2008 New Buildings Program Impact Evaluation

Prepared for
Energy Trust of Oregon

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Contents

Executive Summary

The Energy Trust of Oregon (ETO) retained the Cadmus Group, Inc., (Cadmus) to complete an impact evaluation of the 2008 New Buildings Program, a comprehensive effort to assist owners of newly constructed or substantially renovated commercial and industrial buildings to achieve energy savings through differing tracks. The program's four tracks include: Standard Track, Custom, ENERGY STAR, and LEED. These programs are described as follows:

- The Standard TrackTrack supports prescriptive equipment measures, such as lighting, motors, HVAC, and others, typically through deemed savings and rebate values.
- The Custom Track provides incentives to reduce a building's energy use below the minimally code-compliant value. Measures usually involve more complex energy savings analysis than do prescriptive measures.
- The ENERGY STAR Track assists participants in certifying their buildings through the Environmental Protection Agency's national energy performance rating system.
- LEED Track projects receive incentives for achieving energy savings as part of certification by the U.S. Green Building Council.

The 2008 New Buildings Program was implemented by a third-party program management contractor (PMC), Science Applications International Corporation (SAIC). ETO changed management contractors beginning with the 2009 program year. As part of the changeover process, SAIC staff printed all program documentation, including forms, emails, calculations, invoices, and specification sheets. ETO staff scanned the specific documentation for each evaluated project, and provided it to Cadmus. Unfortunately, it was often difficult to identify pertinent details in the files provided, and measure calculation spreadsheets could not be replicated because the PDF files only showed the spreadsheet calculation results. Cadmus often had to contact the relevant participants, contractors, and mechanical design engineers to obtain the electronic files needed to verify energy savings. Cadmus developed a sample of the 50 largest savings projects for evaluation. The sample experienced attrition, however, primarily due to participant refusals, oversampling of a particular building type, and issues related to simulation modeling. The sample attrition details are shown in Table 7. Where possible, projects removed from the sample were replaced with similar projects. The final sample contained 48 projects, representing 68% of the total program reported savings, as shown in Table 1.

Table 1. 2008 Program and Sample Total Quantities and Reported Savings

	Total Number of Projects	Total Number of Measures	Reported Electricity Savings (kWh)	Reported Gas Savings (therms)	Reported Combined Energy Savings (MBtu)[1]
Program Total	224	1,073	33,138,094	464,905	159,591
Sample Total	48	330	21,680,726	335,236	107,498

[1] MBtu is used throughout this report to indicate million Btu.

Cadmus evaluated the program through site visits and reviews of engineering calculations and models. Site visits validated proper installation and functioning of incented equipment, and provided operational characteristics data to support engineering analysis. The Standard Track measures primarily were evaluated using industry standard algorithms. Custom measures were analyzed through algorithms, detailed calculation spreadsheet reviews, simulation modeling, and/or short-term metering. Cadmus' subcontractor, Heschong Mahone Group (HMG) analyzed differences between baseline and as-built simulation models for LEED projects. Through the impact evaluation, Cadmus identified a variety of issues reducing the program realization rate, as shown in Table 2. The total combined reported energy savings (electric and gas) represented 159,590 MBtu. Cadmus calculated the total combined evaluated energy savings to be 137, 958 MBtu, for an 86% overall realization rate (see Table 25).

Table 2. Overall 2008 Program Realization Rates and Energy Savings[2]

Measure Category	Total Number of Measures	Reported Electric Savings (kWh)	Reported Gas Savings (therms)	Ex Post Electric Savings	Ex Post Gas Savings	Electric Savings Realization Rate	Gas Savings Realization Rate
Standard Lighting	546	6,731,354	0	8,126,552	-	121%	-
Standard Motors	62	1,922,886	0	1,825,995	-	95%	-
Standard HVAC	245	1,025,395	77,860	1,091,095	92,427	106%	119%
Standard Other	56	141,343	58,090	121,344	36,858	86%	63%
Custom	64	4,454,088	116,881	4,102,231	84,274	92%	72%
Custom Gas	10	0	58,191	-	55,583	-	96%
Custom HVAC	13	3,319,194	51,034	672,075	47,228	20%	93%
Custom Lighting	52	10,961,855	0	10,205,862	-	93%	-
Custom Motor	10	1,443,220	0	493,283	-	34%	-
LEED	15	3,138,759	102,849	1,473,062	103,761	47%	101%
Total	1,073	33,138,094	464,905	28,111,498	420,132	85%	90%

Primary issues reducing realization rates included:

- Incenting measures either just met building code requirements or were standard practice.
- Variations between reported and observed equipment quantities.
- Variations between actual operating conditions and deemed prescriptive assumptions for operating hours.
- Variations between Cadmus and PMC assumptions regarding calculation variables.
- Calculation errors.

[2] All savings values listed in the impact evaluation are gross values. The calculation of a net-to-gross ratio was outside the scope of this evaluation.

- Reduced facility usage as a result of unfavorable economic conditions.[3]

Most of these issues could be resolved through more effective implementation, particularly in the area of energy code requirements. The PMC should conduct a more rigorous review of the custom analysis calculations submitted by the participant or contractor to reduce incidence of errors. In addition, several measures identified, such as demand controlled ventilation, should not have been included as prescriptive measures due to the complexity and quantity of variables required to estimate savings. Several other measures appeared to be more appropriate to move from custom to prescriptive analysis, such as ENERGY STAR clothes washers and dishwashers.

[3] In some cases, such as with demand controlled ventilation, the reduced facility usage could actually increase measure energy savings.

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MEMO

Date: November 22, 2010
To: Board of Directors
From: Sarah Castor, Evaluation Project Manager
Jessica Rose, Business Sector Manager, New Buildings Program
Subject: Staff Response to the 2008 New Buildings Program Impact Evaluation

The results of the 2008 New Buildings Impact Evaluation show that overall realization rates for electric and gas - while lower than in previous program years - are still within an acceptable range. Low realization rates for certain categories of measures – including custom HVAC, custom motors, and “standard other” – were caused mainly by a small percentage of projects with incorrect assumptions or savings calculations, rather than systematic program errors. The program has been aware of the incorrect calculation of savings for LEED projects since 2009 and calculation methods were corrected going forward when PECI took over as Program Management Contractor (PMC) at the beginning of that year.

Since the transition to the new PMC, the program has instituted several other changes, including conducting routine evaluation of measures available and coordinating with planning and evaluation on a monthly basis to make updates due to changing standards and new codes. Currently, the program is undergoing a re-design that simplifies and standardizes many processes used to calculate savings in new buildings. It should also be noted that the program re-design eliminated program tracks that are referred to by evaluators.

To insure that savings calculations are performed correctly, the program has instituted simplified calculators that streamline a number of HVAC measures, including demand control ventilation, unitary HVAC equipment, VFDs, fan power, air-to-air heat exchangers, and economizers. All project submittals receive two complete reviews for compliance with program requirements. For Standard incentives, these reviews focus on the product cut sheets and invoices. A second review is conducted on all project documentation that includes checking measures against program requirements and state energy code, and reviewing all models and calculations for modeled or calculated projects. Realization rates for 2009 projects, to be evaluated in 2011, should provide a more accurate picture of the program as it currently operates under the new PMC.

The evaluator made several specific recommendations for program improvements based on 2008 project findings (in italics) which we will address as follows:

- *Provide adequate scrutiny of calculation spreadsheets; provide a second review of savings calculations for projects exceeding a relatively high savings threshold*
  The Technical Guidelines have been greatly enhanced and clarified since 2008 and program reviews are more stringent. The 2009-2010 Program Process Evaluation findings reflect this change in feedback from energy analysts that the current review is very strict. Second reviews are completed on all projects, regardless of size. The highest scrutiny of review is applied to those measures with the largest savings. Custom (modeled) project submittals undergo two complete technical reviews by a program engineer. These technical reviews focus on :
  - Alignment between the energy model, design or construction documents, and as-built building;
  - Compliance with the program's Technical Guidelines, specifically the baseline systems modeled;
  - Standard modeling review of overall energy use by end-use and correct input of building occupancy schedules;
  - Review of incremental costs.

  In addition, all LEED projects undergo two reviews by program engineers. The LEED reviews focus on:
  - Reasonableness of claimed energy savings;
  - Review of baseline for potential fuel switching;
  - Preparation of site verification form from LEED Letter Template or building plans.

- *Confirm measure requirements relative to state code*
  Existing and new Standard Track measures are continually evaluated to ensure they exceed the Oregon energy code. Currently, the program has two sets of measures – one for projects permitted under 2007 code and one for projects permitted under 2010 code. All Custom or modeled measures are evaluated to ensure they exceed the relevant code. The Standard Track measures for each project are checked to make sure they meet program requirements. Quality assurance includes strict review of cut sheets provided by project teams, site verification upon completion for all projects receiving over $10,000 and 10% of all other projects (multiple site visits are conducted if additional verification is needed).

- *Remove incentives for LED exit signs*
  LED Exit signs were removed from the program in the second quarter of 2009.

- *Move demand control ventilation (DCV) projects to the Custom track*
  A more complex calculator for DCV measures has been developed as part

of the HVAC calculator and will replace the Standard Track measure.

- *Maintain ENERGY STAR appliances in the Standard track*
  While track is a project level designation, and may not be changed to Standard for appliances within a Custom project, we will insure that savings and incentives are calculated in a the same manner as standard track appliance measures. Whenever possible, appliance measures are segregated out of Custom track projects and paid through the Standard measures.

- *Segregate prescriptive and custom lighting*
  The current project review process should catch redundant incentives of any measure type. In addition, the program is eliminating Standard Track lighting and shifting to only Lighting Power Density-based incentives calculated in a lighting calculator. This shift will eliminate the possibility of redundant incentives.

- *Improve consistency among measure categories*
  Evaluation will review the measure categories applied to projects and make sure they are consistent and sufficiently descriptive.

- *Require building simulation model contractors to sign release forms*
  The program is now collecting model files for all LEED and modeled projects going forward. The application terms and conditions have also been updated to specify that project owners agree to provide Energy Trust with the energy simulation models and inputs.

Introduction

The Energy Trust of Oregon (ETO) retained the Cadmus Group, Inc., (Cadmus) to complete an impact evaluation of the 2008 New Buildings Program. The program's process evaluation will be completed by another firm. The New Buildings Program is a comprehensive effort to assist owners of newly constructed or substantially renovated commercial and industrial buildings to achieve energy savings through four differing tracks: Standard, Custom, ENERGY STAR, and LEED.

- The Standard Track supports prescriptive equipment measures, such as lighting, motors, HVAC, and others, typically through deemed savings and rebate values.
- The Custom Track provides incentives to reduce a building's energy use below the minimally code-compliant value. Measures included typically involved more complex energy savings analyses than did prescriptive measures.
- The ENERGY STAR Track assists participants in certifying their buildings through the Environmental Protection Agency's national energy performance rating system.
- The LEED Track projects receive incentives for achieving energy savings as part of certification by the U.S. Green Building Council.

The 2008 program was managed by a third-party program management contractor (PMC), Science Applications International Corporation (SAIC). This PMC was replaced by Portland Energy Conservation, Inc., (PECI) at the beginning of the 2009 program year.

During the 2008 program year, 224 projects received incentives through the Standard, Custom, and LEED Tracks. No ENERGY STAR building projects were approved. Cadmus' subcontractor, Heschong Mahone Group (HMG) analyzed differences between baseline and as-built simulation models for LEED projects.

The following tables show total quantities of measures and first-year reported energy savings for each track in the 2008 program year. The Standard and Custom Tracks were further divided into subcategories based on measure categories.

Table 3. 2008 Standard Track Total Measures and Reported Savings

Measure Category	Total Number of Measures	Total Electric Savings (kWh)	Total Gas Savings (therms)
Standard Lighting	546	6,731,354	0
Standard HVAC	245	1,025,395	77,860
Standard Motors	62	1,922,886	0
Standard Other	56	141,343	58,090
Standard Track Total	909	9,820,978	135,950

Table 4. 2008 Custom Track Total Measures and Reported Savings

Measure Category	Total Number of Measures	Total Electric Savings (kWh)	Total Gas Savings (therms)
Custom	64	4,454,088	116,881
Custom Gas	10	0	58,191
Custom HVAC	13	3,319,194	51,034
Custom Lighting	52	10,961,855	0
Custom Motor	10	1,443,220	0
Custom Track Total	149	20,178,357	226,106

Table 5. 2008 LEED Track Buildings and Reported Savings

Measure Category	Total Number of Measures	Total Electric Savings (kWh)	Total Gas Savings (therms)
LEED	15	3,138,759	102,849

Table 6. 2008 Total Program Measures and Reported Savings

Measure Category	Total Number of Measures	Total Electric Savings (kWh)	Total Gas Savings (therms)
Total 2008 Program	1,073	33,138,094	464,905

The following section presents Cadmus’ methodology for evaluating the 2008 program.

Methodology

The impact evaluation, designed to verify reported program participation and estimate gross energy savings, measured gross energy changes, using data collected on site, program tracking data, and engineering models.

The impact evaluation included the following approaches to determine the energy savings attributable to the program:

- Sample Development
- Data Collection
- Engineering Analysis

Savings were calculated to measure changes between baseline and installed efficiency measures. Program tracking data, assessed for assumptions and accuracy, were used in savings calculations.

Sampling Methodology

At the study's beginning, Cadmus met with ETO staff to develop a sampling plan, review appropriate evaluation methods, and discuss specific program details. ETO staff, noting the top 50 projects represented the majority of 2008 program savings, suggested these might represent a reasonable sample of measures. Cadmus converted energy and natural gas savings into units of millions of British thermal units (MBtu) to have a standard metric for comparing projects. All 2008 projects were ranked by their total savings in MBtu, and the top 50 projects were selected. Cadmus provided the sample projects list to ETO staff to supply documentation. Cadmus reviewed Standard projects to ensure the final sample contained all major measure types as well as a representative quantity of standard practice measure types. Upon review, Cadmus determined all major measure categories previously outlined were represented in the sample. Almost all prescriptive measures Cadmus considered standard practice were included, except for chillers. Most Standard HVAC projects involved air conditioning and heat pump measures, and chillers represented another important type of HVAC equipment for analysis. Cadmus counted four chiller measures installed in 2008, but none were represented in the top 50 projects. After consultation with ETO, Cadmus removed the lowest-saving project of the top 50 and replaced it with the top-saving project containing a chiller measure.

Additional attrition occurred throughout the evaluation. Reasons for attrition are outlined in Table 7, with the predominant reasons being: participant refusal for a site visit and simulation model complications.

Despite repeated requests and without an adequate rationale, one engineering firm refused to release the simulation model for a 2008 project. Another simulation was done with Trane TRACE software, to which neither Cadmus nor HMG had access. The final simulation model issue involved one project with only 40% occupancy, which is generally too low for reliable calibration to utility billing data. The building also had undergone significant tenant improvements, in the form of an office built within the warehouse space, which would have required significant time and budget to adjust the detailed simulation model. Cadmus determined the model revisions, in conjunction with unreliable calibrations, represented an unreasonable level of effort for that project, and it was removed from the sample.

Table 7. Sample Attrition Details

Participant	Project Type	Building Type	Reported Savings (MBtu)	Reason for Attrition
ETONB0850	NBE Standard	Office	1,058	No longer in business.
ETONB0851	NBE LEED-NC	Mixed use Residential	3,786	Engineering firm refused to release simulation model.
ETONB0852	NBE Standard	Office	743	Participant refused site visit.
ETONB0853	NBE LEED-NC	Warehouse and Storage	1,015	Low occupancy, with significant changes required to the project model from tenant improvements.
ETONB0854	Custom	Mercantile (Retail Other Than Mall)	865	Large sample already included for this building type and corporate chain.
ETONB0855	NBE Standard-Custom	Mixed use Residential	5,013	Energy model software incompatible with Cadmus and HMG modeling tool.
ETONB0856	NBE Standard	Mixed use Residential	1,429	Participant refused site visit.
ETONB0857	NBE Standard	Other	3,586	Participant refused site visit.

In general, projects were replaced by the next-highest energy-saving project outside of the original sample. One project, ETONB0857, involved direct-fired radiant heating, a measure with a relatively low sampling rate. It was replaced by the next-highest energy-saving project that included the measure. Projects removed from the sample after mid-July 2010 were generally replaced with the next-highest saving project in the Portland Metro area, given the urgent timeline and additional effort required for travel.

Given continued attrition, the final evaluation sample included 48 projects. This sample still represented 68% of reported program savings, as shown in Table 8.

Table 8. 2008 Reported Program and Evaluation Sample Details[4]

	Total Number of Projects	Total Number of Measures	Total Electricity Savings (kWh)	Total Gas Savings (therms)	Total Energy Savings (MBtu)
Program Total	224	1,073	33,138,094	464,905	159,591
Sample Total	48	330	21,680,726	335,236	107,498

The final evaluation sample represented a cross-section of major measure categories and types, as shown in Table 9. Custom measures represented both the largest category of energy savings and the most frequent type of measure installed (as part of 34 projects). Standard measures were second in terms of savings and frequency (as part of 31 projects).

[4] MBtu is million Btus throughout this report.

Table 9. Sample Energy Savings by Measure Category

Measure Category	Total Number of Measures	Total Energy Savings (kWh)	Total Gas Savings (therms)	Total Energy Savings (MBtu)
Standard Lighting	97	1,899,415	0	6,481
Standard HVAC	72	577,010	22,386	4,207
Standard Motors	29	1,087,078	0	3,709
Standard Other	23	86,612	27,294	3,025
Custom	105	16,228,251	214,696	76,840
LEED	6	1,886,569	70,860	13,523
Total	332	21,764,935	335,236	107,786

Cadmus calculated that estimating the mean project realization rate for a random sample (with a 90% confidence level and 10% confidence interval) would require evaluation of 52 out of 224 projects. As our sample primarily consisted of the largest energy-saving projects, the confidence interval for the mean realization was even narrower.

For comparison, Table 10 shows the portion of each measure represented in the overall program or sample population. The sample distribution was reasonably consistent with the overall program project distribution. However, the sample featured less prescriptive lighting and a larger proportion of the more complex Custom measures, which required significantly more analysis. These differences in distribution were consistent with our process of selecting projects that saved more energy, and increased the precision of both the measure level and project level mean realization rates.

Table 10. Reported and Evaluated Measure Portions of Population

Measure Type	Reported Measure Quantity	Reported Portion of Total	Evaluated Measure Quantity	Evaluated Portion of Sample
Standard Lighting	546	51%	97	29%
Standard Motors	62	6%	29	9%
Standard HVAC	245	23%	72	22%
Standard Other	56	5%	23	7%
Custom	149	14%	105	32%
LEED	15	1%	6	2%
Total	1,073	100%	332	100%

The sample also represented a mix of building types, shown in Table 11. The primary building type was Mercantile—predominantly grocery stores. The “Other” building types were generally various types of manufacturing facilities.

Table 11. Building Types Represented in Evaluation Sample

Building Type	Quantity	Portion of Total
Education	2	4%
Health Care (Inpatient)	2	4%
Lodging	3	6%
Mercantile (Retail Other Than Mall)	18	38%
Mixed use Residential	7	15%
Office	4	8%
Other	10	21%
Public Assembly	2	4%
Total	48	100%

For comparison, Table 12 shows building types for the 2008 program population. The sample distribution roughly matches that of the program population, particularly with the larger representation of Mercantile and Other buildings. However, 54 of the 224 projects did not have a listing for building type, which distorted the program's representation of buildings such as mixed-use residential.

Table 12. Building Type Represented in 2008 Program Population

Building Type[5]	Quantity	Portion of Total
Education	5	2%
Food Service	3	1%
Health Care (Inpatient)	3	1%
Health Care (Outpatient)	8	4%
Lodging	3	1%
Mercantile (Retail Other Than Mall)	71	32%
Mixed use Residential	2	1%
No listing	53	24%
Office	18	8%
Other	37	17%
Religious Worship	3	1%
Service	1	0%
Warehouse and Storage	17	8%
Total	224	100%

Data Collection

Available documentation (e.g., audit reports, savings calculation work papers, etc.) were reviewed for a sample of sites, with particular attention paid to the calculation procedures and documentation for savings estimates. The analyses originally used to calculate expected savings were reviewed, and analysis operating and structural parameters were verified. Site visits were used to verify installations and determine any changes to operating parameters following the measures' installation. In some cases, Cadmus performed short-term metering of energy demand, lighting, or temperature. Site visit and metering data informed savings impact calculations. Individual measure savings, aggregated into measure categories, were used to calculate measure-level realization rates. These rates were then applied to program-level reported savings

[5] Based on major categories used in F.W. Dodge building stock data

associated with the respective measure type. Total adjusted savings were summed to determine the overall, program-level, energy savings realization rate. The site visit data and analysis also provided information that enabled Cadmus to develop recommendations for future studies.

Document Review

The evaluation began with a review of relevant documentation and other program materials.

In the 2008, the New Buildings Program was managed by a third-party PMC, SAIC. ETO changed PMCs for the 2009 program. As part of the changeover, SAIC staff printed all program documentation, including forms, emails, calculations, invoices, and specification sheets. During the evaluation, ETO staff scanned paper files for the evaluated sample and placed these on an FTP site for Cadmus to download. Most resulting PDF files were unlabeled and contained a mix of information. This caused considerable difficulty in identifying the most relevant project details. In addition, Cadmus was often unable to replicate the detailed measure calculation spreadsheets developed by participants or contractors as the PDF files only showed spreadsheet calculation results. In many cases Cadmus was able to contact the participant or relevant contractor to obtain and update the original calculation sheet, based on site visit data, utility billing information, or other sources. Cadmus also experienced difficulty obtaining energy simulation models for Custom and LEED projects.

During documentation review, Cadmus paid particular attention to calculation procedures and documentation of savings estimates. Information reviewed for all sample sites included: program forms, the tracking database extract, audit reports, and savings calculation work papers for each rebated measure (if applicable).

Each project file was reviewed for the following information:

- Documentation on equipment installed, including: (1) descriptions; (2) schematics; (3) performance data; and (4) other supporting information.
- Information about savings calculation methodologies, including: (1) what methodology was used; (2) assumption specifications, and the sources for these specifications; and (3) calculation accuracy.

Site Verification Visits

Site visits were used to: verify measure installations; collect primary data to calculate savings impacts; and interview facility contacts. To avoid business disruptions, the team sought to minimize the number of site visits and surveys.

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

1. Verified installation of all measures for which participants received incentives. To the extent possible, field engineers verified energy-efficiency measures were in place, installed correctly, and properly functioning. They also verified operating parameters for installed equipment.
2. Collected physical data required to analyze energy savings realized from installed measures. Field engineers determined the pertinent data to collect from each site using in-depth reviews of project files. Data required were unique to each measure.

3. Conducted interviews with the facility operations staff to confirm project documentation's accuracy and obtain additional data on operating characteristics for the installed systems.

During several site visits, field engineers noted equipment counts differed from those incented, with either fewer or greater measures in place. In cases with fewer measures in place, Cadmus reduced realization rates accordingly. Cadmus also increased realization rates for sites with more measures, provided the measures represented the same types receiving incentives (rather than treating them as part of a separate spillover analysis). Cadmus noted as-built equipment quantities could vary from design counts due to changes in building structures or space usage. Regardless of actual quantities, incented amounts could be considered as reducing installation costs of the overall measure type.

Short-Term Metering

Cadmus performed short-term metering for five projects in the 2008 program sample. All projects were incented through the Custom Track, and represented relatively complex interactions. Cadmus determined short-term metering over a period of two weeks to one month presented the most effective method for achieving precision in these projects' energy savings calculations. Specific metering details have been explored in greater detail in site-specific evaluation reports. Installed metering equipment included:

- HOBO light loggers for Custom Lighting projects, two of which had occupancy sensors.
- A HOBO temperature logger for one Custom HVAC project.
- Energy Logger Pro's for metering cooling tower fan motor and chilled water pump VSD energy on one Custom Motors project.
- Energy Logger Pro's for metering water-source heat pump energy, water loop temperatures in several locations, supply and return air temperatures, and VSD energy use. These were installed on economizer ventilation fans, cooling towers, and a water loop pump for one Custom HVAC project.

Engineering Analysis

Procedures used to verify savings through engineering analysis depended on the type of measure being analyzed. The following major measure groups were included in this program:

- Standard Lighting
- Standard HVAC
- Standard Motors and Variable Speed Drives
- Standard Other (prescriptive water heating, cooking, and refrigeration equipment)
- Custom
- LEED

The following section describes: the focus of site visits; and the procedures used to verify savings from different types of measures installed through the program.

Standard Lighting Measures

Two types of projects were used for verifying lighting measures:

- Installation of high-efficiency lamps, ballasts, and/or fixtures expected to reduce lighting power densities below the code-required value. These measure types reduced demand, and did not affect operation hours between baseline and as-built conditions.
- 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 occupancies.

Analyzing savings for lighting measures required documentation of the fixture wattage, quantity, and operation hours, which were reviewed within each file prior to conducting on-site inspections.

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

We evaluated lighting control systems specifically by focusing on functionality and operation hours. Occupancy sensors were checked twice per site visit, initially to trigger the sensor activating the lights and again to determine whether the lights were turned off. Lighting automation systems were visually inspected for scheduled operation hour set points, and then verified against claims used in submitted calculations.

In addition to parameters listed above, we conducted on-site interviews with building operators and facility staff to verify the operation hours and areas where fixtures were installed. The field engineer calculated lamp and ballast information for each fixture, counting the number of fixtures installed, and organizing fixtures affected by lighting controls systems.

Standard HVAC Measures

For sites with HVAC measures, Cadmus focused on equipment operating characteristics and "equivalent full load hours" (EFLHs) of affected equipment, based on applications, geographical locations, and operation types. Site inspections included interviews with facility personnel, which enabled Cadmus to verify operation hours and proper installation of energy-efficient equipment.

Cadmus generally calculated savings based on differences between code-minimums and installed equipment efficiencies (rated in SEER, EER, COP, or HSPF), and multiplied by the EFLH for the specific building types and applications. Some measures, such as demand-controlled ventilation, involved more complex calculations, accounting for all HVAC and ventilation parameters as well as occupancy patterns within the buildings.

Standard Motors and Variable Speed Drives

For high-efficiency motor and VSD installation measures, savings parameters included efficiency of the code baseline motor, efficiency of the installed motor, the load factor, and operation hours. Cadmus collected nameplate information for motors during on-site inspections as well as other technical information provided by facility contacts. In this case, field verification focused on proper installation of rebated equipment and verification of operating parameters.

Cadmus applied VSD energy saving factors, based on end-use and system operating characteristics, such as constant or variable volume air flows. Energy savings factors were derived from values cited in secondary sources.[6]

Standard Other Measures

Cadmus noted a subset of Standard Track measures did not fit into the primary categories. Largely, these included cooking, refrigeration, and water heating equipment. During site visits, Cadmus collected data on numbers of units, sizes, model numbers, and other pertinent information, and then verified these data against program documentation. Much of the cooking and refrigeration equipment was rated through ENERGY STAR. Cadmus verified energy savings for these measures through on-line ENERGY STAR calculators. Condensing water heater savings were calculated by comparing manufacturers' specified efficiencies with code requirements. Each unit's EFLH was calculated using ASHRAE guidelines for average daily hot water use per person or meal.[7]

Custom Measures

Custom Track projects represented a range of measures, from relatively prescriptive ENERGY STAR appliances to complex water-source heat pump installations. The diversity of projects was matched by the variety of calculation methods used to estimate energy savings. Primarily, these included calculation spreadsheets and building simulation modeling.

For each project, Cadmus performed a site visit to verify correct installation of incented equipment and confirm quantities and operating characteristics. We then determined whether the initial analysis approach was reasonable, and applied a revised calculation approach, if necessary. Calculations and simulation models were adjusted to reflect as-built parameters confirmed through site visits and interviews with facility operations staff.

LEED Building and Custom Track Simulation Models

In the 2008 program evaluation sample, all six LEED Track buildings and five Custom Track projects reported savings calculated using building energy simulation models. Measurement-Based Calibrated Engineering Method (MCEM) was the methodology used to evaluate savings for these projects. This approach was: (1) based on *in situ* measurements and observations; (2) calibrated to best available energy use indices; and (3) employed well-developed and sophisticated engineering analysis tools, such as DOE-2.

The analysis focused on the following issues:

- Quantifying as-built building 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).

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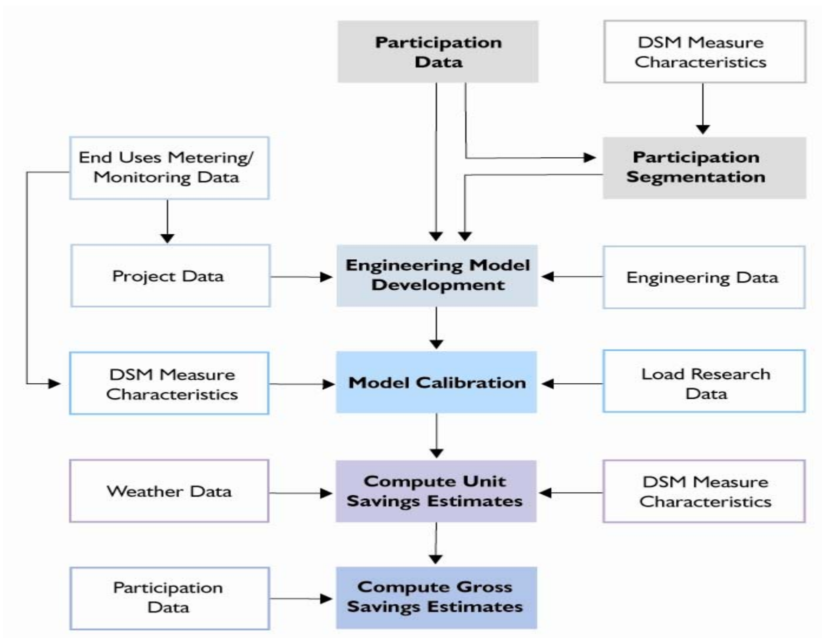
[6] Mid-Atlantic Technical Reference Manual, May 2010 <http://neep.org/uploads/EMV%20Forum/EMV%20Products/Mid%20Atlantic%20TRM_V1d_FINAL.pdf>

[7] *ASHRAE Handbook*, 1984 Systems.

- Reviewing energy-efficient measure assumptions and performance variables for each building to develop input data revisions to the calibrated as-built model for creating the baseline model by removing the energy-efficient measures.
- Comparing calibrated, as-built model energy use results with the baseline model to determine individual building annual energy savings.
- Summarizing energy savings for each building and, for Custom Measures, each individual incented measure. Along with participation data, these values were extrapolated to the population to estimate gross savings for the program.

Figure 1 graphically describes the MCEM application.

Figure 1. Measurement-Based Calibrated Engineering Method Flowchart



Model Calibration

As this was a new construction program, the only model to calibrate was the as-built model. Thus, this represented our starting point. We obtained almost all as-built models for building measure projects in the sample. However, the mechanical design firm for the highest-saving LEED project refused to release the DOE-2 simulation model; so it was removed from the sample.

The as-built models were based on the building: size and configuration; shell characteristics (such as window shading coefficients and wall insulation values); HVAC equipment specifications; lighting densities and control methods; occupancies; and schedules. This information was confirmed using project files and detailed data collection reports from site visits. Through site interviews, we determined occupancy levels achieved during the previous year, and adjusted the equipment operating characteristics for spaces modeled.

The models primarily were calibrated to annual electricity and gas consumption, and we reviewed monthly variation for discrepancies. Minor discrepancies resulted from use of typical meteorological year (TMY3) data in DOE-2, rather than actual historical weather data for the calibration period. It is difficult to develop actual historical weather data files due to the variety of parameters required by DOE-2, particularly hourly solar radiation values. Cadmus noted 2009 weather conditions for the Portland Metro area (the location of 28 out of 48 sites visited) were reasonably close to the averages used in TMY3 weather files, as shown in Table 13 below.

Table 13. Average Weather Data vs. Actual 2009 Conditions[8]

	Heating Degree Days	Cooling Degree Days
Average	4,169	467
2009	4,224	627
Difference	1%	34%

Cooling degree days were 34% more than normal, but cooling energy typically represents a small fraction of annual energy use compared to heating energy. Therefore, Cadmus and HMG did not attempt to create new weather files based on historical weather data for the calibration period.

[8] < http://www.faqs.org/sec-filings/100225/PORTLAND-GENERAL-ELECTRIC-CO-OR-_8-K/dex991.htm>

Results and Findings

This section presents the results of: engineering analysis applied to the sample; adjustments to reported values; and extrapolation of realization rates to the full 2008 program population. It also includes general observations regarding discrepancies and other factors influencing measure-level realization rates. Finally, we examine energy use intensity data derived from the sample.

Sample Adjusted Savings

Reported and adjusted evaluated energy savings values were compared through measure-level realization rates, as shown in Table 14. The overall sample electric realization rate was 80%, and the natural gas realization rate was 88%. Cadmus adjusted electric and gas savings due to measure-specific reasons outlined below. Summary reports for each individual project, developed separately, for selected projects have been provided to ETO.

Table 14. Sample Reported and Adjusted Savings

Measures Type	Reported Electric Savings (kWh)	Reported Gas Savings (therms)	Evaluated Electric Savings (kWh)	Evaluated Gas Savings (therms)	Electric Savings Realization Rate	Gas Savings Realization Rate
Standard Lighting	1,899,415	0	2,293,104	0	121%	-
Standard Motor	1,087,078	0	1,032,302	0	95%	-
Standard HVAC	577,010	28,846	613,981	34,243	106%	119%
Standard Other	86,612	20,834	74,357	13,219	86%	63%
Custom	3,700,104	111,444	3,407,809	80,354	92%	72%
Custom Gas	0	55,445	0	52,960	-	96%
Custom HVAC	2,238,730	47,807	453,301	44,242	20%	93%
Custom Lighting	8,767,965	0	8,163,275	0	93%	-
Custom Motor	1,437,243	0	491,240	0	34%	-
LEED	1,886,569	70,860	885,392	71,489	47%	101%
Total	21,680,726	335,236	17,414,761	296,507	80%	88%

Adjustment Considerations

Applicable Energy Code

Cadmus noted many projects were completed in early 2008 or before. The revised 2007 Oregon Structural Specialty Code took effect October 2007. New construction and renovation projects are required to follow the code in effect at the time they apply for a building permit. Cadmus assumed that many of the 2008 projects submitted their permits under the previous 2004 code when considering the amount of time required for permit reviews, construction, and build-outs. Code differences primarily affected smaller HVAC units, which had lower SEER and HSPF requirements under the 2004 code.

Occupancy Level

Only one project's savings were significantly impacted by low occupancy. Project ETONB0808, an office building, had a 54% occupancy level. For this project's measures, Cadmus applied a savings methodology proposed by ETO. Energy savings were first calculated separately, based on current operating conditions, and then on expected parameters at full occupancy. Evaluated energy savings were set as the average of these two values. Cadmus determined this was a reasonable approach to balance present and future savings.

Standard Lighting

Standard Lighting measures involved efficient lighting fixtures, and controls such as occupancy sensors and daylight dimming. Lighting measures achieved a 121% realization rate compared with reported savings. Cadmus noted Standard Lighting savings were based on deemed values, regardless of building type and actual hours of operation. Some measure savings were based on a deemed average for a range of fixture sizes (such as “CFL 18 to 26 Watt”). Cadmus evaluated measures based on actual wattages, ballast factors, and operation hours determined through site visits and review of invoices and manufacturer specification sheets.

The other primary factors influencing the realization rate included: LED exit sign deemed savings; higher average operating hours in the sample; alterations in fixture quantities; and addition of HVAC interaction factors.

LED Exit Signs

Cadmus noted, after January 1, 2005, the Energy Policy Act of 2005 (EPAct 2005) prohibited manufacture of exit signs with usage higher than 5 Watts per face. Older signs presumably could be found in inventories or from foreign vendors. However, EPAct 2005 resulted in LED exit signs as the standard practice for new construction.

Nevertheless, the 2008 New Buildings Program incented LED Exit Signs and provided two different incentive levels, as shown in Table 15. Program documentation did not indicate why LEDs were incented at all, why the “2008” measure was developed, or why savings were increased.

Table 15. Deemed LED Exit Sign Measure Savings

Measure	Deemed Energy Savings (kWh)	Operating Hours	Deemed Demand Savings (W)
LED Exit Sign	175	8,760	20
LED Exit Sign 2008	245	8,760	28

In the evaluation, Cadmus set the baseline at the maximum allowed value of 5 Watts per face, or 10 Watts total for double-faced signs. In the manufacturer’s specification sets, many LED exit signs listed ratings ranging from of 1 to 3 Watts. This provided some savings over the baseline value, but overall savings decreased by 54,732 kWh (or 71%), as shown in Table 16. This represented a substantial reduction, but was a relatively small portion (2%) of the overall evaluated Standard Lighting energy savings of 2,286,480 kWh.

Table 16. LED Exit Sign Reported vs. Evaluated Savings

Measure	Reported Savings (kWh)	Evaluated Savings (kWh)	Realization Rate
LED Exit Sign	18,900	5,901	31%
LED Exit Sign 2008	58,800	16,367	28%
Total	77,700	22,268	29%

Fixture Count Adjustments

Cadmus field engineers occasionally noted discrepancies between reported and observed fixture counts. During the construction phase, participants reevaluated their lighting needs, and adjusted fixture counts accordingly. For calculation purposes, both the baseline and as-built fixture counts were adjusted to match observed quantities.

The participant for project ETONB0801 received an incentive for installing CFLs. During the site visit, the Cadmus field engineer noted installed units were actually four-lamp, T8 fixtures. The participant reported a significant quantity of CFL ballast failures led them to replace the CFLs with T8 lighting. The participant did not receive a separate incentive for installing T8 lighting. Cadmus allowed savings to be adjusted for this project as the participant received an incentive for high-efficiency lighting, and the replacement wattage still achieved energy savings over the baseline fixture. However, the installed fixture wattage increased from 89 to 112 Watts, reducing annual energy savings by 2,870 kWh.

HVAC Interaction Factors

Though the interactive effect of installing more efficient fixtures and controls reduces cooling requirements, it can result in requiring additional heating. Cadmus accounted for HVAC interactions in our calculations. Values were obtained from the Northwest Power and Conservation Council's Commercial Sector Deemed Savings Calculation Methodology.[9] On average, inclusion of interactive factors resulted in a slight increase in evaluated lighting savings.

Sample Average Operating Hours

The evaluated sample project lighting measures operated for longer periods than the values used in deemed energy savings estimates, which increased the realization rate. For example, Cadmus back-calculated 3,800 operating hours from deemed savings for T8 fixtures. Cadmus examined average operating hours in the evaluated sample, weighted by their total reported lighting energy savings. The sample average was 5,272 operating hours per year, which resulted in substantially higher savings. Evaluated operating hours were higher because the sample included a large number of buildings operating either 24 hours per day (such as manufacturing facilities) or closing only short periods at night (such as grocery stores).

Segregate Prescriptive and Custom Lighting

Cadmus noted project ETONB030 received incentives for a prescriptive lighting measure through the Standard Track as well as incentives for reductions in lighting power density through the Custom Track. The prescriptive lighting measure was installed in the same space used to determine reductions in lighting power density. Consequently, this measure was double-counted,

[9] <http://www.nwcouncil.org/energy/rtf/supportingdata/APPENDIXM2.XLS>

and the participant received twice the appropriate incentive. Due to this, Cadmus did not attribute any savings to the Standard Track measure as it was more appropriate to evaluate under Custom Lighting.

Standard Motors

The Standard Motor category included premium-efficiency motors, variable speed drives (VSDs), and electrically-commutated motors (ECMs) for refrigeration cases. The realization rate for this subset was 95%. Energy savings adjustments were influenced by: actual observed equipment counts; Cadmus assumptions for energy savings factors, equivalent full-load hours (EFLH); and whether installed measure exceeded code minimum requirements.

Cadmus Assumptions

Cadmus noted reported measure savings appeared to have been based on end use, such as ventilation fans or HVAC pumps. Cadmus adjusted measure savings using projected EFLHs according to the building type and end use. For premium efficiency motors, Cadmus' assumptions resulted in a 164% average realization rate.

Cadmus applied energy savings factors for VSDs based on end-use and system operating characteristics, such as constant or variable volume air flow. Energy savings factors were derived from values cited in secondary sources.[10] The resulting realization rate for VSDs was 95%, after applying EFLH assumptions.

Cadmus requested calculation spreadsheets from refrigeration contractors for all ECM projects. Our engineers reviewed and approved the assumptions used to develop calculation spreadsheets, and confirmed equipment quantities through invoices. These measures had realization rates of 100%.

Code Minimum Requirements

For several measures, Cadmus noted an incented measure either just met the code's minimum efficiency or was required by code. In these cases, no energy savings could be assigned. On project ETONB0808, the installed 10 hp motor had 89.5% efficiency, as required by code. For project ETONB0838, the tracking database indicated two VSDs were installed, controlling 9 hp motors. During the site visit, the Cadmus field engineer determined these actually controlled one 20 hp and one 30 hp motor. By code, any motor exceeding 10 hp would be required to install a VSD. Therefore, no savings were attributed to these measures. The savings reduction resulting from these issues were 58,913 kWh, equaling 5.4% of total reported sample savings for this measure category.

Standard HVAC

Standard HVAC projects covered a range of electric and gas measures, including high-efficiency air conditioners, heat pumps, chillers, boilers, direct-fired radiant heating, demand-controlled ventilation (DCV), and air-to-air heat exchangers. The overall realization rate for these measures was 114%. Energy savings adjustments were primarily influenced by: Cadmus' assumptions for

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[10] Mid-Atlantic Technical Reference Manual, May 2010 <http://neep.org/uploads/EMV%20Forum/EMV%20Products/Mid%20Atlantic%20TRM_V1d_FINAL.pdf>

EFLH; observed equipment counts; and efficiency ratings from manufacturer specification sheets. Realization rates were favorable for most measures, but Cadmus noted significant issues regarding savings values for DCV systems.

Electric HVAC Measures

As shown in Table 17, Cadmus determined large realization rates for most electric HVAC measures, such as packaged air conditioners and heat pumps.

Table 17. Reported vs. Evaluated Savings for Electric HVAC Measures

Measure	Reported Savings (kWh)	Evaluated Savings (kWh)	Realization Rate
HVAC	53,609	79,705	149%
Heat Pump	322,616	463,147	144%

Cadmus field engineers observed most equipment counts were accurate, although additional units were added on several projects. For example, project ETONB0804 was a large, multifamily building with five high-efficiency water-source heat pumps added beyond the incented quantity. The additional 7,121 kWh savings from these units were factored into the overall project savings and realization rate. Primary factors influencing the higher realization rate included: a minor variation between Cadmus and PMC assumptions on EFLH, and the actual versus deemed differences between the baseline and installed efficiencies.

The most significant discrepancy involved a measure for 76 package terminal heat pumps at project ETONB0817. Two different sizes were installed on site: ¾-ton units (73) and 1-ton units (3). Reported savings were 152,000 kWh. Cadmus calculated 13,638 kWh in savings by comparing the manufacturer's efficiency data against code requirements using standard industry algorithms and assumed EFLH values.

Cadmus found the PMC included specification sheets and an equipment review sheet in the project documentation. The specification sheets included highlights for 1-ton and 1.5-ton units, indicating the participant originally reported larger equipment sizes. The PMC's equipment review sheet stated actual units were ground source heat pumps, with a required 15 SEER/EER value. As the units had EER values of 10.5 and 11.5, the PMC noted these units failed review. However, Cadmus found the units were actually package terminal heat pumps with above-code efficiency. We could not reconcile the discrepancy in the PMC's review sheet or reported savings values. As a result, this measure was evaluated with a 9% realization rate.

Gas HVAC Measures

Gas HVAC measures included heating methods such as direct-fired radiant, condensing boilers, and unit heaters. Cadmus reviewed the calculation methodology for direct-fired radiant heaters and assumed values for resulting reductions in heating energy. We determined the reported values were reasonable in each case, and applied a 100% realization rate to these measures.

The sample included one measure for non-condensing, high-efficiency unit heaters with electronic ignition. Cadmus calculated significantly higher annual savings of 3,318 therms for this measure, based on the manufacturer's specification sheet and assumed EFLHs, compared with reported savings of 788 therms. Assumptions for deemed savings estimates may have been too conservative.

Demand Controlled Ventilation

Cadmus calculated the highest variation from Standard Track deemed savings with DCV projects. DCV systems use CO_2 sensors to indirectly determine the amount of occupancy in building spaces and adjust the ventilation, heating, and cooling requirements accordingly. These measures typically achieve both electric and gas savings. However, Cadmus found a DCV measure for project ETONB0808 that did not claim any electric savings, although the reduction in ventilation fan energy was a principal component of measure energy savings. This is because ventilation fans operate for a larger portion of the year than heating and cooling systems to deliver fresh outside air to interior spaces as required by ASHRAE standard 62.1. When a DCV system is installed it should deactive ventilation air delivery to unoccupied spaces, resulting in considerable electricity savings.

DCV calculations involved a significant number of variables, including: specific details of heating and cooling equipment; ventilation fan sizes; equivalent full-load hours for all HVAC equipment; fractions of occupancy for controlled spaces; and whether the system included heat recovery. However, the ETO rebate was based solely on the ventilation system CFM, which was insufficient to accurately quantify measure savings.

Cadmus calculated savings for DCV measures through on-site observation of required inputs and assumptions for equivalent full-load hours and other parameters. The resulting savings were significantly higher than deemed savings, as shown in Table 18 for three of the five DCV projects. The magnitude of realization rates indicate that the methodology and deemed values were too conservative.

Table 18. Comparison of Reported and Calculated Savings for DCV Measures

Project	Reported Electric Savings (kWh)	Reported Gas Savings (therms)	Calculated Electric Savings (kWh)	Calculated Gas Savings (therms)	Electric Savings Realization Rate	Gas Savings Realization Rate	Energy Savings Realization Rate
ETONB0806	344	434	53,734	3,754	15,620%	865%	1,254%
ETONB0808	0	780	100,881	13,023	N/A	1,670%	2,111%
ETONB0829	2,393	3,020	17,776	13,111	743%	434%	442%

Cadmus found the realization rate for ETONB0808 resulted partly from the buildings' low occupancy levels (54%). Without DCV, the HVAC system would unnecessarily provide heating, cooling, and ventilation to unoccupied sections of the buildings. For this project, the realization rate was the average of current and fully-occupied energy savings.

The overall Standard HVAC realization rate would be significantly distorted by including the calculated values for DCV measures. Consequently, Cadmus chose to accept the reported DCV savings values as a conservative lower bound for the evaluated savings.

Standard Other

The Standard Other category represented the remaining measures with deemed savings, and included water heating, refrigeration, and cooking measures.

Water Heating Measures

The water heating measures primarily involved condensing water heater tanks, along with one tankless water heater and one dishwasher measure. Cadmus calculated condensing water heater savings by comparing the manufacturer's specified efficiency with the code requirement. Each unit's EFLH was calculated using ASHRAE guidelines for average daily hot water use per person or meal.[11] Condensing tanks had a 123% overall realization rate, indicating reported values used slightly conservative, but not unreasonable, assumptions.

Cadmus applied a similar calculation for the tankless water heating measure for project ETONB0823, and found a much lower 43% realization rate. This project involved several gas-saving measures, including a Custom Gas measure for desuperheating. Overall gas savings were based on the contractor's calculations. Cadmus found reported savings exceeded the project's actual gas utility usage, thus the low realization rate was appropriate.

The remaining water heating measure was an ENERGY STAR dishwasher with both gas and electric savings. Cadmus used the measure's on-line ENERGY STAR calculator to determine the reported savings were conservative. The measure's evaluated realization rate was 189%.

Refrigeration Measures

The incented refrigeration equipment involved ENERGY STAR appliances, such as refrigerators and ice-making machines. Cadmus determined savings through the applicable ENERGY STAR calculators. The resulting realization rate was 99%, indicating the original savings assumptions were reasonable.

Cooking Measures

These measures involved both electric and gas equipment, including convection ovens, electric hot food cabinets, electric steamers, and infrared gas fryers. This equipment was also rated through ENERGY STAR, and Cadmus determined savings through the applicable calculators. As shown in Table 19, deemed values for these measures appeared too large. Cadmus found various ENERGY STAR calculators have been revised and updated in recent years, and this may have resulted in discrepancies.

[11] *ASHRAE Handbook*, 1984 Systems.

Table 19. Comparison of Reported and Evaluated Savings for Cooking Measures

Project	Measure	Reported Electric Savings (kWh)	Reported Gas Savings (therms)	Evaluated Electric Savings (kWh)	Evaluated Gas Savings (therms)	Energy Savings Realization Rate
ETONB0829	Electric Hot Food Cabinet	46,907	0	24,080	0	51%
ETONB0841	Electric Hot Food Cabinet	6,701	0	3,134	0	47%
ETONB0806	Electric Steamer	3,748	0	3,731	0	100%
ETONB0841	Electric Steamer	7,496	0	12,233	0	163%
ETONB0829	Direct-Fired Convection Oven	0	1,128	0	179	16%
ETONB0829	Infrared Gas Fryer	0	548	0	156	28%
Total Electric Savings		64,852	0	43,178	0	67%
Total Gas Savings		0	1,676	0	335	20%

Custom Projects

Custom Projects represent a "catch all" subcategory of nonprescriptive measures with both gas and electric savings. Many of these involved controls systems or specialty refrigeration measures. Cadmus found many measures with the generic Custom label were more appropriate for a different subcategory, such as Standard Other, Custom Gas, or Custom HVAC. However, Cadmus kept these measures in their reported subcategories because the variations were assumed to be consistent throughout the remaining program population. The Custom Track measure realization rate was 83%.

Custom Measure Calculations

Cadmus evaluated Custom measure energy savings through a review of available data and calculation spreadsheets, supported by on-site verification and utility billing data. Since a prescriptive methodology was not appropriate for most of these measures, Cadmus relied heavily on calculation spreadsheets developed by contractors, participants, and the PMC. Since the PMC no longer managed the program, most of these spreadsheets initially were available only as scanned PDF files. Cadmus reviewed the program documentation to determine calculation sources for each measure, and contacted the sources (generally refrigeration contractors) to obtain the original calculation spreadsheets. Cadmus compared the inputs and cross-linked cells against available data to confirm the methodology and results, or adjusted values as necessary. In most cases, Cadmus determined the methodology and reported savings values were reasonable, although significant adjustments were occasionally required.

Custom ENERGY STAR Measures

Cadmus found the Custom Project sample of 49 measures included seven ENERGY STAR measures, which had also been designated as prescriptive under the Standard Track. These measures included: clothes washers, dishwashers, refrigerators, electric hot food cabinets, electric steamers, and ice-making machines. Cadmus could not identify any definitive reasons why these measures were not treated under Standard Track as they were functionally identical to others in that category.

Table 20 shows realization rates for electric measures were relatively consistent for the Custom ENERGY STAR measures compared with those reported under the Standard Other category.

However, Cadmus calculated only a 3% gas saving realization rate for two gas-saving ENERGY STAR measures in the Custom category. Primarily, this was due to significant discrepancies between assumptions used for reported savings compared with the ENERGY STAR calculator. The PMC claimed to use 2007 EPA baseline data for calculating annual ENERGY STAR clothes washer savings at 168 therms per unit for 27 units in a condominium building. The ENERGY STAR calculator indicated this value should actually have been 4 therms per year. Primary savings from an ENERGY STAR clothes washer resulted from more efficient motors and spin orientations, not a significant reduction in hot water usage.

Table 20. Comparison of Realization Rates for ENERGY STAR Measures

Measure Category	Reported Electric Savings (kWh)	Reported Gas Savings (therms)	Calculated Electric Savings (kWh)	Calculated Gas Savings (therms)	Electric Savings Realization Rate	Gas Savings Realization Rate
Standard Other	86,612	2,081	74,357	930	86%	45%
Custom	38,458	5,200	28,693	162	75%	3%

Database Tracking Discrepancies

Cadmus found discrepancies between program tracking documentation and the tracking database for four Custom measures. One of these appeared to be a data entry error, with 4,554 therms in savings recorded as 4,544 therms in the tracking database. The other three discrepancies (all on the same project) could not be resolved. Total savings listed in the program documentation were 23,313 kWh, but total savings recorded in the database were 8,505 kWh. Reported savings for each measure were significantly different from program documentation, without further discussion as to adjustments.

Custom Gas

Custom Gas measures primarily were installed in grocery stores and condominium projects, and represented measures such as discharge heat reclaim, gas cooktops, gas fryers, and boilers. Cadmus found many similar measures were reported under the “Custom” category, without differentiation down to the “Custom Gas” level. The realization rate for these projects was 96%.

Custom Lighting

The majority of Custom Lighting projects involved reductions in lighting power density (LPD) over code or standard practice. The remaining projects included a variety of lighting control strategies, such as refrigeration case controls, energy management systems, time clocks, and daylighting systems. The realization rate for these measures was 93%.

For most projects, Cadmus determined the claimed space identifications were reasonable, and fixture counts and operating hours were close to the reported values. On one project, the Cadmus field engineer found significant discrepancies in the space allocations used to calculate LPD reductions. The production portion of the facility, with a higher allowable baseline LPD of 1.9 W/ft^2, actually primarily included warehouse space, with a much lower baseline of 0.9 W/ft^2. As a result, this project only achieved a 56% realization rate.

Cadmus field engineers identified a number of discrepancies in lighting control measures for several high-rise condominium projects. Proposed measures included time clocks to control portions of fixtures in various spaces as well as daylight dimming. During site visits, the facility staff noted these measures had not been implemented, which reduced their realization rates.

Short-Term Light Metering

Cadmus installed HOBO light meters at three facilities receiving incentives, including the project with the largest overall reported savings, and the project with the largest Custom Lighting reported savings. These two monitored projects reduced lighting power density in their manufacturing spaces and installed occupancy sensors. Cadmus installed meters for three weeks to more accurately characterize lighting operating hours as well as actual lighting power reductions achieved by the occupancy sensors. Table 21 shows results for all three projects.

Table 21. Realization Rates for Metered Custom Lighting Projects

Project	Reported Electric Savings (kWh)	Calculated Electric Savings (kWh)	Electric Savings Realization Rate
ETONB0837	1,320,191	1,244,882	94%
ETONB0811	501,891	415,044	83%
ETONB0824	308,974	308,437	100%
Total	2,131,056	1,968,363	92%

In each case, Cadmus was able to refine the average operating hours parameter used in the energy savings calculations. The on-site verification also resulted in adjustments to space allotments and baseline LPD on project ETONB0811. The metering data indicated occupancy sensor savings were equal to: 15% of the LPD reduction savings for ETONB0837, and 16% of the LPD reduction savings for ETONB0824.

Manufacturing Lighting Power Density

Six Custom Lighting projects received incentives for manufacturing spaces, which were exempt from LPD requirements under state code.[12] However, the Oregon Business Energy Tax Credit program considered a standard practice of 2.1 Watts per square foot for the maximum allowable LPD. Cadmus considered that value a reasonable baseline, and it was used to calculate energy savings and incentives for all manufacturing spaces on New Buildings projects.

Custom Motors

Custom Motors measures primarily involved ECM motors for refrigeration measures and VSDs for non-HVAC systems. Cadmus reviewed calculation sheets and data provided by participants and contractors. Cadmus determined the methodology and reported values were reasonable for seven of the nine measures in this category; their realization rate was 100%.

However, Cadmus noted issues with the two largest measures—both VSD installations for project ETONB0836, which reduced the category's overall realization rate to 34%. One measure involved VSDs installed on 150 hp chilled water pumps. Cadmus determined no savings were achieved for this measure because the 2004 Structural Specialty Code for Oregon stipulated all variable pumping systems would have VSDs for motors over 10 HP.[13] Cadmus discussed the

[12] Oregon Structural Special Code, Energy Conservation, Section 1317.10.3.1 (Page 354, Footnote 1).
[13] Oregon Structural Special Code, Energy Conservation, Section 1317.10.3.1 (Page 244R.16).

issue with the project's design engineer, who claimed to be unaware this measure was required by code.

For the other measure, the participant installed three induced draft cooling towers with VSDs. The cooling towers had two cells, each with a 20 hp fan motor. Reported annual savings were 199,521 kWh. The base case was defined by the 2004 Oregon Structural Specialty Code as a two-speed motor. Cadmus confirmed the installation of the cooling towers and VSDs, and performed short-term metering on energy consumption of two cooling towers for one month. Based on metered data, Cadmus determined the cooling towers consistently operated at nearly a full load, negating most VSD benefits. Resulting savings were only 3,551 kWh per year, for a 1.8% realization rate.

Custom HVAC

The Custom HVAC measures represented a variety of applications, including: water-source heat pump systems, condensing boilers, radiant heating systems, and other innovative HVAC technologies. These measures proved considerably difficult to analyze due to the systems' complexity, weather dependence, and interaction factors with the building envelope and other mechanical systems. Cadmus evaluated these projects through: short-term metering of system parameters; review of the design engineer's calculations; and/or building simulation models. The resulting realization rate was 48%. A number of specific issues related to these measures are explored below.

Radiant Heating

Project ETONB0818, a hospital, installed radiant heating in a new waiting room. The heating measure consisted of an under-floor system to allow lowering the delivery temperature of hot water, thus saving space heating energy. Rather than a conventional, 72°F setting, the system was designed to keep occupants comfortable at 68°F. However, Cadmus found the facility's building management system set the radiant loop temperature at 72°F. Cadmus installed two HOBO temperature loggers to record two weeks of ambient temperature data in the waiting room. The data confirmed a 72°F set point. Consequently, no savings could be attributed to this measure, resulting in a savings reduction of 1,785 therms.

Calculation Error

Project ETONB0824, a manufacturing facility, installed an innovative HVAC system for the production and office areas of a new building. This comprehensive measure had the single largest reported savings of any in the 2008 program population, at 1,864,772 kWh and 24,208 therms. A water-source heat pump loop was tied into waste heat from air compressors to offset the need for a boiler; heat from the loop was rejected through a chiller. The measure also included VSDs on economizer fans, cooling tower fans, and loop pumps.

Due to the system's complexity, Cadmus installed meters for one month for a sample of three heat pumps, three VSDs, and temperatures in various locations of the water-source loop. These data helped Cadmus better characterize the HVAC system's operation and interaction, particularly in response to ambient temperature conditions.

However, Cadmus found a significant discrepancy in the calculation spreadsheet used as the basis for reported savings. Neither the participant nor HVAC contractor retained an electronic version of the calculation spreadsheet; so Cadmus had to reconstitute the spreadsheet based on a scanned PDF file. Cadmus discovered a significant conversion error in the course of rebuilding the spreadsheet and examining relationships between cells. On the baseline and design HVAC system calculations, the participant converted annual electric usage from Watt-hours to kilowatt-hours by dividing by 100, rather than 1,000. During project review, the PMC either failed to note or did not correct the conversion error.

In addition, the participant accounted for water-source heat pump electric use during cooling, but not heating. Both issues reduced annual electric savings to 88,337 kWh, a 5% realization rate. This reduction was equal to 8% of total sample reported electric savings, and represented the single largest factor in the overall reduction in evaluated electric savings. However, Cadmus found the gas savings on this project were calculated relatively accurately, with a 100.3% realization rate. As a result, the overall project energy savings realization rate was 31%.

LEED Buildings

Cadmus conducted site visits for the six LEED-certified buildings in the evaluation sample. The field engineers completed an extensive data collection form to accurately characterize as-built parameters for mechanical equipment, lighting power density, and plug load density. The field engineers also interviewed the facility operations staff to gain a detailed understanding of building operations, occupied hours, and set points.

Cadmus provided the building characteristic data to HMG, the modeling subcontractor. HMG compared as-built building characteristics to values specified in the DOE-2 simulation model. Where possible, HMG also calibrated the models to actual electric and gas billing data. Project ETONB0848 involved an addition to an existing building, and only the addition was modeled. However, the utility billing data covered the entire facility. Therefore, this project could not be calibrated to billing data, and the original inputs were evaluated for reasonableness. Table 22 shows the resulting realization rates.

The adjustments Cadmus made to develop the calculated energy savings are discussed in the next two subsections.

Table 22. LEED Building Realization Rates

Project	Building Type	Reported Electric Savings (kWh)	Reported Gas Savings (therms)	Calculated Electric Savings (kWh)	Calculated Gas Savings (therms)	Electric Savings Realization Rate	Gas Savings Realization Rate
ETONB0807	Mixed use Residential	463,863	16,737	133,902	18,457	29%	110%
ETONB0821	Mixed use Residential	296,354	5,536	17,123	7,948	6%	144%
ETONB0825	Education	312,832	8,000	180,770	8,153	58%	102%
ETONB0828	Office	335,820	9,853	199,783	7,598	59%	77%
ETONB0847	Education	370,101	7,259	336,992	6,533	91%	90%
ETONB0848	Lodging	107,599	23,475	16,824	22,799	16%	97%
Total		1,886,569	70,860	885,392	71,489	47%	101%

Calculation Methodologies

Two methods were used to calculate LEED project savings. For five of the six sample projects, energy savings were calculated as the difference in annual energy use between the baseline and counterfactual models. These energy savings were relative to the ASHRAE 90.1-2004 standard, the required standard for establishing LEED EAc1 points. The program implementer degraded energy savings by 5% to convert from a baseline of ASHRAE 90.1-2004 to the 2007 Oregon Structural Specialty Code. Cadmus determined the 5% conversion factor was a reasonable value. Cadmus confirmed the value by interpolating research performed by Architecture 2030,[14] which estimated the "2030 Challenge Code" would save 30% more energy than ASHRAE 90.1-2004 and 25% more energy than Oregon code. The difference between the two codes results in a 5% reduction from ASHRAE 90.1-2004.

However, the new program implementer, PECI, noted the code conversion factor should be applied to the baseline energy use. Cadmus confirmed the previous implementer incorrectly applied the 5% conversion factor to energy savings instead of the baseline energy use. Cadmus evaluated the sample energy savings by applying the code conversion factor to baseline energy use. The difference in methodology resulted in an overall reduction of four percentage points in the estimated electricity savings realization rate and a three percentage point reduction in the gas savings realization rate for the five sample projects that were analyzed using the simulation model approach, as shown in Table 23.

[14] "Meeting the 2030 Challenge Through Building Codes," Architecture 2030, June 20, 2008.

Table 23. Impact of Corrected Application of Savings Conversion Factor

Project	Code Conversion Factor Applied to	Calculated Electric Savings (kWh)	Calculated Gas Savings (therms)	Electric Savings Realization Rate	Gas Savings Realization Rate
ETONB0807	Energy Savings	221,139	21,537	48%	129%
	Baseline	133,902	18,457	29%	110%
ETONB0821	Energy Savings	55,699	10,523	19%	190%
	Baseline	17,123	7,948	6%	144%
ETONB0825	Energy Savings	262,811	9,227	84%	115%
	Baseline	180,770	8,153	58%	102%
ETONB0847	Energy Savings	379,469	7,929	103%	109%
	Baseline	336,992	6,533	91%	90%
ETONB0848	Energy Savings	48,843	24,178	45%	103%
	Baseline	16,824	22,799	16%	97%
Total	Energy Savings	967,961	73,395	51%	104%
	Baseline	885,392	71,489	47%	101%

For project ETONB0828, the implementer compiled energy use intensity (EUI) values from PGE post-1985 data for a selection of buildings. For the LEED project calculations, the building spaces were defined by their use and percentage of the overall building area. The baseline EUI was set 10% below the PGE data. The “energy budget” building energy use was reduced from PGE baseline data by the percentage of savings estimated through the LEED points for Energy and Atmosphere Credit 1 (EAc1). Energy savings were calculated as the difference between annual baseline and budgeted energy use. This methodology did not accurately characterize energy savings and operation conditions, and project ETONB0828 achieved the second lowest realization rate of the six projects on a total energy (MBtu) basis.

Discrepancies Between the Modeled and As-Built Project

Energy savings were also adjusted due to significant differences between the simulation model and as-built structure. One significant weakness with LEED NC v2.2 (and the prior LEED versions) was a lack of accountability for construction of energy-efficient measures. A developer could design a highly energy-efficient building and receive the appropriate number of EAc1 credits, but not be required to actually construct the green features and systems. There was no mechanism for tracking as-built energy use to confirm a building continued to meet LEED specifications.[15]

These issues were reflected in the evaluated sample, as two examples will illustrate. The simulation model for project ETONB0828 included overhangs on the east and west faces to reduce solar gain through windows, but these were not present in the as-built structure. Project ETONB0825 used daylight dimming to reduce lighting energy in the simulation model, but the

[15] This issue may be addressed by LEED v3, which requires all certified projects to commit to sharing whole-building energy usage data with USGBC for a period of five years after occupancy.

building owner did not actually install that system. In many cases, as-built lighting power densities differed from those indicated in the simulation model.

Another significant issue involved changes to space uses, particularly the addition of server rooms in all nonresidential projects. Server rooms introduce a large plug load, coupled with significant residual heat. These spaces typically require dedicated cooling systems. While some server rooms were included in simulation models, Cadmus determined the model's power density underrepresented actual power use. For example, project ETONB0828 modeled a server room with consistent demand of 2 kW. The participant's control system indicated demand was actually 14 kW, much more than the participant originally anticipated. On this project, the server room's original dedicated air conditioning unit performed inadequately, and was replaced by two larger units. In general, electric savings were reduced by the required additional cooling load for increased computing power.

A final issue involved the effects of unfavorable economic conditions. The as-built projects maintained a lower rate of occupancy, either because retail spaces in a mixed-use residential tower was not leased, or an office was partially vacant due to reduced economic activity. The HVAC set points and lighting for these spaces were set to the unoccupied condition, which reduced overall energy use for the baseline and budget models. Therefore, energy savings were slightly lessened by the reduction in overall energy use.

Extrapolation to the Program Population

The final step in the realization rate analysis was extrapolating the sample findings to the 2008 program population. Cadmus divided the total program population into the same measure categories identified for the sample. Cadmus then calculated total savings per category by multiplying evaluated realization rates by total reported savings. These values were summed to determine the total adjusted evaluated savings and program-level realization rates, as shown in Table 24.

Table 24. Program Level Electric and Gas Savings

Measure Category	Total Number of Measures	Reported Electric Savings (kWh)	Reported Gas Savings (therms)	Ex Post Electric Savings	Ex Post Gas Savings	Electric Savings Realization Rate	Gas Savings Realization Rate
Standard Lighting	546	6,731,354	0	8,126,552	-	121%	-
Standard Motors	62	1,922,886	0	1,825,995	-	95%	-
Standard HVAC	245	1,025,395	77,860	1,091,095	92,427	106%	119%
Standard Other	56	141,343	58,090	121,344	36,858	86%	63%
Custom	64	4,454,088	116,881	4,102,231	84,274	92%	72%
Custom Gas	10	0	58,191	-	55,583	-	96%
Custom HVAC	13	3,319,194	51,034	672,075	47,228	20%	93%
Custom Lighting	52	10,961,855	0	10,205,862	-	93%	-
Custom Motor	10	1,443,220	0	493,283	-	34%	-
LEED	15	3,138,759	102,849	1,473,062	103,761	47%	101%
Total	1,073	33,138,094	464,905	28,111,498	420,132	85%	90%

Cadmus used the total of measure-level summary results to determine overall electric, gas, and total energy realization rates, indicated in Table 25.

Table 25. Program Level Realization Rates

Fuel Type	Realization Rate
Electric (kWh)	85%
Gas (therms)	90%
Total Energy (Mbtu)	86%

Sample Energy Use Intensity

Cadmus also examined the sampled projects' EUI by examining buildings' area in square feet and utility billing data for gas and electric usage. Six projects were not examined as they comprised a portion of a much larger facility. In those cases, neither overall square footage nor utility data from all meters were available, and thus would not provide a meaningful comparison source.

Table 26 shows EUI data for the 42 remaining projects.

Cadmus found the majority of Mercantile projects were grocery stores with relatively large refrigeration and water heating loads, and, therefore, larger EUIs. Buildings categorized as Other were generally manufacturing facilities. Cadmus assigned building types based on the predominant use in situations where a building had multiple functions. For example, project ETONB0847, divided by space into 60% classrooms and 40% offices, was classified as Education. Appendix A contains additional EUI data for comparison purposes.

Table 26. EUIs for Evaluation Sample Buildings

Project	Building Type	Area (sf)	EUI (kWh/sf)	EUI (therms/sf)	EUI (kBtu/sf)
ETONB0801	Education	94,780	14.0	0.72	120.0
ETONB0802	Office	171,365	6.6	0.11	33.1
ETONB0803	Mixed use Residential	357,000	4.9	0.15	31.7
ETONB0804	Mixed use Residential	431,631	4.9	0.12	28.4
ETONB0805	Other	75,000	2.7	0.00	9.1
ETONB0806	Public Assembly	30,000	14.9	0.40	90.8
ETONB0807	Mixed use Residential	282,879	5.9	0.02	22.2
ETONB0808	Office	83,000	12.2	0.18	59.9
ETONB0809	Mercantile (Retail Other Than Mall)	39,000	17.7	0.20	80.1
ETONB0810	Other	129,639	2.0	0.29	36.2
ETONB0811	Other	64,000	18.3	0.14	76.7
ETONB0812	Mercantile (Retail Other Than Mall)	172,604	24.8	0.40	124.6
ETONB0813	Mercantile (Retail Other Than Mall)	172,813	18.2	0.31	93.1
ETONB0814	Mercantile (Retail Other Than Mall)	172,264	27.5	0.46	139.5
ETONB0815	Mercantile (Retail Other Than Mall)	124,491	30.0	0.25	127.8
ETONB0816	Mercantile (Retail Other Than Mall)	69,000	13.9	0.13	60.9
ETONB0817	Lodging	45,573	10.5	0.49	84.4
ETONB0819	Other	80,000	5.1	0.16	33.4
ETONB0821	Mixed use Residential	110,000	8.6	0.14	43.2
ETONB0822	Other	215,000	51.9	0.00	177.0
ETONB0823	Mercantile (Retail Other Than Mall)	52,000	39.2	1.16	249.8
ETONB0825	Office	104,000	10.4	0.38	73.9
ETONB0826	Mercantile (Retail Other Than Mall)	32,154	54.1	0.95	279.5
ETONB0827	Mercantile (Retail Other Than Mall)	44,100	48.9	1.15	281.4
ETONB0828	Office	100,953	25.6	0.16	103.5
ETONB0829	Public Assembly	56,000	6.8	1.59	181.8
ETONB0830	Mercantile (Retail Other Than Mall)	37,870	43.6	1.16	265.2
ETONB0831	Mercantile (Retail Other Than Mall)	56,102	46.9	0.96	255.8
ETONB0832	Mercantile (Retail Other Than Mall)	57,000	43.6	1.30	278.8
ETONB0833	Mercantile (Retail Other Than Mall)	45,256	42.9	1.14	260.3
ETONB0834	Mercantile (Retail Other Than Mall)	41,729	54.3	0.71	256.7
ETONB0835	Mercantile (Retail Other Than Mall)	55,000	47.4	1.06	267.6
ETONB0837	Other	208,840	10.9	0.14	50.9
ETONB0839	Mercantile (Retail Other Than Mall)	78,000	42.2	0.15	158.9
ETONB0840	Other	36,000	29.2	0.60	159.5
ETONB0841	Mercantile (Retail Other Than Mall)	45,687	54.6	1.25	311.4
ETONB0842	Mixed use Residential	45,000	4.7	0.20	36.0
ETONB0843	Mixed use Residential	340,000	4.3	0.09	23.2
ETONB0844	Mixed use Residential	560,000	3.6	0.10	22.2
ETONB0845	Mercantile (Retail Other Than Mall)	64,778	13.8	0.09	55.9
ETONB0846	Other	239,178	1.4	0.00	4.9
ETONB0847	Education	152,728	7.9	0.15	42.3

Conclusions and Recommendations

Cadmus conducted an impact evaluation of the 2008 ETO New Buildings Program by analyzing energy savings for 330 measures in 48 projects. The measures belonged to three different program tracks (Standard, Custom, and LEED) and represented a wide variety of subcategories. Cadmus performed verification site visits for each project. Cadmus 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.

Appropriate methodologies and assumptions were applied for many measures, and the reported energy savings were reasonable. However, a significant minority of measures included incorrect assumptions, methodologies, equipment counts, or calculation errors, which reduced program-level realization rate to 86%.

Cadmus identified a number of areas for program improvement. The most significant factor would involve the PMC applying increased scrutiny to measure calculations and code requirements. We also determined several measures were inappropriate for the track through which they were processed. Cadmus also noted process issues that could improve future evaluation efforts. These potential improvements are reflected in the following recommendations.

Perform Quality Control on Custom Projects

Cadmus noted several minor errors in calculation spreadsheets used to determine Custom project energy savings. One major, but easily identifiable, conversion error also occurred in a project's calculation spreadsheet, which reduced the program-level electric savings realization rate by 8%. As the PMC receives copies of the participant or contractor's calculation spreadsheets to determine the accuracy of savings calculations, Cadmus recommends the PMC provide adequate scrutiny of calculation spreadsheets to identify any obvious mistakes, such as conversion errors. In addition, the PMC should consider whether the calculation methodology and assumptions are reasonably appropriate.

Cadmus understands a high level of scrutiny is not feasible for each measure and project, which results in expected levels of minor errors. Cadmus recommends the PMC provide a second review of savings calculations for projects exceeding a relatively high savings threshold, such as 1,000,000 kWh or 20,000 therms. For the 2008 sample, this would have included nine projects with Custom Track measures out of a total of 224. However, calculation errors and incorrect assumptions for these nine large projects had a disproportionate effect on the overall sample.

Confirm Measure Requirements Relative to State Code

Cadmus identified four motor measures, primarily VSDs, which received incentives although required under code. Cadmus could not attribute any savings for these four measures as they did not exceed code requirements, resulting in a 805,310 kWh reduction in electric savings. Cadmus recommends the PMC maintain awareness of all relevant code requirements, particularly given the new 2010 Oregon Structural Specialty Code.

Remove Incentives for LED Exit Signs

As noted in the Standard Lighting results section, LED Exit Signs became standard practice after EPAct 2005 eliminated the U.S. manufacture of exit signs with usage exceeding 5 Watts per face. Though this measure remains viable for existing buildings, it is not appropriate for a new construction program. Cadmus recommends ETO no longer provide incentives for this measure.

Move DCV Projects to the Custom Track

DCV projects currently are treated as prescriptive measures through the Standard Track, with the incentive based on ventilation system CFM. However, DCV calculations involve a significant number of variables, including: specific details of heating and cooling equipment; ventilation fan size; equivalent full load hours for all HVAC equipment; fractions of occupancy for controlled spaces; and whether systems include heat recovery.

DCV measures Cadmus evaluated in the sample revealed reported savings significantly understated achieved savings. In one case, the PMC did not report electric savings, although ventilation fan reduction was a principal component of DCV energy reduction. Cadmus calculated realization rates in the range of 400% to 2,100%, which indicates significant issues with the methodology the Standard Track used to define savings. Cadmus recommends treating each DCV measure as a Custom project, with savings based on appropriate variables unique to each system. Revising the analysis method should result in significantly increased energy savings from these measures.

Maintain ENERGY STAR Appliance Measures in the Standard Track

In the evaluated sample, Cadmus identified seven Custom measures that were ENERGY STAR appliances. Similar ENERGY STAR appliances were also processed through the Standard Track. The measures are more appropriate for the Standard Track's prescriptive approach, particularly considering the ease of application involved with on-line ENERGY STAR calculators. Cadmus recommends all ENERGY STAR appliances be incented through the Standard Track.

Segregate Prescriptive and Custom Lighting

Cadmus found project ETONB030 received incentives for a prescriptive lighting measure through the Standard Track as well as incentives for reductions in lighting power density through the Custom Track. The prescriptive lighting measure was installed in the same space used to determine the reduction in lighting power density. Therefore, this measure was double-counted, and the participant received twice the appropriate incentive. Cadmus recommends this type of measure only be evaluated as a reduction in lighting power density through the Custom Track, with no prescriptive incentives provided.

Maintain Consistency Among Custom Subcategory Measures

The PMC assigned identical Custom Track measures to various subcategories. For example, VSDs and high-efficiency refrigeration case motors could be found in both the Custom and Custom Motor subcategories, and discharge heat reclaim could be found in both Custom and Custom Gas. Cadmus recommends consistent labeling to help the PMC and evaluator understand basic measure characteristics without requiring extensive documentation review. This would also allow more granularity in refining measure-level realization rates and extrapolating those values to program-level savings.

Require Building Simulation Model Contractors to Sign Release Forms

Cadmus and its subcontractor, HMG, used DOE-2 software to evaluate energy simulation models for LEED buildings and a subset of the Custom projects. This required Cadmus to contact participants and building simulation model contractors to obtain the original models used to calculate savings. Though a time-consuming task, almost all modeling contractors complied. However, the engineering firm that developed the model for the highest-saving LEED project refused to comply, without citing any reasonable justification. This firm also developed the model for at least one of the highest-saving 2009 program LEED buildings.

Cadmus recommends ETO require building simulation model developers sign a consent form, releasing the model for evaluation purposes, as a requirement for LEED Track incentives. This will improve the likelihood that a project can be evaluated. ETO or the PMC may also consider obtaining and storing relevant electronic simulation models during each program year to reduce the time required to contact and obtain models during the evaluation process.

Retain PMC Electronic Files During Transitions

ETO replaced SAIC as the New Buildings Program PMC after the 2008 program year. SAIC printed out copies of all electronic files and email correspondence, and provided these files to ETO. For evaluation purposes, ETO scanned the paper files for relevant projects, and provided these to Cadmus. The PDF files were unlabeled and in no particular order, which significantly increased the time and effort necessary to conduct the evaluation. It also increased the risk that particularly relevant information could be overlooked in a single page of a lengthy, but seemingly unrelated, PDF file.

Cadmus recommends that during PMC transitions, ETO should attempt to retain all electronic files obtained by the implementation contractor during the program period. This is particularly important for calculation spreadsheets, which represent the most critical aspect of impact evaluation analysis. This should streamline the impact evaluation process, and improve the precision of results.

Appendix A: Comparison Energy Use Intensity Data

The EUI data for the FY 2008 sample from Table 26 can be compared with other available data to determine the relative performance of these new constructions projects. Several example data sets are presented in the tables below.

Table 27. PGE Data for Post-1985 Buildings[16]

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

[16] ETO FY2008 program savings calculation spreadsheet, "2005398 01 18 2008 River East Center Form 520L 540L Final.xls"

Table 28. Ecotope Mean EUI Data for Buildings with Majority New Construction in Oregon, 2002-2004[17]

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

Grocery stores represented the largest segment of the FY 2008 sample, represented under the category "Mercantile (Retail Other Than Mall)." These projects are broken out from the category sample in Table 29 below for comparison purposes.

Table 29. FY2008 Grocery Store EUIs

Grocery Project	EUI (kBtu/sf)
ETONB0823	195.3
ETONB0826	411.1
ETONB0827	248.1
ETONB0830	247.3
ETONB0831	294.1
ETONB0832	291.2
ETONB0833	336.6
ETONB0834	310.5
ETONB0835	313.6
ETONB0839	208.7
ETONB0841	326.5
Average	289.4

[17] Ecotope, "Baseline Energy Use Index of the 2002-2004 Nonresidential Sector: Idaho, Montana, Oregon, and Washington," Table A-11, December 2008