electric (kWh)	*Ex Post* Electric (kWh)	Electric Realization Rate
Standard Clothes Washer	20	238,231	200,352	84%
Standard Controls	-	-	-	N/A
Standard Food Service	33	169,517	176,103	104%
Standard HVAC	42	1,383,636	1,374,924	99%
Standard Lighting	79	5,586,108	5,632,080	101%
Standard Motors	5	523,318	535,900	102%
Standard Refrigeration	26	141,664	151,036	107%
Standard Water Heating	83	1,726,845	1,572,905	91%
Standard Sub-Total	**288**	**9,769,319**	**9,643,300**	**99%**
Market Solutions	**7**	**622,771**	**622,016**	**100%**
Custom Controls	1	758,947	714,915	94%
Custom Gas	-	-	-	N/A
Custom HVAC	41	2,250,478	2,240,054	100%
Custom Lighting	11	1,703,230	1,617,024	95%
Custom Other	16	854,852	695,392	81%
Custom Refrigeration	8	424,739	419,477	99%
Data Center	7	5,948,447	5,087,513	86%
LEED	-	-	-	N/A
Custom Sub-Total	**84**	**11,940,693**	**10,774,375**	**90%**
Total	**379**	**22,332,783**	**21,039,691**	**94%**

Below, we provide additional information about the electric realization rates for specific measure categories which deviated by more than 5%. There was a total of six different measure categories which had realization rates that differed by more than 5%: Standard Clothes Washers, Standard Refrigeration, Standard Water Heating, Custom Controls, Custom Other, and Data Center.

The remaining categories all had individual measure or projects which were adjusted, but there were no significant adjustments that drove the overall program results.

3.3.1.1 | Standard Clothes Washers

The clothes washer measure category was adjusted mostly due to the installed equipment not meeting program requirements in two projects. In one multifamily project, the customer had installed two-thirds of the apartments with stand-alone washers and dryers. The remaining one-third received stackable washers and dryers. The total quantity verified during the site visit was consistent, but none of the stackable units met program or ENERGY STAR efficiency requirements. Therefore, the electric realization rate for the stackable units was 0%.

The other project involved a tracking error where the washers were claimed as having an MEF above 2.46, but the units actually had an MEF of 2.4. Michaels adjusted the savings to the "MEF 2.2-2.45, electric DHW" version of the clothes washer measure. The electric realization rate for this measure was 67%.

3.3.1.2 | Standard Refrigeration

The electric realization rate increase for standard refrigeration measures was due to a single grocery store site. The customer had actually installed 84 ft. of horizontal night covers instead of the claimed quantity of 40 ft. This increased the savings for this measure, resulting in an electric realization rate of 210%.

3.3.1.3 | Standard Water Heating

Standard water heating measures had lower realization rates driven almost exclusively by low flow devices such as shower heads, shower wands, and faucet aerators. The details regarding low flow devices installed in both multifamily strata were described previously in section 3.2.3.

There were three additional Assisted Living sites where low flow device measures required an adjustment. For two projects, the customer had removed the faucet aerators or shower wands due to tenant complaints. The third project resulted in an increase in the savings because twice as many shower wands were found during the site visit.

The average electric realization rate for low flow devices in the sample was 82%. The aggregate adjustment to electric savings was a decrease of 153,958 kWh, less than 1% of the total sample kWh.

3.3.1.4 | Custom Measures

There were three custom measure types with adjustments greater than 5%: Custom Controls, Custom Other, and Data Center. The adjustments to custom measures were driven largely by the key college/university and data center projects previously discussed in sections 3.2.1 and 3.2.2, above. In fact, the adjustments to the three data center projects accounted for the entire adjustment to custom controls and data center measures. Similarly, the key college/university project was the major contributor to the custom other measures realization rate. If these changes had not been needed (i.e. each project received a 100% electric realization rate), the overall realization rate for custom electric measures would have been 99% instead of 90%.

The remaining adjustments to custom electric measures were due to actual equipment operation based on data collected during the site visit. The differences were often found with actual temperature control setpoints, lighting hours of operation, and facility schedules. There was a total of 72 custom electric measures sampled, outside of the key projects discussed above only 24 of which (33%) had some modification made as a result of the evaluation data collected. The average adjustment made to these 24 measures was a 4% reduction from their *ex ante* savings, resulting in an aggregate decrease of 76,766 kWh, approximately 0.3% of the sample kWh savings.

3.3.1.5 | Measure Adjustment Impacts

Michaels analyzed the data at the measure type level to determine if the adjustments to the program were driven by lots of small adjustments, or by a small number of very large adjustments. Figure 11 plots the total adjustments to electricity savings as a percent of the total sample electricity savings versus the realization rate bin of that measure. For example, a standard measure with a 79% realization rate would be accounted for in the 75% to 90% category. The savings for all of the measures within that realization rate group were totaled and divided by the total sample kWh savings to determine the relative impact on the sample results. Viewing the results in this manner shows the relative impact of each grouping of measure realization rates on the overall results. Results for standard[18] and custom measure types are shown separately.

[18] For the purpose of this analysis, Market Solutions measures were included with Standard.

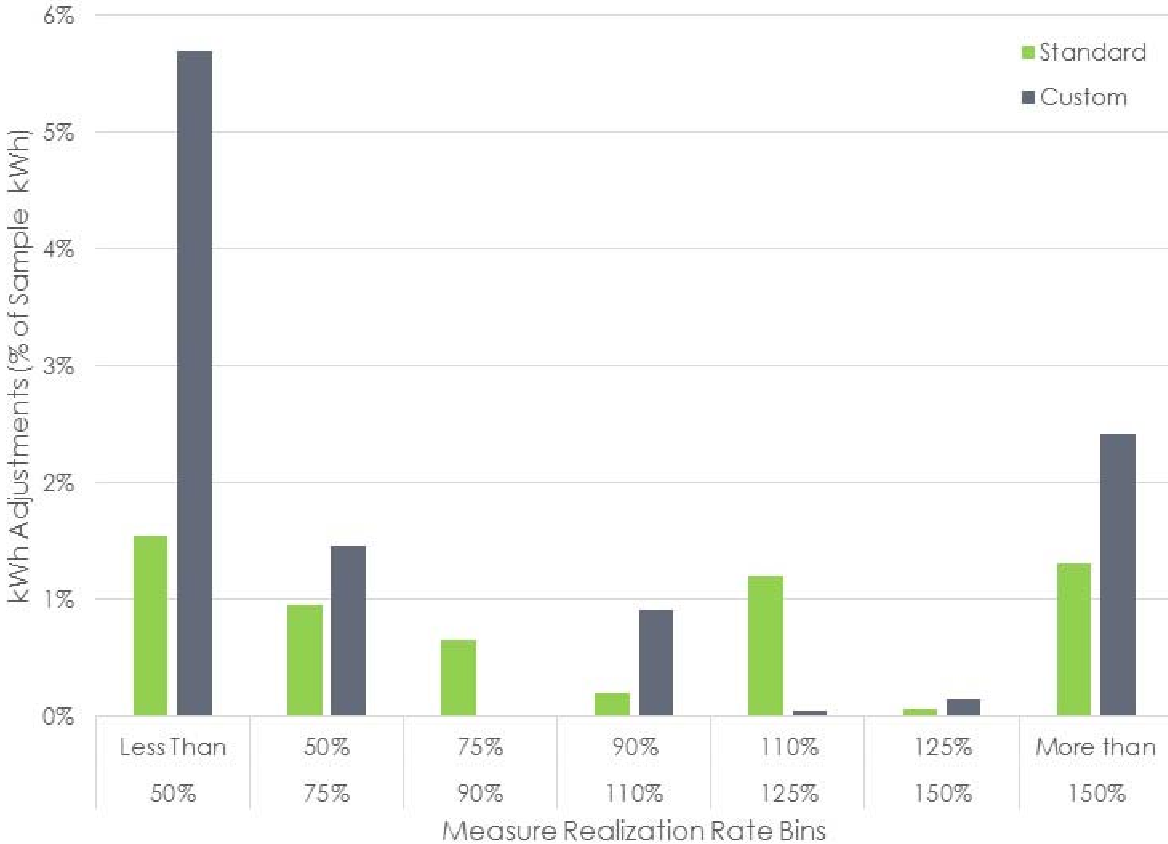

Figure 11 | Total Electric Adjustments as a Percent of Sample kWh for Certain Measure Realization Rate Ranges, by Measure Type

The data from Figure 11 are complimentary to those shown in Figure 9 and Figure 10. Recall that those figures showed the total number of measures within the realization rate bins, but did not establish what sort of impact those measures had on the overall sample kWh savings. The results from Figure 11 put those results into context. For instance, if the largest contribution to the sample adjustment was in the 90% to 110% realization rate group, we would conclude that they had a significant impact on the program in aggregate, even though adjustments at the individual measure level were small..

The data for the 2014 New Buildings evaluation indicate that custom measures where the measure level realization rate was 50% or less had the largest impact on the program as a whole. Figure 10 showed that seven individual measures had realization rates less than 50%, demonstrating that a very small number of significant adjustments was the primary cause for a reduction in the program electric realization rate. This is also consistent with the building type and measure type findings discussed in sections 3.2 and 3.3.

The results for standard measures indicate that the overall impact on the sample kWh savings from standard measures was much less. The largest custom measure impact was nearly 6% of the sample kWh savings, while the largest standard measure was a third as much. The relative consistency of the impact of standard electric measures on sample kWh savings across the realization rate groups also shows consistency across the sample. There were no "big hitters" that fundamentally changed the overall results of the program, as there were with the custom measures.

3.3.2 | Gas Measures

A similar analysis was completed for the gas measures included in the sample. Three of the measure types had savings values which were increased or changed only marginally. While six measure types did have more substantial adjustments, it is important to note that the overall unweighted realization rate for gas measures was relatively high (89%). A summary of the realization rates for each measure type can be seen in Table 16.

Table 16 | Unweighted Gas Realization Rates by Measure Type

Measure Type	Measure Count in Sample	*Ex Ante* Gas (therms)	*Ex Post* Gas (therms)	Gas Realization Rate
Standard Clothes Washer	12	2,533	2,824	112%
Standard Controls	-	-	-	N/A
Standard Food Service	23	13,594	11,909	88%
Standard HVAC	42	125,395	112,982	90%
Standard Lighting	-	-	-	N/A
Standard Motors	-	-	-	N/A
Standard Refrigeration	-	-	-	N/A
Standard Water Heating	95	101,090	98,865	98%
Standard Sub-Total	**172**	**242,612**	**226,580**	**93%**
Market Solutions	**3**	**5,760**	**5,762**	**100%**
Custom Controls	2	42,050	31,866	76%
Custom Gas	3	3,205	2,346	73%
Custom HVAC	24	141,313	119,343	84%
Custom Lighting	-	-	-	N/A
Custom Other	8	19,879	18,931	95%
Custom Refrigeration	-	-	-	N/A
Data Center	-	-	-	N/A
LEED	-	-	-	N/A
Custom Sub-Total	**37**	**206,447**	**172,486**	**84%**
Total	**212**	**454,818**	**404,828**	**89%**

Below, we provide additional information about the gas realization rates for the measure categories which had adjustments of greater than 5%. These measure types included: Standard Clothes Washers, Standard Food Service, Standard HVAC, Custom Controls, Custom Gas, Custom HVAC. We also include a discussion of Standard Water Heating measures, where a change to the program midway through 2014 caused a measurable impact on the results.

Market Solutions measures were a small portion of the sample savings, and a small documentation error caused an increase of two (2) therms for one measure.

3.3.2.1 | Standard Clothes Washers

Similar to the electric savings, described in Section 3.3.1.1, the gas savings for standard clothes washers were driven by one measure. This involved the installation of (12) clothes washers in an assisted living facility. The savings for the clothes washers were claimed assuming they were located within tenant units. However, the site visit found that they are communal washers, and would be used considerably more. The savings for this measure were adjusted to be consistent with the savings claimed for washers installed in multifamily common areas and laundromats. Making this change resulted in an 852% gas realization rate for this measure. The total adjustment of 410 therms, had a minimal effect on the overall sample gas savings.

3.3.2.2 | Standard Food Service

Standard food service measures were most impacted by a tracking error in the documentation for a single project. A steam cooker installed at an assisted living facility was found to be an electric unit, not a gas unit. The program staff verification that was completed noted that the unit was ENERGY STAR, but did not verify the specific model number or the fuel type. While Michaels did add 2,652 kWh to the *ex post* electric savings for this category, removing 1,308 therms impacted the gas realization rate. There were an additional three measures within the food service measure category where the units were improperly recorded as gas versus electric.

The aggregate change for this measure category was a decrease of 1,685 therms, approximately 0.3% of the sample therm savings.

3.3.2.3 | Standard HVAC

Gas standard HVAC measures include technologies such as condensing furnaces, condensing boilers, infrared heaters, and economizers. The standard HVAC measure type had a lower realization rate as a result of two specific measures.

The first was one condensing boiler installed as part of a water loop heat pump system. Since the heat pump was the primary source of heating at the facility, the condensing boiler was rarely utilized. The prescriptive savings for condensing boilers were not developed for this type of supplemental heating application, and therefore over predicted the savings for this boiler. Michaels corrected the hours of operation for the boiler, resulting in a 5% realization rate for this measure. The total downward adjustment of 4,158 therms was approximately 1% of the sample therm savings.

The other measure which contributed to the adjustment for gas savings was infrared heaters. There were two instances where significant changes were made. The first was the baseline adjustment as part of the warehouse and storage project described in section 3.2.5. The other was a college/university project where the quantity of the installed heaters was less than assumed. During the site visit, (12) heaters were verified versus the claimed quantity of (16). The reduced quantity of installed units resulted in a gas realization rate of 75% for this measure.

The aggregate adjustment for the two infrared heater measures was a decrease of 7,359 therms, approximately 2% of the sample gas savings.

3.3.2.4 | Standard Water Heating

The standard water heating measure included two main types of measures; water heater installations, and low flow devices.

There were a total of (26) low flow device measures in the 2014 sample. The total gas realization rate for low flow devices was 42%. This is largely due to adjustments to quantities listed in the project documentation, and to customers removing the measures for satisfaction reasons. Additional details for these adjustments were previously discussed in sections 3.2.3 and 3.3.1.3. The aggregate decrease in gas savings for low flow devices was 21,988 therms, approximately 5% of the sample therms savings.

The standard water heating measure category was also affected by a significant savings increase. The program made a calculation change to condensing hot water heater savings in September of 2014. The updated calculation utilized deemed savings for natural gas condensing tank water heaters depending on seven different building type options: multifamily, lodging, restaurant, laundry, office/retail, K-12 school, and college/university. The calculation used prior to September 2014 had only two choices: multifamily and non-multifamily.

All types of facilities in the sample installed condensing tank water heaters; however, higher hot water consuming building types, such as multifamily, assisted living properties, and hotels/motels (included in the restaurant/lodging/hotel/motel building stratum), comprised a majority of the condensing tank water heater savings in the sample. Michaels revised the savings for all condensing water heaters to be consistent with the updated savings methodology. This resulted in an aggregate increase of 19,738 therms, approximately 4% of the sample therm savings. The average realization rate for condensing water heater measures was 241%.

3.3.2.5 | Custom Gas

There were only three (3) measures from the sample within the custom gas measure group. The custom gas measure group realization rate was affected by a high efficiency laundry system. The customer had originally installed an Aquanomics system, which is a high efficiency chemical detergent that allows the customer to lower the water temperature and eliminate the soft soak and a rinse cycle. However, after several months of "clothes not being clean," the customer replaced it with a "standard" laundry detergent dispensing system. The replaced system did not have the same advantages of reduced water temperature and water use as the Aquanomics system, so the savings for this measure were set to 0. This measure had a 0% realization rate, but the downward adjustment of 873 therms had a minimal effect on the sample therm savings.

3.3.2.6 | Custom HVAC

The custom HVAC measure type included measures such as HVAC controls, heat recovery units (HRV), and high efficiency roof top units. The main adjustment to the custom HVAC measure type was the large college/university project mentioned previously in section 3.2.1. The results for this project decreased the custom HVAC gas savings by 10,130 therms, approximately 3% of the sample therm savings.

The second most significant adjustment was two projects which installed HRVs. The savings for the HRVs were calculated using the most recent version of the HVAC calculation tool, which was found to be reasonable and accurate. However, one of the HRV installations was set to manual control, and the customer does not use the system. This particular site would benefit from such a system, but the customer indicated that they don't need it and don't turn it on. Michaels reduced the operating hours from 10 hours per day to one (1) hour per day, five days per week, resulting in an 8% realization rate for this measure.

The second significant HRV project was installed in a multifamily building and runs continuously to serve the hallways of the building. The space temperature in the hallway is maintained at 70°F throughout the year. The *ex ante* calculation for this measure assumed that the heating balance point for these spaces would be 70°F. The balance point of a space is the outdoor air temperature at which heating (or cooling) is needed. However, since the hallway is heated to 70°F, and there are internal loads such as people, the balance point would not be equivalent to the heating setpoint. This is true for most balance point calculations, as a majority of spaces have some sort of internal gains. Michaels reduced the balance point to 60°F based on our experience with heating systems in similar multifamily buildings. This adjustment resulted in a realization rate of 51% for this measure.

The aggregate change for these two HRV measures was a decrease of 7,956 therms, approximately 2% of the sample therm savings.

3.3.2.7 | Measure Adjustment Impacts

The gas measures exhibited similar characteristics to the electric measures when the impact of adjustments on the program was examined. Figure 12 shows the sum of gas measure adjustments as a percent of the total sample gas savings versus the realization rate bin for that measure. For example, a standard measure with a 160% realization rate would be accounted for in the more than 150% category. The savings for all of the measures within each realization rate group were totaled and divided by the total sample kWh savings to determine the relative impact on the sample results. Viewing the results in this manner shows the relative impact of each grouping of measure realization rates on the overall results. Results for standard and custom measure types are shown separately.

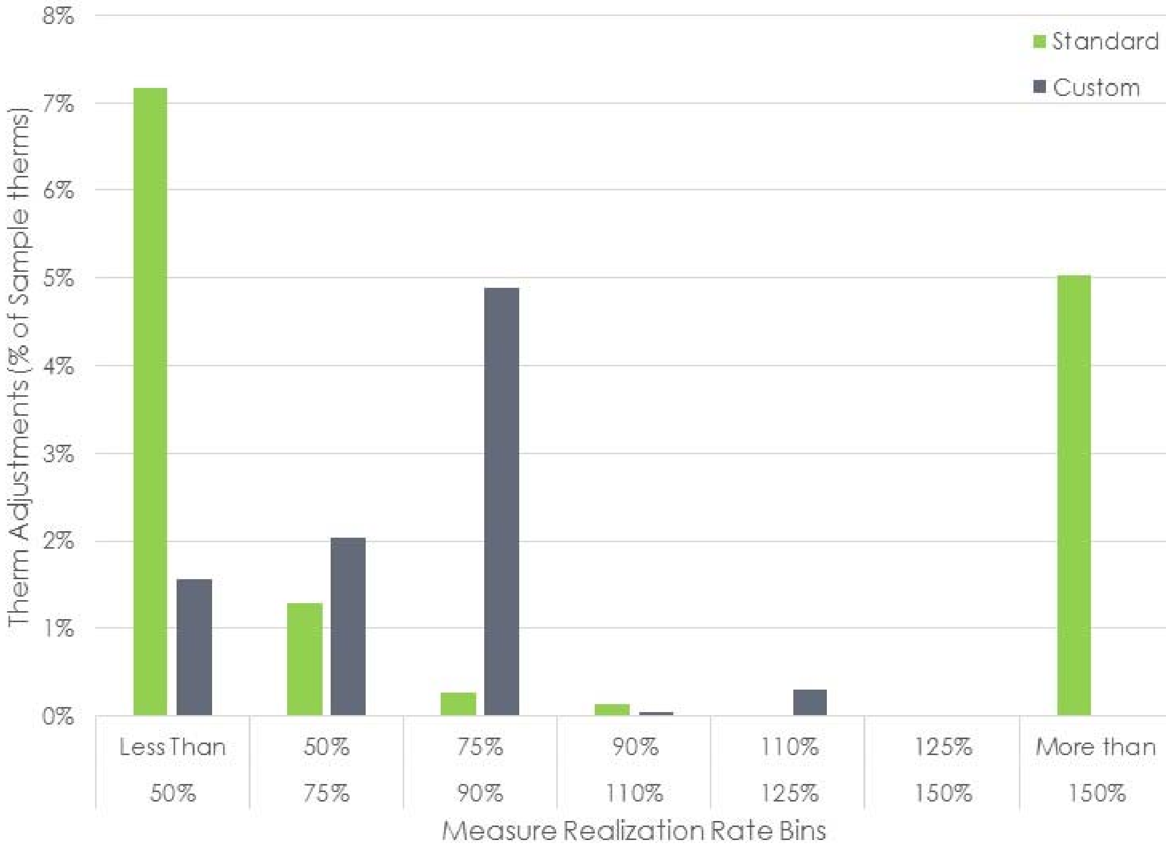

Figure 12 | Total Gas Adjustments as a Percent of Sample Therms for Certain Measure Realization Rate Ranges, by Measure Type

The data from Figure 12 are complimentary to those shown in Figure 9 and Figure 10. Recall that those figures showed the total number of measures within the realization rate bins, but did not establish what sort of impact those measures had on the overall sample kWh savings. The results from Figure 12 put those results into context. For example, if the largest contribution to the sample adjustment came from the 90% to 110% realization rate group, we would conclude that while those adjustments at the individual measure level were small, they had a significant impact on the program in aggregate.

Standard gas measures showed some similar characteristics to custom electric measures. A small number of standard gas measures (34) had the most significant downward adjustment to the program. However, in contrast to the electric results, there was also a significant upward adjustment of 5% of sample therm savings from measures with 150% or greater realization rates. Both of these swings are concentrated in the standard water heating measure type where significant downward (low flow devices) and upward (condensing tank water heater) adjustments were made.

Finally, a small number (8) of custom gas projects in the 75% to 90% group also contributed to a reduction in the overall gas results. These were the custom HVAC measures included as part of the large college/university site evaluated.

3.3.3 | Reasons for Adjustment

Identifying the adjustments made to project savings only tells half of the story. Understanding why projects were adjusted is equally important. To better understand why projects were adjusted, we will categorize each type of adjustment. The specific categories used were determined based on discussions with Energy Trust, and are listed below:

- ✓ **Documentation Error:** These adjustments were made because the quantities or efficiencies of measures verified during the site visit were inconsistent with the project documentation. This would include a different number of lighting fixtures or finding a water heater is heated with natural gas instead of electricity.
- ✓ **Baseline Change:** Calculations resulting in incorrect savings from using the wrong baseline equipment, system, or efficiency are included in this group. This would include using the incorrect baseline HVAC system from the Oregon Energy Efficiency Specialty Code, for example.
- ✓ **Tracking Error:** These are adjustments made because the savings in the calculations do not match the savings ultimately used to determine the incentive for the project.
- ✓ **Calculation or Engineering Error:** These are adjustments made because of errors in applying engineering principles, calculation errors, or errors to building simulations. These could include mathematical errors such as dividing instead of multiplying by an efficiency value, or an incorrect unit conversion.
- ✓ **Operated or Installed Differently:** These are adjustments made because the equipment operates differently than expected. This could include differing loading, schedules, or customers removing equipment. This factor is applied to custom measures, building simulations, or calculated savings inputs where information directly from the customer was used to determine the *ex ante* savings.
- ✓ **Unknown:** These are adjustments where a cause could not be identified. Often this is due to incomplete or missing models or calculations in the project documentation.

Figure 13 shows the savings impact due to each of the adjustment categories. The first note is that none of the aggregate reasons for adjustment are very large. Even the largest adjustment category only affects 3% of the sample energy savings. Categorical adjustments in excess of 10% are generally indicative of a recurring issue or an extremely large project. The program's ability to keep adjustments to less than 4%, and in many cases less than 1%, shows very good accuracy overall.

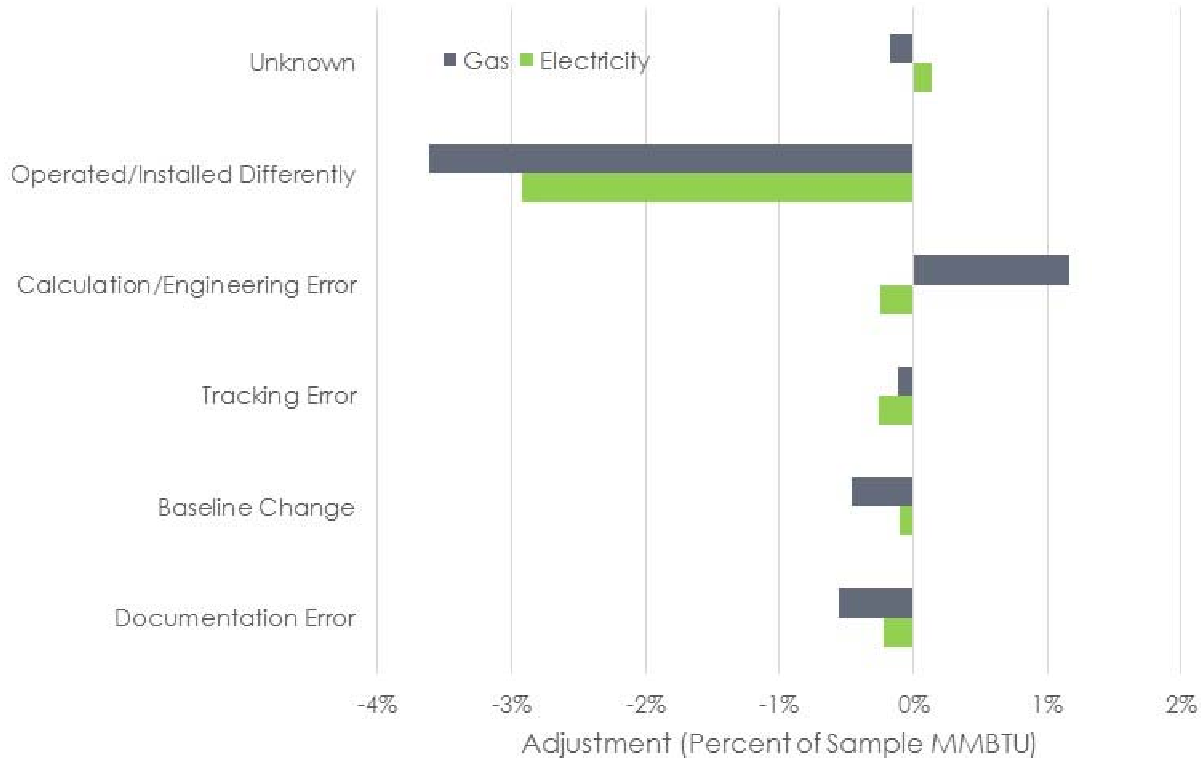

Figure 13 | Electric and Gas Savings Impact by Evaluation Adjustment Type

One important observation from Figure 13 is that there were minimal impacts due to baseline changes. Using the appropriate baseline for new construction measures is second in importance only to the anticipated operation. The small impact that changes to the baseline had on the program savings overall speaks to the careful consideration that takes place for accurately quantifying baselines for custom measures.

The large impact on gas savings from calculation and engineering errors was related to condensing tank water heaters. The Michaels team updated the savings for this measure to be consistent with the savings values by building type which was used after September 2014, which increased savings.

The most significant reason for adjustment for both electric and natural gas measures was that equipment was operated or installed differently than assumed. This was found to be true at the program level for both electricity and gas savings, as well as across measure types. This is as expected for new construction programs since there is no historical data or practices on which to base assumptions for a particular customer. Additionally, new construction buildings have long lead times, and things very often change during and after construction once a customer or tenants begin occupying a new building.

It is important to note that the operated and installed adjustments are nearly entirely driven by the key projects identified in Sections 3.2.1 and 3.2.2. The remaining measures had minor adjustments on average. For example, lighting measures changed due to hours of use differences verified during the site visit averaged a 95% realization rate, very close to program estimated lighting hours of use.

3.4 | Energy Intensity Analysis

The energy use intensity analysis examined both electricity and gas usage, normalized to per square foot of building area, in order to examine the effectiveness and efficacy of participant buildings. As detailed in section 2.3.7, the Michaels team attempted to examine the usage histories for all customers included in the sample. After removing customers where no history was available, electric or natural gas usage was missing, and any outliers, 84 buildings were included. To ensure that as many of the projects were operating under typical conditions as possible, the calendar year 2015 was used as the basis. Individual projects were examined on a case by case basis if ramp-up periods at the facility extended into 2015. However, 12 months of data were used for each project included in the analysis. The Michaels team calculated the sampled projects' EUI by examining building floor area in square feet and 2015 energy usage data for gas and electricity.

These calculated EUIs were compared to other regional sources to gauge the performance of program buildings. Additionally, the energy intensity was analyzed as a function of several key variables such as HVAC system type, to determine if any characteristics of low-usage buildings could be identified.

3.4.1 | Program Comparison

The 2015 EUIs for individual 2014 program projects range from 3.25 to 1,870 kBtu/SF, with a mean of 132.3 kBtu/SF, indicating how wide-ranging these values are and how diverse the population of participating buildings was in 2014.

Table 17 shows the 2014 sample building energy use intensity by building type, including the number of buildings used in the Michaels analysis contributing to the mean EUI value. Note that the number of sites per building type ranges from one to 15, demonstrating the difficulty of drawing meaningful conclusions about the EUI for each building type, particularly for segments with 5 or fewer sample points. Conducting an EUI analysis also has other limitations in that it's simply a measure of energy usage at a facility. This type of analysis does not take average operating hours, occupancy levels, or other building specific operations into account. When samples are large enough, these shortcomings do not have as significant an impact. The main purpose of our EUI analysis is to provide a high-level comparison of projects completed during the 2014 program year to other program years and to benchmark studies to determine if energy intensities were higher, lower, or in line with other data.

We compared the EUIs for the 2014 impact sample to several other studies: the previous (2012) impact evaluation[19], the 2014 NEEA Commercial Building Stock Assessment (CBSA)[20], and the national 2012 Commercial Buildings Energy Consumption Survey (CBECS)[21]. These results are presented in Table 17 below. The building types listed in Table 17 do not match the sample building categories precisely since the other referenced sources contain slightly different building type breakdowns. For some building strata in the 2014 sample, the results were split by the actual building type. An example would be the restaurant/lodging/hotel/motel strata in the 2014 New Buildings Evaluation sample, which was split into two categories for the EUI analysis, one for restaurant, and one for lodging/hotel/motel.

Table 17 | Comparison of 2014 Participant EUIs

Study Name and Date	2014 NB Participants (n=84)		2012 NB Participants (n=34)		2014 NEEA CBSA (n=1,278)		2012 CBECS (national)
Building Type	**n**	**kBtu/sf**	**n**	**kBtu/sf**	**n**	**kBtu/sf**	**kBtu/sf**
Retirement/Assisted Facilities	7	54					
Multifamily Residential	15	31	5	12			
Retail	5	76	2	74	152	65	89
Data Center	5	699	1	177			
Schools K-12	8	41	7	106	117	64	69
College/University	5	62	1	44	13	64	69
Warehouse	10	58	2	14	105	30	34
Office	8	69	3	41	171	76	78
Other	6	43	3	87	111	85	145
Lodging/Hotel/Motel	6	74			100	91	97
Assembly	1	41			137	91	86
Grocery	1	127	7	252	129	240	210
Religious/Spiritual	1	29					38
Restaurant	4	781	2	404	159	352	283
Hospital	2	294	1	181	25	174	231

EUIs for the 2014 New Buildings program participants in the evaluation sample were in line with the benchmark studies for some building types, others were higher, and others were significantly lower . There were a few building types, such as grocery or assembly where the number of data points was very small and no conclusions could be drawn.

The five retail buildings, five college/university buildings, and eight offices analyzed here were generally in line with EUIs from the benchmark studies. However, both college/university and

[19] 2012 New Buildings Program Impact Evaluation. The Cadmus Group. April 26, 2015. https://energytrust.org/wp-content/uploads/2016/12/2012_New_Buildings_Program_Impact_Eval_final_w_SR.pdf

[20] 2014 COMMERCIAL BUILDING STOCK ASSESSMENT. Navigant Consulting. December 16, 2014. http://test.neea.org/resource-center/regional-data-resources/commercial-building-stock-assessment

[21] Commercial Building Energy Consumption Survey (CBECS) website. https://www.eia.gov/consumption/commercial/

office were significantly higher than the 2012 evaluation sample. In the 2014 evaluation sample, there were three different office projects which had increased EUIs due to longer than typical operating hours. This is likely the cause of the increase in EUI between 2012 and 2014.

The EUI for schools K-12 and lodging/hotel/motel were found to be significantly lower than the other referenced studies. This first demonstrates that the program had a significant influence on energy intensity with these types of buildings during the 2014 program year, driving EUIs to decrease by approximately 30% relative to regional averages. Secondarily, the larger buildings included in 2014 may have lowered the average, as larger buildings tend to be less energy intensive. Schools K-12 averaged 61,000 square feet and lodging/hotel/motel averaged 63,000 square feet compared to 46,000 square feet and 56,500 square feet, respectively, from the CBSA.

There were two building types, warehouse and restaurants, which had significantly higher EUI values than the referenced studies. At 58 kBtu/SF, mean EUI for the 10 warehouses in the evaluation sample was much higher than for the other studies, mostly because the warehouse buildings from the sample were not only storage warehouses. One of the warehouse projects was a public transit maintenance garage, another a water pumping station. The warehouse category also included four expansions, which presented complications while calculating the EUI for those buildings.

The four restaurants in the evaluation sample had an average EUI that was more than double that for the CBSA and CBECS. This is largely due to one of the restaurant buildings sampled during the 2014 evaluation. This one restaurant, an Asian influenced restaurant, had extremely high gas usage from its wok burners. These burners run continuously when the restaurant is open, and lead this one restaurant to consume more natural gas annually than the other three combined.

3.4.2 | Building Type Analysis

During the site visits and desk reviews of the projects within the sample, the Michaels team categorized the sampled projects' heating fuel, cooling fuel, primary heating source, primary cooling source, secondary heating source, secondary cooling source, air handling type, ventilation type, and energy recovery capability. Michaels then analyzed the energy intensity within each air handling type and building type to determine if there were any key observable trends. The sites listed as "unknown" were desk review projects where detailed HVAC specifications and documentation was not available. The total number of sites in this analysis is also lower than the EUI analysis since the five data center projects were not included, and an additional 3 sites were removed due to insufficient information.

The average energy intensity for each building type and characteristic were determined. The averages were then ranked with the lowest EUI being ranked number "1". The rankings are displayed in the tables below. The results of this analysis provide additional qualitative feedback for the program on which types of characteristics tended to result in lower energy usage.

Based on this analysis, there was one trend across air handling types, primary heating source, and primary cooling source - that simpler systems tended to result in lower EUIs on average. Table 18 shows the energy intensity by air handling type, with simpler systems marked with an (*).

Table 18 | Ranking of Energy Intensity by HVAC System Type and Building Type

Air Handling	Assisted Living Property n=7	College/ University n=5	Grocery n=3	K-12 School n=8	MultiFamily < 70,000 Ft2 n=8	MultiFamily 70,000+ Ft2 n=8	Office /Retail n=10	Other n=8	Restaurant/ Lodging/ Hotel/Motel n=10	Warehousing/ Storage n=10
Heat Pump / VRF	1			4	2	2	2		2	
Furnace / DX *	2			2			3		1	
Unknown	3	4			3			2		1
Packaged RTU, SZ *		1	1		1	1	1	4	3	2
Packaged RTU, VAV		2		1			4	3		
Central VAV		3		3						
Fan Coils				5						3
None								1		4

The data show that packaged single zone, and the similar furnace/DX systems, tended to be less energy intensive than other system types. Packaged single zone systems ranked first or second in lowest EUI in six out of the eight building types analyzed. The restaurant/lodging/hotel/motel had furnaces with DX cooling as the lowest EUI, while furnace/DX systems ranked second in two other categories. Packaged single zone systems and furnace/DX systems also had the lowest average ranking across all the air handling types, at 1.8 and 2.0, respectively.

Packaged single zone systems are very simple, with one HVAC unit serving a single zone of spaces in a building. These systems are simple to engineer, simple to model, simple to operate, and simple for customers to understand. They also tend to be very difficult for customers to "tinker" with. Michaels has seen this consistently through our program implementation experience as well where the systems that tend to perform the best, are the ones the customers can handle.

Energy intensity ranking by primary heating and cooling types can be seen in Table 19 and Table 20, respectively.

Table 19 | Ranking of Energy Intensity by Primary Heating Type

Primary Heating Source	Assisted Living Property n=7	College/ University n=5	Grocery n=3	K-12 School n=8	MultiFamily < 70,000 Ft2 n=8	MultiFamily 70,000+ Ft2 n=8	Office /Retail n=10	Other n=8	Restaurant/ Lodging/ Hotel/Motel n=10	Warehousing/ Storage n=10
Condensing Boiler *		3		3				2		
Conventional Boiler *				1						
Indirect Gas (Furnace/RTU) *		1	2	2		1	1	4	3	1
Air Source Heat Pump	1				1	2		5	2	
Water Source Heat Pump							3			
Air Source VRF				4	2		2		1	
Electric Resistance				5						
IR Heaters - Gas		2						1		2
Direct Fired - Gas			1					3		

Table 20 | Ranking of Energy Intensity by Primary Cooling Type

Primary Cooling Source	Assisted Living Property n=7	College/ University n=5	Grocery n=3	K-12 School n=8	MultiFamily < 70,000 Ft2 n=8	MultiFamily 70,000+ Ft2 n=8	Office /Retail n=10	Other n=8	Restaurant/ Lodging/ Hotel/Motel n=10	Warehousing/ Storage n=10
Air Cooled DX *		1	1	1		1	2	2	3	1
Air Source Heat Pump	1				1	2		3	2	
Water Cooled DX		2								
Water Source Heat Pump							3			
Air Source VRF				3			1		1	
Water Cooled Chiller		3		2						
None				4				1		2

Especially in the case of primary cooling type, these two tables support the conclusion that straightforward systems tend to perform better on average. Indirect gas furnaces and air cooled DX systems ranked lowest across more building types, and are also common systems for single zone air handling types.

This data is not suggesting that all system types other than simple single zone systems are bad. But, it does show that overdesigning systems and state of the art technologies do not always produce superior results. In some cases, complex controls can significantly reduce the energy intensity of a building, such as those with interactions between multiple systems, onsite generation, and most industrial systems. However, the results of this analysis simply suggest that program staff should also emphasize ease of operation and customer knowledge levels before suggesting intricate systems with complex controls.

3.5 | Interactive Effects

During the evaluation, Michaels and Energy Trust had several discussions surrounding how to properly account for measures that result in cross-fuel interactive savings. Examples of this would be LED lighting that results in a natural gas heating penalty, or a heat recovery unit that saves natural gas but results in an electricity penalty due to the addition of a new fan.

Current Energy Trust policy does not allow claiming interactive savings at the *measure level*. The savings for the New Buildings program are analyzed at the measure level to determine if they are cost-effective. Any negative measure level interactions are included during the cost-effectiveness testing. However, if a measure is cost effective, and that measure has a negative cross fuel interaction, the negative savings are not carried through into the Energy Trust tracking system. This results in tracking system savings, which are used for evaluation purposes, that are inconsistent with incented savings and project documentation.

Whole building projects where the savings were calculated using a building simulation and each measure has total positive savings do not have this problem, as the total savings for the project are forced to match the total interactive savings determined by the models. This forces the overall project savings to include the interactive savings from individual measures, which is then correctly reported into the Energy Trust tracking system.

3.5.1 | Documented Interactions

One of the possible issues with the current rules regarding negative savings in the tracking system is that total savings for a given project depend on how the measure level savings are recorded.

Figure 14 shows one possible scenario (scenario A)[22] for how savings could be calculated for the project and then recorded into the Energy Trust tracking system.

Project Savings Calculation

Measure ID	Electric Savings (kWh)	Gas Savings (therms)
Lighting	100	0
Heat Recovery Chiller	200	-25
High Efficiency Chillers	300	50
High Efficiency Boiler	0	100
Total	**600**	**125**

Energy Trust Tracking System

Measure ID	Electric Savings (kWh)	Gas Savings (therms)
Lighting	100	0
Heat Recovery Chiller	200	0
High Efficiency Chillers	300	50
High Efficiency Boiler	0	100
Total	**600**	**150**

Figure 14 | Savings Scenario A

The important aspect of scenario A is that the negative savings for the heat recovery chiller were not recorded in the Energy Trust tracking system, even though the project as a whole registers positive natural gas savings. Based on Michaels understanding of how the tracking system operates, this situation could occur for any type of analysis. The key is that there are one or more measures with negative fuel savings while there are positive savings for that fuel for the whole project.

Scenario B is the exact same project, however, the heat recovery chiller measure and high efficiency chiller measure were combined into one "Chiller Plant" measure. Figure 15 shows a possible alternative scenario for the same project.

Project Savings Calculation

Measure ID	Electric Savings (kWh)	Gas Savings (therms)
Lighting	100	0
Chiller Plant	500	25
High Efficiency Boiler	0	100
Total	**600**	**125**

Energy Trust Tracking System

Measure ID	Electric Savings (kWh)	Gas Savings (therms)
Lighting	100	0
Chiller Plant	500	25
High Efficiency Boiler	0	100
Total	**600**	**125**

Figure 15 | Savings Scenario B

Savings scenario B combined the high efficiency chiller and heat recovery chiller into one measure. When this group of measures is entered into the Energy Trust tracking system, the 25 therm penalty from the heat recovery chiller is already included in the chiller plant savings. Since no specific measure has a negative savings value, the total electric and natural gas savings are entered into the tracking system in a manner consistent with the project file calculations.

The sampled projects included several instances of calculated negative measure interactions that were not ultimately claimed in Energy Trust's tracking data. The Michaels team examined the frequency and magnitude of the negative interactive savings measures. In the sample of 99

[22] These scenarios are fictitious and the savings values for each measure are not technically accurate, but used for illustration purposes only.

projects, there was a total of 493 measures, 13 of which (2.6%) have negative interactions. All of these instances are primarily gas savings measures, which also have an electric penalty. These result in a total of 104,357 kWh (0.5% of sample kWh savings) of electric penalty which is not applied to the sample realization rates, and therefore not applied to the program. These negative interactions would have had a very small impact on the overall realization rate for electricity savings during the 2014 program year.

It is important to note that this is only a problem when a customer's electricity and gas are supplied by member utilities. Negative measure level savings for non-member utilities do not have to be claimed by Energy Trust.

3.5.2 | Undocumented Interactions

There are also measures which currently do not have any documented negative measure interactions. LED lighting, and other efficient lighting equipment is the best example of this from the 2014 program year. The current Energy Trust lighting calculator was used extensively for determining the savings for efficient lighting. However, there is no inclusion of HVAC interactive effects either as an additional benefit (reduced cooling needs) or as a penalty (increased heating needs).

Michaels completed a high-level examination of the impact that including HVAC interactions for lighting would have made on the 2014 program year results. To estimate the impact, Michaels made some high-level assumptions.

1. All lighting measures were installed in air conditioned space
2. All of the customers utilized natural gas heat.

It is important to note that these assumptions are not consistent with actual participants in the program. Michaels made these assumptions for simplicity and also to show an upper bound on the effect that the program might expect to see.

The interactive effects factors used were taken from the Regional Technical Forum's (RTF) HVAC lighting factors summary spreadsheet[23]. The average HVAC interaction for the "new" building age category across all building types was calculated as 1.08 kWh/kWh saved, and -1.64 kbtu/kWh saved. These factors were multiplied by the total lighting savings to determine the interactive effects.

There was a total of approximately 7,300,000 kWh of claimed savings for efficient lighting technologies in the sample of projects the Michaels team evaluated. Using the RTF interactive factors would have resulted in an additional 593,000 kWh of electrical savings from reduced cooling loads. This equates to just less than 3% of the entire sample electricity savings.

[23] Regional Technical Forum Commercial Lighting HVAC Interaction Materials. Spreadsheet titled, "Com HVAC Factors_Summary EUI and IF Results 2016 02 23.xlsx"

However, it also would have resulted in a penalty of 119,000 therms from the increased heating required (again assuming all savings were in buildings with gas heat). This is 26% of the natural gas savings from the sample.

The interactive effects of efficient lighting would have a significant impact on the overall program if they were included in the evaluated savings. This also demonstrates that there are significant interactions at the program level, and portfolio level, which Energy Trust is not currently taking into account.

4. Findings and Recommendations

The Michaels team evaluated a total of 99 different projects and 493 individual measures across 11 different building types. The evaluated projects included standard, calculated, market solutions, custom engineering and building simulation measures for end uses ranging from hot water to lighting and HVAC controls.

The Michaels team completed onsite verification for 71 of the sampled projects and completed project file reviews for the remaining 28. During site visits, Michaels field engineers verified equipment counts, efficiency levels, and collected metered data from data logger installations or the customer's energy management systems.

This collected data was used in conjunction with customer energy usage data to revise engineering savings estimates for each measure in the sample. Prescriptive measure methodologies were not adjusted, but quantities of claimed measures and any necessary adjustments were made. Operational data collected during the site visits were used to update any calculation templates for custom projects. Finally, energy usage data and operational information were used to update any building simulations that had been used by the program.

The results of the evaluation determined that the program achieved a 96% realization rate for electricity (kWh) savings and a 94% realization rate for natural gas (therm) savings. Overall, both of the gas and electric realization rates were near 100%. They are also consistent with the realization rates seen during the previous five evaluations of this program. Program performance as a whole appears to be good, and consistent over time.

Based on the data collected during this evaluation, and the resulting data analysis, the Michaels team found that program implementation staff did an excellent job estimating electricity and natural gas savings during the 2014 program year. In order to build on that success and maintain high levels of realized savings, the Michaels team developed several key recommendations for the program to consider:

- **Continue improving documentation of modeling files.** Modeling projects and the associated modeling files can be complex. Projects can undergo multiple design iterations, and program staff are not the ones creating the original model files. The 2012 evaluation noted that modeling files were inconsistent and that the evaluator had difficulty analyzing building simulation savings. During the 2014 evaluation, Michaels did not have notable difficulty with incomplete or inconsistent modeling files. This indicates the program made significant strides since 2012. Not all modeling files followed precise naming conventions. However, baseline, as-built, interactive, and measure level models were included with project files or available via request to PMC staff. Continued work regarding naming conventions will further improve the review process internally by Energy Trust and PMC staff, as well as by evaluators.
- **Connect verification site visit results to the claimed savings.** During the Michaels evaluation, there were several instances where the equipment or specifications needed to be updated based on findings onsite. However, for three of these cases, the same adjustments had already been noted by the PMC’s post-construction verification site

visits. These notes, and in some instances, photos, were located in the documentation provided to Michaels for the projects. This indicates that there is some missing link in the feedback loop since savings were not adjusted using the findings from the PMC's visits. Michaels recommends that the program makes changes to the verification process. For example, compare the claimed and "verified" savings on the cover sheet of the site visit documentation. This would make any significant difference more visible and help reduce documentation errors.

- **Verify primary or secondary equipment.** One site visited during the evaluation was found to have claimed savings for a condensing boiler that was installed as a backup to a heat pump system. Since the boiler is used only when the heat pump system cannot supply the necessary heat, the operation is significantly less than that of a primary space heating boiler. This project, while small, pointed to a gap in the 2014 verification process, as it does not appear program staff specifically inquired about backup or redundant equipment. The inspection for this project correctly noted that the equipment was installed. However, the savings for this, and many other HVAC measures do not account for backup or redundant equipment. Energy Trust indicated that this practice has been updated since the 2014 program year. Therefore, Michaels recommends that the next evaluation of the New Buildings program include some additional focus on ensuring backup equipment, especially for HVAC equipment and pumping VFDs, are being properly counted.
- **Consider delaying verification of new buildings for as long as possible during the current program year.** The previous (2012) evaluation noted a similar recommendation: having "ramp up" periods for projects. While that recommendation was focused specifically on large projects, a similar process may be helpful for smaller projects. Michaels found that differences in the assumed operation of systems (used to claim savings) and how customers actually operated systems was the most common reason for savings adjustment. One possible way to help mitigate these risks is for the program to complete any onsite verification as late as possible in the program year. This will allow as much time as possible for projects to get "up and running" after completion while still claiming the savings in the current year.
- **Engage customers during late stage project completion about low flow devices.** Low flow faucet aerators, shower wands, and shower heads had a realization rate of 82% for electric savings and 42% for gas savings. This was due in part to customers removing them for satisfaction reasons. Continuing engagement with customers who install these measures could help to keep the customer reminded about their benefits and alert the program to early replacement by the customer.
- **Consider expanding the verification for multifamily buildings.** Similar to the previous recommendation, there were six projects in the evaluation sample (four multifamily and two assisted living) where the claimed quantity of low flow devices and HVAC equipment (PTHPS or ductless mini-splits) did not match the quantities from the project documentation. While onsite verification from program staff is occurring in 10% of the units in a building, there are still discrepancies between the claimed and actual quantities of measures. One way to reduce this is to complete a larger percentage of verifications for each building. However, this can be cost prohibitive and can lay an

additional burden on customers. An alternative approach would be to require that a final unit list or map be obtained for each multifamily building and that it be included in the project documentation and project audit file. This would ensure that the final counts of units and the appropriate number of bathrooms are included in the claimed savings.

- **Identify phased projects early and separate them from the “regular” population of projects.** Energy Trust has already begun this process to some extent, as very large industrial customers are already separated from the remainder of the New Buildings Program. There were two large data center projects in the sample for this evaluation that were found to be in various stages of construction. One had finished the third and final phase of the build-out in 2016, so it was included in the evaluation sample. The other was planned to finish the final phase in 2017. This project was ultimately dropped from the sample to ensure the facility was fully operational and to avoid contacting the customer multiple times for each phase evaluation. Energy Trust has recently set up a process for evaluating large and complex new construction projects and is currently soliciting qualifications for a pool of evaluation contractors. Utilizing this process for any significant projects, and identifying these projects early, will aid evaluators considerably, and be more transparent for large customers where “contact fatigue” can be a significant concern.
- **Verify seasonal changes within modeling projects.** One of the modeling projects evaluated, a large university building, had summer and winter schedules for some, but not all, of the equipment. This resulted in a realization rate for the lighting measures of 61%. Most modeling software packages have the ability to apply more than one equipment operating schedule, and more than one internal load schedule (such as people or equipment loads). These seasonal changes can be significant, especially for educational facilities. Model reviewers should take care to validate the equipment and loading schedule to ensure it is consistent with the anticipated operation of the building.
- **Engage and educate data center customers on advanced UPS control functions.** The largest adjustment to the electric realization rate was caused by very low loading for a data center uninterruptible power supply (UPS) system. Data centers will always have some sort of UPS system, and many of the new systems are capable of either variable module management system (VMMS) or energy saving system (ESS) controls. The customer indicated they run their system with the UPS units in parallel to ensure redundancy. This left the UPS units underutilized and operating at low efficiency. Michaels has seen this similar situation for other data centers examined in Energy Trust territory and others. Engaging customers about the benefits of the EES or VMMS controls, while demonstrating how they do not add operational risk, could help ensure customers are utilizing these controls when available.
- **Consider methodologies for claiming negative measure level interactive savings.** There were several measures identified during the evaluation where negative measure interactions were calculated, but not recorded in Energy Trust tracking system. This is due to current Energy Trust policy which does not allow claiming negative cross fuel savings to avoid penalizing other member utilities unnecessarily. During the 2014 evaluation, these interactions were small, affecting only 2.3% of the measures claimed and 0.5% of the sample kWh savings. However, large dual fuel interactive measures, such as heat

recovery chillers, could cause significant discrepancies for future years. Michaels recommends that some additional controls be put in place within the Energy Trust tracking system to verify savings in the tracking system versus the calculated savings at the project level. Energy Trust should check that the total claimed savings at the project level recorded in the tracking system match those provided in the calculation files. This will ensure the savings for the entire project are accurately recorded in the Energy Trust tracking system. Note this only applies when both fuels are provided by member utilities.

- **Consider claiming HVAC interactions for lighting measures.** High efficiency lighting measures, such as LED lighting, have significant interactions with a facility's HVAC systems. These interactions can be both positive and negative. Michaels completed a simplified estimation of the impact of HVAC interactions for lighting measures assuming all customers with lighting were both air conditioned and had natural gas heat. While neither of these assumptions was accurate for the New Buildings Program, it did provide an upper bound on the impact of HVAC interactive effects. Claiming these interactions for lighting would have added approximately 3% in additional electricity savings, but would have penalized the program gas savings by 26%. Michaels recommends that Energy Trust examines methods for tracking and claiming these types of interactions in the future. A possible starting point would be to track the interactive savings at the measure or project level, and then use the evaluation of the program year to "true-up" the negative interactions accumulated during the year. This could be done initially for the New Buildings program on an informational basis. Once the impact is known, further decisions regarding how to implement this change in conjunction with savings goals, payments, and other policy considerations could be made.
- **Set defined criteria for the application of the Technical Guidelines.** During the evaluation, one modeling project was completed during a time frame in which two different versions of the Energy Trust Technical Guidelines (specifically, the modeling requirements in SEED Appendix L) were available. The versions of the Technical Guidelines did not provide clear direction on what versions were applicable to which projects. Michaels recommends that a specific date is used as the effective date for future revisions of the Technical Guidelines. One possible option for this would be the project enrollment date. Using this date would ensure that updated guidelines are in place prior to modeling work beginning on the project. Additionally, this would aid with consistency across the project both from a technical and customer clarity standpoint.

Evaluation Measure Type	Tracking Data Measure "measuredesc"
Market Solutions	Market Solutions Package, Office, Good HVAC 2 Measures
Market Solutions	Market Solutions Package, School, Best (6 Elective Measures)
Market Solutions	Market Solutions Package, Office, Best HVAC, 2 Measures
Market Solutions	Market Solutions Package, MF, Best (5 Electives)
Market Solutions	Market Solutions Package, MF, Good
Market Solutions	Market Solutions Package, School, Better (4 Elective Measures)
Market Solutions	Market Solutions Package, Office, Better HVAC, 4 Measures
Market Solutions	Market Solutions Package, Office, Better HVAC, 2 Measures
Market Solutions	Market Solutions Package, Office, Better HVAC, No Measures
Market Solutions	Market Solutions Package, Office, Best HVAC, 4 Measures
Market Solutions	Market Solutions Package, MF, Better (3 Electives)
Custom Controls	Controls - Custom
Custom Gas	Custom Gas
Custom HVAC	HVAC - Custom
Custom HVAC	HVAC, AC/HP, 2010 Code Calc
Custom HVAC	VFD, 2010 Code Calc
Custom HVAC	HVAC, Fan Energy Optimization, 2010 Code Calc
Custom Lighting	Lighting - Custom
Custom Lighting	Lighting Controls - Custom
Custom Other	Custom
Custom Other	Custom Modeled Savings, Non-Cost Effective
Custom Other	Envelope - Shell - Custom
Custom Other	Windows - Custom
Custom Refrigeration	Floating Head Pressure Controls
Custom Refrigeration	VFD on Condenser
Custom Refrigeration	FSPC & FHPC
Custom Refrigeration	Floating Suction Pressure Controls
Data Center	Custom
Data Center	Custom Modeled Savings, Non-Cost Effective
Data Center	HVAC - Custom
Data Center	Uninterruptible Power Supplies VFI
Data Center	Lighting, Interior, 2010 Code Calc
LEED	LEED - NC
Standard Clothes Washer	Commercial Clothes Washer, Gas Water Heat
Standard Clothes Washer	Clothes Washer, MEF >=2.46, In-Unit, Ele DHW
Standard Clothes Washer	Commercial Clothes Washer, Electric Water Heat
Standard Clothes Washer	Clothes Washer, MEF >=2.46, In-Unit, Gas DHW
Standard Clothes Washer	Clothes Washer, MEF 2.2-2.45, In-Unit, Ele DHW
Standard Clothes Washer	Clothes Washer, MEF 2.2-2.45, In-Unit, Gas DHW
Standard Controls	HVAC, DCV, 2010 Code Calc
Standard Controls	Anti-sweat Heater Controls - Low temp
Standard Controls	Anti-sweat Heater Controls - Med temp

Evaluation Measure Type	Tracking Data Measure "measuredesc"
Standard Food Service	Electric Steam Cooker
Standard Food Service	Gas Fryer
Standard Food Service	Electric Hot Food Holding Cabinet - Full Size
Standard Food Service	Gas Convection Oven - Full Size
Standard Food Service	Single Tank Conveyor, High Temp, Gas hot water
Standard Food Service	Vent Hood - Gas Heat
Standard Food Service	Ice Machine RCU < 1000 IHR, CEE Tier 1
Standard Food Service	Undercounter - high temp - Gas water heat
Standard Food Service	Single Tank Door/Upright - High Temp - Gas water heat
Standard Food Service	Vent Hood - Electric Heat
Standard Food Service	Ice Machine RCU >= 1000 IHR, CEE Tier 1
Standard Food Service	Electric Convection Oven - Full Size
Standard Food Service	Ice Machine IMH >= 450 IHR, CEE Tier 1
Standard Food Service	Ice Machine IMH < 450 IHR, CEE Tier 1
Standard Food Service	Single Tank Door/Upright - Low Temp - Gas water heat
Standard Food Service	Gas Griddle
Standard Food Service	Gas Steam Cookers
Standard Food Service	Electric Convection Oven - Half Size
Standard Food Service	Ice Machine SCU >= 175 IHR, CEE Tier 1
Standard Food Service	Single Tank Door/Upright - High Temp - Ele water heat
Standard Food Service	Ice Machine SCU < 175 IHR, CEE Tier 1
Standard Food Service	Electric Hot Food Holding Cabinet - Half Size
Standard HVAC	Ductless Mini-Split
Standard HVAC	Stand-alone Economizer, AC Unit, 3-Ton
Standard HVAC	High Efficiency Condensing Furnace
Standard HVAC	Commercial Infrared Radiant Heaters, Non-modulating
Standard HVAC	Commercial Infrared Radian heaters, Modulating
Standard HVAC	Stand-alone Economizer, AC Unit, 4-Ton
Standard HVAC	Direct-fired Radiant Heating
Standard HVAC	AC Unit 12.5 ton 2010 Code
Standard HVAC	Gas-fired Condensing Boiler >= 300 kbtuh, <= 2500 kbtuh 0.9 ET
Standard HVAC	AAHX, 2010 Code Calc
Standard HVAC	HVAC, Economizer, 2010 Code Calc
Standard HVAC	PT Heat Pump
Standard HVAC	Heat Pump, Water Source, 2 Ton
Standard HVAC	Heat Pump, Water Source, 3 Ton
Standard HVAC	Gas-fired Condensing Boiler > 2500 kbtuh 0.9 EC
Standard HVAC	AC Unit 6 ton 2010 Code
Standard HVAC	AC Unit 10 ton 2010 Code
Standard HVAC	AC Unit 15 ton 2010 Code
Standard HVAC	AC Unit 17.5 ton 2010 Code
Standard HVAC	Stand-alone Economizer, AAHP Unit, 3-Ton
Standard HVAC	Controls, HVAC, Hotel occ sensor
Standard HVAC	High Efficiency Condensing Unit Heater

Evaluation Measure Type	Tracking Data Measure "measuredesc"
Standard Lighting	LED Case Lighting T8-LED (<4w/ft)
Standard Lighting	LED Case Lighting T8-LED (4w/ft - 7.5w/ft)
Standard Lighting	Lighting, Interior, 2010 Code Calc
Standard Lighting	Lighting, Exterior, 2010 Code Calc
Standard Lighting	Lighting Controls, 2010 Cade Calc
Standard Lighting	Motion Sensor on LED Refrigerated Case
Standard Lighting	T5 or T8 High Efficiency 2-lamp fixture with electronic ballast
Standard Lighting	Occupancy Sensor, Wall or Ceiling Mount
Standard Lighting	Daylight controlled dimming - Flourescent
Standard Lighting	T8 lamp with electronic ballast per 4 ft. section
Standard Lighting	LED lamp <10W (PAR/R/MR/GU)
Standard Lighting	LED lamp >20W (PAR/R/MR/GU)
Standard Lighting	LED Street Light (City Owned)
Standard Lighting	LED lamp 10-19W (PAR/R/MR/GU)
Standard Lighting	LED lamp 20-40W (R/PAR/MR/GU)
Standard Lighting	New Exit Sign, Self & Photoluminescent
Standard Motors	ECM Motor for Refrigeration Systems
Standard Refrigeration	Refrigerator Res Size Tier 1 (20% Better)
Standard Refrigeration	Night Covers - Vertical
Standard Refrigeration	Freezer Rez Size Tier 1 (10% Better)
Standard Refrigeration	Refrigerator Res Size Tier 2 (30% Better)
Standard Refrigeration	Refrigerator, Comm, Solid door
Standard Refrigeration	Night Covers - Horizontal
Standard Water Heating	Showerhead Gas DHW (Avg GPM)
Standard Water Heating	Aerator Kitchen, Gas 1.5 gpm
Standard Water Heating	Condensing Tank
Standard Water Heating	Aerator Bathroom, Gas 0.5 gpm
Standard Water Heating	Showerhead Ele DHW (Avg GPM)
Standard Water Heating	Aerator Bathroom, Ele 0.5 gpm
Standard Water Heating	Aerator Kitchen, Ele 1.5 gpm
Standard Water Heating	Condensing Tank - Multifamily
Standard Water Heating	Shower Wand Gas DHW
Standard Water Heating	Tankless/Instantaneous w/Electronic Ignition
Standard Water Heating	Shower Wand Gas DHW 1.5 GPM
Standard Water Heating	Shower Wand Ele DHW 1.5 GPM
Standard Water Heating	Shower Wand Ele DHW
Standard Water Heating	Aerator Bathroom, Gas Only 0.5 gpm
Standard Water Heating	Aerator Kitchen, Gas Only 1.5 gpm
Standard Water Heating	Condensing Tank - Lodging

Evaluation Building Type	Tracking Data Building Type "bu1_deprecated"
Assisted Living Property	Assisted Living Property
College/University	College/University
Data Center	Data Center
Grocery	Grocery
Grocery	Convenience Store
K-12 School	K-12 School
MultiFamily < 70,000 Ft2	Multifamily Property
MultiFamily < 70,000 Ft2	Market Rate Multifamily Property
MultiFamily < 70,000 Ft2	Affordable Multifamily Property
MultiFamily 70,000+ Ft2	Multifamily Property
MultiFamily 70,000+ Ft2	Affordable Multifamily Property
MultiFamily 70,000+ Ft2	Market Rate Multifamily Property
Office/Retail	Office
Office/Retail	Retail
Other	Gym/Athletic Club
Other	Assembly
Other	Wood Product Manufacturing
Other	Winery
Other	Fire Protection
Other	Commercial
Other	Auto Services
Other	Beverage and Tobacco Product Manufacturing
Other	Military (Armory, etc.)
Other	Jail/Reformatory/Penitentiary
Other	Unspecified Government/Public Sector
Other	Parking Structure/Garage
Other	Religious/Spiritual
Other	Health
Other	Machinery Manufacturing
Other	Car Dealership/Showroom
Other	Hospital
Other	Police
Other	Campus Living Property
Other	Museum
Other	Transportation Infrastructure (Tunnel, Roadway, Dock, etc.)
Other	Brewery
Other	Paper Manufacturing
Other	Food Manufacturing
Other	Manufacturing
Other	Bank/Financial Institution
Other	Amusement/Recreational
Restaurant/Lodging/Hotel/Motel	Restaurant
Restaurant/Lodging/Hotel/Motel	Lodging/Hotel/Motel
Warehouse and Storage	Warehouse and Storage
Warehouse and Storage	Industrial

Appendix B | Building Energy Intensity

The building EUI analysis used the following parameters to characterize the buildings included in the sample.

Cooling Fuel	Primary Cooling Source	Primary Heating Source	Secondary Heating Source	Secondary Cooling	Air Handling	Ventilation	Energy Recovery
Electricity	Air Cooled DX	Condensing Boiler	El Resistance	Radiant Panel	Central VAV	DOAS	Yes
District CW	Air Source Heat Pump	Conventional Boiler	Hot Water	Chilled Beam	Packaged RTU, SZ	Fixed (No Economizer)	No
Thermal Absorption	Water Cooled DX	Indirect Gas (Furnace/RTU)	Radiant Water		Packaged RTU, VAV	Variable (Economizer)	
	Water Source Heat Pump	Air Source Heat Pump	Radiant Electric		Heat Pump / VRF		
	Air Source VRF	Water Source Heat Pump			Furnace / DX		
	Water Source VRF	Air Source VRF			Fan Coils		
	Air Cooled Chiller	Water Source VRF					
	Water Cooled Chiller	El Resistance					
	Geo Heat Pump	Geo Heat Pump					

Building Type	Area (sf)	Electricity EUI (kWh/sf)	Gas EUI (therms/sf)	Total Energy EUI (kBtu/sf)
Data Center	518,844	547.9	-	1,870
Restaurant	1,500	86.4	12.3	1,523
Restaurant	1,760	56.9	4.6	651
Data Center	73,600	170.2	-	581
Data Center	73,600	170.2	-	581
Restaurant	2,867	73.7	3.1	557
Restaurant	2,148	3.3	3.8	393
Hospital	700,000	45.4	2.2	375
Data Center	186,650	90.2	-	308
Hospital	378,000	32.1	1.0	212
Data Center	260,000	42.2	0.1	158
Warehouse	150,000	33.4	0.4	155
Grocery	18,092	25.0	0.4	127
Retail	139,356	24.5	0.4	121
Office	74,060	22.7	0.3	112
Retail	137,715	22.5	0.3	106
Retail	39,976	30.8	-	105
Office	76,000	30.5	-	104
Retirement/Assisted Facilities	30,000	23.9	0.2	103
Lodging/Hotel/Motel	70,700	8.5	0.7	102
Lodging/Hotel/Motel	71,933	10.6	0.6	99
Lodging/Hotel/Motel	25,000	10.9	0.6	97
Office	7,700	-	0.9	92
Warehouse	29,991	9.4	0.6	92
College/University	12,874	22.1	0.2	91
Other	122,600	16.4	0.3	89
Retirement/Assisted Facilities	28,000	15.3	0.3	80
Multifamily Residential	18,211	7.0	0.5	75
Warehouse	13,778	13.4	0.2	65
Schools K-12	134,163	7.0	0.4	64
Office	70,221	18.5	-	63
Warehouse	103,860	9.5	0.3	63
Schools K-12	22,350	4.9	0.5	63
Lodging/Hotel/Motel	31,825	8.6	0.3	63
Warehouse	135,700	1.8	0.5	61
College/University	650,000	14.4	0.1	60
Schools K-12	52,254	6.5	0.3	57
Retirement/Assisted Facilities	33,503	16.6	-	57

Building Type	Area (sf)	Electricity EUI (kWh/sf)	Gas EUI (therms/sf)	Total Energy EUI (kBtu/sf)
Office	20,000	16.3	0.0	56
College/University	293,280	0.4	0.5	55
College/University	238,200	10.1	0.2	54
Lodging/Hotel/Motel	175,000	10.2	0.2	54
Other	74,905	11.1	0.2	54
Multifamily Residential	111,000	14.5	0.0	54
Multifamily Residential	81,320	7.7	0.3	53
Retirement/Assisted Facilities	50,000	15.3	-	52
Schools K-12	4,115	7.0	0.3	52
Retirement/Assisted Facilities	37,000	15.3	-	52
College/University	18,348	10.5	0.2	51
Multifamily Residential	30,113	14.9	-	51
Office	31,785	9.0	0.2	50
Warehouse	160,000	13.8	-	47
Other	80,981	7.4	0.2	47
Warehouse	233,833	8.4	0.2	44
Other	54,730	12.4	-	42
Assembly	171,366	7.4	0.2	41
Warehouse	12,650	11.1	-	38
Office	97,550	9.8	0.0	36
Office	26,000	7.5	0.1	36
Retail	62,100	10.2	0.0	36
Multifamily Residential	30,000	5.7	0.1	32
Schools K-12	86,018	8.9	-	30
Schools K-12	39,600	4.7	0.1	29
Religious/Spiritual	20,425	3.7	0.2	29
Multifamily Residential	22,667	5.1	0.1	29
Multifamily Residential	167,000	4.8	0.1	29
Schools K-12	146,263	3.8	0.1	27
Lodging/Hotel/Motel	4,200	1.9	0.2	27
Multifamily Residential	212,920	7.8	0.0	27
Multifamily Residential	62,000	6.8	0.0	25
Multifamily Residential	448,497	3.3	0.1	25
Multifamily Residential	660,955	4.5	0.0	20
Retirement/Assisted Facilities	107,000	-	0.2	19
Multifamily Residential	6,000	5.7	-	19
Other	344,466	2.3	0.1	17
Warehouse	99,093	4.0	0.0	15
Multifamily Residential	219,541	4.1	0.0	15
Multifamily Residential	130,000	2.7	0.0	13
Retail	144,164	3.9	-	13
Retirement/Assisted Facilities	217,800	3.5	-	12
Other	9,923	3.3	-	11
Schools K-12	4,397	2.0	0.0	9
Multifamily Residential	66,240	0.1	0.0	5
Warehouse	792,560	0.7	0.0	3

MichaelsEnergy

Memo

Date: March 31, 2017

To: Dan Rubado, Energy Trust of Oregon

From: Mike Frischmann, Michaels Energy

Subject: Impact Evaluation of Selected 2011 – 2012 New Buildings Projects

cc: Sarah Castor, Energy Trust of Oregon

Jeff Ihnen, Michaels Energy

This memorandum provides a summary of the impact evaluation activities and updated impact evaluation results for four different New Buildings projects. The 2011 and 2012 New Buildings program year impact evaluations were originally completed in 2013 and 2015, respectively. During these evaluations, four total projects were identified in which more time was needed for occupancy levels and equipment loads to stabilize. The four projects included in this investigation were: a data center, two hospital central plants and a hospital main building.

Michaels Energy (Michaels) was contracted to provide a supplementary evaluation of these projects and report the updated realization rates and any relevant recommendations for these types of projects going forward.

Evaluation Approach

To evaluate these four projects, Michaels completed four main activities for each project.

1. Review project files
2. Complete an onsite visit and customer interview
3. Update the savings calculations
4. Develop a final site report

Review project files

Michaels obtained the background documentation and calculation files for all four of the projects reviewed. Once the files were obtained, Michaels reviewed the background information to develop a more detailed understanding of the project, the important components and equipment, and any relevant site specific details. Similarly, the savings calculations were also reviewed for appropriate baselines, engineering accuracy, and to determine key parameters for further investigation during the onsite visit.

The final purpose of the project file review was to inform the development of the measurement and verification plan for each site. The measurement and verification plan detailed how the ex ante calculations were completed, the information that would be discussed with the customer, and the details of any trended data that would be requested. Additional details of the measurement and verification plans can be found in the final site reports for each site.

Complete Onsite

Once the initial review was completed, Michaels recruited the customers for site visits. Michaels was able to successfully recruit and complete site visits for all four of the projects required. During the site visits, the customer was interviewed in detail regarding the operation of the building systems, setpoints, equipment, and the facilities. Photographs or screenshots of pertinent equipment were taken (when permitted by the customer), and controls settings, schedules, and other operational details were recorded as found during the onsite.

Each of the customers was also able to provide trended data for the systems relevant to each project. Trended data capabilities ranged from one month to one year, depending on the parameter of interest and customer. In all cases, Michaels obtained the maximum amount of information that was readily available and obtainable by the customer.

Finally, Michaels requested energy usage histories for each of the three customers. Energy Trust was able to provide monthly energy (kWh) and natural gas (therms) usage for the last several years. The customers were interviewed to determine if any significant changes at the facility had happened which would have affected their billed usage, as well as if any significant changes were going to happen in the near future.

Update Savings Calculations

Michaels used the trended data and operational information to update the savings calculations for each of the four projects. Three of the projects were calculated using building simulations, while the last was determined using engineering calculations.

Building Simulations

Building simulations were updated to reflect the most recent operational and controls information obtained during the site visits Michaels completed. In all three cases, the existing modeling files were used as the basis for these analyses. This removed any differences that could occur from creating and developing different building simulations from scratch.

Each of the building simulations was analyzed using actual historical weather information and the customer's previous 12 months of electric bills to ensure it was properly calibrated. All of the detailed operating information, controls setpoints, and equipment sequencing information collected during the site visits was used to fine tune the operation of the final "as built" ex post model. The ex post savings were determined by running through the various permutations and iterations of the modeled measures using TMY (typical meteorological year) weather data to ensure the final ex post savings were representative of a typical year of operation.

Engineering Calculations

Similar to the building models, the original calculation files, or calculation methodologies, were used whenever possible to determine the ex post savings. For example, the savings for a chiller were examined using a weather normalized bin analysis in both cases. Equipment operational profiles and efficiencies were updated based on the customer supplied information and trended data. All weather sensitive measures were normalized to TMY weather data by developing correlations of the actual operation to actual weather conditions (i.e. chiller kW as a function of average outdoor air temperature). These correlations were used in conjunction with TMY weather data to predict normalized ex post savings estimates.

Develop Final Site Reports

The final step was to develop final site reports (FSRs) for each of the four projects evaluated. These FSRs provide a majority of the detailed technical information and methodologies used to evaluate these four projects. Each FSR contains the following sections:

1. Summary of Ex Ante Calculations – a summary of how the ex ante savings for each measure were determined, along with any key variables and assumptions.
2. Measurement and Verification Plan – the methodology proposed to be completed during the onsite visit.
3. Description of the Verification – the actual onsite activities completed during the site visit, and a description of any key parameters obtained during the site visit.
4. Ex Post Calculation Description – a description of the calculation methodology and findings based on the data collection activities.

The FSRs for these four projects were submitted, confidentially, to Energy Trust along with this memo.

Summary of Results

The overall project level results for each of the four projects can be seen in Table 1.

Table 1: Summary of project level results

Measure	Ex Ante		Ex Post		Realization Rate	
	Electric (kWh)	Gas (therms)	Electric (kWh)	Gas (therms)	Electric	Gas
Project 1	2,149,879	33,647	596,314	44,796	28%	133%
Project 2	1,125,170	19,010	875,639	14,062	78%	74%
Project 3	1,248,241	43,981	877,019	43,419	70%	99%
Project 4	4,817,566	214	1,007,000	-	21%	0%
TOTAL	**9,340,856**	**96,852**	**3,355,972**	**102,277**	**36%**	**106%**

Negative Measure Savings

There was one project evaluated in this group which had a negative cross fuel interaction. This negative interaction appears to have been taken into account during the incentive payment calculation, and cost benefit testing. However, it was not translated into the Energy Trust tracking system.

Energy Trust's tracking system records savings at the *measure* level. In most cases, especially those with building simulations, the total interactive savings across all measures are allocated to the measure level to take into account any interaction between the measures. This process works smoothly when all of the savings for all fuels and measures are positive.

The problem appears to arise when measure level savings are entered into the tracking system which have a negative cross-fuel interaction. This issue arose with the measure level savings for the heat recovery chiller. The total interactive savings from the project documentation were 997,277 kWh (excluding the gas savings of the system). This included the negative 261,500 kWh required by the heat recovery chiller. These savings were also recorded on that measure line item in the savings summary documentation.

When these measures were entered into the Energy Trust tracking system, the negative savings for that one measure were ignored, due to Energy Trust's policy of not claiming negative measure level savings between fuels. Therefore, in this case, this is a tracking system error because the savings recorded in Energy Trust's tracking system don't match the program calculated savings for the project.

Had the negative measure level savings been properly accounted for in the tracking data, this project would have received a 91% realization rate for gas, compared to the 70% calculated with the penalty included.

Recommendations

Based on the evaluations of these four projects, Michaels developed several recommendations for Energy Trust to consider.

- **Use cycling fan baselines for cooling towers.** Cooling tower fans left unmodified, will cycle on and off as needed. This is also true for two-speed fans as they will cycle between low and off, and then between high and low speed in order to match the loading on the tower.

- **Ensure measure interactions are taken into account.** Each of these projects included numerous measures, some of which can interact significantly with each other. Energy Trust currently has procedures to account for how to handle this regarding modeling files. At its core, the procedure indicates that the entire interactive building simulation, going from baseline to proposed building configurations, should be used as the final claimed savings for the project. The measure level savings can then be apportioned based on the entire interactive model.

  This type of procedure should also be used during evaluations. This is especially true when building simulations are used in conjunction with engineering analyses. Evaluation contractors should always take into account interactions between measures, and Energy Trust could require further explanation of calculation methodologies for projects which are significant to any samples (i.e. certainty sites) or those which Energy Trust is aware are utilizing multiple calculation methodologies.

- **Explore methods to validate equipment loading.** Variances between anticipated IT loading and central plant utilization were two of the main drivers for the changes seen in both evaluations of these projects. Customers changing the operation of equipment is one of the most common reasons for savings adjustment across all energy efficiency programs. Unfortunately, it is also a variable programs have little or no control over, which makes correcting it difficult.

  Michaels has seen various attempts, with mixed levels of success, by different programs to account for these issues. Below is a list of different types of methods used by other programs which Energy Trust can consider for use with the New Buildings program.
    - *Making a portion of the incentive contingent on evaluated results.* Splitting the incentive does delay payment, which could impact customer satisfaction with the program. However, it does put some additional responsibility on the customer, or building designer, to follow through with the project as planned. Similar to this is the process of splitting projects into multiple phases over several years if there are significant construction or operational changes or delays.
    - *Developing "typical" loads for central plant and datacenter projects.* Using previously evaluated projects, Energy Trust could develop typical values seen for overall IT utilization and central utility plant utilization. These wouldn't be used as the basis for developing savings estimates, but would instead be used as a flag for further investigation should a customer propose something higher than what is typically seen.
    - *Continuing with follow-up evaluations at later dates.* Energy Trust is already engaging in this process as it is what was used for this follow-up. Having the ability to re-evaluate projects in the future after the appropriate loading may have

been realized is a reasonable approach. This process should continue when possible and determined to be a productive use of evaluation funds.

- **Establish processes for accurately claiming negative, measure level, cross fuel savings.** Energy Trust's tracking system appears to be ignoring measure level negative interactions due to how data is entered into the system. These measure level savings ultimately result in ex ante claimed savings that differ from the program staff calculated estimates for a given project. Due to this being a documentation and tracking error, Energy Trust should explore options for adding cross-checks at the project level to ensure that the proper interactive measure level savings are recorded in the system.