CADMUS

2017 New Buildings Program Impact Evaluation

May 31, 2020

Prepared for:

Energy Trust of Oregon

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List of Acronyms

ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
Btu	British thermal unit
CBECS	Commercial Building Energy Consumption Survey
CBSA	Commercial Building Stock Assessment
CFL	Compact fluorescent lamp
CV	Coefficient of variation
DOE	Department of Energy
DSM	Demand-side management
DVC	Demand controlled ventilation
EEM	Energy efficiency measure
EERE	Energy efficiency and renewable energy
EMS	Emergency management system
EUI	Energy use intensity
GSHP	Ground source heat pump system
HVAC	Heating, ventilation, and air conditioning
IPMVP	International Performance Measurement and Verification Protocol
kBtu	1,000 British thermal units
kWh	Kilowatt-hour
LED	Light-emitting diode
LEED	Leadership in Energy and Environmental Design
LPD	Lighting power density
M&V	Measurement and verification
MAD	Measure approval document
MMBtu	One million British thermal units
NEEA	Northwest Energy Efficiency Alliance
TRACE	Tool for Rapid Assessment of City Energy

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MEMO

Date: June 5, 2020
To: Board of Directors
From: Jay Olson, Senior Program Manager, Commercial
Dan Rubado, Evaluation Project Manager
Subject: Staff Response to 2017 New Buildings Impact Evaluation

The 2017 New Buildings impact evaluation conducted by Cadmus found high electric and gas realization rates (98% and 92%, respectively), showing the program continues to accurately claim savings for most projects and conduct a reasonable level of engineering review and quality control. Large adjustments that brought down the overall realization rates were concentrated in the retail, grocery and multifamily sectors. Hot water measures had lower than average realization rates, including faucet aerators, showerheads and water heaters, due to differing installed quantities, efficiency ratings and water usage. Refrigeration measures also had relatively low realization rates, particularly cooler doors, where a measure with an existing construction baseline was used for part of the year before being updated later in the year. In addition, several whole building and custom pool projects realized lower gas savings than expected, primarily due to higher than expected gas loads.

Although the program has improved its project documentation and QC processes, a few small issues remain where Cadmus provided recommendations for small potential improvements, which the Program is considering. These include:

- Ensuring only the final energy models are included in project documentation and verifying they support the savings being claimed
- Documenting all measure qualification criteria in project files for prescriptive measures and Market Solutions projects, and citing the Measure Approval Document version used
- Obtaining as-built mechanical construction documents, equipment schedules and HVAC controls documentation and including them in project files
- Checking custom lighting calculations against a reasonable proxy when no code provision exists

In addition, the findings of this evaluation indicate the removal and substitution of low flow water devices poses an ongoing moderate level of risk to the program's gas savings. These findings are consistent with a trend seen in several previous program impact evaluations. We believe further investigation is needed to understand when and why low flow devices are removed and put processes in place to preserve these savings and improve gas realization rates.

Cadmus also recommended discontinuing incentives for new, remote, medium temperature refrigerated cases because these cases almost always have doors. Cadmus also evaluated many large buildings with Energy Management Systems (EMS's) where trended equipment operation data would have been invaluable but was not available because trending had not been enabled. Cadmus recommended the program do more to encourage participants and facility operators to enable EMS data trends. This will allow future evaluators to more accurately assess building operations and energy savings, especially for whole building project using energy simulation models.

Executive Summary

Energy Trust of Oregon (Energy Trust) retained Cadmus to complete an impact evaluation of the 2017 New Buildings program, a comprehensive effort to help owners of newly constructed or substantially renovated commercial and industrial buildings achieve energy savings through these different tracks:

- **Data Center:** Offers customers incentives specifically focused on improving data center design, construction, and operation.
- **Market Solutions:** Offers customers with Good, Better, Best, and Very Best packages of measures specific to different building types using workbooks based on pre-modeled prototype buildings to calculate energy savings and incentives.
- **System-Based:** Offers a combination of individually selected prescriptive and custom-calculated measures to quantify savings and incentives for individual systems within a building.
- **Whole-Building:** Offers custom building simulation models developed by approved program allies to quantify whole-building and measure-level energy savings.
    - **Path to Net Zero:** A part of the whole-building track, this path offers opportunities to designers and developers to achieve net zero energy use. These projects are unique because of their aggressive goals and use of on-site renewables.

A third-party program management contractor, CLEAResult, implemented the 2017 New Buildings program. Cadmus evaluated the program through site visits and reviews of engineering calculations and building simulation models. During site visits, we validated the proper installation and functioning of equipment for which incentives were provided and recorded operational characteristics data to support our engineering analysis. Cadmus evaluated the Standard Track measures primarily using industry-standard algorithms and the Custom Track measures through algorithms, detailed calculation spreadsheet reviews, simulation modeling, and energy management system (EMS) trend data. Cadmus engineers analyzed the differences between baseline and as-built simulation models for Leadership in Energy and Environmental Design (LEED) and custom whole building projects. Through this impact evaluation, we identified various factors that reduced the overall program realization rate (the ratio of evaluated to reported savings). Savings values listed in the impact evaluation are gross values. Calculation of a net-to-gross ratio fell outside the scope of this evaluation.

The reported program total savings were 43,009,127 kWh and 724,767 therms. The evaluation verified program total savings of 42,338,522 kWh for a 98% overall electric savings realization rate and 668,879 therms for a 92% natural gas savings realization rate. Realization rates were high for most measure types and the program total energy savings were primarily reduced from 100% due to evaluation adjustments to reported energy savings at grocery and retail buildings (mainly refrigeration measures), as well as some custom HVAC projects in various building types. Adjustments included the following:

- Observed equipment quantities differed from reported quantities.
- Some incentivized equipment did not meet program requirements.

- Evaluated equipment operation differed from the patterns expected and used to develop deemed savings estimates—usually either due to differences in as-built energy consumption or different applications than assumed for deemed savings.
- Building simulation model calibration determined that as-built conditions and operating parameters varied from as-designed expectations.

Overall, the 2017 program implementer performed a reasonable level of review and quality control to achieve high average project savings and realization rates. The measure types with lower evaluated savings represented large, complex measures with final operating patterns that can be difficult to predict, particularly in a new construction application. The implementer's efforts to streamline and improve the program's delivery mechanisms appear to have been effective.

Cadmus' key objective for the 2017 New Buildings program evaluation was to estimate program total gross electricity and natural gas savings, each with better than ±10% precision at 90% confidence, as well as total gross savings directly attributable to each building type with ±20% precision at 90% confidence. Cadmus achieved this by evaluating 86 projects at distinct sites from the 2017 program population, where we sampled projects using a stratified sample design with building type strata.[1] Using evaluated project data, we estimated the population total savings and realization rates shown in Table 1 for both fuel types with better than ±5% precision overall and better than ±10% precision within building type on average, exceeding the confidence and precision targets of the evaluation. Throughout the remainder of this report, we present evaluation findings by fuel type as well as building type, project track, and measure category.

Table 1. Evaluated Savings by Building Type

Building Type	Count of Sites Evaluated	Electricity Savings		Gas Savings		Realization Rate	
		Reported (kWh)	Evaluated (kWh)	Reported (therms)	Evaluated (therms)	Electricity Savings	Gas Savings
Assisted Living Property	5	2,528,420	2,601,194	56,608	51,440	103%	91%
Education	10	1,509,216	1,504,938	90,721	92,886	100%	102%
Grocery	6	1,977,119	1,656,253	31,816	22,485	84%	71%
Lodging/Hotel/Motel	7	276,268	276,357	80,485	79,041	100%	98%
Manufacturing/Food Processing	5	3,839,002	3,835,630	8,918	8,918	100%	100%
Multifamily Property	7	11,422,863	11,806,180	261,814	227,717	103%	87%
Office	12	3,133,459	3,013,767	23,699	23,700	96%	100%
Other	13	7,549,940	7,843,333	93,473	82,423	104%	88%
Restaurant	5	232,577	232,559	50,561	60,473	100%	120%
Retail	12	3,453,843	2,791,895	17,397	11,236	81%	65%
Warehousing and Storage	4	7,086,420	6,776,415	9,276	8,561	96%	92%
Total[a]	**86**	**43,009,127**	**42,338,522**	**724,767**	**668,879**	**98%**	**92%**

[1] Although the target sample size was n=88, two sampled participants refused a site visit.

[a] Totals may not match due to rounding.

Table 2. provides the evaluated savings by project track and Table 3 by measure category. These tables describe the magnitude of adjustments made to reported savings for each project or measure category that contributed to the electric and natural gas savings realization rate for the program. There was one Data Center track project in the program population, which was not included in the evaluation sample.

Table 2. Evaluated Savings by Project Track

Track	Count Projects Evaluated	Electricity Savings		Gas Savings		Realization Rate	
		Reported (kWh)	Evaluated (kWh)	Reported (therms)	Evaluated (therms)	Electricity Savings	Gas Savings
Market Solutions	14	9,169,923	9,140,014	155,314	135,903	100%	88%
System Based	64	28,331,626	27,604,475	463,652	435,812	97%	94%
Whole Building	8	5,057,004	5,125,950	105,801	97,164	101%	92%
Total[a]	**86**	**43,009,127**	**42,338,522**	**724,767**	**668,879**	**98%**	**92%**

[a] Totals may not match due to rounding.

Table 3. Evaluated Savings by Measure Category

Measure Category	Count Measures Evaluated	Electricity Savings		Gas Savings		Realization Rate	
		Reported (kWh)	Evaluated (kWh)	Reported (therms)	Evaluated (therms)	Electricity Savings	**Gas Savings**
Food Service and Appliance	53	579,548	586,066	83,703	88,621	101%	106%
HVAC	30	3,788,059	3,903,581	69,847	66,936	103%	96%
HVAC - Custom	23	4,257,173	4,393,508	119,906	112,420	103%	94%
Lighting	107	23,707,607	23,028,137	(1,719)	(1,496)	97%	87%
Lighting - Custom	6	995,514	1,027,443	-	-	103%	N/A
Market Solutions	32	1,994,005	2,006,125	24,243	21,435	101%	88%
New Construction	5	1,340,309	1,296,813	7,029	7,197	97%	102%
Other - Custom	19	2,368,371	2,437,058	40,704	37,688	103%	93%
Refrigeration	46	2,036,946	1,709,978	37,778	26,592	84%	70%
Refrigeration - Custom	8	245,825	203,832	-	-	83%	N/A
Water Heating	112	1,464,583	1,506,998	341,865	308,574	103%	90%
Weatherization - Custom	1	231,186	238,984	1,412	912	103%	65%
Total[a]	**442**	**43,009,127**	**42,338,522**	**724,767**	**668,879**	**98%**	**92%**

[a] Totals may not match due to rounding.

Methodology

Cadmus evaluated the 2017 New Buildings program through site visits; phone interviews; and reviews of program assumptions, project documentation, engineering calculations, and building simulation models. We performed verification site visits for 74 projects and desk reviews, including phone verifications, for 12 projects in the sample. We used these data to evaluate 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 savings calculation, calculation spreadsheets, and building simulation models.

During site visits conducted between July and October, 2019, we validated the proper installation and functioning of incentivized equipment and recorded operational characteristics data to support our engineering analysis. Cadmus evaluated the Standard Track measures primarily using Measure Approval Documents (MADs) and lighting calculation workbooks. We evaluated measures installed in the Custom Track through detailed calculation spreadsheet reviews, simulation modeling, and energy management system (EMS) trend data. We analyzed the differences between baseline and as-built simulation models for whole building custom measures and Leadership in Energy and Environmental Design (LEED) projects. Through this impact evaluation, we identified a variety of factors that reduced the overall program realization rate (the ratio of evaluated to reported savings). Savings values listed in the impact evaluation are gross values. Calculation of a net-to-gross ratio fell outside the scope of this evaluation.

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

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

- Sample development
- Documentation Review
- Data collection
- Engineering analysis
- Calibrated simulation analysis

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

Sample Development

Cadmus employed stratified random sampling to select sites for the evaluation. Table 4 provides an overview of the building type strata, population of sites, and sample sizes. We selected the 10 building

types that each account for 5%[2] or more of the program total electric and gas savings. These building types represented 82% of total electric savings and 87% of total gas savings. We pooled the remaining building types into the "other" category. In each stratum, we calculated the sample size to meet 90% confidence and ±20% precision targets within each building type, and better than 90% confidence and ±10% precision for the program overall. We used a coefficient of variation (CV) specific to each building type, based on the measures and previous evaluations. For building types expected to have a broader mix of measures and heterogeneous evaluated savings, we assumed higher CV values.

Cadmus selected projects using probability proportional to size sampling in each stratum, where size refers to the reported savings estimate of each project. This approach resulted in selecting and evaluating projects that contributed more savings with higher probability and provided a highly accurate and precise estimate of the stratum-total and program-total evaluated savings. Cadmus verified that gas-only, electric-only, and dual-fuel projects were represented in the evaluation through additional stratification of projects. Within each building-type stratum, we sub-stratified projects into gas-only, electric-only, and dual-fuel saving projects. Within each of these substrata, we allocated the building-type sample size proportional to the percentage of reported savings (Btu) each fuel substratum contributed to the total savings within the building-type.

Table 4. Original Sampling Plan provides an overview of the population and the sample design, with the expected precision at 90% confidence. As shown in the table, some fuel-type substrata had sample sizes of zero.

[2] Electric and gas savings in the grocery segment were less than the 5% savings threshold, but we included grocery as a building-type stratum to ensure representation of the distinct characteristics and measures implemented in the sector (primarily refrigeration).

Table 4. Original Sampling Plan

Building Type	Population Size (Projects)				MMBTU				MMBTU %			Target Sample Size				Expected Precision @ 90% Confidence
	Total	Dual Fuel	Electric Only	Gas Only	Total	Dual Fuel	Electric Only	Gas Only	Dual Fuel	Electric Only	Gas Only	Total[d]	Dual Fuel	Electric Only	Gas Only	
Assisted Living Property	11	8	3	N/A	14,288	13,448	840	N/A	94%	6%	N/A	5	5	-	N/A	20%
Education	34	15	16	3	14,222	11,128	1,707	1,387	78%	12%	10%	10	8	1	1	20%
Grocery	14	9	5	N/A	9,928	9,266	662	N/A	93%	7%	N/A	6	6	-	N/A	<25%
Lodging/Hotel/Motel	13	9	2	2	8,991	7,323	481	1,187	81%	5%	13%	7	6	-	1	20%
Manufacturing/Food Processing[a]	24	5	19	N/A	13,991	1,480	12,511	N/A	11%	89%	N/A	5	1	4	N/A	20%
Multifamily Property[b]	77	44	32	1	65,158	50,509	14,561	88	78%	22%	0%	12	9	3	-	20%
Office	53	14	38	1	13,062	4,307	8,738	17	33%	67%	0%	10	3	7	-	<25%
Restaurant	51	20	15	16	5,850	4,090	199	1,560	70%	3%	27%	5	4	-	1	20%
Retail	45	12	31	2	13,525	5,098	8,229	197	38%	61%	1%	10	4	6	-	<25%
Warehousing and Storage	33	4	28	1	25,107	1,438	23,429	240	6%	93%	1%	5	0	5	-	20%
Other	113	44	64	5	35,109	16,778	17,318	1,013	48%	49%	3%	13	6	6	1	20%
Total[c]	**468**	**184**	**253**	**31**	**219,231**	**124,866**	**88,675**	**5,690**	**57%**	**40%**	**3%**	**88**	**52**	**32**	**4**	**<10%**

[a] The New Buildings program provides incentives for measures included in the construction of new industrial facilities that are not related to production processes. Energy Trust's Production Efficiency program provides incentives for efficient production processes and equipment and helps to maintain relationships with industrial customers

[b] Multifamily properties contained an average of 107 units.

[c] Stratum values may not sum to totals due to rounding.

[d] Although the total target sample size was n=88, two sampled sites refused a site visit.

Documentation Review

After identifying the impact evaluation sample (n=88), we requested the 2017 program activity data for each sampled project. We examined pertinent documentation for energy efficiency measure (EEM) data, scope of data, analysis methods, and building construction and operation details. These data helped our team determine the appropriate measurement and verification (M&V) methods for each site prior to developing the site-specific evaluation plan.

We reviewed information for all sampled sites, including program forms, the tracking database extract, audit reports, and savings calculation work papers for each rebated measure (if applicable). Our review examined each project file for the following information:

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

Analysis Approach

We selected one of the following the analysis methods for each site based on the project track and project complexity, typically applying the method that most closely aligned with CLEAResult's analysis approach:

- **Simple validation** for prescriptive measures and market solutions packages.
- **Engineering calculation models** for custom projects with spreadsheet calculated savings estimates.
- **Analysis of measurement and EMS data** (where available), in conjunction with engineering modeling or simulation modeling, to improve accuracy of results in custom project analyses.
- **Simulation model analysis** for sites with whole-building models, including Path to Net Zero.

Data Collection

Site-Specific Evaluation Plans and Data Collection Tools

Cadmus developed site-specific evaluation plans and determined the appropriate analysis and data collection methods for each building in the sample, based on its review of the project files. Sites with nonprescriptive measures had more detailed plans because they are, by nature, more complex.

Data Collection Methods

Cadmus' data collection methods included on-site verification, facility staff interviews (by phone or in person), emails to the participant, EMS trend data acquisition, or any combination of these approaches. We determined the appropriate M&V methods for each measure by reviewing the project files, measure mix, building type, building size, the project track for the measure, and the scale of reported savings.

International Performance Measurement and Verification Protocol (IPMVP)

Cadmus primarily used M&V methods established by the IPMVP.[3] This protocol was first published in 1996 to develop a consensus approach to measuring and verifying efficiency investments to overcome existing barriers to efficiency. The goal is to increase investment in energy efficiency and renewable energy (EERE) by increasing energy savings, reducing the cost of financing projects, and encouraging better project engineering. The protocol also helps to demonstrate and capture the value of reduced emissions from EERE investments and increase public understanding of energy management as a public policy tool. Finally, the IPMVP also helps national and industry organizations promote and achieve resource efficiency and environmental objectives. The IPMVP methods used to evaluate measure performance are:

- **Operational Verification**. Cadmus verified some prescriptive measures (particularly those with relatively small reported savings) on site or by phone to confirm that measures were installed in the reported quantity and operating in a manner consistent with deemed-savings assumptions.
- **IPMVP Option A: Key Parameter Measurement.** Under this method, Cadmus used engineering calculations and partial site measurements to verify savings from specific measures. We estimated parameters not measured.
- **IPMVP Option B: All Parameter Measurement.** Under this method, we used engineering calculations and ongoing site measurements to verify the savings resulting from the change in energy use.
- **IPMVP Option D: Calibrated Simulation.** Under this method, we employed computer energy simulation models to calculate savings as a function of key independent variables. The models included verified inputs that accurately characterized the system and were calibrated to monthly post-occupancy utility billing data.

Site Visits and Facility Operator Interviews

Cadmus conducted data-collection activities for three primary reasons: (1) to perform rigorous investigation during our site visits, (2) to fully explain discrepancies between expected and evaluated impacts, and (3) to provide insights to Energy Trust to improve reported savings.

[3] We excluded Option C, Whole Facility pre/post usage data analysis because this program applies to new buildings.

On-Site M&V

Cadmus conducted 86 site visits as outlined in the approved site-specific evaluation plans. We anticipated most prescriptive and small custom measures would only require site or phone verification because of the relatively small energy savings and the deemed measure approaches. For example, for projects involving lighting, we obtained the most accurate available estimate of operating hours based on posted hours or lighting control system parameters. Although we asked facility personnel about operating hours, we typically relied on posted hours or control system data because, in our experience, self-reported operating hours are often less consistent and reliable.

Most custom measures required detailed information for analysis based on the appropriate IPMVP option. Based on Energy Trust's feedback for the site-specific evaluation plan, we created a form for each measure and captured data on a specific measure or equipment type.

Cadmus developed a comprehensive data collection form for whole-building simulation model projects. Field staff used streamlined versions of the form for all evaluated projects, focusing on specific end uses when verifying individual measures at a site. During the site visits, our field engineers focused on these three primary tasks:

- **Verifying installation of all measures for which participants received incentives.** To the extent possible, field engineers verified that EEMs were correctly installed, remained in place, and functioned properly. They conducted spot measurements, collected EMS trend data, or made visual inspections, as appropriate. Field engineers also verified operating parameters for installed equipment.
- **Collecting the physical data required to analyze energy savings realized from installed measures.** Field engineers conducted in-depth reviews of project files to determine the pertinent data regarding counts and specification of the rebated equipment, site-specific conditions and operating hours, for collection from each site.
- **Conducting interviews with the facility operations staff** to confirm project documentation accuracy and to obtain additional data on operating characteristics for installed systems.

During several site visits, Cadmus field engineers noted equipment counts that differed from those for which incentives were provided. When we found fewer measures in place, we reduced the realization rates accordingly, and vice versa. We noted that the as-built equipment quantities may vary from design counts because of changes in building structures or space usage.

Interviews with Facility Personnel

For all sites included in the study, we talked to the staff involved with the project and familiar with facility operation. For projects not warranting an in-person visit, Cadmus conducted interviews via phone.

The purpose of the interviews was to confirm installation and functionality of all equipment, current occupancy or facility use, adjustments in control schemes, and other items significantly impacting

energy consumption. This allowed our team to further verify the accuracy of assumptions that relate to energy-savings calculations and re-calculate savings, as needed.

Impact Analysis

The impact analysis included multiple components:

- Site-level savings, realization rates, and descriptions of any adjusted parameters with rationale
- Program-level savings and realization rates, including savings breakdowns by sample stratum, measure category, and building type
- Building energy use intensity (EUI) calculations and comparisons
- Observations and recommendations for program improvements

We submitted site-level savings results for any projects with significant variance to Energy Trust for review and comment before initiating any program-level analysis. We acted on a case-by-case basis if the review determined further investigation was required. Once we finalized all site-level results, we estimated total program-level savings values using a savings-weighted expansion process.

Site-Level Analysis

Cadmus completed site-level analyses as outlined in the approved site-specific evaluation plans by means of simple validation, engineering calculation models, measurement analysis, or calibrated simulation modeling. Where appropriate, we used utility billing data to inform and calibrate our engineering approaches. Our analysis methods are described here:

- **Simple Validation.** Cadmus verified some prescriptive measures (particularly with relatively small reported savings) on site or by phone, confirming that they are installed in the reported quantity, using the appropriate fuel type, and operating in a manner consistent with measure approval documents (MADs) and Market Solutions workbooks. We also verified recorded nameplate efficiency data against manufacturer's specifications. If we confirmed these details, we accepted the reported savings without further investigation. If we identified inconsistencies, we adjusted savings based on the equipment and operating parameters found on site or based on the phone interview.
- **Engineering Calculation Models.** In many cases, CLEAResult or the installation contractor developed calculation spreadsheets to analyze energy savings for a variety of measures. Calculation spreadsheets require relevant parameter inputs such as quantity, fixture wattage, square footage, and efficiency value. The project files typically have engineering algorithms to estimate energy savings using these data. We reviewed input requirements, algorithms, and output estimates to determine if the approach was reasonable. Where applicable, we created or updated calculations using on-site verification data.
- **Analysis of Measurement and EMS Data (IPMVP Options A and B).** Cadmus estimated relevant operational parameters to inform engineering calculation models using EMS trend data. During the site visits, we confirmed key factors such as setpoints, sequence of operations, and

operating schedules. We estimated baseline energy performance based on program documentation, site conditions, facility interviews, and relevant energy code requirements.

- **Simulation Model Analysis (IPMVP Option D).** Cadmus' whole-building simulation approach entails the use of industry best-practice software such as eQuest and IES-VE, and follows methods recommended in the U.S. Department of Energy's (DOE's) M&V Guideline and ASHRAE Guideline 14.[4,5]

Simulation Model Analysis

After obtaining existing simulation models and documentation, we compared the code baseline and as-built models. For eQuest and IES-VE simulation models, we reviewed model inputs, outputs, and project documentation. We also tracked any errors or concerns, assumptions, or inputs verified on site and differences between the reported and evaluated model outputs. If we identified discrepancies, we updated the model as needed and began the calibration process. For some sites, we requested additional utility data from Energy Trust as the original dataset provided either had missing data points or data for different project sites.

Following the site visit, we input verified values and typical meteorological year weather data for the appropriate location and time period into the model, tested statistical calibration with the monthly utility data, targeted a monthly accuracy within a mean bias error of ±5% and a coefficient of variation root mean square error of ±15% per ASHRAE Guideline 14. If the analysis did not meet this target, we further reviewed graphical analysis results and made improvements based on engineering judgment where we identified anomalies. We also accounted for fluctuations such as those from building commissioning or first-year occupancy changes in our analysis.

We developed the baseline model, ensuring that only appropriate changes existed compared to the as-built model and that the model met any measure stipulations, such as code requirements. Finally, we determined savings by comparing results from the calibrated typical year as-built and baseline models. We input the results of the baseline and proposed models, as well as the results from any EEM-specific models or parametric runs, into the Savings Summary Workbook to calculate the adjusted measure-level savings for each EEM.

Program Savings

Cadmus calculated population-level realization rates and savings based on the realization rates, evaluated savings, and reported savings observed for all evaluated projects in the sample. Cadmus developed and applied stratified sampling weights based on the probability of selecting each sampled

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[4] U.S. DOE. 2015. *M&V Guidelines: Measurement and Verification for Performance-Based Contracts Version 4.0.* https://www.energy.gov/sites/prod/files/2016

[5] ASHRAE. 2014. *Guideline 14-2014 -- Measurement of Energy, Demand, and Water Savings.*

project within building type strata and fuel-type substrata, and applied the sampling weights to evaluated projects to estimate population-level metrics.

Cadmus estimated evaluated savings and realization rates for the program population and different subpopulations using the following steps:

Step 1. We calculated sampling weights for each project within each building-type stratum as a function of the probability of selection to account for the probability proportional to size sampling approach.

Step 2. We estimated weighted realization rates within each building-type stratum by applying project-level sampling weights to evaluated and reported savings.

Step 3. We applied the weighted realization rates to the project population in each stratum to estimate evaluated savings for all projects. The same realization rate was applied to all measures within projects in each stratum.

Step 4. Finally, we aggregated evaluated project savings within program track and measure categories to estimate the total evaluated savings and realization rates in those subpopulations.

Cadmus estimated the precision within each building type stratum, and overall, at 90% confidence.

Energy Use Intensity Analysis and Benchmarking

Cadmus calculated the EUI of evaluated projects. For each building, we determined the square footage based on program tracking data, site-visit data, and secondary sources. Then, using utility billing data, we summarized annual 2017 and 2018 electricity, natural gas, and combined energy use (in kBtu) for each building. We calculated EUI by dividing annual energy consumption by square footage. We collected EUI from sites in the 2017 New Buildings evaluation, as well as previous evaluations,[6] and benchmarked them. Specifically, we compared the EUIs from program sites to EUIs in the general population that we collected from other studies, including Northwest Energy Efficiency Alliance's (NEEA's) 2014 Commercial Building Stock Assessment (CBSA),[7] the national Commercial Building Energy Consumption Survey (CBECS) data from 2012,[8] and the City of Portland's Building Energy Performance Reporting Results.[9] Cadmus examined trends of average EUI within Energy Trust's New Buildings program compared to the general population to draw conclusions about the program's impact on commercial new construction efficiency in Oregon.

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

Cadmus. 2015. *2012 New Buildings Program Impact Evaluation.* https://www.energytrust.org/wp-content/uploads/2016/12/2012_New_Buildings_Program_Impact_Eval_final_w_SR.pdf

[7] Navigant Consulting. 2014. *2014 Northwest Commercial Building Stock Assessment*. Prepared for NEEA. https://neea.org/img/documents/2014-cbsa-final-report_05-dec-2014.pdf

[8] U.S. Energy Information Administration. 2012. "Commercial Building Energy Consumption Survey (CBECS)." https://www.eia.gov/consumption/commercial/

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Impact Evaluation Findings

This section presents the results of the impact evaluation. This includes the results of engineering analyses, as applied to the sample; historical savings and realization rates, adjustments to reported savings values; calculation of realization rates; and estimation for the 2017 program population. It includes general observations regarding discrepancies between working and evaluated savings that influenced realization rates. Finally, it examines EUI data derived from the sample. Table 5 provides the evaluated savings by building type stratum for electric and gas measures.

Table 5. Program Evaluated Savings and Realization Rates by Building Type

Building Type	Count of Sites Evaluated	Electricity Savings			Gas Savings			Realization Rate	
		Reported (kWh)	Evaluated (kWh)	Precision	Reported (therms)	Evaluated (therms)	Precision	Electricity Savings	Gas Savings
Assisted Living Property	5	2,528,420	2,601,194	5%	56,608	51,440	5%	103%	91%
Education	10	1,509,216	1,504,938	1%	90,721	92,886	1%	100%	102%
Grocery	6	1,977,119	1,656,253	6%	31,816	22,485	12%	84%	71%
Lodging/Hotel/Motel	7	276,268	276,357	2%	80,485	79,041	1%	100%	98%
Manufacturing/Food Processing	5	3,839,002	3,835,630	0%	8,918	8,918	0%	100%	100%
Multifamily Property	7	11,422,863	11,806,180	5%	261,814	227,717	14%	103%	87%
Office	12	3,133,459	3,013,767	4%	23,699	23,700	0%	96%	100%
Other	13	7,549,940	7,843,333	12%	93,473	82,423	8%	104%	88%
Restaurant	5	232,577	232,559	0%	50,561	60,473	32%	100%	120%
Retail	12	3,453,843	2,791,895	9%	17,397	11,236	38%	81%	65%
Warehousing and Storage	4	7,086,420	6,776,415	5%	9,276	8,561	0%	96%	92%
Total[a]	**86**	**43,009,127**	**42,338,522**	**3%**	**724,767**	**668,879**	**5%**	**98%**	**92%**

[a] Totals may not match due to rounding.

Figure 1 and Figure 2 provide a historical context on energy savings and evaluation realization rates for the New Buildings Program from 2008 to 2017. Note that Energy Trust did not conduct an evaluation for the 2013 program year. On the electricity side, the trend since 2012 has been toward higher electricity savings and relatively high realization rates. For natural gas, energy savings have increased for three years, along with steadily increasing realization rates.

Figure 1. Historical Reported and Evaluated Electricity Savings with Realization Rates

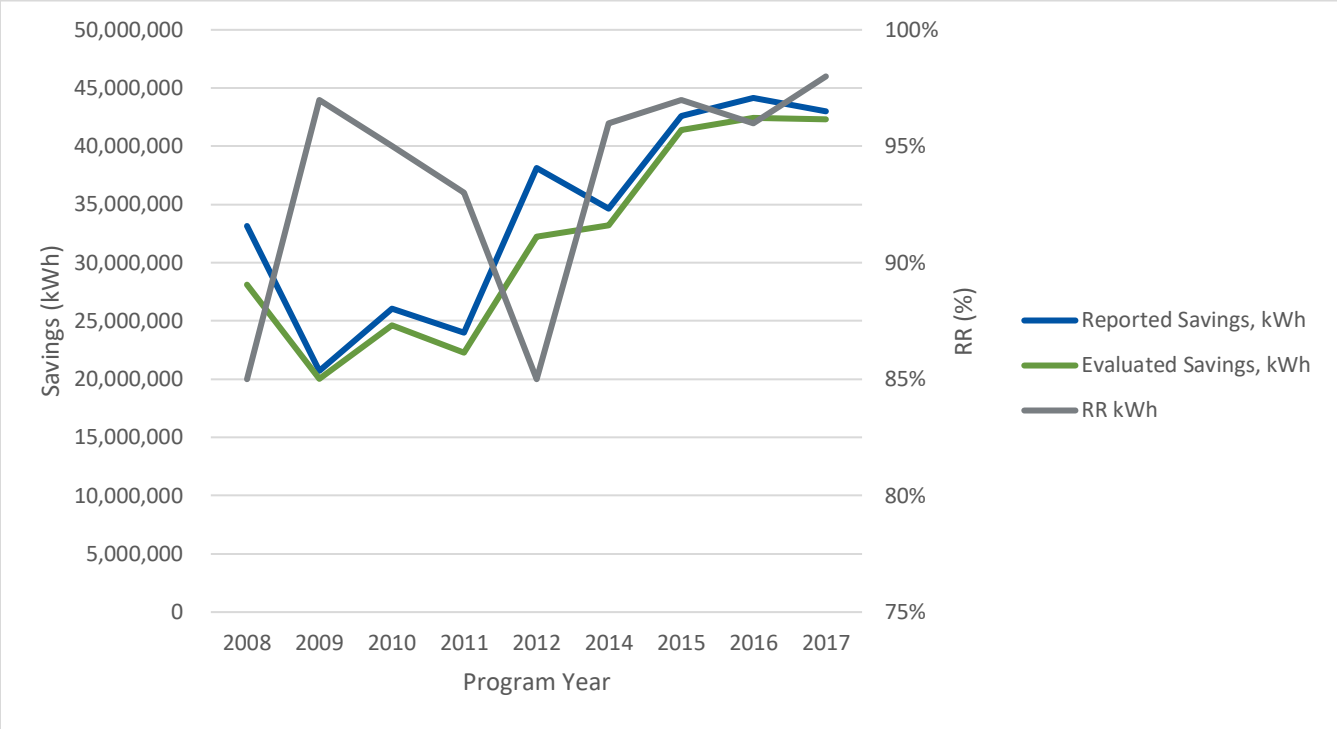
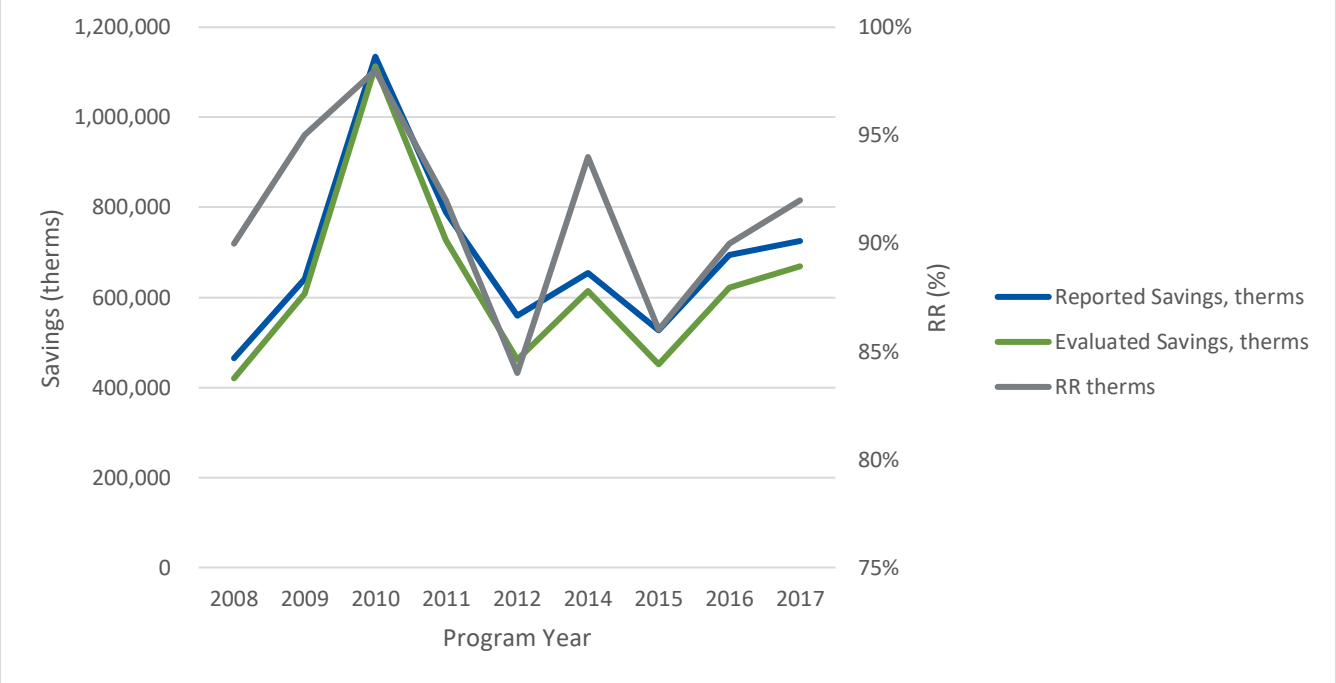


Figure 2. Historical Reported and Evaluated Gas Savings with Realization Rates



End-Use Findings

Cadmus adjusted electricity and gas savings resulting from the measure-specific reasons described in the sections below. We allocated sites to each analysis methodology category (custom, simulation modeling, and prescriptive) based on the specific requirements for selected projects. Table 6 provides program-level realization rates by measure category.

Table 6. Program Evaluated Savings and Realization Rates by Measure Category

Measure Category	Count Measures Evaluated	Electricity Savings			Gas Savings			Realization Rate	
		Reported (kWh)	Evaluated (kWh)	Precision	Reported (therms)	Evaluated (therms)	Precision	Electricity Savings	**Gas Savings**
Food Service and Appliance	53	579,548	586,066	21%	83,703	88,621	20%	101%	106%
HVAC	30	3,788,059	3,903,581	8%	69,847	66,936	7%	103%	96%
HVAC - Custom	23	4,257,173	4,393,508	11%	119,906	112,420	10%	103%	94%
Lighting	107	23,707,607	23,028,137	4%	(1,719)	(1,496)	149%	97%	87%
Lighting - Custom	6	995,514	1,027,443	27%	-	-		103%	
Market Solutions	32	1,994,005	2,006,125	12%	24,243	21,435	40%	101%	88%
New Construction	5	1,340,309	1,296,813	8%	7,029	7,197	3%	97%	102%
Other - Custom	19	2,368,371	2,437,058	11%	40,704	37,688	14%	103%	93%
Refrigeration	46	2,036,946	1,709,978	8%	37,778	26,592	17%	84%	70%
Refrigeration - Custom	8	245,825	203,832	23%	-	-		83%	
Water Heating	112	1,464,583	1,506,998	15%	341,865	308,574	9%	103%	90%
Weatherization - Custom	1	231,186	238,984	36%	1,412	912	140%	103%	65%
Total[a]	**442**	**43,009,127**	**42,338,522**	**3%**	**724,767**	**668,879**	**5%**	**98%**	**92%**

a Totals may not match due to rounding.

Market Solutions Track

For the Market Solutions Track, Cadmus evaluated eight projects that involved packaged Market Solutions offerings, primarily for office and multifamily buildings. We verified measures using the appropriate MADs for projects in this track. Cadmus reviewed multiple versions of MADs for some measures such as fan static pressure reduction in small offices and retail businesses, to determine the appropriate guiding document to verify project savings.

We verified that the measures were installed and operating as intended for seven of the projects. For the other project, we verified the installation of LED fixtures throughout the facility and confirmed the site achieved a 30% LPD reduction which qualified for the 25% LPD reduction measure. The site verification found that the actual floor area was 2% larger than reported. We used the same approach as reported savings, but updated the square footage of the facility based on the site findings. The energy savings increased since the verified number of fixtures was the same as reported, for a realization rate of 102%.

Six other projects in the Market Solutions Track installed measures more appropriately evaluated in conjunction with those in categories for the System Based and Custom Tracks, such as water heating and custom measures. We included all appropriate findings on the six projects' measures in the following sections for those tracks.

System Based Track

Food Service and Appliance

The Standard Track food service and appliance category represented equipment used in cooking, dishwashing, and clothes washing. Cadmus verified equipment counts and ENERGY STAR eligibility for these measures. Energy savings adjustments resulted from revised calculations, based on verified equipment quantities. The electric realization rate for measures in the evaluation sample was 98% and the gas realization rate was 108%

On one project, Cadmus verified one additional ENERGY STAR convection oven installed and operational, for a total of four ovens. This increased the electric savings.

For another project, we verified the installation of two new three-vat gas fryers during the phone interview and by reviewing the project invoices. We also verified the ENERGY STAR certification using the make and model number of the installed units. The project documentation listed two single-vat gas fryers, which the reported savings were based on, so the verification of larger installed fryers increased gas savings.

On a third project, the application showed two ENERGY STAR high-temperature single tank conveyer dishwashers. We only located one conveyer dishwasher during the site visit and verified that the unit is ENERGY STAR-rated. The site contact reported that the second dishwasher was defective and had to be replaced. Cadmus located a single-tank door/upright high-temperature dishwasher that replaced the other conveyer unit. Cadmus used the 2014 version of the commercial dishwashers measure (MAD #35) to determine the appropriate savings for both dishwashers. This adjustment reduced both the electricity and gas savings.

HVAC

Standard HVAC projects covered a range of electric and gas space conditioning measures, including economizers, mini-split air conditioners, boilers, furnaces, ventilation, and direct-fired radiant heating. The sample measures had an electric realization rate of 99.7% and gas realization rate of 100%.

Cadmus adjusted energy savings on one project in the sample based on differences in observed equipment quantities. One site reported installing 16 4-ton Carrier gas-pack rooftop units with economizer units, but Cadmus only found 15 to be installed and operational. At the same site, we verified that the reported 3-ton rooftop units were not installed on site. Both issues resulted in reduced savings for the project.

Lighting

Standard Track lighting measures included interior and exterior lighting power reductions below code allowances, LED case lighting, and controls such as occupancy sensors and daylight dimming. Lighting measures had an electric realization rate of 97%.

The primary factors influencing the realization rate were:

- Alterations in fixture quantities and wattages
- Different operating hours in the sample than those used to develop deemed savings estimates

Fixture Count Adjustments

Cadmus field engineers noted discrepancies between reported and observed fixture counts. During the construction phase, participants may re-evaluate their lighting needs and sometimes adjust fixture counts accordingly. For savings evaluation purposes, we adjusted baseline and as-built fixture counts to match observed quantities. In many instances, LPD calculations adjusted savings to account for smaller than reported quantities of installed equipment verified on-site. This resulted in higher electric savings and realization rates greater than 100%.

Sample Lighting Fixture Average Operating Hours

Cadmus updated operating hours based on lighting schedules observed during the site visits in the calculation of savings. Evaluated sample project lighting fixture measures sometimes operated for different periods than values used in deemed energy savings estimates. This is expected, since the deemed savings estimates rely on assumptions of operating hours across a range of building and usage types. Cadmus evaluated lower average operating hours than reported. This, in conjunction with fixture count adjustments, resulted in reduced energy savings.

Refrigeration

Refrigeration measures include equipment such as ice machines and refrigerators, as well as energy efficiency upgrades to equipment, including cooler doors, anti-sweat heater controls, and LED case lighting. The refrigeration measures in the sample had electric realization rate of 66% and gas realization rate of 53%. Many measures achieved a 100% realization rate, but Cadmus found discrepancies on numerous cooler door and LED case lighting projects that lowered energy savings, on average.

Cooler Doors

Cadmus determined that the cooler door projects reviewed did not meet the measure requirements (as described in the 2014-2019 versions of MAD 47). According to the MAD, doors must be retrofit onto cooler cases where the existing condition is open coolers or open coolers at or near end of life replaced with coolers with doors. This measure, as described in the MAD, is only applicable to existing construction, not new construction. On six projects, Cadmus re-calculated savings using the relatively new measure for cooler doors in new construction (MAD 201), which applies to cooler case doors in new construction. The savings for the new construction measure (MAD 201) were lower than for the previous retrofit measures (MAD 47), which decreased energy savings.

In one case, Cadmus found an installation that did not meet the requirements of the new cooler door measure (MAD 201) either, and adjusted the savings for these measures to zero. The new measure (MAD 201) specifically excludes "self-contained condensing unit display cases ." In one case, the participant installed a row of self-contained beverage display cases that did not meet the measure requirements. The overall realization rate for cooler door measures in the sample was 25% for electricity savings and 53% for gas savings. We note that the cooler door measure adjustments represented the primary reason for relatively low realization rates for the Grocery building type.

LED Case Lighting

In seven cases, Cadmus found more linear feet of eligible LED case lighting installed than reported. This increased the energy savings. This adjustment resulted in a realization rate of 103% for LED case lighting.

Water Heating

The Standard Track water heating category represented the remaining measures with deemed savings, including water heaters and measures significantly influencing water heating loads, such as dishwashers and showerheads. Cadmus adjusted energy savings to account for energy consumption, nonstandard applications, and correct fuel type. The realization rates across the sampled measures in this category were 93% for electric and 92% for gas.

Tanked Water Heater Consumption Adjustments

Cadmus evaluated 13 condensing water heater tank measures. The resulting realization rate for all but two of these measures was 100%. The evaluated savings differed from reported values for two projects due to lower than reported verified quantities or differing efficiency ratings, which reduced gas savings. The overall realization rate for natural gas savings in this category was 97%.

Showerhead and Shower Wand Adjustments

Cadmus adjusted savings for showerheads and shower wands due to verified shower usage being lower than measure savings assumptions (one project) or higher than reported flowrates verified on installed fixtures (three projects). Cadmus verified 2.5 gpm showerheads were installed at multiple sites rather than lower-flow units. This was the code maximum flow rate, so we evaluated zero savings for these showerheads. At another site, we interviewed staff who reported that the showers were rarely used. Therefore, we adjusted the savings to zero for that project. The overall realization rates for this measure category were 83% for electricity savings and 78% for natural gas savings.

Faucet Aerator Adjustments

We adjusted savings for faucet aerators due to higher than reported installed counts (one project) or higher flow rate verified on installed fixtures than reported (five projects). We also adjusted savings at one site where we verified 2.5 gpm sink aerators were installed and operational in sinks throughout the facility. The 2.5 gpm aerators do not meet the qualifications for this measure. The overall realization rates for this measure category were 97% for electricity savings and 92% for natural gas savings.

Custom Track

HVAC – Custom

Custom HVAC measures represented a range of projects that either did not fit the specifications needed for deemed measure savings (i.e., boilers with efficiency ratings outside the range used for deemed savings) or complex measures involving interactive effects with other systems. The calculation methodologies primarily involved Excel workbooks and prototypical model assumptions. Cadmus evaluated each measure based on the methodology employed to estimate savings, and adjusted savings as necessary. The custom HVAC measures combined achieved an electric realization rate of 118% and gas realization rate of 99% for projects in the sample.

For one measure, we verified that the make-up air unit was installed correctly. The calculation methodology set the ambient temperature threshold for operation at 70°F. However, the site personnel reported that they only used the unit when the weather was cold and they needed to close the garage doors. Based on their feedback, Cadmus revised the calculation workbook with an operating threshold of 65°F. This reduced the gas savings, for a realization rate of 80%.

Another measure involved the installation of a variable refrigerant flow (VRF) system at a site. Cadmus verified that the VRF was installed and operating as intended. However, the participant installed a system with larger cooling capacity than reported. We updated the savings calculation workbook with the additional tonnage, which increased energy savings. This measure had an electric realization rate of 168%.

At another site, we found that the custom infrared radiant modulating heater measure was installed and operating as expected. The reported savings applied deemed savings values for less efficient, non-modulating infrared radiant heaters. The evaluation used Standard Track measure deemed savings values for modulating infrared radiant heaters to determine evaluated savings. This increased the energy savings for an electric realization rate of 174% and gas realization rate of 152%.

HRV measures

Cadmus also evaluated several projects that installed heat recovery ventilation systems. We found that the assumptions used to estimate gas savings for each project were generally reasonable and most achieved 100% realization rates for gas. For one measure, we updated the operating hours based on the air-balance report provided by the site contact. This resulted in lower operating hours, and therefore lower energy savings.

However, these measures also involve an electricity consumption penalty due to the increased fan power needed to overcome the additional static pressure resulting from the heat exchange system. The implementer did not account for the increased electricity usage on a measure or project level. Cadmus accounted for the electric penalties for these measures, which reduced electric realization rates for the custom HVAC measure category and relevant projects.

Lighting – Custom

The custom lighting measures involved projects that generally fell outside conventional analysis for comparison to Oregon Energy Code allowances. We evaluated six projects in this category, three of which involved whole building simulation modeling. Those three are discussed in the Whole Building Track section below. Of the remaining three projects, two required Cadmus to adjust savings downward. Together, these three custom lighting measures achieved an 87% electric realization rate.

On one project, Cadmus revised lighting operating hours downward based on findings from the verification site visit, which decreased electricity savings. On another project, a participant installed LED lighting in a new residential care facility. There is no lighting code requirement for this building type, so the implementer developed a custom measure calculation using ratios between fluorescent and LED lighting. Cadmus recently completed the latest regional Commercial Building Stock Assessment. For the 11 residential care facilities in Oregon, the weighted average LPD was 0.71 W/ft^2, and the average facility was built in 1998. We revised the analysis for this project to use the Oregon average LPD of 0.71 W/ ft^2 for the baseline energy consumption. This resulted in a decrease in electricity savings, for a 73% realization rate. This level of variance implied that the original calculation methodology was flawed in the scale of savings that could be expected from this type of project.

Other – Custom

Custom "Other" measures primarily include offerings through the Market Solutions and System Based Tracks. We evaluated 19 measures in this category, of which three measures involved whole building simulation modeling. Those three are discussed in the Whole Building Track section below. The realization rate across all remaining measures in this category was 100% for electricity and 97% for gas.

Cadmus verified the measure details on site, and only adjusted the energy savings on one custom pool project. For this project, Cadmus found numerous differences between the data confirmed during the site visit and the data used in the pool savings calculator workbook. We updated the workbook to reflect the details found on site, particularly the smaller pool size than used in the savings calculator. We adjusted the operating hours, increased the water temperature setpoint in the calculator, and adjusted the weighted average of the pool and hot tub temperatures by area. These adjustments both increased the savings. However, the calculator was configured for a 3,000 ft^2 pool. Correcting this to 630 ft^2 decreased the total gas savings, for a final realization rate of 88%.

Refrigeration - Custom

Custom refrigeration includes refrigeration measures for existing refrigeration systems, such as variable frequency drives and pressure controls. The evaluation sample included custom refrigeration measures for grocery and retail building types, mainly under the Market Solutions Track. Cadmus did not adjust any savings for Custom Refrigeration measures and those in the sample achieved a 100% realization rate.

Weatherization – Custom

The sampled custom weatherization measure was a custom building envelope measure that was installed as intended. The electric and gas realization rate was 100%.

Whole Building Track

Cadmus evaluated eight projects with four measure types (Custom HVAC, Custom Lighting, Custom Other, and LEED New Construction) requiring whole-building simulation model analysis. Table 7 provides the energy savings and realization rates for each project. The specific evaluation details for each project follow.

Table 7. Energy Savings and Realization Rates for Whole Building Modeling Measures

Project ID	Measure Type	Number of Measures	Electricity Savings		Gas Savings		Realization Rate	
			Reported (kWh)	Evaluated (kWh)	Reported (therms)	Evaluated (therms)	Electricity Savings	Gas Savings
1	LEED NC	1	121,278	103,140	7,029	7,983	85%	114%
2	Custom HVAC	1	114,470	137,753	6,645	7,291	120%	110%
2	Custom Lighting	1	73,358	70,759	-	-	96%	N/A
10	LEED NC	1	1,174,739	1,174,739	-	-	100%	N/A
11	Custom HVAC	1	100,912	121,438	9,336	10,244	120%	110%
11	Custom Other	1	64,670	62,738	0	0	97%	N/A
12	Custom HVAC	4	578,606	785,886	21,991	6,881	136%	31%
12	Custom Lighting	1	28,300	28,300	-	-	100%	N/A
13	Custom Other	2	-	-	8,148	1,416	N/A	17%
16	Custom HVAC	1	535,469	866,624	-	-	162%	N/A
16	Custom Lighting	1	52,488	38,954	-	-	74%	N/A
17	Custom HVAC	3	775,183	772,581	12,977	12,810	120%	110%
17	Custom Other	1	-	-	396	382	N/A	96%

Project 1 – LEED New Construction

For this LEED project, natural gas billing data was not available until after the primary evaluation, so Cadmus calibrated the energy model to the electricity data only. The original energy model underpredicted annual electricity consumption by approximately 30%. The profile of the modeled monthly electricity consumption dropped off sharply during the months of June through August, however, the utility data showed consumption that was consistent throughout the year. The original model and electricity billing data closely matched during the shoulder months, showed a moderate difference during the winter months, and a much larger difference during the summer months.

To bring the model into calibration, Cadmus made several adjustments to increase the modeled electricity and natural gas consumption throughout the year, with a particular increase in the summer months. We eliminated the holiday schedule during June through August and kept the regularly occupied schedules for HVAC system and internal loads in place during this time. We also changed the unoccupied setback strategy from a temperature setback with HVAC fan cycling and outside air turned off, to only a temperature setback. This increased the HVAC fan energy consumption during the winter

months, and resulted in a higher overall electricity consumption during the summer months due to increases in both the fan and cooling system energy. The pump and fan energy consumption of the building as-built is higher than the baseline, so increasing HVAC system run time resulted in decreased energy savings.

Following the primary evaluation period, the participant provided the natural gas billing data for the site to Cadmus. This showed the calibrated value for natural gas was only slightly lower than the billing data. Cadmus applied an engineering adjustment to account for the slight difference in consumption and evaluate the natural gas savings. This project achieved an electricity realization rate of 85% and gas realization rate of 114%.

Project 2 – Custom HVAC and Lighting

For the custom HVAC measure on this project, Cadmus verified that the two boilers and roof-top units were installed and operational. Cadmus intended to perform energy model calibration to evaluate the custom savings. However, we were unable to obtain the correct baseline energy model for this project, and therefore would not have been able to evaluate the energy savings. Instead, Cadmus applied the realization rates determined by the energy model calibration for Project 11, another elementary school. We are confident that this approach is an appropriate substitute because both projects used versions of the exact same energy model, and the electricity and natural gas total consumption and annual profiles were similar in both cases. We evaluated realization rates for this measure of 120% for electricity and 110% for gas.

Cadmus followed a similar approach on the custom lighting measure at this site. We verified LED interior lighting with advanced occupancy sensing and daylight harvesting features installed and operational. We also applied the realization rate determined by the energy model calibration for Project 11 for this measure. Evaluated savings for this measure resulted in a realization rate of 97%.

Project 10 – LEED New Construction

On this project, Cadmus received extensive utility billing data for the multi-building campus. However, we did not have sufficient information to isolate the specific meters and billing data that served the building in question. We conducted a site visit and verified that all installed measures matched the project documentation. We then performed an engineering desk review because we were unable to identify the correct billing data. Cadmus reviewed all project documentation, re-ran the simulation models, and successfully reproduced the reported model output. Based on this, we verified the accuracy of the energy savings calculations. We evaluated 100% realization rates for electricity and gas savings for this project.

Project 11 – Custom HVAC and Other

For the custom HVAC measure, Cadmus verified four gas-fired domestic water heaters, two boilers, and one tankless water heater were installed and operational. We also verified thermal efficiency was 92% or greater. To verify the custom savings calculated using energy simulation modeling, Cadmus performed energy model calibration using electricity billing data for the period of September 2018 through August 2019. The original energy model underpredicted annual electricity consumption by

approximately 35%. The profile of the monthly electricity consumption over the year, as shown by both the original model and the billing data, was basically flat. The difference between the original model and billing data was consistent during the occupied months of the school year. The original model closely matched the electricity billing data during the unoccupied months of July and August. To bring the model into calibration, Cadmus reduced the miscellaneous equipment loads and reduced the unoccupied cooling space temperature setpoint from 90°F to 85°F.

Cadmus also compared the energy model to natural gas billing data for the period of September 2018 through August 2019. The original energy model significantly underpredicted annual natural gas consumption by approximately 75%. The greatest difference occurred during the winter months, indicating that the model underpredicted heating energy consumption. Based on a follow-up call with the site contact, Cadmus suspected that the variance resulted from the night setback strategy when the building is in heating mode. We considered it likely that the HVAC systems used a temperature setback during unoccupied hours, but was not cycling the fans or closing the outside air intake. However, we could not obtain any trend or other operational data to confirm this is the case. Therefore, we relied only on calibrating the model to the electricity billing data. Evaluated savings for the custom HVAC measure were 121,438 kWh and 10,244 therms, for a realization rate of 120% and 110%, respectively.

For the custom lighting measure, Cadmus verified LED lighting throughout the facility with occupancy sensor and daylight harvesting controls installed and operational. As described for the custom HVAC measure, we performed energy model calibration to verify the custom savings calculated using energy simulation modeling. The adjustments Cadmus made to the calibrated energy model did not include any significant changes to the lighting system. Therefore, model provided only minor variation from the reported to the evaluated savings for this measure, for a realization rate of 97%.

Project 12 – Custom HVAC and Lighting

This project installed four custom HVAC and one custom lighting measures. To verify the custom savings calculated using energy simulation modeling, Cadmus calibrated the energy model to electricity and natural gas billing data for the period of November 2018 through October 2019.

The original energy model slightly underpredicted annual electricity consumption by approximately 18%. The profile of the monthly electricity consumption over the year, as shown by both the original model and the billing data, was fairly flat with a slight increase during the winter months. The difference between the original model and electricity billing data was consistent for all months during the year. The original energy model underpredicted annual natural gas consumption by approximately 42%. The profile of the monthly natural gas consumption over the year, as shown by both the original model and the billing data, followed a curve with greater consumption during the winter months and low consumption during the summer months. The difference between the original model and natural gas billing data was relatively consistent for all months during the year.

To bring the model into calibration, Cadmus made several adjustments, based on data from the site verification and a follow-up call with the site contact, to increase the modeled electricity and natural gas consumption throughout the year. We eliminated the heating and cooling space temperature setbacks

in the common areas so that these spaces were conditioned at all hours of the day. We also increased the heating space temperature setpoint in the common areas from 70°F to 72°F. We increased the minimum outside airflow rate for the 100% outside air units from 20% to 100% so that they constantly provided the same amount of ventilation air. And finally, we increased the miscellaneous plug loads in the residential dwelling spaces, with a slightly greater increase during the winter and shoulder months and a smaller increase during the summer months.

The first custom HVAC measure was a VRF system with dedicated outdoor air system (DOAS) units. The evaluated electricity savings for this measure were higher than reported. Because of the increase in internal gains and increased HVAC system run time, the efficient VRF cooling system with lower fan power was able to realize larger savings over the standard baseline chilled-water cooling system. Because of the increase in heating requirements, the DOAS was not able to realize large savings over the standard baseline system. Therefore, the evaluated gas savings were lower than reported. Evaluated savings resulted in a realization rate of 139% for electricity and 23% for gas.

The second custom HVAC measure was a vent hood system with make-up air unit that we verified as installed and operating as intended. The adjustments Cadmus made to the calibrated energy model included increased outside air intake for the kitchen make up air unit. This measure realized higher fan energy savings (electricity) but lower heating savings (natural gas). Evaluated savings for this measure resulted in realization rates of 109% for electricity and 77% for gas.

The third measure categorized as custom HVAC involved 95% efficient domestic water heaters. The adjustments Cadmus made to the calibrated energy model did not include any changes to the domestic hot water system directly. However, the natural gas billing data showed consistently lower natural gas base loads than indicated in the model. Cadmus adjusted the water heating load downward accordingly, which resulted in lower gas savings for this measure. Evaluated savings for this measure resulted in a gas realization rate of 80%.

For the fourth custom HVAC measure, we verified a CO sensor and exhaust motor VFD were installed and operating as intended. The adjustments we made to the calibrated energy model did not include any changes to the parking garage fans directly. Adjusting the calibrated model output using the overall revisions to model consumption resulted in a higher realization rate for this measure. We evaluated an electricity realization rate of 107%.

On the custom lighting measure, we verified the LED lighting was installed in garage areas and operating as expected. This measure achieved 100% electricity realization rate.

Project 13 – Custom HVAC and Custom Other

The project installed a custom HVAC and custom other measure. For the custom HVAC measure, we verified the heat recovery ventilators on two air handlers and the heat recovery unit were installed and operating as intended. This facility receives electricity service from a People's Utility District, not one of Energy Trust's partner utilities, so Energy Trust did not report any electric savings and could not provide electricity billing data. Therefore, Cadmus calibrated the energy model to natural gas billing data only for the 2018 calendar year.

The original energy model significantly underpredicted annual natural gas consumption by approximately 58%. The profile of the monthly natural gas consumption over the year indicated by the original model followed a gentle curve with slightly greater consumption during the winter months and lower consumption during the summer months. However, the billing data showed a much sharper curve with gas consumption much higher during October through April (monthly gas consumption during the winter months was approximately twice the monthly consumption during May through September), and the consumption during the summer months was twice what the original model predicted.

To bring the model into calibration, Cadmus made several adjustments based on site visit data and a follow-up call with the site contact. These adjustments increased the modeled natural gas consumption throughout the year, and to a greater degree during the winter months. The area of focus was the indoor pool. We increased the supply airflow capacity for the air handling unit which serves this space, from the originally modeled value of 13,669 cfm to 25,550 cfm as specified in the mechanical schedule. There was no humidity control modeled for this space, so we added limits of 60% maximum humidity and 45% minimum humidity. We also added a gas process load during the winter months to represent swimming pool water heating energy consumption.

Only a portion of the heating energy savings was realized because the heating energy in the calibrated model increased so substantially from what the original model predicted. The natural gas consumption for the indoor pool system dwarfed that of the HVAC systems serving the rest of the facility. Evaluated savings for this measure resulted in a realization rate of 19%.

For the custom other measure, we verified the installation of two efficient condensing domestic water heaters. Cadmus adjusted the calibrated energy model to address the changes noted previously, but did not make any changes directly to the domestic hot water system. Adjusting the calibrated model to account for the indoor pool loads resulted in a lower savings for this measure, which achieved a gas realization rate of 17%.

Project 16 – Custom HVAC and Lighting

This project installed both a custom HVAC and custom lighting measure. The site did not use natural gas, so Cadmus calibrated the energy model only to electricity billing data for the period of September 2018 through August 2019.

The original energy model underpredicted annual electricity consumption by approximately 41%. As this is an all-electric facility, the profile of the monthly electricity consumption over the year, as shown by both the original model and the billing data, shows a peak during the winter months and a smaller peak in the height of summer in July. The difference between the original model and electricity billing data was largest during the winter months and smallest during the summer. To bring the model into calibration, Cadmus made several adjustments to increase the modeled electricity consumption throughout the year, with a greater increase during the winter months. We changed the unoccupied setback strategy from a temperature setback with HVAC fan cycling and outside air turned off, to only a temperature setback. We also changed the cooling space temperature setpoint from 75°F to 72°F. The evaluated electricity savings were higher than reported. Effectively increasing the HVAC system run time

led to greater gains from the more efficient system over the standard baseline system. The evaluated electricity savings resulted in an electricity realization rate of 162%.

For the custom lighting measure, Cadmus adjusted the savings based on the updated loads needed to calibrate the model. This resulted in lower energy savings, for an electricity realization rate of 74%.

We noted that this site had planned to pursue the Path to Net Zero. Based on the original modeling results, the participant had already installed a solar canopy in the parking lot and had planned to install a roof-mounted photovoltaic system to offset the remainder of their electric consumption. As their actual electricity consumption results came in, the participant learned that the size of solar installation needed to offset the consumption was several times larger than their roof capacity. So, they would not be able to achieve net zero certification despite their best efforts. It was clear that the participant was both frustrated and disappointed to not realize this fact earlier in the process, based on how the original model underpredicted electricity consumption.

Project 17 – Custom HVAC and Other

The final whole building simulation modeling project installed three custom HVAC and one custom other measures. For the first custom HVAC measure, Cadmus verified that the VRF system with DOAS units were installed and operating as intended. We also verified that outside unit model numbers and quantities were consistent with reported amounts. Cadmus calibrated the energy model to electricity and natural gas billing data for the period of November 2018 through October 2019. The original energy model closely predicted annual electricity consumption, although it was slightly too high during the summer months. The profile of the monthly electricity consumption over the year, as shown by both the original model and the billing data, was fairly flat with a slight increase during the winter months. The original energy model underpredicted annual natural gas consumption by approximately 27%. The profile of the monthly natural gas consumption over the year, as shown by both the original model and the billing data, followed a curve with greater consumption during the winter months and low consumption during the summer months. The difference between the original model and natural gas billing data was most pronounced during the summer months and smaller during the shoulder months, with the winter months matching closely.

Cadmus made several adjustments to process loads to bring the model into calibration. We slightly decreased the miscellaneous plug loads in the residential dwelling spaces, which served to slightly decrease the cooling energy consumption during the summer months. We also added a gas process load to the model for the months of March through October, to represent swimming pool water heating energy use. Because the calibrated model adjustments focused on process loads that were applied to the Baseline and Proposed models identically, the evaluated savings for the first custom HVAC measure resulted in a realization rate of 100% for electricity and 99% for gas.

For the second custom HVAC measure, Cadmus verified that carbon monoxide sensors were installed in garage parking areas and VFD control was enabled on the garage exhaust fan. The adjustments we made to the calibrated energy model did not include any changes to the parking garage fans directly. Evaluated savings for this measure resulted in an electricity realization rate of 100%.

The results for the third custom HVAC measure were similar to the first and second measures. Cadmus verified four domestic water heaters were installed and operating as intended. The adjustments we made to the calibrated energy model did not include any changes to the domestic hot water system directly. Evaluated savings for this measure resulted in a gas realization rate of 100%.

On the custom other measure, we verified a make-up air unit with direct gas-fired furnace was installed and operational. The adjustments Cadmus made to the calibrated energy model did not include any changes to the kitchen makeup air system directly. But, adjusting the loads in the calibrated model output resulted in a slightly lower gas savings for this measure, for a realization rate of 97%.

Project Track

Cadmus compared reported and evaluated energy savings values for each project track, as shown in Table 8. The findings by project were detailed in the measure-level results in the previous section. There was one Data Center track project in the program population, which was not included in the evaluation sample.

Table 8. Program Evaluated Savings and Realization Rates by Project Track (MMBtu)

Track	Count Projects Evaluated	Electricity Savings			Gas Savings			Realization Rate	
		Reported (kWh)	Evaluated (kWh)	Precision	Reported (therms)	Evaluated (therms)	Precision	Electricity Savings	Gas Savings
Market Solutions	14	9,169,923	9,140,014	6%	155,314	135,903	17%	100%	88%
System Based	64	28,331,626	27,604,475	4%	463,652	435,812	6%	97%	94%
Whole Building	8	5,057,004	5,125,950	9%	105,801	97,164	14%	101%	92%
Total[s]	**86**	**43,009,127**	**42,338,522**	**3%**	**724,767**	**668,879**	**5%**	**98%**	**92%**

[s] Totals may not match due to rounding.

Energy Use Intensity Analysis Findings

Cadmus calculated the EUI of sampled projects in this evaluation and collected previously calculated EUI values from other studies for comparison purposes. We collected billing data for the evaluated sites, removed duplicate entries, and combined multiple meters when more than one meter was associated with a site. We verified the square footage in the program tracking database with data collected on site using a subsample of the evaluated sites. We found that square footage was reported accurately in the tracking database and no adjustments were required.

Four sites included on-site supplemental solar energy generation. For these sites, we estimated annual solar electricity production and added it to the energy usage calculated from the billing histories to calculate EUI for those sites. Appendix A contains each site's calculated electric, natural gas, and combined energy (in kBtu) EUIs. Cadmus conducted additional quality reviews to identify sites with low-quality data or extreme EUI values (outliers), which we removed from the EUI analysis. We removed 24

of the 86 sites from the EUI analysis for the following reasons (these sites are also indicated in Appendix A):

- Two sites had on-site supplemental solar generation but the amount of energy production was unknown.
- Billing data for six sites were missing one or more months of energy use.
- EUIs for 16 sites were substantially higher or lower than the other sites (by an order of magnitude), either because the meters associated with those sites also metered other sites, were missing some months or meters of billing data, or were mixed-use buildings (e.g., office and manufacturing).

Cadmus estimated building type EUI in the 2017 New Buildings program by summing the total annual energy use and then dividing by the total square footage within each building type. We collected building type EUI for previous program years from Energy Trust's evaluation reports and for non-program buildings from the sources identified in the previous section. When more granular building-type EUI were provided in these sources, we aggregated them to the broader categories used in this analysis using a weighted average, with number of buildings as the weight (or no weight, if building quantity was not available from the study). The analysis does not consider average operating hours, occupancy, or other building-specific operations. The 2017 building-type EUI are provided Table 9.

Table 9. Building-Type EUI (kBtu/sf) Data by Building Type

Building Type	n	2017 New Buildings EUI	NEEA 2014 CBSA	National CBECS 2012	Portland CBECS 2012
Assisted Living Property	4	21	N/A	97	97
Education	8	41	64	69	66
Grocery	4	147	240	210	170
Gym/Athletic Club	2	120	91	86	79
Hospitals	1	24			
Lodging/Hotel/Motel	7	85	91	97	97
Multifamily Property	5	32	N/A	97	97
Office	8	46	76	78	67
Other	13	197	85	145	159
Restaurant	5	367	351	283	36
Retail	10	22	65	89	57
Warehousing and Storage	4	32	30	34	100

Cadmus assessed trends in EUI over time in evaluated program buildings.[10] Figure 3 shows these trends within each building type. Key findings from this analysis include the following:

[10] Sources for non-program benchmarks include findings from past studies in the following reports:

Michaels Energy. 2019. *2015-2016 New Buildings Program Impact Evaluation*.

(Michaels Energy 2017).

- EUI is decreasing significantly (at 90% confidence) over time in these buildings:
  - Grocery
  - Restaurant (including fast food)
  - Retail (non-mall)
- EUI is increasing significantly (at 90% confidence) over time in these building types:
  - Warehouse/storage
- Results were inconclusive (not enough data or not significant) for other building types

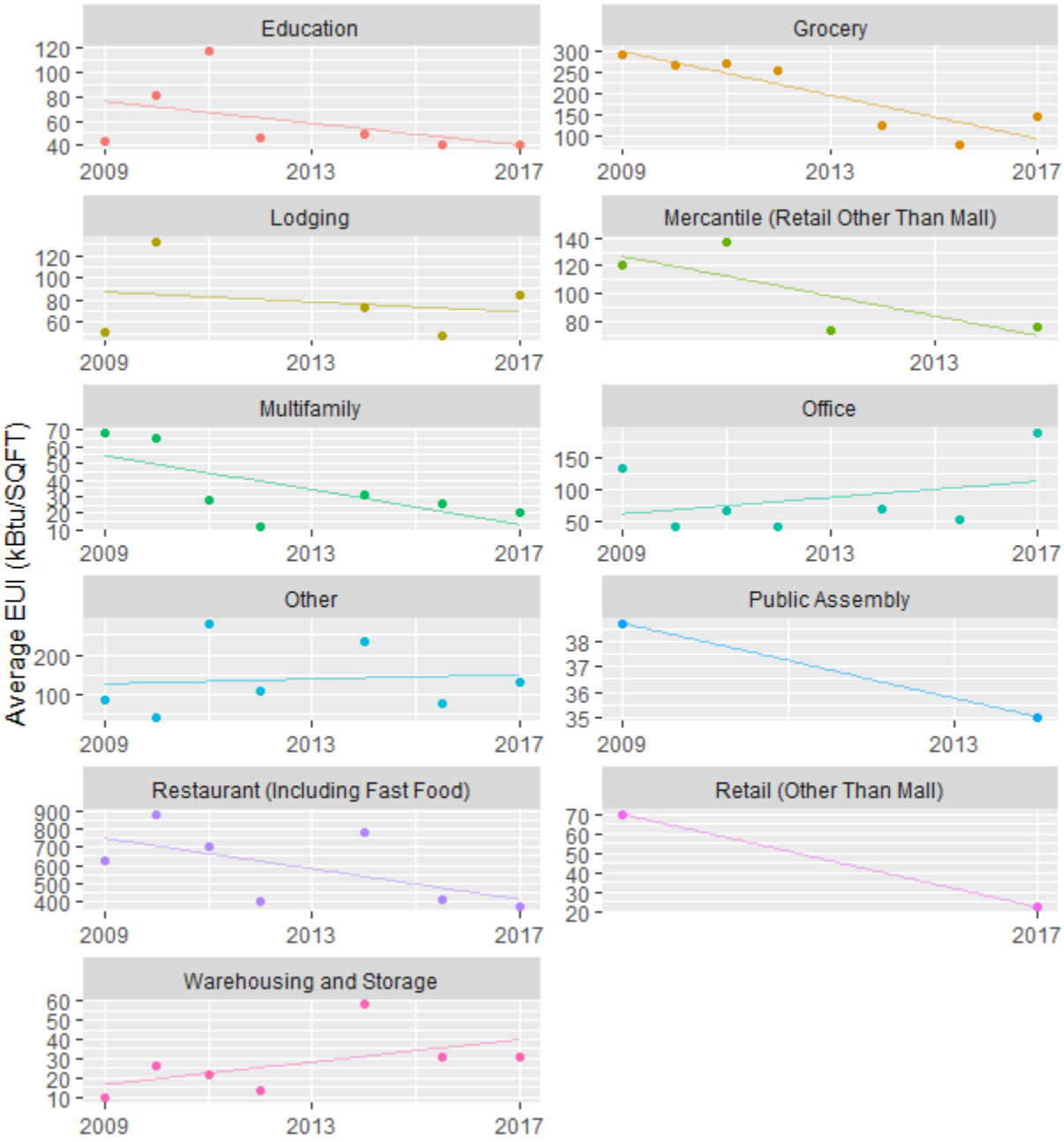
(Cadmus 2015).

Cadmus. 2013. *2011 New Buildings Program Evaluation*. https://www.energytrust.org/wp-content/uploads/2016/12/New_Buildings_Program_Impact_Evaluation_wSR.pdf

Cadmus. 2012. *2010 New Buildings Program Impact Evaluation.* https://www.energytrust.org/wp-content/uploads/2016/12/ETO_NBE_2010_Impact_Evaluation_Report.pdf

Cadmus. 2011. *2009 New buildings Program Impact Evaluation.* https://www.energytrust.org/wp-content/uploads/2016/12/111104_NB_Impact_2009.pdf

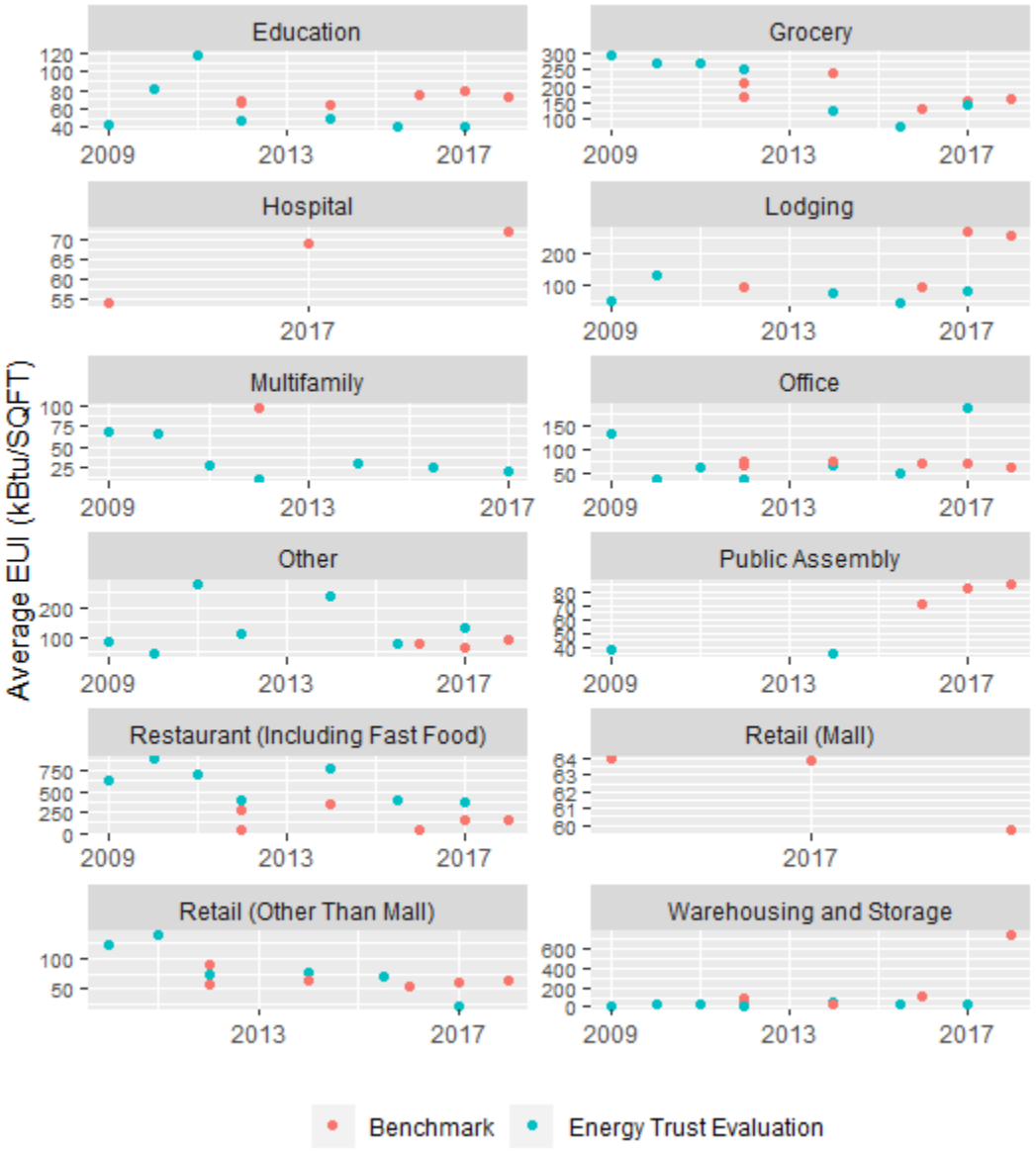
Figure 3. New Buildings Program EUIs



Cadmus compared EUI in program buildings to non-program building within building type and found mixed results. In most building types, benchmarked EUIs and program EUIs are intermingled with the following two exceptions:

- Program education buildings consistently have lower average EUI than benchmarked buildings
- Program restaurant buildings consistently have higher average EUI than benchmarked buildings

Figure 4. Benchmarked EUIs



We also considered how code changes and average temperatures may have affected these trends. Oregon updated its energy codes in 2010 and 2014, and the years following each of these years generally show lower EUIs. Based on average temperature data for Portland, the years 2014 and 2015 had the highest average summer temperatures, with 2017 and 2018 close behind. Also, 2017 was one of the coldest winters in recent history; this combined with the high summer temperatures in 2017 resulted in higher heating and cooling needs than average. The higher EUIs due to extreme weather effects are shown in Year 2016 of the EUI trends shown in Figure 3**Error! Reference source not found.** t hrough Figure 4 because the calculated EUI associated with that program year is for the calendar year following participation (2017). Given the higher than normal heating and cooling loads, 2016 program participants still have lower EUIs than 2014 participants in the year following participation, although 2015 also had higher cooling requirements. Given the small sample sizes it is difficult to make

conclusions other than noting that, in general, EUIs have trended downward over time (consistent with increasing code requirements and program savings).

Conclusions and Recommendations

Cadmus conducted an impact evaluation of the 2017 Energy Trust New Buildings program by analyzing energy savings for 406 measures implemented across 86 projects. The measures belonged to three different project tracks (Market Solutions, System-Based, and Whole-Building) and represented a variety of subcategories. The overall program electricity and gas realization rates were 98% and 92%, respectively.

Energy Trust and its implementer, CLEAResult, applied the appropriate methodologies and assumptions for many measures; however, Cadmus' evaluated savings differed from reported energy savings for 55 of 86 projects in the sample. For many measures, the assumptions we used to evaluate energy savings differed from those used to estimate reported savings based on site verification and phone interview findings, including, equipment counts, heating and cooling loads, and controls settings based on participant feedback. This resulted in variation between proposed and as-built model performance.

Overall, the 2017 program implementer performed a reasonable level of review and quality control to achieve high average project savings and realization rates. The measure types with the lowest evaluated savings were in the refrigeration (both custom and prescriptive) and water heating measure categories, as well as in the grocery and retail building types.

Recommendations

Cadmus identified several areas for program improvements. The most significant involve changes in tracking energy use for simulation modeling and methods for reporting to improve future evaluation efforts. There are also steps the implementer can take to ensure appropriate measure installations and encourage participants to collect data useful for ongoing commissioning and evaluation efforts.

Cadmus recommends the following actions to improve ongoing evaluation efforts and the program overall.

Document Program Qualifications for Measures Implemented through the Market Solutions Track.

Program qualifications for measures offered through the 2017 Market Solutions Track were based on multiple versions of the MADs. This was due to an inconsistency between dates of approval for MADs and the roll out of program offerings. We used the same versions of calculators as the implementor to determine savings and incentives at the project level to determine the version of the offering the project was completed under. Additionally, measures flagged as not being cost-effective in the MADs, such as fan static pressure reduction in small offices and retail businesses were included in the offerings based on a "blessing" memo issued by Energy Trust. Cadmus reviewed multiple versions of MADs to determine measure qualifications and recommends including program eligibility criteria as part of the project documentation.

Consider Discontinuing Cooler Door Measure

The cooler doors retrofit measure used a deemed savings value for adding doors to open refrigeration cases to estimate reported savings. The requirements for this measure state that the doors must be retrofit onto cooler cases where the existing condition is open coolers or open coolers at or near end of life replaced with coolers with doors. However, the project documentation review and site verifications found that refrigeration cases were typically new cases that were purchased as part of the project. Cadmus found that, overwhelmingly, any medium-temperature multi-deck case that could have a door had one installed. We acknowledged the new MAD 201 applies savings to new construction cooler doors. However, it is likely that newly purchased remote medium-temperature multi-deck cases will almost always have doors, regardless of program intervention. As such, we do not consider this measure to be appropriate for a new construction program. Cadmus recommends a review of sales data to determine if there is a significant portion of cooler door cases that ship without doors. If not, we recommend that Energy Trust consider discontinuing this measure.

Maintain Consistent Documentation on Simulation Model Files

Cadmus found the project documentation for simulation projects was inconsistent from one project to the next. This made it difficult to determine the appropriate savings and relevant material to support energy savings. The implementer should consistently categorize and clearly label the basis of the final incentive, supporting documentation (including any post-processing calculations performed on the raw model output), final incentive amount, and simulation models across all projects. There is no need to provide superseded versions of any documents as this is likely confuse the evaluator.

Ensure Simulation Models Match Approved Savings

One project file included simulation models that did not match the final approved building performance energy savings calculations. The implementer should clearly label the models with the exact information they support. We also recommend the implementer verify that the models match the energy consumption output on a gross-savings level.

Encourage Participants to Enable Energy Management System Trends

Cadmus has found that, in general, new construction facilities have energy management systems and are capable of enabling trending on major equipment and controls systems. These data are critical to the evaluation effort and can also provide important information to the participant about how the facility is operating. However, we were not able to obtain trend data for any of the projects that used simulation modeling to calculate energy savings. For any projects that will be evaluated using simulation model calibration according to IPMVP Option D, trend data are beneficial to inform adjustments during the calibration process. Otherwise, we must rely on equipment metering or educated assumptions regarding the specifics of the building systems operations and modeled energy end-use breakdowns. We recommend that Energy Trust and the implementer consider methods to encourage participants to enable EMS trending. Options could include a bonus incentive or requiring trending as a condition for an incentive on any project with savings estimated based on a whole building simulation model.

Obtain Mechanical As-Built or Construction Documents

All projects using energy simulation modeling are evaluated using model calibration. As such, the implementer should provide basic design documentation so we can quickly develop a clear understanding of the building. This includes a full set of mechanical/HVAC drawings and equipment schedules. Additionally, the implementer should provide HVAC system controls documentation, including sequences of operation for all major system types, to inform the model adjustments necessary for calibration.

Check Custom Lighting Calculations for Reasonableness

When developing custom calculations for new construction lighting projects that do not rely on code LPD allowances, the implementer should benchmark energy savings using the code LPD allowance for the nearest applicable building type. This calculation will allow the implementer to determine whether the savings achieved are within a reasonable range. Savings that are too high or too low (defined as more than 20% variance from the reported value) implies that the calculation methodology requires refinement to better meet the expectations of the Oregon energy code.

Appendix A. Energy Use Intensity Findings

Table 10 shows Energy Use Intensity findings for 80 projects included in analysis.

Table 10. Energy Use Intensities for 2017 Analysis

Project	Building Type	Area (sf)	Electricity EUI (kWh/sf)	Gas EUI (therms/sf)	Total Energy EUI (kBtu/sf)	Used in Building Type Analysis
1	K-12 School	134,189	6.35	-	25.92	N
2	Primary School	94,731	3.27	0.23	37.68	Y
3	Office	42,601	7.36	0.02	34.63	Y
4	Commercial	86,944	22.41	0.74	149.99	Y
5	Market Rate Multifamily Property	141,357	3.20	0.22	32.77	Y
6	Unspecified Government/Public Sector	35,635	12.69	0.87	129.98	Y
7	Warehousing and Storage	30,211	65.72	-	224.26	Y
8	Market Rate Multifamily Property	61,070	4.92	0.03	19.62	Y
9	Middle School	94,000	-	0.30	29.50	N
10	Office	429,779	8.49	2.01	230.01	N
11	Primary School	94,731	2.73	0.27	39.77	Y
12	Multifamily Property	135,000	0.06	0.01	0.94	N
13	Gym/Athletic Club	45,249	-	1.31	130.99	Y
14	Retail	26,000	12.09	0.20	61.65	Y
15	Affordable Multifamily Property	41,850	8.04	0.08	35.88	Y
16	Hospital	64,548	2.19	0.13	24.42	N
17	Assisted Living Property	225,000	0.04	0.00	0.56	N
18	Assisted Living Property	157,055	-	0.09	9.01	N
19	Office	44,865	23.36	0.03	82.48	Y
20	Parking Structure/Garage	704,877	5.18	1.23	140.24	Y
21	Primary School	59,896	3.60	0.23	34.97	Y
22	Middle School	79,042	5.15	0.31	48.66	Y
23	Education	9,500	42.86	2.59	404.85	N
24	Manufacturing	36,748	812.86	-	2,773.59	Y
25	Lodging/Hotel/Motel	54,360	-	0.18	18.47	Y
26	Office	117,333	6.72	0.01	24.17	Y
27	Grocery	4,404	765.16	272.08	29,812.71	N
28	Plastics and Rubber Products Manufacturing	373,700	22.89	0.05	83.17	Y
29	Grocery	31,918	57.39	2.36	431.75	Y
30	Amusement/Recreational	28,600	6.09	0.06	26.49	Y
31	Retail	7,220	13.19	0.12	57.30	Y
32	Auto Services	50,000	5.72	0.26	45.63	Y
33	Gym/Athletic Club	7,215	11.29	0.13	51.62	Y
34	College/University	4,921	1,430.97	1.15	4,997.77	N
35	Lodging/Hotel/Motel	5,505	82.03	2.99	578.54	N
36	Retail	5,000	4.13	0.75	89.12	Y
37	Market Rate Multifamily Property	150,000	5.39	0.08	26.54	Y
38	Office	51,940	22.18	0.50	125.78	Y

Project	Building Type	Area (sf)	Electricity EUI (kWh/sf)	Gas EUI (therms/sf)	Total Energy EUI (kBtu/sf)	Used in Building Type Analysis
39	Enclosed Mall	1,500,000	0.23	0.02	3.03	Y
40	Office	75,148	119.31	0.81	488.46	N
41	Grocery	86,450	31.68	0.18	126.58	Y
42	Retail	107,981	14.54	0.17	66.74	Y
43	Market Rate Multifamily Property	184,619	2.29	-	7.83	N
44	Assisted Living Property	55,000	8.73	0.64	93.81	Y
45	Refrigerated Warehousing and Storage	174,326	22.85	-	77.97	Y
46	Wood Product Manufacturing	89,359	322.29	0.12	1,111.65	Y
47	Retail	34,117	8.36	0.26	54.45	Y
48	Lodging/Hotel/Motel	59,279	-	0.30	29.62	Y
49	Grocery	28,038	29.36	0.39	138.91	Y
50	Restaurant	2,776	35.98	1.37	259.70	Y
51	Warehousing and Storage	788,845	9.75	-	33.26	Y
52	Grocery	2,901	44.72	0.25	177.73	Y
53	Retail	9,100	9.89	-	33.73	Y
54	Parking Structure/Garage	126,700	55.24	0.19	207.50	N
55	Manufacturing	25,106	7.13	0.05	29.64	Y
56	Restaurant	4,716	60.41	3.01	507.17	Y
57	Office	4,625	50.74	3.59	531.63	N
58	Office	11,335	2.77	0.28	37.07	Y
59	Lodging/Hotel/Motel	81,531	9.54	0.39	71.86	Y
60	Office	476,508	7.66	1.81	207.45	N
61	Commercial	113,144	0.92	-	3.14	N
62	Warehousing and Storage	494,464	0.21	-	0.72	N
63	Retail	164,013	25.38	0.57	144.04	Y
64	Retail	10,043	14.72	0.35	85.24	Y
65	Restaurant	2,000	-	0.40	40.09	Y
66	Office	52,748	0.01	-	0.04	N
67	Grocery	42,105	35.63	0.70	191.80	Y
68	Affordable Multifamily Property	50,000	9.64	0.22	55.00	Y
69	Lodging/Hotel/Motel	183,827	15.66	0.73	125.94	Y
70	Lodging/Hotel/Motel	44,500	-	0.42	42.16	Y
71	Manufacturing	185,195	4.18	0.14	28.20	Y
72	Office	24,718	0.04	0.36	35.81	Y
73	Assisted Living Property	255,000	-	0.32	31.81	Y
74	Car Dealership/Showroom	26,368	13.05	-	44.54	Y
75	Office	8,089	10.24	0.26	60.96	Y
76	Agriculture, Forestry, Fishing and Hunting	102,000	3.03	-	10.33	Y
77	Lodging/Hotel/Motel	135,000	11.86	0.42	82.37	Y
78	Restaurant	4,031	96.89	3.13	643.97	Y
79	Restaurant	4,322	-	1.74	174.18	Y
80	Education	29,860	-	0.25	25.21	Y