
# 2012 Existing Buildings Program Impact Evaluation

March 24, 2015

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EnergyTrust of Oregon

# MEMO

**Date:** April 9, 2015
**To:** Board of Directors
**From:** Spencer Moersfelder, Business Sector Senior Program Manager
Dan Rubado, Evaluation Project Manager
**Subject:** Staff Response to Impact Evaluation of the 2012 Existing Buildings Program

This impact evaluation of the Existing Buildings program establishes the realized energy savings for 2012, based on a sample of projects. It should be noted that these results reflect the performance of the past Program Management Contractor (PMC), Lockheed Martin, whose contract came to an end with the close of 2012. The program level realization rates for both gas and electric savings are within the range of what we've seen in past impact evaluations of this program. Electric realization rates, particularly for the lighting and standard tracks, were relatively high. Custom track projects, which are larger and more complex, had low gas and electric realization rates which reduced the overall program realization rates. Although there were a few outliers, we feel that the sample was representative of the program and that the findings are valid and defensible. As a result, these realization rates will be adopted to true-up the 2012 program results and added to the three-year rolling average used for budgeting and forecasting.

This report also describes the causes for deviations from the expected savings. There was a substantial amount of variability observed in project level savings realization, particularly in the custom track. This is not surprising, given the nature of custom projects, and is consistent with past findings. Many of the causes of lower than expected savings were unpredictable and out of the program's control, but there were cases where additional scrutiny of custom projects could have uncovered issues before the incentives were paid and savings claimed. Staff will be working with the PMC to strike the right balance between how comprehensive the post-installation verification protocol should be in relation to the relative cost of such an effort. The evaluation also recommended that the program require system commissioning for large and complex custom projects. This has been recommended in the past and the program does sometimes include the cost of commissioning to calculate incentives and evaluate the cost-effectiveness of custom measures such as direct digital controls (DDC). However, the program will not pay for commissioning for all measures because of the high expense relative to its value to the program. Nor will the program require that the customer pay for commissioning because it would present a potentially large barrier to participation.

There are also a few standard track measures where the evaluation findings call in to question the savings assumptions that Energy Trust used. The report provides a number of process improvement recommendations to address some of the observed issues. Some of the recommended changes have already been implemented by the PMC or are pending implementation. Other recommendations are being considered, but are potentially expensive to implement. Energy Trust is working with the PMC to determine which changes are feasible and cost-effective.

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# Executive Summary

Energy Trust of Oregon (Energy Trust) retained Cadmus to complete an impact evaluation of the 2012 Existing Buildings program, a comprehensive effort to assist owners of existing commercial buildings in achieving energy savings by offering incentives for different types of measures. These measures fall into three program tracks—standard, custom, and lighting—which are described below:

- The standard track supports prescriptive equipment measures in categories such as HVAC, appliances, refrigeration, insulation, domestic hot water, and computer/data. Savings for these projects were estimated using deemed savings or simplified calculation workbooks.
- The custom track provides incentives for measures that are more comprehensive or interactive than prescriptive measures. They also usually involve more complex energy savings analysis than prescriptive measures.
- The lighting track provides incentives for lighting measures. Lighting measures are also included in standard and custom tracks, but for the evaluation process, Cadmus included all lighting measures in a separate lighting track.

This evaluation did not include projects in the 2012 Existing Buildings program that were performed under the Rooftop Unit (RTU) Tune-up Initiative, the Building Performance Tracking and Control Systems (BPTaC) Pilot, the Cool Schools Pilot, and the Comprehensive Lighting Pilot.

A third-party program management contractor (PMC), Lockheed Martin, implemented the 2012 Existing Buildings program.

Specifically, Cadmus evaluated 202 measures that participants installed at 74 sampled sites. As shown in Table 1, the final sample represented 23% of the program's total reported electric energy savings and 54% of the program's total reported gas savings.

The sample included 11 of the sites with the largest savings and a random sample of 63 smaller sites. When developing the evaluation plan, Energy Trust and Cadmus agreed to limit the amount of effort spent on lighting measures. The results of past evaluations of lighting measures have consistently shown high realization rates. Out of the 63 randomly sampled sites, 10 included lighting projects. The largest 11 sites did not include lighting projects.

Table 1. 2012 Program and Sample Totals

| Group | Total Projects* | Total Measures** | Reported Savings | |
|---|---|---|---|---|
| | | | Electricity (kWh) | Gas (therms) |
| Program Total | 2,756 | 8,072 | 91,319,647 | 1,498,629 |
| Sample Total | 74 | 202 | 20,868,215 | 801,844 |
| Portion of Total Sampled | 3% | 3% | 23% | 54% |

*Number of unique combined project ID and site ID.
**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 data to support our engineering analysis. We evaluated the standard and lighting 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. For the sites with the largest reported savings, we performed utility billing analysis. For some of the custom projects originally analyzed with energy simulation models, Cadmus engineers analyzed the differences between baseline and as-built simulation models. Through this impact evaluation, we identified a variety of factors that reduced 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 | 1,103 | 8,139,347 | 376,389 | 7,771,477 | 442,410 | 95% | 118% |
| Custom | 279 | 33,055,968 | 1,122,240 | 27,626,115 | 732,265 | 84% | 66% |
| Lighting | 6,690 | 50,124,332 | - | 51,513,055 | - | 103% | - |
| **Total Program** | **8,072** | **91,319,647** | **1,498,629** | **86,910,648** | **1,174,676** | **95%** | **79%** |

*Number of unique measure IDs.

For comparison of the program over time, the evaluation results for the Existing Buildings program from 2008 through 2012 are presented in Table 3. The number of sites, electricity savings, and gas savings had

all increased each year from 2008 to 2011. For 2012, all three decreased from the 2011 levels. The 2012 electricity realization rate has increased from the 2011 program year, however the gas realization rate has decreased.

**Table 3. Evaluated Savings by Program Year 2008-2012**

| Program Year | Sites | Reported Savings | | Evaluated Savings | | Realization Rate | |
|---|---|---|---|---|---|---|---|
| | | Electricity (kWh) | Gas (therms) | Electricity (kWh) | Gas (therms) | Electricity Savings | Gas Savings |
| 2008 | 1,170 | 42,105,793 | 862,294 | 41,887,080 | 746,564 | 99% | 87% |
| 2009 | 1,590 | 74,426,951 | 941,618 | 63,537,310 | 705,644 | 85% | 75% |
| 2010 | 2,544 | 85,813,714 | 1,729,547 | 91,884,445 | 1,486,729 | 107% | 86% |
| 2011 | 3,778 | 108,759,845 | 2,118,681 | 98,776,194 | 2,148,020 | 91% | 101% |
| 2012* | 2,543 | 91,319,647 | 1,488,443 | 86,910,648 | 1,174,676 | 95% | 79% |
| | | | | | Average | 95% | 86% |

*Excludes RTU Tune-up Initiative, BPTaC Pilot, Cool Schools Pilot, and the Comprehensive Lighting Pilot.

For program year 2012, most measure types in the standard track achieved high realization rates, with the exception of server virtualization and computer management measures. There was also a very large standard track pipe insulation measure at one site with a low realization rate. The lighting track achieved high realization rates.

The primary reduction to overall program energy savings resulted from adjustments to energy savings for custom track projects. The following are issues from specific projects that were primary factors that lowered the overall realization rate:

- The systems at several sites were not functioning as designed in the energy efficiency measures and the facility staff were still working to commission them. These were primarily HVAC systems and controls measures in the custom track.
- Building simulation models for several sites did not accurately reflect as-built conditions or operating parameters. When Cadmus engineers updated the models with observed conditions and calibrated them to actual utility data, the evaluated savings were less than reported savings.
- Evaluated equipment and system operation differed from the expected patterns used to develop savings estimates. This was usually due to differences in the operating setpoints, operating conditions, or the operating hours.
- Observed equipment quantities differed from reported quantities.
- For sites with multiple measures, the interaction between the measures was not accounted for in the energy savings analysis, thus savings were being over-estimated.
- Systems were decommissioned and no longer in service.

The measure types with lower evaluated savings represented large, complex measures, primarily under the custom track. We also found a large amount of variability in the measure level savings, with measures at some sites achieving substantially higher savings than predicted and others achieving substantially less. The variability in the savings is an indication that there is an opportunity for improvement in implementer quality control on the custom projects.

We also observed that Energy Trust implemented several of the recommendations made during earlier evaluations. In general, we found continued improvement in the project documentation that Energy Trust provided to the evaluation team. We received more complete calculation documentation and more of the energy model files than in past program years.

## Introduction

Energy Trust of Oregon (Energy Trust) retained Cadmus to complete an impact evaluation of the 2012 Existing Buildings Program, a comprehensive effort to assist owners of existing commercial buildings in achieving energy savings by offering incentives for different types of measures. These measures fall into three program tracks—standard, custom, and lighting—which are described below:

- The standard track supports prescriptive equipment measures in categories such as HVAC, appliances, refrigeration, insulation, domestic hot water, and computer/data. Savings for these projects were estimated using deemed savings or simplified calculation workbooks.
- The custom track provides incentives for measures that are more comprehensive or interactive than prescriptive measures. They also usually involve more complex energy savings analysis than prescriptive measures.
- The lighting track provides incentives for lighting measures. Lighting measures are also included in standard and custom tracks, but for the evaluation process, Cadmus included all of the program lighting measures in the lighting track.

A third-party program management contractor (PMC), Lockheed Martin, implemented the 2012 Existing Buildings program. During the 2012 program year, 8,072 measures received incentives through the standard, custom, and lighting tracks.

Table 4 through Table 7 show the total numbers of measures and first-year reported energy savings for each track for the 2012 program year. We further divided the standard and custom tracks into measure categories based on measure types.

**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 Appliance | 11 | 6,292 | 2,283 |
| Standard HVAC | 245 | 1,009,236 | 182,406 |
| Standard Insulation | 97 | 714,645 | 51,210 |
| Standard Kitchen | 498 | 876,645 | 117,349 |
| Standard Refrigeration | 130 | 2,557,016 | - |
| Standard Water | 51 | 38,347 | 23,141 |
| Standard Virtualization/IT | 71 | 2,937,166 | - |
| **Standard Track Total** | **1,103** | **8,139,347** | **376,389** |

*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 Controls | 70 | 15,493,920 | 455,285 |
| Custom HVAC | 127 | 15,879,264 | 609,633 |
| Custom Other | 82 | 1,682,784 | 57,322 |
| **Custom Track Total** | **279** | **33,055,968** | **1,122,240** |

*Number of unique measure IDs.

Table 6. 2012 Lighting Track Total Measures and Reported Savings

| Measure Category | Total Number of Measures* | Total Electricity Savings (kWh) | Total Gas Savings (therms) |
|---|---|---|---|
| Lighting | 6,690 | 50,124,332 | - |

*Number of unique measure IDs.

Table 7. 2012 Total Program Measures and Reported Savings

| Measure Category | Total Number of Measures* | Total Electricity Savings (kWh) | Total Gas Savings (therms) |
|---|---|---|---|
| Total 2012 Program | 8,072 | 91,319,647 | 1,498,629 |

*Number of unique measure IDs.

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

We 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. We then extrapolated the results from the sample to the total population.

## *Sampling Methodology*

This evaluation did not include projects in the 2012 Existing Buildings program that were performed under the RTU Tune-up Initiative, the Building Performance Tracking and Control Systems (BPTaC) Pilot, the Cool Schools Pilot, and the Comprehensive Lighting Pilot. For the remaining projects in the 2012 Existing Building program, Cadmus undertook the following steps in designing the sampling approach:

1. ***Described the program structure and confidence and precision requirements.*** We designed the sample to meet a 90% confidence level with 10% precision at the program level and within two measure categories of particular interest to Energy Trust: Custom HVAC and Custom Controls. These measure categories were of interest because they represented a large portion of the program savings—approximately 75% of gas savings and 36% of electric savings—and custom measures historically have the potential for a lot of variability.
2. ***Identified the primary sampling unit***. Cadmus reviewed the measure data and determined that the appropriate sampling unit for the evaluation is the unique combination of site ID and project ID listed in the tracking database. The combination prevents the sampling of multiple sites within one project and sampling multiple unrelated projects at one site.
3. ***Identified basic sampling and analysis domains.*** To produce accurate savings and realization rate estimates, we used both stratified sampling and certainty (census) sampling within strata in order to achieve the goals of this evaluation. Cadmus first mapped all completed measures to the three program tracks: standard, custom, and lighting. We further divided the standard and custom tracks into the following unique sampling domains:
    a. Census: large projects chosen for evaluation due to their size.
    b. Electric & Gas (E&G): projects expected to produce both electricity and gas savings.

c. Gas Only: projects expected to produce only gas savings.

d. Electric Only: projects expected to produce only electric savings.

These unique domains helped to ensure we evaluated the largest projects, chose a sample from similar projects, and included a reasonable number of gas and electric savings projects in the sample. The lighting track was not divided into sampling domains. The lighting sample was pulled from the total population.

4. ***Determined appropriate stratification.*** We determined the final stratification for this sample based on the research interests of Energy Trust and the measures installed through the program. In general, we split each sampling domain into large and small strata. The large stratum contains a smaller number of projects with the largest amount of savings within the domain. The small stratum contains the remaining projects. Actual division of projects into the large and small strata was based on the distribution of savings within the sampling domain. Instead of large and small strata, we divided the standard gas-only sampling domain into three strata: large boiler, boiler, and other gas. This stratification matches the measures installed and expected savings within this domain. The custom gas-only sampling domain was not further stratified due to the small number of projects within this domain.

   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.

5. ***Determined 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.

6. ***Additional adjustments to the sample.*** Cadmus worked with Energy Trust and the program team to review and identify any sites in the sample that were known to have barriers preventing successful inclusion in the evaluation activities. Examples of barriers 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. As a result of this review, Cadmus did not make any significant changes to the sample.

Table 8 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 8. 2012 Reported Program Evaluation Sample Details

| Group | Total Projects | Total Number of Measures | Reported Electricity Savings (kWh) | Reported Gas Savings (therms) |
|---|---|---|---|---|
| Program Total | 2,756 | 8,072 | 91,319,647 | 1,498,629 |
| Sample Total | 74 | 202 | 20,868,215 | 801,844 |
| Sample Portion of Program Total | 3% | 3% | 23% | 54% |

As shown in Table 9, the final evaluation sample represented a cross-section of major measure categories and types, with custom track measures representing the majority of energy savings. This reflects Energy Trust's request to focus the evaluation on the Custom HVAC and Custom Controls measures.

Table 9. Sample Reported Energy Savings by Measure Category

| Measure Category | Total Number of Measures | Reported Electricity Savings (kWh) | Reported Gas Savings (therms) |
|---|---|---|---|
| Standard HVAC | 19 | - | 97,293 |
| Standard Insulation | 5 | 213,944 | 15,495 |
| Standard Kitchen | 11 | 10,864 | 2,706 |
| Standard Water | 6 | 742 | 9,142 |
| Standard Virtualization/IT | 6 | 1,340,415 | - |
| Custom Controls | 19 | 8,035,190 | 302,982 |
| Custom HVAC | 36 | 9,387,676 | 367,901 |
| Custom Other | 12 | 273,173 | 6,325 |
| Lighting | 88 | 1,606,211 | - |
| **Total 2012 Sample** | **202** | **20,868,215** | **801,844** |

Cadmus calculated the sampling precision to determine whether it was acceptable, based on standard statistical levels of rigor, to estimate the overall program population energy savings from the sample energy savings.[1] The target was a 90/10 level for the program level and for the Custom HVAC and Custom Controls categories. We designed the original sample based on our experience with commercial programs and the variance observed in past studies.

[1] The confidence level and interval determine precision. Values for total program, for example, indicate Cadmus can be 90% certain, based on sampling error, the population value falls within ± 13% of the population estimated value.

For each of the three targets, Cadmus determined the confidence interval (precision) for a 90% confidence level and found the overall sample did not meet a 90/10 level, as shown in Table 10. We also have presented the confidence interval for a 90% confidence level for the standard and lighting tracks. Ultimately, our sample results contained more variance than our sample design anticipated, causing the program-level and targeted measure category relative precision to be less precise than the target.

**Table 10. 2012 Sample Precision**

| Track / Category | Confidence / Precision Target Level | Confidence Level | Relative Precision (kWh) | Relative Precision (therms) |
|---|---|---|---|---|
| Standard Track | N/A | 90% | 22% | 24% |
| Custom Track | N/A | 90% | 12% | 16% |
| Custom HVAC Category | 90/10 | 90% | 21% | 17% |
| Custom Controls Category | 90/10 | 90% | 19% | 28% |
| Lighting Track | N/A | 90% | 23% | - |
| **Program Total** | **90/10** | **90%** | **13%** | **13%** |

For comparison purposes, Table 11 shows distributions of measure savings in the overall program and sample population. The proportion of standard track project savings is consistent between the sample and the overall program; however, the sample included less lighting track savings and a larger proportion of the more complex custom 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 more energy and Energy Trust's desired focus areas.

**Table 11. Total and Sample Portions of Energy Reported Savings**

| Measure Category | Population Measure Energy Savings (MMBtu) | Portion of Program Population Measure Savings | Sample Measure Energy Savings (MMBtu) | Portion of Sample Measure Savings |
|---|---|---|---|---|
| Standard | 65,410 | 14% | 17,807 | 12% |
| Custom | 225,011 | 49% | 128,100 | 84% |
| Lighting | 171,024 | 37% | 5,480 | 4% |
| **Total** | **461,446** | **100%** | **151,387** | **100%** |

As shown in Table 12, the evaluation sample and program population represented a mix of building types, which is similar to the 2010-2011 program cycle. The most frequently evaluated building types in 2012 were offices, hospitals, and institutions/government. The sample distribution of building types roughly matched the program population, with a few exceptions. Offices, hospitals, and institutions/government facility types were oversampled, and auto services, grocery, retail, and warehouse facility types were under sampled.

Table 12. Building Types Represented in Evaluation Sample and Population

| Building Type | Sample Measure Quantity* | Portion of Total Sample (MMBtu basis) | Population Measure Quantity* | Portion of Total Population (MMBtu basis) |
|---|---|---|---|---|
| Assembly | 60 | 3.4% | 249 | 3.5% |
| Auto Services | 3 | 0.7% | 601 | 4.8% |
| College/University | 7 | 3.2% | 327 | 3.7% |
| Data Center | 2 | 0.4% | 11 | 0.8% |
| Funeral/Cremation | 0 | 0.0% | 1 | 0.1% |
| Grocery | 3 | 0.1% | 663 | 6.3% |
| Gym/Athletic Club | 0 | 0.0% | 88 | 1.3% |
| Hospital | 10 | 27.2% | 88 | 11.4% |
| Infrastructure | 2 | 0.7% | 14 | 0.3% |
| Institution/Government | 3 | 14.2% | 5 | 4.7% |
| Laundry/Dry Cleaners | 0 | 0.0% | 46 | 0.4% |
| Lodging/Hotel/Motel | 8 | 3.9% | 225 | 6.7% |
| Manufacturing | 5 | 0.0% | 10 | 0.1% |
| Multifamily Residential | 0 | 0.0% | 1 | 0.0% |
| NULL | 0 | 0.0% | 5 | 0.0% |
| Office | 41 | 32.5% | 1,331 | 22.7% |
| Other | 5 | 3.9% | 653 | 4.6% |
| Other Health | 4 | 1.2% | 118 | 1.6% |
| Other Residential | 0 | 0.0% | 13 | 0.1% |
| Parking structure/Garage | 2 | 0.5% | 23 | 0.4% |
| Religious/Spiritual | 0 | 0.0% | 514 | 1.9% |
| Restaurant | 16 | 0.5% | 624 | 3.6% |
| Retail | 8 | 1.5% | 1,377 | 10.9% |
| Retirement/Assisted Facilities | 1 | 0.0% | 9 | 0.1% |
| Schools K-12 | 14 | 4.4% | 243 | 3.9% |
| Warehouse | 8 | 1.6% | 833 | 6.2% |
| **Total** | **202** | **100%** | **8,072** | **100%** |

*Quantities are based on the number of unique measure IDs.

## Data Collection

Cadmus reviewed the available documentation (e.g., 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 some of the custom track projects, Cadmus calibrated the energy models developed by the project teams to analyze actual 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. We applied full savings for several of the standard categories that were not included in the sample, such as appliances and refrigeration. 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 project files. Although Cadmus observed an improvement in the quality of the documentation provided when compared to previous years, in several cases Cadmus could not identify calculation spreadsheets or relevant data for measure savings calculations. We determined that the utility data for several sites was incomplete. When we identified documentation and utility data issues, we typically contacted Energy Trust program staff for assistance in obtaining additional project data. In some cases, we contacted the participant or relevant contractor to obtain and update original calculation workbooks, based on site visit data, utility billing information, or other sources. In most cases, we were able to obtain the required data.

Cadmus also experienced difficulty obtaining energy simulation models for several custom track projects. For some projects, the documentation provided by Energy Trust included scanned copies of model inputs and outputs, but not the actual model files. Cadmus successfully worked with Energy Trust or project teams to obtain the final versions of the modeling files.

We reviewed information for all sample sites, 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 the following materials and data:
  - Descriptions
  - Schematics
  - Performance data
  - Other supporting information
- Critical information concerning savings calculation methodologies:
  - The methodologies used

- Specification assumptions and the sources for these specifications
- The accuracy of calculations

For custom track sites where an energy simulation model or whole-building analysis was to be used for the evaluation analysis, we also reviewed utility billing data provided by Energy Trust. If the program documentation included a report with a utility data summary, we would double check the historical data against the project documentation. For several projects we determined that utility data were incomplete and we worked with Energy Trust to obtain the required data.

### 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, Cadmus 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 were 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 sample included these major measure groups:

- Standard HVAC
- Standard Insulation
- Standard Kitchen
- Standard Water
- Standard Virtualization/IT
- Custom Controls
- Custom HVAC
- Custom Other
- Lighting

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.

### Standard HVAC Measures

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. For several measures we also checked the reported savings by conducting utility bill analysis.

### Standard Insulation Measures

For sites with standard insulation measures, Cadmus focused on verifying that the installation matched the program documentation.

### Standard Kitchen Measures

This category includes a variety of measures, including high-efficiency food service appliances, such as dishwashers, refrigerators, and cooking equipment. Cadmus verified equipment counts and confirmed that these units met program efficiency requirements.

### Standard Water Measures

The standard water category includes measures focused on saving energy associated with domestic hot water, including condensing tank water heaters and aerators. Cadmus verified equipment counts and confirmed that these units met program efficiency requirements.

### Standard Virtualization/IT Measures

Cadmus developed this category for measures related to server virtualization and computer power management. Field engineers conducted interviews with IT personnel at the sites to determine if the measures were implemented and to collect performance data.

### Custom Measures

Custom track projects included a range of measures, including building controls upgrades, chiller system upgrades, boiler system upgrades, and other HVAC upgrades that fell outside of the standard track. The diversity of projects required a variety of calculation methods to estimate energy savings, primarily calculation spreadsheets and building simulation modeling. We also performed utility billing analysis for several sites where participants implemented comprehensive whole-building upgrades.

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. We adjusted our calculations and simulation models to reflect the as-built parameters, which we confirmed through site visits and interviews with facility operations staff.

## Custom Track Simulation Models

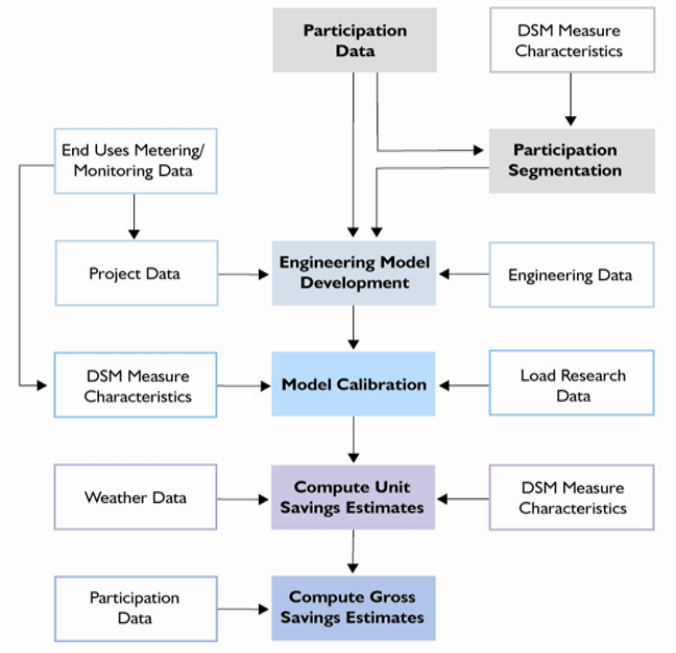
For the 2012 program impact evaluation sample, several of the custom track projects reported savings calculated using building energy simulation models. Where models were available, Cadmus used a measurement-based calibrated engineering method (MCEM) to evaluate savings for these projects. We based this approach on *in situ* measurements and observations, calibrated the models to the best available energy use indices, such as utility billing data, and conducted the modeling with industry-accepted engineering analysis tools, such as DOE-2 or TRACE.

To perform the analysis, Cadmus focused on the following activities:

- Quantifying as-built construction characteristics, energy systems operational characteristics, and energy-efficient measure characteristics (such as quantities, capacities, and efficiencies) and calibrating models to the best available consumption indices (including billing records). We used the original energy models provided with the program documentation and created by the project teams.
- Reviewing energy-efficient measure assumptions and performance variables for each building to revise the inputs for the calibrated, as-built model. We then created the baseline model by removing the energy-efficient measures in the simulation.
- 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 project.

Figure 1 depicts the MCEM approach.

**Figure 1. Measurement-Based Calibrated Engineering Method Flowchart**



### *Model Calibration*

Cadmus obtained models for several projects in the final sample; these models were based on the following characteristics:

- 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

To calibrate the models, we first checked the model files against the project file documentation. Some of the project documentation included hard copies of the model outputs instead of the electronic model files. If there was a discrepancy in the documentations, 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.

We calibrated the models primarily to annual electricity and gas consumption, and we reviewed monthly variation for discrepancies. We also used historical weather data for the calibration period on each project for the calibration process.

### Lighting Measures

The lighting track included two primary types of measures:

- **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 fixture retrofits and upgrades**. These measures typically involved replacing or retrofitting existing fixtures with higher efficiency lighting equipment.

Analysis of lighting measure savings required documentation on fixture wattages, quantities, and operating hours.

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 installation, functionality, and operating hours. 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 and controls were 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.

# Analysis and Findings

This section presents the results of engineering analysis as applied to the sample; this includes 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.

## *Evaluated Savings for the Sample*

Cadmus compared reported and evaluated energy savings values for the sample for each strata. The realization rates for the strata are shown in Table 13. The realization rates in the table are the initial values based on the sample and have not been weighted based on the probability of selection. The realization rates discussed in this section are the raw values (the sum of evaluated savings divided by the sum of reported savings for the measure category) and are not weighted values.

**Table 13. Sample Reported and Evaluated Savings and Realization Rates by Sampling Stratum**

| Sampling Stratum | Total Measures* | Electricity Savings | | Gas Savings | | Realization Rate** | |
|---|---|---|---|---|---|---|---|
| | | Reported (kWh) | Evaluated (kWh) | Reported (therms) | Evaluated (therms) | Electricity Savings | Gas Savings |
| Standard Census | 6 | 793,800 | 340,841 | 26,027 | 2,982 | 43% | 11% |
| Standard Electric & Gas Large | 5 | 75,576 | 75,576 | 22,605 | 22,605 | 100% | 100% |
| Standard Electric & Gas Small | 6 | 14,097 | 14,097 | 1,102 | 1,102 | 100% | 100% |
| Standard Electric Only Large | 4 | 654,743 | 426,218 | - | - | 65% | - |
| Standard Electric Only Small | 4 | 27,749 | 31,669 | - | - | 114% | - |
| Standard Gas Only Boiler Large | 10 | - | - | 58,913 | 58,913 | - | 100% |
| Standard Gas Only Boiler Small | 5 | - | - | 12,513 | 12,351 | - | 99% |
| Standard Gas Only Other | 7 | - | - | 3,476 | 5,547 | - | 100% |
| Custom Census | 21 | 11,407,917 | 6,723,181 | 517,282 | 418,441 | 59% | 81% |

| Sampling Stratum | Total Measures* | Electricity Savings | | Gas Savings | | Realization Rate** | |
|---|---|---|---|---|---|---|---|
| | | Reported (kWh) | Evaluated (kWh) | Reported (therms) | Evaluated (therms) | Electricity Savings | Gas Savings |
| Custom Electric & Gas Large | 11 | 3,141,704 | 3,518,114 | 53,456 | 5,660 | 112% | 11% |
| Custom Electric & Gas Small | 11 | 804,755 | 598,759 | 65,027 | 37,374 | 74% | 57% |
| Custom Electric Only Large | 14 | 2,200,623 | 1,810,753 | - | - | 82% | - |
| Custom Electric Only Small | 5 | 141,000 | 222,740 | - | - | 158% | - |
| Custom Gas Only | 5 | - | - | 41,443 | 32,858 | - | 79% |
| Lighting | 88 | 1,606,211 | 1,650,710 | - | - | 103% | - |

*Based on quantity of unique measure IDs.
**Realization rate not calculated for strata with zero gas savings or electric savings.

From the sample results, Cadmus also compared reported and evaluated energy savings values for the sample through measure category-level realization rates, as shown in Table 14. Cadmus adjusted electricity and gas savings for the measure-specific reasons described in the sections below. The realization rates in Table 14 are the initial values based on the sample and have not been weighted based on the probability of selection.

Table 14.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 HVAC | 19 | - | - | 97,293 | 76,308 | - | 78% |
| Standard Insulation | 5 | 213,994 | 213,944 | 15,495 | 15,495 | 100% | 100% |
| Standard Kitchen | 11 | 10,864 | 10,864 | 2,706 | 2,706 | 100% | 100% |
| Standard Water | 6 | 742 | 742 | 9,142 | 8,991 | 100% | 98% |
| Standard Virtualization/IT | 6 | 1,340,415 | 662,851 | - | - | 49% | - |
| Custom Controls | 19 | 8,035,190 | 4,924,411 | 302,982 | 149,880 | 61% | 49% |
| Custom HVAC | 36 | 9,387,676 | 7,666,253 | 367,901 | 343,737 | 82% | 93% |
| Custom Other | 12 | 273,173 | 282,885 | 6,325 | 714 | 104% | 11% |
| Lighting | 88 | 1,606,211 | 1,650,710 | - | - | 103% | - |

*Based on quantity of unique measure IDs.

**Realization rate not calculated for measures with zero gas savings or electric savings.

Although they are not used to estimate the program total savings or realization rate, we calculated building type realization rates as a tool to identify particular building types where reported and evaluated savings differed substantially. The realization rates of the sample, categorized by building type, are included in Appendix B. The building types representing the biggest impact on the realization rates were:

- Electric
  - Hospitals - 48% realization rate for sample
  - Lodging/Hotel/Motel - 59% realization rate for sample
  - Offices - 72% realization rate for sample
- Gas
  - Institutions/Government - 61% realization rate for sample
  - Schools K-12 - 66% realization rate for sample
  - Offices - 72% realization rate for sample

Restaurants (44% realization rate for sample) and Data Centers (-47% realization rate for sample) also contributed to the reduced gas realization rates, although these two building types represented a small portion of the savings.

The results of the evaluation savings analysis for the measures included in the sample are presented in the following sections.

## *Standard Program Track*

The standard program track includes the prescriptive measures for food service, motors, other, and water heating.

### Standard HVAC

Standard HVAC projects covered a range of gas measures, including high-efficiency condensing boilers, high-efficiency condensing furnaces, pipe insulation, and steam traps. The sample measures had an overall gas realization rate of 78%. For the condensing boilers and furnaces, field engineers observed mostly accurate equipment counts and nameplate data. The steam trap measures achieved a high realization rate based on Cadmus' calculations of savings. The overall realization rate was reduced by pipe insulation measures at one site, a school, which had significantly overestimated savings. Using the deemed savings approach, the project team predicted that 40% of the total building gas consumption would be reduced by installing pipe insulation. This is an unreasonable expectation for this type of measure. Cadmus used utility billing analysis and determined the project achieved an 11% realization rate, saving only 4.5% of the total building gas consumption. This is the range of savings we would expect from installing pipe insulation.

This was the only site in the sample with pipe insulation measures and one of five sites in the 2012 population with pipe insulation measures. However, this site reported savings of 30,962 therms which represented 84% of the 36,718 therms savings reported for pipe insulation in the full program.

### Standard Insulation Measures

Standard insulation projects included building envelope insulation. Sampled measures include both roof and wall insulation. These measures had electric and gas realization rates of 100%. For sites with standard insulation measures, Cadmus found that the installation matched the program documentation.

### Standard Kitchen Measures

The standard food service category represented refrigeration, cooking, and kitchen appliance measures, which had a 100% overall electric realization rate and a 100% gas realization rate. Cadmus verified that equipment counts at each site matched reported values and that equipment met the program specifications.

### Standard Water Measures

The standard water heating category represented measures significantly influencing water heating loads, such as condensing tank water heaters and aerators. The electric and gas realization rates for all measures in this category were 100%. Cadmus verified that equipment counts at each site matched reported values and that equipment met the program specifications.

### Standard Virtualization/IT Measures

Cadmus developed this category for measures related to server virtualization and computer power management. The electric realization rate for these measures was 49%. This category had the largest impact on the overall standard track realization rates. Based on interviews with IT staff at the project

sites and reviews of the performance data they provided, Cadmus found a variety of differences between the reported and installed measures.

One site, a municipal entity, reported that the computer power management software was not deployed. The site had only reported 4,000 kWh savings so even though it achieved a realization rate of 0%, the overall impact was minor. At another site, a healthcare entity, the reported computer power management savings were assumed to be 200 kWh per computer and a quantity of 3,969 computers. This yielded a reported savings value of 793,800 kWh. At our request, the site IT staff provided a system report that indicated 4,767 computers were included under their power management program, but the annual savings per desktop was 71.5 kWh. The yielded an evaluated savings of 340,841 kWh for a realization rate of 43%.

Cadmus also found the server virtualization measures differed from the reported savings. Conditions at two additional server virtualization sites differed from the reported conditions as well. The deemed savings for the server virtualization measure are 2,309 kWh per server. This is based on a consolidation ratio of more than 10:1 (10 existing servers being consolidated into one virtual server). Cadmus found that the two sites each had consolidation ratios of approximately 2.9:1, so the actual savings were substantially less than the reported savings. One site, a university, had reported savings of 157,012 kWh and evaluated savings of 68,222 kWh for a realization rate of 43%. The second site, a healthcare entity, had reported savings of 240,136 kWh and evaluated savings of 107,327 kWh for a realization rate of 45%.

## *Custom Track Projects*

Custom track projects are for non-prescriptive measures with gas and electricity savings and involved building controls upgrades, chiller system upgrades, boiler system upgrades, and other HVAC upgrades that fell outside of the standard track. Overall, the custom track sample achieved a 73% realization rate for both electric and gas (unweighted).

The biggest contributor to the reduced realization rate result was the custom controls category. The projects sampled in this category had an electric realization rate of 61% and a gas realization rate of 49%. The custom HVAC category also contributed to the reduced realization rate with an electric realization rate of 82% and gas realization rate of 93%. Deviations from the reported savings occurred as a result of several factors that were observed during the evaluation site visits and documentation reviews. For an implemented custom HVAC or controls project, a reduced realization rate is generally attributed to the fact a system is not functioning according the design intent of the reported measure. We observed the following:

- Facility teams for four of the sites with comprehensive custom projects reported that the systems had not been functioning as expected and were still being commissioned.
- Setpoints and system settings at four sites did not match the assumptions used in the reported energy savings calculations.

We estimate that the conditions we observed at 11 of the 16 sites with lower realization rates in the custom track could potentially have been identified during the PMC review and verification process.

### Custom HVAC, Controls, and Other

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 followed up with Energy Trust, 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 measures represented a variety of applications, including high-efficiency HVAC technologies, building controls upgrades, and a variety of other custom measures including dryers, heat wrapping machines, coffee makers, and refrigeration. At several facilities, Cadmus used new data collected at the site to update the calculations or energy models; in most cases this resulted in reduced energy savings. Table 19 in Appendix C contains the raw results of the custom measures for each site.

Examples of findings at specific sites and measures that impacted the realization rate for the custom track are discussed in the following paragraphs. Sites are referenced to Appendix C by the site number in Table 19.

**Site 1 –Hospital, 167,674 kWh and 6,372 therms reported savings–** This site was a custom controls project. The PMC's notes show their staff confirmed that the new controls system was installed, however the main basis of the reported savings was the interconnection of the control system to existing floor isolation dampers. The air handling system in this building served all of the floors, one of which was occupied for longer hours than the other floors. Part of the new control system strategy was to implement a sequence to close the isolation dampers during unoccupied hours for most of the floors while one floor remained occupied. This would reduce the energy consumption of the air handling units. Cadmus' review at the site and conversations with the installing controls contractor confirmed that the dampers were never connected to the control system, thus the expected savings were not generated. A small amount of savings was confirmed from a duct static pressure reset sequence of operation that was installed. Overall, this site achieved an electric realization rate of 5% and gas realization rate of 0%.

**Site 2 –Hospital, 587,400 kWh and 82,819 therms reported savings–**This site involved a custom controls project that included several systems. The first part of the measure included reducing outside airflows on a 100% outside air unit from full to 80% flow. During the evaluation verification visit, the facility staff reported that they were not able to make a change to the outside airflows of the system due to the outside airflow design requirements of the spaces being served.

The second part of the measure at the site included modifications to other fan systems in the building. The savings calculations used a system without a VFD as a baseline. Upon review of documentation and discussions with the site staff, our field engineers determined that the baseline system had a VFD installed and baseline system performance should have been calculated using a system with a VFD.

Overall, the update to the savings calculations did result in some savings, but the project had a 39% electric realization rate and a 44% gas realization rate.

**Site 3 – Hospital, 727,459 kWh and 2,225 therms reported savings**–At this site, the customer's project team analyzed and reported savings for three custom HVAC and controls measures; however, the savings analysis did not account for the interaction between two of the measures. Two of the measures were actually separate options for the same piece of equipment. One measure calculated savings if an inlet guide vane was installed on an air handling unit fan and another calculated savings for installing a VFD on the same fan. The project team could have calculated savings for each option as an incremental change (i.e. option one savings are calculated from the baseline, option two savings are calculated assuming option one is installed and uses option one performance level as the option two baseline), however, both options used the existing conditions as the baseline, thus counting savings for one measure twice. The evaluated savings we adjusted to reflect that a VFD was installed on the fan, which eliminated the savings from the inlet guide measure. When this adjustment was made, the site achieved an electric realization rate of 69% and a gas realization rate of 100%.

**Site 6 – Lodging/Hotel, 1,554,200 kWh reported savings**– Cadmus found one site with multiple HVAC and custom measures installed; however, the reported savings showed each measure was analyzed separately and did not account for the interaction between measures. These measures included a installing a new DDC system, adding economizer control, and installing new high-efficiency HVAC units. After properly accounting for the interactions, Cadmus calculated a reduction in overall project savings of approximately 20%. We also observed that HVAC setpoints for supply air temperature reset control schemes differed from the reported conditions and found savings over-reported for one measure (that is, reported savings did not match the project documentation). When adjustments for all of these factors were taken into account the site achieved a realization rate of 59%.

**Site 10 – Office, 548,443 kWh reported savings**– At this site, Cadmus found several differences between the installation and operating conditions and the predicted system performance and reported upgrades. The project team installed custom HVAC and controls measures. The site had reported installing six zone-level $CO_2$ sensors, but only two were installed. Cadmus field engineers found that the installed $CO_2$ sensors were out of calibration, rendering the implemented demand control ventilation sequence of operations nonfunctional. The third measure at the site was designed to utilize fan powered terminal boxes to deliver heat from interior zones to perimeter zones, reducing the need for electric reheat. We determined that the measure was not functioning as predicted because heat recovery effectiveness was reduced based on operating conditions. The original calculations assumed a plenum air temperature of 75°F that could be used for heat recovery to offset the use of electric heat in certain zones; however, a check of plenum temperatures found the average to be 68°F, which is too low to meet the design intent

of the heat recovery sequence. When adjustments for all of these factors were taken into account the site achieved a realization rate of 30%.

**Site 12 –Office, 1,792,000 kWh reported savings–** At this large commercial office site, the customer's project team performed a custom controls project involving a whole-building control system upgrade. The facility staff reported no significant changes to occupancy levels, no space usage changes, and no other changes to the building systems from the baseline period to the time of the evaluation at this site. To calculate the evaluated savings, Cadmus performed a utility billing analysis at the building level. Overall, we found that site consumed more energy in the post-installation period than the pre-installation period (using weather normalized data). The billing analysis showed that the building consumed 338,202 more kWh per year after the energy project was completed.

We believe several factors we observed at the site may have contributed to this. The facility staff reported that the system air flows were not rebalanced as part of the project. They also noted that the system was not formally commissioned at the time of installation, and the facility team was working internally to commission the system. The site also recently enrolled in Energy Trust's Strategic Energy Management program, so the facility team is taking a closer look at building performance.

**Site 21 – College/University, 11,621 therms reported savings**–This site was a laundry facility with a solar hot water system which was included under the evaluation team's custom other category. The site staff reported to the Cadmus field engineer that the system had not been working properly, so it was decommissioned. This measure achieved a realization rate of 0%. A second measure at the site involving a preheat system for the HVAC system was found to be installed and functioning. Overall, this site achieved a realization rate of 61%.

**Site 25 –Office, 1,605,048 kWh and 13,020 therms reported savings–** At a large commercial office site that was similar to Site 12, the project team performed boiler and chiller upgrades, as well as a control systems upgrade. Cadmus performed a utility billing analysis at the building level since facility staff reported no significant changes to occupancy levels or space usage from the baseline period to the time of the evaluation. Overall, we found that site consumed more energy in the post-installation period than the pre-installation period (using weather normalized data). From the analysis, it appeared the primary issue for the total energy increase was related to the new boiler system. The original system was commissioned as part of the project; however, site facility staff reported that the system had performance issues. At the time of the evaluation visit, they were working with another commissioning provider to commission the systems again. The reported savings for the new boiler were based on the prescriptive boiler calculations, however, because the controls systems issues was creating more gas consumption, the increased efficiency of the boiler actually contributed to more gas savings. Overall, the site achieved an electric realization rate of 75% and a gas realization rate of 234%.

**Site 28 – Restaurant, 3,391 therms reported savings**– This site involved a custom HVAC project. During the evaluation site visit, Cadmus found that the kitchen ventilation system measure had been decommissioned after it was installed. The site staff reported to Cadmus that the size of the restaurant

was reduced and the HVAC system went out of balance, so the hood system was decommissioned. With the reduction of the kitchen space, less exhaust air was required. This project was determined to have a realization rate of 0%.

**Site 30 –Lodging/Hotel, 1,798 therms reported savings–** This site had installed high-efficiency gas dryers. The site had actual operating loads significantly less than those used in the reported savings. The predicted savings were based on 14 loads of laundry per day. However, during the site visits, facility staff reported they actually run seven to eight loads per day during the summer and four to five loads per day during the winter when occupancy is lower. Adjustments to these values reduced the evaluated energy savings and the site achieved a realization rate of 40%.

## *Lighting Measures*

Lighting measures included efficient interior and exterior lighting fixtures and controls such as occupancy sensors and centralized control systems. Lighting measures achieved a 103% electric realization rate compared with reported savings.

Cadmus analyzed measures based on actual wattages and operating hours, as determined through site visits and reviews of invoices and manufacturer specification sheets and generally found the reported values matched the observed installations.

Cadmus found two primary factors influencing the realization rate:

- Alterations in fixture quantities and wattages; and
- Differences in actual operating hours in the sample compared with assumptions used to develop savings estimates.

### 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. To calculate savings, we adjusted baseline and as-built fixture counts to match observed quantities.

### Sample Lighting Fixture Average Operating Hours

During the site visits, field engineers noted that the evaluated sample lighting measures sometimes operated for different periods than reported in the energy savings estimates. For lighting measures, we found several sites 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.

## Calculate Program Realization Rate

### Methodology

As described earlier, the measurement and verification process involved analyzing measures at project sites, with a sample estimated to be large enough to provide 90/10 confidence and precision for the program. Cadmus calculated the realization rates observed among measures in each stratum (e.g., custom electric and gas- large, standard electric only – small, etc.) in the sample and used these observations to estimate savings at the program (population) level. We weighted sample observations based on strata to estimate population totals.[2] 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 strata based on all sampled measures within the stratum (e.g., custom electric only), as shown in Equation 1.

**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 sample stratum realization rate, we estimated the program total evaluated savings within each strata by multiplying the realization rate for the stratum by the total reported program savings, as shown in Equation 2.

**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

[2] Cadmus used sampling weights based on the number of project-sites (a combination of the project ID and site ID in the tracking database) in each strata in the sample and in the population to estimate the population total verified savings, standard errors, and precision.

Finally, we estimated the program total evaluated savings across strata by summing the program evaluated savings from each stratum, as shown in Equation 3. We estimated the program total realization rate by dividing the population total evaluated savings estimate by the total reported savings, as shown Equation 4.

**Equation 3:**

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

**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

## Program Realization Rate Results

Table 15 shows final evaluated savings by sampling stratum and Table 16 shows track level and program level realization rates by fuel type.

**Table 15.Program-Level Electricity and Gas Savings by Sampling Stratum**

| Sampling Stratum | Electricity Savings | | Gas Savings | | Realization Rate** | |
|---|---|---|---|---|---|---|
| | Reported (kWh) | Evaluated (kWh) | Reported (therms) | Evaluated (therms) | Electricity Savings | Gas Savings |
| Standard Census | 793,800 | 340,841 | 26,027 | 2,982 | 43% | 11% |
| Standard Electric & Gas Large | 80,705 | 80,705 | 35,829 | 35,829 | 100% | 100% |
| Standard Electric & Gas Small | 251,465 | 251,465 | 39,810 | 39,810 | 100% | 100% |
| Standard Electric Only Large | 1,828,385 | 1,190,226 | - | - | 65% | - |
| Standard Electric Only Small | 5,176,916 | 5,908,240 | - | - | 114% | - |
| Standard Gas Only Boiler Large | - | - | 58,913 | 58,913 | - | 100% |
| Standard Gas Only Boiler Large | - | - | 64,910 | 64,070 | - | 99% |
| Standard Gas Only Other | - | - | 150,900 | 240,806 | - | 100% |
| Custom Census | 11,407,917 | 6,723,182 | 517,282 | 418,441 | 59% | 81% |
| Custom Electric & Gas Large | 5,755,484 | 6,445,053 | 113,845 | 12,052 | 112% | 11% |
| Custom Electric & Gas Small | 6,136,105 | 4,565,424 | 364,639 | 209,575 | 74% | 57% |
| Custom Electric Only Large | 7,291,647 | 5,999,834 | - | - | 82% | - |
| Custom Electric Only Small | 2,464,815 | 3,892,622 | - | - | 158% | - |
| Custom Gas Only | - | - | 126,474 | 92,199 | - | 79% |
| Lighting | 50,124,332 | 51,513,055 | - | - | 103% | - |

**Realization rate not calculated for measures with zero gas savings or electric savings.

Table 16. Program-Level Electricity and Gas Savings by Program Track

| Program Track | Total Measures* | Reported Savings | | Evaluated Savings | | Realization Rate** | |
|---|---|---|---|---|---|---|---|
| | | Electricity (kWh) | Gas (therms) | Electricity (kWh) | Gas (therms) | Electricity Savings | Gas Savings |
| Standard Track | 1,103 | 8,139,347 | 376,389 | 7,771,477 | 442,410 | 95% | 118% |
| Custom Track | 279 | 33,055,968 | 1,122,240 | 27,626,115 | 732,265 | 84% | 66% |
| Lighting Track | 6,690 | 50,124,332 | - | 51,513,055 | - | 103% | - |
| **Total Program** | **8,072** | **91,319,647** | **1,498,629** | **86,910,648** | **1,174,675** | **95%** | **79%** |

*Based on quantity of unique measure IDs

**Realization rate not calculated for measures with zero gas savings or electric savings.

# Conclusions and Recommendations

Cadmus conducted an impact evaluation of the 2012 Energy Trust of Oregon Existing Buildings program by analyzing energy savings for 202 measures implemented in 74 projects. The measures belonged to three different program tracks: standard, custom, and lighting. Each track included measures from a variety of subcategories.

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, these data informed prescriptive algorithms, calculation spreadsheets, and building simulation models.

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. For example, we found systems that were still being commissioned by the facility teams and were not operating according to the design intent of the measures, systems that were decommissioned and no longer in operation, installations that did not match reported measures, and operating setpoints that differed from reported conditions.

Cadmus calculated a 95% program-level electric realization rate and 79% gas realization rate. This is an increase from the 91% electric realization and a decrease 101% gas realization for the 2011 program year. Cadmus determined that the main contributors to the realization rates are:

- Custom Controls measure category had an electric realization rate of 61% and gas realization rate of 49%. (This was the biggest contributor.)
- Standard Virtualization/IT measure category had a 49% electric realization rate.
- Custom HVAC measure category had an 82% electric realization rate.
- Standard HVAC measure category had a 78% gas realization rate.

Cadmus identified several areas for program improvements. Some of these build upon the recommendations from the 2008-2009 and 2010-2011 program evaluations. Cadmus recognizes that the implementer made improvements based on previous recommendations regarding project documentation; however, we observed additional areas for improvement. 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.

## *Consider Commissioning Completion as a Program Requirement*

Cadmus selected four sites with comprehensive custom measures in the sample that were still being commissioned by facility 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 system commissioning process has been completed. 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 for custom HVAC and controls projects.

## *Consider Incorporating Facility Staff Training as a Program Requirement*

Cadmus worked with facility staff at each site during the evaluation site visits. We found that the facility teams had a range of familiarity with the measures installed at their sites. This is not unexpected, as some sites have facility staff that are more knowledgeable about their systems and more engaged in monitoring system performance than others. Also, the measures being evaluated were installed under the 2012 program year. However, we believe this indicates an area of opportunity. For custom projects, Cadmus recommends that Energy Trust add a program requirement that the customer's project team that is designing and installing the measures provide a verification checklist as a project deliverable. The checklist should outline the information required to verify that a measure is still installed and functioning. This will provide the facility staff a useful document to help track that the measures are installed and maintain persistence of measure functionality over time.

## *Maintain Consistent Documentation on Simulation Model Files*

Cadmus found the 11 projects that used energy simulation modeling had project documentation that 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. We did observe that documentation was more complete than previous program years, but there is still room for improvement.

Cadmus used energy simulation software to evaluate several custom track projects. We used the energy models created by the project teams, updating them based on field observations and calibrating the models using utility billing data. As part of the 2011 program evaluation, the evaluation team had recommended the implementer obtain electronic copies of the energy simulation models. Although Cadmus found an improvement in the availability of modeling files when compared to the 2011 evaluation, we still found project files that did not include the electronic version of the models. We had to request the files from Energy Trust or, 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 an additional amount of time reviewing model files to confirm the correct versions were provided.

Cadmus recommends the implementer continue to work with project teams to obtain energy simulation model files during the program year.

## Encourage Participants to Enable Energy Management System Trends

Cadmus has found that several of the facilities that implemented comprehensive custom measures had energy management systems. In some 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 other 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 encourage participants to enable EMS trends during the commissioning process.

## Improve Implementer Post-Installation Audit Process

During verification site visits, Cadmus found several projects with discrepancies from reported values, or other issues with equipment performance. Some of the issues are out of the control of Energy Trust and the program staff, such as operating schedules and changes to the facility. We estimate that 13 of the projects had issues that potentially could have been identified earlier in the approval process, or at least during the post-installation checks by the implementer. Examples include:

- On one custom controls project, the implementer's notes show their staff confirmed that the new controls system was installed, however the main basis of the savings reported was the interconnection of the control system to floor isolation dampers. Our review at the site and conversations with the installing controls contractor confirmed that the dampers were never connected to the control system, thus the expected savings were not generated.
- In another case, the project team analyzed and reported savings for three measures; however, the savings analysis did not account for the interaction between the three measures. Our review of the calculations showed that savings for one measure was essentially counted twice.
- For a third case, Cadmus found that the facility staff were not able to implement one measure, which involved making a change to the outside airflows of one system. Cadmus' review of documentation and discussions with the site staff also revealed that savings for one measure were calculated using the incorrect baseline.

We recommend the implementer review the post-installation audit process being applied for custom measures. The post-installation inspection process should include a check of the operating sequences as well as confirmation of the installation of the equipment. If Energy Trust implements the recommendation above that project teams should be required to submit a verification checklist for custom measures, the checklist could also be used during the post-installation check.

## Improve Server Virtualization Savings Methodology

Cadmus found a large variance between reported conditions and the actual installation during verification site visits for the virtualization measure category in the standard track. The savings for the

server virtualization measure are calculated based on a consolidation ratio of greater than or equal to 10 to 1 (ten servers consolidated to one virtualized server.) Cadmus reviewed four sites, two of which only had consolidation ratios of approximately 3 to 1, so savings were over predicted.

Cadmus recommends that the deemed savings approach be updated to allow a sliding scale based on the consolidation ratio of the servers.

## *Implement Project Savings "Sanity" Checks*

The standard HVAC measure category gas realization rate was impacted by one site that had a very low realization rate for a pipe insulation measure. Using the deemed savings approach, the project team predicted that 40% of the total building gas consumption would be reduced by installing pipe insulation. This is an unreasonable expectation for this type of measure. Cadmus used utility billing analysis and determined the project achieved an 11% realization rate, saving only 4.5% of the total building gas consumption. This is the range of savings we would expect from installing pipe insulation. Cadmus believes that a comparison of the estimated savings to the utility data for the site during the implementer's review of the project may have caught this discrepancy.

Cadmus recommends that Energy Trust implement a process requiring the project team or implementer to check the energy savings of a measure against the total energy consumption at the site when estimated savings for standard measures are above 300,000 kWh for electric or 10,000 therms.

We also recommend the deemed savings calculation for the pipe insulation measure be reviewed.

# Appendix A. Measure Type Mapping

The program tracking database contained 8,027 individual measures, based on the count of measure ID. Program administrators assigned each of these measures one of 47 entity codes ("ENTITYCODE") (and a corresponding description of the code, "entitydesc"). For the evaluation, these entity codes were grouped into 11 measure categories to make the analysis results more easily discernible. We further grouped the measure categories into three program tracks. The measure type mapping to entity codes is shown in Table 17.

**Table 17. Measure Type Mapping**

| Evaluation Track | Evaluation Measure Category | Program Entity Description |
|---|---|---|
| Standard | Appliance | Clothes washer |
| Standard | Appliance | Dishwasher |
| Standard | HVAC | Boiler |
| Standard | HVAC | Gas furnace |
| Standard | HVAC | Gas unit heater |
| Standard | HVAC | Heat pump |
| Standard | HVAC | HVAC |
| Standard | HVAC | Pipe insulation |
| Standard | HVAC | Radiant heating |
| Standard | HVAC | Steam traps |
| Standard | Insulation | Ceiling insulation |
| Standard | Insulation | Wall insulation |
| Standard | Kitchen | Food equipment |
| Standard | Kitchen | Freezer |
| Standard | Kitchen | Icemaker |
| Standard | Kitchen | Refrigerator |
| Standard | Refrigeration | Controls |
| Standard | Refrigeration | Custom controls |
| Standard | Refrigeration | Custom refrigerator |
| Standard | Refrigeration | Motors |
| Standard | Refrigeration | Night covers |
| Standard | Water | Faucet aerator |
| Standard | Water | NULL |
| Standard | Water | Showerhead |
| Standard | Water | Tanked water heater |
| Standard | Water | Tankless water heater |

| Evaluation Track | Evaluation Measure Category | Program Entity Description |
|---|---|---|
| Standard | Virtualization | Virtualization |
| Custom | Custom Controls | Custom building controls |
| Custom | Custom Controls | Custom energy management system |
| Custom | Custom HVAC | Custom boiler |
| Custom | Custom HVAC | Custom chiller |
| Custom | Custom HVAC | Custom ducts |
| Custom | Custom HVAC | Custom economizer |
| Custom | Custom HVAC | Custom gas measure |
| Custom | Custom HVAC | Custom heat recovery |
| Custom | Custom HVAC | Custom HVAC |
| Custom | Custom HVAC | Custom thermostat |
| Custom | Custom HVAC | Custom VAV |
| Custom | Custom HVAC | Custom ventilation |
| Custom | Custom HVAC | Custom VFD |
| Custom | Custom Other | Custom motor |
| Custom | Custom Other | Custom other measure |
| Lighting | Lighting | Custom de-lamping |
| Lighting | Lighting | Custom lighting |
| Lighting | Lighting | Custom lighting control |
| Lighting | Lighting | Lighting |
| Lighting | Lighting | Lighting controls |

# Appendix B. Building Type Analysis

Although they are not used to estimate the program total savings or realization rate, we calculated building type realization rates as a tool to identify particular building types where reported and evaluated savings differed substantially. Cadmus calculated realization rates for building types in the sample using the ratio between the sum of evaluated savings and the sum of reported savings across all measures at sites within each building category. Cadmus did not validate or correct the building type categories within the program database, so all information is listed as it was entered in the program database by program staff.

Table 18 shows resulting realization rates for each building type category in the sample. Building types that were in the total population but not in the sample are not listed in the table. The quantity of measures by building type in both the sample and population were presented in Table 12.

**Table 18. Building Type Realization Rates from the Sample**

| Building Type | Quantity of Sites in Sample | Reported Electricity Savings (kWh) | Evaluated Electricity Savings (kWh) | Reported Gas Savings (therms) | Evaluated Gas Savings (therms) | Electricity Savings Realization Rate | Gas Savings Realization Rate |
|---|---|---|---|---|---|---|---|
| Assembly | 3 | 393,306 | 414,263 | 38,015 | 29,201 | 105% | 77% |
| Auto Services | 1 | 321,667 | 321,667 | - | - | 100% | - |
| College/ University | 3 | 378,955 | 378,955 | 36,254 | 32,144 | 100% | 89% |
| Data Center | 2 | 123,877 | 126,716 | 1,464 | (683) | 102% | -47% |
| Grocery | 3 | 23,220 | 18,765 | - | - | 81% | - |
| Hospital | 7 | 3,823,333 | 1,823,490 | 281,853 | 230,908 | 48% | 82% |
| Infra-structure | 1 | - | - | 10,890 | 10,890 | - | 100% |
| Institution/ Government | 2 | 955,215 | 955,215 | 183,032 | 112,285 | 100% | 61% |
| Lodging/ Hotel/Motel | 4 | 1,554,242 | 924,000 | 6,478 | 5,243 | 59% | 81% |
| Manu-facturing | 1 | 3,378 | 3,378 | - | - | 100% | - |
| Office | 20 | 10,399,433 | 7,504,877 | 136,559 | 97,678 | 72% | 72% |

| Building Type | Quantity of Sites in Sample | Reported Electricity Savings (kWh) | Evaluated Electricity Savings (kWh) | Reported Gas Savings (therms) | Evaluated Gas Savings (therms) | Electricity Savings Realization Rate | Gas Savings Realization Rate |
|---|---|---|---|---|---|---|---|
| Other | 2 | 1,250,898 | 1,192,570 | 16,605 | 16,605 | 95% | 100% |
| Other Health | 3 | 463,997 | 415,575 | 2,618 | 1,920 | 90% | 73% |
| Parking structure/ Garage | 1 | 217,161 | 315,752 | - | - | 145% | - |
| Restaurant | 10 | 30,008 | 33,542 | 6,097 | 2,706 | 112% | 44% |
| Retail | 3 | 527,658 | 541,825 | 4,015 | 4,015 | 103% | 100% |
| Retirement/ Assisted Facilities | 1 | - | - | 80 | 80 | - | 100% |
| Schools K-12 | 5 | 742 | 742 | 67,076 | 44,031 | 100% | 66% |
| Warehouse | 2 | 401,125 | 441,331 | 10,808 | 10,808 | 110% | 100% |

# Appendix C. Custom Measure Sample Results

Table 19 contains the raw results of the evaluation results for the Custom HVAC and Custom Controls measures for each site that was evaluated. The table includes the measure type, building type, reported electric and gas savings, evaluated electric and gas savings, and the realization rates. If multiple measures were installed at a site, the results for each measure are listed separately.

**Table 19. Custom Measure Sample Results**

| Site ID | Measure Category | Building Type | Reported Savings | | Evaluated Savings | | Realization Rate | |
|---|---|---|---|---|---|---|---|---|
| | | | Electricity (kWh) | Gas (therms) | Electricity (kWh) | Gas (therms) | Electricity Savings | Gas Savings |
| 1 | Custom Controls | Hospital | 167,674 | 6,372 | 8,928 | 0 | 5% | 0% |
| 2 | Custom Controls | Hospital | 587,400 | 82,819 | 230,690 | 36,175 | 39% | 44% |
| 3 | Custom Controls | Hospital | 331,848 | 2,225 | 331,848 | 2,225 | 100% | 100% |
| 3 | Custom HVAC | Hospital | 220,856 | - | 0 | - | 0% | - |
| 3 | Custom HVAC | Hospital | 174,755 | - | 174,755 | - | 100% | - |
| 4 | Custom Controls | Office | 251,222 | 9,089 | 163,130 | 3,888 | 65% | 43% |
| 4 | Custom HVAC | Office | 10,400 | - | 10,400 | - | 100% | - |
| 5 | Custom Controls | Institution/ Govern-ment | 955,215 | 165,210 | 955,215 | 94,463 | 100% | 57% |
| 6 | Custom Controls | Lodging/ Hotel / Motel | 509,800 | - | 293,501 | - | 58% | - |
| 6 | Custom HVAC | Lodging/ Hotel / Motel | 484,700 | - | 289,546 | - | 60% | - |
| 6 | Custom HVAC | Lodging/ Hotel / Motel | 418,500 | - | 249,996 | - | 60% | - |
| 6 | Custom HVAC | Lodging/ Hotel / Motel | 141,200 | - | 90,915 | - | 64% | - |
| 7 | Custom Controls | Office | 5,221 | 1,400 | 0 | 0 | 0% | 0% |
| 8 | Custom Controls | Office | 494,441 | 2,403 | 494,441 | 2,403 | 100% | 100% |
| 9 | Custom Controls | Office | 1,267,969 | - | 1,102,115 | - | 87% | - |

| Site ID | Measure Category | Building Type | Reported Savings | | Evaluated Savings | | Realization Rate | |
|---|---|---|---|---|---|---|---|---|
| | | | Electricity (kWh) | Gas (therms) | Electricity (kWh) | Gas (therms) | Electricity Savings | Gas Savings |
| 9 | Custom HVAC | Office | 249,641 | 22,442 | 292,259 | 23,090 | 117% | 103% |
| 9 | Custom HVAC | Office | 88,075 | 40,225 | 90,243 | 40,640 | 102% | 101% |
| 9 | Custom HVAC | Office | 68,708 | 4,249 | 66,510 | 4,330 | 97% | 102% |
| 10 | Custom Controls | Office | 167,038 | - | 52,025 | - | 31% | - |
| 10 | Custom HVAC | Office | 374,221 | - | 115,195 | - | 31% | - |
| 10 | Custom HVAC | Office | 7,184 | - | 0 | - | 0% | - |
| 11 | Custom Controls | Office | 104,540 | 10,449 | 121,650 | 7,428 | 116% | 71% |
| 12 | Custom Controls | Office | 1,792,000 | - | -338,203 | - | -19% | - |
| 13 | Custom Controls | Office | 438,365 | - | 438,365 | - | 100% | - |
| 13 | Custom HVAC | Office | 706,796 | - | 577,636 | - | 82% | - |
| 13 | Custom HVAC | Office | 547,500 | - | 447,449 | - | 82% | - |
| 14 | Custom Controls | Office | 268,168 | - | 100,310 | - | 37% | - |
| 15 | Custom Controls | Office | 192,724 | 12,822 | 379,344 | -6,197 | 197% | -48% |
| 15 | Custom HVAC | Office | 462,628 | 19,401 | 910,604 | -9,377 | 197% | -48% |
| 15 | Custom HVAC | Office | 17,554 | - | 34,552 | - | 197% | - |
| 16 | Custom Controls | Other | 191,548 | 7,575 | 191,548 | 7,575 | 100% | 100% |
| 16 | Custom HVAC | Other | 824,269 | - | 824,269 | - | 100% | - |
| 16 | Custom HVAC | Other | 176,753 | 9,030 | 176,753 | 9,030 | 100% | 100% |
| 16 | Custom HVAC | Other | 54,328 | - | 0 | - | 0% | - |
| 17 | Custom Controls | Other Health | 76,230 | 2,618 | 74,992 | 1,920 | 98% | 73% |
| 17 | Custom Controls | Other Health | 32,780 | - | 32,248 | - | 98% | - |

| Site ID | Measure Category | Building Type | Reported Savings | | Evaluated Savings | | Realization Rate | |
|---|---|---|---|---|---|---|---|---|
| | | | Electricity (kWh) | Gas (therms) | Electricity (kWh) | Gas (therms) | Electricity Savings | Gas Savings |
| 18 | Custom Controls | Parking structure/ Garage | 201,007 | - | 292,264 | - | 145% | - |
| 18 | Custom HVAC | Parking structure/ | 16,154 | - | 23,488 | - | 145% | - |
| 19 | Custom HVAC | Assembly | 134,598 | 20,615 | 147,844 | 11,801 | 110% | 57% |
| 19 | Custom HVAC | Assembly | 20,590 | - | 28,301 | - | 137% | - |
| 19 | Custom HVAC | Assembly | - | 13,020 | - | 13,020 | - | 100% |
| 20 | Custom HVAC | College/ University | - | 24,627 | - | 25,044 | - | 102% |
| 21 | Custom HVAC | College/ University | - | 7,100 | - | 7,100 | - | 100% |
| 21 | Custom Other | College/ University | - | 4,527 | - | 0 | - | 0% |
| 22 | Custom HVAC | Data Center | 1,500 | 1,464 | 11,266 | -683 | 751% | -47% |
| 23 | Custom HVAC | Hospital | - | 189,317 | - | 189,317 | - | 100% |
| 24 | Custom HVAC | Hospital | 1,547,000 | - | 736,428 | - | 48% | - |
| 25 | Custom HVAC | Office | 692,506 | - | 600,258 | - | 87% | - |
| 25 | Custom HVAC | Office | 647,942 | - | 426,208 | - | 66% | - |
| 25 | Custom HVAC | Office | 185,000 | - | 121,691 | - | 66% | - |
| 25 | Custom HVAC | Office | 79,600 | - | 52,360 | - | 66% | - |
| 25 | Custom HVAC | Office | - | 13,020 | - | 30,425 | - | 234% |
| 26 | Custom HVAC | Office | 866,700 | - | 910,468 | - | 105% | - |
| 26 | Custom HVAC | Office | 53,167 | - | 55,852 | - | 105% | - |
| 27 | Custom HVAC | Other Health | 114,851 | - | 201,007 | - | 175% | - |
| 28 | Custom HVAC | Restaurant | - | 3,391 | - | 0 | - | 0% |
| 29 | Custom Other | Grocery | 6,966 | - | 7,037 | - | 101% | - |

| Site ID | Measure Category | Building Type | Reported Savings | | Evaluated Savings | | Realization Rate | |
|---|---|---|---|---|---|---|---|---|
| | | | Electricity (kWh) | Gas (therms) | Electricity (kWh) | Gas (therms) | Electricity Savings | Gas Savings |
| 29 | Custom Other | Grocery | 9,288 | - | 9,382 | - | 101% | - |
| 29 | Custom Other | Grocery | 6,966 | - | 2,346 | - | 34% | - |
| 30 | Custom Other | Lodging/ Hotel / Motel | - | 1,798 | - | 714 | - | 40% |
| 21 | Custom Other | Restaurant | 2,969 | - | 2,969 | - | 100% | - |
| 32 | Custom Other | Retail | 69,264 | - | 74,659 | - | 108% | - |
| 32 | Custom Other | Retail | 66,172 | - | 66,172 | - | 100% | - |
| 32 | Custom Other | Retail | 57,288 | - | 57,288 | - | 100% | - |
| 32 | Custom Other | Retail | 25,370 | - | 34,142 | - | 135% | - |
| 32 | Custom Other | Retail | 22,680 | - | 22,680 | - | 100% | - |
| 32 | Custom Other | Retail | 6,210 | - | 6,210 | - | 100% | - |