Final Report: Impact Evaluation of the 2013-2014 Existing Buildings Program

Prepared for:

Energy Trust of Oregon

February 9, 2017

Prepared by:

ADM Associates, Inc.

3239 Ramos Circle
Sacramento, CA 95827
(916) 363-8383

Table of Contents

List of Figures

List of Tables

1. Executive Summary

ADM Associates was selected as an independent third party to evaluate the energy impacts garnered from the Existing Buildings (EB) program during the 2013 and 2014 program years (PY).

The EB program offers incentives for the installation of electric and gas energy efficiency measures in existing commercial buildings in Oregon, as well as gas energy efficiency measures commercial buildings served by NW Natural in Washington.[1] The program is implemented on behalf of Energy Trust by a program management contractor (PMC), ICF International (ICF), who has delivered the program since 2013. Prior to 2013, Lockheed Martin delivered the EB program; some projects completed in 2013 were initiated under Lockheed Martin's tenure. In 2013 and 2014, the program had three main tracks[2]:

- Standard: Prescriptive measures in categories such as HVAC, appliances, refrigeration, insulation, food service, domestic hot water, and IT. Savings for these projects were estimated using deemed savings or simplified calculation workbooks.
- Lighting: Includes both lighting fixtures and lighting controls. The Lighting track is implemented by Evergreen Consulting Group under subcontract to the PMC. In addition to projects in the Lighting track, lighting measures may also be part of Standard or Custom track projects. For this evaluation, lighting measures from all tracks were grouped under the Lighting track.
- Custom: Measures that are more comprehensive or interactive than prescriptive measures. They also usually involve more complex energy savings analysis than prescriptive measures.

The impact evaluation was designed around the following overarching evaluation goals:

- Develop estimates of actual EB program gas and electric savings to establish realization rates for the 2013 and 2014 program years individually.
- Report observations from the evaluation and make recommendations to help Energy Trust understand substantial deviations from claimed savings and to improve ex ante savings estimates and the effectiveness of future engineering studies and impact evaluations of Existing Buildings projects.

---

[1] Washington projects were not included in this impact evaluation. Since the program is implemented identically in Oregon and Washington, it is ADM's understanding that the findings from Oregon gas projects will be applied to Washington.

[2] Other tracks and pilots comprised a small percentage of projects and savings for 2013 and 2014, and were not included in this impact evaluation.

ADM employed a site-specific approach in which the M&V method(s) were tailored to each unique measure evaluated. The M&V methods leveraged were consistent with industry standards including the International Performance Measurement & Verification Protocols (IPMVP)[3] Options A, C, and D.[4] Site visits were performed, except for a subset of small lighting measures, to collect primary data used to derive the ex post energy impacts. Site visits were also used to verify that the expected measure(s) were installed and still operating. The sub-set of lighting measures not visited received phone interviews from which primary data was collected and measure operability verified. Two measure categories, custom building controls and custom HVAC measures, received in-depth focus in this evaluation through increased sample sizes for those categories within the sample frames.[5]

A summary of the program's performance for the 2013 and 2014 program years is provided here in the executive summary while a more thorough discussion of our results, key findings, and recommendations can be found in Section 3. Table 1-2 summarizes overall the combined ex post program impacts for the 2013 and 2014 program years. We also note here that current Energy Trust policy is to estimate prescriptive and custom lighting measure savings without heating & cooling interactive factors (HCIFs) and previous evaluation results have been reported consistent with this policy.[6] However; one of the primary goals for this evaluation was to report actual program electric and gas impacts. Since lighting measures represent most of the EB program impacts and affect both electric and gas fuel sources, ADM recommends that it is important to include HCIFs for such measures to meet this evaluation goal. Thus, we provide Table 1-1 which demonstrates the impact(s) these HCIFs have on program level savings. For the remainder of this report all numbers will be provided without HCIFs.

Table 1-1 Lighting HCIF Impacts on Program Savings

	Electric	Gas	MMBTU
2013	-0.3%	-27%	-7%
2014	0.2%	-38%	-9%
Total	**-0.1%**	**-32%**	**-8%**

It can be seen in Table 1-1 that the lighting HCIFs have a negligible impact on program level electric savings. However; they do have a demonstrated impact on the gas savings,

[3] Published by the Efficiency Valuation Organization. http://evo-world.org/en/

[4] Note that IPMVP Option B was not a viable approach since this was a post hoc evaluation. There was no opportunity to collect primary baseline data through sub-metering affected equipment.

[5] The final sample frame and sampling approach is detailed in Section 2.1

[6] HCIFs account for the impact lighting system improvements have on facility heating and cooling loads. Efficient lighting systems introduce less waste heat into their surroundings. When located within conditioned space the result is a reduction in cooling loads and an increase in heating loads.

resulting in an overall reduction to program savings by 8% on an MMBTU basis. Thus, one of our recommendations includes reviewing the current HCIF policy.

Table 1-2 Summary of 2013 and 2014 Program Populations & Sample Frame

	# of Projects	# of Measures	Ex ante Electric Savings (kWh)	Ex ante Gas Savings (therms)
2013 Population	2,696	5,699	90,673,022	1,365,946
2013 Sample	59	120	18,572,110	544,034
Percent of 2013 Population in Sample	2%	2%	20%	40%
2014 Population	3,145	6,182	102,559,554	1,349,209
2014 Sample	66	117	25,792,780	430,560
Percent of 2014 Population in Sample	2%	2%	25%	32%

Table 1-3 Total Ex Post Program Impacts (2013 & 2014 Program Years Combined)

# Projects	# Measures	**Electric**		**Gas**	
		kWh	*RR*	*Therms*	*RR*
5,837	11,881	162,310,809	84%	1,885,065	69%

1.1. Summary of Estimates of EB Program Gas and Electric savings

The final, verified energy impacts for the 2013 and 2014 EB program years are summarized individually in Table 1-4 below. The sample frame was designed to report program impacts with 10% precision at the 90% confidence interval (for each program year). The final sample achieved 9% precision for the 2013 PY and 10% precision for the 2014 PY.[7] A detailed accounting of the sampling frame is provided in Section 2.1.

Table 1-4 Summary of Program Impacts by Year

Program Year	***# Projects***	***# Measures***	***Electric Impacts***		***Gas Impacts***	
			kWh	*RR*	*Therms*	*RR*
2013	2,696	3,141	79,612,150	88%	911,922	67%
2014	5,699	6,182	82,698,659	81%	973,143	72%

[7] At the 90% confidence interval

The two program years share several similarities including how measures were implemented, how ex ante estimates were derived, and their verified performances. Notably, the key findings identified within each measure category were common across program years.[8] Given these similarities, ADM found it suitable to combine the two sample frames into a single frame in order to review the performance of particular measure categories which is summarized in Table 1-5. Measure category results are discussed in further detail, and presented separately by program year, in Section 3.

Table 1-5 Summary of Impacts by Measure Category

Measure Category	*Electric*		*Gas*		*Sampling Precision*
	kWh	*RR*	*Therms*	*RR*	
Custom: Building Controls	14,788,702	65%	479,412	65%	10%
Custom: HVAC	14,676,234	72%	298,266	80%	11%
Custom: Other	6,482,960	61%	280,976	63%	11%
Lighting: Controls	7,400,315	80%	0	N/A	46%
Lighting: Fixtures	92,330,541	93%	0	N/A	8%
Lighting: Street	17,675,633	110%	0	N/A	4%
Standard: All	8,459,433	56%	667,003	58%	32%

It can be seen in the table above that the *Lighting: Fixtures* measure category represents the majority of program savings (roughly 55%) garnered through the EB program. In fact, the three lighting-focused measure categories combined represent about 72% of the program savings of 2013 and 2014 together.

1.2. Summary of Observations and Recommendations

The program was observed to perform relatively consistent with previous years (e.g. number of projects and magnitude of impacts), though the realization rates are lower for PY 2013 and PY 2014 relative to past program years.

[8] While some issues were identified, they were common across both program years.

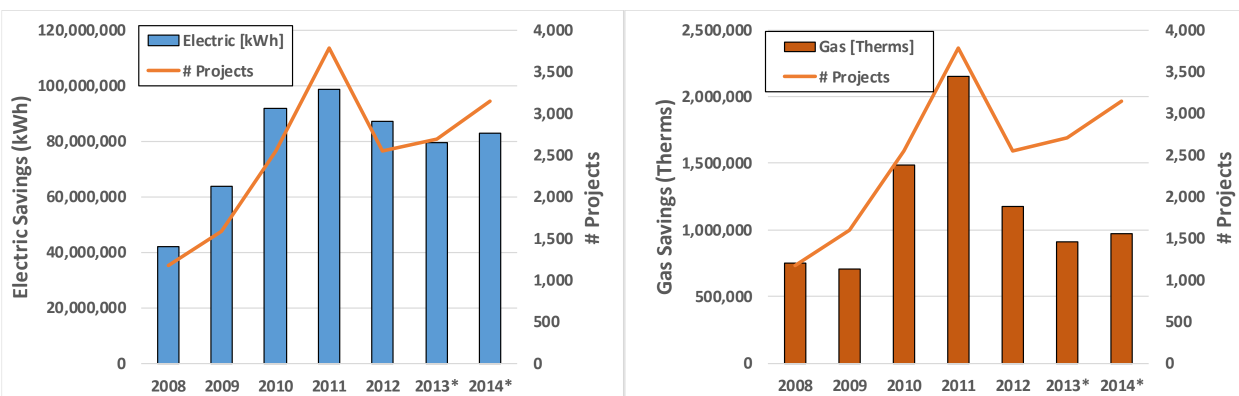
Table 1-6 compares the 2013 and 2014 program year impacts and realization rates to past program years.

Table 1-6 Program Savings by Year and Fuel Source

Program Year	# Projects	Verified Savings		Realization Rates	
		Electric (kWh)	*Gas (Therms)*	*Electric*	*Gas*
2008	1,170	41,887,080	746,564	99%	87%
2009	1,590	63,537,310	705,644	85%	75%
2010	2,544	91,884,445	1,486,729	107%	86%
2011	3,778	98,776,194	2,148,020	91%	101%
2012	2,543	86,910,648	1,174,676	95%	79%
2013	2,696	79,612,150	911,922	88%	67%
2014	3,141	82,698,659	973,143	81%	72%

The trends in program performance over time can be seen in Figure 1-1. In general, the magnitude of the verified program savings follows closely with the number of projects. However; it also appears that as the program has matured the magnitude of the savings on a per project basis has decreased (particularly evident for gas impacts). This may largely be due to all the “low hanging fruit” being harvested during earlier program years, but it is also likely an indication that the program is having an impact on the overall market. As commercial facilities become more efficient, subsequent projects will have a lower savings potential.

Figure 1-1 Illustration of Verified Program Savings (Gas & Electric) Over Time



Program documentation was generally very thorough and included the requisite materials to understand the project’s scope and a general overview of how the ex ante energy savings were calculated. Many of the projects for which simulations were used to derive the ex ante savings estimates included both a Technical Analysis Study (TAS) as well as the simulation files (typically TraneTRACE or eQuest). The set of documents we received was generally consistent; however about 20% of the custom projects were missing either the simulation files or live calculations (e.g. spreadsheet) used to generate the ex ante savings estimates. For such projects, it was more difficult to provide a thorough explanation regarding the deviances. Furthermore, since many of the measures were implemented as part of a larger project, the key findings (as they relate to realization rates) are shared across measure categories and the final realization rates for individual measure categories are somewhat contingent upon that of other measure categories.[9]

When we reviewed the recommendations from the previous program impact evaluation (2012) we observed that most of the recommendations had been implemented at least partially. Two of the recommendations that had not been fully implemented at the time of the 2013/2014 program implementation did impact the program's performance[10] for this current impact evaluation:

- Improve the post-installation inspection process
- Implement "sanity" checks on ex ante savings values

Some examples of the above seen in the 2013/2014 program evaluation include one site for which a VFD was found programmed to run at full speed (60 Hz)[11] as well as several sites for which the ex ante savings estimates exceeded the total consumption of the facility. The most common findings from this evaluation are listed in Table 1-7.

Table 1-7 List of Common Findings and Their Frequency

Category	Description	# of Measures		# of Projects	
		2013 N=120	2014 N=117	2013 N=68	2014 N=78
Operating Assumptions	Assumed operating conditions (e.g. set-points, fan schedules, equipment sequencing) were different on-site from what was assumed in the ex ante calculations.	56	56	30	33
Model Calibration	Issues were found with the level or accuracy of ex ante energy model calibration.	29	22	14	9
Hours of Use	The assumed hours of use (HOU) differed from the actual HOU observed on-site.	25	23	7	10
Controls Savings Factors	Observed differences between the savings assumed for lighting controls and those sourced by the evaluation.	18	8	3	2
Measure Stacking	Interactions between measures (where multiple measures were implemented) were not appropriately accounted for.	13	4	4	2

[9] This is due to the fact that the savings for many measures are "interactive." Take for example a lighting fixture retrofit that included lighting controls (two important measure categories in this program). If the lighting hours of operation are found to be lower for the fixtures this will also impact the savings for the controls which are dependent on the fixtures.

[10] Realization rates

[11] And for which a post-installation inspection photo of this VFD was found also running at 60 Hz

Category	Description	# of Measures		# of Projects	
		2013 N=120	2014 N=117	2013 N=68	2014 N=78
Fixture Counts	Observed fixture counts differed from the assumed fixture counts.	7	8	2	2
Lack of Sanity Checks	Ex ante savings estimates exceeded or represented an unreasonable majority of the utility meter consumption at the facility.	8	7	4	5
Weather Normalization	Where weather normalized, ex ante estimates were normalized to TMY2 rather than TMY3 weather data.	7	5	3	4
Missing Measure(s)	The scope of the project implemented differed from that expected per the Technical Analysis Study (TAS) and ex ante calculations.	6	5	4	4

The following is a summary of our recommendations, which are based on the findings summarized above:

- Several issues related to the ex ante energy simulation process were identified. Specifically, ADM noted that the calibration process was either not completed, was only partially complete (e.g. only executed for one fuel source when it should have been done for both), or complete but executed incorrectly. We recommend that Energy Trust and the PMC work together to develop and distribute a Modeling Guidelines Document to ensure that simulations are calibrated and executed appropriately. This document can be distributed to trade allies and energy auditing firms commonly submitting project applications.
- Several projects were reviewed for which a simple comparison between the ex ante savings estimate and facility billing histories would have immediately identified problems with the savings magnitude. ADM recommends that, to the extent resources allow, a “billing data sanity check” be added to the current application review process for custom track measures/projects. If it is intractable to perform this for a census of projects, then ADM recommends that a threshold be established such that a census of projects whose savings exceed the threshold receive the sanity check and then sample the remaining projects.
- Many of the measure approval documents lack a clear description of the assumptions, methods, and specific inputs used to generate the ex ante prescriptive savings. Where inputs were found, some were inconsistent with the RTF (floating head and suction pressure controls, for example). We expect that many of the measures exhibit the issues identified. ADM recommends that Energy Trust execute a review of the current Unit Energy Savings estimates for standard

track measures and update the assumptions such that they are consistent with current standard sources. We expect that the RTF and Energy Star will represent the most applicable sources for most measures.[12] While a review of the approval documents for all measures would be beneficial, it would also require a significant (and potentially intractable) amount of labor. Thus, it may make more sense to target specific, "high impact", measures in this review. Because a minority of measures comprise the majority of savings for standard measures[13] one can capture 90% of the measure category gas and electric savings by reviewing the following measure types:

1. Anti-sweat heater controls (Electric)
2. Lighting (Electric)
3. Food equipment (Gas and Electric)
4. Ceiling insulation (Electric)
5. Floating head pressure controls and floating suction pressure controls (Electric)
6. Heat pump (Electric)
7. Electrically commutated motors for refrigeration (Electric)
8. Boiler (Gas)
9. Radiant heat (Gas)

- The Energy Trust lighting calculator has a formula that overwrites the calculated fixture savings (column T) if the measure description results in a case in which a "cooling credit" is calculated in Column AI. The formula that is entered resulted in a significant overestimate of kWh savings for the one instance in which a "Cooling Credit" was observed. We recommend that the lighting calculator receive a thorough review and update such that the reported savings are consistent with the values calculated in the Fixture table.
- The ex ante lighting calculations assume 4,380 hours of use annually for exterior lighting.[14] While this can be used as a rough approximation, the evaluation opted to use a slightly more rigorous value for Dawn to Dusk hours per year in the Portland area which is 4,112 hours. This value was calculated using Dusk and Dawn times published by the U.S. Naval Observatory.[15]
- As mentioned, current Energy Trust policy omits HCIF factors on lighting measures for both custom and prescriptive projects. Given the large saturation of gas heating

[12] Some measures may require additional sources. Potential sources may include the Database for Energy Efficiency Resources (DEER), the Idaho Power Technical Reference Manual (TRM), or regional studies on specific end-use consumption(s).

[13] As observed in the 2013/2014 program population.

[14] Derived by dividing the total number of hours in a year (8,760) by two.

[15] http://aa.usno.navy.mil/data/docs/Dur_OneYear.php

in Oregon (and the relatively large contribution of lighting projects to the EB program), ADM found that the gas "penalty" associated with lighting efficiency improvements are non-negligible. We understand that it is unproductive to penalize the gas programs due to activities in the electric programs; however, it is also important to account for impacts (both positive and negative) across fuel sources.

One way to do this is to only incorporate the impacts on all fuel sources when determining the cost effectiveness of certain measures (Total Resource Cost, Utility Cost Test, etc.). This would help programs to more thoroughly evaluate the costs/benefits of measures without penalizing gas (or electric) utility programs due to activities of the other.

- A real-time evaluation of the program would enable evaluation staff to work with program participants as projects are implemented, making the recruiting of customers and data collection efforts significantly more efficient. Furthermore, it would also allow for more accurate characterization of baseline/existing conditions. Finally, a more proximate evaluation will help identify currently relevant recommendations. When the evaluation occurs several years following implementation, its recommendations are often based on 'stale' information as the program design and implementation adapts and evolves over time. If real-time evaluation does not fit within Energy Trust's evaluation framework, then ADM recommends that the evaluation occur within one year of its implementation.

Our key findings are discussed in more detail by measure category in Section 3.1 and a detailed listing of recommendations can be found in Section 4.

MEMO

Date: February 9, 2017
To: Board of Directors
From: Jay Olson, Sr. Program Manager, Commercial Sector
Sarah Castor, Evaluation Sr. Project Manager
Subject: Staff Response to the 2013-2014 Existing Buildings Program Impact Evaluation

The 2013-2014 impact evaluation for the Existing Buildings program observed that the program performed relatively consistently across both years, though not quite as well as in previous years. It provided the first look at program realization rates under the new program management contractor (PMC), ICF International. Based on changes to the program since the evaluated projects were completed, we expect to see improvements in the realization rates for program year 2015 and later.

The evaluator, ADM Associates, noted several opportunities for improvement with regard to custom track projects, mostly around methods used to model estimated savings: better calibration of models to energy usage data, changes to measure stacking order and the use of up-to-date weather data. Some of these needed improvements were also noted in the 2012 Impact Evaluation, completed in early 2015, but changes to the program were not able to be implemented in time to affect 2013 and 2014 projects. We note that the issues identified by the evaluator were less prevalent in 2014 measures/projects than in 2013, indicating that the program was already starting to make positive changes to methods by that time. ICF began comparing project savings to overall building energy use (which the evaluator called a “sanity check”) for custom track projects in late 2014 and will continue this practice, as recommended. Also under ICF’s management, the program maintains a guide to modeling that provides recommendations to Allied Technical Assistance Contractors (ATACs) on general modeling practices. Based on findings and recommendation in this evaluation, the program reviewed the modeling guide in late 2016 and will incorporate more detail on specific modeling requirements in its 2017 revisions.

The evaluation revealed greater variation in standard track measure performance than expected or seen in previous impact evaluations, possibly due to the relatively small number of standard track projects sampled for the evaluation. The evaluator recommended reviewing the measure approval documents and savings estimation methods for nine of the most common standard measures. After discussions with ADM about specific projects and measures, Energy Trust planning staff have identified a few measures, such as insulation and food equipment, where a detailed review of savings estimation methods or breaking the measure into specific use cases (by building hours of use or equipment size) would improve the measures, and possibly realization rates.

Staff will explore these changes in the course of regularly scheduled updates to these measures.

Lighting projects generally performed well, and in line with previous impact evaluations. The evaluator recommended reviewing the lighting calculator tool for an error in a particular cell, affecting a small number of measures. Staff will examine the lighting tool and make any necessary correction, if it has not already been made. The evaluator made a separate recommendation to revise the assumed hours of use for exterior lighting. The current assumption has been in use for many years, and program and planning staff believe it is reasonable. For now, the program will continue using the current assumption, and will look to the next evaluation for further information on whether it is appropriate or should be revised.

The last recommendation about lighting was to review current Energy Trust policy with regard to accounting for the impacts of efficient lighting on energy use for heating and cooling. While the evaluator felt that the increase in gas use caused by installing efficient lighting was significant enough to require accounting in overall program savings, Energy Trust believes that the heating and cooling interaction factors (HCIFs) used by the evaluator, originally from the Regional Technical Forum, are not precise enough to give a valid estimate of the interactive effects for our lighting measures. The HCIFs are based on regional data, have wide error bands, and the cumulative effects seen in the evaluation seem to be larger than reasonable given Oregon's relatively mild climate. In addition, making adjustments for HCIFs to estimated lighting savings would be a complicated process, if not impossible in the case of midstream lighting offerings, and take the measures from standard to custom. Energy Trust will keep in mind the possible interactive effects for lighting when making decisions about the lighting portfolio and individual measure cost-effectiveness.

As noted above, recommendations from the 2012 impact evaluation were received too late to affect 2013 and 2014 projects; however, we expect to see improvements in 2015 and 2016 projects, which will be evaluated in 2017. This will conform with the recommendation by the evaluator to conduct evaluation closer to program implementation. Going forward, Energy Trust plans to conduct impact evaluation for the Existing Buildings program one year after implementation.

2. Impact Evaluation Methodology

The EB program offers incentives for the installation of electric and gas energy efficiency measures in existing commercial buildings in Oregon, as well as gas energy efficiency measures commercial buildings served by NW Natural in Washington.[16] The program is implemented on behalf of Energy Trust by a program management contractor (PMC), ICF International (ICF), who has delivered the program since 2013. Prior to 2013, Lockheed Martin delivered the EB program; some projects completed in 2013 were initiated under Lockheed Martin's tenure. The program as implemented in 2013 and 2014 had three main tracks[17]:

- Standard: Prescriptive measures in categories such as HVAC, appliances, refrigeration, insulation, food service, domestic hot water, and IT. Savings for these projects were estimated using deemed savings or simplified calculation workbooks.
- Lighting: Includes both lighting fixtures and lighting controls. The Lighting track is implemented by Evergreen Consulting Group under subcontract to the PMC. In addition to projects in the Lighting track, lighting measures may also be part of Standard or Custom track projects. For this evaluation, lighting measures from all tracks were grouped under the Lighting track.
- Custom: Measures that are more comprehensive or interactive than prescriptive measures. They also usually involve more complex energy savings analysis than prescriptive measures. ADM Associates was selected as an independent third party to evaluate the energy impacts garnered from the Existing Buildings (EB) program during the 2013 and 2014 program years (PY).

For this impact evaluation ADM employed a *site-specific* approach in which the M&V method(s) were tailored to each unique (sampled) measure. Note, too, that our approach expanded the sample frame to include not only the sampled measures but any measure implemented as part of a common project with the sampled measures. This allowed us to capture the impacts resulting from measures interacting with one another. Our approach followed the following basic steps:

1. ADM first developed a sample design and randomly selected projects/measures consistent with the sample design;

[16] Washington projects were not included in this impact evaluation. Since the program is implemented identically in Oregon and Washington, it is ADM's understanding that the findings from Oregon gas projects will be applied to Washington.

[17] Other tracks and pilots comprised a small percentage of projects and savings for 2013 and 2014, and were not included in this impact evaluation.

2. Next we performed Measurement & Verification (M&V) on, and developed realization rates for, each sampled measure/project;
3. Finally, we extrapolated the individual project/measure results to estimate program performance per the sample plan while identifying key factors contributing to the overall performance of the program and its measure tracks.

In this Section, we discuss how each of the above steps was executed throughout this impact evaluation.

2.1. Sample Design & Project/Measure Selection

We used Stratified Ratio Estimation (SRE) in our sample design, given the high costs of C&I site measurement and metering.[18] This approach was particularly applicable since the EB program is well established with a history of realization rates for different tracks and measure types that could be used to generate reliable initial estimates for error ratios (ER).[19] The sampling plan was designed such that program energy savings could be reported with 10% precision (or better) at the 90% confidence level (90/10) for each of the two program years. [20] Additionally, the program population was stratified by measure category and project size, with the *Custom: HVAC Controls* and *Custom: Building Controls* measure categories separately sampled for 10% precision at the 90% confidence interval. Because many projects claim savings for both gas and electric impacts, we elected to combine the project/measure energy savings estimates into a *total measure savings* in units of MMBTU which was used to facilitate the sample design. Projects were further stratified into "gas" or "electric" categories based on the fuel-source from which most of the project's expected savings came.

An initial sample frame was developed in which we intentionally oversampled measures to make allowances for larger error ratios in the ex post results and to accommodate eventualities in which the evaluation needed to drop projects/measure from the sample. The initial sample frame is presented in Table 2-1and Table 2-2.

[18] 2004 California Evaluation Framework Chapter 13, pages 328 – 340.

[19] The initial error ratios used for lighting and standard measures are based on ADM's experience evaluating similar measures. The error ratios used for the custom projects are based on the variance in the ex post realization rates for custom projects in the most recent impact evaluation of the EB program (PY 2012).

[20] Note that a few program tracks were removed from the evaluated program population as they were/are subject to separate impact evaluations.

Table 2-1 PY Initial Sample Design: PY 2013 (9.9% Overall Precision)

Stratum	Mean mmBTU	Population	Total mmBTU	ER	Sample	$Pr_{Measure}$
Custom: Building Controls, Electric 1	463	32	14,819	0.65	10	10%
Custom: Building Controls, Electric 2	2,057	7	14,396	0.65	7	
Custom: Building Controls, Gas 1	662	34	22,497	0.65	13	
Custom: Building Controls, Gas 2	2,475	7	17,326	0.65	7	
Custom: HVAC, Electric 1	271	45	12,203	0.63	7	9%
Custom: HVAC, Electric 2	1,551	12	18,613	0.63	12	
Custom: HVAC, Gas 1	365	11	4,011	0.63	3	
Custom: HVAC, Gas 2	11,094	2	22,188	0.63	2	
Custom: Non-Lighting, Electric 1	253	51	12,906	0.6	2	27%
Custom: Non-Lighting, Electric 2	2,518	5	12,589	0.6	2	
Custom: Non-Lighting, Gas 1	457	30	13,717	0.6	2	
Custom: Non-Lighting, Gas 2	7,015	2	14,029	0.6	2	
Lighting: Controls, Electric 1	19	520	9,827	0.3	1	34%
Lighting: Controls, Electric 2	1,741	4	6,962	0.3	1	
Lighting: Fixtures, Electric 1	27	3,546	97,105	0.3	4	21%
Lighting: Fixtures, Electric 2	436	135	58,810	0.3	3	
Lighting: Street 1	302	15	4,530	0.3	1	32%
Lighting: Street 2	4,275	3	12,825	0.3	1	
Standard: All, Electric 1	24	648	15,864	0.5	2	32%
Standard: All, Electric 2	290	26	7,530	0.5	1	
Standard: All, Gas 1	73	554	40,488	0.5	3	
Standard: All, Gas 2	1,273	10	12,733	0.5	1	

Table 2-2 Initial Sample Design: PY 2014 (9.3% Overall Precision)

Stratum	Mean mmBTU	Population	Total mmBTU	ER	Sample	$Pr_{Measure}$
Custom: Building Controls, Electric 1	363	34	21,344	0.65	6	9%
Custom: Building Controls, Electric 2	1,358	10	31,234	0.65	10	
Custom: Building Controls, Electric 3	3,051	4	14,750	0.65	4	
Custom: Building Controls, Gas 1	604	27	17,699	0.65	7	
Custom: Building Controls, Gas 2	4,071	2	41,394	0.65	2	
Custom: Building Controls, Gas 3	9,739	2	24,668	0.65	2	
Custom: HVAC, Electric 1	76	61	16,509	0.63	4	9%
Custom: HVAC, Electric 2	520	25	26,122	0.63	9	
Custom: HVAC, Electric 3	1,635	6	15,652	0.63	6	
Custom: HVAC, Gas 1	361	12	14,468	0.63	4	
Custom: HVAC, Gas 2	1,626	5	11,585	0.63	5	
Custom: HVAC, Gas 3	4,789	2	22,188	0.63	2	
Custom: Non-Lighting, Electric 1	78	36	12,771	0.6	1	37%
Custom: Non-Lighting, Electric 2	408	11	11,355	0.6	1	
Custom: Non-Lighting, Electric 3	1,089	3	11,941	0.6	1	
Custom: Non-Lighting, Gas 1	161	34	16,942	0.6	1	
Custom: Non-Lighting, Gas 2	1,312	5	10,800	0.6	1	
Custom: Non-Lighting, Gas 3	2,582	2	17,191	0.6	1	
Lighting: Controls, Electric 1	20	464	19,249	0.3	1	31%
Lighting: Controls, Electric 2	662	2	2,700	0.3	1	
Lighting: Controls, Electric 3	4,192	1	9,779	0.3	1	
Lighting: Fixtures, Electric 1	36	4,151	293,722	0.3	5	18%
Lighting: Fixtures, Electric 2	1,250	9	15,487	0.3	1	
Lighting: Fixtures, Electric 3	7,378	3	29,824	0.3	3	
Lighting: Street 1	200	33	8,750	0.3	1	27%
Lighting: Street 2	2,201	7	26,954	0.3	1	
Lighting: Street 3	5,197	3	19,238	0.3	1	
Standard: All, Electric 1	34	563	41,191	0.5	2	28%
Standard: All, Electric 2	619	5	4,384	0.5	1	
Standard: All, Electric 3	3,495	1	3,495	0.5	1	
Standard: All, Gas 1	66	604	73,639	0.5	3	
Standard: All, Gas 2	279	34	23,336	0.5	1	
Standard: All, Gas 3	696	21	20,464	0.5	2	

Sampled points were selected through simple random sampling within each stratum. Once the initial list of measures was randomly selected we then reviewed the tracking data to determine the unique listing of projects represented in those measures. We found that there were 161 projects in which the initial 179 sampled measures were implemented. Given the minimal incremental cost associated with evaluating all measures on a project (rather than just one of them) we expanded our evaluation activities to include all measures implemented as part of projects represented in our initial sample of measures. Finally, we reviewed the distribution of savings represented by various building type categories within the program population. This distribution was compared to our sample frame to confirm that the building types contributing most to the program's impacts were appropriately represented in the sample. This comparison can be found in Table 2-4.

The final sample frame differed from the initial design in three ways:

1) The final error ratios, based on the results from this evaluation, were generally larger than the initial estimates.
2) 34 projects representing 49 measures were dropped from the evaluation. 20 projects (29 measures) were dropped as these customers were included in other evaluation efforts and Energy Trust waned to limit burn-out to the customer. The remaining 14 projects (20 measures) were dropped due to scheduling issues and site contacts declining to allow us on-site.
3) As noted above, we elected to evaluate all measures at projects of which the initial sampled measures were a part (significantly increasing the initial sample frame size).

The observed error ratios (based on ex post realization rates) are compared to their initial estimates in Table 2-3. The error ratios represent how much variance (or uncertainty) is observed in the measure realization rates. They are used to derive the statistical precision associated with the sampling plan. More consistent realization rates will result in a lower error ratio which in turn requires fewer sample points to achieve a targeted precision. Note that the magnitude by which the observed error ratios differed from the initial estimates varied by measure category with some coming in lower than estimated and others higher. This impacts the final sampling precision for each measures category, as well as the overall sample (shown in *Table 2-5* and Table 2-6).[21] Despite some differences between the expected and observed error ratios, the evaluation met its overall precision targets of 10% at the program level for each program year.

[21] Higher error ratios increase sampling uncertainties whereas lower error ratios reduce uncertainties.

Table 2-3 Final Error Ratios for 2013/2014 Impact Evaluation

Category	Initial	Electric	Gas
Custom: Building Controls	0.65	0.83	0.33
Custom: HVAC	0.60	0.65	0.55
Custom: Other	0.63	0.55	0.42
Lighting: Controls	0.30	0.54	N/A
Lighting: Fixtures	0.30	0.28	N/A
Lighting: Street	0.30	0.10	N/A
Standard: All	0.50	0.45	0.69

Table 2-4 Building Type Distributions for Program Population and Sample Frame

Building Type	Measure Count		Portion of Total Savings*	
	Population	Sample	Population	Sample
Office	1,795	105	19%	31%
Retail	3,189	29	14%	3%
Other	1,081	18	11%	6%
College/University	496	24	9%	20%
Warehouse	1,138	23	9%	10%
Restaurant	1,380	6	8%	1%
Hospital	191	20	6%	12%
Grocery	579	10	4%	0%
Schools K-12	284	13	4%	3%
Infrastructure	46	2	4%	4%
Lodging/Hotel/Motel	461	8	3%	1%
Assembly	78	5	2%	4%
Auto Services	375	2	2%	0%
Gym/Athletic Club	90	4	2%	2%
Other Health	117	9	1%	3%
Religious/Spiritual	459	1	1%	0%
Data Center	14	5	1%	1%
Retirement/Assisted Facilities	29	1	0%	0%
Manufacturing	3	0	0%	0%
Parking structure/Garage	21	0	0%	0%
Laundry/Dry Cleaners	29	0	0%	0%
Parking Structure	7	0	0%	0%
Multifamily Residential	1	1	0%	0%
Funeral/Cremation	16	0	0%	0%
Institution/Government	1	0	0%	0%
Other Residential	1	0	0%	0%

** Portions calculated on an MMBTU basis.*

Table 2-4 shows that the sample frame does not include building types in proportion to their counts in the overall program population. This can be explained by the sample frame being optimized to capture program performance, as defined by accrued energy savings, at the measure level. Furthermore, one specific goal for this evaluation was to evaluate more closely the impacts from Custom Building Controls and Custom HVAC measure categories which led to a slight reduction in the sampling precisions for lighting and standard measures. Since neither the measure counts nor their energy savings are evenly distributed across building types, this led to certain building types receiving higher sample rates than others. For example, Office buildings account for the largest portion of energy impacts from custom building controls and custom non-lighting measures. They also represent the second largest source of energy savings from custom HVAC measures. Thus a significant number of projects implemented in office buildings occur in the sample. Retail stores, on the other hand may represent the largest population (by count) of projects, however; the projects implemented in retail stores predominately fall within the lighting fixtures measure category. Fewer retail stores are therefore found in the evaluation sample. Similarly, 85% of the energy impacts claimed by restaurants came from standard measures which is why they have a lower representation in the sample. The final sample frame is shown in Table 2-5 and Table 2-6.

Table 2-5 Final Sample Frame for PY 2013 (Final Precision = 9%)

Stratum	Population	Electric Savings (kWh)	Gas Savings (therms)	Sample	Precision
Custom: Building Controls, Electric 1	32	4,060,989	9,632	12	13%
Custom: Building Controls, Electric 2	7	4,052,307	5,700	6	
Custom: Building Controls, Gas 1	34	694,282	201,286	13	
Custom: Building Controls ,Gas 2	7	1,218,448	131,688	4	
Custom: HVAC, Electric 1	45	3,327,218	8,509	15	8%
Custom: HVAC, Electric 2	12	5,455,266	0	10	
Custom: HVAC, Gas 1	11	440,957	25,069	2	
Custom: HVAC, Gas 2	2	1,244,967	179,397	2	
Custom: Non-Lighting, Electric 1	51	3,660,226	4,177	7	21%
Custom: Non-Lighting, Electric 2	5	3,689,707	0	3	
Custom: Non-Lighting, Gas 1	30	17,125	136,584	3	
Custom: Non-Lighting, Gas 2	2	67,500	137,988	2	
Lighting: Controls, Electric 1	520	2,880,250	0	4	39%
Lighting: Controls, Electric 2	4	2,040,529	0	1	
Lighting: Fixtures, Electric 1	3,546	28,459,831	0	19	14%
Lighting: Fixtures, Electric 2	135	17,236,205	0	4	
Lighting: Street 1	15	1,327,718	0	1	11%
Lighting: Street 2	3	3,758,723	0	1	
Standard: All, Electric 1	648	4,649,491	0	7	37%
Standard: All, Electric 2	26	2,206,778	0	1	
Standard: All, Gas 1	554	181,353	398,696	2	
Standard: All, Gas 2	10	3,152	127,219	1	

Table 2-6 Final Sample Frame for PY 2014 (Final Precision = 9%)

Stratum	Population	Electric Savings (kWh)	Gas Savings (therms)	Sample	Precision
Custom: Building Controls, Electric 1	34	3,416,268	6,702	14	12%
Custom: Building Controls, Electric 2	10	3,394,626	20,003	6	
Custom: Building Controls, Electric 3	4	3,130,406	15,217	4	
Custom: Building Controls, Gas 1	27	1,016,097	128,508	7	
Custom: Building Controls, Gas 2	2	499,348	64,384	2	
Custom: Building Controls, Gas 3	2	1,149,234	155,560	2	
Custom: HVAC, Electric 1	61	1,361,990	106	9	16%
Custom: HVAC, Electric 2	25	3,575,001	8,019	11	
Custom: HVAC, Electric 3	6	2,874,875	0	5	
Custom: HVAC, Gas 1	12	324,047	32,291	5	
Custom: HVAC, Gas 2	7	1,647,609	120,848	4	
Custom: Non-Lighting, Electric 1	36	826,095	0	3	37%
Custom: Non-Lighting, Electric 2	11	1,314,144	0	2	
Custom: Non-Lighting, Electric 3	3	957,925	0	2	
Custom: Non-Lighting, Gas 1	34	53,171	52,841	2	
Custom: Non-Lighting, Gas 2	5	23,397	64,786	3	
Custom: Non-Lighting, Gas 3	2	0	51,633	1	
Lighting: Controls, Electric 1	464	2,761,258	0	3	57%
Lighting: Controls, Electric 2	2	388,275	0	1	
Lighting: Controls, Electric 3	1	1,228,521	0	1	
Lighting: Fixtures, Electric 1	4,151	43,884,445	0	15	14%
Lighting: Fixtures, Electric 2	9	3,297,011	0	2	
Lighting: Fixtures, Electric 3	3	6,487,532	0	3	
Lighting: Street 1	33	1,931,266	0	1	8%
Lighting: Street 2	7	4,515,721	0	1	
Lighting: Street 3	3	4,569,307	0	1	
Standard: All, Electric 1	563	5,593,470	2	4	37%
Standard: All, Electric 2	6	1,931,989	0	1	
Standard: All, Gas 1	604	153,345	395,989	1	
Standard: All, Gas 2	55	253,181	232,320	1	

2.2. Measurement & Verification of Sampled Measures/Projects

Once the sampled measures were selected we then verified the savings for each sample point using one or more of Measurement and Verification (M&V) Options defined in the International Performance Measurement and Verification Protocol (IPMVP). The M&V path for each project/measure is generally determined by first assessing the relative contribution of a given measure to the overall project impacts and then by considering evaluation resource allocations, data availability, site conditions, etc. The general process can be outlined in the following steps:

- First, site-specific data collection guides were drafted detailing site data collection needs/activities and outlining the M&V methodology to be leveraged;
- ADM field engineers then visited the facility to collect the requisite data and verify measure operability. Some non-custom lighting projects received an engineering desk review for which primary data was collected via telephone interview rather than a site visit;
- Once data was collected, the measure energy impacts were calculated congruent with the data collection guide;
- Finally, the M&V results are compiled in a database along with our key findings. ADM engineers also wrote site-specific reports detailing the M&V results and findings.

2.2.1. Data Collection Guides

After a full review of project documentation and, when necessary, brief exploratory interviews with program staff or the participant, ADM developed data collection guides for all evaluated measures, which contained the following information:

- A description of project/measure(s) being evaluated;
- The expected M&V methodology describing its application[22] to the site;
- Expected data-collection requirements.

The data collection guides were prepared by ADM engineers and made available to customers upon request during the scheduling process to help them better understand the information we were collecting and the scope of our site visit.

2.2.2. Site Visits and Data Collection

Site visits accomplished two major things. First, field staff verified that the energy efficiency measures of interest were indeed installed, that they were installed correctly, and that they still functioned properly. Second, staff collected data – through observation, facility operator interviews one time measurements, and short term monitoring. Additional

---

[22] Including contingencies and alternate approaches.

data was collected from Energy Management Systems (largely for HVAC & HVAC controls measures). The data collected on site was then used to analyze the electric and gas savings for the installed measures. On-site, we also obtained appropriate information to analyze the performance of the different types of energy systems at the facility. This included collecting information on the quantity, sizing, servicing, and scheduling for HVAC, lighting, refrigeration, motors, process and other equipment. We also collected information on the capabilities of building control systems (e.g., whether centralized or distributed, capabilities for control monitoring, automation possibilities, and expansion possibilities). We employed the data collection guides described above to ensure that the information needed to analyze energy efficiency measures was collected for each facility visited.

To minimize the inconvenience to customers, ADM worked with Energy Trust and ICF to contact customers using the most efficient means. During the kick-off meeting it was determined that ADM would provide to ICF the listing of project ID's and project titles, project types (e.g. custom/standard/lighting), and project locations which fell within the evaluation sample. ICF reviewed this listing and informed ADM which customers could be contacted directly and which customers needed to be contacted in coordination with an account representative. In the process, 14 sites had extenuating circumstances which prevented ADM from visiting. Reasons included busy schedules, skepticism of the evaluation effort, missing staff, and non-response.

2.2.3. Calculate Measure Impacts

We followed the data collection guides to develop estimates of realized gross savings and realization rates for all sampled measures. While certain measure/equipment types may favor certain M&V approaches; the crux of any data collection guide is discerning the most appropriate M&V methodology consistent with the evaluation's objectives (including its finite resources), the availability of quality data sources, and industry best practices. ADM employed several key references used to guide this process. The most common references are the IPMVP, the Uniform Methods Project (UMP), and American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) Guideline 14 (Measurement of Energy, Demand and Water Savings). However; we also relied on our extensive experience to discern an appropriate rigor level for each site. The exact approaches used for each site are provided in the site-specific M&V Reports provided as separate documents to Energy Trust with this report (described below).

There are significant differences in evaluating lighting based projects relative to other measures (e.g. Refrigeration, HVAC, Controls, etc.) – the latter of which often require greater flexibility in M&V methods from site to site. Conversely, available M&V options (e.g. IPMVP Options) were limited to Options A, C, and D as this was a *post-hoc* evaluation and there were no opportunities to develop/collect any baseline data in support of an Option B Analysis. Given the above limitations we have summarized our M&V approaches for several standard measure categories.

- *Savings from Lighting Measures:* For lighting measure projects we used IPMVP Option A. We reviewed *ex ante* lighting calculations and supporting documents. This review included checking that the invoices and cut sheets for the purchased materials matched the specified lighting upgrades in the calculation spreadsheet. If there were any discrepancies or internal inconsistencies in the documentation these were identified as researchable issues in the site specific M&V plan. The on-site work focused on determining the hours of operation and verifying the baseline fixtures. During the scheduling process, a preliminary interview informed the site contact of our data collection needs. Our approach to verifying the baseline fixtures and controls is summarized below:

    1. If any of the supplanted fixtures were in storage on site, ADM field staff were instructed to photographically document the baseline fixtures. During the scheduling process we asked if this is possible, since the opportunity may exist to ask the site contact to either retain a sample fixture or to document the make/model.
    2. If the above was not possible but the site contact could attest that fixtures like the baseline fixture were still in utilization in other areas of the facility, those fixtures were documented as proxies for the supplanted fixtures.

    If neither of the above was possible, the site contact (or if applicable, the most knowledgeable person on-site in the matter) was asked to describe the baseline fixtures. Our field staff are trained interviewers and can often obtain enough information to help piece together the connected load of the supplanted fixtures. Typically the hours of operation need to be metered. If the new fixtures were high bays with integral occupancy sensors, then the preferred approach was to meter current at the electrical panel. Otherwise, light level loggers or lighting on/off loggers sufficed.

- *Savings from HVAC Measures:* The required M&V approach largely depended on the type and complexity of the affected equipment. IPMVP Options include A, C, or D. Often we employed multiple options in order to 'triangulate' the final savings estimates through different approaches.
- *Savings from EMS (HVAC Controls) Measures:* These measures exhibit the same range in complexity and appropriate M&V approaches as found in the HVAC measures above. EMS measures rarely provide sufficient savings on their own to measure using Option C; typical M&V methods used were Options A and D.
- *Savings from Refrigeration Measures:* Refrigeration measures are usually project-specific, and the methods used to evaluate savings differed from case to case. We often performed an Option A analysis using engineering principles aided by monitored

data and corroborated using Option C. Data on equipment runtime was collected through short-term monitoring where applicable.

- *Savings from Natural Gas Boilers*: The M&V approaches for natural gas equipment are often constrained by the availability of quality data. Often the only metered data is a whole facility gas meter. Measures affecting boilers which serve heating loads are particularly suited for Option C (our preferred approach when possible) analysis except where multiple boilers are present. If Option C was not possible then we employed an Option A analysis which used pre- and post-combustion efficiency tests in combination with a billing analysis to estimate boiler loads.

Each measure-level analysis yields two estimates of gross savings: an expected gross savings estimate (as reported in the project documentation and program tracking system) and the verified gross savings estimate developed through our verification and evaluation procedures. Thus, we calculated realization rates for each project. We identified measures and projects with high variances in savings and further investigated the supporting analyses to determine reasons driving these differences and whether they can be controlled by the EB program. The results of this process have been compiled into the key findings presented in this report and informed our recommendations for the program going forward.

2.2.4. Site-Level M&V Reports

For each sampled project, ADM prepared a site-specific M&V report which characterizes the project & measures installed, summarizes the data collected, and discusses the M&V method(s) employed. Site reports also provide ex post energy impacts and report differences between collected data and that contained in project implementation documents which result in a significant variance in energy savings.

2.3. Extrapolate Program Impacts & Report Findings/Recommendations

In this last step, we extrapolate the individual measure impacts to the rest of the program population to estimate the final verified program impacts. Program-level gross savings were developed by applying achieved savings realization rates calculated for the analysis sample to program-level data for reported savings. Realization rates describe the relationship between calculated savings and program expected savings estimates. The realization rates are calculated as the ratio of ADM's verified measure savings to the ex ante reported savings. Reported savings are developed by the implementation contractor as part of the program application and recorded in the program tracking database.

The procedure for estimating gross savings for the program is an application of ratio estimation, which improves the precision of the estimates. A Gross Realization Rate (GRR) is calculated to determine the energy savings (kWh or therms) for the entire population of sites participating in the project for the given year. The GRR is defined as the ratio of the sum of the savings from the M&V sample to the sum of the ex ante (i.e., expected) savings recorded in the project tracking database for the same sample.

Our findings and recommendations for the program are communicated in Sections 3 and 4. Measure level results can be found summarized in Appendix A: Listing of Evaluation Results by Measure.

3. Program Results & Evaluation Findings

In this section, we provide a detailed discussion of the EM&V results, including key findings. We also review the EM&V recommendations from the most recent evaluation and discuss the progress of their implementation.

The final, verified energy impacts for the 2013 and 2014 EB program years are summarized individually in Table 3-1. We also note here that current Energy Trust policy is to estimate prescriptive and custom lighting measure savings without heating & cooling interactive factors (HCIFs) and previous evaluation results have been reported consistent with this policy.[23] However; one of the primary goals for this evaluation was to report actual program electric and gas impacts. Since lighting measures represent most of the EB program impacts and affect both electric and gas fuel sources, ADM recommends that it is important to include HCIFs for such measures to meet this evaluation goal. Thus, we provide Table 1-1 in the executive summary which demonstrates the impact(s) these HCIFs have on program level savings. All other impacts reported are provided without HCIFs.

Table 3-1 Summary of Program Impacts by Year

Program Year	# Projects	# Measures	Electric Impacts		Gas Impacts	
			kWh	RR	Therms	RR
2013	2,696	3,141	79,612,150	88%	911,922	67%
2014	5,699	6,182	82,698,659	81%	973,143	72%

While the magnitude of the energy savings garnered by the program in 2013 and 2014 was consistent with historical rates, it can be said that the overall program level realization rates for PY 2013 and PY 2014 are some of the lower rates received by the program in recent years. This can be seen in Table 3-2 which compares the 2013 and 2014 program year impacts and realization rates to past program years.

[23] HCIFs account for the impact lighting system improvements have on facility heating and cooling loads (and the subsequent energy required to meet these loads). Efficient lighting systems introduce less waste heat into their surroundings. When located within conditioned space the result is a reduction in cooling loads and an increase in heating loads.

Table 3-2 Program Savings by Year and Fuel Source

Program Year	# Projects	Verified Savings		Realization Rates	
		Electric (kWh)	*Gas (Therms)*	*Electric*	*Gas*
2008	1,170	41,887,080	746,564	99%	87%
2009	1,590	63,537,310	705,644	85%	75%
2010	2,544	91,884,445	1,486,729	107%	86%
2011	3,778	98,776,194	2,148,020	91%	101%
2012	2,543	86,910,648	1,174,676	95%	79%
2013	2,696	79,612,150	911,922	88%	67%
2014	3,141	82,698,659	973,143	81%	72%

To explore the driving factors behind the 2013 and 2014 realization rates we start by looking at the distribution of realization rates (un-weighted) between the two program years and then across different measure categories. Figure 3-1 and Figure 3-2 demonstrates this cross-section of realization rates for both electric and gas measures. Note that the realization rates plotted below are 'un-weighted' by the sample weights associated with the measure(s) they represent.

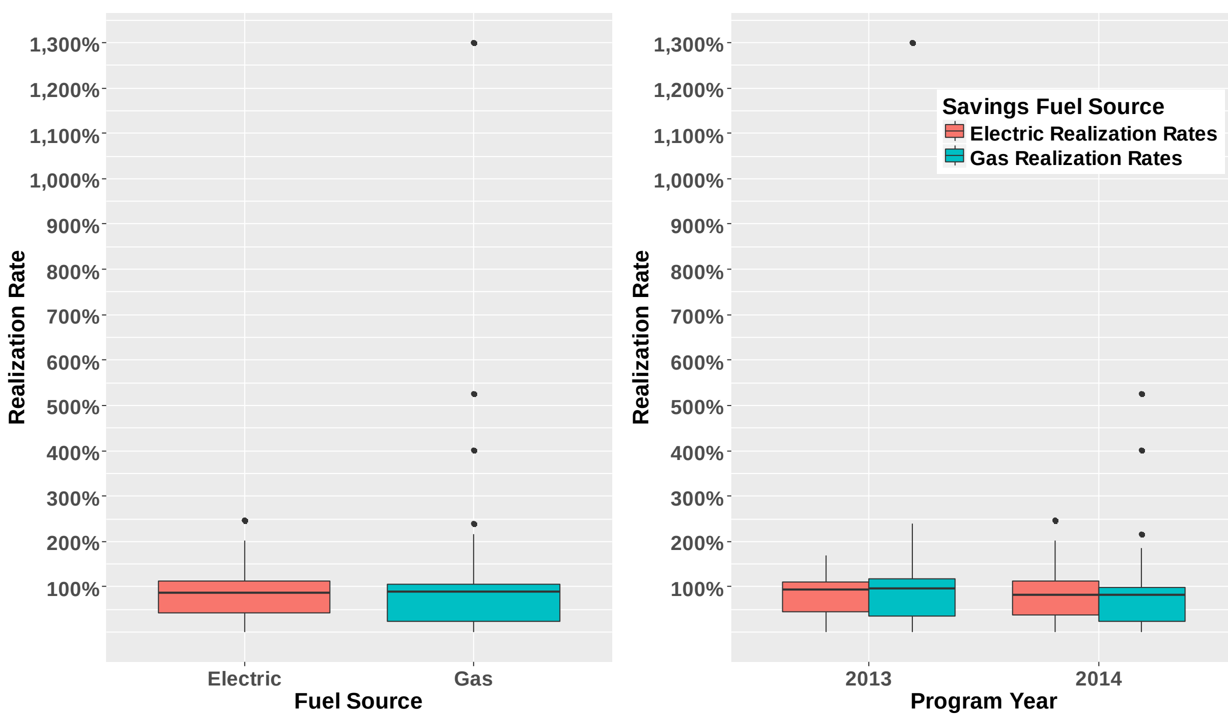


Figure 3-1 Distribution of Measure Realization Rates (Un-Weighted) by Fuel Source and Program Year

The realization rates for gas measures demonstrated a greater variance than those for electric measures. Note how most of the outliers observed in Figure 3-1 for example occur for gas measures. The reasons for this variance are described in detail in Section 3.1, however, a large part of this variance appears to be due to the ex ante energy models lacking calibration to the gas utility billing data. Figure 3-2 demonstrates that the gas measure outliers are located squarely in the custom measure categories for which the ex ante calculations tended to rely heavily on energy models (either building simulation software or detailed bin calculations).

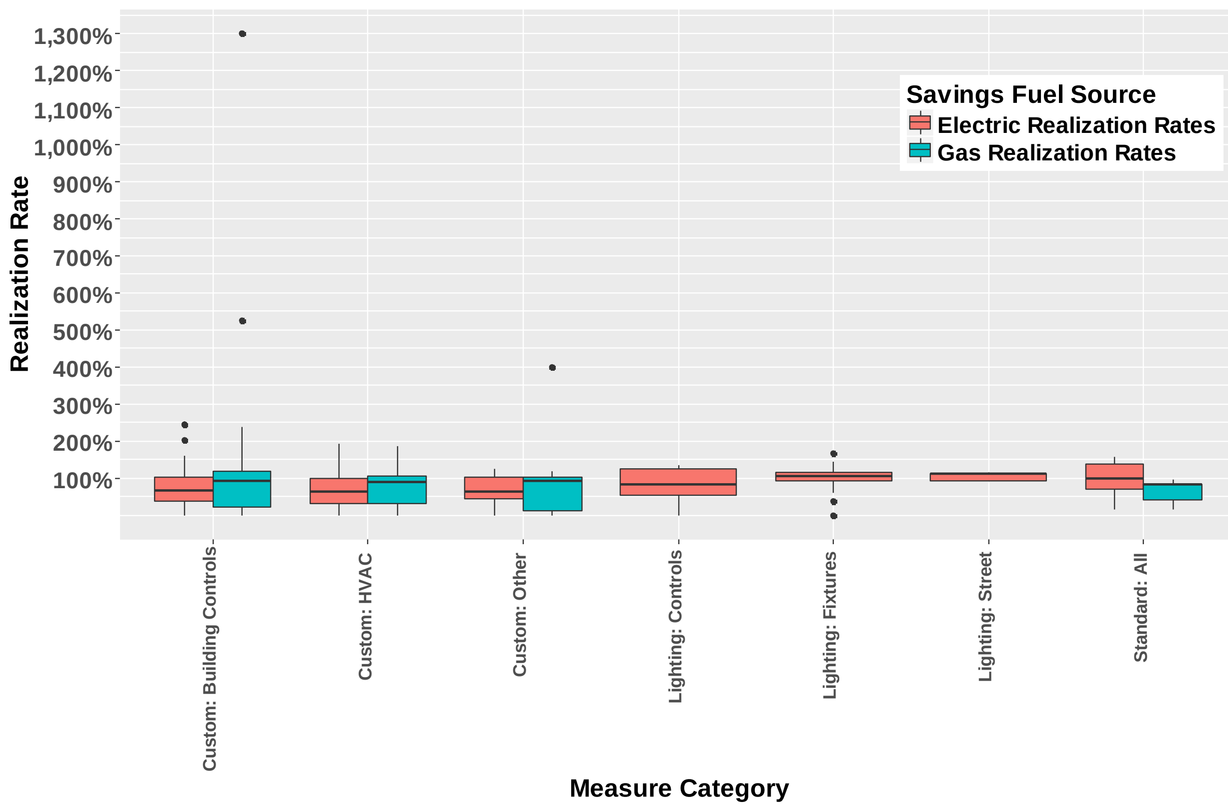


Figure 3-2 Distribution of Measure Realization Rates (Un-Weighted) by Measure Category

The Standard measure category is the only one that shows a very distinct difference between the electric and gas realization rates. This is largely driven by two projects (one in 2013 and one in 2014) for which there were significant differences between the assumptions and methods used to generate prescriptive savings estimates found in the Energy Trust Measure Approval Documents and those used in the evaluation. More discussion on this point can be found in Section 3.1.4.

Next we examine how each measure category contributed to the evaluated program performance. Few differences were present in how measures were implemented across the two program years, including how ex ante estimates were derived. Notably, the key findings identified within each measure category were common across program years as well. Given these similarities, ADM found it suitable to combine the two sample frames into a single frame to review the performance of measure categories which is summarized in Table 3-3.

Table 3-3 Program of Impacts by Measure Category

Measure Category	Electric (kWh)	Electric RR	Gas (Therms)	Gas RR	Sampling Precision
Custom: Building Controls	14,788,702	65%	479,412	65%	10%
Custom: HVAC	14,676,234	72%	298,266	80%	11%
Custom: Other	6,482,960	61%	280,976	63%	11%
Lighting: Controls	7,400,315	80%	0	N/A	46%
Lighting: Fixtures	92,330,541	93%	0	N/A	8%
Lighting: Street	17,675,633	110%	0	N/A	4%
Standard: All	8,459,433	56%	667,003	58%	32%

The above data is graphically represented in Figure 3-3 where it is further disaggregated by program year. It can be seen in Figure 3-3 that the PY 2013 and PY 2014 performed similarly. Lighting measures represent the clear majority of claimed and verified energy impacts for the electric fuel source while the Custom categories combined represent the largest source of gas impacts.

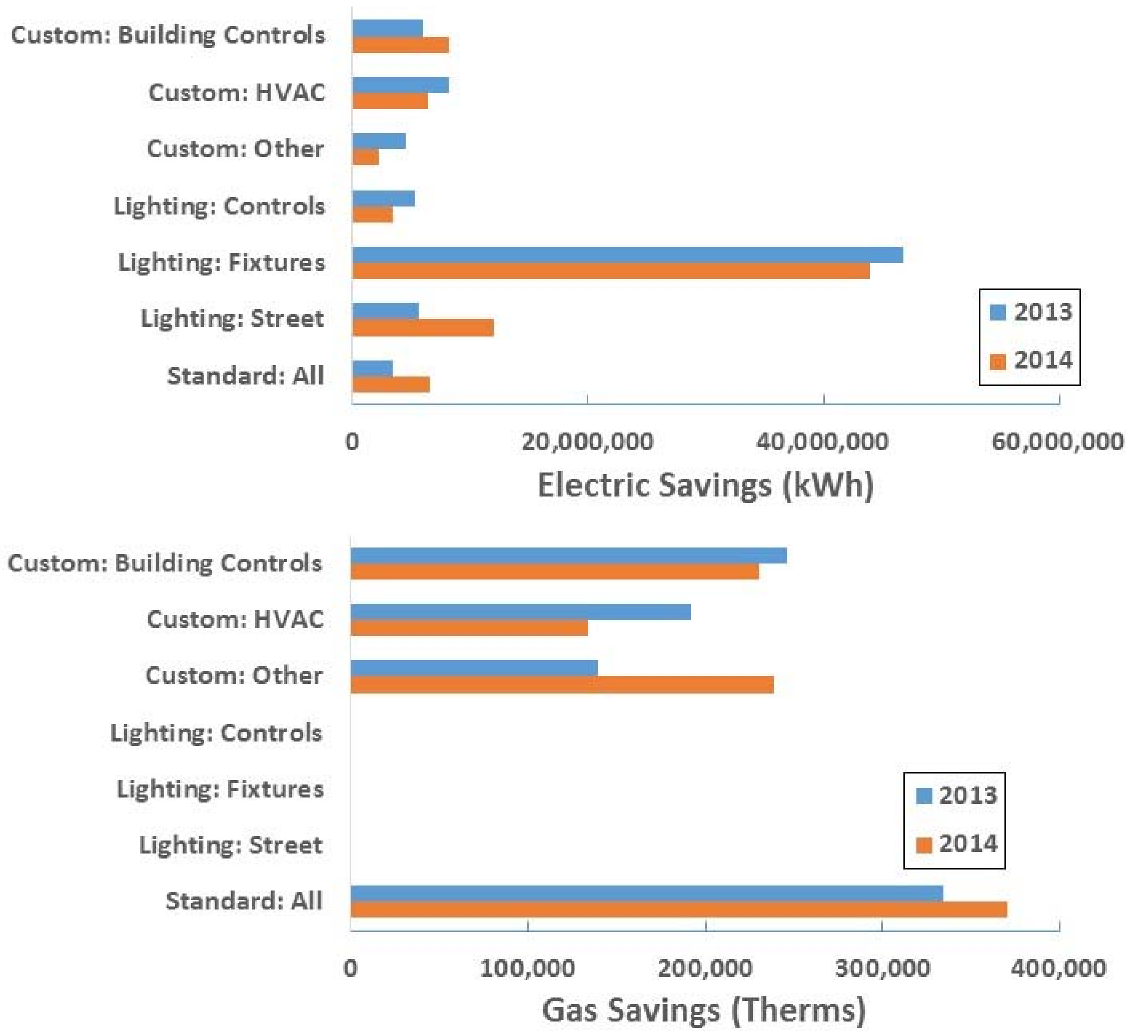


Figure 3-3 Graphical Comparison of Measure Track and Program Year Performance (Gas and Electric)

Realization rates for each measure category are compared across fuel sources and program years in Figure 3-4. The realization rates were overall relatively consistent between 2013 and 2014, but showed some divergence for three measure categories:

- **Lighting: Fixtures (electric) –** One project in 2014 significantly overestimated the lighting hours of use for the interior space which led to a low realization rate for the project.
- **Standard: All (electric) –** A single (very large) project in 2013 was assumed to have an electric water heater when in fact the heating source was geo-thermal.
- **Custom: Other (gas) –** Lack of energy model calibration led to a 400% realization rate for one project in 2014. If removed the realization rates between 2013 and 2014 are consistent.

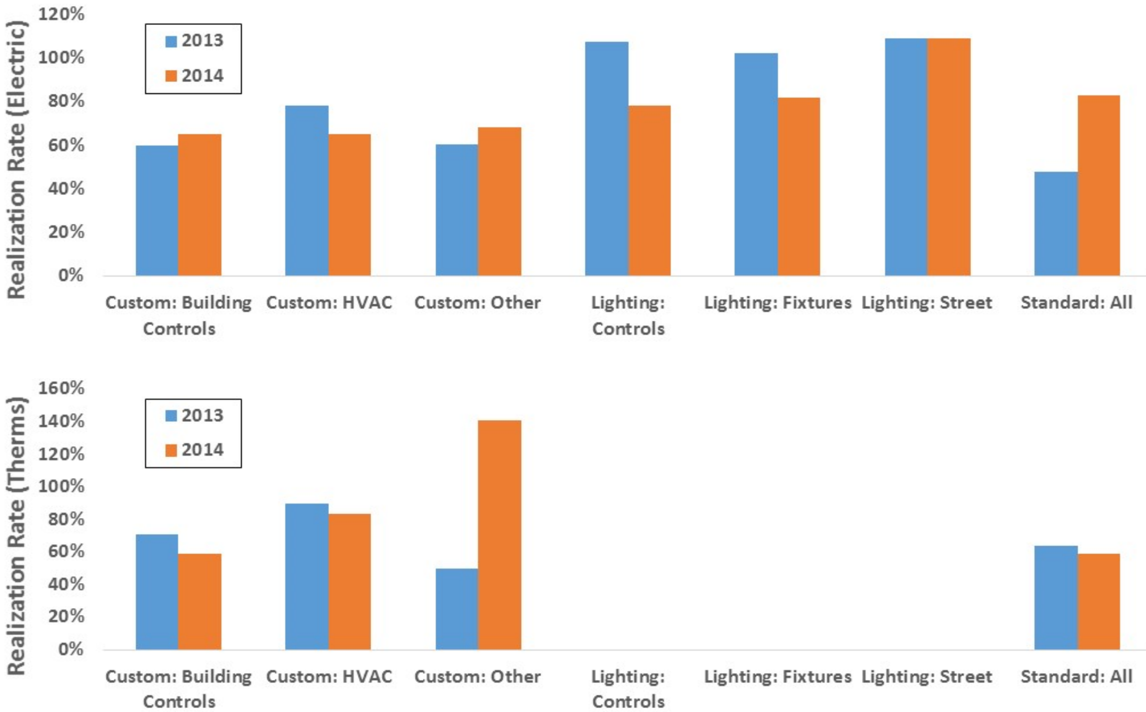


Figure 3-4 Measure Track Realization Rates (Gas and Electric)

3.1. Key Findings by Measure Category

In the following sections we provide some additional discussion regarding our evaluation findings (including factors driving the realization rates) for each of the measure categories. It should be noted that the observed factors were common between program years and as such the following key findings do not differentiate between 2013 and 2014 program years. In each, we've distilled our findings into a discrete number of common factors.

3.1.1. Custom: Building Controls & Custom: HVAC

The ex ante energy savings estimates for *Custom: Building Controls* and *Custom: HVAC* measures largely relied on building energy simulation. The specific simulation approach varied from spreadsheet-driven models of the specific HVAC/Central Plant equipment impacted by the measure(s) to fully calibrated eQuest or TraneTRACE models. Of the sampled custom projects, 16% (17 projects) included both building controls and HVAC measures. Given that similar approaches were used to generate the ex ante estimates it is not surprising to note that ADM's key findings were common across sample points within these two measure categories. The following represents our key findings for these two measure categories combined. Key findings can be generally classified into 6 categories (listed here in order of frequency observed):

Table 3-4 Categorized Key Findings for Custom Building Controls and HVAC Measures

Category	Description	# of Measures		# of Projects	
		2013 N=64	2014 N=69	2013 N=39	2014 N=45
Operating Assumptions	Assumed operating conditions (e.g. set-points, fan schedules, equipment sequencing) were different on-site from what was assumed in the ex ante calculations.	34	40	18	25
Model Calibration	Issues were found with the level or accuracy of ex ante energy model calibration.	25	20	14	8
Measure Stacking	Interactions between measures (where multiple measures were implemented) were not appropriately accounted for.	10	4	4	2
Lack of Sanity Checks	Ex ante savings estimates exceeded or represented an unreasonable majority of the utility meter consumption at the facility.	6	6	4	4
Weather Normalization	Where weather-normalized, ex ante estimates were normalized to TMY2 rather than TMY3 weather data.	6	5	3	4
Missing Measure(s)	The scope of the project implemented differed from that expected per the Technical Analysis Study (TAS) and ex ante calculations.	3	4	3	4

3.1.1.1. Operating Assumptions

ADM identified that 74 of the evaluated measures exhibited different operating conditions (e.g. set-points, fan schedules, equipment sequencing) than assumed in the ex ante calculations. Since the difference in conditions are varied and unique to each project, we don’t spend time here to provide more detail. Instead, more details for each project can also be found in the site-specific reports provided separate to this report. However, it can be noted that the differing assumptions took one of four forms:

- Differences related either to schedules/runtimes for fans & motors or thermostats.
- Differences between the assumed and actual set-points or equipment specifications (for example, efficiency).

- Inaccurate baseline assumptions. In one case, a baseline heat-pump was assumed to have a coefficient of performance (COP) of 1, for example.[24]
- Improper extrapolation from prototypical models to actual site. In one instance, a prototypical building model was used to estimate the savings per square-foot for the implemented measure and was extrapolated using the wrong square footage for the space.

To a certain extent, differences in operating conditions are expected since the operating conditions for building controls measures are often somewhat nebulous at first while facility staff learn how to operate the system and work through commissioning efforts. In the process, many of the original assumptions are subject to revision. While this issue was observed the most frequently, it is difficult to discern to what extent it has impacted the program realization rates as it is typically accompanied by one or more of the other factors discussed in this section. Where this factor appears to have had the greatest impact is on projects for which un-calibrated energy modeling was used to generate the ex ante estimates and on measures targeting cubic feet per minute (CFM) reductions through static pressure reset or air balancing.

3.1.1.2. Model Calibration

ADM found that 45 of the evaluated measures which employed energy simulations to derive ex ante estimates either lacked sufficient calibration to utility billing data or leveraged an incorrect process when doing so. While some documentation was present from which we could review the ex ante calibration results (and to some extent its process), there was little description in the project documentation or TAS reports regarding potential issues that may have been encountered in calibrating the model. Calibration issues took one of the following forms:

- No calibration at all.
- Models only calibrated to a single fuel source. About 36% of measures in these two measure categories claimed both gas and electric savings. However, only a minority of the models used to predict their savings were calibrated to both gas and electric utility data.
- In at least two instances, ADM observed that the ex ante models were calibrated using TMY weather data rather than actual weather for the period of the billing data to which the model was being calibrated.

[24] A COP of one is equivalent to electric resistance heat and is much too low to be considered reasonable for a heat-pump. A more reasonable assumption may be COPs of between 2.5 and 4 depending on the size, age, and type of unit.

- In at least one instance, the model was calibrated using averaged[25] billing data as opposed to the actual billing histories.

Each of the above calibration errors will result in a model that is not sufficiently grounded in the real-world operations of the system(s) being modeled, introducing inaccuracies once the model is used in a predictive capacity (e.g. simulating energy savings).

3.1.1.1. Measure Stacking

ADM observed 14 instances where projects implementing multiple, interactive, measures incorrectly 'stacked' the measures by simulating each in the absence of the others and then adding them independently. This process will typically overestimate project (and individual measure) savings. Instead, the simulator should select an implementation order and then simulate each successive measure assuming the presence of previous measures.

3.1.1.2. Lack of Sanity Checks

Closely related to calibration, a quick 'sanity check' between the facility billing histories and the savings estimate can quickly identify issues with the assumptions/models being used to predict energy savings. Twelve measures were evaluated for which the ex ante savings estimates either exceeded the utility meter consumption at the facility or represented an unreasonable majority of metered consumption. Many observations correlated with projects for which the ex ante savings estimates were generated using temperature bin analysis and about 50% of the projects exhibiting this factor also lacked proper calibration. It is likely that one contributing factor is that the temperature bin analyses were more difficult to calibrate as they only represent a sub-set of the buildings' systems and can't be calibrated directly to utility billing data.

3.1.1.3. Weather Normalization

Eleven of the weather sensitive measures were 'normalized' to TMY2 data[26] in the ex ante calculations. While the process of weather normalization to TMY weather data is indeed appropriate, the TMY weather dataset was updated in 2007 by NREL to more accurately reflect 'current typical conditions' (TMY3[27]) and this dataset was used to estimate ex post savings.

---

[25] When observed, the ex ante calculations typically averaged monthly utility billing data from 2 to 3 years (e.g. average January consumption for the 3-year period, February, etc.).

[26] Average daily meteorological data for a typical year, based on 1961-1990, from the National Solar Radiation Data Base.

[27] Average daily meteorological data for a typical year, based on 1991-2005, from the National Solar Radiation Data Base.

3.1.1.4. *Missing Measure(s)*

In seven cases, ADM found that the scope of the project implemented (or at least programmed/operating) differed from that expected per the Technical Analysis Study (TAS) and ex ante calculations. In some cases, controls were never calibrated and in others only a sub-set of controls strategies were implemented and operating.

3.1.2. Custom: Other

About 50% of the *Custom: Other* measures were observed to be part of larger projects, including measures in the *Custom: Building Controls* and *Custom: HVAC* categories. It is therefore not surprising that many of the factors identified in for these two categories are also present for *Custom: Other*. Referring to Figure 3-4, the reader can see that the gas realization rates for this measure track differ quite substantially between PY 2013 and PY 2014. The reason for this difference is simply that there are a few exaggerated cases of the above factors that happen to lie on opposite extremes. For example, one project from the 2014 program year had ex ante savings based on a simulation model that lacked calibration and resulted in a 400% realization rate for gas savings once properly calibrated. However, a 2013 project resulted in a 0% realization rate for gas[28]. Thus, while the realization rates for gas differ significantly between program years for this measure category, the factors driving these differences are common across years and listed in the table below.

Table 3-5 Categorized Key Findings for Custom Other Measures

Category	Description	# of Measures		# of Projects	
		2013 N=15	2014 N=13	2013 N=13	2014 N=12
Operating Assumptions	Assumed operating conditions (e.g. set-points, fan schedules, equipment sequencing) were different on-site from what was assumed in the ex ante calculations.	9	9	8	8
Model Calibration	Issues were found with the level or accuracy of ex ante energy model calibration.	3	2	2	2
Measure Stacking	Interactions between measures (where multiple measures were implemented) were not appropriately accounted for.	3	0	2	0

[28] The project assumed that a VFD installed on an air-handler would result in therms savings. When combined with an appropriate controls upgrade, and given certain baseline conditions, this is not unreasonable. However, for this project the billing analysis showed that there were no gas savings present for the retrofit.

Category	Description	# of Measures		# of Projects	
		2013 N=15	2014 N=13	2013 N=13	2014 N=12
Lack of Sanity Checks	Ex ante savings estimates exceeded or represented an unreasonable majority of the utility meter consumption at the facility.	2	1	2	1
Missing Measure(s)	The scope of the project implemented differed from that expected per the Technical Analysis Study (TAS) and ex ante calculations.	0	5	0	5

3.1.2.1. Operating Assumptions

ADM found 18 of the evaluated measures exhibited different operating conditions (e.g. set-points, fan schedules, equipment sequencing) than assumed in the ex ante calculations. Similar to the other custom measures, the differences in conditions are varied and unique to each project. Therefore, we don't spend time here to provide more detail. Instead, more details for each project can also be found in the site-specific reports provided separate to this report. However, it can be noted that the differing assumptions took one of the following forms:

- Inaccurate baseline assumptions, or
- Differences between the assumed post operating conditions and the observed operation.

To a certain extent, differences of this nature are expected since the operating conditions of many of these measures are dependent upon the commissioning and final set-points for other measures implemented at the same time.[29] In the process, many of the original assumptions are subject to revision. However, there were two measures which combined represented a reduction in the expected savings for this measure category by approximately 1,200,000 kWh, and could have been addressed with either more care in the ex ante calculations, or a more careful post-install inspection.

In the first case, the project assumed that the baseline loading profile for an air-handler fan followed a constant volume curve when the actual pre-existing equipment modulated using inlet guide vanes. More careful review of the ex ante simulation model and its "key" inputs would have likely caught this discrepancy. In the second case, a pool pump was fitted with a VFD and expected to modulate down to provide the minimum required flow-rate. However, ADM found it programmed to operate at 60 Hz year around. Upon review of the project documentation ADM also found a picture taken during the PMC post

[29] For example, installed in air-handlers will be impacted by the final commissioning and programing of any direct digital controls (DDC) measures installed at the same time.

inspection showing the pump running at 60 Hz. It is likely that a more thorough follow-up between the PMC and facility staff would have caught this discrepancy as well.

3.1.2.2. Model Calibration

ADM found that seven of the evaluated measures which employed energy simulations to derive ex ante estimates either lacked sufficient calibration to utility billing data or leveraged an incorrect process when doing so. These measures corresponded to four unique projects, three of which also implemented custom building controls and HVAC measures. While some documentation was present from which we could review the ex ante calibration results (and to some extent its process), there was little description in the project documentation or TAS reports regarding potential issues that may have been encountered in calibrating the model. Calibration issues took one of the following forms:

- There are two instances that show no indication of any calibration at all.
- In at least two instances, ADM observed that the ex ante models were calibrated using averaged weather data (either TMY or other) rather than actual weather for the period of the billing data to which the model was being calibrated.
- In at least three instances, the model was calibrated using averaged[30] billing data as opposed to the straight billing histories.

Each of the above calibration errors will result in a model that is not sufficiently grounded in the real-world operations of the system(s) being modeled, introducing inaccuracies once the model is used in a predictive capacity (e.g. simulating energy savings).

3.1.2.3. Measure Stacking

ADM observed four instances where projects implementing multiple, interactive, measures incorrectly ‘stacked’ the measures by simulating each in the absence of the others and then adding them independently. The four measures corresponded to two unique projects, each of which also implemented custom building controls and HVAC measures. This process will typically overestimate project (and individual measure) savings. Instead, the simulator should select an implementation order and then simulate each successive measure assuming the presence of previous measures.

3.1.2.4. Lack of Sanity Checks

Five measures were observed as part of projects for which the ex ante estimates either exceeded the utility meter consumption at the facility. For several others, ex ante estimates represented an unreasonable majority of metered consumption. The five measures observed were implemented in three different projects, two of which also

[30] When observed, ex ante calculations typically averaged monthly utility billing data from 2 to 3 years (e.g. average January consumption for the 3-year period, February, etc.).

included custom building controls and HVAC measures. The final project/measure exhibited issues with the ex ante model calibration process which used averaged utility meter data and for which the gas consumption showed particularly poor fit. The actual equipment would have had to operate with unrealistic loading in order to achieve the savings predicted by this model.

3.1.2.5. Missing Measure(s)

In two cases, the energy savings for measures in this category were impacted by other missing measures. In each case, the measure installed was a VFD on air-handler fans. In each case, the energy savings for the VFDs were contingent upon on direct digital controls (DDC) measures implemented at the same time. And, in each case, it was found that these controls were either not implemented or only partially implemented. Thus, while the Custom: Other measures were indeed present, their energy impacts were indirectly affected by the un-implemented controls measures.

3.1.3. Lighting: Controls, Lighting: Fixtures, Lighting: Street

Similar to the custom building controls and HVAC measures, the evaluation found that many of the identified factors were common across the Lighting: Controls, Lighting: Fixtures, and Lighting: Street measure categories. Furthermore, lighting controls were typically installed along with upgraded lighting fixtures as a single project. Thus, the findings for one measure category also impacted the other. As such they are presented combined here.

Table 3-6 Categorized Key Findings for Lighting Controls, Fixtures, and Street Lighting Measures

Category	Description	# of Measures		# of Projects	
		2013 N=30	2014 N=25	2013 N=10	2014 N=12
Hours of Use	The assumed hours of use (HOU) differed from the actual HOU observed on-site.	25	23	7	10
Controls Savings Factors	Observed differences between the savings assumed for lighting controls and those sourced by the evaluation.	18	8	3	2
Fixture Counts	Observed fixture counts differed from the assumed fixture counts.	7	8	2	2

3.1.3.1. Hours of Use

While some minor differences in hours of use (HOU) for indoor fixtures were observed for several sites with most differences relating to exterior lighting. The evaluation noted that the ex ante estimated hours of use for exterior fixtures was 4,380 hours.[31] While this can be used as a rough approximation, the evaluation opted to use a slightly more rigorous value for Dawn to Dusk hours per year in the Portland area which is 4,112 hours. This value was calculated using Dusk and Dawn times published by the U.S. Naval Observatory.[32]

While the above is generally true, there was one project for which the assumed HOU were significantly different than what was verified during ADM's on-site visit. The original assumption for this warehouse was 7,508 hours which could be reasonable for many warehouses operating with 3-shifts. However, during our on-site verification, facility staff indicated that this warehouse does not operate over-night and the verified HOU were 4,797 hours. Because the project included both fixture measures and controls measures, both categories were impacted by this finding.

3.1.3.2. Controls Factors

The evaluation referenced look-up values from the Regional Technical Forum (RTF) for controls measures.[33] The values leveraged by the ex ante calculators were hard-coded and their sources could not be verified. This generally resulted in a slight increase in controls savings.

3.1.3.3. Fixture Counts

Fixture counts varied to some extent for fifteen measures (across four projects). This represented a minor impact to the category savings and, to some extent, is expected. Largely speaking, the fixture counts were found to be consistent with ex ante project documentation.

3.1.3.1. Heating & Cooling Interactive Effects

The evaluation reviewed the impacts of heating and cooling interactive effects where appropriate (including a gas heating penalty where sites used gas heating equipment). As discussed earlier in this report, per Energy Trust's policy, HCIFs are not factored into the ex ante calculations for prescriptive lighting track measures and therefore the ex post impacts reported do not include HCIFs either. However; it is our recommendation that this policy be reviewed and HCIFs considered in the savings estimates (see Section 4 for more on this recommendation).

---

[31] Derived by dividing the total number of hours in a year (8,760) by two.

[32] http://aa.usno.navy.mil/data/docs/Dur_OneYear.php

[33] https://rtf.nwcouncil.org/standard-protocol/non-residential-lighting-retrofits

3.1.4. Standard: All

The primary factor that drove differences between the ex ante and ex post savings for standard track measures was a difference in the assumptions used to develop Unit Energy Savings (UES) estimates for the measures. In fact, in all of the evaluated projects ADM verified that the measure counts were consistent with the project documentation.

ADM received and reviewed Energy Trust Measure Approval Documents for many of the standard measures, however not all assumptions/calculations were available for detailed review. Furthermore, the measure approval documents in some cases lacked sources or other information that could be used to verify the reasonableness of any fundamental assumptions used to support the ex ante estimates. The evaluation employed standard sources and engineering formulas to derive UES estimates for Standard measures including Energy Star, RTF, and even some assumptions documented in the Energy Trust Measure Approval Documents. In this process we noted the following:

- There are some inconsistencies between the assumptions used in the Measure Approval Documents and by the RTF for Floating Head and Floating Suction Pressure controls measures.
- Many of the Measure Approval Documents do not provide a clear picture of how the final prescriptive numbers were derived (e.g. final assumptions, calculator inputs, live calculations, etc.).
- The energy savings between electric and gas savings for the same measure (steam cookers) are an order of magnitude different when compared with equivalent units.

Table 3-7 lists each of the evaluated measure categories showing the impacts that their realization rates had on the overall measure category savings. A negative percentage represents that the measure type contributed to an overall reduction in the expected (ex ante) savings. On the electric side it can be seen that Showerheads and Faucet aerators contributed the largest impacts, closely followed by anti-sweat heater controls. Gas savings were largely impacted by the Food Equipment and Ceiling Insulation measure types.

Table 3-7 Evaluated Standard Measure Types and Their Impacts on Category Savings

Electric Savings	
Measure Type	Percent Impact
Showerhead	-12%
Faucet aerator	-12%
Anti-sweat heater controls	-7%
Lighting	-2%
Floating head and suction pressure controls	1%
HVAC	1%
Motors for refrigeration	2%

Gas Savings	
Measure Type	Percent Impact
Food equipment	-24%
Ceiling insulation	-14%
Boiler	-1%

The results for the faucet aerators and showerheads measures were largely driven by a single project at which a large number of both were installed and combined represented 70% of the ex ante savings for this measure type. It was assumed that the site used electric resistance heat for water heating when it actually used geo-thermal.

Similarly, two measures were evaluated from the Food Equipment category (steam cookers), each of which saw similar realization rates. ADM reviewed the Measure Approval Documents for the steam cookers measure and the ex ante estimates are based on the EnergyStar calculator for this measure, which is consistent with how the ex post savings were calculated. However; the ex ante prescriptive savings estimates were derived using default EnergyStar inputs whereas we applied specific values for unit size, hours of use, etc. as verified through this evaluation. The differences between the ex ante and ex post savings estimates are predominately driven by differences between the EnergyStar default hours of use and the hours of use verified on-site. Additional deviation is introduced through differences in unit size/capacity, though these had a smaller impact then hours of use.

Table 3-8 summarizes the program tracking data (2013 and 2014 combined) by measure type for Standard measures, listing the claimed savings for each and their rank within the program.[34] It can be seen that the evaluation included most of the top ranked measure types for both gas and electric fuel sources[35] and that the issues identified above impact a significant portion of the program savings.

[34] Ranked by % of ex ante savings relative to total ex ante savings for the measure category.

[35] Notably, no virtualization measures fell into the evaluation sample.

Table 3-8 Ranking of Standard Measures Relative to Their Importance in the Program

Measure Type	Electric Savings (ex ante kWh)	Rank
Virtualization	5,468,057	1
Anti-sweat heater controls	2,546,672	2
Lighting	1,611,486	3
Food equipment	1,029,574	4
Ceiling insulation	942,154	5
Floating head and suction pressure controls	859,410	6
Heat pump	757,983	7
Motors for refrigeration	607,198	8
Refrigerator	519,469	9
HVAC	177,767	10
Icemaker	110,081	11
Night covers	106,516	12
Showerhead	62,149	13
Wall insulation	59,717	14
Faucet aerator	52,605	15
Radiant heating	27,040	16
Freezer	15,038	17
Clothes washer	11,870	18
Lighting controls	4,270	19
Ozone laundry	3,152	20
Compressed air	386	21
Dishwasher	165	22

Measure Type	Gas Savings (ex ante therms)	Rank
Food equipment	630,800	1
Boiler	190,399	2
Ceiling insulation	188,970	3
Radiant heating	52,162	4
Wall insulation	13,618	5
Tankless water heater	12,970	6
Pipe insulation	11,036	7
Refrigerator	10,170	8
Showerhead	9,580	9
Tanked water heater	8,765	10
Gas furnace	8,592	11
Ozone laundry	7,101	12
Steam traps	4,480	13
Clothes washer	4,141	14
Faucet aerator	1,440	15
Dishwasher	2	16

3.2. Previous Impact Evaluation Recommendations

The 2012 impact evaluation for the Existing Buildings program was completed in early 2015 and included seven recommendations for the program:[36]

- Consider commissioning completion as a program requirement
- Consider incorporating facility staff training as a program requirement
- Maintain consistent documentation on simulation model files
- Encourage participants to enable energy management system trends
- Improve implementer post-install audit process
- Improve server virtualization savings methodology[37]
- Implement project savings “sanity” checks

As the report was published after the 2013 and 2014 program years were completed, the observations ADM makes below reflect only on the extent to which the issues behind the 2012 impact evaluation recommendations still persisted in 2013 and 2014 projects. It is not possible for the 2012 report recommendations to have affected 2013 and 2014 program implementation, although the change in PMC may have resulted in some changes to program processes that affected the outcomes of projects included in this evaluation.

In a memo published with the 2012 impact evaluation report, Energy Trust indicates that the first recommendation (requiring commissioning) represents a barrier to participation and that while there are some instances where the program includes these costs, it is not universally included due to the high costs. This is consistent with ADM’s observations of the evaluated controls measures. When commissioned, the commissioning was at the direction of the site and not by PMC or other program staff. In fact, lack of commissioning for several measures led to lower realized savings for this measure category. Similarly, we observed a mix of training levels for staff on-site. In many cases, there had been staff turn-over such that the current facility personnel are no longer even familiar with the project/measure(s) implemented. We expect that a requirement to train site staff in the operating of the measure(s) exhibits the same difficulties that requiring commissioning does.

Program documentation was generally very thorough and included the requisite materials to understand the project’s scope and a general overview of how the ex ante energy savings were calculated. Many of the projects for which simulations were used to derive the ex ante savings estimates included both a Technical Analysis Study (TAS) as well as

[36] 2012 Existing Buildings Impact Evaluation. http://energytrust.org/wp-content/uploads/2016/12/2012_Existing_Buildings_Program_Impact-Eval_2015-03-24.pdf

[37] No server virtualization projects fell into this evaluation’s final sample frame. As such, ADM is unable to provide any commentary regarding the effectiveness or status of this recommendation.

the simulation files (typically TraneTRACE or eQuest). The set of documents we received was generally consistent, however about 20% of the custom projects were missing either the simulation files or live calculations (e.g. spreadsheet) used to generate the ex ante savings. For such projects, it was more difficult to provide a thorough explanation regarding the deviances.

Many of the projects we evaluated indeed had trending data available for our review and, when available, customers readily provided the data to us. We did not find that this data was lacking (when required) for this evaluation, indicating that the participants in the 2013/2014 evaluation sample made this more available then it was for the 2012 evaluation. It is unclear to what extent this was affected by PMC and other program staff, though it did not represent an issue. Since many of the controls measures were upgrades from older, pneumatic, systems to new DDC systems it was typical that baseline trending data was simply unavailable due to lack of infrastructure.

One of the projects we evaluated received a low realization rate due to a VFD programmed to operate at 60 Hz rather than to modulate as was originally expected. Reviewing the project documentation, we found a picture of the VFD display indicating that it was running at 60 Hz during the post installation inspection. Thus, for at least one project we can note that findings could have been remedied by a more thorough post-installation inspection. Approximately 47% of the measures in our sample showed some deviation between the assumed operating conditions and the actual operating conditions.[38] While some variations are to be expected (and some of these differences were assumptions regarding the baseline equipment rather than the post equipment), this statistic indicates that there is still some room to improve either the post-installation inspection or the process by which findings from the post-installation inspection are used to revise the final savings estimates.

Finally, it is unclear how many projects from the 2012 impact evaluation were used to make the recommendation for a “sanity” check on the final ex ante savings estimates, but ADM noted that fifteen measures in the 2013/2014 sample would have benefited from such a check, and is making the same recommendation in this impact evaluation.

[38] Observed at the time of this evaluation.

4. Evaluation Recommendations

The following recommendations are derived from our observations regarding the main factors driving program realized savings to differ from the estimated savings. While some factors cannot be controlled for,[39] many of the key factors discussed in the previous section can be controlled during program implementation.

4.1. Develop and Implement a Modeling Guidelines Document

Several issues related to the ex ante energy simulation process were identified in the Key Findings section(s) above. Specifically, ADM noted that the calibration process was either not completed, was only partially complete (e.g. only executed for one fuel source when it should have been done for both), or complete but executed incorrectly. We recommend that Energy Trust and the PMC work together to develop and distribute a Modeling Guidelines Document used to ensure that simulations are calibrated and executed appropriately. This document can be distributed to trade allies and energy auditing firms commonly submitting project applications. Specific features that should be included are as follows:

- The document should address basic model calibration considerations:
  1. The model should be calibrated to any fuel source for which savings are being claimed. If project resources do not permit a full calibration, then the simulator should at the very least perform a “sanity check” against the billing data to confirm that the simulated results are reasonable.
  2. Calibration should use billing histories (or collected data) for a specific period (e.g. non-averaged).
  3. Calibrations should use weather data corresponding to the specific period over which the billing histories (or other data) are observed (e.g. non-averaged and not TMY).
- The document should also discuss proper methods to estimate savings in cases of multiple, interactive measures (e.g. measure stacking).
- The document should have a corresponding check-list that can be submitted with the project documentation (TAS report, application etc.) to verify that the model(s) were developed in accordance with the guidelines.

4.2. Implement Sanity Checks for Custom Track Projects

Several projects were reviewed for which a simple comparison between the ex ante savings estimate and facility billing histories would have immediately identified problems with the savings magnitude. ADM recommends that, to the extent resources allow, a

---

[39] For example, actual conditions on-site vs. assumed conditions in prescriptive measures.

"billing data sanity check" be added to the current application review process for custom track measures/projects. If it is intractable to perform this for a census of projects, then ADM recommends that a threshold be established such that a census of projects whose savings exceed the threshold receive the sanity check and then sample the remaining projects.

4.3. Consider Reviewing Current Prescriptive Savings Estimates for Standard Track Measures

In Section 3.1.4 we note that many of the measure approval documents lack a clear description of the assumptions, methods, and specific inputs used to generate the ex ante prescriptive savings values used for standard measures. Where inputs were found, some were inconsistent with the RTF (floating head and suction pressure controls for example). Furthermore, there is at least one case (steam cookers) where the gas and electric savings for the same measure are internally inconsistent. We expect that many of the measures exhibit the issues identified.

ADM recommends that Energy Trust execute a review of the current Unit Energy Savings estimates for standard track measures and update the assumptions such that they are consistent with current standard sources. We expect that the RTF and Energy Star will represent the most applicable sources for most measures.[40] While a review of the approval documents for all measures would be beneficial, it would also require a significant (and potentially intractable) amount of labor. Thus, it may make more sense to target specific, "high impact", measures in this review. Because a minority of measures comprise the majority of savings for standard measures[41] one can capture 90% of the measure category gas and electric savings by reviewing the following measure types:

- Anti-sweat heater controls (Electric)
- Lighting (Electric)
- Food equipment (Gas and Electric)
- Ceiling insulation (Electric)
- Floating head pressure controls and floating suction pressure controls (Electric)
- Heat pumps (Electric)
- Electrically commutated motors for refrigeration (Electric)
- Boiler (Gas)
- Radiant heat (Gas)

[40] Some measures may require additional sources. Potential sources may include the DEER, the Idaho Power TRM, or regional studies on specific end-use consumption(s).

[41] As observed in the 2013/2014 program population.

4.4. Review Energy Trust Lighting Calculator

The Energy Trust lighting calculator has a formula that overwrites the calculated fixture savings (column T) if the measure description results in a case in which a “cooling credit” is calculated in Column AI. The formula that is entered resulted in a significant over estimate of kWh savings for the one instance in which a “Cooling Credit” was observed. We recommend that the lighting calculator receive a thorough review and update such that the reported savings are consistent with the values calculated in the Fixture table.

4.5. Update Hours of Use Assumption for Exterior Lighting

The ex ante lighting calculations assume 4,380 hours of use annually for exterior lighting.[42] While this can be used as a rough approximation, the evaluation opted to use a slightly more rigorous value for Dawn to Dusk hours per year in the Portland area which is 4,112 hours. This value was calculated using Dusk and Dawn times published by the U.S. Naval Observatory.[43]

4.6. Review Current Policy Regarding Application of Lighting HCIFs

As mentioned elsewhere in this report, current Energy Trust policy omits HCIF factors on lighting measures for both custom and prescriptive projects. Given the large saturation of gas heating in Oregon (and the relatively large contribution of lighting projects to the EB program), ADM found that the gas “penalty” associated with lighting efficiency improvements are non-negligible. We understand that it is unproductive to penalize the gas programs due to activities in the electric programs; however, it is also important to account for impacts (both positive and negative) across fuel sources.

One way to do this is to only incorporate the impacts on all fuel sources when determining the cost effectiveness of certain measures (Total Resource Cost, Utility Cost Test, etc.). This would help programs to more thoroughly evaluate the costs/benefits of measures without penalizing gas (or electric) utility programs due to activities of the other.

4.7. Consider Coordinating the Program Evaluation Closer to Its Implementation

ADM found that it was particularly difficult to contact customers and collect requisite site data given the large lag between the evaluation and the program implementation (particularly true for PY 2013 participants). Significant effort went into explaining our role and the purpose of this evaluation to customers, as many customers had forgotten about the project details and many facilities have had turn-over with their staff. Thus, many of the contacts had changed and the current staff had little to no information about the project(s).

---

[42] Derived by dividing the total number of hours in a year (8,760) by two.

[43] http://aa.usno.navy.mil/data/docs/Dur_OneYear.php

A real-time evaluation of the program would enable evaluation staff to work with the program participants as projects are implemented, making the recruiting of customers and data collection efforts significantly more efficient. Furthermore, it would also allow for more accurate characterization of baseline/existing conditions. Finally, a more proximate evaluation will help identify currently relevant recommendations. When the evaluation occurs several years following implementation, its recommendations are often based on ‘stale’ information as the program design and implementation adapts and evolves over time. If real-time evaluation does not fit within Energy Trust’s evaluation framework, then ADM recommends that the evaluation occur within one year of its implementation.

5. Appendix A: Listing of Evaluation Results by Measure

Measure ID	ADM ID	Category	Program Year	Realization Rate (Electric)	Realization Rate (Gas)
1	CST2013 - 18	Custom: Building Controls	2013	4%	NA
2	CST2013 - 20	Custom: Building Controls	2013	24%	NA
3	CST2013 - 34	Custom: Building Controls	2013	44%	NA
4	CST2013 - 26	Custom: Building Controls	2013	40%	NA
5	CST2013 - 21	Custom: Building Controls	2013	55%	NA
6	CST2013 - 23	Custom: Building Controls	2013	46%	NA
7	CST2013 - 31	Custom: Building Controls	2013	43%	NA
8	CST2013 - 15	Custom: Building Controls	2013	8%	100%
9	CST2013 - 13	Custom: Building Controls	2013	0%	0%
10	CST2013 - 35	Custom: Building Controls	2013	42%	NA
11	CST2013 - 40	Custom: Building Controls	2013	75%	NA
12	CST2013 - 49	Custom: Building Controls	2013	0%	0%
13	CST2013 - 17	Custom: Building Controls	2013	67%	1301%
14	CST2013 - 06	Custom: Building Controls	2013	80%	89%
15	CST2013 - 17	Custom: Building Controls	2013	67%	1301%
16	CST2013 - 21	Custom: Building Controls	2013	55%	NA
17	CST2013 - 17	Custom: Building Controls	2013	67%	1301%
18	CST2013 - 16	Custom: Building Controls	2013	64%	150%
19	CST2013 - 17	Custom: Building Controls	2013	67%	1300%
20	CST2013 - 07	Custom: Building Controls	2013	100%	39%
21	CST2013 - 25	Custom: Building Controls	2013	96%	21%
22	CST2013 - 22	Custom: Building Controls	2013	100%	100%
23	CST2013 - 02	Custom: Building Controls	2013	NA	42%
24	CST2013 - 37	Custom: Building Controls	2013	100%	0%
25	CST2013 - 03	Custom: Building Controls	2013	NA	118%
26	CST2013 - 03	Custom: Building Controls	2013	NA	118%
27	CST2013 - 36	Custom: Building Controls	2013	NA	126%
28	CST2013 - 01	Custom: Building Controls	2013	NA	98%
29	CST2013 - 01	Custom: Building Controls	2013	125%	100%
30	CST2013 - 11	Custom: Building Controls	2013	103%	103%
31	CST2013 - 55	Custom: Building Controls	2013	160%	240%
32	CST2013 - 12	Custom: Building Controls	2013	134%	60%
33	CST2013 - 14	Custom: Building Controls	2013	122%	162%
34	CST2013 - 50	Custom: Building Controls	2013	117%	NA

Measure ID	ADM ID	Category	Program Year	Realization Rate (Electric)	Realization Rate (Gas)
35	CST2013 - 10	Custom: Building Controls	2013	NA	7%
36	CST2013 - 06	Custom: HVAC	2013	77%	NA
37	CST2013 - 16	Custom: HVAC	2013	43%	150%
38	CST2013 - 17	Custom: HVAC	2013	67%	NA
39	CST2013 - 18	Custom: HVAC	2013	100%	NA
40	CST2013 - 18	Custom: HVAC	2013	100%	NA
41	CST2013 - 23	Custom: HVAC	2013	46%	NA
42	CST2013 - 23	Custom: HVAC	2013	46%	0%
43	CST2013 - 27	Custom: HVAC	2013	13%	NA
44	CST2013 - 27	Custom: HVAC	2013	54%	NA
45	CST2013 - 27	Custom: HVAC	2013	66%	NA
46	CST2013 - 30	Custom: HVAC	2013	160%	NA
47	CST2013 - 30	Custom: HVAC	2013	160%	NA
48	CST2013 - 32	Custom: HVAC	2013	83%	NA
49	CST2013 - 32	Custom: HVAC	2013	96%	NA
50	CST2013 - 32	Custom: HVAC	2013	100%	NA
51	CST2013 - 32	Custom: HVAC	2013	111%	NA
52	CST2013 - 33	Custom: HVAC	2013	114%	NA
53	CST2013 - 43	Custom: HVAC	2013	40%	89%
54	CST2013 - 44	Custom: HVAC	2013	135%	NA
55	CST2013 - 46	Custom: HVAC	2013	NA	102%
56	CST2013 - 49	Custom: HVAC	2013	11%	27%
57	CST2013 - 51	Custom: HVAC	2013	23%	NA
58	CST2013 - 51	Custom: HVAC	2013	25%	NA
59	CST2013 - 51	Custom: HVAC	2013	25%	NA
60	CST2013 - 51	Custom: HVAC	2013	20%	NA
61	CST2013 - 51	Custom: HVAC	2013	15%	NA
62	CST2013 - 53	Custom: HVAC	2013	100%	100%
63	CST2013 - 55	Custom: HVAC	2013	160%	NA
64	CST2013 - 57	Custom: HVAC	2013	100%	NA
65	CST2013 - 27	Custom: Non-Lighting	2013	5%	NA
66	CST2013 - 04	Custom: Non-Lighting	2013	36%	NA
67	CST2013 - 26	Custom: Non-Lighting	2013	40%	NA
68	CST2013 - 23	Custom: Non-Lighting	2013	46%	NA
69	CST2013 - 13	Custom: Non-Lighting	2013	64%	0%
70	CST2013 - 23	Custom: Non-Lighting	2013	46%	NA
71	CST2013 - 06	Custom: Non-Lighting	2013	76%	109%
72	CST2013 - 32	Custom: Non-Lighting	2013	100%	NA
73	CST2013 - 32	Custom: Non-Lighting	2013	102%	NA
74	CST2013 - 33	Custom: Non-Lighting	2013	114%	NA

Measure ID	ADM ID	Category	Program Year	Realization Rate (Electric)	Realization Rate (Gas)
75	CST2013 - 09	Custom: Non-Lighting	2013	NA	0%
76	CST2013 - 45	Custom: Non-Lighting	2013	NA	12%
77	CST2013 - 03	Custom: Non-Lighting	2013	NA	118%
78	CST2013 - 19	Custom: Non-Lighting	2013	76%	97%
79	CST2013 - 08	Custom: Non-Lighting	2013	NA	56%
80	LGT2013 - 04	Lighting: Controls	2013	54%	NA
81	LGT2013 - 04	Lighting: Controls	2013	66%	NA
82	CST2013 - 07	Lighting: Controls	2013	100%	NA
83	LGT2013 - 06	Lighting: Controls	2013	131%	NA
84	LGT2013 - 07	Lighting: Controls	2013	125%	NA
85	LGT2013 - 01	Lighting: Fixtures	2013	84%	NA
86	LGT2013 - 10	Lighting: Fixtures	2013	0%	NA
87	LGT2013 - 10	Lighting: Fixtures	2013	75%	NA
88	LGT2013 - 02	Lighting: Fixtures	2013	94%	NA
89	LGT2013 - 07	Lighting: Fixtures	2013	94%	NA
90	LGT2013 - 07	Lighting: Fixtures	2013	99%	NA
91	LGT2013 - 04	Lighting: Fixtures	2013	95%	NA
92	LGT2013 - 01	Lighting: Fixtures	2013	97%	NA
93	LGT2013 - 04	Lighting: Fixtures	2013	100%	NA
94	LGT2013 - 07	Lighting: Fixtures	2013	100%	NA
95	LGT2013 - 08	Lighting: Fixtures	2013	103%	NA
96	LGT2013 - 08	Lighting: Fixtures	2013	101%	NA
97	LGT2013 - 07	Lighting: Fixtures	2013	112%	NA
98	LGT2013 - 06	Lighting: Fixtures	2013	124%	NA
99	LGT2013 - 06	Lighting: Fixtures	2013	113%	NA
100	LGT2013 - 08	Lighting: Fixtures	2013	123%	NA
101	LGT2013 - 06	Lighting: Fixtures	2013	168%	NA
102	LGT2013 - 08	Lighting: Fixtures	2013	108%	NA
103	LGT2013 - 07	Lighting: Fixtures	2013	105%	NA
104	LGT2013 - 07	Lighting: Fixtures	2013	115%	NA
105	LGT2013 - 06	Lighting: Fixtures	2013	140%	NA
106	LGT2013 - 06	Lighting: Fixtures	2013	126%	NA
107	LGT2013 - 07	Lighting: Fixtures	2013	112%	NA
108	STD2013 - 06	Standard: All	2013	17%	NA
109	STD2013 - 06	Standard: All	2013	18%	NA
110	STD2013 - 03	Standard: All	2013	71%	NA
111	STD2014 - 10	Standard: All	2014	71%	NA
112	STD2014 - 10	Standard: All	2014	80%	NA
113	STD2013 - 03	Standard: All	2013	85%	NA
114	STD2013 - 03	Standard: All	2013	100%	NA

Measure ID	ADM ID	Category	Program Year	Realization Rate (Electric)	Realization Rate (Gas)
115	STD2014 - 13	Standard: All	2014	107%	NA
116	STD2013 - 09	Standard: All	2014	122%	NA
117	STD2013 - 09	Standard: All	2014	138%	NA
118	STD2013 - 03	Standard: All	2013	141%	NA
119	LGT2013 - 05	Lighting: Street	2013	93%	NA
120	LGT2013 - 03	Lighting: Street	2013	115%	NA
121	CST2014 - 106	Custom: Building Controls	2014	31%	527%
122	CST2014 - 88	Custom: Building Controls	2014	21%	NA
123	CST2014 - 72	Custom: Building Controls	2014	13%	1%
124	CST2014 - 97	Custom: Building Controls	2014	50%	NA
125	CST2014 - 92	Custom: Building Controls	2014	38%	NA
126	CST2014 - 104	Custom: Building Controls	2014	8%	216%
127	CST2014 - 69	Custom: Building Controls	2014	0%	NA
128	CST2014 - 84	Custom: Building Controls	2014	32%	51%
129	CST2014 - 117	Custom: Building Controls	2014	0%	0%
130	CST2014 - 89	Custom: Building Controls	2014	47%	0%
131	CST2014 - 116	Custom: Building Controls	2014	51%	83%
132	CST2014 - 118	Custom: Building Controls	2014	82%	22%
133	CST2014 - 92	Custom: Building Controls	2014	38%	NA
134	CST2014 - 102	Custom: Building Controls	2014	43%	NA
135	CST2014 - 65	Custom: Building Controls	2014	40%	0%
136	CST2014 - 62	Custom: Building Controls	2014	87%	92%
137	CST2014 - 71	Custom: Building Controls	2014	73%	96%
138	CST2014 - 62	Custom: Building Controls	2014	87%	92%
139	CST2014 - 107	Custom: Building Controls	2014	100%	NA
140	CST2014 - 101	Custom: Building Controls	2014	100%	7%
141	CST2014 - 96	Custom: Building Controls	2014	104%	100%
142	CST2014 - 113	Custom: Building Controls	2014	246%	NA
143	CST2014 - 113	Custom: Building Controls	2014	246%	NA
144	CST2014 - 85	Custom: Building Controls	2014	202%	NA
145	CST2014 - 113	Custom: Building Controls	2014	246%	NA
146	CST2014 - 113	Custom: Building Controls	2014	246%	NA
147	CST2014 - 113	Custom: Building Controls	2014	246%	NA
148	CST2014 - 113	Custom: Building Controls	2014	246%	NA
149	CST2014 - 93	Custom: Building Controls	2014	126%	NA
150	CST2014 - 64	Custom: Building Controls	2014	42%	29%
151	CST2014 - 78	Custom: Building Controls	2014	28%	NA
152	CST2014 - 60	Custom: Building Controls	2014	78%	76%
153	CST2014 - 88	Custom: Building Controls	2014	105%	NA
154	CST2014 - 91	Custom: Building Controls	2014	61%	98%

Measure ID	ADM ID	Category	Program Year	Realization Rate (Electric)	Realization Rate (Gas)
155	CST2014 - 94	Custom: Building Controls	2014	7%	24%
156	CST2014 - 68	Custom: HVAC	2014	39%	NA
157	CST2014 - 89	Custom: HVAC	2014	47%	NA
158	CST2014 - 74	Custom: HVAC	2014	47%	86%
159	CST2014 - 97	Custom: HVAC	2014	50%	NA
160	CST2014 - 86	Custom: HVAC	2014	20%	NA
161	CST2014 - 108	Custom: HVAC	2014	39%	NA
162	CST2014 - 86	Custom: HVAC	2014	22%	NA
163	CST2014 - 97	Custom: HVAC	2014	50%	NA
164	CST2014 - 86	Custom: HVAC	2014	23%	NA
165	CST2014 - 91	Custom: HVAC	2014	61%	NA
166	CST2014 - 111	Custom: HVAC	2014	1%	NA
167	CST2014 - 90	Custom: HVAC	2014	69%	NA
168	CST2014 - 73	Custom: HVAC	2014	31%	33%
169	CST2014 - 62	Custom: HVAC	2014	87%	NA
170	CST2014 - 111	Custom: HVAC	2014	1%	NA
171	CST2014 - 117	Custom: HVAC	2014	47%	78%
172	CST2014 - 104	Custom: HVAC	2014	15%	114%
173	CST2014 - 87	Custom: HVAC	2014	80%	8%
174	CST2014 - 98	Custom: HVAC	2014	98%	89%
175	CST2014 - 103	Custom: HVAC	2014	83%	NA
176	CST2014 - 62	Custom: HVAC	2014	87%	NA
177	CST2014 - 60	Custom: HVAC	2014	NA	100%
178	CST2014 - 67	Custom: HVAC	2014	100%	186%
179	CST2014 - 59	Custom: HVAC	2014	NA	24%
180	CST2014 - 114	Custom: HVAC	2014	101%	NA
181	CST2014 - 112	Custom: HVAC	2014	103%	NA
182	CST2014 - 72	Custom: HVAC	2014	113%	111%
183	CST2014 - 60	Custom: HVAC	2014	148%	NA
184	CST2014 - 83	Custom: HVAC	2014	192%	NA
185	CST2014 - 61	Custom: HVAC	2014	18%	NA
186	CST2014 - 115	Custom: HVAC	2014	119%	NA
187	CST2014 - 104	Custom: HVAC	2014	33%	NA
188	CST2014 - 92	Custom: HVAC	2014	38%	NA
189	CST2014 - 77	Custom: HVAC	2014	118%	NA
190	CST2014 - 98	Custom: Non-Lighting	2014	0%	NA
191	CST2014 - 69	Custom: Non-Lighting	2014	53%	NA
192	CST2014 - 114	Custom: Non-Lighting	2014	91%	NA
193	CST2014 - 77	Custom: Non-Lighting	2014	118%	NA
194	CST2014 - 93	Custom: Non-Lighting	2014	126%	NA

Measure ID	ADM ID	Category	Program Year	Realization Rate (Electric)	Realization Rate (Gas)
195	CST2014 - 91	Custom: Non-Lighting	2014	61%	NA
196	CST2014 - 66	Custom: Non-Lighting	2014	27%	NA
197	CST2014 - 74	Custom: Non-Lighting	2014	120%	400%
198	CST2014 - 100	Custom: Non-Lighting	2014	NA	103%
199	CST2014 - 62	Custom: Non-Lighting	2014	NA	92%
200	CST2014 - 91	Custom: Non-Lighting	2014	NA	98%
201	CST2014 - 70	Custom: Non-Lighting	2014	NA	0%
202	CST2014 - 63	Custom: Non-Lighting	2014	NA	76%
203	LGT2014 - 17	Lighting: Controls	2014	54%	NA
204	LGT2014 - 22	Lighting: Controls	2014	0%	NA
205	LGT2014 - 16	Lighting: Controls	2014	120%	NA
206	LGT2014 - 21	Lighting: Controls	2014	135%	NA
207	LGT2014 - 23	Lighting: Controls	2014	36%	NA
208	LGT2014 - 23	Lighting: Fixtures	2014	61%	NA
209	LGT2014 - 23	Lighting: Fixtures	2014	61%	NA
210	LGT2014 - 17	Lighting: Fixtures	2014	38%	NA
211	LGT2014 - 13	Lighting: Fixtures	2014	91%	NA
212	LGT2014 - 22	Lighting: Fixtures	2014	94%	NA
213	LGT2014 - 23	Lighting: Fixtures	2014	94%	NA
214	LGT2014 - 16	Lighting: Fixtures	2014	107%	NA
215	LGT2014 - 16	Lighting: Fixtures	2014	120%	NA
216	LGT2014 - 15	Lighting: Fixtures	2014	110%	NA
217	LGT2014 - 21	Lighting: Fixtures	2014	102%	NA
218	LGT2014 - 16	Lighting: Fixtures	2014	146%	NA
219	LGT2014 - 24	Lighting: Fixtures	2014	125%	NA
220	LGT2014 - 20	Lighting: Fixtures	2014	129%	NA
221	LGT2014 - 16	Lighting: Fixtures	2014	111%	NA
222	LGT2014 - 15	Lighting: Fixtures	2014	104%	NA
223	LGT2014 - 24	Lighting: Fixtures	2014	117%	NA
224	LGT2014 - 15	Lighting: Fixtures	2014	116%	NA
225	LGT2014 - 23	Lighting: Fixtures	2014	61%	NA
226	LGT2014 - 23	Lighting: Fixtures	2014	94%	NA
227	LGT2014 - 13	Lighting: Fixtures	2014	139%	NA
228	STD2013 - 03	Standard: All	2013	144%	NA
229	STD2013 - 01	Standard: All	2013	159%	NA
230	STD2014 - 12	Standard: All	2014	NA	16%
231	STD2013 - 04	Standard: All	2013	NA	40%
232	STD2013 - 07	Standard: All	2013	NA	84%
233	STD2014 - 15	Standard: All	2014	NA	84%
234	STD2013 - 05	Standard: All	2013	NA	95%

Measure ID	ADM ID	Category	Program Year	Realization Rate (Electric)	Realization Rate (Gas)
235	LGT2014 - 18	Lighting: Street	2014	92%	NA
236	LGT2014 - 19	Lighting: Street	2014	112%	NA
237	LGT2014 - 14	Lighting: Street	2014	112%	NA

6. Appendix B: Listing of Evaluation Results by Project

ADM ID	Key Findings for Project
CST2013 - 01	The small difference in savings can be attributed to the calibration effort put forth by ADM on the provided eQuest model. Small adjustments within the model were made in order to meet ADM's precision requirement for energy simulation models. ADM also calibrated to a custom weather file for the corresponding billing data year. ADM believes the original ex-ante model may have been calibrated to TMY2 weather data as commonly seen in other similar projects.
CST2013 - 02	The ex-ante therm savings was based on eliminating the entire heating portion calculated for FC-2. ADM's on site verification and interview with the facility director determined that FC-2 does still have heating capacity installed. Therms were still saved by the project based on the new scheduling of the units. Therm savings were determined by regression analysis of sub-metered gas usage provided by the facility manager. Ex-ante claimed savings were approximately 75% of the entire building's gas usage. Calculated savings for this project are approximately 54% of previous usage.
CST2013 - 03	Ex-ante savings estimates were calculated using engineering bin calculations which relied on various assumptions. The realized savings are larger than ex-ante estimates and can be attributed to the use of actual pre and post billing data. The utilized billing analysis also does not rely on the same form of assumptions used in the ex-ante analysis and thus the level of uncertainty in the realized savings is much lower.
CST2013 - 04	The low realization rate can be attributed to the ex-ante analysis utilizing a constant volume fan control in their baseline eQuest model and failing to include the chilled water savings in their overall annual energy savings calculation. By utilizing a constant volume fan control in the baseline model, the results of the ex-ante simulation significantly overestimated the annual consumption of the baseline system thus overestimating the potential energy savings. This error accounts for majority of difference in savings. As a cursory review, ADM ran the models with both IGVs and constant volume baseline fans. When the model was ran with constant volume fans, the realized savings would have had a realization rate slightly over 100%.
CST2013 - 06	The low realization rates for the project can be attributed to the original eQuest models, not iteratively calculating the savings for each subsequent measure. In addition to this the ex-ante changed the load profile of the process load on chilled water system in the EEM1 model as compared to the baseline model. This resulted in an artificially high savings for the measure as well as the other measures as this change in load profile also occurred in the other models. Finally, the ex-ante models were simulated using TMY2 weather data while ADM opted to use TMY3 weather data.

ADM ID	Key Findings for Project
CST2013 - 07	Found controls installed and operating as expected. Controls were recently recommissioned. 1) Electric Savings were found as expected (RR ~ 100%). 2) Gas savings significantly lower than expected. The Ex ante estimates were developed using eQuest (inferred from audit report); however, it is unclear to what extent the model was calibrated. If the model was calibrated only to electric data (a common practice) then that would explain the divergent RR for gas. While modeling decisions/assumptions may have also played a role ADM did not receive the .inp file(s) for review and thus can only speculate. Given the detailed data collection effort shown in the audit report we suspect the underlying difference to be more an artifact of calibration.
CST2013 - 08	The engineering review showed that the ex ante savings estimation fell within the bounds of the minimum and maximum savings from the new boiler; however, the ex ante analysis calculated the savings using pre-project consumption. The savings are actually based on an increase in efficiency from a code-based baseline, and savings are contingent on load, rather than consumption. Plant load is assumed to be the same before and after the project. Due to the faulty methodology used in the ex ante calculations, ADM has determined the best estimation of savings will be an average of the minimum and maximum possible savings.
CST2013 - 09	There are no attributable savings to the project for a number of reasons. The project application claimed that the existing air-to-air heat recovery system was replaced due to the unit failing. If the unit had indeed failed the savings from the installation of the new system would be evident in the billing analysis performed by ADM. However, the billing analysis shows no savings and in fact shows that the natural gas consumption of the facility has in fact increased since the new unit was installed. Secondly the claimed savings were based on the assumption that in the baseline condition there would not be a heat recovery system present as the original unit failed. This assumption is in correct as in instances where a system has failed and is replaced on burn-out, the current energy code at the time of replacement becomes the baseline for analysis purposes, i.e. 2010 Oregon Energy Efficiency Specialty Code. Since there was a heat recovery system before, it can be concluded that the space served by the system required large amounts of outdoor air which is common for indoor pool areas. Therefore, section 503.2.6 becomes relevant which requires an energy recovery system to be used for a system in which the minimum outside air being supplied is greater than 70% of the design supply air. Since a heat recovery system is required it can also be assumed that the replacement of the system was considered maintenance and therefore there can be no savings attributed to the project.
CST2013 - 10	The Ex Ante savings were derived using a TraneTRACE simulation model. It appears that the model was roughly calibrated to baseline billing data. However; the simulation considerably under-estimates the post consumption. Furthermore, post operating conditions did not match modeled assumptions (only a sub-set of control strategies were actually implemented relative to expectations).

ADM ID	Key Findings for Project
CST2013 - 11	The small difference in savings can be attributed to ADM triangulating the savings for the project through the use of two separate analysis methodologies. The small increase in reported savings from the eQuest model can be explained through the ex-ante model using TMY2weather data as opposed to the TMY3 weather data used by ADM. The other contributing factor can be attributed to the ex-ante only compiling the eQuest model with one chiller, as opposed to two chillers which are currently in use at the facility.
CST2013 - 12	The difference in savings for both electricity and natural gas can be attributed to a difference in the weather data used in the bin analyses. The ex-ante utilized an unknown weather file, while ADM adjusted the hours in each temperature bin based upon TMY3 weather data for the Portland, OR area. ADM discovered no other issues with the assumptions of methodologies used in the ex-ante temperature bin analysis.
CST2013 - 13	During the M&V site visit, it was determined that the controls had not been commissioned. Furthermore, the Ex Ante savings reported in the tracking data are more than the sum of the savings listed in the TAS for implemented EEMs.
CST2013 - 14	Ex ante models were not calibrated to bills. The models significantly underpredicted gas and electric usages. Underpredicting the usages of the building led to less potential for savings. The model inputs weren't provided, so further explanations cannot be provided. The ex post billing analysis has a high amount of certainty based on the models having good fits to the data, therms R2 of 0.932 adjusted R2 of 0.927 and kWh R2 of 0.948 adjusted R2 0.942.
CST2013 - 15	The majority of the expected (Ex Ante) electric savings came from schedule changes. During our site-visit we verified that many of the assumed schedule changes were not implemented.
CST2013 - 16	The ex ante analysis uses Trane Trace simulation to calculate energy savings. Only a small portion of the building was modeled and was not calibrated to utility billing data. Did not observe evidence of other types of calibration. The ex post analysis uses calibrated simulation to calculate energy savings.
CST2013 - 17	The Ex-Ante eQuest model(s) were not available for ADM to perform a thorough review - thus we are unable to provide a detailed explanation regarding the difference in savings estimate. However; we reviewed the TAS and found that the Ex Ante baseline model was calibrated to TMY weather data as opposed to actual weather data for the billing periods being used. This is a likely contributor to the difference in savings. Given the model outputs we suspect that some control strategies were not included in the Ex Ante eQuest model (for example a heating lockout control strategy was expected present to limit the operation of the boilers during periods of warmer weather. This appears to be the most logical explanation as the base heating loads in the summer dropped dramatically as seen in the Billed Vs. Regressed Monthly Therms graphic). It also should be noted that the original TAS reported a negative therms savings for the 4th floor dual duct to VAV measure, but in the project application zero therms savings were attributed. Negative heating impacts should be claimed on measures when the electric savings are claimed - particularly in projects where other measures are claiming gas impacts.

ADM ID	Key Findings for Project
CST2013 - 18	The model(s) used to simulate Ex Ante savings estimates incorrectly "stacked" savings for subsequent measures (Major factor). Furthermore, the post implementation fan schedules are different than assumed in model (Minor Factor). Each parametric model (e.g. the model used to simulate each EEM) should assume the presence of previous EEMs such that their interacting impacts can be accounted for in the final estimates. Finally, Ex Post models run with TMY3 weather files as opposed to TMY2 files as used by the ex-ante. (Minor Factor)
CST2013 - 19	Several factors contributed to the difference between the ex ante and ex post savings. The ex ante estimation relied on a Cleaver Brooks calculator to determine the time that boilers spend within different firing rate bins. This was used along with nameplate input capacity and efficiency to calculate the annual boiler load. Ex ante savings are based on the difference between as-built and baseline boilers' efficiencies and prescribed savings percentages from the O2 trim, parallel positioning and economizer. Alternatively, the ex post analysis utilized trended firing rate and efficiency data to calculate time spent in each firing rate bin. The efficiency resulting from O2 trim and parallel positioning are implicit in the trended data. As savings are proportional to plant load, the higher plant load calculated in the ex post should result in higher savings; however, the combination of the nominal efficiency and the additional assumed efficiency from the O2 trim and parallel positioning resulted in an ex ante efficiency 2.7% higher than the ex post efficiency (without accounting for the economizer) and resulted in a decrease in savings of 7%. For the economizer, the ex ante analysis treated it as additional efficiency with the same loading in the baseline and as-built plants; however, the economizer actually decreases the loading between the baseline and as-built plants. The ex post methodology resulted in additional economizer savings of 4%.
CST2013 - 20	The Scope of work for this project was adjusted mid-implementation - removing several of the measures/units included in the Ex Ante savings calculations (Some AHU affected were in the process of being replaced / upgraded).
CST2013 - 21	Ex Ante project documentation indicates that the Ex Ante eQuest simulation (also provided to us for review) was calibrated, however; when ADM compared the model outputs to utility billing histories we found that it significantly over estimates energy usage. The ex post analysis employed IPMVP Option C to regress pre/post electric consumption. It is estimated that with proper calibration of the baseline model the RR for this project would have close to 100%,
CST2013 - 22	Regression analysis for natural gas and electric savings were not possible due to multiple energy savings measured being implemented in the facility. The ex-ante eQUEST model was reviewed and model inputs and outputs were within reason for the facilities systems. The ex-ante analysis commented that the natural gas bills were higher than anticipated during the summer months and assumed the additional usage was due to the simultaneous heating and cooling the AHUs were having trouble with. Controls reprogramming was modeled by adjusting typical AHU zone sensor throttling range.
CST2013 - 23	Ex-ante used uncalibrated Trane TRACE model. Could not verify model. Billing regression used for electric savings. Gas savings zero due to some measures using more gas which negates small savings claimed in other measure.

ADM ID	Key Findings for Project
CST2013 - 25	Ex ante models were not calibrated to "actual" billing data, rather they were calibrated to a three year average baseline period (Major Factor). Note that when averaging billing data the result smooths out specific building responses to 'extreme' weather events and ultimately flattens out the consumption profile. When a model is calibrate to such data it cannot be expected to appropriately model weather sensitive systems/measures. This can also be demonstrated by looking at the magnitude of the Ex Ante savings with respect to the billing data. The Ex Ante models estimate a 50% reduction in gas consumption which is not a typical magnitude for this measure (heating set-backs). The Ex Post model estimates an 11% reduction in gas which, while still a significant savings for this EEM, is of a more reasonable magnitude.
CST2013 - 26	The expected savings are 68% of typical electric annual usage for the building. It is unreasonable since the baseloads of the building are over 60%. The ex post analysis employed IPMVP Option C to regress pre/post electric consumption. The realized savings are still significant at 26% of the annual usage, which is more reasonable for only reducing HVAC load.
CST2013 - 27	The ex ante analysis relies on Trane Trace building simulations. The expected savings are 125% of typical annual usage for the building. The ex post analysis employed IPMVP Option C to regress pre/post electric consumption. The realized energy savings are still a significant reduction at 28% of the total annual usage.
CST2013 - 30	The provided ex ante analysis uses bin analysis methodology. The results from the bin analysis are higher than the expected savings values. Justifications for the expected savings values were not provided. The bin analysis uses some conservative assumptions (operating hours, return/mix air temps), which underestimated savings. The ex post analysis employed IPMVP Option C to regress pre/post electric consumption.
CST2013 - 31	Ex Post leveraged IPMVP Option D (Calibrated Simulation) which represents an increase in rigor relative to the Ex Ante calculations. In the process we identified that the operating hours used in the Ex Ante model(s) differed from what was found on-site (Ex-Ante assumed the system operated on Saturdays and Sundays from 10 am till 2 pm, while contacts informed ADM that the HVAC system is turned off on weekends).
CST2013 - 32	The small difference in savings can be attributed to small inconsistencies between the models for each measure that were not part of the scope of the measure being modeled. For example, in between the models for measure #2 and 3, additional changes to HVAC systems that were not part of the scope for the measure. This occurred mainly for supply systems #3, 6, 7, and 8, in which small changes were made to the heating capacity, maximum supply temperatures, and heat setpoint temperatures of the units. These inconsistencies were also carried through the remaining models for measures #4, 5, and 6 which explains the small differences in savings for those measures.
CST2013 - 33	The ex ante analysis relies on engineering equations and bin calculations. The calculations are reasonable, but due to not having post data, they don't account for all the actual post conditions. The expected savings are slightly conservative. Some of the bins assume lower usage and/or shorter run times. Thus, the realized savings are slightly more.

ADM ID	Key Findings for Project
CST2013 - 34	Ex Ante models (Trane Trace simulation) overestimated baseline consumption and underestimated post-implementation consumption when compared to billing histories. The Ex post Analysis uses employed Option C (regression of utility billing histories) to verify energy impacts. It is estimated that had the Ex Ante model's been calibrated appropriately to the baseline billing data that the realization rate would have been ~99%.
CST2013 - 35	The low realization rate can be attributed to the assumptions and methodology used by the ex-ante. The ex-ante analysis used an 8760 hourly load calculation to determine the savings for the project. From reviewing their calculation, the heating/cooling load for the water source heat pump is strictly dependent upon a linear correlation to outside air. For the hourly consumption for a baseline unit was calculated by using the assumed heating/cooling load multiplied by the unit's efficiency. For the as-built it is the same equation but multiplied by an assumed room occupancy rate for the hour and the average rental rate for the hotel for the month. The analysis gives no consideration to room temperature setpoints during occupied and unoccupied periods or if housekeeping staff setbacks the temperatures of the rooms when cleaning is performed. The ex-ante calculates an annual savings of 741.75 kWh/ton of controlled water source heat pump while ADM's regressions determines an annual savings of 314.96 kWh/ton. These two savings numbers are within reason for typically reported savings from Technical Reference Manuals from across the country. However, the one difference being the common practice employed by the housekeeping staff of adjusting the temperature setpoint when a guest room has been cleaned. The number reported by the ex-ante is in line with instances where housekeeping staff do not adjust the setpoints, while ADM's number closely reflects situations where housekeeping staff adjust the setpoints. Interviews with the site contact also support the fact that the housekeeping staff were indeed adjusting setpoints.
CST2013 - 36	The ex ante methodology uses bin analysis. The baseline and post retrofit conditions, design flows, minimum outside air flows, return air temperatures, and heating efficiencies are all assumed. Actual conditions are likely different. Based on post billing data, it appears the ex ante analysis underestimated the gas usage with all of the assumptions. The ex post billing analysis has a high amount of certainty based on the models having good fits to the data, R2 of 0.939 adjusted R2 of 0.935.
CST2013 - 37	Ex Ante methodology employed Trane TRACE simulation to estimate impacts. This model, when compared to billing data was found to lack calibrations - particularly in therms consumption. The utility history indicates that the building uses significantly more gas than predicted by the mode (both pre and post). The electric calibration is however much more accurate. Ex Post analysis employed IPMVP Option C for both gas and electric fuel sources. The electric billing history regression corroborates the Ex Ante savings estimates. The gas billing history regression however indicates that there are zero therms impacts (even a possible increase in gas useage). This is not un-expected given that the nature of the measures implemented are not expected to result in gas savings as they target specifically Fan/Pump/Cooling end-uses.

ADM ID	Key Findings for Project
CST2013 - 40	The customer installed a Direct Digital Control (DDC) system and variable frequency drives (VFD) on supply and exhaust fans. The electric realization rate is 75%. The difference in realization is due to different savings analysis approaches between the ex ante and ex post calculations. The ex ante used a bin analysis approach while the ex post used a whole facility energy use weather dependent regression approach. The ex post analysis uses baseline and as-built site specific whole facility end use energy while the ex ante uses baseline trended data and assumes as-built site specifications. However, if actual as-built site visit observations are input into the ex ante bin analysis, savings are consistent between the modified ex ante calculations and the ex post regression results. Modifications include; accounting for supply and exhaust fan motor efficiency, confirmed minimum outside air percentage (15%), and using a confirmed fan schedule. The ex ante used a 6am to 6pm fan schedule while the ex post used the energy management system confirmed fan schedule of 4am to 6pm. If the actual as-built site visit observations are input into the ex ante bin analysis the realization rate is 105%.
CST2013 - 43	The ex ante models were not calibrated to actual billing data. The ex post analysis calibrated the models to actual post billing data. In the process of calibrating the models, it was found that the ex ante model used electric pre-heat in the baseline. The facility does not have electric pre-heat; thus, the therms heating usage and other electric baseloads were significantly underestimated. The electric pre-heating usage of the as-built model was assumed to be savings (~900,000 kWh) and was a contributing.
CST2013 - 44	The difference in realization is due to the ex ante analysis utilizing a Trane Trace model to estimate the ex ante savings; however the model was not calibrated to the facilities actual monthly energy use. The ex ante analysis compared an average of the last three years annual energy use to the annual energy use of the Trane Trace model. While the annual energy use was comparable, the monthly energy uses varied and decreased the accuracy of the model. The lack of model calibration lead to decreased accuracy and contributed most to the high realization rate.
CST2013 - 45	Energy savings for the implemented measures were determined through IPMVP Option A: Partially Measured Retrofit Isolation analysis methodology. ADM performed an engineering review of the ex ante calculations. The biggest contribution to the low realization rate was due to differences in how the ex ante and ex post analyses calculate the dryer heating energy in the as-built configuration. The ex ante uses an equation of unknown origin while the ex post uses an equation calculated from a document found in the 2014-12-15 Technical Support Document: Energy Efficiency Program for Consumer Products and Commercial and Industrial Equipment: Commercial Clothes Washers.
CST2013 - 46	The ex ante analysis used bin calculations. Hours and loads for each temperature bin were assumed for pre and post conditions. The assumptions resulted in a slightly conservative estimate. The ex post analysis doesn't rely on any assumptions. The ex post analysis uses actual billing data to regress pre/post therms usage.

ADM ID	Key Findings for Project
CST2013 - 49	The customer pointed to there being fan energy savings associated with a reduction in supply duct static pressure (DSP) setpoint from 1.5 in. w.g. (baseline induction system), to 1.0 in. w.g. (new FPVAV system). ADM reviewed the data presented in post-implementation BMS screenshots of the two central supply fan systems serving the Tower (i.e. "SF-1" and "SF-2"), which indicated DSP setpoints of 1.5 in. w.g. This means the baseline and post-implementation fan systems operated at the same DSP, so claimed fan energy savings for this component were not realized. The ex ante model used a total static pressure (TSP) of 4.5 in. w.g. for the baseline, and 2.5 in. w.g. for the post-implementation system. Although elevated DSPs are common in induction systems and would warrant using 4.5 in. w.g., the site contact said they could reduce the induction system's DSP setpoint to 1.5 in. w.g. The customer also indicated the new DDC system allows the minimum airflow to be reduced from approximately 50% with the baseline induction system, to approximately 5% with the new FPVAV boxes. This translates into fan energy savings. ADM used a 10% value for the new FPVAV boxes (instead of 5%), based on reviewing the data shown in several FPVAV box BMS screenshots provided by the customer. eQUEST help tutorials also supported not going below 10%. The minimum flow ratios used in the ex ante models were 1 (i.e. 100%) in the baseline, and 0.1 to 0.2 (i.e. 10-20%) post-implementation. In addition to the differences in ex ante and ex post eQUEST models previously discussed, several additional concerns were discovered in the ex ante models: 1. A VAVS (Variable Air Volume System) system type was selected for the baseline, rather than SZCI (Single Zone Ceiling Induction), which was the actual baseline system type present at the facility. 2. The energy efficiency measures (EEMs) associated with this incentive were applied to a larger area (3.2 times larger) than that occupied by Portland State University (i.e. Suite 100B). 3. The same baseline model was referenced for calculating energy savings for each of the two EEMs associated with this incentive (i.e."EEM1a" , the induction to FPVAV retrofit, and"EEM2" , the new DDC). As a result, some double counting of energy savings associated with a reduction in supply fan TSP was made; EEM2 included a reduction in TSP of 4.5 in. w.g. to 3.5 in. w.g. 4. Savings for EEM2 were based on adjustments to temperature setpoint schedules, the Chilled Water Loop on/off schedule, and the Hot Water Loop on/off schedule. This is surprising, because there was no mention of the new DDC having that impact, either in the description of EEM2 in the Technical Analysis Study, provided as part of the project documentation, or by the site contact when asked how EEM2 results in energy savings. The site contact's response was that the new DDC allows minimum airflow at the terminal boxes to be reduced, and provides for a tighter deadband. He also said a previous DDC upgrade had enabled temperature setback capability.
CST2013 - 50	The electric realization rate for this project is 117%. The ex ante eQuest model was not provided therefore, no appreciable comparisons can be inferred between the ex post and ex ante eQuest models.

ADM ID	Key Findings for Project
CST2013 - 51	The ex ante analysis methodology involved outside air temperature bins and several assumptions including a 20% RTU efficiency derating for the baseline units' age, supply fan motor efficiencies, unit compressor cooling and heating run times, as a percentage, of total hours in each temperature bin, night low limit cycling percentages, and compressors and supply fans do not run during the cooling season during unoccupied times in the post-implementation scenario. ADM used eQUEST software as previously described, which alleviated most of the assumptions made in the ex ante analysis due to eQUEST's more robust design. Also, an efficiency derating factor was not applied, since no data was available to support this assumption. Baseline and post-implementation motor efficiencies were left unchanged, for the same reason. There were also no compressor energy savings realized during the heating season, because the site representative stated there were no heating setbacks in place.
CST2013 - 53	The realization rate is 100% since the ex ante analysis methodology was considered sufficient.
CST2013 - 55	The provided ex ante analysis uses bin analysis methodology. The results from the bin analysis are higher than the expected savings values. The bin analysis would've resulted in a 100% Therms realization rate. The electric realization rate for both projects (P00000764623 & P00000888625) would've been 101% using the savings from both Technical Analysis Studies (TAS). The expected savings values were not justified.
CST2013 - 57	The realization rate of 100% is a result of the ex ante analysis methodology utilizing an IPMVP Option D analysis methodology, which was considered sufficient by ADM.
CST2014 - 100	Although the realization rate was close to 100%, the ex ante analysis methodology was significantly different than ex post. Claimed savings were almost exclusively attributed to water heating energy savings. There are no water heating savings, only dryer savings, because the only difference between baseline and installed washing machines is the spin cycle cylinder speed, in units of G-force (i.e. 100 vs. 200), and resulting remaining moisture content in the clothes.
CST2014 - 101	At some point the savings estimates in the TAS were revised for this measure (EEM2) increasing both the gas and the electric savings estimates. The electric savings estimates were revised to include an additional fan upgrade (VFD addition to 7 AHUs). The gas savings were also increased at the same time though the logic behind the manually entered formula is unclear. The original gas savings were estimated to be 8,195 Therms/Year based on the estimated loss durring a hot water leak event which triggered the back-up boilers. The savings were updated as follows : 8195/2*12 = 49,170 Therms/Year. This revised number is 171 % of the observed consumption on that meter ADM reviewed the Gas billing history to quantify the magnitude of the historical leak events relative to 'typical' consumption and determined that when a leak even occurs the savings are approximately 10,000 Therms. However; in the histories we observed only one instance of a leak event in the three years of "pre" consumption. Thus the annualized savings were discounted accordingly. There are several instances in the post period that appear to be possible "leak" events, though based on site interviews/visit we conclude that they are just as likely to be caused by variances in site usage.

ADM ID	Key Findings for Project
CST2014 - 102	The difference in savings can be attributed to the ex-ante analysis utilizing prototypical eQuest models while ADM opted to utilize pre/post billing regression. The ex-ante prototypical eQuest models were not provided to ADM for review, therefore exact specifics to any deficiencies cannot be given. However, a common limitation in using prototypical simulation models to calculate savings for measures in which there are no predefined system control, is trying to accurately reflect inconsistent scheduling within the model. If a calibration effort had been used the level of uncertainty in the ex-ante analysis would have been significantly reduced. As a way to eliminate the uncertainty associated with prototypical simulations, ADM opted to utilize a pre/post billing regression. Since the analysis uses actual billing data for the approach, it eliminates the inconsistent operation of lighting and HVAC system by the employees that would otherwise skew the savings of a prototypical modeling approach.
CST2014 - 103	The customer installed economizers on two 4 ton Marvair Compac II package HVAC units used for process cooling. ADM calculated the annual energy savings for the energy conservation measures using an eQuest model. eQuest simulation files were provided as part of the project documentation and were reviewed by ADM to ensure accurate representation of this facility. TMY weather data from the Portland Airport was used to calculate energy consumption in 4 orientations to find the typical energy consumption of the facility in baseline and as-built configurations. The baseline and as-built energy consumption of the eQuest model was then normalized by the actual facility and eQuest model's square footage. The normalized savings is the difference between the two model's energy consumption.
CST2014 - 104	The ex ante Trane Trace model produced electric savings that were 79% of the 2013 total utility electric meter consumption, which included the consumption of two other buildings, as previously discussed. Also the total annual electric consumption of the Trace model was 1,433,237 kWh, which was higher than the 2013 total utility electric meter consumption of 952,480 kWh. This was because the Trace model was incorrectly calibrated to the sum of two utility electric meters (i.e. Account# 1178871-20-1 and Account# 1178871-20-2). During ADM's site visit, the customer representative said the center is served by only one electric meter. It should be noted that the ex ante model did not account for savings due to the temperature setback capability of the new DDC System. However, this acted to improve the realization rate, since ADM's eQUEST model did take setbacks into account. It also explains the large gas realization rate of 216%, since setbacks were accounted as part of the Controls Upgrade measure.

ADM ID	Key Findings for Project
CST2014 - 106	The ex-ante savings were calculated using a Trane Trace energy simulation model in which the following control strategies were claimed to be enabled with the installation of the new DDC System: hot water reset, supply air reset, static pressure reset, fan speed reduction below 40 hertz, and DCV. The difference in savings can be attributed to not all the claimed control strategies being implemented upon the installation of the new DDC system. During the site visit, through interfacing with the EMS terminal and interviews with site contacts, the only control strategies enabled were supply air reset, static pressure reset, and DCV. The other contributing factor can be attributed to the Tran Trace energy simulation model not being properly calibrated to the pre-retrofit billing data. Per the provided Technical Analysis Study, the model had an average monthly kWh deviation from the bills of -19.4% and an average monthly Therms deviation of -23.8%. These large deviations in monthly energy consumption shows that the model does not accurately reflect the actual operation of the building and therefore has large amount of uncertainty in the model.
CST2014 - 107	Through the review process ADM determined that the savings claimed by the ex-ante were within reason as the approach followed industry accepted calculation methods. ADM's prototypical model also calculated a savings that was within 5% of the claimed savings and therefore the full claimed savings was attributed to the project.
CST2014 - 108	The low realization rate can be attributed to the ex-ante analysis assuming the existing heat pump systems having a COP of 1, which is equivalent to electric resistance heat. This is an incorrect assumption as per the manufacturer the heat pumps have a COP of 3.1, resulting in an efficiency 3 times higher than what was claimed in the ex-ante analysis. Also, the claimed savings is unreasonable as the savings is almost as much as the annual consumption of the office building before the installation of the heat pumps, further proving the assumed baseline COP of 1 is incorrect.
CST2014 - 111	Ex ante energy savings were not provided in the project documentation. However, a “sanity check" was performed on claimed savings for the Server Room heat pump installation, which were found to be 58% of the theoretical max (i.e. 8,760 EFLH) annual heat pump energy consumption. This same check was not performed for the Suite C heat pump retrofit, because a submittal could not be located for the unit. However, an even higher percentage would be expected given the operating conditions, similar size of the unit, and claimed savings. Both units affected by this incentive were small (i.e. 2 tons or less), with savings driven by the improved efficiency ratings, so savings should not be large.
CST2014 - 112	The 103% realization rate is due to the temperature setpoint schedules being different than claimed. ADM used the cooling and heating setpoints indicated on the thermostats during the site visit. This impact was partially offset by the ante using a slightly less efficient baseline cooling heat pump efficiency (13 vs. 14 SEER). As previously mentioned, ADM's value was referenced from the 2014 Oregon Energy Code.

ADM ID	Key Findings for Project
CST2014 - 113	The ex ante report stated what the installed energy efficiency measures (EEMs) were and how they would save energy in the report; however, the ex ante calculations were not provided. From the ex ante report, it appears that not all of the expected savings for each measure were expected to save energy. Some measures didn't claim full savings because the building uses purchased chilled water. It appears that the ex ante analysis didn't account for any pump or auxiliary equipment energy savings. Furthermore, there is significant energy savings that wasn't accounted for calibrating the demand controlled ventilation (DCV) equipment. The building has electric heating, and DCV saves a significant amount of heating energy. The ex post analysis employed IPMVP Option C to regress pre/post electric consumption. This methodology accounts for all possible measures and their interactive effects.
CST2014 - 114	The 101% realization rate associated with the HVAC unit retrofit is due to the window of occupied hours being a little larger than claimed. The 91% realization rate associated with insulation is due to the surface area insulated being less than claimed (i.e. 1,200 vs 1,400 sqft). This was partially offset by the heating efficiency of the air conditioning equipment being slightly less than claimed (8.9 vs 9.3 HSPF), as well as the window of occupied hours being a little larger than claimed.
CST2014 - 115	The ex ante used an hourly analysis to estimate the savings using known chiller plant sequence of operations and set-points. The ex ante analysis outputs were reviewed and deemed reasonable, however equations and methodologies used were not available and a full desk review could not be performed. Therefore, the ex post analysis utilized a whole facility regression analysis to further ensure the estimated savings were reasonable.
CST2014 - 116	The ex-ante savings are based on an estimated 15% savings for electric and gas. No additional calculations or assumptions were provided. The realized savings are less than ex-ante estimates and can be attributed to the use of actual pre and post billing data. The utilized billing analysis also does not rely on assumptions or typical savings percentages for typical control upgrade work which used in the ex-ante analysis and thus the level of uncertainty in the realized savings is much lower.

ADM ID	Key Findings for Project
CST2014 - 117	The customer pointed to there being fan energy savings associated with a reduction in supply duct static pressure (DSP) setpoint from 1.5 in. w.g. (baseline induction system), to 1.0 in. w.g. (new FPVAV system). ADM reviewed the data presented in post-implementation BMS screenshots of the two central supply fan systems serving the Tower (i.e."SF-1" and"SF-2"), which indicated DSP setpoints of 1.5 in. w.g. This means the baseline and post-implementation fan systems operated at the same DSP, so claimed fan energy savings for this component were not realized. The ex ante model used a total static pressure (TSP) of 4.5 in. w.g. for the baseline, and 2.5 in. w.g. for the post-implementation system. Although elevated DSPs are common in induction systems and would warrant using 4.5 in. w.g., the site contact said they could reduce the induction system's DSP setpoint to 1.5 in. w.g. The customer also indicated the new DDC system allows the minimum airflow to be reduced from approximately 50% with the baseline induction system, to approximately 5% with the new FPVAV boxes. This translates into fan energy savings. ADM used a 10% value for the new FPVAV boxes (instead of 5%), based on reviewing the data shown in several FPVAV box BMS screenshots provided by the customer. eQUEST help tutorials also supported not going below 10%. The minimum flow ratios used in the ex ante models were 1 (i.e. 100%) in the baseline, and 0.1 to 0.2 (i.e. 10-20%) post-implementation. In addition to the differences in ex ante and ex post eQUEST models previously discussed, several additional concerns were discovered in the ex ante models: 1. A VAVS (Variable Air Volume System) system type was selected for the baseline, rather than SZCI (Single Zone Ceiling Induction), which was the actual baseline system type present at the facility. 2. The energy efficiency measures (EEMs) associated with this incentive were applied to the full 6th floor of the Tower, rather than just the north half of the Tower, which is the area occupied by the Oregon Medical Examiners (i.e. Suite 620). 3. The same baseline model was referenced for calculating energy savings for each of the two EEMs associated with this incentive (i.e."EEM1a" , the induction to FPVAV retrofit, and"EEM2" , the new DDC). Thus, some double counting of energy savings associated with a reduction in supply fan TSP was made; EEM2 included a reduction in TSP of 4.5 in. w.g. to 3.5 in. w.g. 4. Savings for EEM2 were based on adjustments to temperature setpoint schedules, the Chilled Water Loop on/off schedule, and the Hot Water Loop on/off schedule. This is surprising, because there was no mention of the new DDC having that impact, either in the description of EEM2 in the Technical Analysis Study, provided as part of the project documentation, or by the site contact when asked how EEM2 results in energy savings. The site contact's response was that the new DDC allows minimum airflow at the terminal boxes to be reduced, and provides for a tighter deadband. He also said a previous DDC upgrade had enabled temperature setback capability.

ADM ID	Key Findings for Project
CST2014 - 118	Based upon the individual savings for each reprogramming the low realization rates are attributed to the supply air reset portion of the DDC reprogramming. Per the TAS the ex-ante savings for this measure were calculated through engineering based equations. From a sister project at this site in which calculations were provided, ADM discovered an inconsistency in the used hours of operation as compared to what was discovered during the site visit. The ex-ante assumed that the system was operation on Saturdays and Sundays from 10 am till 2 pm, while contacts informed ADM that the HVAC system is turned off on weekends. It could be assumed that this would also occur in the supply air reset savings calculations and this overestimation of annual hours of operation would result in an overestimation of annual savings.
CST2014 - 59	The ex ante report stated that the existing system didn't provide outside air. After reviewing all documentation and visiting the site, ADM concluded that the existing system was providing ventilation air . The expected therms savings are 159% of the normalized annual usage. Over half of the therms usage is base loads. That means that less than half of the total annual usage is for space heating. The realized savings is 39% of the normalized annual therms usage. The ex post analysis shows that the heat recovery has reduced the heating usage by about 90%.
CST2014 - 60	The ex-ante analysis methodology consisted of a temperature bin analysis mixed with fan power measurement and some logging data. The reviewed operational characteristics for the equipment appeared in line with what was observed on site for the new control system except for the fan run hours. The main discrepancy in savings amounts is due to the ex-ante assumption of fan hours. Ex-ante analysis assumed 11 hours of fan operation per day when the site contact stated hours to be 17 hours per day.
CST2014 - 61	The low realization rate can be attributed to the baseline used in the ex-ante calculations. Though the actual calculations were not provided to ADM for review, there is project documentation showing that the baseline was assumed to be two equally sized centrifugal chillers and a constant flow primary chilled water system. This assumption would have been correct if in fact the installed chiller was replacing an existing system, but upon ADM's site visit it was determined that the new chiller was installed alongside the existing chillers and is now used as backup. This is also confirmed in the provided project documentation. Since no chillers were replaced, the existing configuration is considered the baseline resulting in reduced savings. This also allowed ADM to utilize a billing analysis to determine the annual energy savings for the project.
CST2014 - 62	For the “Upgrade Guestroom Temperature Control” measure, the ex ante calculations use the baseline boiler efficiency in the while the ex post calculations use the as-built boiler efficiency so as not to double count savings from the new boiler. Also, the ex ante calculations estimate a Btu/(h*sqft*degf) value for the building using assumed fenestration U-values, wall and ceiling measurements, and temperature set points. The ex post calculations use regressed annual heating load found using billed therm use and vary the Btu/(h*sqft*degf) value until the calculated load equaled the regressed load. This calibrated the calculation and ensured all the savings were being realized. For the boiler replacement measure, the ex ante analysis calculates an estimated heating load using a bin analysis. The ex post calculations use whole building billed therm energy use and regress the monthly heating therms against Heating Degree Days (HDD). TMY3 weather data from Portland International Airport was used to calculate the typical monthly HDDs and the

ADM ID	Key Findings for Project
	typical heating therms. Using the boiler efficiency, typical heating load was calculated using the known baseline boiler efficiency and the as-built heating therms were calculated using the known as-built boiler efficiency. The savings was the difference between the baseline and as-built annual therms. Finally, the ex ante calculations for the “New BAS- Improved Central Plant Control” measure were not included; therefore, no appreciable comparisons can be made for this measure.
CST2014 - 63	Due to the absence of ex ante calculations, ADM opted to use the results from its billing regression model. The low realization rate is supported by the combustion analysis results, which show lower post-project efficiency in Boiler #1, and indicate that the boiler plant efficiency did not improve to the extent that was expected with the ex ante savings.
CST2014 - 64	The low realization rates for the project can be attributed to multiple factors. The first being, differences between the claimed operation of the building and what was verified by ADM during the on-site visit. For example, the project application claims that ASU-1 is scheduled to operate from 7 am to 5 pm during the week; however, during the site visit ADM discovered that the system typical operates from 6 am to 6 pm. This results in an increase in fan and cooling/heating energy thus reducing potential energy savings. Similarly, the dishwasher exhaust fan was supposed to be integrated into the EMS but during the site visit this was determined to not be true. The ex-ante analysis utilized an eQuest model to predict the annual energy savings for the project. ADM reviewed the provided model inputs for both the baseline and as-built configuration and found the model to be compiled quite well and was calibrated to within 2% of the annual bills. However, during the on-site visit ADM was provided copies of the results of the re-balancing of the air side system and found that the inputs in the model overestimated the potential reduction of CFM for many of the zones. For instance, the eQuest model assumed that the as-built flow in Zone 253: Chemistry Lab would be 2,658 CFM after the re-balancing; however, the re-balancing report shows a flow of 3,400 CFM. This overestimation in flow reduction, significantly contributes to the overestimation in energy savings and the low realization rates for the project.
CST2014 - 65	One of the measures (DCV) not being implemented.
CST2014 - 66	The ex-ante savings estimated 178,200 kWh in savings which equates reducing 7,170 equilvalent full load hours of measure cooling tower. This is not realistic when this cooling tower mostly ran in summer as a secondary. ADM's ex post savings is 47,477 kWh which is equal to reduction of 1,910 equivalent full load hours.
CST2014 - 67	1) Regression of gas consumption histories show that the heat recovery chiller can support more heating loads than assumed in the ex ante analysis 2) Since the electric impacts are such a small % of the facilities consumption at the meter a regression was not performed for the electric. Instead ADM reviewed the Ex Ante model's assumptions, inputs, and outputs. We found that the

ADM ID	Key Findings for Project
	assumptions/inputs reflected the conditions found on-site. Furthermore the model outputs are reasonable relative to the billing histories and the Gas side of the simulation was corroborated against billing histories such that the modeled electric savings are verified to be reasonable.
CST2014 - 68	The ex-ante savings are based on provided calculations from Liebert, the manufacturer of the CRAC units. The calculations utilize a temperature bin methodology and assumed IT load profile for the facility; however, only screen shots of the calculations were provided therefore ADM could not fully vet the calculations. However, it was noticed that the calculations assume that the IT load in the datacenter is 105 kW, while during ADM's site visit the site contact informed that the datacenter load is approximately 36 kW. This over estimation in internal load is most likely the contributing factor to the overestimation in savings in the ex-ante calculations and thus the low realization rate.
CST2014 - 69	The low realization rate for the project cannot be fully explained as ex-ante savings calculations were not provided as part of the project documentation. However, ADM can discuss as to why zero savings were attributed to the HVAC controls/economizer operation optimization portion of the project. During the site visit, ADM interviewed the site contact to the scope of this part of the project and was informed that no actual changes to the operation of the economizer occurred as the setpoints in the standalone system matched those in the now connected EMS system. Due to this information, savings was not attributed to the measure as no change in operation actually occurred and the integration of the RTU to the exiting EMS does not guarantee energy savings.
CST2014 - 70	On-site visit verified that several assumptions in the Ex Ante analysis (re: the burner specifications) proved incorrect. Actual Burner specifications found are as follows: 1) Max new burner firing rate: 2,760 MBH (Ex Ante used 7,160 MBH) 2) Min new burner firing rate: 500 MBH (Ex Ante Used 850 MBH) 3) Min existing burner firing rate: 1,000 MBH (Ex Ante Used 1,118) Furthermore there was an error in the post-implementation load profile used in the ex ante calcs in that it matched the baseline firing rate profile rather than the baseline load profile. When the Ex Ante model is updated with the above corrections it predicts zero savings.
CST2014 - 71	The ex ante analysis methodology consisted of an eQUEST building simulation model. Although the model could not be calibrated to the building utility bills, the energy usage falls into a typical range based on energy intensity as described in the TAS report. ADM adjusted the model to utilize Portland TMY3 weather data and reduce the claimed savings from the air compressor to a more typical operational usage (~35% duty cycle from the assumed 75%). This reduced the compressor savings from 2,983 kWh to 1,492 kWh.
CST2014 - 72	39% RR electric, 12% RR gas using billing regression. Split into measures using same ratio as ex-ante calculations.
CST2014 - 73	Ex ante calculations were not included; therefore no appreciable differences between ex ante and ex post savings can be inferred. However, the ex post analysis uses actual billing data to regress pre/post kWh and gas usage.

ADM ID	Key Findings for Project
CST2014 - 74	The difference in savings can be attributed to the ex-ante analysis using an uncalibrated partial facility eQuest model and ADM using a fully calibrated and all-encompassing eQuest model. The ex-ante analysis compiled an eQuest model that only reflected the areas of the facility, in which the measures were occurred. The limitations to this is the fact that they model was not able to be calibrated to natural gas and electric billing data as the modeled portion of the facility represents approximately 20,500 ft2 of an over one million ft2 facility. The uncalibrated aspect of the ex-ante's eQuest model results in an increase in uncertainty in whether the model accurately reflects the true operation of the building and also fails to include interactive effects with adjoining spaces.
CST2014 - 77	The ex ante analysis relies on eQuest building simulations. The model inputs and simulation files weren't provided and couldn't be verified. Thus, there is significant uncertainty with the models. The ex ante as-built conditions over predicted the energy usage; therefore, the savings were underestimated.
CST2014 - 78	The ex ante analysis methodology consisted of an eQUEST whole building simulation. The baseline model appears to calibrate within reason of billing data. However, total annual energy consumption predicted by the post-implementation model is much less than billing data. Since the eQUEST input file was not provided as part of the project documentation, and was not available upon request during the site visit, a detailed review of the model and source of discrepancy is not possible.
CST2014 - 83	Over half of the realized savings are for changing the three-way valves to two-way valves. The ex ante model doesn't seem to account for this; thus, the realized savings are significantly higher. The ex post analysis employed IPMVP Option C to regress pre/post electric consumption.
CST2014 - 84	The customer initially intended to also add demand controlled ventilation, and economizer operations. However, only the ventilation and fan controls were implemented. The project electric realization rate is 32% and the gas realization rate is 51%. Difference in realization is due to the site not implementing all the proposed measures. Economizer operation and demand controlled ventilation were included in the measure savings, however the site contact indicated the measures were not installed and implementation of the measures could not be found resulting in no savings.

ADM ID	Key Findings for Project
CST2014 - 85	In reviewing the model's input and output reports, it's unclear if the energy impacts of the controls tune-up were modeled accurately. AHUs 3 and 4 were modeled as constant volume single zone systems in the baseline, when each AHU serves three different zones, and the dampers to each zone were fixed 100% open. Also, some inaccuracies were found in the Trace model's proposed AHU fan schedules, when compared to screenshots taken of the BMS during ADM's site visit. Since the screenshots indicate some of the AHUs operate more often than proposed, these inaccuracies acted to reduce the realization rate. Another discrepancy was found in the Trace model where AHU-3's post-implementation People and Ventilation schedules for Sunday indicated the full day being unoccupied, while the BMS screenshots indicated occupancy from 7am-1:00pm that day, which was very close to the baseline (i.e. baseline started at 6am instead of 7am). This inaccuracy, however, once again acted to reduce the realization rate. There was also a discrepancy in savings provided by the Trace output reports and claimed savings- 23,642 kWh and 21,011 kWh, respectively. The consultant was unable to explain the discrepancy, but the realization rate would drop to 179% if the former value was used. The ex post analysis uses actual billing data to regress pre/post kWh usage. Savings were found to be 23% of the facility's baseline consumption. For comparison, ADM ran a quick calculation using the algorithm in the Ohio Technical Reference Manual for HVAC VFD savings, and found savings for just the VFD measure to be 24,321 kWh. This value was based on actual annual fan hours of operation, calculated from the BMS schedules, rather than using the TRM default hours. This helps support the ex post savings value of 42,416 kWh, since it was comprised of additional savings components.
CST2014 - 86	The ex ante analysis methodology involved outside air temperature bins and several assumptions including a 20% RTU efficiency derating for the baseline units' age, supply fan motor efficiencies, unit compressor cooling and heating run times, as a percentage, of total hours in each temperature bin, night low limit cycling percentages, and compressors and supply fans do not run during the cooling season during unoccupied times in the post-implementation scenario. ADM used eQUEST software as previously described, which alleviated most of the assumptions made in the ex ante analysis due to eQUEST's more robust design. Also, an efficiency derating factor was not applied, since no data was available to support this assumption. Baseline and post-implementation motor efficiencies were left unchanged, for the same reason. There were also no compressor energy savings realized during the heating season, because the site representative stated there were no heating setbacks in place.
CST2014 - 87	The ex-ante analysis based their savings estimated for the project on Trane Trace energy simulation models. Through the review of the models it was determined that the models appeared calibrated for the baseline configuration but when comparing the as-built model outputs to the post billing data the model tended to deviate at lower outdoor air temperatures, this mainly occurred for natural gas consumption and led to the low realization rate for gas savings.

ADM ID	Key Findings for Project
CST2014 - 88	The customer installed a Delta controls system. The existing control system was installed when the building was built in 1989. The old system was experiencing communication issues between individual controllers and supervisory controllers. The economizer locked out compressors, the air handlers ran 24/7, and many controllers were locked in occupied mode. The new Delta controls system provides SAT reset (55-65F), optimized economizer control with integrated compressor control, and improved scheduling to reduce runtime matching occupancy. The project realization rate is 96%. The ex ante eQuest model was not provided therefore, no appreciable comparisons can be inferred between the ex post and ex ante models.
CST2014 - 89	The ex-ante analysis utilized an eQuest model to calculate the claimed energy savings for the project, however input files for these model were not made available for review purposes. Due to the lack of model input being provided ADM is not able to fully explain the difference in savings. However, through the review of the original Technical Analysis Study, ADM did notice that the eQuest modeler calibrated the original baseline model to TMY weather data as opposed to actual weather data for the billing periods being used. This incorrect calibration method could be a contributor to the difference in savings. As for the zero therms savings being attributed to the overall project, it also should be noted that the original Technical Analysis Study (TAS) reported a negative therms savings for the 1st and 5th floor dual duct to VAV measure but in the project application zero therms savings were attributed. The (TAS) shows a negative savings of -3,441 therms for the VAV conversion, which would result in an overall project savings of -3,213 therms. The overall negative therms that should have been claimed for the project is within reason of the -2,146 therms as calculated in ADM's regression. The practice of not claiming the negative savings for a measure is atypical as it is common practice to claimed negative heating impacts on measures when the electric savings are claimed.

ADM ID	Key Findings for Project
CST2014 - 90	**Heat pump load profiles-** This difference had the largest impact. The ex ante analysis assumed the heat pumps being 100% loaded at outside air dry bulb temperatures of 48oF and below, and had more aggressive load profiles above 48oF. The ex ante analysis assumed a balance point (i.e. 100% loading) at 32oF, with loading that sloped linearly to a load of 0% at 68 oF (i.e. occupied heating setpoint). **Weather profiles-** The ex ante analysis appears to have used a Coos Bay, OR weather file, while the ex post analysis used the closest available TMY weather file, that being North Bend, OR, which is only approximately three miles from Coos Bay. The ex ante weather file is likely for a specific year, rather than an average of several years with TMY weather. At any rate, if the Coos Bay weather file is input to the ex post model, the realization rate increases by 8% to 77%. **Occupancy schedules-** The ex ante analysis used an occupancy schedule of 7a-9p M-F, while the ex ante used 6a-10p M-F (per the customer during ADM's site visit). In conjunction with the weather file difference previously mentioned, the realization rate rises from 77% to 79%. **Unoccupied heating temperature setpoint-** A value of 58oF was used in the ex ante analysis, while 62 oF (per the customer during ADM's site visit) was used in the ex post. This, however, acted to offset the differences above (i.e. the realization rate would have been lower) **Heating efficiencies of new heat pumps-** The ex ante HSPF values were 6.32 and 7.29 for the 7.5 ton and 10 ton units, respectively, while the ex post were 8.2 and 9.3, respectively. This, however, acted to offset the differences above (i.e. the realization rate would have been lower). It's not clear why the ex ante calculation used a lower COP in the conversion to HSPF. ADM referenced the COP at 47oF from the AHRI Certificate of Product Rating for the new heat pumps.
CST2014 - 91	Difference in kWh realization is due to the ex-ante eQuest model including savings for reducing the heating minimum cfm/ft2 flow from the DDC controls ECM. The ex-ante eQuest model reduced the heating minimum flow from 0.65 cfm/ft2 to 0.30 cfm/ft2 resulting in significant kWh savings. However, during the site visit, examination of the building management system showed the heating and cooling flow set points were both set to 1,200 cfm, and did not indicate a heating only flow reduction. Not including the heating flow reduction reduced the project savings resulting in a low realization rate.
CST2014 - 92	The ex ante analysis relies on eQuest building simulations. The model inputs and simulation files weren't provided and couldn't be verified. There was effort to calibrate the model; however, it was calibrated to a 2009 baseline. That's almost 5 years prior to project completion. It is likely that a lot changed in the 5 years prior to project completion. The ex post analysis found a typical baseline usage 20% less. The expected savings were 64% of the typical annual usage for the facility. It's not realistic to expect that high of a reduction for just implementing HVAC measures because the baseloads for the building are more than half of the energy usage. The realized savings are 24% of the typical usage, which is still a significant reduction in HVAC energy usage.

ADM ID	Key Findings for Project
CST2014 - 93	Equipment found installed and operating as expected (though some components are still in the process of being implemented/tweaked). Regardless billing data indicates (IPMVP Option C) that the more savings are being realized than originally estimated. The original bin calculations were not available for review; however, we did review the TAS which summarizes the inputs and assumptions used. It appears that the model may have been 'calibrated' to an average of several years’ worth of billing data which would dampen any model's ability to accurately estimate weather sensitive impacts. This could explain why the Ex Post savings differ from the Ex Ante.
CST2014 - 94	Ex Ante electric claims exceed baseline consumption. Ex Ante bases estimates on simplified bin calculation. It doesn't seem there was any attempt to compare the outputs from this calculator to the utility billing histories as the electric consumption predicted by the bin calculation significantly exceeds the actual building consumption (by 223%). The lack of calibration also extends to the ex ante gas impacts though the consumption in this case was not over-estimated. Rather, it is expected that the thermal loads are not appropriately modeled due to the lack of calibration and thus the differences in realized savings.
CST2014 - 96	The ex ante analysis methodology consisted of a thorough temperature bin analysis. The baseline operation for thermostat setpoints appeared to be only typical heating season and cooling season setpoints, but could not be verified. The savings amounts do not appear to be overinflated and seem normal. The difference in savings can be attributed to ADM recalculating the annual energy savings using the ex-ante temperature bin analysis with TMY3 weather data for the Portland area. The weather used by the ex-ante comes from an unknown source.
CST2014 - 97	The differences in realized and expected savings can be attributed to the ex-ante using an uncalibrated Trane Trace model, while ADM complied a calibrated eQuest model. The calibration effort put forth by ADM ensures that the eQuest model accurately reflects the actual operation and consumption of the facility. Therefore, the calibration effort reduces the uncertainty of the calculated savings by the model.
CST2014 - 98	During the site visit, it was found that the pool pump VFD was operating at a full 60 Hz year round, negating any potential savings from installation of the VFD. Therefore, no savings were granted for that measure. Also, no ex ante calculations for the savings from the installation of the advanced dehumidification system were provided, therefore no appreciable differences can be inferred between the ex post and ex ante savings for that measure.
LGT2013 - 01	1) Assumed fixture wattages slightly different 2) Customer ordered materials prior to project approval and pushed back against recommendation to install occupancy controls. Savings are considered without controls. 3)Light output from the 4-lamp T8 replacing 400W metal halide seem very low, and therefore, suspicious

ADM ID	Key Findings for Project
LGT2013 - 02	The Sylvania LED retrofits had different controls. Roughly 60% are controlled via photocell. The remaining 40% are controlled via timers that mimic a daylight time schedule. Therefore, all light fixtures were assumed to have a Dusk-to-Dawn HOU. The difference in realization rate is due to the difference in HOU used. The ex-ante calculations used 4,380 hours per year, which is half a year's total hours. The ex-post used 4,112 hours per year, which was determined by the U.S. Naval Observatory as the total night time hours per year in Portland, OR. Since the lights are controlled via photocells, the lights are on only during night time hours. As a result, the lower ex-post HOU results in a lower ex-post kWh savings.
LGT2013 - 03	1)Ex Ante & Post use different fixture lookup tables. Ex Post table on average lists higher fixture wattages for HPS than Ex Post (Primary Factor). 2)Verified lower fixture count for HPS100 (1586 versus 1568). 3) Hours changed to reflect actual hours of darkness for photocell controlled streetlights.
LGT2013 - 04	1) Slight differences in assumed fixture wattages 2) Exterior HOU slightly different (4112 vs 4380) 3) Slightly different controls savings % (Post uses RTF)
LGT2013 - 05	The difference in realization rate is due to the difference in HOU used. The ex-ante calculations used 4,380 hours per year, which is half a year's total hours. The ex-post used 4,112 hours per year, which was determined by the U.S. Naval Observatory as the total night time hours per year in Portland, OR. Since the lights are controlled via photocells, the lights are on only during night time hours. As a result, the lower ex-post HOU results in a lower ex-post kWh savings.
LGT2013 - 06	The difference in realization rate is due to the difference in HOU used. The ex-ante calculations used 2,745 hours per year. For Measures *9330, *9333, *9334, and *9335, the HOU is 3,033 hours per year due to site verification. For Measure *9332, the HOU is 8760. - For Measure *9330 the Ex Ante claimed 12 replacement bulbs, however the site visit could only confirm 11 replacement bulbs. - For Measure *9332, the Ex Ante claimed 2 retrofit LED fixtures, but the Ex Post site visit verified 3 retrofit LED fixtures. - For Measure *9333, the Ex Ante claimed 81 fixtures, but the Ex Post site visit verified only 75 fixtures. - For Measure *9336, the Ex Ante calculated controls savings using a 25% factor. The Ex Post calculated controls savings using a 30% factor.

ADM ID	Key Findings for Project
LGT2013 - 07	The difference in realization rate is due to the difference in HOU used. The ex-ante calculations used 4,829 hours per year. The ex-post used 4,713 hours per year, which was determined by the site visit verification. For Measure *9222, the Ex Ante calculated controls savings using a 25% factor. The Ex Post calculated controls savings using a 30% factor. The higher Ex Post savings factor results in a lower kWh savings.
LGT2013 - 08	The ex-ante used 3,254 hours per year, whereas the ex-post used 3,243 hours. The ex-post value is based on the hours of operation for the library. Another cause for the discrepancy is since the ex-post utilized heating interaction factors in the calculations for all light retrofits. The ex-ante assumed no heating interaction with the lights fixtures, thus there were no heating interaction factors in their calculations. There were also slight variances in fixture wattages due to Ex Post using more granular fixture look-ups.
LGT2013 - 10	**Measure ID: M00002036496** realization rate is 75%. There appears to be a reference formula error in the Ex Ante spreadsheet that grabs a cost value [$] and overwrites the actual savings calculation. **Measure ID: M00002036497** realization rate is 0%. Ex-post site visit confirmed that this retrofit was not completed.
LGT2014 - 13	The ex-ante calculations used 4380 hours per year for photocell controls. The ex-post used 4,112 hours per year, which was determined by the U.S. Naval Observatory for Portland, OR. There were also slight variances in fixture wattages due to Ex Post using more granular fixture look-ups.
LGT2014 - 14	1) Ex Post HOU for D to D lighting is 4,112 compared to Ex Ante which is 4,380. 2) Ex Post baseline fixture wattages for HPS varies compared to ex ante (a little higher)
LGT2014 - 15	The difference in realization rate is due to the due to ADM using slightly different wattage values for each light fixture.
LGT2014 - 16	1) Engineering desk review showed that average hours were greater based on phone interview. 2) Ex Post includes some fixture wattage variances due to reference source and for project year current baseline wattage standards.
LGT2014 - 17	1) For Measure *7912, the Ex Post used a 30% control savings factor instead of 35% for the exterior fixtures. 2) For external fixtures, Ex Post HOU is the U.S. Naval Observatory's value for Dawn to Dusk hours per year in the Portland area. 4112 Hrs. rather than 2,300 3) For Measure *7913, the HOU was calculated by a weighted average based on lighting schedules for these fixtures (1,511 rather than 3,806). In addition, there were 158 retrofit fixtures, not 168. 4) The interior fixtures were subject to heating and cooling interaction factors 5) Verified lower number of MH1000 to Induction (158 rather than 168)

ADM ID	Key Findings for Project
LGT2014 - 18	The difference in realization rate is due to the difference in HOU used. The ex-ante calculations used 4,380 hours per year, which is half a year's total hours. The ex-post used 4,311 hours per year, which was determined by the U.S. Naval Observatory as the total night time hours per year in Portland, OR. Since the lights are controlled via photocells, the lights are on only during night time hours. The lower ex-post HOU results in a lower ex-post kWh savings. In Measure *7985, the Ex Ante mistakenly entered the incorrect wattage value for the post-retrofit fixture. Ex Ante entered it as a 50 W LED, but from the specification sheets, the fixture is a 51 W LED.
LGT2014 - 19	The difference in realization rate is due to the difference in HOU used. The ex-ante calculations used 4,380 hours per year. The ex-post used 4,112 hours per year, which was determined by the U.S. Naval Observatory as the total night time hours per year in Portland, OR. Since the lights are controlled via photocells, the lights are on only during night time hours. As a result, this lowers the ex-post kWh values. Some differences in the assumed wattages for HPS fixtures.
LGT2014 - 20	The ex-ante used 1765 hours per year as the HOU for this site. From the site visit, it was determined that the site was open from 8 am to 5 pm (2,274 Hours).
LGT2014 - 21	The difference in realization rate is due to the due to ADM using accounting for interactive factors with the HVAC system when calculating the savings.
LGT2014 - 22	The difference in realization rate is due to the difference in HOU used. The ex-ante used 4,380 hours per year, whereas the ex-post used 4,112 hours, which was sourced from the U.S. Naval Observatory as the dawn to dusk hours per year in Portland, OR. Since the lights are controlled via photocells, the lights are on only during night time hours. For Measure *6963, the site visit concluded that the installed occupancy sensors did not control the lights being installed in this retrofit project. Therefore, the realized kWh savings is 0 kWh.
LGT2014 - 23	1) Ex Ante used 4380 hours per year. for exterior lights. The Ex Post used 4,112 hours per year (U.S. Naval Observatory Portland, OR). 2) Ex Ante used 7508 HOU for indoor. Ex Post used 4797 hours per site contact verification. 3) Ex Ante used different Controls Savings Factors than the Ex Post. 4) Some quantities differed (minor)
LGT2014 - 24	The difference in realization rate is due to the difference in HOU used. The ex-ante calculations used 5,110 hours per year. From site visit verification, the fixtures are controlled via time clocks, thus the ex-post used 6,205 hours per year, which is based on the time clock schedule. This results in higher ex-post kWh values.

ADM ID	Key Findings for Project
STD2013 - 01	The main difference in realization rate can be attributed to the ex-ante analysis using a fixed kWh/unit savings value for shaded pole motor to ECM retrofits, while the ex-post utilized an equation in the RTF that accounts for variation in refrigeration and motor specifications. The ex-ante assumed a savings of 466 kWh/unit, and was then multiplied by the quantity of replacement ECMs. The RTF uses an equation with varying baseline values and energy efficiency ratings to determine savings. Thus, the ex-post calculation resulted in a 740 kWh/unit savings value, thus resulting in higher ex-post savings.
STD2013 - 03	The discrepancy in verified savings comes from different assumptions in engineering calculations. For the heater controllers, assumed kWh savings per unit differed from the linear-foot estimation in the ex-ante calculations. For the lighting, the ex-ante calculation assumed a smaller linear-foot count than was verified on site. The ECM calculation used different assumptions for motor consumption or full-load hours than used in the ex-ante calculation.
STD2013 - 04	The main difference in realization rate can be attributed to the different energy reference codes used for the calculations. The ex-ante multiplied the total square ft. of insulation by a factor of 0.25 to calculate the therms savings. However, there is no reference or reasoning for this calculation. This resulted in 1250 therms saved per year. The ex-post utilized an equation from the RTF which incorporates varying baseline values, energy efficiency ratings and weather data to determine savings. As a result, the ex-post calculation resulted in 500 therms saved per year.
STD2013 - 05	1) Boiler count and specs verified and consistent with documentation/ex ante. 2) Ex ante uses 2.17 Therms/kBTUh assumption. Ex Post calculated using Cap / Eff / EFLH which came out to 2.06 Therms/kBTUh. Divergence like stems from differences in underlying assumptions - mainly EFLH and delta-Eff
STD2013 - 06	facility used a geothermal system to generate hot water for both heating and DHW. As such the assumed water heater efficiency of 100% (Electric Resistance) prooved false. ADM estimated the EUI of the Geothermal plant using engineering assumptions and data about the plant
STD2013 - 07	The reason for the significant difference in realization rate can be attributed to fact that the ex-ante analysis used savings constants from the Energy Trust of Oregon's, while the ex-post utilized equations from EnergyStar for its calculations. The Energy Trust of Oregon assumed a constant savings of 569 therms/unit, then multiplied that value by the quantity of replacement fryers. EnergyStar uses an equation with varying inputs based on baseline and as-built specifications, hours of operation, and equipment use. As a result, the ex-post calculation resulted in a 477 therms/unit savings value, thus resulting in lower ex-post savings.
STD2013 - 09	1) Verified Qty. / Type / Specs of the two new RTUs 2) Ex ante used "stipulated" savings values (kWh/unit) whereas Ex Post used Cap / Eff / EFLH to estimate savings. Divergence is due to differences in underlying assumptions - most likely delta-Eff and EFLH.

ADM ID	Key Findings for Project
STD2014 - 10	The main difference in realization rate can be attributed to the different energy reference codes used for the calculations. The ex-ante utilized the Energy Trust of Oregon's reference codes, while the ex-post utilized the RTF. **For Measure *8117**, the Ex Ante used a savings constant of 324 kWh per linear foot for medium temperature, anti-sweat controls in grocery stores. The RTF states a savings of 230.1 kWh/linear foot for medium, anti-sweat controls in grocery stores. As a result, the ex-post calculation resulted in a lower kWh savings. **For Measure *8118**, the Ex Ante used a savings constant of 104 kWh per linear foot for both low and medium temperature T8 to LED retrofits. The RTF assumed savings constants of 71 kWh per linear foot for T8 to LED low temperature retrofits and 52 kWh per linear foot for T8 to LED medium temperature retrofits. This results in a lower ex-post kWh for the LED retrofit.
STD2014 - 12	The reason for the significant difference in realization rate can be attributed to fact that the ex-ante analysis used a stipulated UES, while the ex-post utilized equations from EnergyStar for its calculations. The Energy Trust of Oregon assumed a constant savings of 1308 therms/unit, then multiplied that value by the quantity of replacement steam cookers. EnergyStar uses an equation with varying inputs based on baseline and as-built specifications, hours of operation, and equipment use. Thus, the ex-post calculation resulted in a 215 therms/unit savings value, thus resulting in significantly lower ex-post savings.
STD2014 - 13	The main difference in realization rate can be attributed to the different assumptions used between UES estimates developed by Ex Ante and RTF (used by Ex Post). The Ex Ante used a savings constant of 569 kWh per HP for FHPCs and FSPCs for both low and medium temperature systems. The RTF states a savings of 685 kWh per HP for low temperature systems and 473 kWh per HP for medium temperature systems. The ex-post calculation distinguishes low and medium temperature systems, thus providing a more accurate savings rather than a fixed constant for all cases.
STD2014 - 15	The reason for the significant difference in realization rate can be attributed to differences in the underlying assumptions between the ex-ante UES estimates and the EnergyStar calculators (used by Ex Post). The Ex Ante assumed a constant savings of 569 therms/unit, then multiplied that value by the quantity of replacement fryers. EnergyStar uses an equation with varying inputs based on baseline and as-built specifications, hours of operation, and equipment use. Thus, the ex-post calculation resulted in a 477 therms/unit savings value, thus resulting in lower ex-post savings.