2012 New Buildings Program Impact Evaluation

April 26, 2015

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The Cadmus Group, Inc.

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MEMO

Date: May 12, 2016
To: Board of Directors
From: Jessica Rose Iplikci, Business Sector Manager, New Buildings Program
Sarah Castor, Evaluation Sr. Project Manager
Subject: Staff Response to the 2012 New Buildings Program Impact Evaluation

Summary
Evaluation results for the New Buildings program were consistently strong for program years 2009 through 2011, with realization rates ranging from 93% to 97% for electric savings and 92% to 98% for gas. The overall program 2012 realization rates, excluding premature results from a few large projects in the report, are consistent with earlier years at 93% for electric savings and 95% for gas. New commercial buildings and major renovation projects can take several years after completion to become fully occupied or for systems to be fully loaded. Energy Trust finds a two year delay between project completion and evaluation to be sufficient in most cases, but based on the evaluator's report, staff found that three projects in the Custom and Data Center tracks were evaluated too early. These projects will be examined further through individual project evaluation plans, separate from this overall program evaluation.

- The 2012 evaluation found realization rates for Standard Track measures were very good, as we have seen in previous evaluations.

- The 2012 evaluation was our first opportunity to see the performance of the first two projects to complete through the new Market Solutions track – a track that represents six different packages specific to building type. Program staff expect the full range of Market Solutions building types to be available for the 2014 evaluation. An evaluator was retained to complete a technical review of the pre-modeled savings packages in late 2013, as a program QC step, and the evaluator found no issues with estimated savings.

- As noted previously and in the report, several large projects are loading their facilities. One data center project site was not fully loaded, as data centers typically take three years to ramp-up. A large hospital was not able to use a custom heat recovery chiller because it was not yet sufficiently occupied, and may connect additional load to the new energy-efficient plant, a common plan. The program has cause to believe that these sites will fully load. To accurately evaluate and reflect long-term project savings, sites are planned for upcoming re-evaluation. To account for this, we are removing these two sites (consisting of three projects) from the evaluation factors and will be applying the project-specific realization rates from a separate follow-up evaluation, expected in 2016.

Excluding premature results from a few large projects provides a much clearer picture of the program's performance across the normal range of projects. The following rates will be applied.

Program Track	Total Measures	Reported Savings		Evaluated Savings		Realization Rate	
		Electricity (kWh)	Gas (therms)	Electricity (kWh)	Gas (therms)	Electricity Savings	Gas Savings
Standard	1,038	16,182,856	286,180	16,623,669	282,621	103%	99%
Custom	128	7,307,513	89,379	6,587,911	88,726	90%	99%
LEED	7	7,449,816	118,510	5,571,041	96,068	75%	81%
Data Center	0	0	0	0	0	N/A	N/A
Market Solutions	13	26,971	1,804	24,034	1,707	89%	95%
Total Program	**1,186**	**30,967,156**	**495,873**	**28,806,655**	**469,122**	**93%**	**95%**

Finally, staff observed several instances where the evaluator, who also performed the evaluations for the 2008-2011 program years, did not adequately take into consideration staff responses made to previous evaluations. In the 2011 Impact Evaluation staff response, program staff detailed adjustments made to program procedures, analysis and documentation (i.e., obtain energy simulation models during the program year, maintain consistent documentation on modeling files, and encourage participants to enable energy management system trends). We found several opinions represented by the evaluator be inaccurate, as noted below, or in conflict with other statements made in the report. A central issue with the report is with lack of documentation and detailed technical analysis provided by evaluators to evidence claims made and adjustments to modeled savings, a significant portion of the program's overall impact.

With the objective of gaining insights needed to improve savings performance, staff requested, and evaluators provided, calibrated building energy modeling files. The program has plans to review calibrated models and understand where improvements may be made.

As a result of experiences in this evaluation, staff conclusions and recommendations for future evaluations are:

- Future evaluations need to clearly document all adjustments evaluators made to building energy simulation models that conclude final evaluated savings, including adjustments in baseline, HVAC schedule, occupancy and load, and provide the basis for these adjustments.

- Timely reporting with the appropriate level of detail are also needed in order for program staff to implement timely process improvements or adjust technical review process.

- Energy Trust has developed and will apply new guidelines for the evaluation of large/complex projects. These guidelines detail the timing of evaluations and set communication protocols for involving customers in evaluation. The guidelines will be used with large or complex projects beginning in 2016 and staff expect to see improvements with evaluation efforts.

- Staff are confident in the program's technical reviews, processes, procedures and guidelines used to review each and every project. It's our conclusion that many improvements have already been made and no further adjustments to the program to improve savings estimation need to be made at this time. Looking ahead, we expect evaluation reports to provide details needed to make adjustments and refine a mature program.

Detailed response to selected evaluation recommendations:
As noted above, the evaluator made several recommendations that were also made in the 2011 program year evaluation and staff have already appropriately addressed them. The new recommendations from the 2012 program year report are listed below, along with the staff response that focuses on our technical procedures used in the context of a new construction program.

(1) *Consider a ramp-up period for savings.*

Aligning evaluation to program procedures for estimating savings and customer plans to load their facilities is part of the planned large/complex project evaluation.

The New Buildings program works with data center projects in the early stages to influence design decisions and equipment selection. When working with data centers, the program bases savings estimates on the assumed IT load over the first three years of operation. Our current estimates take the average load over these first years to estimate the project's energy savings, and assumes that the peak load will not exceed 50% of the design capacity, unless the project team can demonstrate a higher percentage (i.e. by showing loading at a comparable data center). These estimates are revisited at the time of the installation payment to capture the most up-to-date information and loading plans.

(2) *Consider commissioning completion as a program requirement.*

Commissioning is a program offering and can be a very extensive and costly endeavor. Unless there is a clear savings benefit to the customer and savings can be documented for program purposes, which hasn't been made clear in the evaluation report, commissioning would increase the cost of participating in our program.

The way the program has structured the commissioning offering to make it approachable, worthwhile and least-costly for participants is to encourage what's called a "functional test" on equipment and systems where operations are variable; because this is a new construction program, outreach managers engage owners about benefits of "design commissioning", a high-value point of intervention for owners, and focus on what is commonly known as "owner's project requirements" with the objective of supporting building owners in pursuing the level of commissioning they see as appropriate for their project. We expect to see more fully commissioned projects enter the program and more small commercial projects conduct the functional test. Commissioning is best practice when done at the right level and scope for the project, and will not be a requirement to work with the program.

(3) *Develop lower limits for area on Market Solutions projects.*

This recommendation is based on only a single case. Market Solutions requirements have lower and upper limits on project square footage and receive site visits according to the program's quality control plan. In a prior contract, evaluators determined that the program's pre-modeled energy savings estimates and assumptions were reasonable. The program has no concerns with the estimated savings or project implementation on a forward basis.

(4) *Improve feedback mechanism between implementer audit findings and reported savings.*

The evaluator cites only two instances out of 42 projects where a program site-verification finding was not reflected in final savings or incentive payments. Program staff feel that these cases are anomalies and that program procedures are currently sufficiently robust to prevent such occurrences from happening in the future.

(5) *Engage data centers facilities in the evaluation process.*

Staff experienced that the way evaluators engaged the two data centers made getting responses from customers difficult and required many people at the site to engage – resulting in customer service concerns. Through a collaborative engagement effort led by program staff taking the customer's needs into consideration, one data center has since completed a site-specific evaluation, in 2015; the other is able to provide loading information for the planned re-evaluation in 2016.

To summarize, program staff are confident in the program's technical reviews, processes, procedures and guidelines. With the changes we've outlined here for future evaluations, we expect to obtain detailed documentation that will provide a reasonable basis for program adjustments, and in the meantime, program staff will begin to review calibrated models to see where adjustments can be made to custom savings estimates. Revised evaluated savings will be applied and we find consistency in the rates between 2009 and 2012 to be a good indicator of performance.

CADMUS

To: Sarah Castor, Energy Trust of Oregon
From: Brad Jones, Cadmus
Cc: Jeff Cropp, Jennifer Huckett, Cadmus
Subject: 2012 New Building Program – Impact Evaluation
Date: 5/9/16

As requested, Cadmus removed the following sites from the 2012 New Buildings Program Impact Evaluation data set:

- Data center
- Large hospital (involving two Custom track projects)

These sites were removed from the program population and the evaluation analysis was run without the sites. The results of the analysis are shown in Table 1 below.

Table 1. Revised Report Table 1 Sites Removed

Program Track	Total Measures	Reported Savings		Evaluated Savings		Realization Rate	
		Electricity (kWh)	Gas (therms)	Electricity (kWh)	Gas (therms)	Electricity Savings	Gas Savings
Standard	1,038	16,182,856	286,180	16,623,669	282,621	103%	99%
Custom	128	7,307,513	89,379	6,587,911	88,726	90%	99%
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Executive Summary

Energy Trust of Oregon retained The Cadmus Group, Inc., to complete an impact evaluation of the 2012 New Buildings program, a comprehensive effort to assist owners of newly constructed or substantially renovated commercial and industrial buildings in achieving energy savings through three major tracks: Standard, Custom, and LEED. Additionally, the evaluation effort included projects from the Data Centers and Market Solutions Tracks. These tracks are described as follows:

- The Standard Track supports prescriptive equipment measures, such as lighting, motors, HVAC, and others, through deemed savings.
- The Custom Track provides incentives to owners who reduce a building's energy use below a minimally code-compliant value. Measures usually involve more complex energy savings analysis than do prescriptive measures.
- LEED Track projects receive incentives for achieving energy savings as part of certification by the U.S. Green Building Council.
- Data Centers Track projects receive incentives that are targeted specifically at new construction data center projects.
- Market Solutions Track projects are smaller (less than 70,000 square feet) projects that lend themselves to simple, streamlined measures.

The evaluation did not include projects in the 2012 New Buildings program that were performed under the Path to Net Zero, ENERGY STAR, and Small Commercial Efficiency Pilot (Core Performance Pilot).

A third-party program management contractor, Portland Energy Conservation, Inc. (PECI), implemented the 2012 New Buildings program[1].

For its study of the 2012 program, Cadmus evaluated projects permitted under both the 2007 Oregon Structural Specialty Code and the 2010 Oregon Energy Efficiency Specialty Code (OEESC).

Specifically, Cadmus evaluated 285 measures that were installed at 42 sampled sites. For the Standard, Custom, and LEED Tracks the sample included 14 of the sites with the largest savings (all with reported electric savings greater than 1,000,000 kWh or gas savings greater than 10,000 therms) and a random sample of 24 smaller sites. For the Data Center and Market Solutions Tracks, Cadmus evaluated three of the four projects performed in 2012. Cadmus originally included a second data center project in the 2012 program in the sample and evaluation process; however, we removed it during the course of the evaluation effort because the program participant stated they did not have staff available at that time to provide the information that was being requested by Cadmus. The site is not included in the analysis, but Energy Trust plans to evaluate it at a later date. As shown in Table 1, the final sample represented 68% of the program's total reported electric savings and 41% of the gas savings.

[1] PECI was acquired by CLEAResult in 2014. CLEAResult is currently implementing the New Building program.

Table 1. 2012 Standard, Custom, LEED, Data Center and Market Solutions Tracks Program and Sample Totals*

Group	Total Projects**	Total Measures***	Reported Savings	
			Electricity (kWh)	Gas (therms)
Program Total	326	1,211	38,118,923	559,077
Sample Total	42	285	25,839,306	227,311
Portion of Total Sampled	12%	23%	68%	41%

* Does not include the large data center.

**Number of unique project IDs.

***Number of unique measure IDs.

Cadmus evaluated the program through site visits and reviews of engineering calculations and building simulation models. During site visits, we validated the proper installation and functioning of equipment for which incentives were provided and recorded operational characteristics data to support our engineering analysis. We evaluated the Standard Track measures primarily using industry-standard algorithms. We analyzed measures installed in the Custom Track through algorithms, detailed calculation spreadsheet reviews, simulation modeling, and/or energy management system (EMS) trend data. Cadmus engineers analyzed the differences between baseline and as-built simulation models for LEED projects. Through this impact evaluation, we identified a variety of factors that affected the overall program realization rate (the ratio of evaluated to reported savings), as shown in Table 2. Savings values listed in the impact evaluation are gross values. Calculation of a net-to-gross ratio fell outside the scope of this evaluation.

Table 2. Overall 2012 Program Realization Rates and Energy Savings by Measure Category

Program Track	Total Measures*	Reported Savings		Evaluated Savings		Realization Rate	
		Electricity (kWh)	Gas (therms)	Electricity (kWh)	Gas (therms)	Electricity Savings	Gas Savings
Standard	1,038	16,182,856	286,180	16,623,669	282,621	103%	99%
Custom	140	9,641,714	152,370	8,546,389	86,665	89%	55%
LEED	7	7,449,816	118,510	5,571,041	96,068	75%	81%
Data Center	4	4,817,566	214	1,479,527	44	31%	21%
Market Solutions	13	26,971	1,804	24,034	1,707	89%	95%
Total Program	**1,211**	**38,118,923**	**559,077**	**32,244,660**	**467,105**	**85%**	**84%**

*Number of unique measure IDs.

Most measure types in the Standard Track achieved high realization rates. Market Solutions Track measures achieved realization rates of 89% for electric savings and 95% savings for gas, but they accounted for a small portion of the program total savings. The overall program energy savings were primarily reduced by adjustments to Custom, LEED, and Data Center project energy savings. The primary factors that lowered the overall realization rate were as follows:

- Data center loads were observed to be significantly less than the anticipated loads that formed the basis of the energy savings calculations. If the Data Center Track is removed from the analysis, the program electric savings realization rate would be 92%, which is comparable to the 2011 program.
- One measure accounted for a large portion of the gas savings in the sample for the custom category. During the evaluation site visit, the facility staff reported that measure was not able to operate as intended due to a discrepancy between the building loads and equipment sizing. It was non-functional and the facility staff are looking at system modifications in the future to address the issue. This was the largest contributor to the low gas realization rate. Without this measure the custom gas realization rate would have been 83% and the program level realization rate would have been 90%.
- Building simulation models did not always accurately reflect as-built conditions or operating parameters. When the models were updated with observed conditions and calibrated to actual utility data, the evaluated savings were less than reported savings.
- Our verification process showed that some incented equipment only met baseline code efficiency and not the program requirements.
- Evaluated equipment operation sometimes differed from the expected patterns used to develop deemed savings estimates. This was usually either due to differences in as-built energy consumption or different applications than predicted when the deemed savings estimate was developed.
- Observed equipment quantities sometimes differed from reported quantities.

For comparison of the program over time, the evaluation results for the New Buildings program from 2008 through 2012 are presented in Table 3. The number of measures has been holding relatively steady since 2010. Electricity savings increased from 2011 and gas savings decreased. The 2012 electricity and realization rates have decreased from the 2011 program year, and also fell below the five year average.

Table 3. Evaluated Savings by Program Year 2008-2012

Program Year	Number of Measures*	Reported Savings		Evaluated Savings		Realization Rate	
		Electricity (kWh)	Gas (therms)	Electricity (kWh)	Gas (therms)	Electricity Savings	Gas Savings
2008	1,073	33,138,094	464,905	28,111,498	420,132	85%	90%
2009	1,071	20,715,091	640,716	20,029,136	608,621	97%	95%
2010	1,245	26,044,322	1,134,551	24,635,698	1,113,291	95%	98%
2011	1,235	24,005,521	788,302	22,284,382	726,100	93%	92%
2012	1,211	38,118,923	559,077	32,244,660	461,890	85%	84%
					Five-Year Average	91%	92%

*Number of unique measure IDs.

Overall, the 2012 program implementer performed a reasonable level of review and quality control to achieve high average project savings realization rates for the Standard Track measures. The measure types with lower evaluated savings represented large, complex measures whose final operating patterns can be difficult to predict, particularly in a new construction application. However, Cadmus did identify several issues with implementer quality control on one custom refrigeration project and one Market Solutions project. We also observed that several of the recommendations made during previous evaluations have been implemented.

Based on the evaluation findings, Cadmus offers the following recommendations for the program:

- **Consider a ramp up period for savings:** New building program participants can have difficult time predicting the timing of energy consumption patterns at a new facility. The sites can potentially have extended move-in periods before the assumed occupancy and load patterns are established. Cadmus recommends that Energy Trust consider including a ramp up period prior to reporting the full expected savings for projects at the data center projects and central plants when savings are dependent on future loads.
- **Consider commissioning completion as a program requirement:** The evaluation sample included several buildings at which the facility team reported that the systems were still being commissioned because the systems were not operating to meet their design intent. Cadmus observed that this resulted in measures that were not functioning optimally or, in some cases, not functioning at all. This resulted in savings being lower than predicted. Cadmus recommends that Energy Trust consider incorporating the commissioning process completion into its official project milestones.
- **Obtain energy simulation models during the program year:** As part of the 2011 program evaluation Cadmus recommended steps to improve the availability of project energy simulation files for use in the evaluation process. We observed an improvement in file availability from previous years, however, this continues to be an area of opportunity for improvement. Cadmus recommends PECI continue to work with project teams to obtain final versions of energy simulation model files during the program year.

- **Maintain consistent documentation on simulation files:** Cadmus found the project documentation for projects that performed analysis using energy simulation software was inconsistent from one project to the next, which made it difficult to determine the appropriate savings and relevant material to support energy savings. The basis for the final incentive, supporting documentation, final incentive amount, and simulation models should be categorized consistently, and clearly labeled, across all projects. Cadmus also recommends the implementer list any changes made to the simulation models and document the reasons for those changes.
- **Ensure energy simulation models match approved savings:** Specifically for projects utilizing the LEED track, many project files included simulation models that did not match LEED Energy and Atmosphere Credit 1 (EAc1) forms or the final approved building performance. The models should be clearly labeled with the exact information they support. We recommend the implementer verify that the models match the energy consumption output on a gross savings level at the time they are submitted. Final model files should be provided that reflect any revisions to the LEED EAc1 documentation that are made during the final LEED review process. A narrative listing the model files would also be helpful to all parties. One way to ensure accuracy in the models is to request simulation output reports (BEPS, BEPU, ESD) in PDF format, along with corresponding final models with consistent naming convention such that the output reports can be tracked to the corresponding modeling file. Further, verifying that the values reported in simulation output reports are identical to the values reported in the program calculator will significantly reduce the time it takes to track the accurate model.
- **Encourage participants to enable energy management system trends:** Cadmus has found that, in general, new construction facilities have energy management systems. In most cases the sites evaluated for this program year had enabled trend tracking on major equipment and controls systems. Such data were critical to our evaluation effort and can also provide important information for the participants about how their facilities are operating. In a couple of cases, trending was not enabled, although the participant was willing to enable trending at our request. The resulting data were limited but sufficient to make necessary adjustments to simulation models or calculation spreadsheets. We believe it would be helpful for participants and future evaluation efforts for the program to continue encouraging participants to enable EMS trends during the commissioning process.
- **Develop lower limits for area on Market Solutions projects:** Cadmus found one (of two) Market Solutions projects we evaluated was likely not appropriate for the program, based on area and space type. The reported area was 1,618 square feet, compared with the deemed savings model average of 20,000 square feet. The relatively small area resulted in much smaller HVAC consumption (and therefore savings) than estimated from the deemed savings simulation models. Instead of an office, the location was a restaurant event space with a small office in a separate room. We recommend the implementer consider setting a lower limit for Market Solutions project area. In this case, a lower limit of 5,000 square feet may be appropriate for offices to ensure closer agreement with deemed savings estimates.

- **Improve feedback mechanism between implementer audit findings and reported savings:** During verification site visits, Cadmus found several projects with significant discrepancies from reported values, or other issues with equipment performance. In two of those cases, the program documentation showed the implementer had conducted their own post-installation site visit. On one custom refrigeration project, the implementer's notes show their staff identified a discrepancy between reported and verified values, but this discrepancy was not resolved for the reported savings or incentive provided to the participant. In another case, during a site visit, the implementer's staff should have noted that a Market Solutions project was a restaurant event space instead of an office, a heat pump water heater was installed in a conditioned space, and this water heater was likely over-sized for the required load (a hand sink). These on-site observations were not reflected in the final savings or incentive payments for the project. We recommend the implementer examine their mechanism for translating post-installation audit findings into revisions to the reported savings and incentive values.
- **Engage data center facilities in the evaluation process:** The original sample for the 2011 and 2012 program years included a large portion of savings that were associated with data centers. In both program years, the largest of the data centers was eventually removed from the evaluation sample. Data centers are secure facilities and many owners are reluctant to share data center performance data. Additionally, the sites are high profile projects that receive scrutiny from Energy Trust at a variety of levels, so the program participants can experience evaluation "fatigue" when they are approached multiple times with data requests. Although this is a legitimate concern, when the data center sites represent such a large portion of the program savings, it is important to include them in the evaluation process. It is anticipated that the data center market will continue to grow along with energy efficiency potential. The lessons learned from the current projects can help to shape future programs. Cadmus recommends that the implementer start informing the data center program participants about the evaluation activities, data needs and timelines early in the project delivery process to allow them to prepare to support the evaluation process.

Introduction

Energy Trust of Oregon retained The Cadmus Group, Inc. (Cadmus), to complete an impact evaluation of the 2012 New Buildings program. The New Buildings program comprehensively seeks to assist owners of newly constructed or substantially renovated commercial and industrial buildings in achieving energy savings. In 2012, the program served projects through five main tracks:

- The Standard Track supports prescriptive equipment measures, such as lighting, motors, HVAC, and others, typically through deemed savings.
- The Custom Track provides incentives to reduce a building's energy use below the code-compliant minimum value. Included measures typically involve more complex energy savings analyses than prescriptive measures.
- The LEED Track projects receive incentives for achieving energy savings as part of certification by the U.S. Green Building Council.
- Data Center Track projects receive incentives that are tailored specifically for new construction data center projects.
- Market Solutions Track projects are smaller (less than 70,000 square feet) projects that lend themselves to simple, streamlined measure packages.

The evaluation did not include projects in the 2012 New Buildings program that were performed under the Path to Net Zero, ENERGY STAR, and Small Commercial Efficiency Pilot (Core Performance Pilot).

Portland Energy Conservation, Inc., (PECI)[2], a third-party program management contractor, managed the 2012 program. During the 2012 program year, 326 projects received incentives through the Standard, Custom, LEED, Data Center, and Market Solutions Tracks.

Table 4 through Table 9 show the total numbers of measures and first-year reported energy savings for each track for the 2012 program year. The Standard and Custom Tracks have been further divided into subcategories, based on measure types. A detailed list of how the measure categories used in the evaluation process map to the measure entity descriptions assigned by Energy Trust is included in Appendix A.

[2] PECI was acquired by CLEAResult in 2014. CLEAResult is currently implementing the New Building program.

Table 4. 2012 Standard Track Total Measures and Reported Savings

Measure Category	Total Number of Measures*	Total Electricity Savings (kWh)	Total Gas Savings (therms)
Standard Food Service	338	4,120,996	60,673
Standard HVAC	208	1,427,725	158,188
Standard Lighting	272	8,813,817	-
Standard Motors	23	180,805	-
Standard Clothes Washer	27	230,629	2,120
Standard Water Heating	171	1,408,884	65,199
Standard Track Total	**1,038**	**16,182,856**	**286,180**

*Number of unique measure IDs

Table 5. 2012 Custom Track Total Measures and Reported Savings

Measure Category	Total Number of Measures*	Total Electricity Savings (kWh)	Total Gas Savings (therms)
Custom HVAC	68	3,211,901	147,155
Custom Lighting	40	4,825,245	-
Custom Other	8	239,999	5,215
Custom Refrigeration	24	1,364,569	-
Custom Track Total	**140**	**9,641,714**	**152,370**

*Number of unique measure IDs

Table 6. 2012 LEED Track Buildings and Reported Savings

Measure Category	Total Number of Measures*	Total Electricity Savings (kWh)	Total Gas Savings (therms)
LEED	7	7,449,816	118,510

*Number of unique measure IDs

Table 7. 2012 Data Center Track Total Measures and Reported Savings*

Measure Category	Total Number of Measures**	Total Electricity Savings (kWh)	Total Gas Savings (therms)
Data Center	4	4,817,566	214

*Does not include the largest data center project in the program year because it was removed from the evaluation. Refer to Methodology section for discussion of the data center.

**Number of unique measure IDs

Table 8. 2012 Market Solutions Track Total Measures and Reported Savings

Measure Category	Total Number of Measures*	Total Electricity Savings (kWh)	Total Gas Savings (therms)
Market Solutions	13	26,971	1,804

*Number of unique measure IDs

Table 9. 2012 Total Program Measures and Reported Savings

Measure Category	Total Number of Measures*	Total Electricity Savings (kWh)	Total Gas Savings (therms)
Total 2012 Program	1,211	38,118,923	559,077

*Number of unique measure IDs

The 2010 Oregon Energy Efficiency Specialty Code (OEESC) took effect on October 1, 2010. The new code applied to many projects that were completed in the 2012 program year. Approximately 77% of the measures were installed under the 2010 code; these measures equated to approximately 58% of the electric savings and 53% of the gas savings. The balance of the measures were for projects completed under the 2007 code. Table 10 below lists the 2012 program population by prevailing energy code. The prevailing energy code is indicated by the year ("07" or "10") preceding the program track.

Table 10. Measure Population for 2007 and 2010 Energy Code

Program Track	Number of Measures*	Reported Electric Savings (kWh)	Reported Gas Savings (therms)
07 Standard	133	953,499	27,349
07 Standard / Custom	104	4,677,832	31,401
07 Custom	20	2,980,773	81,609
07 LEED	20	7,486,326	119,924
10 Prescriptive Only**	691	9,519,008	229,329
10 Analysis Only**	12	445,118	3,895
10 Prescriptive & Analysis**	214	7,211,830	63,553
10 Data Center	4	4,817,566	214
10 Market Solutions	13	26,971	1,804
Total	**1,211**	**38,118,923**	**559,077**

*Number of unique measure IDs
** Analysis and Prescriptive in 2010 are equivalent to Custom and Standard, respectively, in 2007.

Program year 2012 showed a significant increase in the number of measures implemented under the 2010 Code in comparison to the preceding program year. Figure 1 below shows the increase in adoption of the 2010 code from 2011 to 2012 by the number of measures installed under the two different codes. Figure 2 and Figure 3 below show a comparison of electric and gas savings implemented under the 2007 and 2010 codes during the 2011 and 2012 evaluation cycles.

Figure 1. Transition from 2007 to 2010 Oregon Energy Code – Number of Measures

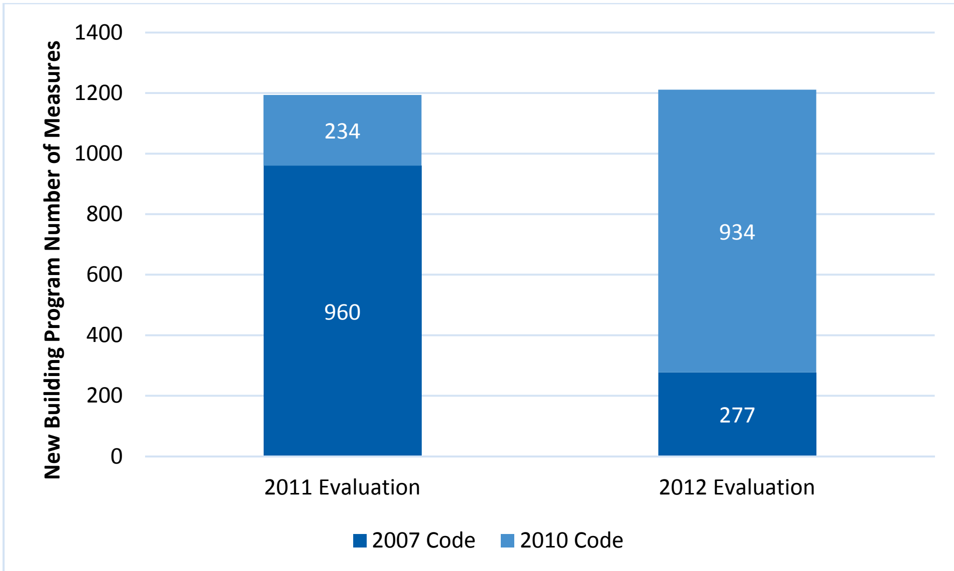


Figure 2. Transition from 2007 to 2010 Oregon Energy Code – Electric Savings

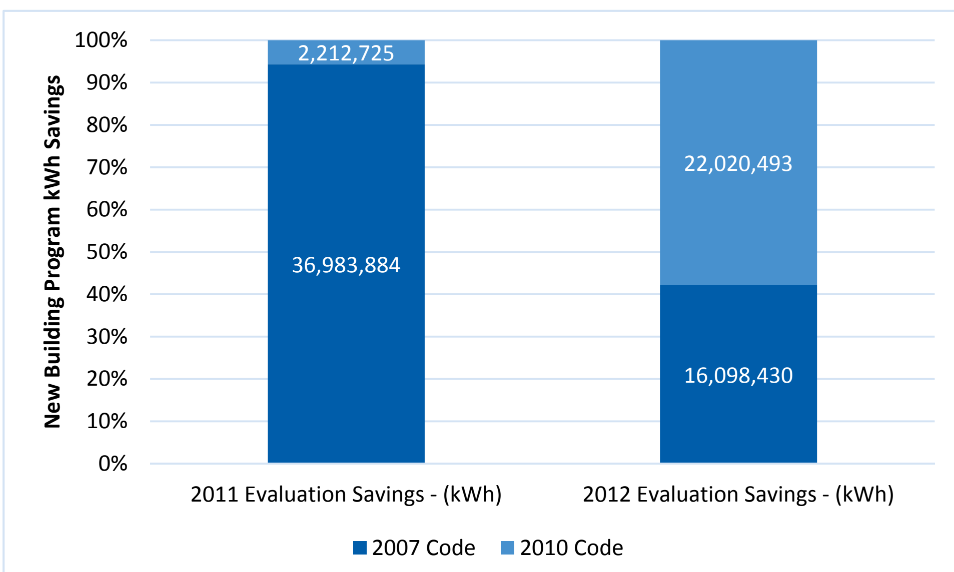
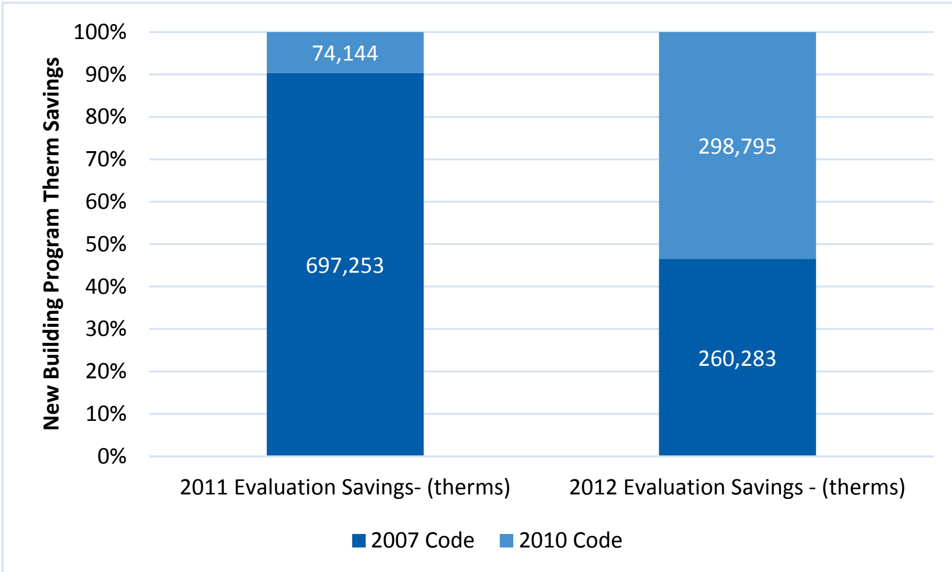


Figure 3. Transition from 2007 to 2010 Oregon Energy Code – Gas Savings



The number of measures permitted under the 2010 code represented 77% of the total, up from 20% in the 2011 program year. This indicates the program transition from the older code is well underway. The only LEED project under the 2010 code in the population was a commissioning measure with no claimed savings, so it was not included in the analysis. Cadmus anticipates the complete transition process to the 2010 code will take several years due to the long timelines associated with new construction projects.

The following section presents Cadmus' methodology for evaluating the 2012 program.

Methodology

To verify reported program participation and estimate gross energy savings in the impact evaluation, Cadmus estimated changes in gross energy consumption using data collected onsite, program tracking data, and engineering models.

We used the following approaches to determine the gross energy savings attributable to the program:

- Sample development
- Data collection, including collection of program documentation, utility data, and site data
- Engineering analysis
- Calibrated simulation analysis

Cadmus calculated savings based on changes between baseline and installed efficiency measures, using program tracking data and assessing the assumptions and accuracy of the original calculations.

Sampling Methodology

The steps Cadmus undertook in designing the sampling approach are these:

1. ***Describe program structure and confidence and precision requirements.*** We designed the sample to meet a 90% confidence level with 10% precision at the program level, within program tracks, and within measure categories of particular interest to Energy Trust.
2. ***Identify the primary sampling unit***. Cadmus reviewed the measure data and determined that the appropriate sampling unit for this project is the Project ID listed in the tracking database.
3. ***Identify unique analysis domains.*** Cadmus and the Energy Trust agreed to include the one Data Center Track project and the two Market Solutions projects in the final evaluation sample. They are not considered in the remaining sampling steps, but are included in the estimation of overall program performance. Cadmus removed any Path to Net Zero pilot projects from the program population as the Energy Trust will complete a separate impact evaluation of this pilot program. We also removed any ENERGY STAR and Small Commercial Efficiency (Core Performance) pilot projects from the population.
4. ***Identify basic sampling and analysis domains.*** To produce accurate savings and realization rate estimates, we used stratified sampling with a certainty (census) stratum. Cadmus first mapped all remaining projects to two evaluation tracks: LEED and Custom / Standard. Our review of the program tracking database showed that it was common that the installation of both Custom and Standard Track measures occurred at the same project. Combining these two tracks for sampling results in the analysis of all measures at each sampled project and site, therefore, increases the number of measures evaluated through this project.
5. ***Determine appropriate stratification.*** Final stratification for this sample was determined based on the research interests of Energy Trust and the measures installed through the program. The LEED domain was split into census and sample strata. The Custom / Standard domain was split

into the following five strata: census, large, medium electric, medium gas, and small. We applied the following rules to determine the appropriate stratum for each Custom / Standard project:

a. Census projects: Projects with kWh savings greater than 1,000,000 kWh or gas savings greater than 10,000 therms.
b. Large stratum: Projects with kWh savings greater than 385,000 kWh that are not in the Census stratum.
c. Medium electric stratum: Projects with kWh savings between 98,000 kWh and 385,000 kWh and gas savings less than 4,900 therms.
d. Medium gas stratum: Projects with gas savings greater than 4,900 therms that are not in the large stratum.
e. Small: All other projects.

These strata align well with the measures installed and expected savings within each domain. The inclusion of a census stratum reduces the overall sampling error in the final result and increases the percentage of program savings evaluated through this study.

6. ***Determine sample size***. Final stratum sample sizes balanced the research interests of Energy Trust and the need to provide a precise estimate of achieved savings for both electricity and gas. The use of stratification reduced the expected variation within each sampling population. Cadmus also reviewed Standard Track projects to confirm the sample contained all major measure types as well as a representative quantity of standard practice measure types.

7. ***Replace sampled 2007 projects***. Cadmus replaced two of the sampled projects in the Custom / Standard domain that were delivered under the 2007 code rules with two similar projects delivered under the 2010 code rules from the same strata. Review of the originally sampled projects showed that the majority of measures installed at these two projects are no longer eligible for incentives from Energy Trust. Replacing these projects with 2010 code projects provides more informative results to the Energy Trust, while not altering the validity of final overall program performance estimates.

8. ***Additional adjustments to the sample.*** Cadmus worked with Energy Trust and the program team to identify any sites in the sample that were known to have barriers preventing successful inclusion in the evaluation activities. Examples of this screening included multiple previous evaluation site visits and activities, anticipated customer reluctance to participate, or known issues at a project site that would not be representative of the larger population. Additionally, through the course of contacting the sites to coordinate, several other sites were removed from the sample, primarily due to reluctance to participate. Where possible, replacement sites were selected from the same strata. One of the census sites, which included the measure with the largest gas savings, was not included in the final sample because the systems were still in the process of being commissioned and did not have an adequate duration of operations for a calibrated simulation analysis. The largest site in the original sample was a data center that was approximately 68% of the total kWh savings of the rest of the projects combined. This site was removed during the evaluation process due to program participant concerns about sharing

facility performance data and lack of resources to support the data request. Due to the size of the site, it was completely removed from the evaluation analysis and will be evaluated at a later date. The final sample represented 68% of remaining reported program electric savings and 41% of the gas savings.

Table 11 shows the final sample and population details for 2012 projects. Cadmus conducted verification and analysis on all measures for each project in the final sample.

Table 11. 2012 Reported Program Evaluation Sample Details*

Group	Total Projects**	Total Measures***	Reported Savings	
			Electricity (kWh)	Gas (therms)
Program Total	326	1,211	38,118,923	559,077
Sample Total	42	285	25,839,306	227,311
Portion of Total Sampled	12%	23%	68%	41%

*Does not include the large data center.

**Number of unique project IDs.

***Number of unique measure IDs.

As shown in Table 12, the final evaluation sample represented a cross-section of major measure categories and measure types, with LEED Track measures representing the largest category of energy savings.

Table 12. Sample Reported Energy Savings by Measure Category

Measure Category	Total Number of Measures*	Reported Electricity Savings (kWh)	Reported Gas Savings (therms)
Standard Food Service	83	2,682,651	9,693
Standard HVAC	45	575,493	42,367
Standard Lighting	26	2,157,669	-
Standard Motors	10	142,824	-
Standard Clothes Washer	6	84,468	804
Standard Water Heating	19	383,550	14,157
Custom HVAC	32	2,680,665	111,695
Custom Lighting	24	4,295,012	-
Custom Other	2	65,005	-
Custom Refrigeration	14	1,067,575	-
LEED	7	6,859,857	46,577
Data Center	4	4,817,566	214
Market Solutions	13	26,971	1,804
Total 2012 Sample	**285**	**25,839,306**	**227,311**

*Number of unique measure IDs.

Cadmus calculated the sampling precision to determine whether it was acceptable, based on standard statistical levels of rigor, to extrapolate sample energy savings to the overall program population.[3] For Standard and LEED Tracks, Cadmus determined the confidence interval (precision) for a 90% confidence level and found the overall sample exceeded a 90/10 level, as shown in Table 13. However, the Custom Track did not meet the precision targets, in particular the gas savings.

Table 13. 2012 Sample Precision

Track	Confidence Level	Relative Precision (kWh)	Relative Precision (therms)
Standard	90%	5%	0%
Custom	90%	12%	75%
LEED	90%	10%	1%
Total	**90%**	**4%**	**13%**

For comparison purposes, Table 14 shows distributions of measure savings in the overall program and sample population. Though the sample distribution was very consistent with the overall program project savings distribution, the sample featured less prescriptive savings and a larger proportion of the more complex LEED and Data Center Track measures, which generally involved greater energy savings and required more analysis. These distribution differences were consistent with the process used for selecting projects that saved the most energy.

Table 14. Total and Sample Portions of Energy Reported Savings*

Track	Population Measure Energy Savings (MMBtu)	Portion of Total Measure Savings	Sample Measure Energy Savings (MMBtu)	Portion of Sample Measure Savings
Standard	90,175	45%	24,441	21%
Custom	52,239	26%	44,110	39%
LEED	37,562	20%	28,329	25%
Data Center	16,459	9%	16,459	15%
Market Solutions	283	<1%	283	<1%
Total	**196,716**	**100%**	**110,895**	**100%**

*Excludes Path to Net Zero, ENERGY STAR, and Small Commercial Efficiency (Core Performance) pilot.

As shown in Table 15, the evaluation sample and program population represented a mix of building types, continuing the trend from 2011. The most frequently evaluated building types in 2012 were

[3] The confidence level and interval determine precision. Values for Standard Track projects, for example, indicate Cadmus can be 90% certain, based on sampling error, the population value falls within ±5% of evaluated electric savings for the sample.

nearly evenly split between grocery stores and education. In previous years, the most common sample building types were:

- 2008: Mercantile(retail other than Mall), Other, Mixed Use Residential, Office
- 2009: Education, Other, Office, Healthcare (Inpatient)
- 2010: Offices, Grocery, Restaurants, K-12 Schools
- 2011: College/University, Warehouses, Restaurants, Retail
- 2012: Grocery, Schools K-12, Multifamily Residential, Office

The sample distribution of building types roughly matched the program population, with a few exceptions. Data Center, grocery, hospital, retail, and office facility types were slightly oversampled, and multifamily residential and other facility types were slightly under-sampled.

Table 15. Building Types Represented in Evaluation Sample and Population

Building Type	Projects in Sample	Portion of Total Sample (MMBtu basis)	Projects in Population	Portion of Total Population (MMBtu basis)
Assembly	-	-	9	1%
Auto Services	-	-	9	11%
College/University	1	5%	11	5%
Data Center	1	15%	1	8%
Grocery	9	16%	23	13%
Gym/Athletic Club	-	-	3	<1%
Hospital	3	15%	6	10%
Infrastructure	-	-	2	<1%
Institution/Government	-	-	3	<1%
Lodging/Hotel/Motel	-	-	3	<1%
Manufacturing	-	-	2	<1%
Multifamily Residential	5	3%	39	7%
Office	4	10%	41	8%
Other	4	9%	32	11%
Other Health	-	-	13	2%
Parking Structure/Garage	-	-	2	<1%
Religious/Spiritual	-	-	5	<1%
Restaurant	2	-	48	4%
Retail	3	13%	31	10%
Retirement/Assisted Facilities	-	-	1	<1%
Schools K-12	8	14%	25	14%
Warehouse	2	-	17	2%
Total	**42**	**100%**	**326**	**100%**

Data Collection

Cadmus reviewed the available documentation such as audit reports, savings calculation work papers, program application forms, utility billing data, and energy models (where applicable) for the sample sites, paying particular attention to the calculation procedures and documentation for savings estimates. We reviewed analyses originally used to calculate expected savings and verified operating and structural parameters. During site visits, we verified installations and determined changes to operating parameters following measure installation.

For Custom and LEED Track projects, Cadmus frequently used calibrated energy models to analyze building performance against reported savings. Site visits, trend data, and calibrated energy models informed savings impact calculations. Individual measure savings, aggregated into measure categories,

allowed calculations of measure-level realization rates (the ratio of evaluated to reported savings). We then applied these rates to program-level reported savings associated with the respective measure categories and summed total adjusted savings to determine the overall, program-level energy savings realization rate. Site visit data and analysis also provided information enabling us to develop recommendations for future studies.

Document Review

The evaluation began with a review of relevant documentation and other program materials from the implementer. If additional clarification or documentation was required, we could usually contact the participant or relevant contractor to obtain the original calculation sheets. If necessary, Energy Trust program staff and the implementer also assisted in obtaining project data.

We reviewed information for all sample projects, including program forms, the tracking database extract, audit reports, and savings calculation documentation for each rebated measure (as applicable). Our review examined each project file for the following information:

- Documentation on equipment installed, including:
  - Descriptions
  - Schematics
  - Performance data
  - Other supporting information
- Information about savings calculation methodologies, including:
  - Methodologies used
  - Specification assumptions and the sources for these specifications
  - Accuracy of the calculations

Site Verification Visits

Cadmus conducted comprehensive site visits for all evaluated projects, focusing on specific end uses when verifying individual measures at a site.

During the site visits, our field engineers focused on these three primary tasks:

- **Verifying installation of all measures for which participants received incentives:** To the extent possible, field engineers verified that energy-efficiency measures had been correctly installed, remained in place, and functioned properly. They collected equipment nameplate data, equipment quantities, and compared site conditions and as-built conditions to the program documentation.
- **Collecting the physical data required to analyze energy savings realized from installed measures:** Field engineers determined pertinent data for collection from each site using in-depth reviews of project files. They conducted spot measurements, collected energy

management system trend data, or made visual inspections, as appropriate. Field engineers also verified operating parameters for installed equipment.

- **Conducting interviews with the facility operations staff:** Field engineers conducted interviews with operations staff at the sites to confirm project documentation accuracy and to obtain additional data on operating characteristics for installed systems.

Engineering Analysis

Procedures used to verify savings through engineering analysis depended on the type of measure analyzed. The program included these major measure groups:

- Standard Food Service
- Standard HVAC
- Standard Lighting
- Standard Motors
- Standard Clothes Washer
- Standard Water Heating
- Custom HVAC
- Custom Lighting
- Custom Other
- Custom Refrigeration
- LEED
- Data Center
- Market Solutions

The following sections describe the focus of site visits and the procedures Cadmus used to verify savings from the different types of measures installed through the program. A detailed list of how the measure categories used in the evaluation process map to the measure entity descriptions assigned by Energy Trust is included in Appendix A.

Standard Food Service

The category includes a variety of measures, including anti-sweat heat controls and floating head pressure controls for refrigerated cases. The program also provides incentives for high-efficiency food service appliances, such as refrigerators and cooking equipment. Much of the cooking and refrigeration equipment had ENERGY STAR ratings.

Cadmus analyzed grocery measures using a variety of methods. Where applicable (such as with LED case lighting), energy savings were calculated using equipment counts, manufacturer specification data, and estimated refrigeration load reduction. For refrigeration controls, we confirmed that equipment capacities matched program records and that system settings met the minimum program requirements.

For the high-efficiency appliances, Cadmus verified equipment counts and confirmed that these units met program efficiency requirements.

Standard HVAC

For most sites with standard HVAC measures, Cadmus focused on equipment counts and verifying that the installed units met the program's efficiency requirements. Our site inspections included interviews with facility personnel, which enabled us to verify operating hours, temperature setpoints, and proper installation of energy-efficient equipment.

Standard Lighting

The analysis included two types of standard lighting projects:

- **Lighting control strategies, including occupancy sensors, daylight dimming controls, and automated lighting control systems.** These measure types typically involved operation-hour reductions to more closely match building occupancy.
- **Lighting power density reductions** for the entire facility below the values prescribed by the 2010 Oregon OEESC.

Analysis of lighting measure savings required documentation on fixture wattages, quantities, and operating hours. We also verified space types and areas for lighting power density calculations.

We verified energy-efficient replacement input wattages using several sources, including the manufacturer lamp and ballast product catalogs and project lighting fixture submittals. Cadmus also evaluated operating hours for each site, based on activities of the buildings' occupants within the relevant spaces.

Our team evaluated lighting control systems by focusing on functionality and operating hours. We visually inspected occupancy sensors. For lighting automation systems we recorded the scheduled operating hour setpoints, which we then verified against claims used in submitted calculations.

We also conducted onsite interviews with building operators and facility staff, verifying operating hours and areas where fixtures had been installed. The field engineer documented lamp and ballast information for fixture types, counting the number of fixtures installed, and noting fixtures affected by lighting controls systems.

Standard Motors

For high-efficiency motor and variable speed drive (VSD) installation measures, Cadmus confirmed equipment counts and verified that the units met the program's efficiency requirements. For verification purposes, we confirmed motors met or exceeded program requirements by motor type, speed, and horsepower rating. Field engineers also reviewed VSD operation to confirm that the drives were active and that they had not been manually overridden to operate at 100% speed.

Standard Clothes Washer

Cadmus developed this category for measures related to clothes washers. Field engineers focused on verifying equipment counts and collecting equipment nameplate data. The equipment nameplate data was used to verify that the units met the program's efficiency requirements.

Standard Water Heating

Cadmus developed a separate category for water heaters and any other measures that significantly influenced water heating loads, such as aerators and showerheads. Field engineers verified equipment counts and collected equipment nameplate data, which were used to verify that the units met the program's efficiency requirements. Where possible, field engineers performed flow tests for showerheads and faucet aerators.

Custom HVAC

Custom HVAC measures represented a variety of applications, including high efficiency HVAC technologies and building envelope improvements. For each project, Cadmus performed a site visit to verify correct installation of incented equipment and to confirm quantities and operating characteristics, thus determining if the initial analysis approach was reasonable, and, if necessary, applying a revised calculation approach. Calculations and simulation models were adjusted to reflect as-built parameters, which we confirmed through site visits and interviews with facility operations staff. Cadmus evaluated these projects through EMS trend data on system parameters, utility billing data, reviews of design engineers' calculations, and building simulation models. Cadmus used new data collected at the site to update the calculations or energy models. Cadmus calibrated simulation models to the actual utility data.

Custom Lighting

Custom Lighting measures included lighting power density reductions, lighting control installations, daylighting, and case lighting controls. Analysis of lighting measure savings required documentation on fixture wattages, quantities, control system settings, and operating hours. We also verified space types and areas for lighting power density calculations.

We verified energy-efficient replacement input wattages using several sources, including the manufacturer lamp and ballast product catalogs and project lighting fixture submittals. Cadmus also evaluated operating hours for each site, based on activities of the buildings' occupants within the relevant spaces.

Our team evaluated lighting control systems by focusing on functionality and operating hours. We visually inspected occupancy sensors. For lighting automation systems we recorded the scheduled operating hour setpoints, which we then verified against claims used in submitted calculations.

We also conducted onsite interviews with building operators and facility staff, verifying operating hours and areas where fixtures had been installed. The field engineer documented lamp and ballast information for fixture types, counting the number of fixtures installed, and noting fixtures affected by lighting controls systems.

Custom Other

The custom other measure category was used for measure that did not fall into the other custom categories. Custom other measures represented a small portion of custom savings—approximately 2% of the total custom reported electric savings and 3% of gas savings. For each project, Cadmus performed a site visit to verify correct installation of incented equipment and to confirm quantities and operating characteristics, thus determining if the initial analysis approach was reasonable, and, if necessary, applying a revised calculation approach.

Custom Refrigeration

Custom refrigeration measures consisted of variable speed drives (VSD) on condenser fans, refrigerant pressure controls, oversized condensers, and several case lighting installations. For these projects, Cadmus field engineers confirmed equipment installations, quantities, capacities, and system settings.

LEED Building and Custom Track Simulation Models

For the 2012 program evaluation sample, the majority of the LEED Track buildings and several of the Custom Track projects reported savings calculated using building energy simulation models. Cadmus used a measurement-based calibrated engineering method (MCEM) to evaluate savings for these projects. This approach was:

- Based on *in situ* measurements and observations
- Calibrated to best available energy use indices
- Conducted with industry-accepted engineering analysis tools, such as DOE-2 or TRACE

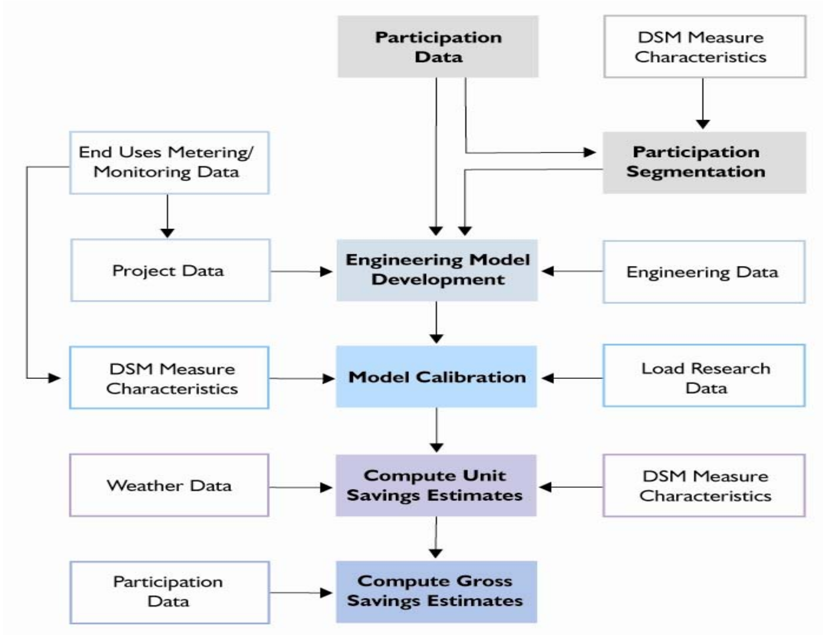
The analysis focused on the following:

- Quantifying as-built construction characteristics, energy systems operational characteristics, and energy-efficient measure characteristics (such as quantities, capacities, and efficiencies).
- Reviewing the energy models provided with the program documentation and created by the project teams. We reviewed energy-efficient measure assumptions and performance variables for each building to ensure that the model inputs accurately reflected the as-built conditions. We also reviewed the baseline model for each building to ensure that it reflected code-prescribed values and complied with standard modeling procedure. When we identified discrepancies we revised the models as necessary.
- Calibrating models to the best available consumption indices (including monthly utility data).
- Comparing the results of calibrated, as-built model energy use with the baseline model to determine the annual energy savings for individual buildings.

- Summarizing energy savings for each building and, for Custom Track measures, each individual incented measure. Along with participation data, these values were extrapolated to the population to estimate gross savings for the program.

Figure 4 depicts the MCEM approach.

Figure 4. Measurement-Based Calibrated Engineering Method Flowchart



Model Calibration

Because this was a new construction program, the model for the as-built building was the only one that could be used for calibration purposes, so this was Cadmus' starting point. We obtained as-built models for projects in the final sample that used energy simulation models to predict energy savings; these models were based on:

- Building sizes and configurations
- Shell characteristics (such as window-shading coefficients and wall insulation values)
- HVAC equipment specifications
- Lighting densities and control methods
- Occupancies
- Schedules

First we checked the model files against the project file documentation. For LEED projects, this included comparing the models to the LEED energy modeling documentation. If there was a discrepancy, we contacted Energy Trust to obtain the correct files. In certain cases, we contacted the design teams directly to expedite the process. We then confirmed the model and project file information through

detailed data collection from site visits. Through site interviews, we determined occupancy levels and operating schedules achieved during the previous year and adjusted equipment operating characteristics for the spaces modeled.

Cadmus calibrated the modeled electricity and gas consumption to monthly utility data for the period of one year. The target variance for calibrated values with respect to the utility data was +/- 10% on a monthly basis and +/- 5% for the annual total. The model simulations incorporated actual historical weather data that corresponded to the calibration period.

Data Center

The 2012 program sample originally included the two data center facilities in the population that implemented custom measures under the Data Center Track. The customized nature of projects required a variety of calculation methods to estimate energy savings, primarily calculation spreadsheets. For the two data center sites, Cadmus worked closely with the implementer to gain information about the facility operations. For the larger data center site, Cadmus was informed the site did not have the resources to participate in evaluation during 2014, so the site was removed from the sample. For the other data center site, we conducted interviews with the facility contacts and submitted a data request to them for information such as trend data from the energy management system. We received comprehensive trend data spanning a period of six months, which allowed the analysis of system performance through summer, winter, and shoulder seasons. The trend data was comprehensive which allowed for the analysis of HVAC system and UPS system performance. The facility team actively used their energy management system to collect trend data on site performance. This data was used in the evaluation analysis to conduct engineering analysis of the implemented measures. Cadmus did not perform a site visit to this second data center as it was not deemed necessary given the availability of electronic data from the participant.

Market Solutions

The 2012 sample included the two projects in the population that implemented measures under the Market Solutions Track. The implemented measures included food service equipment, domestic hot water systems, lighting, appliances, and HVAC. For each project, Cadmus performed a site visit to verify correct installation of incented equipment and to confirm quantities and operating characteristics, and, if necessary, applied a revised calculation approach.

Analysis and Findings

This section presents the results of engineering analysis, as applied to the sample; adjustments to reported values; calculation of realization rates; and estimation of savings for the full 2012 program population. It also includes general observations regarding discrepancies and other factors influencing measure-level realization rates. Finally, it examines energy-use intensity data derived from the sample.

Evaluated Savings for the Sample

Reported and evaluated energy savings values for the sample were compared through measure-level realization rates, as shown in Table 16. The evaluated sample had a 78% electric realization rate and a 74% natural gas realization rate (unweighted values). Cadmus adjusted electricity and gas savings for the measure-specific reasons described in the sections below.

Table 16.Sample Reported and Evaluated Savings and Realization Rates by Measure Category

Measure Category	Total Measures	Electricity Savings		Gas Savings		Realization Rate	
		Reported (kWh)	Evaluated (kWh)	Reported (therms)	Evaluated (therms)	Electricity Savings	Gas Savings
Standard Food Service	83	2,682,651	2,774,402	9,693	9,124	103%	94%
Standard HVAC	45	575,493	575,523	42,367	42,369	100%	100%
Standard Lighting	26	2,157,669	2,237,124	-	-	104%	N/A*
Standard Motors	10	142,824	142,824	-	-	100%	N/A*
Standard Clothes Washer	6	84,468	75,396	804	804	89%	100%
Standard Water Heating	19	383,550	383,550	14,157	14,156	100%	100%
Custom HVAC	32	2,680,665	2,575,896	111,695	61,823	96%	55%
Custom Lighting	24	4,295,012	3,916,448	-	-	91%	N/A*
Custom Other	2	65,005	62,462	-	-	96%	N/A*
Custom Refrigeration	14	1,067,575	648,933	-	-	61%	N/A*
LEED	7	6,859,857	5,129,911	46,577	37,869	75%	81%
Data Center	4	4,817,566	1,479,527	214	44	31%	21%
Market Solutions	13	26,971	24,034	1,804	1,707	89%	95%

*Realization rate not calculated for measures with no gas savings.

Standard Track

The Standard program track includes the prescriptive measures for food service, lighting, motors, other, and water heating. Overall, this category had a 103% electric realization rate and a 99% gas realization rate.

Standard Food Service

The Standard Food Service category represented refrigeration, cooking, and grocery measures, which had a 103% overall electric realization rate and a 94% gas realization rate.

Standard Refrigeration and Cooking Measures

Incented refrigeration equipment included ENERGY STAR appliances such as refrigerators and ice-making machines. Cooking measures covered electric and gas equipment, including convection ovens and electric hot food cabinets. Most cooking appliances were ENERGY STAR rated.

Cadmus verified that equipment counts at each site matched reported values and that equipment met ENERGY STAR specifications. In general, we found participants had installed these measures as reported, and the measures achieved the reported savings. We found that one refrigerator did not meet the ENERGY STAR requirement; the originally specified model was not installed due to a supply issue at the time of the project. One site only had two refrigerators installed instead of three that were incented. We found one gas fryer had been disconnected and taken out of service. The restaurant staff reported that the kitchen needs had changed and they had no plans to put the fryer back into operation. We also found one gas fryer measure to have more savings than reported due to longer operating hours.

Standard Grocery Measures

Grocery measures featured a variety of efficiency improvements to grocery refrigeration systems, such as electrically commutated motors (ECMs), LED case lighting, controls, and night covers. Cadmus reviewed deemed savings estimates and recalculated savings based on verified equipment details or secondary source data. An update to the Regional Technical Forum calculator for LED case lighting that occurred after the projects were completed resulted in an increase to the evaluated savings for this measure. In general, we found participants had installed these measures as reported, and the measures achieved the reported savings. At one site we found five refrigerated display cases with LED lighting, but the occupancy sensors that were reported were not installed. In another case, we found an additional anti-sweat heater control measure that had been installed but not reported.

Standard HVAC

Standard HVAC projects covered a range of electric and gas measures, including high-efficiency air conditioners, heat pumps, boilers, direct-fired radiant heating, demand-controlled ventilation (DCV), and economizers. These measures had overall electric and gas realization rates of 100%.

Standard Electric HVAC Measures

Cadmus calculated a 100% realization rate for purely electric HVAC measures, including packaged air conditioning and air source heat pumps. Field engineers observed mostly accurate equipment counts and nameplate data. One site reported installing a 3.5-ton HVAC unit with electric heat; however, in the onsite verification, we found a 3.0-ton unit with gas heat.

Standard Gas HVAC Measures

Cadmus calculated a 100% realization rate for purely gas HVAC measures such as condensing boilers and high-efficiency radiant heaters. Field engineers observed mostly accurate equipment counts and nameplate data.

Standard Demand Controlled Ventilation

Cadmus evaluated five DCV measures that reported electric and/or gas savings. We verified equipment nameplate information and operational characteristics at four sites; however, one site did not have accessible equipment so the nameplate data could not be confirmed. We assigned a 100% realization rate to the DCV measures.

Standard Lighting

Standard Lighting measures included lighting power density reductions, efficient interior and exterior lighting fixtures, and controls such as occupancy sensors. Lighting measures achieved a 104% electric realization rate compared with reported savings. For previous program years, Cadmus noted Standard Lighting savings were based on deemed values per fixture, regardless of building types and actual operating hours. For 2010 code projects, the program made the transition to using a lighting power density approach for site-level lighting savings, as required by energy code.

To evaluate savings, Cadmus analyzed measures based on actual wattages and operating hours, as determined through site visits and reviews of invoices and manufacturer specification sheets.

Other primary factors influencing the realization rate were:

- Alterations in fixture quantities and wattages
- Differences in actual operating hours in the sample compared to assumptions used to develop savings estimates
- Claims of savings for code-mandated measures (savings are allowed only for measures that go beyond code requirements)

Lighting Fixture Count Adjustments: Cadmus field engineers occasionally noted discrepancies between reported and observed fixture counts. This is an expected occurrence because as-built conditions often slightly deviate from the original design and changes are not always accounted for in the final project documentation. These changes may be due to changes in space usage requiring different light levels, room reconfigurations, and other field conditions that affect the placement of the fixtures. For savings evaluation purposes, we adjusted baseline and as-built fixture counts to match observed quantities for use in the lighting power density calculations.

Lighting Fixture Average Operating Hour Adjustments: During the site visits, Cadmus noted that the evaluated sample lighting measures sometimes operated for different periods than reported in the energy savings estimates. The original savings estimates rely on assumptions of operating hours prior to building occupancy and a new building may not have established historical occupancy patterns. For this program, we found several projects where the verified operating hours were greater than the reported operating hours. The average evaluated operating hours, in conjunction with fixture count adjustments, resulted in increased energy savings.

Lighting Code Minimum Baseline: Cadmus field engineers determined that one site claimed savings for a lighting control measure that is a code requirement. The project claimed savings for including lighting controls to turn off lighting during unoccupied hours. In this case, no energy savings could be assigned for the lighting control measure at this facility, although the measure reported 8,870 kWh savings so the impact to the category was minimal.

Standard Motors

The Standard Motors category included premium-efficiency motors and VSDs. Cadmus field engineers focused on equipment counts and nameplate data, verifying that the units met the program's efficiency requirements. For verification purposes, we confirmed motors met or exceeded program requirements by motor type, speed, and horsepower rating. Field engineers also reviewed VSD operation to confirm that the drives were active and that they had not been manually overridden to operate at 100% speed. The electric realization rate for this subset was 100%. Cadmus adjusted savings based on as-verified equipment efficiencies and counts.

Standard Clothes Washer

The Standard Clothes Washer category had a sample consisting of washers located primarily in multifamily residential facilities. Field engineers focused on verifying equipment counts and collecting equipment nameplate data. For two projects, installations were found where the installed equipment did not meet ENERGY STAR requirements. The site staff reported that a design change to the room layouts for approximately 33% of the rooms necessitated an equipment model change. The electric realization rate for all measures in this category was 89%. The gas realization rate for all measures in this category was 100%.

Standard Water Heating

The Standard Water Heating category represented the remaining measures with deemed savings, including water heaters and measures significantly influencing water heating loads, such as aerators and showerheads. The electric and gas realization rates for all measures in this category were 100%.

Standard Condensing Tanks

Cadmus evaluated six condensing water heater tank measures. Field engineers focused on verifying equipment counts and collecting equipment nameplate data.

Standard Showerheads and Aerators

Field engineers focused on verifying equipment counts and confirming equipment nameplate data. Where possible, flow tests were performed to confirm actual installation conditions met the rated flow rates.

Custom Track

Custom Track projects are for non-prescriptive measures with gas and electricity savings and involved HVAC, lighting, other, and refrigeration. Overall, Custom projects had an 89% electric savings realization rate and a 55% gas realization rate.

Custom HVAC, Lighting, Other and Refrigeration

Cadmus evaluated custom measure energy savings by reviewing available data and calculation spreadsheets, supported by onsite verification, EMS trend data, energy simulation models, and utility billing data. Because a prescriptive methodology was not appropriate for most of these measures, we relied heavily on models and calculation spreadsheets developed by contractors, participants, and the implementer. We reviewed program documentation, determining calculation sources for each measure and contacting the sources, where necessary, to obtain original calculation spreadsheets or models. We compared inputs and methodologies with available data to confirm methodologies and results, or we adjusted values as necessary.

Custom HVAC and Other measures represented a variety of applications, including high efficiency HVAC technologies and building envelope improvements. Cadmus evaluated these projects through EMS trend data on system parameters, utility billing data, reviews of design engineers' calculations, and building simulation models. At several facilities, Cadmus used new data collected at the site to update the calculations or energy models, leading to reduced energy savings. For example, setpoints for the HVAC system at one site differed from the reported values. In another case, heat recovery effectiveness was reduced based on operating conditions. For several projects, we used calibrated energy models to verify savings. Cadmus calibrated other simulation models to the actual utility data, and several calibrations indicated that actual loads were lower than predicted, thereby reducing the effect of equipment efficiency gains. At one site Cadmus found that a heat recovery chiller was not in operation because the chiller was over sized for the heating loads during the heating season so it could not remain operating. This measure accounted for a large portion of the gas savings and had the biggest impact on the Custom gas savings realization rate.

Custom Lighting projects in the sample involved reductions in lighting power density over code requirements and lighting controls installations. For the lighting power density projects, savings for several projects were calculated using energy simulation calculations for whole building analysis. When Cadmus updated the models to calibrate them to actual energy consumption, several of the calibrated energy models led to increased energy savings for the custom lighting measures. This was offset by lower savings on several projects that claimed energy savings for installing lighting controls to shut off lighting when facilities are unoccupied. This is a code requirement and savings for this measure were not awarded to three projects.

Custom Refrigeration measures consisted of variable speed drives (VSD) on condenser fans, refrigerant pressure controls, oversized condensers, and several case lighting installations. For these projects, Cadmus field engineers confirmed equipment installations, quantities, capacities, and system settings. We observed a variety of installations that did not match the program documentation and updated the savings calculations accordingly. One of the biggest impacts to this category was an error in the calculations for one site. The program documentation calculation form listed the refrigeration system as consisting of 16 compressors each with 147 HP capacity, for a total of 2,352 HP. We verified 16 compressors with a total capacity of 147 HP. The project documentation indicated that the implementer

audited the site and also observed the discrepancy; however, the implementer did not update the reported results in the tracking database. Other examples include condenser capacities lower than reported, floating head pressure and rack pressure control settings not meeting program requirements, and VSDs that were operating at full speed at all times. We identified several projects where the condenser differential temperature settings for floating head pressure control did not meet the program requirements. In the sample of 14 grocery projects, we identified issues at three of those that limited to the measure realization rate at the site to less than 16% and all were related to floating head pressure control. Other projects claimed LED case lighting savings for hours during which facilities were unoccupied and lighting was off. Overall, the issues we observed on the grocery projects were similar to other custom projects.

LEED Track

Cadmus conducted site visits for seven LEED-certified buildings in the evaluation sample and found that this track's projects varied considerably from reported savings. The LEED sample projects achieved an overall electric realization rate of 75% and a gas realization rate of 81%. Cadmus' field engineers collected site data, accurately characterizing as-built parameters for mechanical equipment, lighting power densities, and plug load densities. Field engineers also interviewed facility operations staff to gain a detailed understanding of building operations, occupied hours, and setpoints.

Cadmus compared as-built building characteristics to values specified in the building energy simulation model submitted for the project. Where possible, Cadmus also calibrated models to actual electricity and gas billing data using historical weather data.

Table 17 shows resulting realization rates. The following two subsections discuss Cadmus' adjustments for calculating evaluated energy savings.

Table 17.LEED Building Realization Rates

Building Type	Reported Electricity Savings (kWh)	Evaluated Electricity Savings (kWh)	Reported Gas Savings (therms)	Evaluated Gas Savings (therms)	Electricity Savings Realization Rate	Gas Savings Realization Rate
Office	2,352,203	1,804,200	43	0	77%	0%
Office*	178,421	178,421	25,542	18,547	100%	73%
College/University	1,470,265	1,056,300	4,124	5,263	72%	128%
Office	152,735	104,283	-	-	68%	N/A
Schools K-12	2,651,813	1,828,246	3,147	1,007	70%	32%
Schools K-12	75,332	131,143	11,262	11,891	174%	106%
Institution/Government	13,248	24,968	1,491	193	188%	13%

* The electric utility data were not available for this site, so the energy model could not be calibrated for the electric savings. A 100% realization rate was awarded to the project.

Calculation Methodologies

Energy savings for LEED Track projects were calculated as the difference in annual energy use between baseline and as-built models, with energy savings calculated relative to the ASHRAE 90.1 standard, the required standard for establishing LEED Energy & Atmosphere Credit 1 (EAc1) points. The projects were performed under the 2007 Oregon Structural Specialty Code. For any projects certified under LEED for New Construction v2.2 which uses an ASHRAE 90.1-2004 baseline, PECI reduced the baseline energy consumption by 5% in order to convert from an ASHRAE 90.1-2004 baseline to the 2007 version of the Oregon code. Cadmus reviewed this approach and agreed that the 5% differential was reasonable, confirming the value by interpolating research performed by Architecture 2030,[4] which estimated the "2030 Challenge Code" would save 30% more energy than ASHRAE 90.1-2004 and 25% more energy than Oregon code. For projects certified under LEED v2009, baseline adjustments are not required because this version of LEED uses ASHRAE 90.1-2007 as the reference standard for EAc1.

Discrepancies between the Modeled and As-Built Projects

Cadmus also adjusted energy savings due to differences in equipment and operational parameters used in simulation models and as-built structures. Generally, differences resulted from calibration to actual utility bills and as-built conditions, which we confirmed through site visits. Appendix C, published separately, documents specific issues with model calibration and reasons for variances. The calibration process is explained in LEED Building and Custom Track Simulation Models on page 22. A summary of the major impacts is presented below.

One issue that was noted across several projects was related to modeling variable refrigerant flow (VRF) systems. Cadmus determined that several of the original simulation models for projects with VRF systems suggested substantially higher energy consumption than actual utility meter data showed. After calibration, the resulting evaluated savings were less than the reported value. The energy models contained the appropriate system selections for modeling VRF systems; however, Cadmus had to make other adjustments to the models to calibrate them. More information on the specific projects is listed below and further details are provided in Appendix C. Issues with modeling VRF systems had been observed and commented on during past evaluations and the VRF modeling in the 2012 were improved over past program years.

For site ETONB1202, Cadmus determined that the original model predicted higher electricity consumption than actually occurs now that the building is in operation. Upon review of the model, Cadmus confirmed that the correct system selection was used in the eQUEST model (a VRF system should be modeled using a modified single zone split system heat pump (PVVT)). We determined that several factors contributed to a difference in modeled and actual energy consumption. Based on observed conditions and utility data, Cadmus determined the method used for modeling the plenum zone was incorrect. The original model included plug, lighting, and occupancy loads in the plenum zones.

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[4]Architecture 2030. June 20, 2009. "Meeting the 2030 Challenge Through Building Codes."

The lighting and plug loads entered into the model were also greater than observed at the site. The model was adjusted to eliminate the loads from the plenum zone and reduce the lighting and equipment loads. With these adjustments, the electricity consumption matched the actual utility data. The original simulation model also significantly under predicted gas consumption. The design model predicted that the system would be able to recover heat from the core interior zones and distribute it to perimeter zones that required heating. Site observations and utility data indicate the predicted level of heat recovery is not occurring and additional heat from the gas fired boilers is required. Cadmus updated the model and calibrated the model to the utility data.

Electric utility data were not available for site ETONB1204, so the model was calibrated only for gas consumption. Based on the utility data, the original model over-estimated gas consumption, particularly during winter months. Cadmus determined that space setpoints and occupancy levels used in the model did not match the observed operating conditions. Based on field observations, we adjusted the internal loads and domestic hot water loads, which brought the modeled energy consumption in line with the utility data.

For site ETONB1207, the building contained a VRF system that was modeled in eQUEST. Upon review of the model, Cadmus determined that the correct system selection was used (modified single zone split system heat pump (PVVT)). We used site data to update the model, including the observed boiler efficiency (increased from 90% to 97%) and the fan control strategy for the VRF system (changed from two-speed to constant volume). Overall, the electric savings decreased and the gas savings increased as a result of the calibration.

Site ETONB1213 has a hot water boiler that uses wood pellets as the primary source of fuel for heating and the building is modeled using it as a heat source throughout the year. During the site visit, Cadmus determined the building also contains an electric boiler that is used during the summer months. The facility staff reported that the pellet fired boiler (PFB) is shut down seasonally from June through November, to reduce frequency of operational issues relating to the PFB so any heating load during this period is carried by the electric boiler. Heating loads arising in summer season were assigned to electric end-use after accounting for change in fuel efficiency. There have been a few instances where the PFB was out of commission due to operational issues during winter months. Based on discussions with the facility staff, the building also has a longer operating schedule than the original model contained. Cadmus updated the model with the observed conditions and calibrated it to the electric utility data. Overall, the electric savings decreased as a result of the calibration.

Site ETONB1223 is a school building with a geothermal water-to-water heat pump system providing heating and cooling for the school. During the site visit, Cadmus confirmed that the energy model did not require any changes for the systems installed. Cadmus collected information on schedules and occupancy patterns at the school to update the model. Site staff reported that the gymnasium is used during the summer, but the rest of the building operates in “vacation mode” rather than full occupied mode. Site staff also reported that the school is not expected to reach full capacity until 2025. One floor of a classroom wing in the building is unoccupied. Cadmus updated the model with the observed schedules and occupancy patterns and calibrated it to the electric and gas utility data. Overall, the electric savings decreased as a result of the calibration due to reduced summer operation. The gas savings were also considerably less than the predicted value.

Site ETONB1231 is a school building that was originally modeled as unoccupied during the summer months; however, the site staff reported the building is occupied all year. Additionally, Cadmus determined that the daily schedule is longer than originally modeled based on the data collected at the site. The observed lighting power density was greater than the value contained in the model. Cadmus updated the model with the observed schedules, occupancy patterns, and control sequences and calibrated it to the electric and gas utility data. Overall, both the electric and gas savings increased as a result of the calibration due to increased operating hours for the energy efficiency measures installed in the building.

Site ETONB1237 is a small fire station containing sleeping quarters, kitchen, apparatus bay, and offices. The building is occupied continuously. The original model predicted more electric consumption and less gas consumption than the building actually consumes, based on utility data. During the site visit and the review of the utility data, Cadmus determined that the economizer dampers for the air handling units were not operating properly. To reflect the operating conditions, Cadmus adjusted the amount of outside air for the air handing units in the model. We used the utility data curves to match the shape of the load profile and then also adjusted the plug load values to align the model values with the utility data. Overall, evaluated savings for calibrated energy model were less than the reported savings.

Data Center Track

Cadmus evaluated one data center project, which included multiple measures. The expected server load was 4,000 kW. However, the connected load at the time Cadmus contacted the site in May 2014 was approximately 500 kW. The participant reported the data center hoped to increase site capacity in the next three to five years, but had not yet signed contracts for any additional capacity beyond 500 kW. Without signed contracts or some definitive timeline to reach a larger, mature server load, Cadmus felt it would not be appropriate to estimate future capacity beyond the value observed during the evaluation period. This load reduction decreased the demand for space conditioning and HVAC consumption, which significantly impacted two HVAC measures. The HVAC measures resulted in both electric savings and a small amount of gas savings. A third measure included the installation of an uninterruptible power supply (UPS). Cadmus received trend data from the site facility staff showing input and output power for the UPS. This data was used to calculate the actual efficiency at operating conditions of approximately 80%. Based on these findings, it was determined that although the installed UPS efficiency rating met program requirements, the UPS was oversized for the current connected load and at this operating point it did not meet the efficiency requirements of the program. The site load was reviewed again in the winter of 2015 and the connected load had not significantly changed. The site reported they did not currently have any expectation that the load would increase. The final measure at the site was a lighting installation that received full credit for the reported savings, but it represented a small portion of the overall project savings. This project had a 31% realization rate for electric savings and a 21% realization rate for gas savings.

A second data center was included in the original sample. The project's electric savings equated to 68% of the combined value of all other electric measures in the 2012 New Buildings program. Cadmus began the evaluation process working closely with PECI and Energy Trust staff to coordinate with the customer. Cadmus reviewed program documentation and prepared a list of information that would be required to conduct the evaluation. The program participant ultimately reported that they did not have personnel available to collect the facility performance information Cadmus requested. After discussions with the program team, the site was removed from this evaluation and will be evaluated at a later date.

Market Solutions Track

The 2012 sample included the two projects in the population that implemented measures under the Market Solutions Track. The implemented measures included food service equipment, domestic hot water systems, lighting, appliances, and HVAC. For each project, Cadmus performed site visits to verify correct installation of incented equipment and to confirm measure quantities and operating characteristics, and, if necessary, applied a revised calculation approach.

One site was listed as an office, but Cadmus determined it was not a good fit for the Market Solutions program. The program documentation accurately listed the area as 1,618 square feet, although the program's Market Solutions deemed simulation models estimated energy savings based on an average area of 20,000 square feet. During the evaluation site visit, it was observed that the space was not an office, but an event space on the second floor of a restaurant that included a small room used as an office. The restaurant reported that the event space was rarely used. The site contact claimed the lights were in operation two hours per day or less, which is lower than the reported value of 12 hours per day. The project also provided incentives for a heat pump water heater. This water heater was located in the conditioned space, thereby drawing in air previously heated by the HVAC system and turning it into hot water. The only hot water load in the space was a hand washing sink, for which the heat pump water heater was oversized. The implementer conducted a post-installation site visit for this project, but apparently did not identify the areas of concern noted above.

The second site was a restaurant. Cadmus observed site conditions that matched the program documentation, with the exception of the operating hours. The operating hours were much greater than reported, significantly increasing the lighting energy savings. Overall the Market Solutions Track yielded an electric realization rate of 89% and a gas realization rate of 95%.

Calculate Program Realization Rate

As described earlier, the measurement and verification process involved analyzing measures at projects with a sample large enough to provide 90/10 confidence and precision for the program. Cadmus calculated the realization rates observed among measures of each type (e.g., Standard HVAC, Custom Food Service) in the sample and used these observations to estimate savings at the program (population) level. Sample observations were weighted based on measure categories[5] to estimate population totals. Reported savings are the savings values Cadmus obtained from the program documentation. Evaluated savings are the savings values Cadmus calculated based on our evaluation activities.

We estimated a realization rate for each measure category based on all sampled measures within the measure category, e.g., Standard HVAC (Equation 1), where n_k is the number of measures sampled in the measure category:

Equation 1:

$$RR_k = \frac{\sum_{j=1}^{n_k} Evaluated\ Savings_j}{\sum_{j=1}^{n_k} Reported\ Savings_j}$$

Where:

RR_k = realization rate for the k^{th} stratum
n_k = the number of project-sites sampled in the k^{th} stratum
j_k = the j^{th} project-site in the k^{th} stratum

Using the measure category realization rate for the sample, we estimated the program total evaluated savings within each measure category by multiplying the realization rate for the measure category times the total reported program savings (Equation 2) for that measure category, where N_k is the number of measures in the population:

Equation 2:

$$Program\ Evaluated\ Savings_k = RR_k \times \sum_{j=1}^{N_k} Reported\ Savings_j$$

Where:

RR_k = realization rate of the k^{th} stratum
N_k = the number of project-sites in the population in the k^{th} stratum
j_k = the j^{th} project-site in the k^{th} stratum

Finally, we estimated the program total evaluated savings across measure categories by summing the program evaluated savings from each measure category (Equation 3) and estimated the program total realization rate by dividing the population total evaluated savings estimate by the total reported savings (Equation 4):

Equation 3:

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[5] Sampling weights based on the number of measures in each measure category in the sample and in the population were used to calculate the standard error and precision.

$$Program\ Evaluated\ Savings_{all\ strata} = \sum_{k=1}^{K} Program\ Evaluated\ Savings_k$$

Equation 4:

$$RR_{program} = \frac{Program\ Evaluated\ Savings_{\ all\ strata}}{Program\ Reported\ Savings_{\ all\ strata}}$$

Where:

- RR = realization rate
- k = stratum
- K = total number of strata
- n_k = the total number of project-sites of type k in the sample
- N_k = the total number of project-sites of type k in the population

Table 18 shows final evaluated savings by measure category, stratum, fuel, and at the program level.

Table 18. Program Level Electricity and Gas Savings by Measure Category

Measure Category	Total Measures	Reported Savings		Evaluated Savings		Realization Rate	
		Electricity (kWh)	Gas (therms)	Electricity (kWh)	Gas (therms)	Electricity Savings	Gas Savings
Standard Food Service	338	4,120,996	60,673	4,261,941	55,076	103%	94%
Standard HVAC	208	1,427,725	158,188	1,427,799	158,194	100%	100%
Standard Lighting	272	8,813,817	-	9,138,381	-	104%	-
Standard Motors	23	180,805	-	180,805	-	100%	-
Standard Clothes Washer	26	230,629	2,120	205,859	2,121	89%	100%
Standard Water Heating	171	1,408,884	65,199	1,408,884	65,194	100%	100%
Custom HVAC	68	3,211,901	147,155	3,086,370	81,450	96%	55%
Custom Lighting	40	4,825,245	-	4,399,946	-	91%	-
Custom Other	8	239,999	5,215	230,610	5,215	96%	100%
Custom Refrigeration	24	1,364,569	-	829,463	-	61%	-
LEED	7	7,449,816	118,510	5,571,041	96,068	75%	81%
Data Center	4	4,817,566	214	1,479,527	44	31%	21%
Market Solutions	13	26,971	1,804	24,034	1,707	89%	95%
Total Program	**1,211**	**38,118,923**	**559,077**	**32,244,660**	**467,105**	**85%**	**84%**

Energy Use Intensity of Sampled Projects

Cadmus also calculated the sampled projects' energy use intensity (EUI) by examining building floor area in square feet and utility billing data for gas and electricity usage. One hospital project was not examined, as the project building is part of a larger campus and not individually metered. We did not include one school project in the EUI averages, as its extremely high EUI indicates a possible discrepancy between the square footage of the project and the utility billing data. A few projects were missing either electricity or gas billing data, generally because they were served by a utility other than those which provide funding for Energy Trust. Due to the missing billing data, we omitted those projects from the EUI comparison. Table 19 shows EUI data for the 34 remaining projects.

Table 19. Energy Use Intensities for 2012 Evaluation Sample Buildings

Building Type	Area (sf)	Electricity EUI (kWh/sf)	Gas EUI (therms/sf)	Total Energy EUI (kBtu/sf)
Office	176,272	5.8	0.07	27.0
Office	140,000	7.4	0.09	34.1
College/University	368,993	9.4	0.12	44.0
Grocery	87,301	35.9	0.52	173.9
Office	44,474	12.4	0.19	61.5
Hospital	61,000	44.3	0.30	180.9
Schools K-12	302,270	8.6	0.03	32.8
Retail	187,066	20.6	0.25	95.5
Schools K-12	66,932	7.6	0.25	50.5
Schools K-12	78,174	4.4	0.13	28.3
Grocery	56,500	35.0	1.35	253.9
Schools K-12	68,000	4.8	0.24	40.8
Schools K-12	68,000	5.0	0.24	40.7
Warehouse	83,607	0.5	0.01	2.6
Warehouse	47,714	5.1	0.07	24.4
Grocery	39,810	29.2	0.91	190.8
Data Center	176,800	45.2	0.23	177.4
Other	173,485	15.5	0.03	56.0
Grocery	40,142	38.6	0.98	229.8
Schools K-12	180,000	13.2	0.42	87.6
Multifamily Residential	199,053	3.3	0.05	16.5
Multifamily Residential	172,722	1.7	0.00	6.2
Multifamily Residential	172,722	1.7	0.00	6.2
Schools K-12	4,500	47.8	2.97	459.7
Grocery	42,850	37.1	1.00	226.4
Retail	138,760	12.7	0.10	53.1
Multifamily Residential	398,026	1.5	0.04	9.5
Grocery	40,734	35.2	1.55	275.5

Building Type	Area (sf)	Electricity EUI (kWh/sf)	Gas EUI (therms/sf)	Total Energy EUI (kBtu/sf)
Multifamily Residential	211,560	6.7	0.00	23.2
Grocery	14,036	61.6	2.02	412.2
Safety	6,594	5.9	0.33	53.6
Other	101,640	22.5	0.74	150.9
Restaurant	1,300	44.3	2.23	374.2
Restaurant	5,900	28.0	3.39	434.1

Table 20 shows performance of 2012 sample building energy use intensity, relative to the 2011 evaluation sample buildings[6] and three other studies that have been used previously to benchmark the performance of new construction buildings in Oregon.[7,8,9] Appendix A highlights data from these studies in greater detail.

Table 20. Comparison of EUI Data with Other Studies

Building Type	Buildings in Sample	Average EUI ETO New Buildings 2012 (kBtu/sf)	Average EUI ETO New Buildings 2011 (kBtu/sf)	PGE EUI Data for Post-1985 Buildings (kBtu/sf)	Ecotope New Construction EUI 2002-2004 (kBtu/sf)	Average EUI NEEA CBSA 2014 (kBtu/sf)
College/University	1	44.0	195	89.8	65.9	N/A
Grocery	7	251.8	269.9	198.7	202.8	258.5
Hospital	1	180.9	N/A	230.4	123.1	N/A
Multifamily Residential	5	12.3	28.3	58.4	58.5	N/A
Office	3	40.9	65.5	85.3	81.9	82.6
Other	2	103.4	319.7	N/A	96.3	78.0
Restaurant/ Food Service	2	404.1	708.3	587.8	512.7	371.3
Retail	2	74.3	137	61.2	76.8	68.7
Safety	1	53.6	N/A	N/A	102.8	N/A
Schools K-12	7	46.8	24.5	73.1	48.5	67.7
Warehouse	2	13.5	21.5	32.1	31.8	33.6

[6] Cadmus. October 2013. “Energy Trust of Oregon 2011 New Buildings Program Impact Evaluation.” Table 21.

[7] Energy Trust of Oregon FY2009 program savings calculation spreadsheet, “2005398 01 18 2009 River East Center Form 520L 540L Final.xls”

[8] Ecotope. December 2009. “Baseline Energy Use Index of the 2002-2004 Nonresidential Sector: Idaho, Montana, Oregon, and Washington.” Table A-11.

[9] Northwest Energy Efficiency Alliance. “Commercial Building Stock Assessment 2014 – Appendix A Building Characteristics Summary Tables”. Section A.3 Figure A.3.1 and Figure A.3.6

Many of the sample building types had EUIs within the benchmark range, including hospital, retail, and school buildings.

Cadmus noted that the grocery building type had a higher average EUI than the comparable EUIs in two of the comparison studies, but in line with the most recent comparison study, NEEA's 2014 Commercial Building Stock Assessment. We found the same result for supermarkets during the 2009, 2010, and 2011 program evaluations. The average 2010 grocery EUI was 268 kBtu/sf, almost identical to the 270 kBtu/sf for the 2011 grocery EUI, and similar to the 252 kBtu/sf found for the 2012 grocery.

Cadmus found the two warehouses in the sample achieved lower average EUI than warehouses in the comparison studies. These results are consistent with the 2009, 2010, and 2011 results. However, the small sample size of the 2012 evaluation precluded drawing any conclusions about trends or factors accounting for the differences.

The three sample office buildings used less energy per square foot than buildings in the comparison studies. During the field investigation of the two sample office buildings with the lowest EUI, Cadmus interviewed the building engineers, who reported that the facilities' occupants have become very observant and conservative regarding their lighting and equipment (e.g., printers, plug loads, etc.) usage. This resulted in lower than average lighting and miscellaneous equipment energy consumption, as well as reduced heat gain from these sources, which results in decreased space cooling loads in these buildings. This may be evidence of the potential effect of behavior change programs.

Cadmus found the multifamily residential buildings in the sample achieved a lower average EUI than those in the comparison studies. These results are consistent with the 2009, 2010, and 2011 results. However, it should be noted that since the individual residential units in these buildings have individual electricity meters there is a high degree of variability in the billing data for the overall project.

The one college/university building in the sample had a much lower EUI than either of the comparison studies or the previous program year. It is likely that this difference can be attributed to the limitations of the building type designation for this project. This building was a mixed-use facility and included residential units, which would have a lower average EUI than a typical university building type.

Conclusions and Recommendations

Cadmus conducted an impact evaluation of the 2012 Energy Trust of Oregon New Buildings program by analyzing energy savings for 285 measures implemented in 42 projects. The measures belonged to five different program tracks: Standard, Custom, LEED, Data Center, and Market Solutions. Each track included measures from a variety of subcategories.

From the original sample of 44 sites, we removed a few from the evaluation. As with previous evaluations, the Data Center Track projects represented a large portion of the reported program savings and the site with the largest reported savings was in this track. Cadmus did not evaluate the largest project because the program participant stated they did not have the resources to compile the facility information Cadmus requested. Due to the size of this project's savings, Cadmus completely excluded it from the analysis; Energy Trust will evaluate the project at a later date. We did not evaluate one other project because they did not have enough time operating at fully commissioned and occupied conditions to provide meaningful results.

We performed verification site visits for each remaining project in the sample and evaluated energy savings based on verified equipment counts, operating parameters, and assumptions derived from engineering experience and secondary sources. For each measure, this data informed prescriptive algorithms, calculation spreadsheets, and building simulation models.

Energy Trust and its implementer, PECI, applied appropriate methodologies and calculations for many measures when determining reported savings. However, Cadmus' evaluated savings differed from reported energy savings. Cadmus made revisions to calculation methodologies and equipment counts and found variations between expected and achieved simulation model performance. These combined factors led to an 85% program-level realization rate for electric savings and 84% realization rate for gas savings. This is a decrease from the 93% electric realization rate and 92% gas realization for the 2011 program.

The biggest contributor to this decrease for electric savings is the Data Center project which had a realization rate of 31% due to actual facility server loads that are well below the levels used to calculate the reported savings. Excluding the Data Center project from the analysis, the balance of the program achieved a combined energy realization rate of 93% which is comparable to the 2011 program.

The biggest contributor to the decrease in the gas savings realization rate from the previous year was one measure which accounted for a large portion of the gas savings in the sample for the custom category. During the evaluation site visit, the facility staff reported that measure was not able to operate as intended due to a discrepancy between the building loads and equipment sizing. It was non-functional and the facility staff are looking at system modifications in the future to address the issue. Without this one measure the program level realization rate would have been 90%.

Overall, the 2012 program implementer performed a reasonable level of review and quality control. The measure types with lower evaluated savings represented large, complex measures whose final operating patterns can be difficult to predict, particularly in a new construction application. The implementer has continually worked to streamline and improve the program's delivery mechanisms.

Cadmus identified several areas for program improvements. The most significant would involve changes in simulation model energy savings tracking and reporting methods. There are also steps the implementer could take to obtain a better sense of appropriate measure installations and to encourage participants to collect data useful for ongoing commissioning and future evaluation efforts. The following recommendations reflect potential improvements. Several of these build upon the recommendations from the 2011 program and Cadmus recognizes that the implementer has made improvements based on previous recommendations.

Consider a Ramp up Period for Savings

As with many new building programs, program participants can have difficulty predicting the loads of a new facility. For example, the one data center site that was included in the 2012 evaluation has not been operating at the predicted loads, so the evaluated energy savings were substantially less than the reported energy savings.

A related item is the situation where central plant projects are completed in advance of the buildings that they are designed to serve. This can create a lag between when savings are reported and actually generated. This occurred for one site in the 2011 sample and occurred again in the 2012 sample for a hospital project. For the hospital project, the largest gas measure, which accounted for approximately 24% of the gas savings was determined to be non-functional because the system loads did not match the equipment capacities when the plant and building were connected and put into operation (equipment was too large to operate as designed at the existing loads).

Cadmus recommends that Energy Trust consider including a ramp up period prior to reporting the full expected savings for projects at the data center projects and central plants when savings are dependent on future loads.

Consider Commissioning Completion as a Program Requirement

Cadmus selected several sites in the original sample that were still being commissioned by project teams, even though the measures were installed and incentives paid in the 2012 program year. Several of these sites reported that they were still working on getting the systems to perform as designed. Although payment of incentives will likely continue to occur at the time of project completion, it may be appropriate to hold off claiming any savings from a project until the systems commissioning process has been finished. Energy Trust may also consider withholding part of the payment until the commissioning process is complete.

Cadmus recommends that Energy Trust consider incorporating the commissioning process completion into its official project milestones.

Obtain Energy Simulation Models during Program Year

Cadmus used DOE-2 and Trane TRACE software to evaluate energy simulation models for LEED Track buildings and a subset of Custom Track projects. As part of the 2011 program evaluation, Cadmus had recommended the implementer obtain energy simulation models for review during the program year or require that building simulation model developers sign a consent form releasing models for evaluation purposes. The implementer indicated it would require simulation models to be submitted starting with the 2012 program year. Although Cadmus found an improvement in the availability of modeling files when compared to the 2011 evaluation; we still found project files with incorrect versions of the energy model files. Cadmus relied on PECI's support to search through their archives again to identify the correct modeling files on several of the projects. In other cases, Cadmus contacted design teams and building simulation model contractors for the appropriate models used to calculate savings and they were generally helpful and willing to provide the correct information. Overall, this required the Cadmus team to spend a substantial amount of time reviewing model files to confirm the correct versions were obtained.

Cadmus recommends PECI continue to work with project teams to obtain final versions of energy simulation model files during the program year.

Maintain Consistent Documentation on Simulation Model Files

Cadmus found the project documentation for simulation projects was inconsistent from one project to the next, which made it difficult to determine the appropriate savings and relevant material to support energy savings. The basis for the final incentive, supporting documentation, final incentive amount, and simulation models should be categorized consistently, and clearly labeled, across all projects.

Cadmus also recommends the implementer list any changes made to the simulation models and document the reasons for those changes.

Ensure Simulation Models Match Approved Savings

Specifically for projects utilizing the LEED track, many project files included simulation models that did not match LEED Energy and Atmosphere Credit 1 (EAc1) forms or the final approved building performance. The models should be clearly labeled with the exact information they support.

We recommend the implementer verify that the models match the energy consumption output on a gross savings level at the time they are submitted. Final model files should be provided that reflect any revisions to the LEED EAc1 documentation that are made during the final LEED review process. A narrative listing the model files would also be helpful to all parties. One way to ensure accuracy in the models is to request simulation output reports (BEPS, BEPU, ESD) in PDF format, along with corresponding final models with consistent naming convention such that the output reports can be tracked to the corresponding modeling file. Further, verifying that the values reported in simulation output report are identical to the values reported in the program calculator will significantly reduce the time it takes to track the accurate model.

Encourage Participants to Enable Energy Management System Trends

Cadmus has found that, in general, new construction facilities have energy management systems. In most cases the sites evaluated for this program year had enabled trend tracking on major equipment and controls systems. Such data were critical to our evaluation effort and can also provide important information for the participants about how their facilities are operating. In a couple of cases, tracking was not enabled, although the participant was willing to enable tracking at our request. The resulting data were limited but sufficient to make necessary adjustments to simulation models or calculation spreadsheets.

We believe it would be helpful for participants and future evaluation efforts for the program to continue encouraging participants to enable EMS trends during the commissioning process.

Develop Lower Limits for Area on Market Solutions Projects

Cadmus found one (of two) Market Solutions projects we evaluated was likely not appropriate for the program, based on area and space type. The reported area was 1,618 square feet, compared with the deemed savings model average of 20,000 square feet. The relatively small area resulted in much smaller HVAC consumption (and therefore savings) than estimated from the deemed savings simulation models. Instead of an office, the location was a restaurant event space with a small office in a separate room.

We recommend the implementer consider setting a lower limit for Market Solutions project area. In this case, a lower limit of 5,000 square feet may be appropriate for offices to ensure closer agreement with deemed savings estimates.

Improve Feedback Mechanism between Implementer Audit Findings and Reported Savings

During verification site visits, Cadmus found several projects with significant discrepancies from reported values, or other issues with equipment performance. In two of those cases, the program documentation showed the implementer had conducted their own post-installation site visit. On one custom refrigeration project, the implementer’s notes show their staff identified a discrepancy between reported and verified values, but this discrepancy was not resolved for the reported savings or incentive provided to the participant. In another case, during a site visit, the implementer’s staff should have noted that a Market Solutions project was a restaurant event space instead of an office, a heat pump water heater was installed in a conditioned space, and this water heater was likely over-sized for the required load (a hand sink). These on-site observations were not reflected in the final savings or incentive payments for the project.

We recommend the implementer examine their mechanism for translating post-installation audit findings into revisions to the reported savings and incentive values.

Engage Data Center Facilities in the Evaluation Process

The original sample for the 2011 and 2012 program years included a large portion of savings that were associated with data centers. In both program years, the largest of the data centers was eventually removed from the evaluation sample. Data centers are secure facilities and many owners are reluctant to share data center performance data. Additionally, the sites are high profile projects that receive scrutiny from Energy Trust at a variety of levels, so the program participants can experience evaluation "fatigue" when they are approached multiple times with data requests. Although this is a legitimate concern, when the data center sites represent such a large portion of the program savings, it is important to include them in the evaluation process. It is anticipated that the data center market will continue to grow along with energy efficiency potential. The lessons learned from the current projects can help to shape future programs.

Cadmus recommends that the implementer start informing the data center program participants about the evaluation activities, data needs and timelines early in the project delivery process to allow them to prepare to support the evaluation process.

Appendix A. Measure Type Mapping

The program tracking database contained 1,211 individual measures, based on the count of measure ID. Program administrators assigned each of these measures one of 39 entity codes ("ENTITYCODE") (and a corresponding description of the code, "entitydesc"). For the evaluation, these entity codes were grouped into 14 measure categories to make the analysis results more easily discernible. We further grouped the measure categories into five program tracks. The measure category mapping to entity codes is shown in Table 21.

Table 21. Measure Type Mapping

Evaluation Track	Evaluation Measure Category	Program Entity Description ("ENTITYCODE")
Standard	Food Service	Controls
Standard	Food Service	Food equipment
Standard	Food Service	Freezer
Standard	Food Service	Icemaker
Standard	Food Service	Lighting
Standard	Food Service	Lighting controls
Standard	Food Service	Motors
Standard	Food Service	Night covers
Standard	Food Service	Refrigerator
Standard	HVAC	Boiler
Standard	HVAC	DCV
Standard	HVAC	Dishwasher
Standard	HVAC	Economizer
Standard	HVAC	Gas furnace
Standard	HVAC	Gas unit heater
Standard	HVAC	Heat pump
Standard	HVAC	HVAC
Standard	HVAC	Other measure
Standard	HVAC	Radiant heating
Standard	HVAC	Ventilation
Standard	Lighting	Lighting
Standard	Lighting	Lighting controls
Standard	Motors	Motors
Standard	Other	Clothes washer
Standard	Water Heating	Domestic hot water measures
Standard	Water Heating	Faucet aerator

Evaluation Track	Evaluation Measure Category	Program Entity Description (“ENTITYCODE”)
Standard	Water Heating	Showerhead
Standard	Water Heating	Tanked water heater
Standard	Water Heating	Tankless water heater
Custom	HVAC	Custom controls
Custom	HVAC	Custom gas measure
Custom	HVAC	Custom HVAC
Custom	HVAC	Custom insulation
Custom	HVAC	Custom windows
Custom	HVAC	Motors
Custom	Lighting	Custom lighting control
Custom	Other	Custom motor
Custom	Other	Custom other measure
Custom	Other	Custom VFD
Custom	Other	Other measure
Custom	Refrigeration	Custom refrigerator
Data Center	HVAC	Custom HVAC
Data Center	Lighting	Custom lighting
LEED	LEED	LEED
Market Solutions	Food Service	Food equipment
Market Solutions	Food Service	Icemaker
Market Solutions	Food Service	Refrigerator
Market Solutions	HVAC	Other measure
Market Solutions	Lighting	Lighting
Market Solutions	Water Heating	Tanked water heater

Appendix B. Comparison Energy Use Intensity Data

EUI data for the FY 2012 sample, shown in Table 20, can be compared with other available data to determine the relative performance of new construction projects. The following tables provide two example data sets.

Table 22. PGE Data for Post-1985 Buildings

Building Type	Bldg. w/Elec Heat (kBtu/sf)	Bldg. w/Fossil Fuel Heat (kBtu/sf)
Auditoriums	77.1	93.7
Banks	56.1	62.9
Churches	45.3	56.2
Colleges	78.3	89.8
Department Stores	58.0	61.2
Dormitories	55.0	72.0
Elementary School	35.5	43.2
Fast Food Restaurant	527.8	587.8
Full Service Restaurant	111.8	116.6
General Office	73.2	85.3
High Rise Apartment	55.6	66.0
High Rise Office Building	65.6	73.7
High Schools	60.1	73.1
Hospitals	184.0	230.4
Hotels	78.2	88.3
Low Rise Apartment	48.7	58.4
Medical Clinic	71.4	77.3
Middle Schools	45.8	55.8
Motels	51.6	65.3
Strip Malls	67.4	72.3
Supermarkets	196.1	198.7
Warehouse	28.1	32.1

Source: Energy Trust FY2009 program savings calculation spreadsheet: “2005398 01 18 2009 River East Center Form 520L 540L Final.xls”

Table 23. Ecotope Mean EUI Data for Buildings with Majority New Construction in Oregon, 2002–2004

Building Type	Mean EUI (kBtu/sf)
Assembly	76.3
College	65.9
Education	48.5
Grocery	202.8
Health Services	91.8
Hospital	123.1
Institution	102.8
Office	81.9
Other	96.3
Residential / Lodging	58.5
Restaurant / Bar	512.7
Retail	76.8
Warehouse	31.8

Source: Ecotope: "Baseline Energy Use Index of the 2002-2004 Nonresidential Sector: Idaho, Montana, Oregon, and Washington," Table A-11, December 2009.

Table 24. NEEA Mean EUI Data by End Use for Commercial Buildings in Northwest, 2014

Building Type	Mean Electric EUI (kBtu/sf)	Mean Gas EUI (kBtu/sf)
Assembly	43.3	45.0
Food Service	156.3	215.0
Grocery	194.5	64.0
Lodging	48.8	42.0
Office	54.6	28.0
Residential Care	52.2	47.0
Retail	43.7	25.0
School	32.7	35.0
Warehouse	20.6	13.0
Other	44.0	34.0

Source: NEEA Commercial Building Stock Assessment 2014- Appendix A: Electric and Gas EUI Figure A.3.1 and Figure A.3.6.

Appendix C. 2012 New Buildings Program LEED Calibration Reports

Appendix C is provided as a separate document.