Impact Evaluation

2015 – 2016 New Buildings Program: Final Report

April 24, 2019

Energy Trust of Oregon

Energy Trust of Oregon

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Contents

MEMO

Date: January 10, 2020
To: Board of Directors
From: Jessica Iplikci, Senior Program Manager, Commercial
Dan Rubado, Evaluation Project Manager
Subject: Staff Response to 2015-2016 New Buildings Impact Evaluation

The 2015-2016 New Buildings impact evaluation conducted by Michaels Energy showed high electric realization rates in both years (97% and 96%, respectively) that were consistent with past years of the program. However, gas realization rates were somewhat lower (86% and 90%, respectively) and there were significant variances in evaluated gas savings for a variety of reasons. Michaels Energy offered specific explanations for these variances and found that savings adjustments were frequently not within the control of the program, such as modifications to building schedules and operating parameters. The evaluator provided recommendations for potential improvements, which the Program is considering. These include modifications to specific prescriptive measures to improve savings assumptions. In addition, the evaluator recommended improvements specific to the building simulation modeling process. However, some of the issues and recommendations become irrelevant under the new 2019 Oregon energy code.

New Buildings staff plans to make the following changes and process improvements in response to these recommendations:

- Continue adjusting the site verification process to align with detailed program requirements that are the basis of energy estimates. One adjustment will be to include the number of multifamily units built to account for any final changes made during construction.
- Although the evaluator recommended engaging customers post-occupancy to obtain more accurate information on final equipment specifications and operations, we believe this is beyond the scope of the program and it's not workable for customers, but our evaluation process serves the purpose of calculating final energy saved.
- Parametric model runs were identified by the evaluator as one way to simplify the simulation modeling process rather than developing separate building models to determine the savings impact of each measure implemented. The program allows for parametric modeling; however, it can be cost-prohibitive and is not always the best choice for modeling each project. Under the state's new code, this is expected to become less of an issue.
- Energy Trust's approach to modeling hybrid HVAC systems is to work with customers early in their design process to determine a reasonable hybrid baseline with a similar HVAC fuel mix to the proposed building. Better matching of the baseline model heating fuel ratio, as recommended by the evaluator, would be challenging, time-consuming, and costly. Rather than impose more onerous modeling guidelines, the program will continue to track cross-fuel interactions.
- The condensing boiler measure has been updated to better estimate savings.
- As the program is redesigned to work with the 2019 Oregon energy code, the energy modeling process for LEED projects will have the same modeling requirements as other whole building projects.

The program will continue utilizing TMY3, shorthand for total meteorological year, a historic weather file for building energy modeling, whenever possible to complete the program's technical reviews and will add this detail to our checklist. Energy Trust will also allow the use of the new typical weather year data, currently under development, once available.

Executive Summary

This report summarizes the results of the impact evaluation of the Energy Trust of Oregon 2015-2016 New Buildings program completed by Michaels Energy, in partnership with Evergreen Economics and PWP Inc. (Michaels team or Michaels). The goals for this evaluation were to support Energy Trust's ongoing efforts to improve program performance by:

- Develop reliable estimates of the New Buildings program gas and electric savings for the 2015 and 2016 program years at a 90/10 confidence and precision level for each year.
- Develop reliable estimates of the New Buildings program gas and electric savings for the combined 2015 and 2016 program years at the building-use type level at a confidence and precision level of 90/15.
- Report important observations about New Buildings projects and making recommendations for specific changes to help Energy Trust improve the accuracy and effectiveness of future program savings estimates and the results of future impact evaluations.

The realization rates of this impact evaluation are shown below in Table 1 and Table 2.

Table 1 | Program Level Realization Rates

Year	Fuel	Ex Ante	Ex Post	Realization Rate	Relative Precision, 90% Confidence
2015	Electric (kWh)	42,603,421	41,376,442	97%	1%
	Natural Gas (therms)	527,045	451,519	86%	2%
2016	Electric (kWh)	44,152,290	42,439,181	96%	1%
	Natural Gas (therms)	693,943	621,912	90%	2%

Table 2 | Realization Rates and Relative Precision by Building Type

Building Use Type	Sampled Projects	Realization Rate, kWh	Realization Rate, therms	Relative Precision at 90% Confidence, kWh	Relative Precision at 90% Confidence, therms
Multifamily-Market-Rate/Campus Housing	29	106%	84%	4%	2%
Multifamily-Affordable	8	91%	93%	5%	6%
Multifamily-Assisted Living	9	77%	92%	5%	4%
Data Center	5	93%	N/A	1%	N/A
Warehousing & Industrial	19	96%	89%	2%	3%
Hospitality	13	98%	102%	3%	5%
Elementary School	16	97%	85%	3%	8%
Middle-High School	9	91%	80%	6%	5%
College/University	8	84%	91%	8%	4%
Retail Grocery	13	100%	100%	0%	0%
Retail Non-Grocery	15	92%	92%	10%	5%
Office	8	96%	83%	4%	3%
Health	3	97%	69%	1%	5%
Other	11	103%	84%	6%	3%
Total	**166**	**97%**	**88%**	**1%**	**1%**

Key observations and recommendations to improve the accuracy and effectiveness of future program savings estimates and the results of future impact evaluations are summarized below. In addition to these, Section 4 provides secondary observations and recommendations that had less impact on the program for this evaluation, but have the potential for greater impact in future years if not addressed.

Overall Observation – The program implementer accurately estimated electric and natural gas savings for the program. In particular, adjustments to savings for factors within the implementer's control (documentation error, baseline changes, tracking error, and calculation or engineering error) were less than 4%. This is commendable.

Observation 1 – (38) projects were found to be installed differently than calculated. Many of these adjustments were due to design changes that were not incorporated in the final savings analysis. This issue was most pronounced with multifamily facilities.

> **Recommendation 1A –** Engage customers during the final stage of project completion to ensure final equipment specifications and quantities are consistent with project analysis.

> **Recommendation 1B –** Consider expanding the verification of multifamily buildings and update project analysis based on the completed facility.

Observation 2 – Low flow fixtures (faucet aerators and showerheads) had poor realization rates in the 2014 evaluation with 82% electric and 42% gas savings. The 2015 and 2016 evaluation found significantly better results for these measures at 96% for electric and 87% for gas. However, there were instances of under-claimed quantities related to multi-family facilities using the number of apartments instead of the number of bathrooms for quantities. Devices were also found to be removed due to tenant dissatisfaction. Tenant dissatisfaction varies but stems from low flow fixtures directly impacting day to day activities. Dissatisfied occupants either didn't understand the benefits of reduced water and energy usage or the benefits are not valued enough to offset the day to day impact of the low flow devices.

> **Recommendation 2 –** Continue to engage with customers and tenants where these devices are installed and remind customers about their purpose and benefits to reduce the number of dissatisfied occupants.

Observation 3 – Market solutions measures are entered in the tracking system in several different ways. Specifically, some projects claimed their "package" of measures with one entry while other projects tracked their "package" with individual measures listed as base measures and elective measures. While this does not impact verified savings, it limits the understanding of the market solutions program track measure make-up.

> **Recommendation 3 –** Consider claiming all market solutions packages measure-by-measure indicating the base and elective measures. This will allow the Program Management Contractor (PMC) to make informed decisions about the individual program measure performance.

Observation 4 – Four prescriptive condensing boiler gas projects were found to have claimed savings that represented a significant portion of the facilities natural gas usage – higher than what can be reasonably attributed to the installation of a condensing boiler. This suggests that a combination of oversizing and redundant boilers were incentivized.

> **Recommendation 4 –** Investigate the methodology and inputs such as boiler efficiency and effective full load hours for the Measure Approval Document for hot water condensing gas boilers. In addition, investigate additional screening to identify backup or oversized boiler systems. Alternatively, other metrics could be investigated to estimate savings and y the sizing of the boiler system for a facility. Metrics could include savings based on building type and square footage, or boiler size or quantities capped at typical BTU/square foot for different building types.

Specific recommendations for modeling projects:

Observation 5 – Hybrid Baselines have proven challenging for the program to consistently model correctly. These projects utilize two fuel sources for either heating or cooling or both. These complex systems make it difficult to develop a code compliant baseline that captures the energy savings without calculating savings for a fuel source shift. Not accounting for a fuel source shift amounts to fuel switching which is prohibited in the Energy Trust of Oregon New Buildings Program Technical Guidelines manual section 2.2.4 "Avoiding Fuel Switching".

> **Recommendation 5A –** The Technical Guidelines Manual in section 2.2.4 does provide guidance on selecting the appropriate baseline for hybrid systems. This could be further expanded providing more clarity around additional situations identified by the program such as heat recovery chillers. In addition, these projects could benefit from a hybrid

baseline specific review at the start of the modeling process and again at the end to ensure full compliance with the guidelines.

Recommendation 5B – Regardless of fuel type, any increase in energy usage due to fuel source shifting associated with a measure or project should be accounted for by the program. This can be accomplished by reporting the increased usage with the savings, allowing the other measures to offset the increased usage, or adjusting the baseline model to better match the mix of fuel types in both the baseline and proposed models. The latter is more challenging and will likely not fully mitigate the fuel switch. Modelers would benefit from additional guidance identifying metrics for when the models are close enough.

Observation 6 – As part of the calculation of savings for the LEED projects, ASHRAE 90.1-2004 and 2007 were used to develop the baseline building models. Adjustment factors were applied to the baseline simulated energy use to account for code discrepancies. Updating the baseline models to meet the applicable codes showed that the adjustment factors that were used to estimate the baseline energy use were, in some cases, very inaccurate and could lead to grossly underestimated or overestimated savings.

Recommendation 6 – Baseline building models should be updated to be consistent with all applicable codes, rather than applying an adjustment factor to the baseline energy use to account for code discrepancies.

Observation 7 – Some of the modeling projects that were evaluated included a mixture of modeled measures and prescriptive measures for which the savings were determined independently of the models. In one particular instance, the savings for a central boiler were calculated using a prescriptive track, but because the boiler is a critical part of the HVAC system, in the *ex post* savings calculations the building model was used to determine the boiler savings. This resulted in a significant adjustment to the savings for the boiler. Measures for ENERGY STAR® appliances and other similar items were always calculated outside of the building models, which is reasonable as the modeling software is not designed to calculate appliance loads with high levels of precision.

Recommendation 7 – To most accurately account for interactive effects between measures and equipment types, it is recommended that when building models exist for a project, the building models be used to calculate savings for all HVAC, lighting, and building envelope whenever possible.

Observation 8 – There were a total of 13 measures across seven projects for which the savings were determined by developing a separate building model with the measure implemented, but the savings could have easily been determined using parametric runs. Parametric runs have several benefits over developing separate building models – making changes to the models is easier due to fewer modeling files, it is easier to tell what changes are made with the implementation of measures, and it eliminates the risk of discrepancies existing between building models.

Recommendation 8 – Whenever possible, the savings for energy efficiency measures should be determined using parametric runs.

Observation 9 – Throughout the evaluation process of the modeling projects it was noted that some of the building simulations were run using TMY2 weather data, while some were run using TMY3 weather data. TMY3 weather data is based on more recent weather data and includes actual months of meteorological data rather than average values that exist in TMY2 weather data. TMY3 is widely regarded as the standard for developing weather-dependent savings estimates and metrics.

> **Recommendation 9 –** All reported savings for modeling projects should be determined using simulations run with TMY3 weather data from the nearest weather station.

Observation 10 – In some of the modeling projects evaluated, custom efficiency curves and performance curves were created for the installed energy efficient equipment. However, the data that defines these curves was stored in supplementary files in the file directory for the model, and not in the modeling file itself. Because of this, not all of the received models could be used to run simulations. This was especially prevalent with modeling files that were used to simulate variable refrigerant flow (VRF) system operation. Performance curves were able to be added to the models so simulations could be run, but it is unlikely that the curves that were added to the models are the same as what were used to calculate the *ex ante* savings.

> **Recommendation 10 –** Include all supplementary files used to develop the building model, including any custom performance and efficiency curves.

1. Introduction

Energy Trust of Oregon delivers energy efficiency programs to customers of PGE, Pacific Power, NW Natural, Cascade Natural Gas, and Avista in Oregon as well as NW Natural in southwest Washington. The New Buildings program is a long-standing part of the Energy Trust portfolio and has been offered since 2003[1].

The New Buildings program supports the design, construction, and major renovation of energy efficient commercial buildings from early design to occupancy. It uses a variety of services and incentives, including early design assistance, technical service incentives, and installation incentives. The savings and incentives are determined through four distinct types of measures:

- **Prescriptive:** Prescriptive measures calculate savings based on a standardized or "deemed" savings amount per unit installed. These measures are typically limited to straightforward technologies, such as appliances, or measures with savings values supported by prior research efforts.
- **Calculated:** Calculated measures are more flexible than prescriptive. These measures use a predefined calculation methodology, but the inputs to the analysis are based on actual site conditions. This includes many lighting measures, which are based on actual lighting wattages and hours of operation but use a template for the calculations.
- **Market Solutions:** Market solutions measures use a "bundled" approach with pre-packaged sets of prescriptive and calculated measures for each building type.
- **Custom:** Custom calculated measures are the most flexible approach. These measures use custom-built engineering analyses or building simulations to calculate the impacts of energy efficiency improvements.

Additionally, the projects are completed through four distinct program tracks.

- **Data Center:** This track focuses specifically on data center opportunities.
- **Market Solutions:** This track offers a streamlined participation approach by presenting customers with "Good", "Better", "Best", and "Very Best" packages of measures, specific to the building type. This track uses workbooks based on pre-modeled prototypical buildings to calculate energy savings and incentives.
- **System-based:** This track uses a combination of individually selected prescriptive and custom calculated measures to quantify savings and incentives.
- **Whole Building:** Whole building projects utilize custom building simulations, developed by approved program allies, to quantify whole building and measure-level energy savings. This track is typically reserved for large or complex projects. The whole building track includes Path to Net Zero projects.

The New Buildings program is implemented by a third party program management contractor (PMC). Prior to 2009, Portland Energy Conservation, Inc. (PECI) was the PMC. In 2014, PECI was acquired by CLEAResult, the current PMC.

This report summarizes the results of the impact evaluation of the Energy Trust of Oregon 2015-2016 New Buildings program completed by Michaels Energy, in partnership with Evergreen

[1] 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.

Economics and PWP Inc. (collectively the Michaels team or Michaels). The goals for this evaluation are to support Energy Trust's ongoing efforts to improve program performance by:

- Develop reliable estimates of the New Buildings program gas and electric savings for the 2015 and 2016 program years.
- Develop reliable estimates of the New Buildings program gas and electric savings for the combined 2015 and 2016 program years at the building use type level at a confidence and precision level of 90/15.
- 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.

In addition to these goals, Energy Trust staff also identified the following research questions for the program:

- Are there any specific aspects of the energy simulation models, engineering calculations, analytic approaches, or baselines used in the energy savings analyses that may be of concern to Energy Trust?
- Are there any improvements that could be made to the PMC's technical review of energy savings analyses?
- Are there errors in any of the assumptions used in energy savings analyses, either in the original savings estimates or in the verification of energy savings?
- What factors result in large variances in *ex ante* vs evaluated savings (assumptions too conservative, incorrect hours of operation, etc.)?
- Are there external factors affecting the program's ability to forecast and estimate savings?
- Were recommendations made in previous impact evaluations implemented, and if so, how have these changes affected the program?
- Does Michaels have any specific recommendations regarding the energy savings analysis approaches and assumptions used by the program?
- Low flow devices persistence: does this equipment remain installed? If no, why?
- Building Models: what changes to models and/or calibration are made for savings verification?

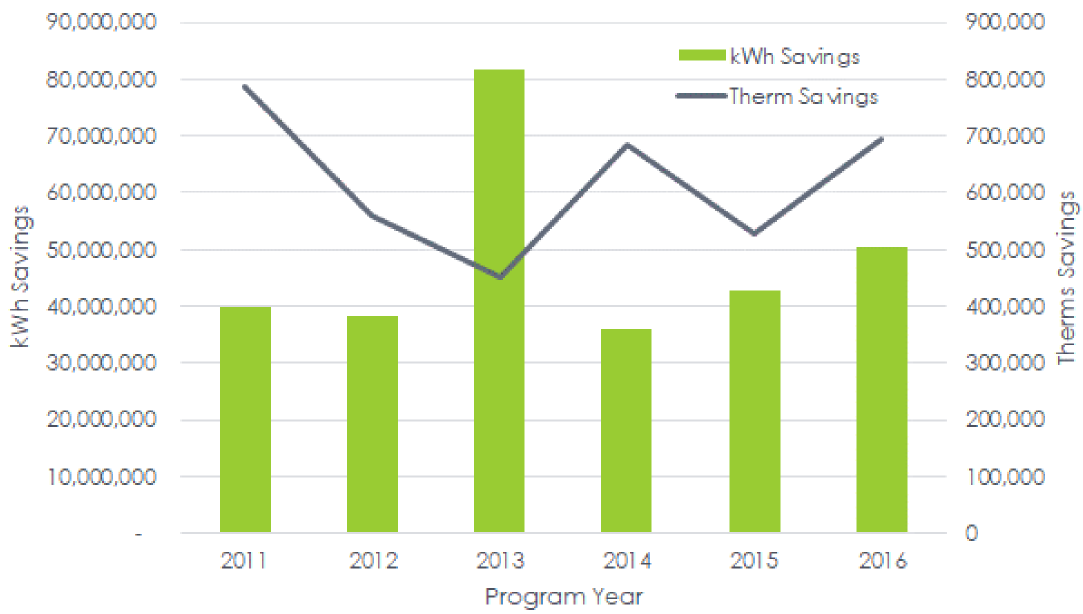
These research questions are addressed throughout this report.

1.1 | Program Background

Since 2011, the electric savings for the New Buildings program have been relatively consistent, with the exception of 2013[2]. A summary of program performance for electric and gas savings for 2011 through 2016 is shown in Figure 1.[3]

[2] The reported electric savings for 2013 were much greater due to five large projects (including one very large project) that accounted for 48 GWh of electric savings - 60% of reported electric savings
[3] The savings shown 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.

Figure 1 | New Buildings Program Performance Summary



1.2 | Savings by Building Type

The New Buildings program provided incentives to a wide variety of building types in program years 2015 and 2016. Data centers had the highest electric energy savings for 2015 and 2016. These seven projects accounted for over 28 GWh, or over 30% of the electric energy savings for the program. Data centers were also a significant portion of the 2014 program year savings, with only retail grocery stores providing more savings. However, in 2014 the seven projects only accounted for 6.2 GWh while in 2015-2016 the seven data center projects accounted for 28.1 GWh. The average savings per data center project in 2015-2016 was 4.5 times as much as in 2014, with the majority of the savings for this category due to two projects completed for the same data center customer. These two projects account for more than 15 GWh. A summary of the savings claimed by building type for the 2015 and 2016 program years is shown in Table 3.

Table 3 | 2015 and 2016 Claimed Savings by Building Type[4]

Building Use Type	Projects	Electric Savings (kWh)	Natural Gas Savings (therms)
Multifamily-Market-Rate/Campus Housing	97	15,188,532	413,694
Multifamily-Affordable	20	1,676,992	45,649
Multifamily-Assisted Living	16	3,386,698	70,264
Data Center	6	21,781,078	0
Warehousing & Industrial	117	13,896,906	63,854
Hospitality	97	2,380,838	172,337
Elementary School	37	1,577,006	102,086
Middle-High School	26	1,472,098	59,460
College/University	24	4,491,164	51,104
Retail Grocery	62	4,607,692	7,676
Retail Non-Grocery	81	5,764,290	54,339
Office	42	3,032,147	41,692
Health	7	539,214	64,205
Other	115	6,961,056	74,628
Total	**747**	**86,755,710**	**1,220,988**

1.3 | Savings by Measure Type

The electric savings for the 2015 and 2016 program years were roughly equal between the custom and prescriptive analysis methods. However, the prescriptive gas savings were double the custom gas savings. For both electric and gas, the measure count is significantly higher for prescriptive measures, while the average savings per prescriptive measure was less than the average custom measure. This is typical for programs with both prescriptive and custom measures.

A summary of the types of custom and prescriptive measures completed through the program in 2015 and 2016 can be seen in Table 4. Several of the measure categories displayed do not fall within only custom or only prescriptive measures. These include data centers, LEED, and market solutions. In addition, the data centers and market solutions measures can be confused with the program tracks with the same names. Specifically, data center measures can occur in multiple program tracks while the data center program track can include measures not specific to data centers, such as lighting or HVAC upgrades. These measures are not included as data center measures. The market solutions measures in the table are limited to the claimed packages of market solutions measures. The individual measures for these projects are not tracked and can therefore not be separated into their individual prescriptive measures. It is noted that the later market solutions projects did track the measures separately and are shown divided into their individual prescriptive measures. The LEED measures are all part of the whole buildings program track and are custom measures largely using building simulations and bundle the savings for all

[4] The savings shown in Table 3 do not include a datacenter project which was removed from the evaluation to be evaluated separately. This project claimed 6,327,333 kWh in the 2016 program year.

of the improvements to the building to meet LEED requirements. The individual measures are not tracked and cannot be separated into different custom measure types.

Table 4 | Summary of 2015 and 2016 Savings Claimed by Measure Type

Measure Type	Count of Measures	Electric Savings (kWh)	Gas Savings (therms)
Standard Clothes Washer	41	344,111	6,674
Standard Controls	6	72,383	0
Standard Food Service	230	618,461	107,743
Standard HVAC	229	5,044,902	160,549
Standard Lighting	739	34,567,537	-994
Standard Motors	8	399,362	0
Standard Refrigeration	75	1,417,207	48,060
Standard Water Heating	445	2,104,458	382,008
Standard Sub-Total	**1,773**	**44,568,420**	**704,041**
Market Solutions	**72**	**7,765,337**	**195,228**
Custom Controls	1	4,706	1,076
Custom Gas	5	568	12,160
Custom HVAC	41	7,735,342	31,195
Custom Lighting	31	1,251,882	0
Custom Other	202	5,399,700	178,759
Custom Refrigeration	7	155,350	0
Data Center	27	24,500,970	0
LEED	10	1,700,769	98,530
Custom Sub-Total	**324**	**40,749,286**	**321,720**
Total	**2,169**	**93,083,043**	**1,220,988**

2. Evaluation Methodology

The approach taken for each step of the evaluation is described in detail in the following sections.

2.1 | Sampling

Energy Trust provided the Michaels Team with the tracking system extract that included the complete 2015 and 2016 program participation data, including all projects and measures. Evergreen Economics (Evergreen) performed the sample design based on this data set and the primary evaluation goals outlined by Energy Trust listed below:

- Verify the electrical energy savings (kWh) and natural gas savings (therms) at the 90/10 confidence and precision level for 2015 and 2016, individually.
- Verify the electrical energy savings (kWh) and natural gas savings (therms) at the 90/15 confidence and precision level for building-use type categories (combined 2015 and 2016 data).

2.1.1 | Sample Design

To achieve the target levels of confidence and precision of 90/10 or better by fuel type for each of the program years as well as 90/15 or better by building-use type, the population of projects was segmented by program year and building-use type as shown in Table 5 and Table 6.

Table 5 | Universe of Projects for 2015 Program Year

Building Use Type	Projects	Electric Savings (kWh)	Natural Gas Savings (therms)
Multifamily-Market-Rate/Campus Housing	37	6,124,488	163,608
Multifamily-Affordable	10	924,563	7,110
Multifamily-Assisted Living	4	348,885	1,826
Data Center	3	14,188,447	0
Warehousing & Industrial	51	7,482,100	52,005
Hospitality	53	767,530	84,063
Elementary School	17	712,301	60,118
Middle-High School	12	957,716	36,670
College/University	5	921,461	0
Retail Grocery	35	2,765,758	5,907
Retail Non-Grocery	36	2,089,603	30,851
Office	17	2,023,184	30,612
Health	3	254,358	9,313
Other	45	3,043,026	44,964
Total	**328**	**42,603,421**	**527,045**

Table 6 | Universe of Projects for 2016 Program Year[5]

Building Use Type	Projects	Electric Savings (kWh)	Natural Gas Savings (therms)
Multifamily-Market-Rate/Campus Housing	60	9,064,044	250,086
Multifamily-Affordable	10	752,429	38,540
Multifamily-Assisted Living	12	3,037,813	68,438
Data Center	3	7,592,631	0
Warehousing & Industrial	66	6,414,806	11,849
Hospitality	44	1,613,308	88,274
Elementary School	20	864,706	41,967
Middle-High School	14	514,382	22,791
College/University	19	3,569,703	51,104
Retail Grocery	27	1,841,933	1,770
Retail Non-Grocery	45	3,674,687	23,488
Office	25	1,008,963	11,080
Health	4	284,856	54,892
Other	70	3,918,030	29,664
Total	**419**	**44,152,290**	**693,943**

Our team reviewed project information from the tracking system and selected a subset of the projects for evaluation as a certainty stratum. These projects included:

- Up to four of the largest electric and/or gas savings projects for each building type.
- Projects that contributed more than10% of the total energy savings for a building-use type.
- All Path to Net Zero (PTNZ) projects, regardless of size or building type.

The remaining (non-certainty) projects for each program year and building-use type were sampled separately by *ex ante* gas savings and *ex ante* electric savings through application of the Dalenius-Hodges method.[6]

Evergreen used the Neyman Allocation method to allocate the desired number of sample points (approximately 160 based on budget constraints) to each of the four sample frames[7]. The Neyman Allocation method is used to determine the optimal distribution of a fixed number of sample points across the segmented sample frame. The allocation is based on the distribution of projects and *ex ante* energy savings across building-use types, the relative variability in *ex ante* savings for each building-use type, and the level of confidence and precision required[8].

[5] The savings shown in Table 6 do not include a datacenter project which was removed from the evaluation due to it being evaluated separately. This project claimed 6,327,333 kWh in the 2016 program year.

[6] For more information on the Dalenius-Hodges method, see Section 5A.7 of Sampling Techniques, 3rd Edition, by William G. Cochran.

[7] kWh for 2015, therms for 2015, kWh for 2016, and therms for 2016

[8] For this evaluation, the desired confidence and precision is 90/10 as stated previously.

Evergreen built in flexibility to add additional sample points for building-use types that contained the largest concentration of projects within the market solutions program track[9]. We found the market solution program track was underrepresented in the 2014 evaluation. By including additional sample points in the evaluation of the 2015 and 2016 program years, we were able to ensure a robust representation of market solutions in this impact evaluation.

Many of the projects completed in 2015 and 2016 contained both electric and natural gas savings. Since the Michaels team evaluated at the project level, we captured both electric and gas savings when there was overlap. In order to account for this within the sample, we computed the "fuel-overlap" ratio for each building-use type and program year. The fuel-overlap ratio is the proportion of projects with both *ex ante* electric and gas savings for the population of projects. As Table 7 shows, the fuel-overlap ratios differ considerably by building-use type and to a lesser degree by the two program years.

Table 7 | Fuel-Overlap Ratio by Building Type for 2015 and 2016 Program Years

Building Use Type	2015 Ratio	2016 Ratio
Multifamily-Market-Rate/Campus Housing	59%	55%
Multifamily-Affordable	40%	60%
Multifamily-Assisted Living	50%	83%
Data Center	0%	0%
Warehousing & Industrial	18%	14%
Hospitality	55%	36%
Elementary School	44%	20%
Middle-High School	29%	50%
College/University	25%	29%
Retail Grocery	0%	47%
Retail Non-Grocery	14%	7%
Office	36%	19%
Health	53%	24%
Other	33%	25%

The fuel-overlap ratio was used to reduce the number of natural gas sampled sites needed within each building type. An example of how the fuel-overlap ratio was used for the 2016 multifamily market-rate stratum can be seen in Figure 2. The fuel-overlap ratio was only applied to the probability strata projects.

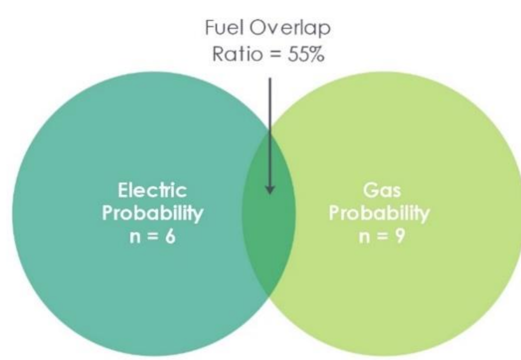


Figure 2 | MF Market Rate Fuel Overlap Sample

In this sampling example each fuel independently would require a total of 15 sample points for the multifamily stratum. However, accounting for

[9] The 2015 and 2016 program data shows that multifamily property, hospitality, and office have the highest concentrations of market solutions projects.

the 55% of electric projects that also contain gas savings allows us to capture the same level of confidence and precision with only 10 probability sites.

2.2 | Sample Summary

In total, the sample for the impact evaluation consisted of 166 sampled projects covering both electric and gas savings projects. There were a total of 75 certainty sites across the 14 building-use types. Certainty sites are projects with particularly large *ex ante* savings relative to other projects within a building-use type. These sites make up 82% of the sample and 62% of the program evaluated kWh savings and 68% of the sample and 44% of the program evaluated therm savings. The remaining 91 sites were randomly selected and are referred to as probability sites.

Table 8 | Summary of Final Sample

Group	Project Count	Measure Count	Electric Savings (kWh)	Gas Savings (therms)
Program Total	747	2165	86,755,710	1,220,988
Sample total	166	729	60,156,639	780,578
Sample Share of Total	22%	34%	69%	64%

The sample provided excellent coverage across the building-use type categories used during this evaluation. Table 9 and Table 10 show the number of sample projects, as well as the *ex ante* electric (kWh) and natural gas (therms) savings for each building-use type.

Table 9 | Sample Frame and Sampled Sites for 2015 Program Year

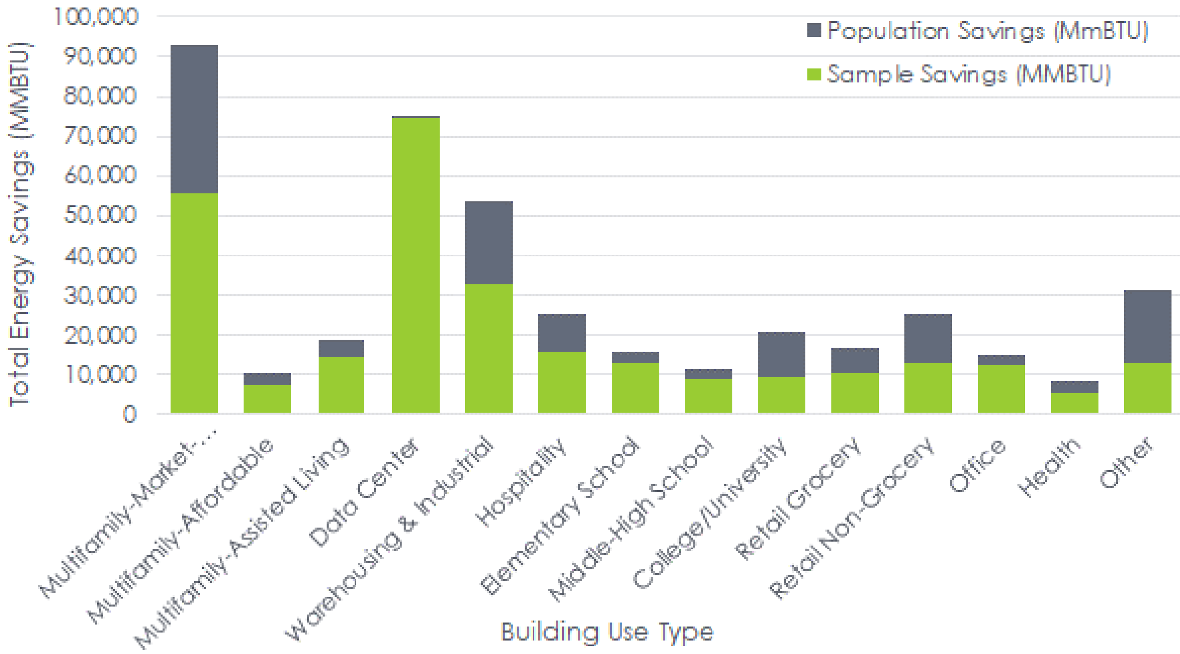
Building Use Type	Projects and Ex Ante Savings			Sample Points		
	Projects	kWh	Therms	Certainty	Probs	Total
Multifamily-Market-Rate/Campus Housing	37	6,124,488	163,608	6	10	16
Multifamily-Affordable	10	924,563	7,110	2	2	4
Multifamily-Assisted Living	4	348,885	1,826	2	0	2
Data Center	3	14,188,447	0	3	0	3
Warehousing & Industrial	51	7,482,100	52,005	3	7	10
Hospitality	53	767,530	84,063	2	5	7
Elementary School	17	712,301	60,118	2	4	6
Middle-High School	12	957,716	36,670	3	2	5
College/University	5	921,461	0	1	1	2
Retail Grocery	35	2,765,758	5,907	3	5	8
Retail Non-Grocery	36	2,089,603	30,851	2	7	9
Office	17	2,023,184	30,612	1	2	3
Health	3	254,358	9,313	0	2	2
Other	45	3,043,026	44,964	4	2	6
Total	**328**	**42,603,421**	**527,045**	**34**	**49**	**83**

Table 10 | Sample Frame and Sampled Sites for 2016 Program Year

Building Use Type	Projects and Ex Ante Savings			Sample Points		
	Projects	kWh	Therms	Certainty	Probs	Total
Multifamily-Market-Rate/Campus Housing	60	9,064,044	250,086	5	8	13
Multifamily-Affordable	10	752,429	38,540	3	1	4
Multifamily-Assisted Living	12	3,037,813	68,438	3	4	7
Data Center	3	7,592,631	0	3	0	3
Warehousing & Industrial	66	6,414,806	11,849	4	4	8
Hospitality	44	1,613,308	88,274	4	2	6
Elementary School	20	864,706	41,967	6	4	10
Middle-High School	14	514,382	22,791	3	1	4
College/University	19	3,569,703	51,104	2	4	6
Retail Grocery	27	1,841,933	1,770	3	2	5
Retail Non-Grocery	45	3,674,687	23,488	2	4	6
Office	25	1,008,963	11,080	2	3	5
Health	4	284,856	54,892	0	1	1
Other	70	3,918,030	29,664	2	3	5
Total	**419**	**44,152,290**	**693,943**	**42**	**41**	**83**

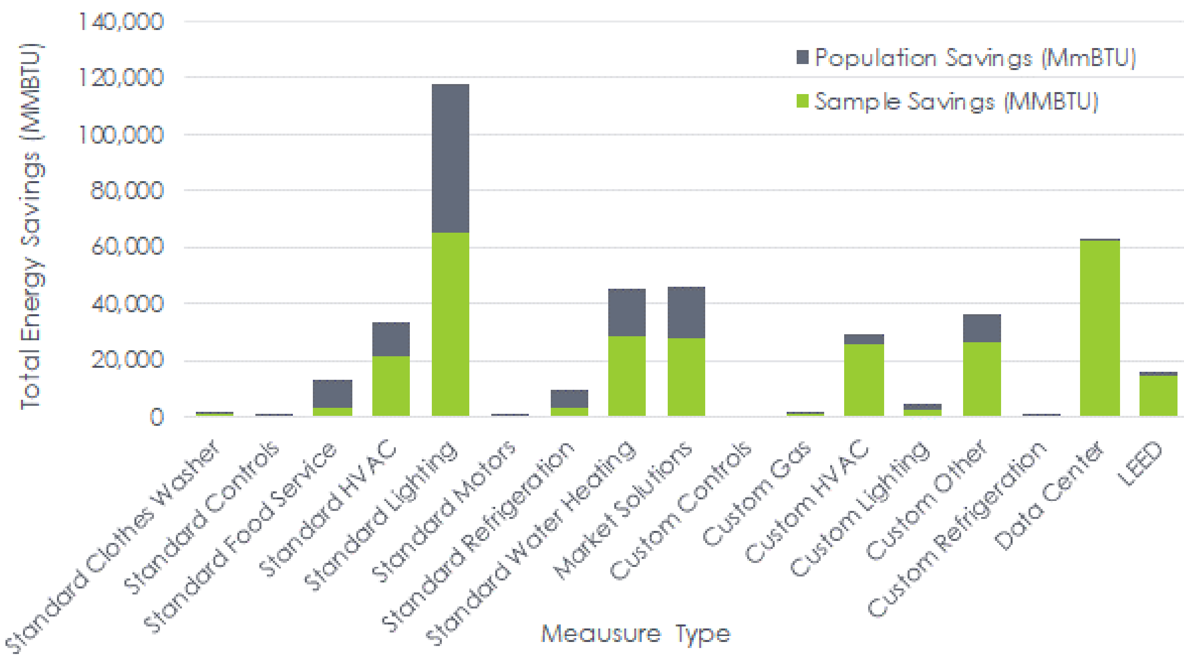
As shown in Figure 3, only two of the 14 building categories (College/University and Other) had less than half of their total energy savings included in the sample. Figure 3 shows the relative savings of the sample compared to the population for each of the building-use types with the electric and therm savings converted to site MMBtu.

Figure 3 | Sample Savings Overlapping Program Population Savings by Building Use Type in MMBtu for 2015 and 2016



The sample was also reviewed to ensure adequate representation of the measure categories included in the program. Figure 4 shows the relative savings at the measure level. The sampled projects included more than half of the savings in the program for Standard: Controls, HVAC, Lighting, Motors, and Water Heaters; Market Solutions; Custom: Gas, HVAC, Lighting, Refrigeration, Data Centers, and LEED. Only four measure types had less than 50% of savings evaluated, which were minor contributors to program savings. A detailed breakdown of measure type mapping can be found in Appendix B | Measure Type Mapping.

Figure 4 | Sample Savings Overlapping Program Population Savings by Measure Type in MMBtu for 2015 and 2016



A summary of the sample savings by building type is shown in Table 11. More details on the building-use type mapping to the tracking system building type can be found in Appendix A | Building Type Mapping.

Table 11 | Summary of Sample Savings and Overlap with Program Population by Building Type for 2015 and 2016

Building Use Type	Projects	Ex Ante kWh Savings	Share of Program kWh Savings in Sample	Ex Ante Therms Savings	Share of Program Therm Savings in Sample
Multifamily-Market-Rate/Campus Housing	29	8,876,810	58%	254,695	62%
Multifamily-Affordable	8	978,719	58%	40,104	88%
Multifamily-Assisted Living	9	2,451,765	72%	57,971	83%
Data Center	5	21,774,374	100%	0	N/A
Warehousing & Industrial	19	8,376,789	60%	40,503	63%
Hospitality	13	1,864,818	78%	90,946	53%
Elementary School	16	1,126,692	71%	88,188	86%
Middle-High School	9	1,106,852	75%	49,347	83%
College/University	8	2,330,858	52%	14,175	28%
Retail Grocery	13	2,822,529	61%	4,440	58%
Retail Non-Grocery	15	2,467,076	43%	41,984	77%
Office	8	2,531,773	83%	33,880	81%
Health	3	482,720	90%	37,471	58%
Other	11	2,964,863	43%	26,874	36%
Total	**166**	**60,156,639**	**69%**	**780,578**	**64%**

2.3 | Data Collection

Michaels worked with Energy Trust and the Program Management Contractor (PMC), CLEAResult, to conduct outreach to project contacts. Specifically, CLEAResult emailed all customers in the sample and provided updated contact information when available. These emails introduced the project contacts to the Michaels team and were beneficial in increasing the number of project contacts that could be reached and scheduled. CLEAResult also identified customers that should not be contacted due to reasons such as dissatisfaction with the program or ongoing disputes.

The majority of the projects evaluated were evaluated directly by the Michaels team. Ecotope was conducting a Code Compliance study at the same time as this evaluation, with eight projects that overlapped with the sample for this program. In order to minimize the customer burden, Ecotope provided final site reports and *ex post* savings for the following overlap sites (NBC15 01, NBC15 04, NBC15 26, NBC16 03, NBC16 33, NBP16 05, and site visit findings and notes for NBC16 06).

Table 12 provides a summary of completed evaluation activities, including the breakdown of desk review, site inspection, and Ecotope overlap. The following sections provide detail for the evaluation activities that met the goals set forth in the Work Plan.

Table 12 | Summary of Evaluation Activities[10]

Evaluation Activity	Project Count	Measure Count	Electric Savings (kWh)	Gas Savings (therms)
Desk Review	42	197	12,512,707	188,333
Site Inspection	110	488	44,440,505	479,367
Ecotope Overlap	8	44	3,203,427	112,877
Total in Sample	160	729	60,156,639	780,578
Evaluated Separately	1	4	6,327,333	0
Total	**161**	**733**	**66,483,972**	**780,578**

2.3.1 | Documentation Review

Energy Trust provided Michaels with information about each project that, with some exceptions, included the following items:

- **Documentation File:** PDF file that included key pieces of documentation such as applications, savings summaries, and important eligibility information or discussions. It also contained specifications for the installed equipment, images of relevant building plans or schematics, and PDFs of spreadsheet calculations when applicable.
- **Verification Site Visit Summary:** PDF file that contained the program's verification results, measures claimed, specifications for pertinent equipment, and verification of equipment installation.
- **Communications:** A list of relevant emails between the customer, Outreach Manager, builder, and technical review team.
- **Final Technical Files:** 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.

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

- 2012 New Buildings Evaluation Report
- 2014 New Buildings Evaluation Report
- Measure Approval Documents (MADs) for the standard and market solutions measures
- New Buildings Program Technical Guidelines
- 2015-2016 program tracking data
- Model Calibration Summary Info
- New Buildings project file structure details

[10] There were a total of 6 projects that had measures claimed in both 2015 and 2016. These projects count in both program years resulting in a total of 166 projects in the evaluation; whereas it's a total of 160 facilities.

The project and program-level data were used to develop a more detailed understanding of each project, the important components, equipment and its specifications, and relevant site specific details. Michaels also used this information to assign projects for a desk review evaluation or for a more rigorous site evaluation approach.

2.3.2 | Desk Reviews

Michaels completed a total of 42 desk review projects. Projects with low levels of uncertainty and low impact were designated as desk reviews. We evaluated additional sites that could not be evaluated through site inspection using a desk review approach. These sites included a site designated as "do not call" at the request of Energy Trust or CLEAResult and two sites that refused a site evaluation. The remaining sites included projects where site contacts changed and new contacts could not be found, building ownership had changed, no response from contact attempts, or responses were limited and were not successful in scheduling a visit.

During the desk reviews, we compared equipment specifications to program qualifications to ensure that all equipment met program requirements. Similarly, we verified the equipment sizes and efficiency levels were properly applied to the deemed savings calculations. Desk reviews were also used to develop the site specific measurement and verification plans (SSMVPs) which detailed the equipment to be inspected and the data to be collected to support the impact evaluation.

2.3.3 | Site Inspection and Data Collection

Michaels completed 110 site visits per the approved site-specific measurement and verification plans (SSMVPs). A site engineer physically verified measures. Depending on the specific measure, this activity included counting lighting fixtures, recording nameplate information from HVAC equipment, and spot-checking the loading of motors for pumping equipment. Critical operating characteristics and control sequences were also investigated and evaluated.

For projects best evaluated with data logging and metering, the SSMVP stipulated the data collected, including the specific equipment metered, the types of meters installed, and the metering intervals and durations. Metered data were used to confirm equipment operating schedules and to develop profiles of typical operation. The operating profiles were used to update the original savings analysis, when warranted. To maximize data collection effectiveness, we supplemented metered data with utility interval data or trend data from building automation systems, whenever possible.

For projects selected for site inspection and evaluation, we conducted interviews with facility operators. During these interviews, we verified the information in the project file such as measure installation, assumptions in the analysis, and operational characteristics of project energy efficiency measures. For desk review projects, the interview focused on high-level characteristics such as equipment types, operating schedules, and control set-points. We also inquired about the availability of utility interval data for applicable systems.

2.4 | 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. The following sections discuss the various data analysis methods employed including: prescriptive (deemed) approach, calculated prescriptive approach, market solutions approach, custom approach, and building simulations approach. Each one of these approaches has its own benefits and limitations and are discussed below. Included is the methodology to calculate the realization rates and how the reasons for adjustments are categorized.

2.4.1 | Prescriptive (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, low-flow plumbing fixtures, high-efficiency water heaters, and some HVAC equipment. A summary of the prescriptive measures that were included in the sample is provided in Table 13.

Table 13 | Summary of Sampled Prescriptive Measures

Measure Category	Measure Count	Electric Savings (kWh)	Gas Savings (therms)
Screw-in LED Lamps	14	1,359,925	0
Efficient Residential Appliances	32	248,398	2,647
Efficient Commercial Laundry Equipment	6	6,305	534
Efficient Commercial Food Service Equipment	50	124,152	26,296
Efficient Water Heaters	52	0	88,717
Low Flow Plumbing Fixtures	93	885,473	120,455
Efficient HVAC Equipment & Controls	75	2,208,173	112,020
Refrigerated Case Measures	9	232,303	0
Total	**331**	**5,064,729**	**350,669**

Many of Energy Trust's measures are based on savings estimates and calculations developed through the Regional Technical Forum (RTF), an advisory committee of the Northwest Power and Conservation Council. Energy Trust reviewed and vetted these measures and has an established process to seek approval for exceptions to OPUC policies in certain cases. Since there has been a considerable review of the prescriptive savings previously, the Michaels team did not duplicate that work during this evaluation.

Instead, field engineers verified the installed quantites for each measure, verified that the installed equipment was being used and still operational, and that the equipment met the program qualifications. The savings for these measures were revised as appropriate by adjusting the quantities of qualifying equipment.

2.4.2 | 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. These calculated savings were most common for lighting measures, but were also used for some electric HVAC measures. A summary of the reviewed measures that utilized calculation templates for the *ex ante* savings is provided in Table 14.

Table 14 | Summary of Sampled Measures with Calculation Template

Measure Category	Measure Count	Electric Savings (kWh)	Gas Savings (therms)
Interior Lighting	77	13,589,985	0
Exterior Lighting	40	2,359,510	0
Interior Lighting Controls	14	1,040,681	0
Packaged Heat Pumps & Unitary Air Conditioners	6	718,775	0
Total	**137**	**17,708,951**	**0**

The parameters used in the calculations were either pre-defined, or specifically defined to match a particular application. For example, the savings for lighting occupancy sensors were fixed at 25% for each site with controls indicated. Lighting hours of use, however, could either use predetermined schedules, or the daily schedule could be used for that customer.

For measures that used calculation templates for the *ex ante* savings, Michaels determined the *ex post* savings using the same calculation template. For each of the evaluated projects the inputs used in the template was checked to ensure they were consistent with the project documentation and the information collected during the site visits. Parameters which were deemed, such as the occupancy sensor control savings percentage, were adjusted if deemed necessary to match site visit findings.

2.4.3 | Market Solutions

Similar to the standard savings measures, market solutions measure savings are determined based on pre-determined per-unit savings values. For some measures, the savings are based on the affected building area (in square feet), while others are based on equipment capacities or quantities.

The analysis approach for the market solutions measures varied widely across the different measures that were reviewed. For the lighting measures, when possible, the actual quantities, wattages, and operating hours of the installed lights were used to determine the as-built energy use. Lighting wattage and lighted areas were used to develop power density in Watts per square foot. This power density is compared to code-allowable power density to determine the *ex post* savings. For many of the market solutions HVAC measures, the installed equipment was checked to ensure that the correct quantities and capacities were being reported, and that all of the installed equipment was used regularly (and not a backup piece of equipment), and adjustments were made to the savings calculations when necessary

2.4.4 | Custom Engineering Calculations

There were 129 measures that used custom engineering calculations with savings of 32,200,768 kWh and 148,079 therms in the sample. A breakdown of these custom measures is provided in Table 15.

Table 15 | Summary of Sampled Custom Measures

Measure Category	Measure Count	Electric Savings (kWh)	Gas Savings (therms)
HVAC	16	4,218,253	3,496
Custom Gas Measure	3	0	11,794
Building Shell	5	124,793	0
Lighting	14	675,454	0
Data Centers	16	24,482,266	0
Commercial Kitchens	4	45,488	2,467
Motors	4	210,166	0
Refrigerated Cases	3	360,018	13,770
Other Measures	64	2,084,330	116,552
Total	**129**	**32,200,768**	**148,079**

Similar to building simulation projects, 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 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 estimate normalized annual *ex post* savings.

2.4.5 | Building Simulations

The sample of projects evaluated included 19 projects for which some or all of the project savings were determined using whole building modeling. Of these 19 projects, 16 analyses were performed using eQuest building models, two using Trane Trace models, and one using Integrated Environmental Solutions Virtual Environment (IESVE) software. The projects with modeling included many different building types including hotels, office buildings, recreation facilities, education facilities, healthcare offices, a gym, and others. Eleven site visits were completed for projects with modeling, and eight projects with modeling were evaluated with a desk review.

The *ex ante* modeled savings are summarized in Table 16. It should be noted that some projects included a combination of measures with modeled savings, measures with prescriptive savings, and measures with custom savings calculations (determined outside of the building models). The table below only includes modeled savings.

Table 16 | Summary of Sampled Building Types with Modeled Savings

Facility Type	Project Count	Ex Ante Electric Savings (kWh)	Ex Ante Gas Savings (therms)
Education	3	516,291	7,253
Healthcare	2	2,110,519	111
Office	5	1,554,202	20,526
Hospitality	2	795,013	2,774
Multifamily	5	369,007	67,951
Other	2	415,293	14,836
TOTAL	**19**	**5,601,517**	**113,451**

A significant portion of the savings for the modeling projects is from energy efficient HVAC systems and equipment that were installed, and other common modeled measures include increased insulation, energy efficient windows, and efficient interior lighting. A breakdown of the types of modeled measures and the savings by measure type is provided in Table 17.

Table 17 | Summary of Sampled Measures with Modeled Savings

Measure Type	Measure Count	Ex Ante Electric Savings (kWh)	Ex Ante Gas Savings (therms)
HVAC	18	3,500,529	23,329
Building Shell	20	281,283	0
LEED	3	1,367,529	83,271
Lighting & Lighting Controls	8	451,494	0
Domestic Hot Water	11	683	6,843

We evaluated modeled measures using the following steps:

1. If a site visit was completed, the *ex ante* savings calculations were checked against the information collected during the site visit and we updated the model as necessary. Updates often involved changing temperature set points and schedules, supply and return water temperatures for heating systems, cooling systems, and condenser water loops, temperature reset schedules, duct pressure set points, ventilation controls, lighting schedules, and occupancy schedules. If only a desk review was completed we checked the models against the information provided in the project documentation, and adjusted the model as necessary.
2. For projects with solar panels on-site, we used historical energy generation of the solar system when available and estimated the monthly energy generation shape using an online tool[11] published by NREL that accounts for the location, rated capacity, and the orientation of the solar panels.
3. If monthly billed energy use data for the facility were available, simulations were run with the as-built model using weather data from the same time period as the billed energy use data. The total energy use (billed energy use plus any solar generation) was

[11] NREL PVWatts Solar Calculator; https://pvwatts.nrel.gov/

compared to the modeled energy use to gauge how well the models reflect the actual operation of the buildings.

4. If discrepancies were found between the energy use of the facility and the simulation results that were determined using actual weather data from the period that billed energy use data were available, adjustments were made based on how the energy use values compared. Possible adjustments include, but were not limited to, the following:
    a. If the simulated energy use was higher or lower than the actual energy use by roughly the same amount each month, this indicates that a constant load needs to be adjusted, which can be done by adjusting parameters used to model the equipment loads (computers, servers, other equipment), lighting schedules, or HVAC fan operation and controls. A review of the model inputs, the information collected during the site visit, and the information provided in the project documentation was used to determine what the most likely source(s) of such discrepancies would be, and what adjustments would be most appropriate.
    b. If the discrepancy in energy use was greater during the summer than during the winter, the controls for the cooling system were reviewed and adjusted if deemed necessary. Quite often this can include adjusting ventilation rates and/or internal energy sources (people, etc.), economizer controls, doing an in-depth review of the cooling temperature schedules for the various areas of the building, and if there is hydronic cooling, an in-depth review of the water temperature and flow controls.
    c. If the discrepancy in energy use was greater during the winter months, the type and configuration of the heating system largely dictated what parameters needed to be evaluated more in depth and adjusted if deemed appropriate and were determined on more of a case-by-case basis. For a building with VRF systems and DOAS, ventilation rates and system efficiencies can have a significant impact on electric energy use and should be checked via any available set points or trended data. In a building with hot water boiler and electric zone reheats, the supply air temperature and ventilation controls significantly impact the electric use during the heating season.

Eight of the projects with modeling did not have billed energy use data available, and thus calibrating the building model to the actual energy use of the facility could not be completed. The absence of billed energy use data was due to a variety of factors, including the building being part of a larger campus of buildings and not being separately metered, the generation of the on-site solar exceeding the energy use of the building (so the billed energy use is zero all the time), or the facility having district steam and/or chilled water that is not accounted for in the billed energy use of the facility. In such cases, the building models were updated simply by using all available pertinent information from the site visit and the project documentation.

When changes were made to as-built building models, the same changes were also made to the baseline models if the changes were not related to a claimed measure or a code requirement. For model parameters relating to a claimed measure, the as-built model was updated according to the information collected during the site visit, and the parameters in the baseline model were checked to ensure they met all applicable code requirements.

Permit dates for the individual projects were checked to ensure the correct codes were used in the development of the baseline models, and the applicable HVAC system efficiencies and controls, lighting power density values and lighting control methods, building construction requirements, and other pertinent requirements were checked (and adjusted if necessary) to ensure that the baseline models met all requirements.

After all adjustments were made to the building models as described above, simulations were run using TMY3 weather data from the nearest location that such weather data were available, and the savings shown by the models and parametric runs for the various measures are the *ex post* savings.

2.4.6 | 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 and each project. 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 electric and gas fuels to determine the electric and natural gas realization rates (as applicable) for each measure.

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

The individual 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 ante* savings for each measure and dividing by the sum of the *ex post* 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 the evaluated results up to the building type results and overall program level realization rates for both electricity and natural gas savings for the 2015 and 2016 program years, as described in Section 2.5.

2.4.7 | Categorization of Adjustments

To understand why projects are adjusted and to identify trends and impacts, we categorized each adjustment. The specific categories used are:

- **Documentation Error:** These adjustments are made because the quantities or efficiencies of measures verified during the site visit were inconsistent with the project documentation. Inconsistencies may include finding a different number of lighting fixtures or discovering that a water heater is heated with natural gas instead of electricity.

- **Baseline Change:** These adjustments are due to the wrong baseline equipment, system, or efficiency used to estimate savings; for example, using the incorrect baseline HVAC system from the Oregon Energy Efficiency Specialty Code.
- **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 and savings claimed by the program.
- **Calculation or Engineering Error:** These are adjustments made because of errors in applied engineering principles, calculations, or building simulations. These could include mathematical errors such as dividing instead of multiplying by an efficiency value, or incorrect unit conversions.
- **Operated or Installed Differently:** These are adjustments made because the equipment operates differently than expected. This could include different loading operating 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.

These adjustment categories help to identify specific issues that need improvement. For instance, baselines apply to all projects but it is possible that HVAC system types for baselines are consistently in error. We have found that categorizing adjustments in this way results in far more actionable recommendations.

2.5 | Data Aggregation

The final step in the evaluation process was to aggregate the electric and gas savings results from individual evaluated projects back to the program population in order to assess the program realization rates by building type as well as by year. In addition, the project results were aggregated by measure type in order to identify notable trends or significant adjustments specific to individual building or measure types.

2.5.1 | Building Type Aggregation

The building-type realization rates were determined based on the weighted average realization rate of all of the projects for that building type. The weight for each project was based on the *ex ante* savings, and the relative size of the project savings and the sampled savings within the strata and the relative size of the strata compared to the total population of the building type.

Specifically, certainty project (very large projects that the evaluation team wanted to ensure were included in the sample) were combined into a certainty stratum. Because these projects were not selected randomly, the realization rates for these projects were not extrapolated to any other project, but instead were applied to that project.

Probability projects (projects selected randomly through the sampling process) were also combined into strata, based on size (for example small projects were combined with other small projects). Within each stratum, the individual project realization rates are weighted, based on the ex ante savings relative to the total sampled savings for the strata, in order to determine an overall strata realization rate. The overall strata realization rate is then applied to the population, based on the relative savings of the population for the strata compared to the total savings for the building type.

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.

The total savings and the savings used to weight the certainty and probability strata within each building category are shown in Table 18 and Table 19 for electric and natural gas savings, respectively.

Table 18 | Sample and Program Population Electric Savings Used for Weighting Building Type Results for 2015 and 2016

Building Use Type	Certainty Sample Electric Savings (kWh)	Probability Sample Electric Savings (kWh)	Program Population Electric Savings (kWh)
Multifamily-Market-Rate/Campus Housing	5,263,998	9,924,535	15,188,532
Multifamily-Affordable	749,702	927,290	1,676,992
Multifamily-Assisted Living	1,770,342	1,616,357	3,386,698
Data Center	21,774,374	6,704	21,781,078
Warehousing & Industrial	6,071,077	7,825,828	13,896,906
Hospitality	1,693,673	687,165	2,380,838
Elementary School	825,907	751,099	1,577,006
Middle-High School	776,148	695,950	1,472,098
College/University	1,961,327	2,529,837	4,491,164
Retail Grocery	1,863,320	2,744,372	4,607,692
Retail Non-Grocery	1,883,552	3,880,738	5,764,290
Office	946,077	2,086,070	3,032,147
Health	0	539,214	539,214
Other	2,233,235	4,727,821	6,961,056
Total Program	**47,812,730**	**38,942,980**	**86,755,710**

Table 19 | Sample and Program Population Natural Gas Savings Used for Weighting Building Type Results for 2015 and 2016

Building Use Type	Certainty Sample Gas Savings (therms)	Probability Sample Gas Savings (therms)	Program Population Gas Savings (therms)
Multifamily-Market-Rate/Campus Housing	164,391	90,304	413,694
Multifamily-Affordable	33,869	6,235	45,649
Multifamily-Assisted Living	30,274	27,697	70,264
Data Center	0	0	0
Warehousing & Industrial	37,099	3,404	63,854
Hospitality	75,686	15,260	172,337
Elementary School	52,641	35,547	102,086
Middle-High School	46,429	2,918	59,460
College/University	12,690	1,485	51,104
Retail Grocery	1,812	2,628	7,676
Retail Non-Grocery	30,312	11,672	54,339
Office	23,244	10,636	41,692
Health	0	37,471	64,205
Other	24,360	2,514	74,628
Total Program	**532,808**	**247,770**	**1,220,988**

2.5.2 | Program Level Aggregation

Once the building-level realization rates were calculated, the program-level realization rates, by year and by fuel, could also be determined. We computed the program level results as the weighted average realization rates across all building types for each fuel and year, utilizing the total savings by building type shown in Table 18 and Table 19.

Due to the complexity associated with the evaluation sample frame and the wide-ranging variability in *ex ante* energy savings per project, we developed approximate confidences intervals using the bias-corrected and accelerated bootstrap method (BCa) developed by Efron[12] (1987). In situations in which the empirical distribution of data is skewed, BCa confidence intervals are more accurate than standard percentile-based methods, while retaining robustness.

2.5.3 | Measure Level Aggregation

The savings for each measure were by measure type. There were a total of 189 different measure types in the 2015 and 2016 program tracking data. The Michaels team rolled these individual measures types into categories of similar measures. A full map of how the measures were categorized can be found in Appendix B | Measure Type Mapping.

Results at the measure level were calculated using a simple sum of savings approach. The sum of *ex post* savings for all measures in that category was divided by the sum of the *ex ante*

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

savings. The end results were not extrapolated back to the population, but instead are only used to understand the frequency and magnitude of adjustments within each measure category.

2.6 | Energy Intensity Analysis

In addition to evaluating the energy savings for each project, the energy use intensity (EUI) for each building was reviewed. The EUI analysis examined the total electric and natural gas usage for each building, normalized per square foot of building area, in order to examine the effectiveness and efficacy of participant buildings.

To determine the energy intensity of each building, the Michaels team requested billed energy use histories for all projects in the sample. Energy Trust was able to provide either electric or natural gas billing histories for 154 of the sites in the sample. The energy usage histories contained monthly billing data from as far back as possible through April 2018. These data were analyzed and cleaned, and the building space types were characterized to provide as-built and reference EUIs for past evaluations and building stock assessment surveys. Electric and gas energy use were aggregated to determine the total building EUI, irrespective of the specific heating fuel type.

2.6.1 | Billed Energy Use Data Cleaning

The customer billed energy use data required a substantial amount of cleaning to provide useful energy use for each project. In some cases, the new building was an addition or part of a larger building complex which contained aggregated billed energy use data for building areas that were not part of the program. In order to draw useful conclusions about the energy intensity in the participating buildings, the billed energy use data were analyzed and cleaned to provide the average annual energy intensity for the subset of building spaces and systems that were part of the program.

After removing customers for which the billed energy use history was not available, or where the energy use for the specific project could not be isolated from aggregate billing, the annual EUI was determined for 77 projects. Usually the most recent 12 months of billing data were used to determine the EUI. However, for 20 buildings, the EUI was estimated from the billed energy use data, or taken from customer-provided sub metering. Estimated values were typically used for the following reasons:

- On-site solar. Some facilities had on-site solar generation which reduced the total billed energy use. When feasible, the solar output of the on-site arrays was estimated for the relevant installation, or was recorded from the solar installations during the site visits.
- Customer sub metering: Several projects were completed on campuses for which did not have utility data for each individual building. If available, sub metered data from the customer was used to estimate the EUI.
- Billing or occupancy anomalies: The billed energy use was estimated if there were billing or occupancy anomalies over the past 12 months.

The 83 projects that EUI data could not be developed occurred for several reasons. Approximately 40 projects have missing electric or gas energy records, about 30 projects were portions of larger buildings or campuses and the energy records could not be separated from the rest of the facility, and an additional 6 projects did not include tenant records resulting in incomplete data sets.

2.6.2 | Building Area Adjustments.

Once the total energy use for each project was known, it was necessary to develop and categorize the building space types and areas. The project building areas for which the billed energy use data had been collected was confirmed using project documents and satellite images. The total energy use was compared to the total relevant area to determine the EUI for each building type.

The as-built EUI for the 2015 and 2016 projects were compared against typical values for that building type from several other data sets. The previous evaluations for 2014[13] and 2012[14], the 2014 NEEA Commercial Building Stock Assessment (CBSA)[15], the National 2012 Commercial Building Energy Consumption Survey (CBECS)[16], and the City of Portland Planning and Sustainability Commercial Building Energy Performance data[17]. In some cases, the project involved two building types or areas. If the secondary building type was significant, then a blended CBECs baseline was developed for these buildings. In most cases, these adjustments were made when the project included a large parking garage that would dilute the consumed energy across a large area. A few projects also included restaurants or other retail spaces on the first floor of an office building. In the end, baseline and as-built EUI data were developed for 77 projects, from each of the strata used in the sample design.

[13] 2014 New Buildings Program Impact Evaluation. Michaels Energy. May 5, 2017. https://www.energytrust.org/wp-content/uploads/2017/12/2014-NB-Impact-Evaluation-Final-Report-wSR.pdf

[14] 2012 New Buildings Program Impact Evaluation. Cadmus Group. April 26, 2015. https://www.energytrust.org/wp-content/uploads/2016/12/2012_New_Buildings_Program_Impact_Eval_final_w_SR.pdf

[15] 2014 Commercial Building Stock Assessment. Navigant Consulting. December 16, 2014. https://neea.org/img/documents/2014-cbsa-final-report_05-dec-2014.pdf

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

[17] City of Portland Commercial Building Energy Performance. https://www.portlandoregon.gov/bps/75062

3. Results

Following the data collection and project level analysis, the Michaels team compiled the results to provide program level results. Michaels also examined the results at the building type level and measure type level to identify trends or reasons for savings adjustments.

3.1 | Program Realization Rates

The Michaels team developed program level estimates of gross electric (kWh) and natural gas (therms) savings based on the 166 projects (83 for 2015 and 83 for 2016) sampled. As shown in Table 20, the results exceed the 90/10 confidence and precision target outlined in the sampling plan.

Table 20 | Program Level Results

Year	Fuel	Ex Ante	Ex Post	Realization Rate	Relative Precision
2015	Electric (kWh)	42,603,421	41,376,442	97%	1%
	Natural Gas (therms)	527,045	451,519	86%	2%
2016	Electric (kWh)	44,152,290	42,439,181	96%	1%
	Natural Gas (therms)	693,943	621,912	90%	2%

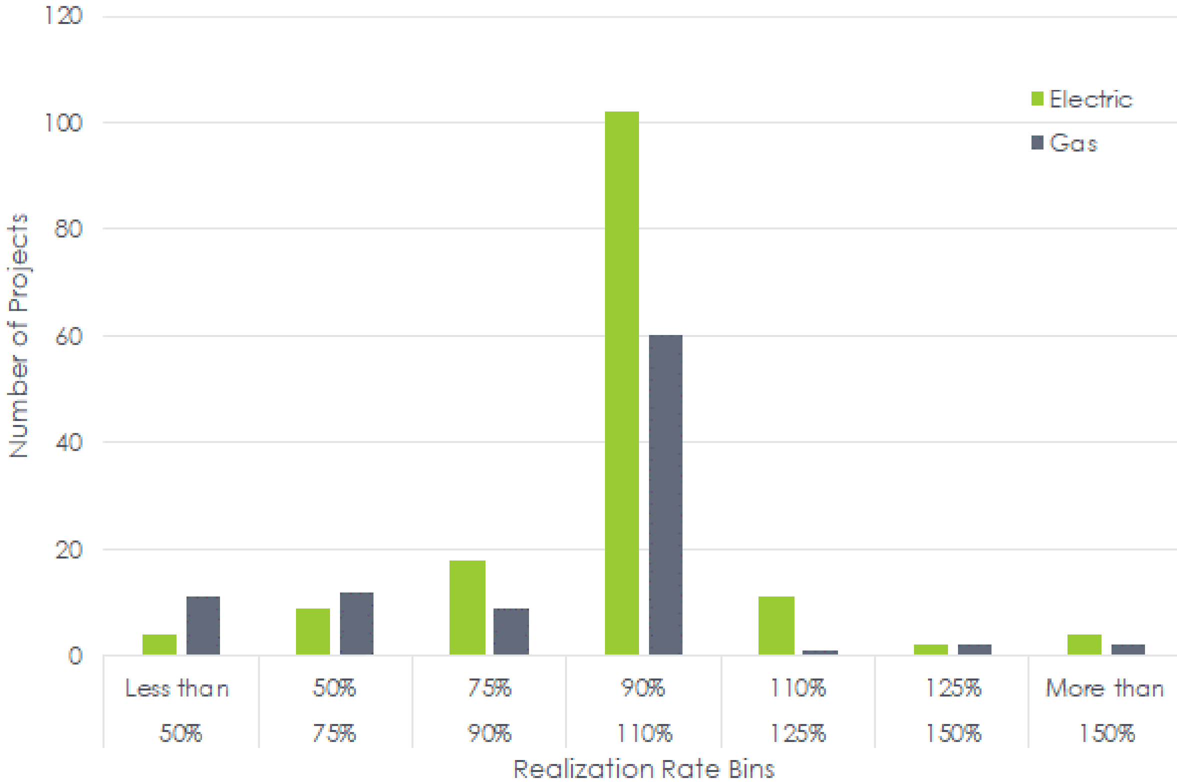
The electric realization rates from the 2015 and 2016 program years were very similar to 2014 and higher than in 2011 and 2012. The gas realization rates from the 2015 and 2016 program years were lower than the previous evaluations. A graph showing the comparison of the realization rates from 2015 and 2016 to the previous six years can be seen in Figure 5.

Figure 5 | Recent Historical Program Realization Rates[18]

The 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 2015 and 2016 evaluation sample. Figure 6 shows the realization rate for each project in the sample grouped into realization rate bins where it is shown that the majority of projects achieve a realization rate near 100%.

[18] Program Year 2013 results were not included in the comparison above. The program did not receive a comprehensive evaluation in 2013 since previous evaluation results had been very consistent.

Figure 6 | Frequency Analysis of Project Realization Rates

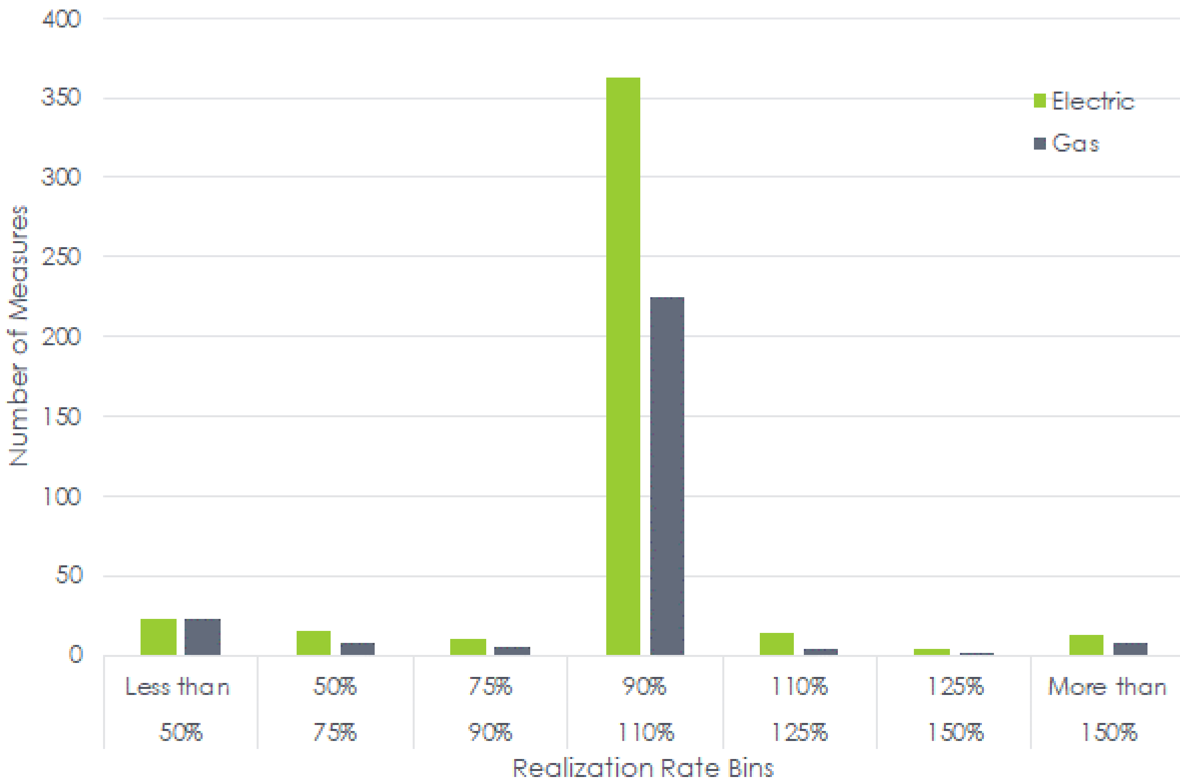


The results from Figure 6 are consistent with the prior evaluation with a small reduction in gas savings compared to previous evaluations. A large number of projects with less than 10% adjustment is due in part to the prescriptive projects. The realization rate for these projects is not changed unless the equipment is not installed, does not qualify, or is claimed incorrectly. These projects tend to have a binary distribution, with realization rates being either near 100% or at 0%, due to measure disqualification. The high number of projects with minimal savings adjustment shows that the PMC is doing a good job screening out ineligible measures.

The PMC is also doing an excellent job of collecting hours of operation, quantities, equipment specifications, and other important operational parameters. The program is accomplishing this through the verification on-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 operation information that feeds custom calculations and building simulations.

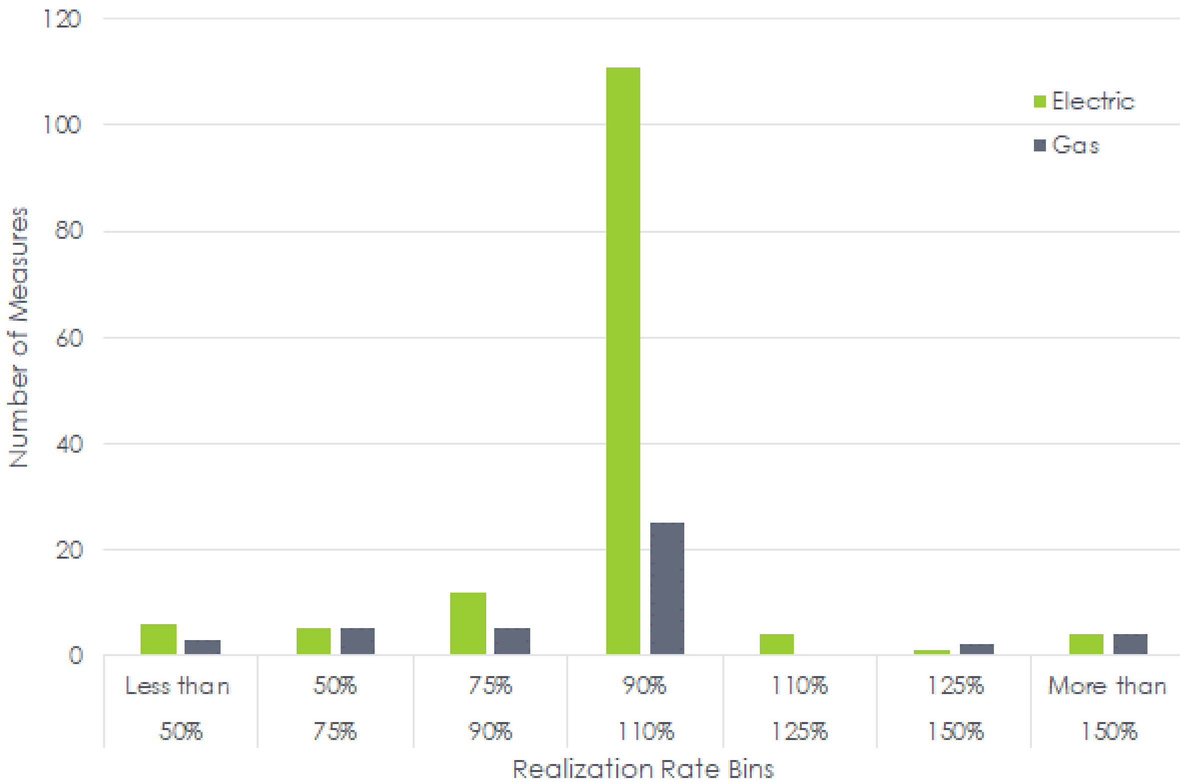
The same type of patterns is visible when the results were examined by overall analysis type, either standard or custom. Standard measures included deemed measures, calculated measures, and market solutions measures. Custom measures included savings determined by custom engineering analyses as well as building simulations. Figure 7 and Figure 8 show the realization rate frequency for standard 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 7 | Standard Measure Realization Rate Frequency Analysis



There were 564 standard measures included in the sample, 442 with electric savings and 272 with gas savings. There were 75 measures with both electric and gas savings. The realization rate for standard electric measures was 96% in the sample. The realization rate for standard gas measures was 88% for measures in the sample.

Figure 8 | Custom Measure Realization Rate Frequency Analysis



There were 164 custom measures included in the sample, 143 with electric savings and 44 with gas savings. There were 11 measures with both electric and gas savings. The realization rate for custom electric measures in the sample was 94%. The realization rate for custom gas measures in the sample was 83%.

3.2 | Results by Program Track

The Michaels team also estimated realization rates for the different program tracts. Table 21 shows the breakdown of savings between the program tracks for the entire population.

Table 21 | Summary of 2015 and 2016 Savings Claimed by Program Track

Program Track	Project Count in Sample	Electric Savings (kWh)	Natural Gas Savings (therms)
Data Center	5	21,774,374	0
Market Solutions	102	12,875,391	323,546
System-Based	608	45,286,046	749,235
Whole Building	32	6,819,900	148,207

Table 22 and Table 23 provide the electric and gas realization rates by program type. Each program track is able to use the prescriptive, standard, and custom measure categories:

Table 22 | Sample Electric Realization Rates by Program Track

Program Track	Project Count in Sample	Ex Ante Electric (kWh)	Ex Post Electric (kWh)	Electric Realization Rate
Data Center	5	21,774,374	20,258,244	93%
Market Solutions	35	7,630,968	7,802,223	102%
System-Based	93	24,631,651	23,403,570	95%
Whole Building	22	6,058,772	5,891,949	97%

Table 23 | Sample Gas Realization Rates by Program Track

Program Track	Project Count in Sample	Ex Ante Gas (therm)	Ex Post Gas (therm)	Gas Realization Rate
Data Center	0	0	0	N/A
Market Solutions	27	189,802	177,250	93%
System-Based	58	458,160	409,930	89%
Whole Building	13	132,616	95,918	72%

Overall, there is little difference in electric realization rates between the four program tracks, but there is a moderate amount of variation in gas realization rates between the program tracks. The four program tracks are run very differently, and for each track there are unique factors that account for the adjustments made to the savings calculations (see section 3.3 | Results by Measure Type for more detail).

3.2.1.1 | Data Center

Seven data center projects were completed in 2015 and 2016. These seven projects account for less than 1% of the program participation, but more than 30% of the total program savings. One large data center project was evaluated separately and not included in this evaluation. The six remaining projects still accounted for more than 25% of the program savings. Five data center projects are included in the sample.

This large savings per project for data centers means that each project has significant potential, but also a significant risk as relatively small changes to operation can result in large changes to the overall project (and program) savings. This is illustrated by project NBC15 11 in this evaluation. The project achieved a 90% realization rate but saw a reduction in savings of 1,515,172 kWh. While relatively small for this project, the savings adjustment accounts for 62% of the operated/installed differently adjustments made to the sample.

3.2.1.2 | Market Solutions

Overall, the market solutions program track had the smallest savings adjustments for both electric and gas, and there were no systematic or common factors found that caused any significant adjustments for this program track. Some of the market solutions measures were claimed as "packages", whereas others were claimed individually, and there is not a significant difference in realization rates between the "package" measures and the individual measures. It is worth noting that these "packages" do make it challenging to fully understand the market solutions program track as it hides the type and number of measures as well as how they perform.

3.2.1.3 | System-Based

The system-based program track covers a large, diverse set of measures. The system-based program track is the largest both in terms of energy savings and number of measures. There were no common or systematic factors that contributed to any significant adjustments to the savings for this program track, although small adjustments were common within specific measure types. The most notable adjustment was the hours of operation adjusted for lighting measures based on the information provided by the customers during the completed site visits.

3.2.1.4 | Whole Building

The whole building track includes several specialty tracks including projects that have included a LEED certification process and projects with aggressive goals of becoming net zero energy. The following tables show the sample realization rates for these project types.

Table 24 | Sample Electric Realization Rate for Whole Building Project Type

Whole Building Project Type	Project Count in Sample	Ex Ante Electric (kWh)	Ex Post Electric (kWh)	Electric Realization Rate
Path to Net Zero	6	597,675	580,332	97%
LEED	5	1,725,733	1,683,674	98%
Standard	11	3,735,364	3,627,943	97%
Whole Buildings Total	22	6,058,772	5,891,949	97%

Table 25 | Sample Gas Realization Rate for Whole Building Project Type

Whole Building Project Type	Project Count in Sample	Ex Ante Gas (therm)	Ex Post Gas (therm)	Gas Realization Rate
Path to Net Zero	6	11,733	11,043	94%
LEED	5	92,430	66,696	72%
Standard	11	28,453	18,179	64%
Whole Buildings Total	22	132,616	95,918	72%

The whole building program track *ex post* savings resulted in a small adjustment to the total electric savings, but included a large reduction in gas savings. Multiple factors contributed to the gas savings reduction, including:

- **Hybrid Baselines –** New buildings are more frequently including advanced heating and cooling systems utilizing two or more fuel sources such as both electric and gas heating. This can create the potential for high efficiency options shifting heating and cooling loads between these fuel sources. This shifting of loads is specifically prohibited in the Energy Trust of Oregon New Buildings Program Technical Guidelines manual section 2.2.4 "Avoiding Fuel Switching". There were two projects found in the course of the evaluation that found hybrid baselines that did not adequately model hybrid baselines for different reasons.

The first project (NBC16 18) involved the installation of variable refrigerant flow (VRF) HVAC systems as well as gas-fired zone heating systems. The baseline model was developed to use both gas and electric just like the proposed model, but the baseline model was configured to use significantly more electric heat and less gas heat. This resulted in significant electric savings while increasing natural gas usage. This increase in usage is not due to interactive effects that can be ignored but due to a portion of the heating load being met by the gas system instead of the electric system in the proposed model. This is prohibited and is to be avoided. The project should have either included the increase gas usage as a penalty or adjusted the baseline model to more closely match the portion of the heating load provided by the gas system to result in no shifting of load.

The second project (NBP15 42) included an HVAC system with hot water coils in the air handling units and reheat boxes. The hot water is provided by gas boilers and a heat recovery chiller. The baseline used a hybrid system with hot water coils in the air handling units and electric resistance heat in the VAV boxes. This shifted a significant portion of the heating load from gas to electric in the baseline. As a result even all of the heat recovered by the heat recovery chiller could not overcome the increased gas load in the proposed model. The baseline selected for this project was an inappropriate hybrid baseline and the Technical Guidelines specifically prohibit modeling the baseline using a different fuel source. The proposed heating system is supplied by gas boilers and the baseline system should also have used hot water for both the air handling unit and the VAV boxes. This would have resulted in the project achieving significant gas savings at the expense of a small increase of electrical usage for the heat recovery chiller. It is important to include the increase in electrical usage for the heat recovery at the project level as it is an integral part of the system to achieve the gas savings. This is no different than including the increased electrical usage for an energy recovery wheel for increased fan power and for operating the wheel.

Hybrid baselines are challenging to model correctly and it is critical that the models do not shift heating and cooling loads between fuel types. The program needs to capture these shifts in fuels to ensure energy savings are not being claimed for a shift in the fuel source. This can be accomplished by including the increased energy usage in the claimed savings or adjusting the baseline model to equalize the fuel sources. However, adjusting the baseline model is more challenging and can create secondary issues with the models.

- **Building & Energy Codes -** The baselines used in some simulations were inconsistent with energy codes. Although they did not have a big impact on savings, the following baseline changes were made in multiple projects:
    - Reducing the window glazing to 30% of vertical above-grade wall area
    - Adjusting baseline gas heating equipment efficiencies to code-minimum values
    - Setting heat recovery effectiveness to 50% where required by code

    - Adjusting baseline lighting power densities to be consistent with code allowable values
- **VRF Systems -** There were several buildings modeled with eQuest that involved the installation of Variable Refrigerant Flow (VRF) HVAC systems to provide heating and cooling throughout the facility. eQuest 3-64 and 3-65 do not have built-in tools for modeling VRF systems, but there are published workarounds for how to set up eQuest to simulate the operation of VRF systems. These workarounds involve importing or manually entering custom performance curves and capacity curves that are applied to air-source heat pump systems in the models, and the curves are saved in supplementary files within the file directory for the eQuest model. In multiple instances, the supplementary files containing the VRF performance and capacity curves were not included with the modeling files. Simulations could not be run with these models until the performance and capacity curves were located online and integrated into the model or the curve inputs were over-written with curves that the evaluator believed were representative of the installed VRF systems.
- **LEED Certifications -** A common theme among all the reviewed LEED projects with modeling files is the use of adjustment factors applied to the modeled baseline energy use. This was done to correct for differences between the applicable building codes used as Energy Trust baseline at the time that the facilities were constructed and the code that was used to develop the baseline building model for the facilities LEED certification. A summary of the adjustment factors and the applicable codes for these projects is summarized in Table 26.

Table 26 | LEED Projects Codes & Adjustments

Project Number	Code Use for Baseline Model	Applicable Code	Adjustment Factor Used
1	ASHRAE 90.1-2004	OEESC 2010	19.25%*
2	ASHRAE 90.1-2007	OEESC 2014	15%
3	ASHRAE 90.1-2007	OEESC 2014	15%
4	ASHRAE 90.1-2007	OEESC 2010	15%

**15% adjustment and 5% adjustment made, net adjustment is 19.25%*

One item of note is that in Table 26, Project numbers 3 and 4 used the same code for the development of the baseline model, but the applicable codes for each project were different. The differences between OEESC 2010 and 2014 are significant enough that the adjustment factors for these two projects should be different, and indicates that the baseline energy use for one or more of the LEED projects was inaccurately estimated.

The accuracy of the savings for these projects could be significantly improved if the baseline models were updated to comply with all applicable building codes rather than applying somewhat arbitrary adjustment factors to baseline models that are developed with expired code requirements.

In addition, Michaels identified the following practices that, although did not significantly impact the savings, are areas of potential risk for adjustment:

- **Parametric Runs -** Within the sample of modeling projects seven of the projects included 13 measures that used separate building models to calculated savings when the modeling software was capable of modeling the change with a parametric run within a single modeling file. Every time a separate model is used to analyze savings it allows an opportunity for future changes to not be carried through the different modeling versions resulting in calculation errors. There were no significant issues identified within this evaluation but this is a practice that's simple to avoider to reduce calculation errors.
- **Weather Data -** Of the 17 projects that used eQuest modeling in the determination of *ex ante* savings, 10 used TMY2 weather data to run building simulations, six used TMY3 weather data, and one project used TMY2 weather data for the baseline model and TMY3 weather data for the as-built model. While both TMY2 and TMY3 can be used to calculate the savings, Michaels recommends that TMY3 weather data files be used consistently across all modeled projects. TMY3 data is based on more recent weather data, is readily available, and uses actual months of weather data rather than average weather data from multiple years. To test the impact of switching from TMY2 to TMY3 weather data, the eQuest models as they were provided to Michaels were run using both weather files. For the projects that were provided with TMY2 weather data, switching to TMY3 data was found to increase the modeled electric savings by 1.2%, and decrease the modeled gas savings by 2.7%.
- **Modeling Libraries -** When custom curve fits or other parameters are used these libraries should be supplied with the modeling file to allow third party review. If they are not supplied, then the evaluation team must select the default curves within the modeling program or input a custom manufacture specific curve. The selected curve may be inconsistent with the curves originally selected by the implementer changing the results.

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 had been used during previous evaluations. More detail can be found in Appendix B | Measure Type Mapping

3.3.1 | Electric Measures

Table 27 shows the sampled electric realization rates for the different measure types included in the evaluation.

Table 27 | Sampled 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	18	164,151	164,099	100%
Standard Controls	5	71,338	71,338	100%
Standard Food Service	34	169,640	168,948	100%
Standard HVAC	50	2,913,634	2,941,556	101%
Standard Lighting	174	18,991,371	17,933,650	94%
Standard Motors	4	210,166	210,166	100%
Standard Refrigeration	25	507,770	507,286	100%
Standard Water Heating	103	985,410	931,810	95%
Standard Sub-Total	**413**	**24,013,480**	**22,928,481**	**95%**
Market Solutions	**29**	**4,496,168**	**4,551,861**	**101%**
Custom Gas	0	0	-4,298	N/A
Custom HVAC	19	7,152,734	7,071,877	99%
Custom Lighting	16	791,862	714,767	90%
Custom Other	87	3,756,849	3,736,630	99%
Custom Refrigeration	4	121,494	121,494	100%
Data Center	13	18,156,056	16,639,926	92%
LEED	5	1,667,997	1,624,322	97%
Custom Sub-Total	**144**	**31,646,992**	**29,904,718**	**94%**
Total	**586**	**60,156,639**	**57,385,060**	**95%**

Below, we provide additional information about the electric realization rates for specific measure categories which deviated from 100% by more than 5%. There are five such measure types: Standard Lighting, Standard Water Heating, Custom Gas, Custom Lighting, and Data Center.

3.3.1.1 | Standard Lighting

Standard Lighting measures overall had lower realization rates driven by changes made in the operating hours used in the savings calculations. The estimated annual operating hours of the lights increased for some projects and decreased for others, but overall, *ex post* savings are less than *ex ante* savings.

3.3.1.2 | Standard Water Heating

The most significant factor contributing to the reduction in savings for standard water heating is the adjustment to the quantities of installed low-flow devices. There were multiple projects for which the quantities were adjusted down, and others for which tracking errors were found that resulted in some increases in savings and some decreases in savings.

Low flow fixtures have been an issue for the Standard Water Heating measure category. In the 2014 program evaluation they were found to have electric savings realization rate of 82%. The realization rate for aerators (faucet and shower) in the 2015 & 2016 sampled projects have improved to 96% for electric. It is noted however that 53% of the electric savings are in market solution "package" measures. These "packages" make it difficult to define the entire population of low flow fixtures.

3.3.1.3 | Custom Gas

The custom gas electric savings were changed from 0 to -4,298 due to project NBC16 16. This project included measures with both electric and gas savings. This one measure for a laundry extractor included the gas savings due to more water removed but did not include the electric penalty for the equipment. Savings adjustment is due to one measure, where a kitchen hood was found to no longer be used.

3.3.1.4 | Custom Lighting

There is one contributing factor to the savings adjustment for the custom lighting measures. Two daylighting controls projects were found to be required by code, which causes a reduction in the baseline operating hours, which in turn causes a reduction in savings.

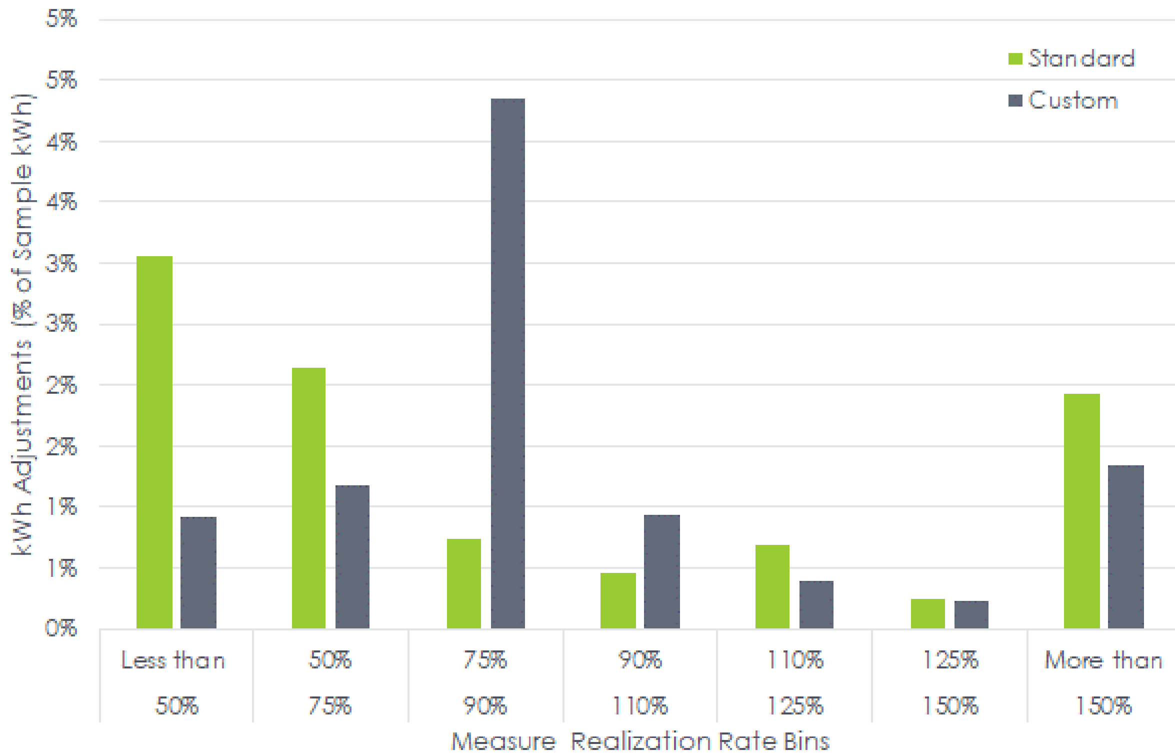
3.3.1.5 | Data Center

Data center savings were reduced primarily due to two projects which were the 3rd and 4th phases of a project at the same facility. Overall, this project achieved 90% realization rate for these two phases but also accounts for most of the data center savings in the program. The project achieved fewer savings due to fewer server racks being installed and different equipment being installed in its place that was not associated with the energy saving measures. This directly affected the scale of the measures implemented at the facility.

3.3.1.6 | Measure Adjustment Impacts

Michaels analyzed 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 9 plots the total adjustments to electric savings as a percent of the total sample electric savings versus the realization rate bin. For example, a standard measure with a 79% realization rate would be accounted for in the 75% to 90% category.

Figure 9 | Frequency Analysis of Sampled Electric Measure Adjustments as a Percent of Sample Electric Savings for 2015 and 2016



The data from Figure 9 are complimentary to those shown in Figure 7 and Figure 8. 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 9 put those results in 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 2015 and 2016 New Buildings evaluation indicate that for the standard measures with measure level realization rates of 50% or less resulted in the largest impact on the program for standard measures. Figure 7 showed that 23 individual standard 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 standard measure electric realization rates. However, this downward adjustment was countered by 13 projects with a significant upward adjustment

The results for custom measures indicate that the overall impact on the sample kWh savings from custom measures was greater than standard measures. The largest custom measure impact was nearly 4.5% of the sample kWh savings, while the largest standard measure was only 3%. The large downward adjustment to custom measure savings was due to a single large project (NBC15 11). This project is discussed above in 3.3.1.5 | Data Center.

3.3.2 | Gas Measures

A similar analysis was completed for the gas measures included in the sample. Table 28 shows the gas realization rates for the sampled measure types included in the evaluation.

Table 28 | Sampled 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	16	3,181	3,213	101%
Standard Food Service	38	28,763	24,635	86%
Standard HVAC	41	116,278	92,043	79%
Standard Lighting	0	-994	-1,192	229%
Standard Refrigeration	2	13,770	13,770	100%
Standard Water Heating	156	248,836	227,457	91%
Standard Sub-Total	**253**	**409,833**	**359,927**	**88%**
Market Solutions	**17**	**124,120**	**118,386**	**95%**
Custom Gas	3	11,794	10,123	86%
Custom HVAC	7	13,752	1,307	10%
Custom Other	31	132,861	130,873	99%
LEED	3	88,217	62,483	71%
Custom Sub-Total	**44**	**246,624**	**204,725**	**83%**
Total	**314**	**780,578**	**683,098**	**88%**

Below, we provide additional information about the gas realization rates for the measure categories which had adjustments of greater than 5%. There was a total of six different measure categories which had realization rates that differed by more than 5%: Standard Food Services, Standard HVAC, Standard Lighting, Standard Water Heating, Custom Gas, and LEED.

3.3.2.1 | Standard Food Service

The savings for standard food service equipment were adjusted down due to units that were found to no longer be used. The affected equipment included gas fryers, steam cookers, and a different model dishwasher installed. There was one ice maker that was found to be a larger size than claimed, increasing its savings.

3.3.2.2 | Standard HVAC

The savings for standard HVAC measures were adjusted downward substantially due to differences between the assumed and the site verified operation of the equipment. For several projects, the billed energy use data for the facility was used to estimate the operation of the applicable HVAC equipment, which was then checked against the operation assumed in the *ex ante* calculations. The results of these calculations were used to determine if projects included redundant equipment that should be removed. These adjustments were significant for the condensing boiler measures. Examples are detailed below.

NBC15 19 - The *ex post* savings for the installation of condensing boilers were determined using a simple billing analysis. Utility meter records for three years of occupancy were used to estimate average annual heating gas usage. Domestic water heating gas usage was accounted for by estimating average gas usage during the non-heating months. The rest of the gas usage was assumed to represent the maximum possible boiler input. The heating load was established assuming an average 92% boiler efficiency. The baseline gas usage was established assuming a standard 80% boiler efficiency. The resulting estimated gas savings is 4,011 therms, which is significantly less than the *ex ante* savings of 13,020 therms. This indicates that the second boiler is not needed to meet facility loads and is a backup boiler. The *ex ante* savings were reduced by 50% with the removal of the second boiler.

NBP16 20 – The savings adjustment for the installation of high efficiency boilers was made based on the billed gas use of the facility. The total gas use for the most recent 12 months totaled 12,799 therms, which is for the boilers, cooking, and the water heaters. The boiler gas use was estimated to account for 9,781 therms, and the operating efficiency of the boilers is expected to average around 92%. The baseline measure is 80% efficient boilers, and based on the estimated heating gas use of the building the savings resulting from the installation of high-efficiency boilers was determined to be 1,467 therms, whereas the *ex ante* savings for the measure was 8,760 therms. This indicates that the installed boilers operate for significantly fewer equivalent full load hours per year than what was assumed in the *ex ante* savings calculations. The second boiler is therefore a backup boiler and was removed from the analysis for *ex post* savings of 50%

3.3.2.3 | Standard Lighting

The gas adjustments associated with lighting measures are due to a single project that included the lighting interactive effects. Based on the evaluation results the lighting savings increased resulting in an increase in the negative gas interactive effects.

3.3.2.4 | Standard Water Heating

The most significant factor contributing to the reduction in gas savings for standard water heating is adjustments in the quantities of low flow fixtures. In addition to low flow fixtures, a few projects had issues with water heater quantities and size not matching the project documentation.

Historically the standard water heating measure category has had issues with low flow fixtures. In the 2014 program evaluation the low flow fixtures were found to have gas savings of 42%. The gas realization rate for the sample of aerators (faucet and shower) for 2015 and 2016 was 84% gas. It is noted, however, that 37% of the gas savings are in the market solutions "package" of measures and the low flow fixtures included in these "packages" are not included. The 2015 and 2016 evaluation specifically looked at these low flow fixtures and more heavily sampled the multifamily and market solutions projects that include the majority of these fixtures resulting in a significantly larger sample. While issues were still found with low flow fixtures being removed, the prevalence of it is significantly less than found in the previous evaluation.

3.3.2.5 | Custom Gas

Savings for several custom gas measures were adjusted substantially downward largely due to differences between the assumed operation of the equipment and what was determined from the information collected during site visits. Examples are described below.

NBC15 32 –We found that exhaust air energy recovery with bypass dampers is required by code for this project. The *ex ante* savings were determined with a baseline of no energy recovery, which is inconsistent with code minimum requirements. The baseline HVAC system was changed to have energy recovery with an effectiveness of 50%. The effectiveness of the installed energy recovery equipment is greater than 50%, resulting in the measure for the installation of energy recovery still achieving energy savings, but at a reduced rate. The savings for the energy recovery bypass dampers were removed as they were determined to be required by code. A final adjustment was due to the boiler being claimed as a prescriptive measure and outside of the building model. The boiler savings were updated based on the modeling results which showed significantly less operating hours than the deemed values.

NBC15 28 - The savings adjustment for the installation of condensing boilers was made based on the billed gas use of the facility normalized for weather. The proposed gas use in the *ex ante* savings calculations was found to be greater than the billed gas use of the facility, so the savings were adjusted proportionately so that the proposed gas use in the savings calculations was consistent with the actual billed gas use of the facility. This results in the savings going from 17,866 therms to 10,879 therms, a reduction of 6,987 therms.

3.3.2.6 | LEED (Leadership in Energy and Environmental Design)

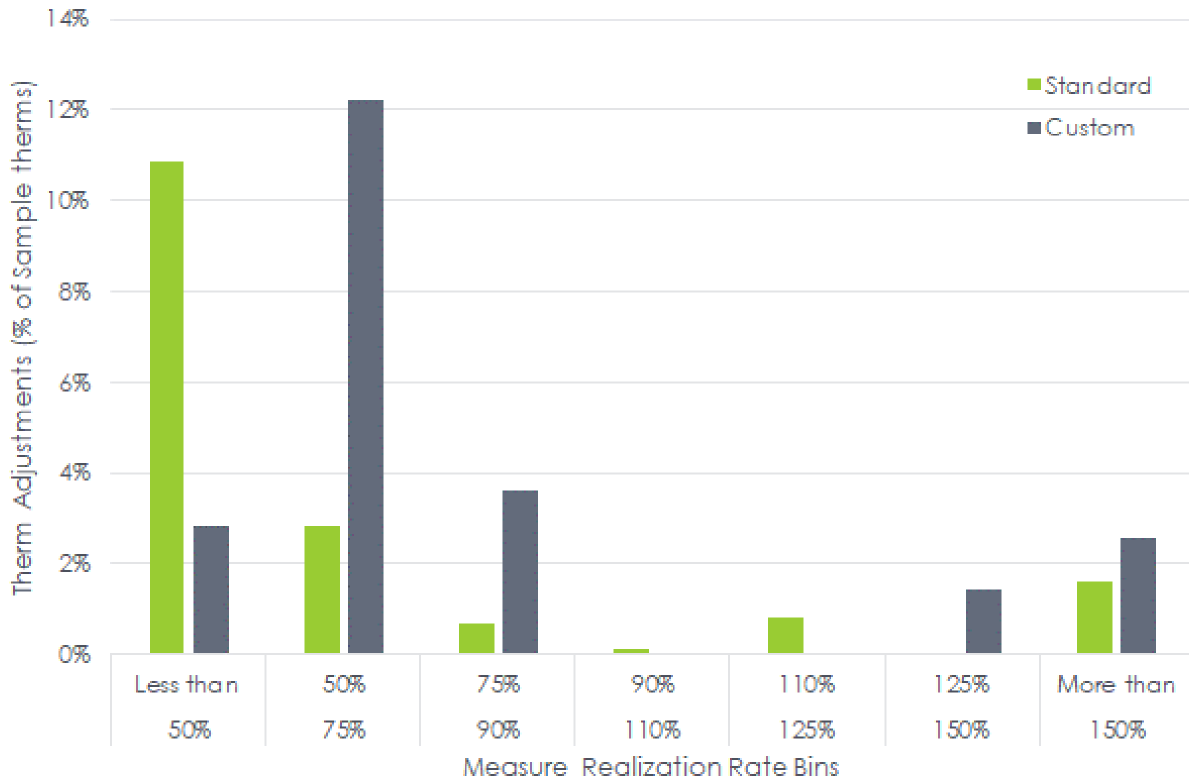
Building models were used to determine savings for LEED projects. However, the baselines used in the analysis were out of date with the appropriate energy code. To compensate for the out of date code, the *ex ante* calculations included adjustment factors. Savings estimates were adjusted to use the appropriate baseline and data collected on-site. One of the LEED projects in particular, NBC16 02, had a large gas adjustment due to the code baseline changes that were made. A significant adjustment made to the baseline model for NBC16 02 was the baseline efficiency of the furnaces being changed from 73.5% to 80%.

3.3.2.7 | Measure Adjustment Impacts

Gas measure adjustments were larger than those of electric measures. Figure 10 shows the sum of gas measure adjustments as a percent of the total sample gas savings versus the realization rate bin. For example, standard projects with realization rates of less than 50% accounted for a downward adjustment of 6.5% on total sampled-project therms. Viewing the results in this manner shows the relative impact of each grouping of measure realization rates on the overall results. Results of standard[19] and custom measure types are shown separately.

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

Figure 10 | Frequency Analysis of Sampled Gas Adjustments as a Percent of Sample Gas Savings for 2015 and 2016



The data from Figure 10 are complimentary to those shown in Figure 7 and Figure 8. Recall that those figures showed the total number of measures within the realization rate bins, but did not quantify the impact those measures had on the overall sample gas savings. Figure 10 puts those results into context.

Standard gas measures showed similar characteristics to standard electric measures; however, the reduction was twice as large. A small number of standard gas measures (23) had the most significant downward adjustment to the program. The standard gas measures did not see a significant upward adjustment like was seen with the standard electric measures.

The custom gas measures also showed similar characteristics to the custom electric measures with the largest adjustment category being influenced by single large projects. A significant downward adjustment was applied to approximatley12% of the custom measure sample in the 50% to 75% realization rate bin. Referring back to Figure 8, the relative number of custom projects were small in this bin and this large downward trend is due to a single large custom project (NBC16 02). This project is discussed above in section 3.3.2.6 | LEED (Leadership in Energy and Environmental Design)

3.4 | Results by Building Type

The Michaels team also calculated realization rates for each building type in the sample. The stratification strategy the team employed provided robust results for each building type. The relative precisions for each building type ranged from 0% to 10%. Overall precision was 1% for both electric and gas. All but one of the building use types had relative precision below the goal of 15%.

The only building types with any significant difference in realization rates are the Multifamily-Assisted Living for electric and Healthcare buildings for gas, with realization rates below 70%. Multifamily, Middle-High school, Office, and Other were all below 85% realization rate. The Multifamily-Assisted Living building type was largely impacted by one project that had installed CFLs instead of the claimed LEDs negating the 547,872 kWh claimed for the measure. The gas savings for the healthcare buildings were largely reduced due to heating systems and boilers. In particular, these healthcare buildings claimed more gas savings than can be justified based on the facilities' energy usage and due to backup equipment being included.

Table 29 | Realization Rates and Relative Precision (at the 90% confidence Level) by Building Type

Building Use Type	Sampled Projects	Electrical (kWh) Realization Rate	Natural Gas (therms) Realization Rate	Electric Relative Precision	Natural Gas Relative Precision
Multifamily-Market-Rate/Campus Housing	29	106%	84%	4%	2%
Multifamily-Affordable	8	91%	93%	5%	6%
Multifamily-Assisted Living	9	77%	92%	5%	4%
Data Center	5	93%	N/A	1%	N/A
Warehousing & Industrial	19	96%	89%	2%	3%
Hospitality	13	98%	102%	3%	5%
Elementary School	16	97%	85%	3%	8%
Middle-High School	9	91%	80%	6%	5%
College/University	8	84%	91%	8%	4%
Retail Grocery	13	100%	100%	0%	0%
Retail Non-Grocery	15	92%	92%	10%	5%
Office	8	96%	83%	4%	3%
Health	3	97%	69%	1%	5%
Other	11	103%	84%	6%	3%
Total	**166**	**97%**	**88%**	**1%**	**1%**

3.5 | Reasons for Adjustment

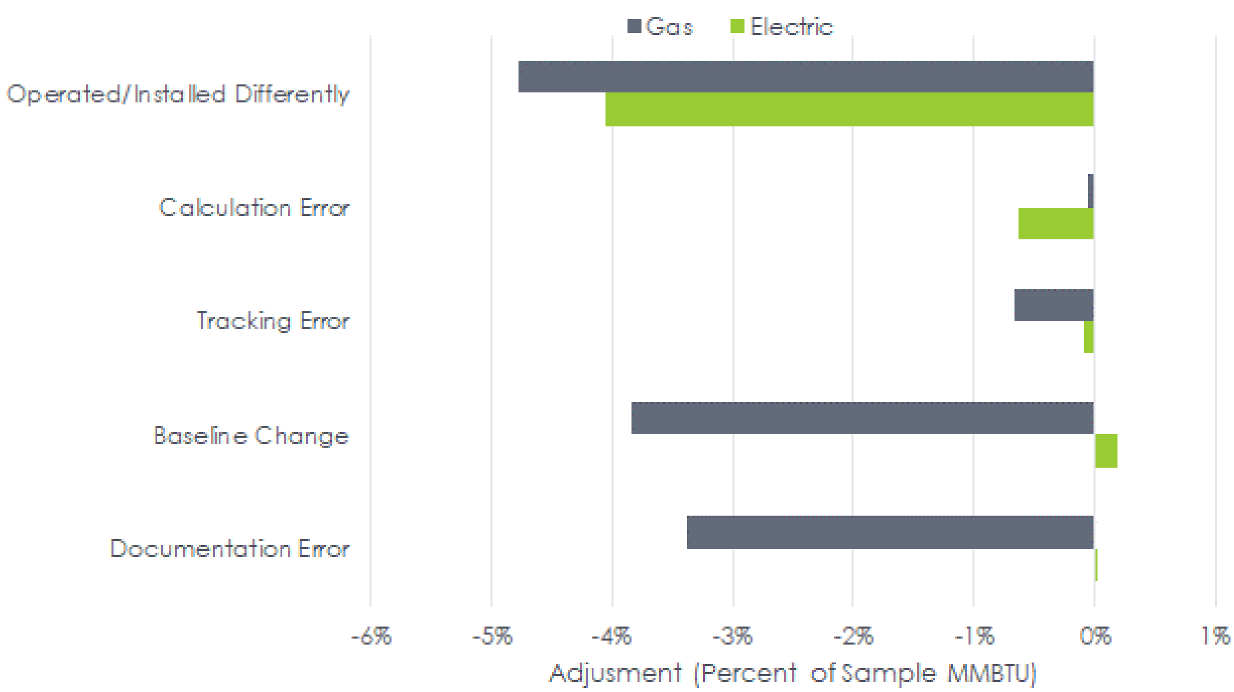
Identifying the adjustments made to project savings only tells half of the story. Understanding why projects were adjusted is equally important. To better understand why projects were adjusted, we will categorize each type of adjustment. The specific categories used were determined based on discussions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

- **Documentation Error**

- **Baseline Change**
- **Tracking Error**
- **Calculation or Engineering Error**
- **Operated or Installed Differently**

Figure 11 shows the savings impact on the sample due to each of the adjustment categories. The first note is that the aggregate reasons for adjustment are small. No adjustment categories exceed 5% of the sampled reported 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 5%, and in many cases less than 1%, shows very good accuracy overall.

Figure 11 | Electric and Gas Savings Impact by Evaluation Adjustment Type



Important observations from Figure 11 are the minimal impacts due to calculation errors and tracking errors for both gas and electric. In addition, the baseline changes including code adjustments along with documentation errors are small for electric measures. These adjustments are the easiest reasons for the PMC to directly control and the program has performed well in these areas. The performance is even better when considering that the gas baseline and documentation error adjustments were found to largely be influenced by adjustments to a single large project in each category. The large baseline change was due to a code adjustment factor in a LEED project not adequately accounting for the incorrect application of code in the modeling file. The documentation errors were largely quantity adjustments for numerous measures ranging from low flow fixtures to HVAC equipment. Furthermore, nearly all adjustments in these two categories were within the multifamily building types.

The most significant reason for electric and a major adjustment for 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 electric 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 the space. This type of adjustment is the most challenging for the PMC to control. Site verifications and frequent customer contact, especially towards the end of the project, are critical in identifying changes and managing this risk.

3.6 | Energy Intensity Analysis

The energy use intensity (EUI) analysis examined both electric and gas usage, normalized to per square foot of building area, to examine the effectiveness and efficacy of participant buildings. As detailed in section 2.6 | Energy Intensity Analysis, the Michaels team attempted to examine the energy usage histories for all projects included in the sample. After removing customers where no history was available, electric or natural gas usage was missing, and any outliers, 77 buildings were included in the analysis, and the EUIs for these buildings were compared to the EUIs from past program years and other benchmark studies. The buildings included in the sample constitute approximately 25% of the claimed savings in the sample. It is important to recognize that the detailed EUI analysis is limited to only a subset of the total program sample. It is also important to recognize that CBECs and other benchmark EUI values represent a mix of building ages, climates, and other parameters, and that the building type categories do not directly map to each other between data sets. The benchmark EUI data does not represent a code minimum or baseline building energy use for Energy Trust.

Table 30 | Subset of Sampled Projects Used in the EUI Analysis

EUI data quality	Verified Savings (kBtu)	Projects	Notes
Good	103,276,100	59	Included
OK	28,996,250	18	Included
Unusable	400,903,430	83	Excluded
Percent included in EUI analysis	25%	48%	

3.6.1 | Program Comparison

Table 31 shows what the base case energy use and actual energy use of the participant buildings are relative to the CBECs baseline. The comparable CBECs data represents the energy consumption of each participant building if they used as much energy per square foot as the average CBECs buildings. The base case scenario is assumed to be the actual energy use for the participant buildings, plus the verified project savings. The actual energy use represents the actual billed energy use of the participant buildings.

The base case energy use is 70% of the comparable CBECs baseline, while the actual energy use EUI analysis subset of buildings is 50% of the comparable CBECs baseline usage. The CBECS data includes older buildings, among other differences, but it is important to note that even though the base case energy use is lower than the CBECs average, the actual energy use of participant buildings in the EUI sample has been reduced further by 20% relative to the CBECs baseline.

Table 31 | Program Energy Use and Savings Relative to CBECs

Comparable CBECs Energy Use (kBtu)	Base Case Energy Use (kBtu) (Actual Use + Verified Project Savings)	Verified Savings (kBtu)	Actual Billed Energy Use (kBtu)	Percent Savings (Verified Savings/Base Case Energy Use)	Base Case compared to CBECS	Actual Energy Use compared to CBECs
680,367,570	473,801,146	132,272,350	341,528,796	28%	70%	50%

The program was also successful across all program tracks. Table 32 and Figure 12 below show that the verified savings ranged from a 30% reduction for the systems-based program track, to a 15% reduction for the whole building track. The market solutions and whole building track projects included in the EUI analysis use the least amount of energy relative the CBECs average of all of the program delivery channels.

Figure 12 | Benchmark CBECs Energy Use, Actual Energy Use, Verified Project Savings

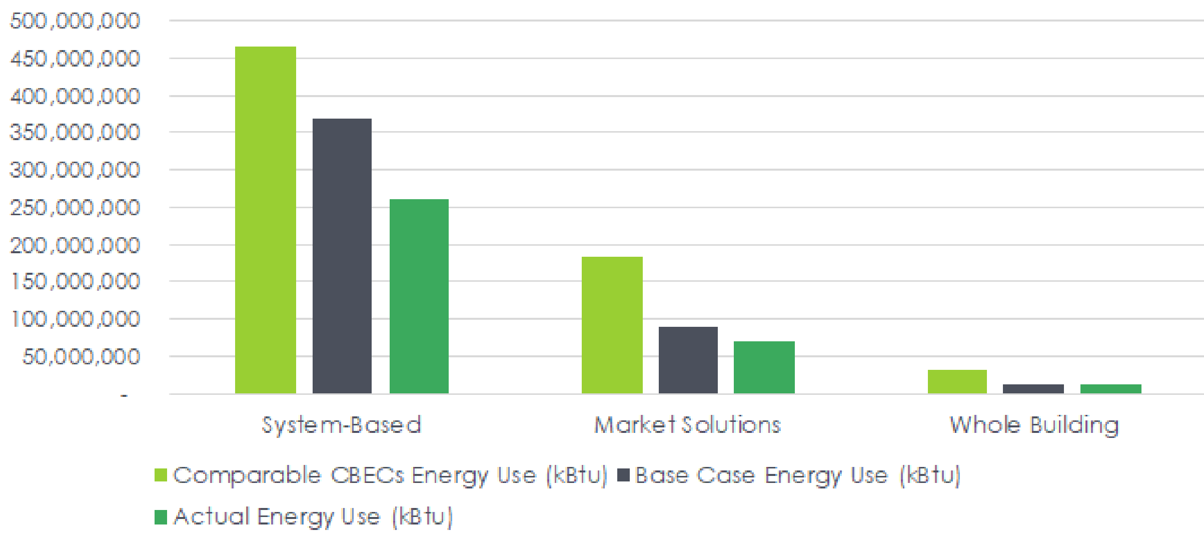


Table 32 | Program Track Building Use and Savings Relative to CBECs

Program Track	Comparable CBECs Energy Use (kBtu)	Base Case Energy Use (kBtu)	Actual Energy Use (kBtu)	Project Count	Actual compared to CBECS	Verified Savings Energy Reduction as % of Actual Use
System-Based	466,151,489	369,843,970	260,665,020	51	56%	70%
Market Solutions	183,133,983	90,229,654	69,229,954	19	38%	77%
Whole Building	31,082,098	13,727,522	11,633,822	7	37%	85%
Total	**680,367,570**	**473,801,146**	**341,528,796**	**77**	**50%**	**72%**

Many building characterizations correlate to significant differences between actual building energy use and the equivalent CBECs energy use. For example, 70 of the 77 buildings for which EUI data could be collected were heated. The buildings that primarily used heat pumps for space heating used much less energy relative to CBECs than buildings that used gas to heat the building. Projects included in the EUI analysis with gas heat had a greater percentage of savings from program measures than projects that utilized heat pumps.

Table 33 | Building Energy Use by Primary Heating Fuel

Heating Fuel	Comparable CBECs Energy Use (kBtu)	Base Case Energy Use	Actual Energy Use (kBtu)	Project Count	Actual Compared to CBECS	Actual Compared to Base Case
Gas	305,719,421	280,279,278	196,453,178	37	64%	70%
Heat Pump	355,157,358	177,472,114	135,009,014	33	38%	76%

We compared the EUIs for the 2015 and 2016 program years to several other data sets: The previous evaluations for 2014[20] and 2012[21], the 2014 NEEA Commercial Building Stock Assessment (CBSA)[22], the National 2012 Commercial Building Energy Consumption Survey (CBECS)[23], and the City of Portland Planning and Sustainability Commercial Building Energy Performance data[24]. The building types do not match the building types in the Energy Trust tracking system precisely. The Energy Trust building types were mapped to the CBECS building categories and are provided in Table 34. Additionally, the energy intensity was analyzed as a function of several key behavioral variables such as the presence of an Energy Management Plan, occupant training or pre-occupancy equipment testing, to determine if any characteristics of low-usage buildings could be identified.

Table 34 shows the 2015-16 sample building energy use intensity by building type, including the number of buildings used in Michaels' analysis contributing to the mean EUI value. Note that the number of sites per Energy Trust building type ranges from two to 12, demonstrating the difficulty of drawing meaningful conclusions about the EUI for individual building types, particularly those with five or fewer sample points. Conducting an EUI analysis also has other limitations in that EUI is simply a measure of energy usage at a facility, and does not take into account average operating hours, occupancy levels, or other building-specific operations. When samples are large enough, these shortcomings do not have as significant of an impact. The main purpose of our EUI analysis is to provide a high-level comparison of projects completed during the 2015-16

[20] 2014 New Buildings Program Impact Evaluation. Michaels Energy. May 5, 2017. https://www.energytrust.org/wp-content/uploads/2017/12/2014-NB-Impact-Evaluation-Final-Report-wSR.pdf

[21] 2012 New Buildings Program Impact Evaluation. Cadmus Group. April 26, 2015. https://www.energytrust.org/wp-content/uploads/2016/12/2012_New_Buildings_Program_Impact_Eval_final_w_SR.pdf

[22] 2014 Commercial Building Stock Assessment. Navigant Consulting. December 16, 2014. https://neea.org/img/documents/2014-cbsa-final-report_05-dec-2014.pdf

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

[24] City of Portland Commercial Building Energy Performance. https://www.portlandoregon.gov/bps/75062

program years to previous program years and to benchmark studies to determine if energy intensities were higher, lower, or comparable with other data.

As shown in Table 34, we compared the EUIs for the 2015-16 impact sample to the studies listed above. Where solar was reported on the site, we added the estimated kWh generated to the annual total to calculate EUIs.

For some building types in our 2015-16 sample, the results were aggregated into the CBECS building type for comparison. For example, the manufacturing and parking structure and garage projects were reported under the "Other" category. And while we show the results for Assisted Living, Affordable and Other Multifamily, and Lodging/Hotel/Motel separately, we have also included a line that combines all 29 projects that fall under the CBECS "Lodging" heading. We have also reported separate EUIs for K-12 Schools and Colleges/Universities rather than the combined Education category used in CBECS.

Table 34 | Comparison of 2015-16 Participant EUIs

Study Name & Date	2015-16 NB Participants (n=77)		2014 NB Participants (n=84)		2012 NB Participants (n=34)		2014 NEEA CBSA (n=1278)	2012 CBECS (national)	Portland CBSA	CBECS categories (also used for Portland CBSA)
Building Type	**n**	**kBtu/sf**	**n**	**kBtu/sf**	**n**	**kBtu/sf**	**kBtu/sf**	**kBtu/sf**	**kBtu/sf**	**Bldg Type**
Retirement/Assisted Living	8	57	7	54				97	97	Lodging
Affordable Multifamily	4	24						97	97	Lodging
Market Rate, Other Multifamily	12	26	15	31	5	12		97	97	Lodging
Lodging/Hotel/Motel	5	71	6	74			91	97	97	Lodging
All CBECS Lodging	28	44						97	97	Lodging
Retail	9	70	5	76	2	74	65	89	57	Retail non-mall
Office	9	52	8	69	3	41	76	78	67	Office
Warehouse	7	31	10	58	2	14	30	34	100	Warehouse/ storage
Schools K-12	6	42	8	41	7	106	64	69	66	Education
College/University	2	38	5	62	1	44	64	69	66	Education
Grocery	4	79	1	127	7	252	240	210	170	Food Sales
Restaurant	3	407	4	781	2	404	351	283	36	Food Service
Gym/athletic club	3	88	1	41			91	86	79	Public Assembly
Other	5	102	6	43	3	87	85	145	159	Other

EUIs for the 2015-16 New Buildings program participants in the evaluation sample was in line with the benchmark studies for some building types; others were higher or significantly lower. There were multiple building types with fewer than five data points; therefore, no conclusions could be drawn. For building types with at least five observations, we noted the following:

- The eight assisted living facilities had an average EUI in line with that of the evaluation of the 2014 program.
- The 16 Multifamily Residential projects had an EUI about 20% lower than the 15 sites in the 2014 New Buildings participant sample, indicating that the New Buildings program continues to improve the efficiency of construction in the multifamily sector. While the CBECS does not have an individual multifamily category, it includes multifamily residential under the Lodging category, which had a much higher average EUI of 97 kBtu/SF.
- The five Lodging/Hotel/Motel sites in the 2015-16 sample, which included two college dorms, had an average EUI about 5% lower than that of the six projects in the 2014 New Buildings sample, but much lower than the EUIs for the NEEA CBSA, CBECS or the Portland CBSA, again showing the effect of the New Buildings program on energy intensity for these types of buildings.
- All 28 projects whose Energy Trust New Buildings program building type maps to the CBECS Lodging building type had an average EUI of 44, or less than half the EUIs for both the CBECS and Portland studies.
- The average EUI for nine retail spaces was lower than EUIs from the previous evaluations and CBECS, but higher than for the NEEA and Portland CBSAs.
- The offices in the impact sample had a significantly lower average EUI than those in the 2014 New Buildings impact sample or in the CBECS and Portland studies, but somewhat higher than the three offices in the 2012 New Buildings impact evaluation sample.
- The average EUI for the seven warehouses was in line with the NEEA CBSA and the CBECS, but much lower than the 10 projects in the 2014 New Buildings evaluation sample and the Portland CBSA. While we do not know the reason for the higher Portland value, the 2014 evaluation- sites were found to have other significant activities that influenced EUI.
- The six K-12 schools had an EUI roughly equal to those in the 2014 New Buildings impact sample, and lower than those in the other studies cited, demonstrating the effect of this sector's continued aggressive pursuit of efficient new building construction through the New Buildings program.

3.6.2 | Effect of Behavioral Variables

The Michaels team also sought to address the effect of behavior and operating practices on overall energy use while -visit participants were asked a series of questions regarding the following aspects of how their buildings are managed, including:

- What steps were taken before the building was occupied to ensure that energy using systems would operate as intended?
- Does the organization have an Energy Management Plan and if so, how closely is it followed?
- How is energy usage tracked?
- How much training, if any, is provided to building operators and occupants?
- Are there signs or placards that encourage responsible operation?
- Are there thermostat covers or locks?

For specific sectors, additional questions were included. For example, for grocery stores, we asked whether strip curtains had been pulled back or otherwise disabled, and for lodging we asked whether guests have the option to re-use towels or linens. However, these questions did not yield enough responses for meaningful analysis.

The question regarding pre-occupancy steps taken to ensure proper building operation was meant to address how effectively the transition from construction to occupancy proceeded; that is, whether there was no more than a standard punch list, some test and balance, some functional performance testing or formal building commissioning. Somewhat surprisingly, almost half of respondents were unaware of what actions might have been taken, as shown in Table 35 below. Of those who knew, however, over 50% said that the building had been formally commissioned, and another 17% said there had been at least some functional performance testing.

Table 35 | Pre-Occupancy Steps to Ensure Proper Operation

Steps taken to ensure systems would operate as intended	% of all (n=110)	% of those who knew (n=58)
None/standard punch list	11%	21%
At least some test and balance	5%	9%
At least some functional performance testing	9%	17%
Formal building commissioning	28%	53%
Don't know or blank	47%	

Respondents were also asked about the extent of training and education provided for building occupants. As shown in Table 36 below, more than 50% of building operators said that no training was provided, and only 10% said that occupants received significant or ongoing training.

Table 36 | Occupancy Training Provided

How much training, information or education is or has been provided to building occupants?	(n=110)
None	58%
Some	27%
Significant or ongoing	10%
No response	5%

Whether an organization has an energy management plan (EMP) can serve as a good indicator of its recognition of behavioral factors and its commitment to operational efficiency. Of the 110 site representatives interviewed, only 28 (25%) said their organization has an EMP. 82 sites did not have an energy plan. As shown in Table 37 below, 71% of those who do have a plan say it is followed strictly or most of the time, and 0% said it is rarely or never followed.

Table 37 | How Strictly Energy Management Plan is Followed

How strictly is the EMP followed?	(n=28)
Strictly	46%
Most of the time	25%
Sometimes	29%
Rarely or not at all	0%

Another indicator of behavior that would be expected to affect energy usage is how carefully energy usage is tracked. Table 38 presents the extent to which building operators employ various tracking strategies and shows that more than 50% either do not track usage or only review the monthly bill and the amount owed, while 39% review actual energy usage, either monthly or within the month via interval data or other trending systems.

Table 38 | How Energy Usage is Tracked

How is Energy Usage Tracked?	(n=110)
Usage not tracked or someone else pays	37%
Monthly bills only	22%
Regular review of monthly usage	32%
Regular review of usage within a month	7%
No answer on how usage tracked	2%

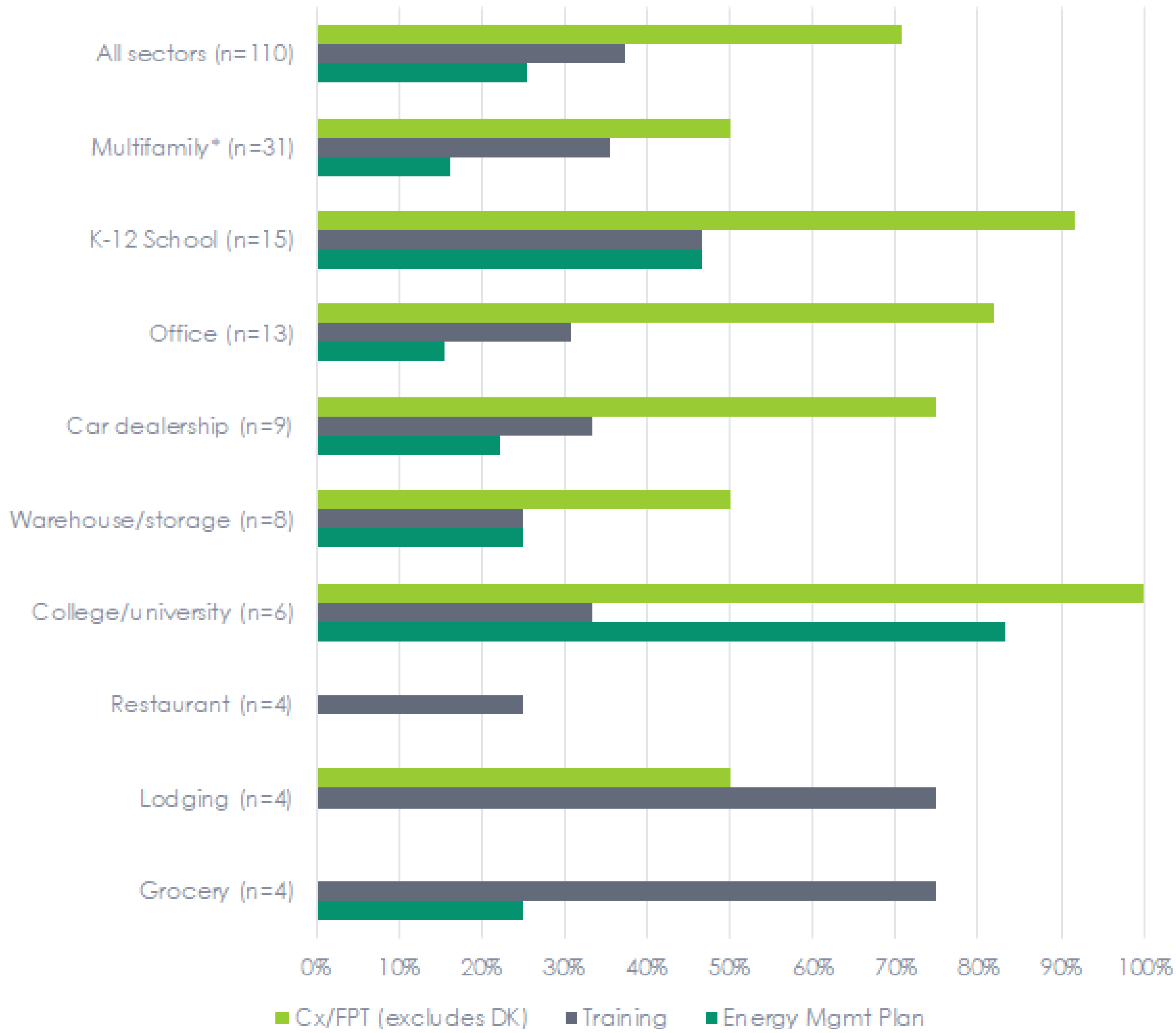
Two final indicators of behavioral affects investigated were the presence of placards or signs encouraging responsible operation and whether access to thermostats or other system controls were restricted. While we found signs posted in just 14% of buildings, 67% of buildings had restricted access to thermostats and other controls.

3.6.3 | Behavioral Responses by Building Type

We also analyzed the behavior-related responses for different building types, using the categories employed by the New Buildings program, aggregated by similar usage patterns, so that the Multifamily category includes Multifamily, Market Rate and Affordable Multifamily, Assisted Living and Campus Living properties. Percentages were calculated only for those building types with at least four buildings in our site visit sample. Figure 13 presents the percentage of each building type in our sample that had either performance testing or commissioning before occupancy, provided at least some occupant training and had an Energy Management Plan in place. The education sector – both K-12 Schools and Colleges/Universities – had the highest percentage of buildings that had functional performance testing or full commissioning. Note that these percentages were calculated excluding the 52 respondents who did not know what pre-occupancy testing had been done.

Hotels/Motels and Grocery Stores had the highest percentage of buildings that provided at least some occupant training (75%), while Restaurants and Warehouses had the lowest (25%). Colleges and Universities had the highest percentage of buildings with an Energy Management Plan (83%), although only two of the five respondents who said their organization had an EMP said the plan was strictly or mostly followed.

Figure 13 | Pre-Occupancy Actions, Occupant Training and EMP, by Building Type



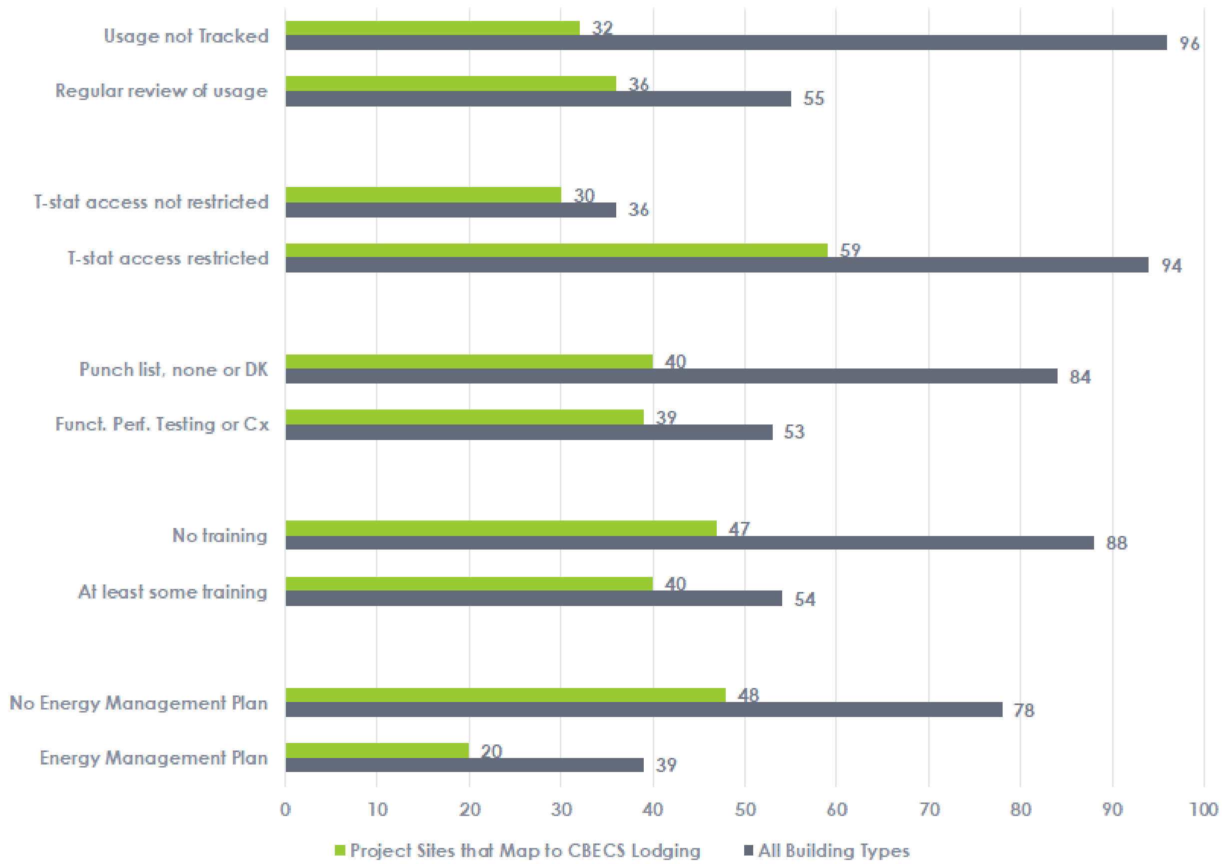
These results indicated that for most sectors, the transition from building completion to occupancy did not incorporate a high degree of focus on the efficient operation of the building to ensure that the savings from energy efficient design were realized by occupants.

To determine whether there is a correlation between these behavioral variables and EUI, we compared the EUI data for projects with different responses for behavioral questions. Of the 110 projects that answered the behavioral questions, 53 had what seemed to be reasonable billing data, so we were able to compare EUIs and behavioral responses for those sites.

Across all 53 projects, those with behavioral responses indicating more active energy management generally had lower EUIs. As shown in Figure 14, projects had lower EUIs if they 1) had an Energy Management Plan, 2) provided at least some occupant training, 3) employed pre-occupancy functional performance testing or commissioning and 4) regularly reviewed their energy usage. On the other hand, the 29 sites that restricted access to thermostats had a much higher average EUI than the 15 sites that did not. However, sites that restrict thermostat use may have more intensive heating and cooling needs than sites that do not. On balance, most positive energy management behaviors were associated with lower EUIs for the overall sample.

The data for 19 projects that fall into the CBECS category of Lodging, which includes Assisted Living, all Multifamily categories, Campus Living and Lodging/Hotel/Motel is also shown in Figure 14. Within this subset of projects, the average EUIs were lower for projects with an Energy Management Plan and with training for occupants, while EUIs for sites with functional performance testing or commissioning were about the same as for those with unknown or no testing prior to occupancy. In contrast, projects with controlled thermostat access and regular review of usage had higher EUIs than those that did not follow these efficient management practices.

Figure 14 | Energy Management Practices and EUI in kBtu/SF



As expected, there was significant variation in EUI across the sampled buildings in the 2015-16 New Buildings impact evaluation. However, the mean EUI compared to previous New Buildings evaluations and benchmark studies support the hypothesis that the New Buildings program continues to improve the efficiency of buildings constructed by program participants compared to the existing building stock.

While much of that variation in EUI among projects was clearly due to differences across building types, the results suggest that at least some energy management practices lead to lower EUIs, including the deployment of an Energy Management Plan, occupant training and use of functional performance testing or building commissioning before a building is occupied. It is clear from responses to the behavioral questions that optimal building operation and management are not standard procedures for program buildings after they are occupied. Making these practices an integral part of the New Buildings program could help ensure that the efficient designs supported by program resources also result in efficient operation.

4. Findings and Recommendations

The results of the evaluation found that the program achieved electric realization rates of 97% and 95% in 2015 and 2016, respectively. The program achieved natural gas realization rates of 84% and 89% in 2015 and 2016, respectively. The gas realization rates are lower than past evaluations for this program, but overall the results have been consistent with past evaluations. Program performance as a whole appears to be good and consistent over time.

The Michaels team offers the following findings and recommendations for the program to consider:

Overall Observation – The program implementer accurately estimated electric and natural gas savings for the program. In particular, adjustments to savings for factors within the implementer's control (documentation error, baseline changes, tracking error, and calculation or engineering error) were less than 4%. This is commendable.

Observation 1 – (38) projects were found to be installed differently than calculated. Many of these adjustments were due to design changes that were not incorporated in the final savings analysis. This issue was most pronounced with multifamily facilities.

> **Recommendation 1A –** Engage customers during the final stage of project completion to ensure final equipment specifications and quantities are consistent with project analysis.
>
> **Recommendation 1B –** Consider expanding the verification of multifamily buildings and update project analysis based on the completed facility.

Observation 2 – Low flow fixtures (faucet aerators and showerheads) had poor realization rates in the 2014 evaluation with 82% electric and 42% gas savings. The 2015 and 2016 evaluation found significantly better results for these measures at 96% for electric and 87% for gas. However, there were instances of under-claimed quantities related to multi-family facilities using the number of apartments instead of the number of bathrooms for quantities. Devices were also found to be removed due to tenant dissatisfaction. Tenant dissatisfaction varies but stems from low flow fixtures directly impacting day to day activities. Dissatisfied occupants either didn't understand the benefits of reduced water and energy usage or the benefits are not valued enough to offset the day to day impact of the low flow devices.

> **Recommendation 2 –** Continue to engage with customers and tenants where these devices are installed and remind customers about their purpose and benefits to reduce the number of dissatisfied occupants.

Observation 3 – Market solutions measures are entered in the tracking system in several different ways. Specifically, some projects claimed their "package" of measures with one entry while other projects tracked their "package" with individual measures listed as base measures and elective measures. While this does not impact verified savings, it limits the understanding of the market solutions program track measure make-up.

Recommendation 3 – Consider claiming all market solutions packages measure-by-measure indicating the base and elective measures. This will allow the Program Management Contractor (PMC) to make informed decisions about the individual program measure performance.

Observation 4 – Four prescriptive condensing boiler gas projects were found to have claimed savings that represented a significant portion of the facilities natural gas usage – higher than what can be reasonably attributed to the installation of a condensing boiler. This suggests that a combination of oversizing and redundant boilers were incentivized.

Recommendation 4 – Investigate the methodology and inputs such as boiler efficiency and effective full load hours for the Measure Approval Document for hot water condensing gas boilers. In addition, investigate additional screening to identify backup or oversized boiler systems. Alternatively, other metrics could be investigated to estimate savings and y the sizing of the boiler system for a facility. Metrics could include savings based on building type and square footage, or boiler size or quantities capped at typical BTU/square foot for different building types.

Specific recommendations for modeling projects:

Observation 5 – Hybrid Baselines have proven challenging for the program to consistently model correctly. These projects utilize two fuel sources for either heating or cooling or both. These complex systems make it difficult to develop a code compliant baseline that captures the energy savings without calculating savings for a fuel source shift. Not accounting for a fuel source shift amounts to fuel switching which is prohibited in the Energy Trust of Oregon New Buildings Program Technical Guidelines manual section 2.2.4 "Avoiding Fuel Switching".

Recommendation 5A – The Technical Guidelines Manual in section 2.2.4 does provide guidance on selecting the appropriate baseline for hybrid systems. This could be further expanded providing more clarity around additional situations identified by the program such as heat recovery chillers. In addition, these projects could benefit from a hybrid baseline specific review at the start of the modeling process and again at the end to ensure full compliance with the guidelines.

Recommendation 5B – Regardless of fuel type, any increase in energy usage due to fuel source shifting associated with a measure or project should be accounted for by the program. This can be accomplished by reporting the increased usage with the savings, allowing the other measures to offset the increased usage, or adjusting the baseline model to better match the mix of fuel types in both the baseline and proposed models. The latter is more challenging and will likely not fully mitigate the fuel switch. Modelers would benefit from additional guidance identifying metrics for when the models are close enough.

Observation 6 – As part of the calculation of savings for the LEED projects, ASHRAE 90.1-2004 and 2007 were used to develop the baseline building models. Adjustment factors were applied to the baseline simulated energy use to account for code discrepancies. Updating the baseline models to meet the applicable codes showed that the adjustment factors that were used to estimate the baseline energy use were, in some cases, very inaccurate and could lead to grossly underestimated or overestimated savings.

> **Recommendation 6 –** Baseline building models should be updated to be consistent with all applicable codes, rather than applying an adjustment factor to the baseline energy use to account for code discrepancies.

Observation 7 – Some of the modeling projects that were evaluated included a mixture of modeled measures and prescriptive measures for which the savings were determined independently of the models. In one particular instance, the savings for a central boiler were calculated using a prescriptive track, but because the boiler is a critical part of the HVAC system, in the *ex post* savings calculations the building model was used to determine the boiler savings. This resulted in a significant adjustment to the savings for the boiler. Measures for ENERGY STAR® appliances and other similar items were always calculated outside of the building models, which is reasonable as the modeling software is not designed to calculate appliance loads with high levels of precision.

> **Recommendation 7 –** To most accurately account for interactive effects between measures and equipment types, it is recommended that when building models exist for a project, the building models be used to calculate savings for all HVAC, lighting, and building envelope whenever possible.

Observation 8 – There were a total of 13 measures across seven projects for which the savings were determined by developing a separate building model with the measure implemented, but the savings could have easily been determined using parametric runs. Parametric runs have several benefits over developing separate building models – making changes to the models is easier due to fewer modeling files, it is easier to tell what changes are made with the implementation of measures, and it eliminates the risk of discrepancies existing between building models.

> **Recommendation 8 –** Whenever possible, the savings for energy efficiency measures should be determined using parametric runs.

Observation 9 – Throughout the evaluation process of the modeling projects it was noted that some of the building simulations were run using TMY2 weather data, while some were run using TMY3 weather data. TMY3 weather data is based on more recent weather data and includes actual months of meteorological data rather than average values that exist in TMY2 weather data. TMY3 is widely regarded as the standard for developing weather-dependent savings estimates and metrics.

> **Recommendation 9 –** All reported savings for modeling projects should be determined using simulations run with TMY3 weather data from the nearest weather station.

Observation 10 – In some of the modeling projects evaluated, custom efficiency curves and performance curves were created for the installed energy efficient equipment. However, the data that defines these curves was stored in supplementary files in the file directory for the model, and not in the modeling file itself. Because of this, not all of the received models could be used to run simulations. This was especially prevalent with modeling files that were used to simulate variable refrigerant flow (VRF) system operation. Performance curves were able to be added to the models so simulations could be run, but it is unlikely that the curves that were added to the models are the same as what were used to calculate the *ex ante* savings.

> **Recommendation 10 –** Include all supplementary files used to develop the building model, including any custom performance and efficiency curves.

Appendix A | Building Type Mapping

Evaluation Building Use Type	Building type "et_marketName"
1a - MF Market-Rate/Campus-Living	Campus Living Property
1a - MF Market-Rate/Campus-Living	Market Rate Multifamily Property
1a - MF Market-Rate/Campus-Living	Multifamily Property
1b - MF Affordable	Affordable Multifamily Property
2 - Data Center	Data Center
3 - Warehousing & Industrial	Beverage and Tobacco Product Manufacturing
3 - Warehousing & Industrial	Brewery
3 - Warehousing & Industrial	Chemical Manufacturing
3 - Warehousing & Industrial	Fabricated Metal Product Manufacturing
3 - Warehousing & Industrial	Food Manufacturing
3 - Warehousing & Industrial	Industrial
3 - Warehousing & Industrial	Manufacturing
3 - Warehousing & Industrial	Repair and Maintenance
3 - Warehousing & Industrial	Transportation Equipment Manufacturing
3 - Warehousing & Industrial	Warehousing and Storage
3 - Warehousing & Industrial	Water Supply Systems
3 - Warehousing & Industrial	Winery
3 - Warehousing & Industrial	Wood Product Manufacturing
4 - Hospitality	Cafeteria
4 - Hospitality	Lodging/Hotel/Motel
4 - Hospitality	Restaurant
5a - Educ K-12 School	Education
5a - Educ K-12 School	High School
5a - Educ K-12 School	K-12 School
5a - Educ K-12 School	Middle School
5a - Educ K-12 School	Primary School
5b - Educ College/University	College/University
6a - Retail Grocery	Grocery
6b - Retail Non-Grocery	Car Dealership/Showroom
6b - Retail Non-Grocery	Convenience Store
6b - Retail Non-Grocery	Retail
7 - Office	Office
8 - Health	Health
8 - Health	Hospital
8 - Health	Medical Office
8 - Health	Veterinarian's Office
9 - Gym/Athletic Club	Gym/Athletic Club
91 - Oth Commercial, Gov, Comm, Infrast	Agriculture, Forestry, Fishing and Hunting
91 - Oth Commercial, Gov, Comm, Infrast	Amusement/Recreational
91 - Oth Commercial, Gov, Comm, Infrast	Animal Production and Aquaculture
91 - Oth Commercial, Gov, Comm, Infrast	Assembly

Evaluation Building Use Type	Building type "et_marketName"
91 - Oth Commercial, Gov, Comm, Infrast	Auto Repair
91 - Oth Commercial, Gov, Comm, Infrast	Auto Services
91 - Oth Commercial, Gov, Comm, Infrast	Bank/Financial Institution
91 - Oth Commercial, Gov, Comm, Infrast	Car Wash
91 - Oth Commercial, Gov, Comm, Infrast	Commercial
91 - Oth Commercial, Gov, Comm, Infrast	Courthouse/Probation Office
91 - Oth Commercial, Gov, Comm, Infrast	Field Crops
91 - Oth Commercial, Gov, Comm, Infrast	Fire Protection
91 - Oth Commercial, Gov, Comm, Infrast	Jail/Reformatory/Penitentiary
91 - Oth Commercial, Gov, Comm, Infrast	Library
91 - Oth Commercial, Gov, Comm, Infrast	Meeting/Convention Center/Hall or Community Center
91 - Oth Commercial, Gov, Comm, Infrast	Military (Armory, etc.)
91 - Oth Commercial, Gov, Comm, Infrast	Museum
91 - Oth Commercial, Gov, Comm, Infrast	Parking Structure/Garage
91 - Oth Commercial, Gov, Comm, Infrast	Police
91 - Oth Commercial, Gov, Comm, Infrast	Religious/Spiritual
91 - Oth Commercial, Gov, Comm, Infrast	Transportation Infrastructure (Tunnel, Roadway, Dock, etc.)
91 - Oth Commercial, Gov, Comm, Infrast	Unspecified Government/Public Sector

Appendix B | Measure Type Mapping

Evaluation Measure Type	Tracking Data Measure "ProductDescription"
Standard Water Heating	Aerator Bathroom or Kitchen, Ele 1.0 gpm
Standard Water Heating	Aerator Bathroom or Kitchen, Ele 1.5 gpm
Standard Water Heating	Aerator Bathroom or Kitchen, Gas 1.0 gpm
Standard Water Heating	Aerator Bathroom or Kitchen, Gas 1.5 gpm
Standard Water Heating	Aerator Bathroom or Kitchen, Gas Only 1.5 gpm
Standard Water Heating	Aerator Bathroom, Ele 0.5 gpm
Standard Water Heating	Aerator Bathroom, Gas 0.5 gpm
Standard Water Heating	Aerator Bathroom, Gas Only 0.5 gpm
Standard Water Heating	Aerator Bathroom/Kitchen, Gas 1.0 gpm
Standard Water Heating	Aerator Bathroom/Kitchen, Gas Only 1.0 gpm
Standard Water Heating	Aerator Kitchen, Ele 1.5 gpm
Standard Water Heating	Aerator Kitchen, Gas 1.5 gpm
Standard Water Heating	Aerator Kitchen, Gas Only 1.5 gpm
Standard Water Heating	Condensing Tank
Standard Water Heating	Condensing Tank - Lodging
Standard Water Heating	Condensing Tank - Multifamily
Standard Water Heating	Condensing Tank - Restaurant
Standard Water Heating	Condensing Tank - School
Standard Water Heating	MS Base, Low-flow fixture, bath aerator, 0.5 gpm (LMF)
Standard Water Heating	MS Base, Low-flow fixture, bath aerator, 0.5 gpm (SMF)
Standard Water Heating	MS Base, Low-flow fixture, kitchen aerator, 1.5 gpm (LMF)
Standard Water Heating	MS Base, Low-flow fixture, kitchen aerator, 1.5 gpm (SMF)
Standard Water Heating	MS Base, Low-flow fixture, showerhead, 1.75 gpm (LMF)
Standard Water Heating	MS Base, Low-flow fixture, showerhead, 1.75 gpm (SMF)
Standard Water Heating	MS Elective, Condensing tank water heater (LMF, 1)
Standard Water Heating	MS Elective, Condensing tank water heater (SMF, 1)
Standard Water Heating	Shower Wand Ele DHW
Standard Water Heating	Shower Wand Ele DHW 1.5 GPM
Standard Water Heating	Shower Wand Gas DHW - 1.5 gpm
Standard Water Heating	Shower Wand Gas DHW 1.5 GPM
Standard Water Heating	Showerhead Ele DHW, 1.5 GPM
Standard Water Heating	Showerhead Ele DHW, 1.75 GPM
Standard Water Heating	Showerhead Ele DHW, 2.0 GPM
Standard Water Heating	Showerhead Electric DHW (Avg GPM)
Standard Water Heating	Showerhead Gas DHW (Avg GPM)
Standard Water Heating	Showerhead Gas DHW, 1.5 GPM
Standard Water Heating	Showerhead Gas DHW, 1.75 GPM
Standard Water Heating	Showerhead, Gas Only, 1.5 GPM
Standard Water Heating	Showerwand - commercial or lodging, 1.5 gpm, gas only
Standard Water Heating	Tankless Water Heater/Instantaneous w/Electronic Ignition
Standard Refrigeration	Cooler Doors, Retrofit GAS Heat

Evaluation Measure Type	Tracking Data Measure "ProductDescription"
Standard Refrigeration	Night Covers - Vertical
Standard Refrigeration	Refrigerator Res Size Tier 1 (20% Better)
Standard Refrigeration	Refrigerator Res Size Tier 2 (30% Better)
Standard Motors	ECM Motor for Refrigeration Systems
Standard Lighting	LED Case Lighting New Open Case (Double) High Power
Standard Lighting	LED Case Lighting New Open Case (Single) Low Power
Standard Lighting	LED Case Lighting New Reach-in Case (Double) High Power
Standard Lighting	LED Case Lighting New Reach-in Case (Single) Low Power
Standard Lighting	LED Case Lighting T8-LED (<4w/ft)
Standard Lighting	LED Case Lighting T8-LED (4w/ft - 7.5w/ft)
Standard Lighting	LED Directional Lamp, in-unit MF
Standard Lighting	LED Lamp (Omnidirectional)
Standard Lighting	LED lamp <10W (PAR/R/MR/GU)
Standard Lighting	LED lamp <20W (PAR/R/MR)
Standard Lighting	LED lamp 20-40W (R/PAR/MR)
Standard Lighting	LED Omnidirectional Lamp, in-unit Assisted Living
Standard Lighting	LED Omnidirectional Lamp, in-unit Hotel
Standard Lighting	LED Omnidirectional Lamp, in-unit MF
Standard Lighting	Lighting Controls, 2010 Cade Calc
Standard Lighting	Lighting Controls, 2014 Code Calc
Standard Lighting	Lighting, Exterior, 2010 Code Calc
Standard Lighting	Lighting, Exterior, 2014 Code Calc
Standard Lighting	Lighting, Interior, 2010 Code Calc
Standard Lighting	Lighting, Interior, 2014 Code Calc
Standard Lighting	MS Base, 15% LPD reduction in common areas (LMF)
Standard Lighting	MS Base, 15% LPD reduction in common areas (SMF)
Standard Lighting	MS Base, 80% high performance fixtures in units (LMF)
Standard Lighting	MS Base, 80% high performance fixtures in units (SMF)
Standard Lighting	MS Elective, 25% LPD reduction in common areas (LMF, 1)
Standard Lighting	MS Elective, 25% LPD reduction in common areas (SMF, 1)
Standard Lighting	MS Elective, Bi-level lighting in corridors (LMF, SMF, 1)
Standard HVAC	7.5 ton HVAC
Standard HVAC	AAHX, 2010 Code Calc
Standard HVAC	AC Unit 10 ton 2010 Code
Standard HVAC	AC Unit 12.5 ton 2010 Code
Standard HVAC	AC Unit 15 ton 2010 Code
Standard HVAC	AC Unit 17.5 ton 2010 Code
Standard HVAC	AC Unit 20 ton 2010 Code
Standard HVAC	AC Unit 6 ton 2010 Code
Standard HVAC	AC Unit 7.5 ton 2010 Code
Standard HVAC	AC Unit 8.5 ton 2010 Code
Standard HVAC	Commercial Infrared Radiant Heaters, Non-modulating
Standard HVAC	Controls, HVAC, Hotel occ sensor

Standard HVAC	Ductless Mini-Split
Evaluation Measure Type	**Tracking Data Measure "ProductDescription"**
Standard HVAC	Gas-fired Condensing Boiler < 300 kbtuh 0.9 AFUE
Standard HVAC	Gas-fired Condensing Boiler > 2500 kbtuh 0.9 EC
Standard HVAC	Gas-fired Condensing Boiler > 94% AFUE
Standard HVAC	Gas-fired Condensing Boiler >= 300 kbtuh, <= 2500 kbtuh 0.9 ET
Standard HVAC	Heat Pump, Air-to-Air, 5 Ton
Standard HVAC	Heat Pump, Water Source, 2.5 Ton
Standard HVAC	Heat Pump, Water Source, 3.5 Ton
Standard HVAC	Heat Pump, Water Source, 4 Ton
Standard HVAC	High Efficiency Condensing Furnace
Standard HVAC	HVAC Unit Heater, Gas Heat
Standard HVAC	HVAC, Economizer, 2010 Code Calc
Standard HVAC	MS Elective, Air barrier (LMF, 3)
Standard HVAC	MS Elective, Air barrier, electric only (SMF, 3)
Standard HVAC	MS Elective, Condensing gas furnace (LMF, 3)
Standard HVAC	MS Elective, ENERGY STAR bathroom fan (LMF, SMF, 1)
Standard HVAC	MS Elective, High performance bathroom fan (LMF, SMF, 2)
Standard HVAC	MS Elective, Packaged terminal heat pump - code comp (LMF, 3)
Standard HVAC	PT Heat Pump
Standard HVAC	Stand-alone Economizer, AAHP Unit, 3-Ton
Standard HVAC	Stand-alone Economizer, AC Unit, 3.5-Ton
Standard HVAC	Stand-alone Economizer, AC Unit, 3-Ton
Standard HVAC	Stand-alone Economizer, AC Unit, 4-Ton
Standard HVAC	VRF Pilot - Custom
Standard Food Service	Electric Combination Ovens
Standard Food Service	Electric Convection Oven - Full Size
Standard Food Service	Electric Convection Oven - Half Size
Standard Food Service	Electric Hot Food Holding Cabinet - Full Size
Standard Food Service	Electric Hot Food Holding Cabinet - Half Size
Standard Food Service	Electric Steam Cooker
Standard Food Service	Gas Combination Ovens
Standard Food Service	Gas Convection Oven - Full Size, v2
Standard Food Service	Gas Fryer 2014
Standard Food Service	Gas Fryer, v2
Standard Food Service	Gas Steam Cookers
Standard Food Service	Ice Machine IMH < 450 IHR, ENERGY STAR
Standard Food Service	Ice Machine IMH >= 450 IHR, ENERGY STAR
Standard Food Service	Ice Machine RCU < 1000 IHR, CEE Tier 3
Standard Food Service	Ice Machine RCU < 1000 IHR, ENERGY STAR
Standard Food Service	Ice Machine RCU >= 1000 IHR, ENERGY STAR
Standard Food Service	Ice machine SCU < 175 IHR, ENERGY STAR
Standard Food Service	Ice Machine SCU >= 175 IHR, ENERGY STAR

Standard Food Service	Single Tank Conveyor - High temp - Gas hot water
Standard Food Service	Single Tank Conveyor - High Temp - Gas Only
Standard Food Service	Single Tank Conveyor - Low temp - Gas hot water
Evaluation Measure Type	**Tracking Data Measure "ProductDescription"**
Standard Food Service	Single Tank Conveyor, High Temp, Gas hot water
Standard Food Service	Single Tank Door/Upright - High Temp - Ele water heat
Standard Food Service	Single Tank Door/Upright - High Temp - Gas water heat
Standard Food Service	Single Tank Door/Upright - Low Temp - Gas water heat
Standard Food Service	Undercounter - high temp - Ele water heat
Standard Food Service	Undercounter - high temp - Gas water heat
Standard Food Service	Vent Hood - Custom
Standard Food Service	Vent Hood - Electric Heat
Standard Food Service	Vent Hood - Gas Heat
Standard Controls	Anti-sweat Heater Controls - Low temp V2
Standard Controls	Anti-sweat Heater Controls - Med temp V2
Standard Clothes Washer	Clothes Washer, MEF >=2.46, In-Unit, Ele DHW
Standard Clothes Washer	Clothes Washer, MEF >=2.46, In-Unit, Gas DHW
Standard Clothes Washer	Clothes Washer, MEF >=2.6, In-Unit, Ele DHW
Standard Clothes Washer	Clothes Washer, MEF >=2.6, 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 Clothes Washer	Clothes Washer, MEF 2.4-2.59, In-Unit, Gas DHW
Standard Clothes Washer	Commercial Clothes Washer, Electric Water Heat
Standard Clothes Washer	Commercial Clothes Washer, Gas Water Heat
Standard Clothes Washer	Commercial Non-MF Clothes Washer, Full Service Territory
Standard Clothes Washer	MF Commercial Clothes Washer, Ele Only Territory
Standard Clothes Washer	MF Commercial Clothes Washer, Full Service Territory
Market Solutions	Market Solutions Package, MF, Best (5 Electives)
Market Solutions	Market Solutions Package, MF, Better (3 Electives)
Market Solutions	Market Solutions Package, MF, Good
Market Solutions	Market Solutions Package, Office, Best HVAC, 2 Measures
Market Solutions	Market Solutions Package, Office, Best HVAC, 4 Measures
Market Solutions	Market Solutions Package, Office, Best HVAC, No Measures
Market Solutions	Market Solutions Package, Office, Better HVAC, 2 Measures
Market Solutions	Market Solutions Package, Office, Better HVAC, 4 Measures
Market Solutions	Market Solutions Package, Office, Good HVAC 2 Measures
Market Solutions	Market Solutions Package, Office, Good HVAC, 4 Measures
Market Solutions	Market Solutions Package, Office, Good HVAC, No Measures
Market Solutions	Market Solutions Package, Office, Very Best HVAC, 4 Measures

Market Solutions	Market Solutions Package, School, Best (6 Elective Measures)
LEED	LEED - NC
Data Center	Server Closet/Telecom Room Mini-Split Air Conditioner
Data Center	Uninterruptible Power Supplies VFI
Custom Refrigeration	Floating Head Pressure Controls
Custom Refrigeration	Floating Suction Pressure Controls
Custom Refrigeration	FSPC & FHPC
Custom Refrigeration	Oversized Condenser w/VFD
Custom Refrigeration	VFD on Condenser
Evaluation Measure Type	**Tracking Data Measure "ProductDescription"**
Custom Other	Custom
Custom Other	Custom Modeled Savings, Non-Cost Effective
Custom Other	Envelope - Shell - Custom
Custom Other	HVAC, AC/HP, 2010 Code Calc
Custom Other	HVAC, Fan Energy Optimization, 2010 Code Calc
Custom Other	MS Elective, Special measure #1 (LMF, SMF, 1)
Custom Other	MS Elective, Special measure #2 (LMF, SMF, 1)
Custom Other	MS Elective, Special measure #3 (LMF, SMF, 1)
Custom Other	Oregon Housing and Community Service (OHCS) savings
Custom Other	VFD, 2010 Code Calc
Custom Other	Windows - Custom
Custom Lighting	Custom Lighting
Custom Lighting	Custom Lighting Control
Custom HVAC	HVAC - Custom
Custom Gas	Custom Gas
Custom Controls	Custom Building Controls

Appendix C | Building Energy Intensity

Building Type	Relevant Building Area (SF)	Electric EUI (kWh/SF)	Gas EUI (Therms/SF)	Total Energy (kBtu/SF)
Restaurant	3,502	47.4	5.2	677.0
Restaurant	2,042	34.0	3.0	416.8
Manufacturing	51,184	92.9	0.3	347.6
Retail	49,656	31.0	0.9	192.1
Lodging/Hotel/Motel	85,000	16.5	1.0	156.4
Restaurant	21,000	5.8	1.1	128.2
Grocery	104,081	31.4	0.1	120.9
Gym/Athletic Club	11,000	15.7	0.6	109.2
Lodging/Hotel/Motel	12,000	9.9	0.7	102.0
Gym/Athletic Club	57,000	1.1	0.9	92.3
Assisted Living Property	18,280	14.3	0.4	84.5
Car Dealership/Showroom	24,319	12.9	0.4	83.9
Assisted Living Property	71,700	13.4	0.4	81.9
Auto Services	16,824	11.1	0.4	80.7
K-12 School	214,033	10.5	0.4	80.4
Grocery	146,790	22.3	0.0	75.9
Grocery	104,000	11.0	0.4	72.7
Auto Services	28,476	14.8	0.2	72.2
Retail	14,207	16.8	0.1	71.4
Car Dealership/Showroom	24,218	12.1	0.3	70.0
Office	11,764	12.9	0.2	68.2
Assisted Living Property	12,755	17.0	0.1	66.8
Car Dealership/Showroom	20,785	15.7	0.1	63.8
Gym/Athletic Club	63,000	8.4	0.4	63.7
Warehousing and Storage	229,415	2.5	0.5	59.9
Car Dealership/Showroom	30,745	9.3	0.3	58.1
Multifamily Property	274,937	15.7	0.0	57.9
Office	68,093	16.9	0.0	57.6
Assisted Living Property	99,595	9.9	0.2	56.1
Office	22,143	1.7	0.5	55.0
Office	14,487	10.0	0.2	54.4
College/University	134,597	12.5	0.1	53.8
Office	11,129	15.6	0.0	53.3
Assisted Living Property	164,433	7.4	0.2	48.8
Lodging/Hotel/Motel	117,520	8.3	0.2	48.4
Courthouse/Probation Office	33,000	11.1	0.1	48.2
Grocery	2,615	14.0	0.0	47.9
Warehousing and Storage	78,560	7.1	0.2	46.4
K-12 School	119,459	4.2	0.3	43.9
Assisted Living Property	157,224	9.0	0.1	41.9

Building Type	Relevant Building Area (SF)	Electric EUI (kWh/SF)	Gas EUI (Therms/SF)	Total Energy (kBtu/SF)
K-12 School	59,630	7.8	0.1	41.0
Warehousing and Storage	219,347	8.5	0.1	40.6
Assisted Living Property	162,512	8.1	0.1	39.2
Office	36,000	11.1	0.0	39.0
Health	97,718	11.0	0.0	37.7
Multifamily Property	50,255	5.6	0.2	35.8
Office	170,648	10.2	0.0	35.5
Assisted Living Property	470,000	7.9	0.1	35.1
Campus Living Property	101,000	6.2	0.1	34.8
Market Rate Multifamily Property	203,854	5.9	0.1	33.9
Car Dealership/Showroom	172,105	3.3	0.2	33.1
Multifamily Property	77,578	6.7	0.1	32.7
Car Dealership/Showroom	106,500	3.8	0.2	32.0
K-12 School	66,088	6.0	0.1	31.9
Affordable Multifamily Property	64,844	9.2	0.0	31.5
Affordable Multifamily Property	47,126	5.7	0.1	28.7
K-12 School	68,088	5.7	0.1	28.5
Market Rate Multifamily Property	140,444	7.5	0.0	28.2
Multifamily Property	119,873	8.1	0.0	27.7
Retail	35,000	4.3	0.1	26.9
K-12 School	69,994	3.4	0.2	26.8
Warehousing and Storage	600,141	2.2	0.2	23.6
Market Rate Multifamily Property	163,607	2.8	0.1	23.6
Warehousing and Storage	156,000	1.7	0.2	23.4
Retail	76,575	6.6	0.0	22.4
Affordable Multifamily Property	60,000	3.0	0.1	22.2
Multifamily Property	319,200	2.1	0.1	20.1
Warehousing and Storage	141,609	4.5	0.0	19.6
Market Rate Multifamily Property	340,031	1.4	0.1	16.8
Market Rate Multifamily Property	144,935	4.6	0.0	15.9
Campus Living Property	30,000	2.0	0.1	13.9
Multifamily Property	83,550	1.4	0.1	13.0
Affordable Multifamily Property	58,000	1.8	0.1	12.9
College/University	5,760	3.7	0.0	12.7
Market Rate Multifamily Property	191,927	3.5	0.0	12.1
Multifamily Property	74,930	2.7	0.0	11.8
Warehousing and Storage	48,420	1.9	0.0	6.5

Appendix D | Behavioral Battery

Before this building was occupied, what steps were taken to ensure that all energy using systems would operate as intended?

- None or standard punch list to confirm equipment installation
- At least some test and balance
- At least some functional performance testing
- Formal building commissioning
- Don't know

Does the building have an energy management plan or policy?

- Yes
- No
- Don’t know

If yes, how strictly would you say the plan is followed?

- Very strictly
- Most of the time
- Sometimes
- Rarely or not at all
- Don’t know

How is energy usage tracked?

- Not tracked, or someone else pays bill
- Review of monthly bills only
- Regular review of monthly usage
- Regular review of usage within a month

How much training, information or education is or has been provided to building occupants regarding appropriate use of building systems to maintain energy efficiency (e.g., don’t touch thermostats, turn of lights as appropriate, close doors/windows)?

- None
- Some
- Significant or ongoing

Are any signs or placards encouraging responsible operation visible (e.g., turn off lights, close refrigerator/freezer doors)?

- Yes
- No

Is access to thermostats or other controls restricted (e.g., thermostat covers or locks)?

- Yes
- No

Grocery stores only

Are any strip curtains pulled back to render them inoperable?

- Yes
- No

Lodging only

Are guests given the option to re-use towels, linens?

- Yes
- No

Multi-family only

Do tenants pay for their own utilities based on their usage?

- Yes
- No

Multi-family, College Dorm, Assisted Living

Are residents encouraged to install high efficiency lighting when bulbs burn out?

- Yes
- No

Are residents discouraged or prohibited from using space heaters or portable air conditioners?

- Yes prohibited
- Yes discouraged
- No

Have any of the low flow devices (showers or sink aerators) been removed or modified (removed flow restrictor washer/screen)?

- Yes
- Not removed
- Never installed

If Yes, what was the reason for the removal or modification

- Tenant made the change
- Tenant requested change?
- Facility staff decision? Record Reason.
- Other?

Was the tenant notified that removal of the device would increase hot water usage and costs? (Record if tenant is responsible for their own hot water costs.)

- Yes
- No
- Don't know if tenant was told
- Tenant is responsible for hot water bill

Appendix E | [CONFIDENTIAL] Final Site Reports