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Evaluation of Continuous Energy Improvement - Draft Report

September 10, 2018

Revised June 28, 2019

Prepared for:

Vermont Public Service Department

112 State Street

Montpelier VT, 05620-2601

Prepared by:
Jim Stewart, Ph.D.
Kristie Rupper
Cheryl Winch
Maggie Buffum
Shannon Greene

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Executive Summary

In 2013, Efficiency Vermont (EVT) launched the Continuous Energy Improvement (CEI) pilot, which sought energy savings from large commercial and industrial utility customers through changes in energy management practices. The pilot sought lasting reductions in energy-use intensities (MWh/unit of output) by encouraging participants to adopt energy management planning, to make changes in operations, maintenance, and behaviors (OM&B), and to track and measure progress towards energy savings goals.

Currently, the pilot enrolls 11 organizations in two cohorts. The first cohort formed in late 2013 and included some of the state's largest commercial and industrial energy customers. The second cohort formed in late 2015 and included utility customers from the dairy industry. Cohort 2, which focused on ammonia refrigeration end uses, included four industrial participants. EVT's account management and engineering staff implemented the program, helping participants identify CEI savings opportunities, implement savings measures, and track, measure, and verify the savings.

EVT reported that the CEI pilot for cohort 1 and 2 achieved annual electricity savings of 2,875 MWh and heating oil and propane savings of 1,807 MMBtu in the 2016 reporting year. The Vermont Public Service Department contracted with Cadmus to evaluate the pilot's energy savings and cost-effectiveness for cohort 1 and 2 in 2016.

Research Objectives

The CEI Pilot evaluation had the following research objectives:

- Measure Cohort 1 and Cohort 2 energy savings: Independently estimate OM&B electricity and natural gas savings at each CEI participant site, accounting for impacts of any capital measures in 2016
- Verify EVT's estimates of site-specific OM&B, capital measures, and total pilot savings
- Assess Cohort 1 savings persistence
- Measure the pilot's overall cost-effectiveness
- Assess customers' satisfaction and perceived value of the program
- Develop recommendations for improving the pilot data collection, measurement and verification (M&V), and impact evaluation approaches, specifically with respect to the following:
  - Facility data reporting and sub-metering
  - Establishing reliable M&V baseline models
  - Collecting program-related costs, including customer costs
- Identify potential OM&B savings for future program planning

To perform the evaluation, Cadmus estimated energy savings, conducted interviews with CEI program managers, and conducted a cost-effectiveness analysis. For each facility, Cadmus estimated a baseline consumption model and predicted consumption (the adjusted baseline consumption) as a function of weather, production, and facility closures during the reporting period. Cadmus estimated each facility's electricity, oil, or propane annual savings by subtracting metered consumption from the adjusted baseline consumption. We obtained an estimate of CEI savings by subtracting savings from capital projects not incentivized by the CEI program from the facility savings estimate.

For the process evaluation, Cadmus interviewed 11 participants from both cohorts to gather information about program implementation and participant experience. Through the interviews, Cadmus identified several potential improvements to EVT's M&V approach that EVT can implement.

Conclusions and Recommendations

The calculation of the electricity savings realization rate does not include five facilities for which Cadmus was unable to estimate savings. It was not possible to estimate their electricity savings because of either the unavailability of data or nonroutine events at the facility that invalidated the baseline model. Since the unavailability of data and non-routine events that prevented evaluation may have been correlated with the facility CEI savings, the savings realization rate for the evaluated facilities may not have validity for the unevaluable facilities. As described below, the program cost-effectiveness calculation that Cadmus performed includes the total cost of the program and only the savings from evaluated facilities.

Evaluated Savings

Utility customers achieved significant energy savings by implementing CEI. In 2016, Cohort 1 and Cohort 2 participant facilities saved 5% of electricity consumption, with savings of 4% attributable to CEI measures. EVT's CEI electricity savings of 4% compare favorably to the savings of SEM or CEI programs of other utilities.

In 2016, Cohort 1 facilities saved 7% of electricity consumption, with savings of 5% attributable to CEI. Cohort 2 facilities, which focused on ammonia refrigeration processes, saved 5% of electricity consumption, with 3% attributed to CEI measures.

Electricity savings of Cohort 1 facilities increased from 3% in 2015 to 5% of consumption in 2016. According to EVT site reports, Cohort 1 ramped up its CEI implementation between year 1 and year 2, which likely accounts for the increase in savings.

Individual facility CEI electricity savings estimates varied, though most were in the range from 1% to 5%. In Cohort 1, percentage electricity savings ranged between -10% and 19%. In Cohort 2, percentage electricity savings ranged between 1% and 7%.[1]

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[1] It is not possible to rule out that CEI implementation caused energy consumption to increase after controlling for changes in facility output and weather between the baseline and reporting period. Though such an increase is unlikely, it is possible that participant facilities could have incorrectly programed control settings leading to an increase in consumption.

Recommendation

EVT should continue to engage customers for more than one year. With continued assistance from EVT, Cohort 1 facilities increased their electricity savings during the pilot's second year.

Savings Realization Rate

The pilot electricity savings realization rate in 2016 was 98%, indicating that on average the evaluation and EVT estimated similar savings for the CEI pilot. The electricity savings realization rates were 92% for Cohort 1 and 104% for Cohort 2. Although there was significant variability in percentage savings between facilities, EVT's reported and the evaluated savings for individual facilities generally aligned. The savings realization rate for the evaluated facilities may not have validity for the unevaluable facilities.

Evaluated Monitoring, Targeting, and Reporting Models

In general, EVT's baseline consumption models appear to be well specified and to accurately estimate energy savings for both cohorts. Cadmus tested many model specifications and often chose different ones than EVT, but the pilot, cohort, and individual facility savings realization rates were close to 100%, suggesting that EVT's monitoring, targeting, and reporting (MT&R) models are yielding accurate savings estimates.

Cadmus was unable to evaluate CEI energy savings in 2016 for five facilities, either because data required for evaluation such as facility production were unavailable or the facilities implemented changes during the baseline or reporting periods that rendered the statistical models invalid. By collecting the required data or resetting the baseline period, it should be possible to estimate savings for these facilities in future years.

Recommendation

Cadmus does not recommend any significant changes to EVT's savings verification process. EVT should continue to use best practices for estimating savings through individual facility baseline models. EVT should consider including control variables for holidays and closures to improve some models' adjusted R^2 statistics. EVT should not submit savings claims for facilities that it is aware need to be re-baselined.

For unevaluable facilities, Cadmus recommends that EVT reset the baselines or attempt to collect data required for evaluation.

Cost-Effectiveness

The CEI pilot was cost effective in 2016 assuming a one-year CEI measure life and for 2015-2016 assuming a CEI measure life of two or more years. Assuming a one-year measure life, the cost per kWh of savings was approximately $0.10 for 2016 and $0.17 for 2015-2016. Assuming a two-year measure life, the cost per kWh of savings was approximately $0.05 for 2016 and 0.09 for 2015-2016. The CEI electricity savings and delivered fuel savings used to calculate cost effectiveness only include savings from the evaluated facilities. The administrative program costs were the costs of administering the program to all participant facilities, not just the 11 facilities that Cadmus evaluated.

Analysis of persistence data for individual CEI measures collected from Cadmus' interviews with energy managers suggests that the CEI pilot has a measure life of two or more years . Of implemented activities, energy managers reported that all remained in place two years later, implying a measure persistence rate of 100%.

CEI Savings Persistence

EVT's CEI pilot is expected to have a lasting effect on participants' energy consumption. Although not every organization fully implemented all key Consortium for Energy Efficiency (CEE) SEM minimum element definitions[2], all participants indicated they were likely to continue implementing lessons learned through their CEI engagement, and eight said they are more likely to conduct energy efficiency projects since participating in CEI. The SEM minimum elements concern customer commitment to energy management, planning and implementation of energy management practices, and establishing systems for measuring and reporting progress towards energy management goals.

Furthermore, persistence for projects implemented in 2016 and still in place in 2018 was 100% overall, indicating customers are committed to retaining energy efficiency improvements over time.

Recommendation

Results from the measure persistence analysis support a change in the assumption of a CEI measure life from one to two years. However, EVT should continue to measure the energy savings of Cohort 1 and Cohort 2 facilities to assess savings persistence. Furthermore, EVT should continue to evaluate the persistence of individual CEI measures and determine the extent to which savings and measure persistence correlate. Future analysis of energy savings and measure persistence should inform updates to measure life assumption for the CEI pilot.

EVT Support

Participants were satisfied with support they received from EVT staff. Participants reported that staff were well equipped to answer questions, provide pertinent information, and resolve problems. Although participants expressed confidence in suggestions and information provided by EVT staff, occasionally responses were delayed as EVT consulted with multiple experts to find answers.

Recommendation

EVT should consider making a list of technical advisors and experts available to participants, enabling organizations to directly contact specific technical support staff. This could potentially reduce the time required for participants to receive a response. EVT could share this list of technical experts at the beginning of each cohort, updating it as needed over the course of a participant's engagement.

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[2] "CEE Strategic Energy Management Minimum Elements." CEE. February 11, 2014. Web: June 16, 2016. http://library.cee1.org/sites/default/files/library/11283/SEM_Minimum_Elements.pdf

Participant Satisfaction with the Pilot

Overall, participants expressed satisfaction with the CEI pilot. Eight participants indicated they were *very satisfied* and three indicated they were *somewhat satisfied*. Four participants identified the workshops and Kaizen events as successful program elements. Four other participants considered the EVT staff's helpfulness and communication as reasons for the program's success. One participant said the ability to involve more hands-on people and share experiences with others in related fields also benefitted the pilot.

Employee Engagement

Participants cited engaging employees as the biggest challenge to their participation. Engaging employees in saving energy was not a primary objective of CEI pilot participants. Cohort 2 participants were primarily motivated to participate in the program to save energy and to reduce energy costs. Although EVT has designed many employee-engagement materials for organizations, only one participant in Cohort 2 completed or plans an employee engagement activity in 2018.

Recommendation

EVT should consider holding webinars with current participants to exchange ideas about low- or no-cost methods to engage employees, allowing participants to learn from this strong peer network. EVT could continue gathering topics and tips from organizations throughout participation via workshops and Kaizen[3] events and could provide updates to participants through monthly energy team meetings or newsletters.

Year-End Report

The year-end report remained important for engaging participants in energy saving activities. EVT's changes to the year-end report resulted in a more streamlined approach to data gathering, producing a report that provided key findings in a manner that allowed participants to easily determine successes and challenges. Despite these improvements, staff suggested including additional quality control checks to the data gathering process as well as establishing more clearly defined report assignments for EVT staff contributions.

Recommendation

EVT should consider reviewing the analysis process to identify additional quality control steps to ensure report accuracy and usefulness. Further, EVT could consider creating a checklist to identify each step in the year-end report process. This checklist could include a task description, the information's source, staff members responsible for completing the analysis and contributing to the report (along with staff responsible for performing previously identified quality control steps). Such a checklist would provide

[3] Kaizen is Japanese for "improvement." When applied to the CEI Pilot, kaizen refers to on-site workshops designed to help customers identify low- or no-cost energy efficiency opportunities while providing peer-to-peer interactions and support.

clear communications to all staff about their responsibilities concerning the year-end report, thus reducing duplication of tasks.

Peer-to-Peer CEI with a Common Energy End Use

Implementing CEI with peers and focusing on a single energy end-use was a successful model. Cohort 2 saved 3% of energy consumption, with individual facilities savings between 1% and 7% of consumption. Cohort 2 participants reported positively about the peer approach, as interactions with peers provided a means to discuss potential savings opportunities and challenges. The focus on ammonia refrigeration allowed EVT to provide technical experts who could consult with every participant in the cohort.

Recommendation

For Cohort 3, EVT is focusing on common energy end uses (health care facilities) and should consider continuing this approach in later cohorts. EVT should consider conducting additional research to determine whether future cohorts should be assembled based on end use, industry, size, or some other characteristic.

Introduction

In 2013, Efficiency Vermont (EVT) launched the CEI Pilot, targeting energy savings from large commercial and industrial (C&I) utility customers. CEI seeks workplace organizational and cultural changes to make reducing energy waste and energy intensities standard practice, from the factory floor to upper management. The Pilot focused on achieving lasting energy savings through energy management planning, changes in operations, maintenance, and behaviors (OM&B), and tracking of progress towards energy savings goals.

In 2016, two cohorts of utility customers were enrolled in the program. Table 1 lists the facilities in each cohort, the customer business segment, and the launch date. To protect the identities of participants, Cadmus assigned a unique identification number to each participant facility. Throughout the report, we use these unique identification numbers (F1-F12) when referring to individual participants and facilities.

Cohort 1 launched in 2013 with eight C&I customers, including some of Vermont's largest energy users. Cascade Energy delivered the pilot to this cohort. Cohort 2 launched in 2015 and included customers with similar energy end uses. Cohort 2 included four utility customers in Vermont's dairy industry, which consumed a large amount of electricity for ammonia refrigeration. EVT facilitated the program for Cohort 2 and plans to continue this role for future cohorts.[4] Despite having the same kickoff dates, Cohort 2 participants were at different CEI implementation stages in 2016, with CEI activities commencing at different times. For the Pilot's third cohort, EVT plans to add seven customers, with a focus on health care facilities.

Table 1. VT CEI Pilot Participants

Participant ID	Industry/Commercial Business Segment	Launch
		Cohort 1
F1	Hospital/Medical Center	02/13/2014
F2	Manufacturing	N/A
F3	Manufacturing	03/25/2015
F4	Manufacturing	06/17/2014
F5	Manufacturing	02/13/2014
F6	Manufacturing	02/01/2014
F7	Resort	02/01/2014
F8	Manufacturing	02/01/2014
		Cohort 2*
F9	Manufacturing (Dairy)	11/11/2015
F10	Manufacturing (Dairy)	11/11/2015
F11	Manufacturing (Dairy)	11/11/2015
F12	Manufacturing (Dairy)	11/11/2015
*All participants attended a kickoff workshop 11/11/2015 but each participant implemented CEI activities at a difference pace.		

[4] EVT used Cascade Energy as a technical consultant for the first Cohort 2 workshop.

Participation Process

Participation in the CEI pilot involved customer recruitment, training presentations, and CEI program implementation.

Customer Recruitment

In both Cohort 1 and Cohort 2, EVT account management staff recruited participants; explaining the fundamentals of CEI along with the benefits of participation. Interested customers attended a kickoff workshop that provided an overview of the pilot and outlined pilot steps and activities. Workshop content for both cohorts was similar with the addition of Cohort 1 feedback included in the workshop for Cohort 2. Cohort 2 participants attended the workshop on November 11, 2015.

Following the kickoff workshop, participants signed a Memorandum of Understanding (MOU) that summarized the customers' commitment to the program. Pilot participation requires corporate and facility level commitment.

Training Presentations

EVT held several workshops for participants. They held similar workshops for both cohorts in the first year of engagement but participants in Cohort 2 also attended two technology-based workshops focused on ammonia refrigeration and held an Ammonia System Blitz. Throughout 2016 and early 2017, the following training presentations were offered to Cohort 2 participants:

- Refrigeration Best Practices (two-part) workshops
- Data Tracking Tools workshop
- Ammonia System Blitz
- Progress workshop
- Year-end reporting workshop

CEI Implementation

Once participants were enrolled, EVT's account management and engineering staff helped participants to undertake the following:

- Identify CEI savings opportunities
- Implement savings measures
- Track, measure, and verify savings
- Improve organizational focus on facility energy management practices

Specifically, each participant identified an energy champion, who could have roles such as facility manager, energy expert or some other facility level contact. To help participants identify savings opportunities, EVT staff conducted site assessments for each company. During these site assessments, EVT staff developed an Energy Management Assessment, identifying significant energy uses and developing regression analysis in MS Excel. Following the site assessment, the company formed an energy management team which included an energy champion at the company along with EVT's account management and engineering staff. During the first few months of engagement the energy team created an energy plan, began metering and data tracking, and established a communication plan. Participants tended to meet with EVT on a regular basis, although the frequency of meetings depended on each company's projects and goals. Through ongoing communication and updates with the energy-team they modified their energy plan.

At the year's conclusion, EVT staff prepared a year-end report that summarized findings from pilot activities, so organizations could identify successes and challenges in considering their goals for the following year.

Methodology

This section describes research methodologies used in conducting the following evaluation tasks, as included in the research plan:

- Document review
- Staff interviews
- Participant interviews
- Energy-savings analysis
- Cost-effectiveness

To answer research questions addressing program design, processes, delivery, and performance, Cadmus conducted interviews with EVT staff and pilot participants. To estimate CEI energy savings and cost-effectiveness, Cadmus conducted individual regression analysis of each facility's energy use. Cadmus evaluated the 2016 facility and CEI energy savings for four Cohort 1 participants and three Cohort 2 participants.

Document Review

Cadmus used the document review to determine which participants could be evaluable and to understand what savings measures were implemented at each facility. Cadmus established that the statistical modeling was the best tool to use to estimate energy savings. Table 2 lists documents reviewed by Cadmus.

Table 2. Reviewed Documents

Document	Description
2016 Monitoring, Targeting, and Reporting (MT&R) reports	Report outlining the organization's implemented actions and data collected
CEI One-Pager	Program description for potential organizations
Statistical Tools	Benefits description for using statistical tools to track energy use
MOU Template	Agreement organizations signed upon starting their engagement with the Pilot
CEI Assessment Tool	Tool outlining program milestones and EVT's scoring procedures
CEI Overview PowerPoint Presentation	Presentation EVT created to introduce the program to potential Pilot participants
CEI White Paper	Paper describing CEI programs' benefits
Sample Energy Plan	Workbook for organizations tracking energy reduction activities and ideas

Interviews

In June and July 2018, Cadmus conducted six telephone interviews with EVT staff: two with the EVT program management staff, three with energy consultants and one with account managers. The interviews addressed the following topics:

- Objectives and goals
- Pilot delivery, data management, communication, and year-end reporting
- Participant motivation
- Successes and challenges
- Suggestions for improvement

Participant Interviews

In August 2018, Cadmus administered telephone interviews with 11 energy managers: six representing Cohort 1 and five representing six facilities in Cohort 2. The objective of these interviews was to assess customer satisfaction and perceived value of the Pilot. The interviews sought to achieve the following objectives:

- Assess implementation challenges and successes
- Achieve insights into adoption and persistence of CEI activities
- Assess satisfaction with program components
- Identify possible implementation improvements

The interview responses generally reflect feedback about participant experience in 2018. Participant Interview provides a copy of the participant interview guide.

Energy Savings Analysis

Cadmus estimated the CEI electricity, oil, and propane savings for each participating facility that reported savings in 2016.[5] To estimate the energy savings, we performed the following:

1. Modeled each facility's energy consumption during the baseline period
2. Predicted what the facility's energy consumption would have been if the facility not implemented CEI (i.e., *adjusted baseline* energy use) as a function of facility output, occupancy, weather, and other determinants of consumption
3. Estimated facility energy savings as the difference between metered consumption and adjusted baseline consumption.
4. Calculated the CEI savings by subtracting savings from incentivized capital projects from the facility savings estimate.

[5] Following the forthcoming Uniform Methods Project on Strategic Energy Management program evaluation, Cadmus defined the facility as the area of a site over which energy use would be measured and analyzed.

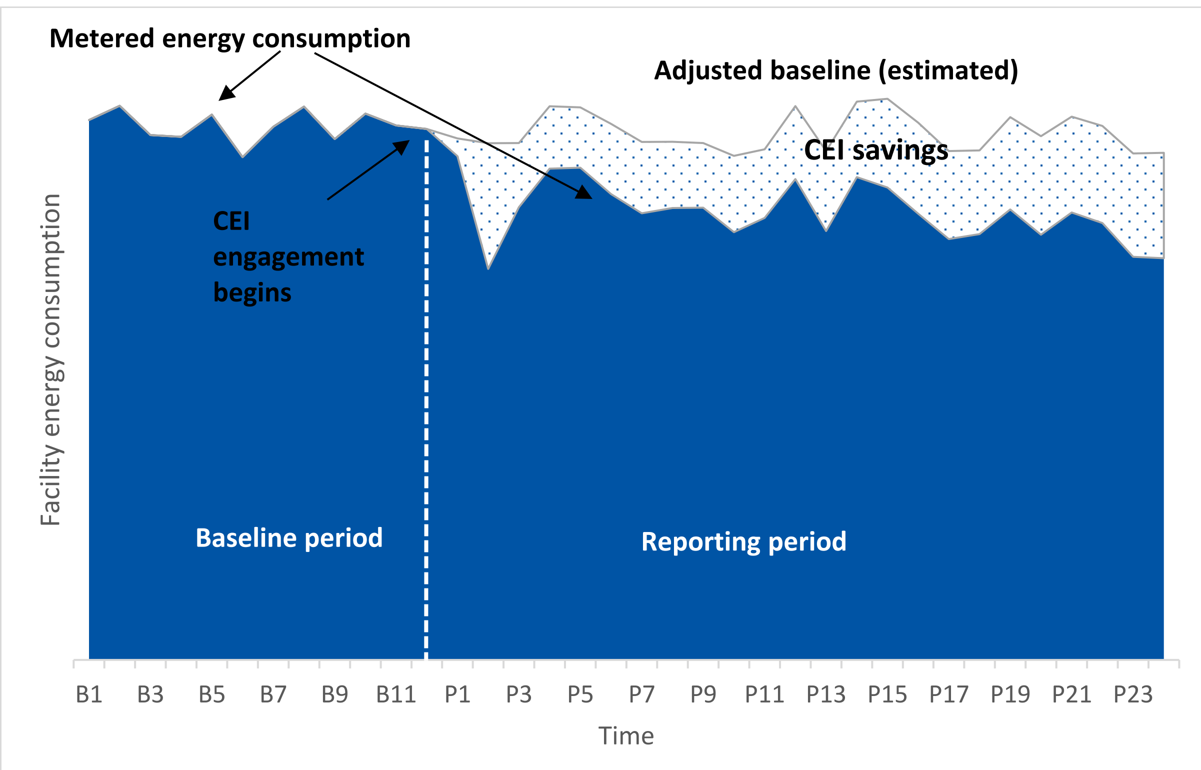
Cadmus followed best practices for conducting whole-facility savings analysis, as outlined in the International Performance Measurement and Verification (2012) *Protocol Option C, Whole Facility Guidelines* and in the U.S. Department of Energy Uniform Methods Project (UMP) *Strategic Energy Management Evaluation Protocol* (2017). The rest of this section describes the methods used in greater detail.

Overview

Cadmus estimated CEI savings for each facility by comparing that facility's metered energy consumption during the *reporting period* with the facility's *adjusted baseline energy consumption* during the same period. The *reporting period* was the period during which CEI savings were estimated. The *baseline period* was the period before CEI activities took place and which the evaluation analyzed to estimate the facility's baseline energy consumption. Adjusted baseline consumption was estimated with a regression model of *baseline period* energy consumption.

Figure 1 illustrates CEI energy savings estimation, showing metered energy consumption and adjusted baseline consumption. The dotted area represents the facility savings (i.e., the area between the adjusted baseline and metered energy use). For simplicity, the example assumes there were not any incentivized capital projects. This implies that the facility savings equal the CEI savings.

Figure 1. Estimation of CEI Energy Savings



Cadmus estimated the adjusted baseline using facility energy-consumption data from the baseline period. Using regression analysis, we adjusted the baseline energy consumption for baseline and reporting period differences in output, weather, occupancy, or other measured variables affecting a facility's energy consumption.

Cadmus estimated facility savings as the difference between metered energy use and adjusted baseline energy use. We estimated CEI savings by taking the difference between estimated facility savings and savings from capital projects receiving incentives through other EVT programs that the facility implemented during the reporting period. If the facility did not implement such capital projects, CEI savings equaled the estimated facility savings.

This approach for evaluating CEI Pilot facility savings yields accurate savings estimates upon meeting the following conditions:

- **No omitted variable bias (no confounding variables):** The regression must be correctly specified and must not omit key variables affecting energy use. Specifically, the model controls for all variables affecting energy use that correlate with CEI implementation.
- **No measurement error:** The model's independent variables were not measured with error. For example, a facility's output must be reported and enter the model accurately.

Cadmus attempted to avoid bias from omitted variables by including all relevant variables in the baseline energy-use model. A description follows of procedures used for selecting the regression model variables. The procedure was designed to minimize potential omitted variable bias. To minimize the potential for measurement error, Cadmus verified the baseline period definition and reviewed the energy-use, output, and occupancy data for outliers and errors.

Energy savings analysis for each facility involved five main steps (listed below and followed by detailed descriptions):

1. Verify the facility boundaries and availability of energy-use data.
2. Define the baseline and reporting periods.
3. Replicate reported model coefficients and savings.
4. Build the baseline regression model.
5. Estimate facility and CEI savings.

Step 1. Verify the Facility Boundaries and Availability of Energy-Use Data

For each facility, Cadmus verified the following:

- Facility boundaries (i.e., the area over which energy use was measured)
- Facility energy use and other key variables at the facility were available

Facility energy use and other variables were measured consistently over time

Cadmus followed up with EVT staff to resolve discrepancies or missing data for a facility. In general, EVT staff or CEI consultants were able to answer these questions or to provide the missing data.

Step 2. Define the Baseline and Reporting Period

Cadmus reviewed the implementer's definitions of the baseline and reporting periods for each facility. We checked whether the baseline period covered a full year. If it did not, we verified sufficient data to build a valid model of facility energy consumption were available. Cadmus deemed 11 months as providing enough baseline data for a valid model.

Step 3. Replicate Reported Model Coefficients and Savings

Cadmus reviewed EVT's model as reported in the site reports and attempted to replicate the model's coefficients using the defined baseline and provided data. Cadmus also sought to replicate reported savings using the reported model coefficients. If it was unable to replicate the reported model coefficients or reported savings, Cadmus followed up with EVT staff to discuss the discrepancies.

Step 4. Build the Baseline Energy-Use Model

Specifically, Cadmus followed these steps to construct the baseline consumption model:

- ***Step 4a. Identify the candidate set of explanatory variables:*** Cadmus selected the candidate variables by reviewing the annual participant report, which included information about facility energy output, weather, and other consumption drivers.
- ***Step 4b. Identify significant energy drivers:*** A critical first step in identifying significant energy drivers was visualization of the consumption, weather, occupancy, and production data. We plotted these variables against each other and time. These graphs depicted bivariate correlations in the data and time trends. For participants with monthly and weekly data, Cadmus fit and tested several baseline model specifications for each facility, selecting the model that best fit the facility's baseline period energy consumption. For two facilities with daily interval consumption data, Cadmus used Least Absolute Shrinkage and Selection Operator (LASSO) regression, an automated model selection process, to select the regression model specification. This approach involved partitioning the baseline period data and performing out-of-sample cross-validation of model predictive accuracy for a large number of candidate models. For remaining facilities with weekly or monthly consumption data, Cadmus selected baseline models by evaluating their predictive accuracy using within-sample measures of fit such as adjusted R^2, F statistics, and the AIC statistics
- ***Step 4c. Review and select the final baseline model:*** Cadmus reviewed the selected model and confirmed that the model was consistent with its understanding of the facility's energy consumption.

The Appendix includes a more detailed description of the steps Cadmus followed to build baseline consumption models.

Step 5. Estimate Facility Savings

The final model selected to estimate a facility's adjusted baseline energy consumption took the following general form:

Equation 1

$$e_t = \alpha + f(output_t, outside\ temperature_t, \beta) + g(other_t, \gamma) + \varepsilon_t$$

With model variables defined as follows:

t	The t[th] time interval (day, week, or month), t=1, 2, …, T. For example, T=365 if daily energy use was modeled and energy-use data were available for a full year.
e_t	Energy consumption of the facility during the t[th] time interval.
α	Intercept indicating facility average base load energy-use per interval.
$output_t$	A vector of different outputs produced at industrial facilities during the t[th] time interval.
$temperature_t$	A vector of different outdoor temperature variables (e.g., HDD, CDD, average daily temperature) affecting facility energy use during the t[th] time interval.
β	A vector of coefficients that indicates the relationship between energy use and key explanatory variables (e.g., outputs, outdoor temperature, and occupancy). For example, the coefficient on output would indicate average energy use per unit of output.
$other_t$	A vector of additional explanatory variables and/or indicators related to a facility's energy consumption during the t[th] time interval. This may contain facility closures, production variables, indicators of changes to the facility, or indicators of changes in measurement.
γ	A coefficient vector that indicates the relationship between the additional explanatory variables and energy consumption.
ε_t	The model error term representing unobservable influences on energy consumption in period t.

To estimate facility savings, Cadmus used Equation 1 to calculate the adjusted baseline energy use, as shown in Equation 2:

Equation 2

$$\hat{e}_t = \hat{\alpha} + f\left(output_t, outside\ temperature_t, \hat{\beta}\right) + g(other_t, \hat{\gamma})$$

where $\hat{e}_t$ is the adjusted baseline energy use for time interval *t,* and ˆ denotes an estimate.

As noted, adjusted baseline energy use is an estimate of energy consumption if CEI had not been implemented during reporting period conditions. Cadmus estimated facility savings during interval *t* of the reporting period s_t, as the difference in adjusted baseline consumption and metered consumption:

Equation 3

$$\hat{s}_{\mathrm{t}} = \hat{e}_t - e_t$$

The sum of savings over the T^P intervals of the reporting period estimated total facility savings during the reporting period, S:

Equation 4

$$S = \sum_{t=1}^{T^P} \hat{s}_{\mathrm{t}}$$

Cadmus estimated CEI savings for each facility by subtracting any capital projects incentivized through other EVT programs (S_K) during the reporting period from S:

Equation 5

$$S_{CEI} = S - S_K$$

Using the facility's annual participant reports, Cadmus obtained estimates of the facility's capital project savings. Cadmus then prorated savings from capital projects implemented in 2015 (if still in-service) and 2016.

Cost-Effectiveness

Camus conducted the cost-effectiveness analysis using the Vermont (VT) 2016 Statewide Screening Tool which EVT provided to Cadmus. EVT uses the societal cost test (SCT) to screen Vermont's energy efficiency programs. Table 3 presents benefits and costs included in the SCT for the RCBS pilot.

Table 3. SCT Benefits and Costs

Benefits	Costs
Electric Energy	Program Administration
Electric Capacity	
DRIPE[a]	
Electric Externalities	
Non-Electric Benefits	

[a]Cadmus incorporated the 2016 DRIPE values included in the tool into the total benefits reported.

Cadmus obtained the estimate of 2016 energy savings from its analysis of participant electricity consumption. EVT provided the pilot administrative costs, and Cadmus assumed participants did not incur additional costs to participate in the program. To estimate the optimal CEI measure life, Cadmus conducted a sensitivity analysis and calculated cost-effectiveness results, where effective useful life (EUL) = 1, 2, 3, and 5 years, as shown in Table 10.

Evaluation Findings

This section describes findings drawn from the document review, staff interviews, participant interviews, energy savings analysis, and cost-effectiveness analysis.

Pilot Goals and Objectives

At the Pilot's beginning, EVT established goals and objectives (as discussed in Appendix E). These goals included identifying cost-effective energy management strategies, engaging customers, and developing systems to track energy saving projects and activities. While efforts to achieve most goals are ongoing, one has been achieved: following the Pilot's first year, EVT demonstrated that savings from behavioral changes could be quantified through a measurement and verification (M&V) approach.

In addition to the pilot's goals and objectives, established at the beginning of Cohort 1, EVT added a cost-effectiveness goal for Cohort 2. While EVT did not set participation goals, it did estimate eight to 10 participants would be required to meet cost-effectiveness goals. Although, EVT did not have savings findings when program management staff spoke with Cadmus, those interviewed felt they were probably on track to meet their cost-effectiveness goals with the four participants (representing seven facilities) enrolled in Cohort 2.

Pilot Tools

This section summarizes interview responses pertaining to the tools participants and EVT staff utilize to implement and participate in the Pilot.

CEI Tools

Pilot participants continue to use many tools and activities employed during their CEI engagement. Table 4 shows the extent to which participants are implementing each activity in 2018. The table shows each tool or activity, the number of pilot participants in each cohort who said they were implementing that tool or activity in 2018 along with details on the frequency of the activity or the specific type of tool implemented.

Table 4. Implementation of CEI Tools in 2018

Tool	Cohort 1: Implementing in 2018 (n=6)		Cohort 2: Implementing in 2018 (n=5)	
	Total	Details	Total	Details
Energy Team Meetings	6	• 33% (2) holds meetings weekly • 50% (3) holds meetings monthly • 17% (1) holds meetings quarterly	3	• 67% (2) holds meetings monthly • 33% (1) holds meetings at least once per year
Employee Engagement Activities	4		1	
Energy Action Plan	4	• 50% (2) updates the plan monthly • 25% (1) updates the plan quarterly • 25% (1) updates the plan annually	3	• 33% (1) updates the plan monthly • 33% (1) updates the plan bi-monthly • 33% (1) updates the plan semi-annually
Energy Management System	6	• 50% (3) use Sensai • 33% (2) use SkySpark • 17% (1) use an internal system	5	• 40% (2) use Cotopaxi • 20% (1) use Sensai • 20% (1) use RS Energy Metrics • 20% (1) use an internal system
Energy Tracking	6	• 17% (1) tracks energy weekly • 50% (3) tracks energy monthly • 17% (1) tracks energy quarterly • 17% (1) tracks energy annually	4	• 70% (3) tracks energy monthly • 25% (1) tracks energy annually

EVT Internal Communication

Throughout most 2016, EVT staff met monthly to discuss CEI, but they currently are in the process of shifting to a quarterly steering committee. They continue to hold ad hoc meetings when needed to discuss workshop ideas and other implementation strategies.

Energy Management Software

Four pilot participants tracked energy use and CEI milestones using SENSEI; two used Strata (Cotopaxi); two used internal systems; and one used SkySpark.

Both EVT staff and pilot participants reported that the energy management tools were easy to use and that they had not experienced major problems. Four participants using SENSEI found the system *very easy* or *somewhat easy* to use in tracking energy usage and CEI milestones, given its user-friendly layout, easy-to-navigate format, and ability to track energy usage at a granular level. Three out of four SENSEI users were Cohort 1 participants, and none of the users reported issues with the tracking tool.

The Cohort 1 participant using SkySpark said the system was *somewhat easy* to us, and one of the two participants using Strata (Cotopaxi) stated that system was *very easy* to use. A participant using an internal system—RS Energy Metrics—said it was only *somewhat easy* to use because making new reports and navigating the software could be cumbersome for those unfamiliar with it. **All participants were satisfied with the energy management systems in place for tracking energy use and milestones, and they did not have any plans to change them**.

Year-End Report

During the last evaluation, EVT staff faced various challenges in gathering consistent information for the database and in compiling a separate year-end report for each facility, which proved time-consuming to complete. At the time, EVT expressed concerns about the report's usefulness to participants due to the great amount of detail included in each report.

Since the initial year-end reporting for the 2015 pilot, EVT has made changes to improve the report and the process. Rather than delivering a separate report for each company, EVT streamlined the report to focus on key findings summarized for each company within a single report. EVT also developed a process to simplify data gathering. Along with this process change, EVT created a spreadsheet to indicate data needed from each company. In the future, EVT plans to have quarterly or semiannual check-in meetings with participants, procuring progress reports; so EVT can begin integrating this information into the year-end report earlier than at the close of the year.

Although the year-end report process has improved, one staff member suggested more direction was needed regarding which EVT staff member was responsible for contributing to each report section. The same staffer suggested incorporating more quality-control steps to make certain the report uses accurate information throughout.

Staff offered another suggestion for improving the year-end report: adding more detail about behavioral changes that, though difficult to measure, could be useful to highlight, elevating visibility for less tangible impacts.

Pilot Satisfaction

In the participant interviews, Cadmus asked questions pertaining to satisfaction with various aspects of the program.

Overall

Overall, participants expressed satisfaction with the CEI program, with eight answering they were *very satisfied* and three answering *somewhat satisfied*.

Cadmus asked participants to elaborate on program aspects that worked particularly well. Four participants identified the workshops and Kaizen events as successful program elements. Four other participants considered the EVT staff's helpfulness and communication as reasons for the program's success. One participant said the ability to involve more hands-on people and share experiences with others in related fields also benefitted the pilot.

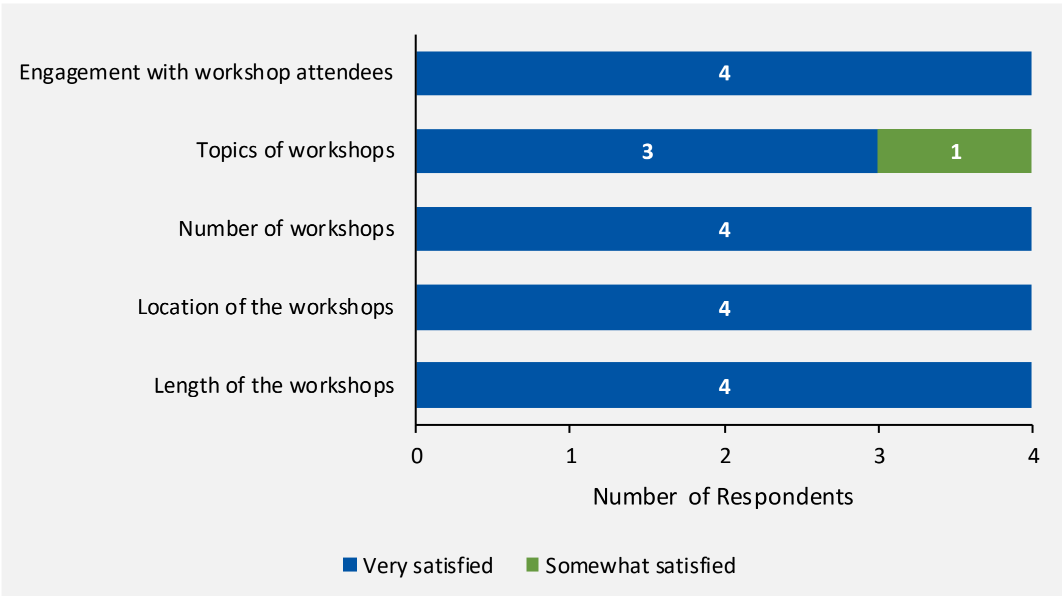
Cohort 1 participants noted that the EVT team, end-of-the-year report, and peer-to-peer networking were the aspects most useful in helping them improve energy performance. EVT staff helped participants realize that their projects were achievable, provided practical experience, and provided expertise in unfamiliar areas. The end-of-the-year report helped participants draw a baseline to which they could compare themselves, determining which areas they could improve.

According to EVT staff, Cohort 2 works well as all participants use the same ammonia refrigeration technologies. All face similar challenges, and peer-to-peer networking helps them identify opportunities they otherwise might not know about. **Focusing the cohort on one technology helps participants identify ideas for improvements and leads to deeper discussions regarding how to make improvements and provides an easier path to success**. Additionally, Cohort 2 was located in the center of the state; so participants found it easier to attend hosted visits or workshops.

Workshops

Four pilot participants attended workshops in 2017 or 2018, with three of four workshop attendees belonging to Cohort 1. Participants answered questions about their satisfaction levels with several key workshop components: workshop locations, workshop lengths, numbers of workshops offered, and topics addressed in each workshop. **Overall, participants expressed satisfaction with all workshop components, as shown in Figure 2.**

Figure 2. Workshop Satisfaction (2017 and 2018)



Source: Participant interview question H1a-e, "Thinking about the workshops you attended as part of your CEI engagement, please tell me how satisfied you were with the following aspects. Were you very satisfied, somewhat satisfied, not too satisfied, or not at all satisfied with …" (n=4)

A Cohort 1 participant said they were *somewhat satisfied* with the topics of each workshop as they were typically geared towards residential and commercial interests, and the participant specialized in industrial production.

Pilot participants provided suggestions for improving the workshops. One Cohort 1 participant said tailoring workshops to businesses with common interests and helping similar business networks would help improve the workshops. A Cohort 2 participant suggested placing a greater focus on refrigeration as it could be the most cumbersome of the energy-saving improvements. Two Cohort 1 respondents did not have recommendations to improve the workshops.

While the interview did not ask pilot participants about specific workshops, EVT staff said that several Cohort 2 participants who attended a workshop on ammonia refrigeration returned to their organizations and immediately made changes, such as lowering the head pressure on their systems. Information they learned from other participants during this workshop inspired them to increase efficiency.

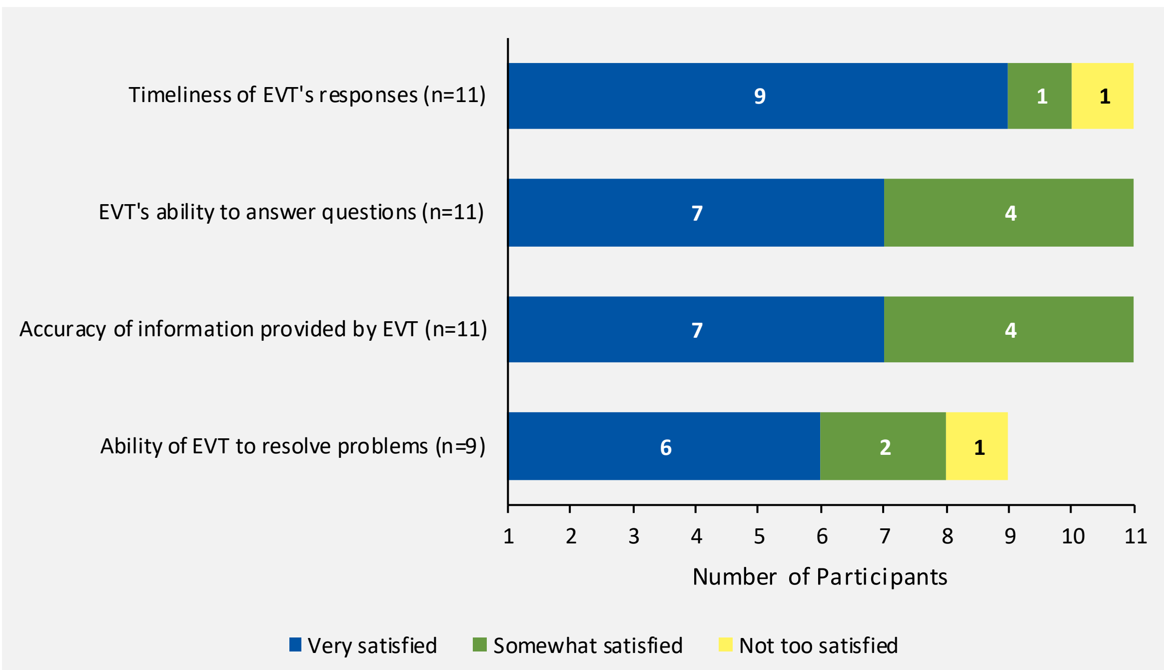
Kaizen Events

Two pilot participants from Cohort 1 attended a Kaizen event in either 2017 or 2018. Both characterized the Kaizen events as *very useful* (n=2). These participants found them helpful in identifying energy-saving opportunities, and they used the event as a springboard for future projects.

Pilot Components

Pilot participants answered questions about their satisfaction with their interaction with EVT staff. As shown in Figure 3, all respondents expressed satisfaction with EVT.

Figure 3. Satisfaction with EVT



Source: Participant interview question J1a-d, "Please answer the following questions about your satisfaction with your [INSERT STATEMENT]. Were you very satisfied, somewhat satisfied, not too satisfied, or not at all satisfied?"

Participants were satisfied with support they received from EVT staff, finding them well-equipped to answer and resolve problems and to provide accurate information. Overall, participants had confidence in the suggestions and information that EVT staff provided due to their attention to detail and broad knowledge of various equipment types. One Cohort 2 participant was *not too satisfied* with the timeliness of EVT's responses and their ability to resolve problems. This participant felt EVT staff lacked engagement with their project, reflected in their overall responsiveness. Three other participants said turnarounds to resolve issues or answer questions sometimes took longer as questions had to be deferred to others.

Participants also answered a question about the most important information provided by their CEI coach. Seven participants cited EVT's willingness to answer questions, provide information, and offer alternative options for improvements. One participant was impressed by their CEI coach's ability to bring in a full range of equipment experts. Another participant highlighted the importance of receiving outside perspectives from other facilities during a Kaizen event.

Project Implementation and Persistence

Participants answered questions regarding the status of projects implemented during the CEI pilot. Cadmus' questions addressed the status of up to six of the projects with the highest expected savings listed in the 2016 year-end report for each participant. Of 46 total project activities, 34 were implemented. **Of implemented activities, 34 remained in place two years later, implying a measure persistence rate of 100%.**

Table 5. CEI Project Implementation and Persistence Rates

Cohort	Total Projects	Projects Implemented	Implementation Rate	Projects Still in Place	Persistence Rate
Cohort 1	10	10	100%	10	100%
Cohort 2	36	24	67%	24	100%
Total	**46**	**34**	**74%**	**34**	**100%**

Note: Table shows project implementation and persistence rates for up to six projects at each facility with higher expected savings. Projects were sampled from the list in the 2016 year-end report.

One Cohort 2 participant did not implement five of six planned project activities due to higher-than-anticipated initial equipment costs. Although the activities could be implemented in the future, they have no plans to implement them in the coming year, unless they receive additional funding. Another Cohort 2 participant cited similar cost concerns moving forward with a project adding VFDs to evaporator fans.

Cadmus asked Cohort 1 participants if activities they implemented during their first year remained in place in 2018, with 15 of 16 activities remaining in place from the first year. One participant could not recall if they implemented one program activity. One R&D compressor replacement project and one personal space heater related activity were not implemented for the first year. The participant indicated they replaced their main compressor and had not replaced the R&D compressor as it was a supplemental unit. The participating facility also found it too difficult to enforce turning off personal space heaters in a diverse work environment.

According to EVT staff, most participants in Cohort 1 continued engaging in the pilot to varying degrees, and they continued to meet as an energy team to conduct their energy assessment. EVT staff said these utility customers have identified many new capital, operational, and maintenance projects since the first year.

Motivation for Participation

The interviews asked both EVT staff and participants why utility customers were motivated to participate in the Pilot. Responses differed between the two interview groups. According to EVT staff, Cohort 1 participants continued to engage in CEI as they had committed resources and continued to realize savings from former and current projects. According to Cohort 1 participants, management and EVT support motivated them to continue some CEI engagement elements while Cohort 2 participants said they were motivated to participate due to peer-to-peer networking, given the focus on ammonia refrigeration.

Participants were primarily motivated to participate in the CEI pilot by energy and cost savings. Cohort 1 interview participants said they continued to engage with the pilot as it helped them reduce energy consumption, complete their projects, and achieve green initiatives. One participant said they could not have completed their projects without the CEI program's help.

Cohort 2 interview participants said they participated in the pilot to save money and reduce energy consumption (three of five responses). One participant enrolled in the CEI program to fulfill requirements for B-Corp Certification.

Pilot Engagement

Cohort 2 focused on businesses with the same end use—ammonia refrigeration—rather than on different end uses, as Cohort 1 did. According to EVT staff and participants' self-report, this singular technology focus helped participants remain engaged in the pilot as they could discuss successes and challenges while benefitting from their peers' knowledge. For example, they could share audit results and prepare a similar action plan for improvements due to similar technologies. Although all Cohort 2 participants were participants in the dairy industry, they shared ideas with one another throughout their engagement. They did not express concerns with EVT staff regarding sharing of energy efficiency strategies. EVT staff suggested this cooperation occurred because these companies were not in direct competition and used similar technologies.

Challenges

Cadmus asked both interview groups to indicate challenges Pilot participants faced implementing CEI. **Both cohorts indicated that obtaining 'management and staff participation' and 'finding time to attend workshops and hold energy management team meetings' were challenges.**

Nine of 11 pilot participants indicated the following challenges:

- Bringing management and other staff onboard with the program (four responses)
- Finding time to attend workshops and to meet with EVT staff (two responses)

- A lack of communication with EVT staff [6] (one response)
- Actual savings falling short of anticipated savings (one response)
- Motivating staff to change old habits (one response)

In the 2015 evaluation, pilot participants listed finding time for attending workshops and implementing projects as top challenges (two of five), but this was less frequently mentioned (one of nine) in these interviews.

Table 6 summarizes all participants' challenges, including those discussed previously in this report.

Table 6. Participant Challenges

Challenges
Resources and Employee Engagement
• Finding enough time to focus on CEI
• Taking time off to share ideas and coordinate schedules among participants
• Difficult to focus on employee engagement at the start of the CEI process as participants focused on operational and maintenance changes
• Maintaining management support
• Management turnover
Data Management
• Difficult to adjust regression models when production changed or changes were made to equipment systems such as HVAC
• Getting timely energy data from utility
Other
• Maintaining interest in between activities

Although Cohort 2 has largely been successful, EVT staff identified the following challenges for future cohorts:

- Competition among companies producing similar products and unwillingness to share proprietary production information
- Travel time for site visits among participants and Kaizen events
- Keeping companies focused after their first year of CEI engagement
- Not having an established end date for engagement

[6] Although one pilot participant stated communication with EVT staff was a challenge they said it may be due to internal staff changes.

Suggestions for Improvements

Both pilot participants and EVT staff provided suggestions for improvement. Six of 11 pilot participants suggested recommendations to improve the program:

- Provide more resources for employee engagement
- Facilitate better scheduling with management to increase program participation
- Provide more support from those with hands-on experience in the field
- Achieve a faster return-on-investment from the program
- Schedule more workshops in proximity to business locations
- Arrange more face-to-face time with EVT staff

EVT staff recommended continuing to use the common end-use cohort approach as it encouraged continued engagement. One staff member recommended standardizing data required from participants, allowing EVT to use the data for internal quarterly progress reports to determine whether goals are being met. One staff member said it would be helpful if EVT established a timeline for active engagement and follow-up activities.

Future Participation

All 11 pilot participants said they were *very* or *somewhat likely* to continue to implement lessons learned through their CEI engagement. Eight pilot participants said they were *more likely* to conduct energy efficiency projects after participating in the CEI program, while two said the program *made no difference*, and one participant said they were *less likely*. No differences emerged across cohorts regarding their likelihood of conducting energy efficiency projects.

The Cohort 1 participant who was *less likely* to conduct energy efficiency projects said a lack of funding and interest from their administration impeded their efforts. The pilot participants said they were *more likely* to conduct such projects due to resources, increased awareness, and project opportunities provided by the program.

Energy-Savings Analysis

This section provides estimates of facility and CEI savings in 2016 for evaluated facilities. To preserve the confidentiality of participating facilities, Cadmus assigned a unique ID to each evaluated facility and uses the unique IDs when referring to individual facilities. Facilities operated by the same customer share the first letter and number of the ID. For example, the same customer operates facilities F7-E1 and F7-E2.

Analysis Sample

In 2016, EVT's CEI pilot included seven participants in Cohort 1 (nine separate facilities) and four participants in Cohort 2 (seven separate facilities). Table 7 provides brief descriptions of the facilities, including customer segments, fuel types, frequency of available data, and dates when CEI engagement began. *Appendix C Facility Descriptions* provides further details on each facility. Note that several participants enrolled more than one facility in the pilot. Cadmus estimated savings for each facility separately, using the methods described in the *Energy Savings Analysis* section of *Methodology*.

Cadmus determined that five of 16 participant facilities could not be evaluated in 2016.[7] Reasons for this varied, but it largely was attributable to a lack of necessary data or an energy-driving event unrelated to the pilot coincided with the pilot's beginning. One facility discontinued CEI engagement, while another had not started CEI engagement by 2016.

F2: This facility chose to not to continue engagement with the 2016 CEI pilot.

F3: Cadmus could not obtain the data necessary to evaluate 2016 pilot savings.

F4: The facility installed a new machine, used in production after the baseline period, thus rendering the baseline period invalid for estimating adjusted baseline consumption.

F5: EVT established this facility's baseline during the 2016 reporting year and did not report 2016 savings.

F9–E1: EVT could not obtain an important production variable that Cadmus required for building a satisfactory model.

F10– E1: Cadmus determined the current baseline period was inappropriate for estimating adjusted baseline consumption because, in the first month of the program year, the facility made significant changes to its operations that were not captured by production variables and were unrelated to the CEI pilot.

Cadmus conducted a separate analysis for each facility, building, and fuel type, evaluating 15 models in total: 11 electric models, three propane models, and one oil model.

7 Although Cadmus could not estimate CEI savings in 2016 for these facilities, program costs from implementing CEI at these facilities were included in the pilot cost-effectiveness calculations. By collecting additional data required for evaluation (F3, F9-E1) or establishing 2016 as the baseline period instead of a previous year (F4, F5, F10-E1) it may be possible to reduce the number of facilities that were not evaluable through statistical analysis.

Table 7. Facility Characteristics

Cohort	Facility ID	Industry/Commercial Building Segment	Fuels	Data Frequency	CEI Beginning Engagement Date
Cohort 1	F1	Hospital/Medical Center	Electric	Daily	02/13/2014
	F2*	Manufacturing	Electric	N/A	N/A
	F3	Manufacturing	Electric	N/A	03/25/2015
	F4	Manufacturing	Electric	N/A	06/17/2014
	F5	Manufacturing	Electric	N/A	02/13/2014
	F6	Manufacturing	Electric	Weekly	02/01/2014
	F7–E1	Resort: Hotel/Conference Center/Dining	Electric Propane, Oil	Electric: Daily; Propane: Monthly; Oil: Monthly	02/01/2014
	F7–E2	Resort: Private club for events/Dining	Electric, Propane	Electric: Weekly; Propane: Monthly	02/01/2014
	F7–E3	Resort: Fitness/Pool/ Indoor Tennis	Electric, Propane	Electric: Weekly; Propane: Monthly	02/01/2014
	F8	Manufacturing	Electric	Daily	02/13/2014
Cohort 2	F9–E1	Manufacturing	Electric	N/A	11/11/2015
	F9–E2	Manufacturing	Electric	Weekly	11/11/2015
	F9–E3	Manufacturing	Electric	Weekly	11/11/2015
	F10–E1	Manufacturing	Electric	Monthly	11/11/2015
	F10–E2	Manufacturing	Electric	Monthly	11/11/2015
	F11	Manufacturing	Electric	Weekly	11/11/2015
	F12	Manufacturing	Electric	Monthly	11/11/2015

*This participant opted not to engage with CEI in 2016

Pilot Annual Savings Estimates

This section reports CEI Pilot annual savings estimates by cohort and fuel type. Facility savings were estimated as the difference in the facility's adjusted baseline consumption and metered consumption and included capital projects implemented during the reporting period. CEI savings are savings attributable to the CEI program and were estimated by subtracting savings from capital project receiving EVT incentives. Electricity savings are presented in MWh, while oil and propane savings are presented in MMBtu. Cadmus provided precision only for facility savings as it did not have standard errors for capital project savings.

Evaluated Facility and CEI Percentage Savings

Figure 4 shows the percentage capital project, CEI, and facility savings in 2016 by fuel type and cohort. Percentage savings were calculated as the ratio of savings over adjusted baseline consumption for 2016.

In 2016, participant facilities saved 5% of electricity consumption, with savings of 4% attributable to CEI measures. Facility electricity savings were statistically different from zero, with a margin of error of

+/- 1% with 90% confidence. EVT's CEI electricity savings of 4% compare favorably to the savings of SEM or CEI programs of other utilities.[8]

In 2016, Cohort 1 facilities saved 7% of electricity consumption, with savings of 5% attributable to CEI. Cohort 2 facilities saved 5% of electricity consumption, with 3% attributed to CEI measures. The difference in 2016 savings between cohorts could be attributable to the differences in customer business segments or the duration of treatment. 2016 was the Cohort 1's second year of participation.

Between 2015 and 2016, Cohort 1's CEI electricity savings increased by two percentage points. In 2015 Cohort 1 facilities saved over 5% of electricity savings, with CEI savings of almost 3%.[9] In both reporting years, capital projects accounted for about 2% of savings. Cohort 2 achieved first-year CEI savings in 2016 approximately equal to the first-year savings of Cohort 1 in 2015. **In 2016, Cohort 1 facilities saved 24% of oil consumption, but propane savings were not statistically different from zero.** Three facilities in Cohort 1 consumed propone, oil, or both fuels. Although the savings were statistically different from zero, there is high uncertainty about the true savings. The 90% confidence interval for oil savings ranges from 10% to 39%. Cadmus did not evaluate oil and propane savings for the 2015 pilot evaluation because of the unavailability of required data.

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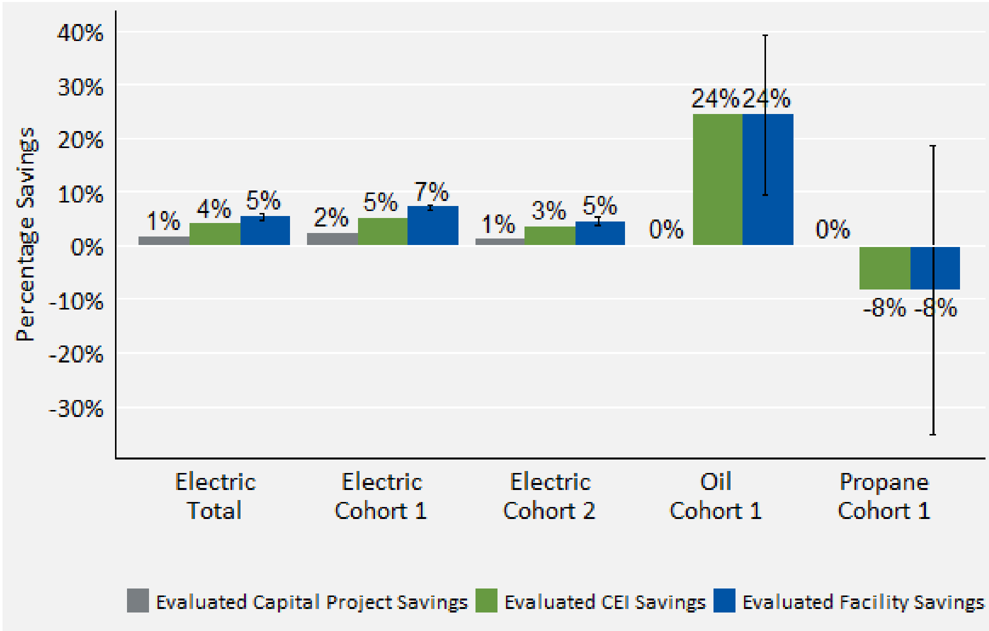
8 Strategic Energy Management (SEM) Evaluation Report. Report. SBW Consulting, Inc. & The Cadmus Group. February 2017. https://www.bpa.gov/EE/Utility/research-archive/Documents/Evaluation/170222_BPA_Industrial_SEM_Impact_Evaluation_Report.pdf.

Resource Conservation Manager Program Evaluation Final Report. Puget Sound Energy's & The Cadmus Group July 2018. https://conduitnw.org/Pages/File.aspx?rid=4525

9 Reference 2015 report: https://projects.cadmusgroup.com/sites/6560-P01/CEI/Shared%20Documents/Report/VT%20PSD%20CEI%202015%20Full%20Report_Final.docx?web=1

Figure 4. 2016 CEI Savings as a Percentage of Consumption, by Fuel Type



Note: Error bars around evaluated facility savings indicate confidence intervals at 90% confidence.

Evaluated CEI Savings and Realization Rates

Cadmus evaluated 2016 CEI electricity savings of 2,875 for the pilot, 1,284 MWh for Cohort 1, and 1,591 MWh for Cohort 2. Table 8 shows 2016 evaluated electricity savings and realizations rates by fuel type and cohort. In 2016, Vermont saved from capital project and CEI measures 1,840 MWh in Cohort 1 facilities and 2,095 MWh in Cohort 2 facilities. Both facility savings estimates were statistically different from zero with 90% confidence. After removing capital project savings, Cadmus estimated that Cohort 1 saved 1,284 MWh and Cohort 2 saved 1,591 MWh from CEI measures. These OM&B savings accounted for 70% and 76% of total facility savings in Cohort 1 and Cohort 2, respectively. The total CEI savings in 2016 measured 2,875 MWh.

Cadmus evaluated a CEI electricity realization rate of 98% for the pilot, 92% Cohort 1, and of 104% Cohort 2. Cadmus obtained very similar CEI electricity savings estimates as EVT. This suggests that EVT's M&V processes are yielding accurate savings estimates. For the 2015 evaluation, Cadmus estimated a very similar savings realization rate for Cohort 1 of 91%.

Table 8. 2016 Evaluated Electric Cohort Energy Savings (MWh/year)

Cohort	Number of Facilities	Evaluated Facility Savings	Relative Precision	Capital Project Savings	Evaluated CEI Savings	Reported CEI Savings	Realization Rate
Cohort 1	6	1,840	10%	556	1,284	1,397	92%
Cohort 2	5	2,095	25%	504	1,591	1,531	104%
Total	**11**	**3,935**	**15%**	**1,060**	**2,875**	**2,928**	**98%**

The calculation of the electricity savings realization rate does not include five facilities for which Cadmus was unable to estimate savings. It was not possible to estimate their electricity savings because of either the unavailability of data or nonroutine events at the facility that invalidated the baseline model. Since the unavailability of data and non-routine events that prevented evaluation may have been correlated with the facility CEI savings, the savings realization rate for the evaluated facilities may not have validity for the unevaluable facilities. As described below, the program cost-effectiveness calculation that Cadmus performed only included the savings from evaluated facilities.

Cadmus evaluated CEI electricity savings of 946 MMBtu for oil but estimated statistically insignificant facility propane savings. Table 9 shows 2016 evaluated electricity savings and realizations rates for oil and propane. For one facility with heating oil, Cadmus estimated CEI savings of 946 MMBtu. For three facilities with propane gas, Cadmus estimated propane savings of -471 MMBtu. This estimate was not statistically different than zero, however. None of the oil or gas facilities implemented any capital projects during the pilot period.

Cadmus evaluated a 65% savings realization rate for CEI facility oil savings. While the heating oil savings realization rate was only 65%, there was high uncertainty about the true savings. For both fuels, the reported savings were within Cadmus' estimated 90% confidence intervals.

Table 9. 2016 Evaluated Oil and Propane Cohort Energy Savings (MMBtu/year)

Fuel	Number of Facilities*	Evaluated Facility Savings	Relative Precision	Capital Project Savings	Evaluated CEI Savings	Reported CEI Savings	Realization Rate
Oil	1	946	61%	0	946	1,452	65%
Propane	3	-471	324%	0	-471	335	-525%
Total	**4**	**224**	**133%**	**0**	**224**	**1,807**	**12%**

*Number of unique models; EVT had some facilities with multiple sites and propane and oil savings for one facility.

Facility-Level Savings

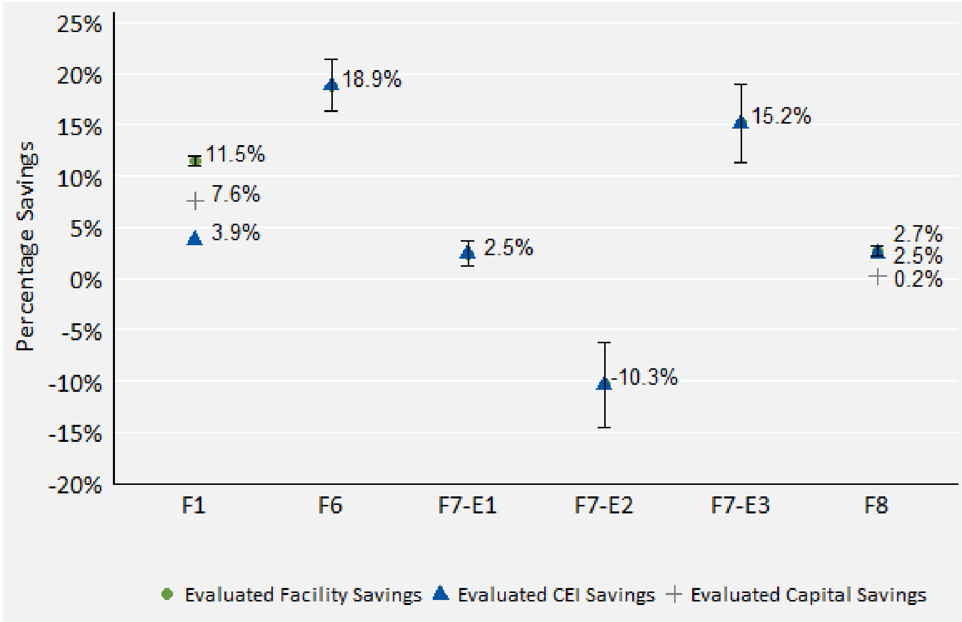
In this section, Cadmus presents estimates of individual facility savings and compares the reported and evaluated facility and CEI savings for individual facilities.

Electricity

Figure 5 shows evaluated facility savings, evaluated CEI savings, and evaluated capital project savings as a percentage of adjusted baseline consumption in the 2016 reporting period for facilities for facilities in Cohort 1. For facilities without capital project savings, the facility and CEI savings will be equal and the savings markers in Figure 5will overlap.

Evaluated CEI savings for Cohort 1 ranged between -10% (F7-E2) and 19% (F6), but savings were positive for all facilities except F7–E2. Overall, evaluated facility savings were estimated with good precision, as suggested by the small error bars in Figure 5; uncertainty was largest for facility F7–E2 at +/-6% of estimated facility savings. Except for this facility, Cadmus evaluated positive facility savings that significantly differed from zero for all facilities in Cohort 1.

Figure 5. Cohort 1 2016 Evaluated Electricity Savings as a Percentage of Consumption

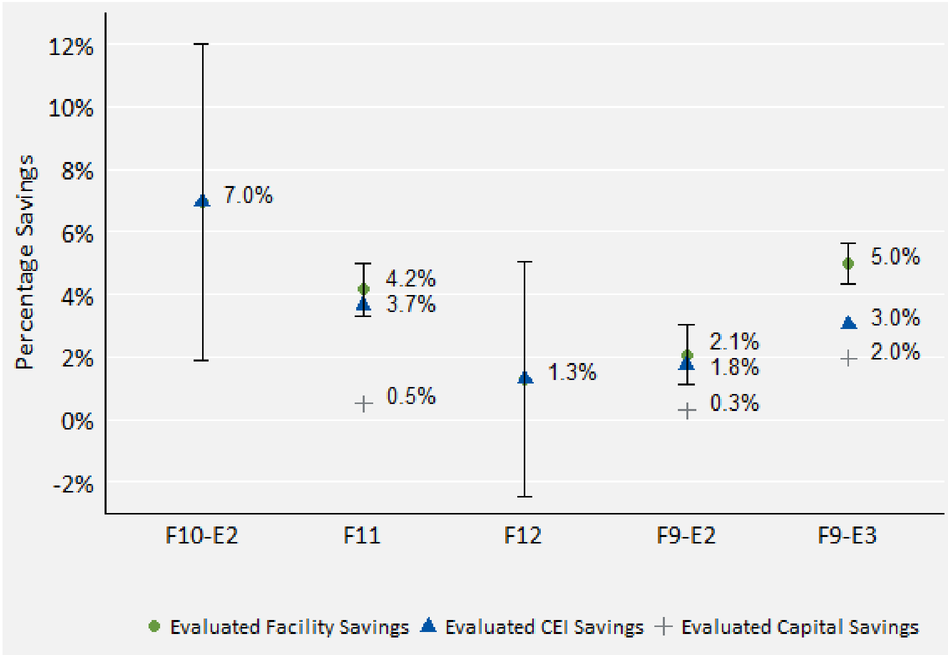


Note: Error bars around evaluated facility savings indicate the confidence intervals at 90% confidence.

Figure 6 shows evaluated facility savings, evaluated CEI savings, and evaluated capital project savings as a percentage of adjusted baseline consumption during the 2016 reporting period for facilities in Cohort 2.

Cadmus evaluated statistically significant positive facility savings for all facilities in the cohort, excepting facility F12 (where the confidence interval included zero). Evaluated CEI savings ranged between 1.3% and 7.0%. Cadmus estimated the largest uncertainty for F10-E2 facility savings (5% of estimated facility savings).

Figure 6. Cohort 2 2016 Evaluated Savings as a Percentage of Consumption



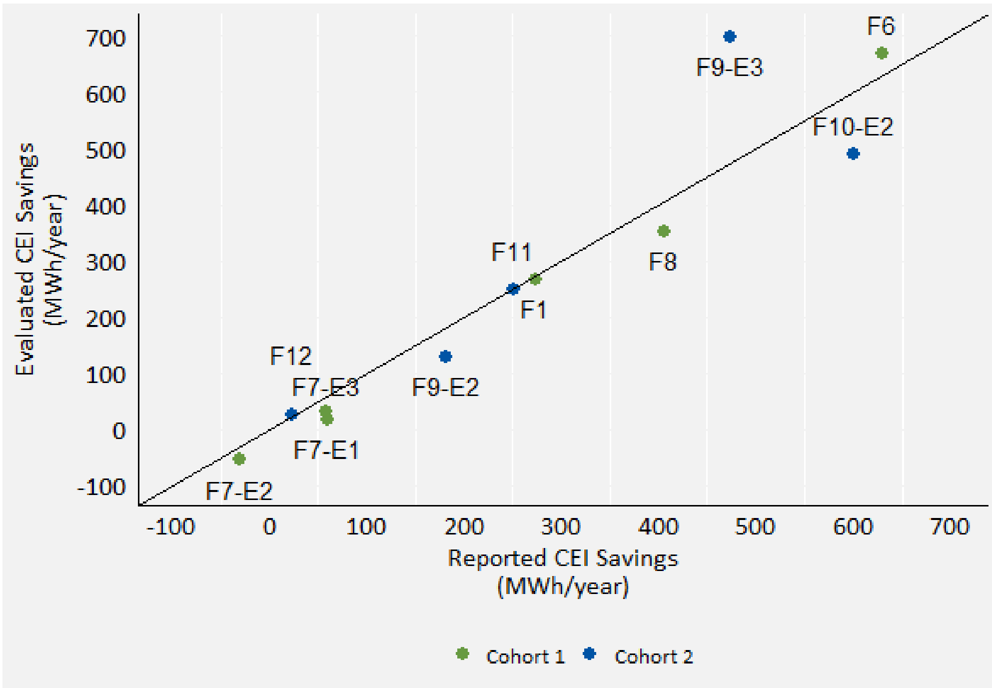
Note: Error bars around evaluated facility savings indicate the confidence bounds at 90% confidence.

Figure 7 plots evaluated CEI savings against reported CEI savings for individual facilities. The 45-degree line is the set of points where reported savings equaled evaluated savings, indicating a 100% realization rate. If the reported and evaluated savings were approximately equal, the points will lie close to the 45-degree line.

For most facilities the evaluated CEI savings approximately equaled those reported by EVT. For seven of 11 evaluated facilities, we did not find significantly different 2016 facility savings estimates. Cadmus evaluated significantly different facility savings than those EVT reported for four facilities: facility F9–E3 and all three facilities of participant F7. Although CEI savings realization rates for F7 facilities ranged from 27% to 177%, the absolute differences in savings were small and did not heavily impact the realization rates for Cohort 1. Cadmus also evaluated statistically different facility savings for Facility F9–E3, which had a substantial impact on the Cohort 2 realization rate. This was driven due to difference in model specifications.

Model Descriptions provides further descriptions of each model.

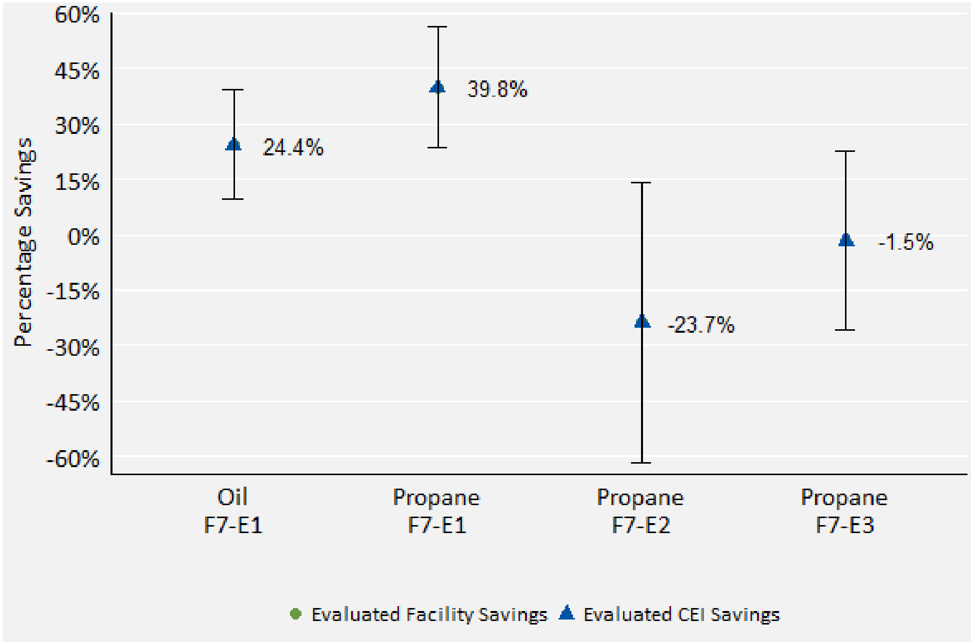
Figure 7. Electricity Evaluated and Reporting CEI Savings



Oil and Propane

Figure 8 presents evaluated facility savings, evaluated CEI savings, and evaluated capital project savings as a percentage of facility electricity consumption during 2016. The propane gas savings ranged between -24% and 40%. However, uncertainty of propane savings was large for all facilities, as shown by the wide confidence intervals. The largest uncertainty occurred around evaluated facility savings for facility F7–E2, with plus or minus 38% savings. The estimate of heating oil savings was 24% for facility F7-E1.

Figure 8. 2016 Evaluated Oil and Propane Savings as a Percentage of Consumption



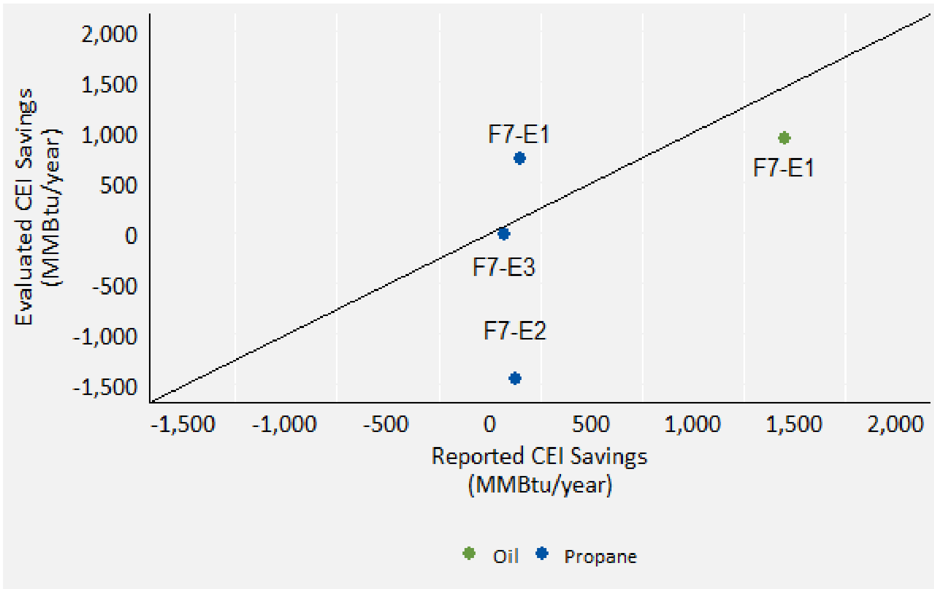
Note: Error bars around evaluated facility savings indicate the confidence bounds at 90% confidence.
Facility oil and propane savings equal CEI savings for these facilities.

Figure 9 compares evaluated and reported oil and propane CEI savings. As in **Error! Reference source not found.**, the 45-degree line shows where reported savings equaled evaluated savings, indicating a 100% realization rate.

For oil and propane facilities, there was considerable variance between the evaluated and reported savings. However, Cadmus did not find significantly different 2016 facility savings for three of the four facilities due to imprecisely estimated evaluated savings. Though savings realization rates for facilities F7–E1 Oil, F7–E2, and F7–E3 propane ranged from -1,098% to 65%, facility savings estimates did not statistically differ from the EVT savings estimate. Facility F7–E1 was the only propane facility to reduce consumption during the 2016 reporting period as well as the only facility to statistically differ from the EVT facility savings estimate. For this facility, Cadmus evaluated a 486% realization rate. Differences in final model specification was the biggest driver of the large savings realization rate.

Model Descriptions provides a further description of each model.

Figure 9. Oil and Propane Evaluated and Reporting CEI Savings



Cost-Effectiveness

Table 10 shows CEI program inputs for the 2016 cost-effectiveness calculation. In 2016, total administrative program costs were $323,852, total electricity savings were 2,875 MWh, and total delivered fuel savings were 64 MMbtu. The CEI electricity savings and delivered fuel savings are taken from Table 8 and Table 9 and only include savings from the evaluated facilities. As discussed above, the savings realization rate for evaluated facilities may not have validity for unevaluable facilities. The administrative program costs were the costs of administering the program to all participant facilities, not just the 11 facilities that Cadmus evaluated.

Table 10. Statewide Screening Tool Inputs

Parameter	Value
2016 Total Program Costs	$323,852
2016 Electricity Savings (kWh)	2,874,846
2016 Delivered Fuel Savings (MMbtu)	64
EUL's	1, 2, 3, 5
Load shape	Industrial Process

Table 11 shows the CEI pilot's cost-effectiveness in 2016 for different assumptions about the pilot's measure life. Cadmus calculated program cost-effectiveness under the assumptions of measure life of one year, two years, three years, and five years. There is lack of evidence about CEI savings persistence, and little agreement in the DSM industry about measure life. However, the results from this study about the persistence of individual measures suggest that the CEI measure life is at least two years. It is most common for program administrators to assume a CEI measure life of three years.[10]

The cost-effectiveness analysis indicates that the pilot program was cost-effective in 2016 for all measure life assumptions, accruing higher net benefits as the assumed EUL increased. The B/C ratio increased from 1.1 for a one-year measure life to 3.0 for a three-year measure life. Thus, even if EVT assumes conservatively that the measure life was one-year, the pilot remains cost-effective.

[10] Until recently, there was little research to substantiate assumptions about energy management program measure life. However, in 2018, Energy Trust of Oregon and Puget Sound Energy published a joint ACEEE study that provided evidence to substantiate a SEM measure life assumption of three years. See Vetromile et al. (2018). "Persistence Is Not Futile." ACEEE Summer Study on Energy Efficiency in Buildings. Available at: https://aceee.org/files/proceedings/2018/#/paper/event-data/p266. ETO collected measure life data for O&M and behavioral measures implemented through its energy management programs. The authors found that the median life of energy management measures was greater than three years. In a separate study, PSE found that 97% of energy management measures persisted at the time of evaluation, which was between 6 and 30 months after the start of participation in the industrial optimization program.

Table 11. 2016 CEI SCT Cost-Effectiveness Results

Parameter	EUL=1	EUL=2	EUL=3	EUL=5
Benefits	$316,410	$619,833	$911,929	$1,513,167
Costs	$298,359	$300,887	$303,390	$308,774
Net Benefits	$18,050	$318,946	$608,539	$1,204,393
Benefit/Cost Ratio	1.06	2.06	3.01	4.90
Levelized $/kWh	$0.11	$0.05	$0.04	$0.02

The CEI pilot was cost-effective over its first two years with assumed measure life of two or more years. With a benefit-to-cost ratio of 0.73, the 2015–2016 CEI pilot did not prove cost-effective when assuming a measure life of one year. This was largely due to the program participants starting CEI implementation mid-year and only savings energy for part of 2015. The benefit-to-cost ratio increased to 1.41, 2.07, and 3.34, assuming two, three, and five-year measure lives respectively.

Table 12 shows the 2015–2016 portfolio-level cost-effectiveness results for the CEI pilot.

Table 12. 2015-16 CEI SCT Cost-Effectiveness Results[a]

Parameter	EUL=1	EUL=2	EUL=3	EUL=5
Benefits	$479,379	$935,275	$1,374,599	$2,232,999
Costs	$658,903	$661,430	$663,933	$669,317
Net Benefits	($179,523)	$273,845	$710,665	$1,563,681
Benefit / Cost Ratio	0.73	1.41	2.07	3.34
Levelized $/kWh	$0.17	$0.09	$0.06	$0.04

[a]The 2015-2016 portfolio cost-effectiveness results are expressed in 2016 dollars.

Cadmus' analysis of persistence of individual measures in CEI participant facilities based on interviews with energy managers supports the assumption of a CEI measure life of two or more years. Two years after the 2016 program year, 100% of CEI measures in Cohort 1 and Cohort 2 facilities remained in place.

While the measure persistence analysis suggests that CEI savings would also persist for at least two years, the analysis is not conclusive. Self-reports by participants of persistence of individual measures may not correlate exactly with savings. A more rigorous and comprehensive analysis of savings persistence would analyze the consumption of CEI participant facilities and potentially involve site visits or other verification to corroborate energy manager reports about measure persistence.

Appendix A. Participant Interview

Efficiency Vermont

Continuous Energy Improvement Participant Interview Guide 2018

Researchable Questions	Item
Assess implementation challenges and barriers	L1-L2
Gain insight into adoption and persistence of CEI activities	B1-B2,D1-D2, E1, F1-F2, G1-G6,K1-K3,O1,N1
Identify improvements for implementation	C2,C3,H3,J3,M3
Assess satisfaction with pilot components	C2,G3,G5,H1,H2,I1,I2,J1,J2,K4,K5,M2,M1
Assess implementation and persistence of capital projects	0-E4

A. Introduction

A1. May I speak with **[CONTACT NAME]**? OR **[IF NO NAME]** May I speak with the person who is most familiar with your facilities Continuous Energy Improvement pilot program? **[IF THAT PERSON IS NOT AT THIS PHONE NUMBER, ASK FOR THEIR NAME AND PHONE NUMBER AND START AGAIN]**

1. Yes
2. No or not a convenient time **[ASK IF RESPONDENT WOULD LIKE TO ARRANGE A MORE CONVENIENT TIME OR IF YOU CAN LEAVE A MESSAGE FOR A MORE APPROPRIATE PERSON]**

98. (Don't know) **[ASK TO SPEAK WITH SOMEONE WHO KNOWS AND BEGIN AGAIN]**
99. (Refused) **[THANK AND TERMINATE]**

A2. Hello, I'm **[INSERT NAME]** calling from Cadmus on behalf of Efficiency Vermont. We are conducting an important study about your participation in the Continuous Energy Improvement program. It is our understanding that you are the energy champion at [FACILITY NAME]. Is this correct? **[IF NOT, ASK FOR THE PERSON WHO IS MOST FAMILIAR WITH THE CONTINUOUS ENERGY IMPROVEMENT OR CEI PROGRAM AT YOUR FACILITY?]**

1. Yes
2. No, person is able to come to phone **[ASK FOR PERSON WHO IS AND START AGAIN]**
3. No, person is not able to come to phone **[GET NAME AND PHONE NUMBER, SCHEDULE CALL BACK]**

98. (Don't know) **[ASK TO SPEAK WITH SOMEONE WHO KNOWS AND BEGIN AGAIN]**
99. (Refused) **[THANK AND TERMINATE]**

[COHORT ONE: We may have spoken with you or another representative from your company a few years ago. We are contacting you again to see how the program has changed since we last spoke.]

B. Energy Team

B1. Do you have an energy management team at your facility? [IF NEEDED: This is dedicated staff for energy and energy efficiency.]

1. (Yes)
2. (No) [SKIP TO NEXT SECTION]

B2. How frequently does the energy team meet? [READ LIST IF NEEDED]

1. (Weekly)
2. (Bi-weekly)
3. (Monthly)
4. (Quarterly)
5. (Semi-annually)
6. (Annually)
7. (Other) [SPECIFY]
98. (Don't know)
99. (Refused)

C. Energy Management Assessment

[IF COHORT 2, ASK C2-C3 IF THEY CONDUCTED AN EMA]

C1. Do you remember creating an energy management assessment? [IF NEEDED: This is also known as the CEI assessment. It lists process steps and milestones such as selecting an energy champion, writing an energy policy, creating an action plan, performing audits and other milestones.]

1. Yes
2. No
98. Don't know

C2. How useful was the energy management assessment in implementing the program?

1. Very useful
2. Somewhat useful
3. Not too useful
4. Not at all useful

C3. Why do you say it was [INSERT ANSWER FROM C2]?

1. [RECORD RESPONSE]

[ASK IF COHORT 1 AND COMPLETED AN EMA IN YEAR ONE]

C4. You conducted an energy management assessment when you started participating in the program. When was the last time you updated it? [IF NEEDED: This is also known as the CEI assessment. It lists process steps and milestones such as selecting an energy champion, writing an energy policy, creating an action plan, performing audits and other milestones.]

1. Never updated it
2. [SPECIFY YEARS]
98. Don't know

D. Employee Engagement

D1. Have you already conducted or are you planning to conduct any energy related employee engagement activities in 2018?

1. (Yes) [ASK D1a]
   D1a. What kinds of activities have you completed or are planning for 2018?
2. (No)

[IF D1=2]

D2. Why aren't you going to conduct any employee engagement activities in 2018?

1. [RECORD RESPONSE]

E. Energy Action Plan (Energy Management Plan)

E1. During the program, you developed a list of planned processes, programs, and projects. How frequently do you update this list? Would you say … [READ LIST]

1. (Weekly)
2. (Bi-weekly)
3. (Monthly)
4. (Quarterly)
5. (Semi-annually)
6. (Annually)
7. (Other) [SPECIFY]
98. (Don't know)
99. (Refused)

[ASK E2-E4 IF COHORT 2. ASK IF COHORT 1 AND NEW MEASURES ADDED SINCE LAST INTERVIEW]

E2. I have some questions about the status of some of the projects implemented during the CEI program. I'll read each one. Please tell me if the activity was implemented. If it was implemented please let me know if it is still in place? [ASK ABOUT 6 MEASURES]

E2b. Did you implement [ACTIVITY]?

1. (Yes)
2. (No)
3. (Don't know)

E2c. [IF YES] Is it still in place?

1. (Yes)
2. (No)
3. (Don't know)

[ASK IF E2C=NO]

E3. Why was [EACH MEASURE NOT IMPLEMENTED IN E2c] removed?

1. [RECORD RESPONSE]

99.

[ASK IF E2B=NO]

E4. Are you planning to implement it?

1. (Yes)
2. (No)

[ASK IF COHORT 1 FOR EVERY MEASURE IMPLEMENTED DURING FIRST YEAR]

E5. [ASK IF IMPLEMENTED IN FIRST YEAR AND IS A CONTINUOUS MEASURE] I would like to discuss the activities you implemented during your first year. I'll read the activities and please tell me if the activity is still in place or is still being implemented.

1. Yes
2. No [ASK ABOUT EACH NO RESPONSE]

E5a. Why did you stop implementing this activity? [SPECIFY]

E5b. Are you planning to implement it again in the future?

E6. [ASK FOR ANY ACTIVITY NOT IMPLEMENTED IN FIRST YEAR] Now, I'll read the activities your organization had not implemented when I last contact your organization. Let me know if any of these has been implemented since then. [FOR EACH NO, ASK IF THEY PLAN TO IMPLEMENT IT IN THE FUTURE.]

F. Energy Performance

F1. As part of the program, you tracked energy performance. Have you continued to track energy performance since you started participating in the program?

1. (Yes)
2. (No)

[ASK IF F1=1]

F2. How frequently is energy performance reviewed? [READ LIST IF NEEDED]

1. (Daily)
2. (Weekly)
3. (Bi-weekly)

4. (Monthly)
5. (Quarterly)
6. (Semi-annually)
7. (Annually)
8. (Other) [SPECIFY]

G. Energy Management System

Now I have a few questions about how you track energy use in your organization.

G1. What system do you use to track energy usage and CEI milestones?
   1. [RECORD REPSONSE]

[ASK COHORT 1 ONLY]

G2. Is this the same system you used when you first began the program?
   1. Yes
   2. No
      G2c. Why did you change to a different system to track energy usage and CEI milestones?

[ASK IF G1=1]

G3. What specifically do you track?
   1. [RECORD RESPONSE]

G4. How easy or difficult is it to use the [INSERT EMS SYSTEM] system to track energy usage and CEI milestones? Would you say ... [READ LIST]
   1. Very easy
   2. Somewhat easy
   3. Neither easy nor difficult
   4. Somewhat difficult
   5. Very difficult

G5. Why do you say it is [INSERT ANSWER FROM G3] to use that system to track energy usage and CEI milestones?
   1. [RECORD ANSWER]

G6. Are you going to continue to use this system to track energy use and CEI milestones?
   1. (Yes)
   2. (No)
      G6d. Why did you stop using this system? [RECORD RESPONSE]

H. Workshop Satisfaction

H1. Thinking about the workshops you attended as part of your CEI engagement in 2017 or 2018, please tell me how satisfied you were with the following aspects. Were you very satisfied, somewhat satisfied, not too satisfied, or not at all satisfied with [STATEMENT]? [AFTER FIRST ONE REPEAT SCALE AS NEEDED] [RANDOMIZE ORDER]

H1e. Location of the workshops

H1f. Length of the workshops

H1g. Number of workshops that were part of the program

H1h. Topics of each workshop

H1i. Engagement with other attendees during the workshops

[ASK FOR EACH STATEMENT IN H1 WHERE RESPONDENT SAID SOMEWHAT, NOT TOO, OR NOT AT ALL SATISFIED]

H2. Why were you [INSERT RESPONSE FROM H1e-H1h]?

1. [RECORD RESPONSE]

H3. What suggestions, if any, do you have for improving the workshops?

1. [RECORD RESPONSE]

I. Kaizen Events Usefulness

I1. How useful were the Kaizen events in helping you improve energy performance? Would you say … [READ LIST]

1. Very useful
2. Somewhat useful
3. Not too useful
4. Not at all useful

I2. Why were the Kaizen events [INSERT RESPONSE FROM I1]?

1. [RECORD RESPONSE]

J. Satisfaction

J1. Please answer the following questions about your satisfaction with your communication with Efficiency Vermont. Let's start with [STATEMENT]. Were you very satisfied, somewhat satisfied, not too satisfied, or not at all satisfied with [STATEMENT]? [AFTER FIRST ONE REPEAT SCALE AS NEEDED] [RANDOMIZE ORDER]

J1j. Accuracy of information provided to you throughout the program by Efficiency Vermont

J1k. Efficiency Vermont's ability to answer all your questions

J1l. Timeliness of Efficiency Vermont's response to you
J1m. Ability of Efficiency Vermont to resolve problems

[ASK FOR EACH STATEMENT IN J1 WHERE RESPONDENT SAID SOMEWHAT, NOT TOO, OR NOT AT ALL SATISFIED]

J2. Why were you [INSERT RESPONSE FROM J1j-J1m]?
1. [RECORD RESPONSE]

J3. Thinking about your CEI coach, what was the most important information he or she provided to you during your participation in the CEI program?
1. [RECORD RESPONSE]

K. Motivations and Influence

K1. [COHORT 2] What motivated your organization to participate in the CEI program?

[RECORD RESPONSE]

K2. [COHORT 1] What is the main reason for your organization continuing to participate in the program?
1. [RECORD RESPONSE]

K3. After your participation in the program, how likely are you to continue to implement the lessons you learned during your CEI engagement?
1. Very likely
2. Somewhat likely
3. Not too likely
4. Not at all likely

K4. What tools or aspects of the program were most useful in helping your organization improve energy performance?
1. (Workshop) [ASK: Which ones?]
2. (Kaizen events)
3. (Energy management assessment)
4. (Regression model)
5. (End of program report)
6. (Efficiency Vermont energy team)
7. (Peer to peer networking)
8. (Other) [SPECIFY]

K5. Why was that useful in helping your organization improve energy performance?
1. [RECORD ANSWER]

L. Challenges

L1. What challenges, if any, did you encounter participating in the CEI program?

1. [RECORD ANSWER]

L2. What challenges, if any, do you think you will have continuing to implement the practices and activities you initiated during your CEI participation?

1. [RECORD ANSWER]

M. Overall Satisfaction

M1. Thinking about your overall satisfaction with the program, how satisfied were you overall with the program? Would you say … [READ LIST]

1. Very satisfied
2. Somewhat satisfied
3. Not too satisfied
4. Not at all satisfied

M2. Thinking about the entire program, what worked particularly well?

1. [RECORD ANSWER]

M3. Overall, what suggestions, do you have to improve the program?

1. [RECORD ANSWER]

N. Future Engagement

N1. After participating in the CEI pilot program, would you say your facility is more likely or less likely to conduct energy efficiency projects or has it made no difference?

1. (More likely)
2. (Less likely)
3. (No difference)

N2. Why do you say that?

1. **[RECORD RESPONSE]**

O. Closing

O1. Do you have any other comments about the program or feedback for Efficiency Vermont at this time?

1. **[RECORD RESPONSE]**

Those are all of our questions. Your responses are very important to Efficiency Vermont. We appreciate your participation and thank you for your time. Have a good day.

Appendix B. Energy savings analysis: Step 4

Step 4a. Identify a candidate set of explanatory variables. First, Cadmus constructed variables to measure the sensitivity of the facility's energy consumption to outside temperatures (e.g., the facility's demand for space heating or space cooling or the impact of outside temperature on the manufacturing process). We collected mean daily temperatures for each facility from the closest National Oceanic and Atmospheric Administration weather station, and, for the baseline and the reporting period, computed daily heating degrees and cooling degrees for a range of base temperatures (between 0°F and 85°F).[11] The degree day variables were aggregated to the same frequency as the site data (i.e., weekly or monthly).

To determine optimal base temperatures for heating degree days (HDDs) and cooling degree days (CDDs), Cadmus regressed consumption on every possible HDD and CDD combination (with the constraint that CDD base temperatures had to be greater or equal to the HDD base temperature) and facility production variables. We then defined and selected the optimal HDD/CDD base temperature combination, based on R^2 statistics. The optimal HDD-CDD pair became the candidate variables in the variable/model selection process (described below).[12]

Cadmus then identified other candidate explanatory variables for the baseline regression model. We selected the candidate variables by reviewing the annual participant report, which included information about facility energy output, weather, and other consumption drivers. The baseline EVT model always served as a starting point for identifying candidate variables. EVT's and its consultants' prior modeling significantly reduced the time required to build an energy-use model and improved the final model's quality.

Step 4b. Identify significant energy drivers. Once Cadmus identified the candidate set of explanatory variables, we fit and tested several baseline model specifications for each facility, selecting the model that best fit the facility's baseline period energy consumption. When only monthly or weekly data were available, Cadmus fit a separate model for every combination of candidate variables by OLS, choosing the one with the best adjusted R^2 and Akaike Information Criterion (AIC).[13]

When daily data were available, Cadmus explored richer models, without limits on the number of variables that could be included. To select the model specification, Cadmus used Least Absolute

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11 Cadmus considered low base temperatures (i.e., less than 45 °F) for facilities in Cohort 2, dairy processing facilities, where many spaces were likely required to remain at low temperatures.

12 HDDs and/or CDDs were most commonly used when selecting weather variables for the model, though testing included other temperature variables (e.g., the average temperature in Step 4).

13 The AIC is similar to the R^2 in that it quantifies the variance in observed responses accounted for by the current model, but it places a greater penalty on including more variables in the model, helpful when we are limited by degrees of freedom, such as with monthly data.

Shrinkage and Selection Operator (LASSO) regression—a model regularization and selection method that employs out-of-sample validation of the model's predictive accuracy.

Though an automated variable selection process can help to identify variables affecting facility energy use that an engineering analysis may not, it also can omit variables that engineering knowledge indicates should be included as regressors in the model. To avoid omitting relevant variables, Cadmus carefully reviewed the model specification selected through the automated procedure, and added or removed variables as necessary, based on knowledge of the site type modeled and the site's production.

Step 4c. Select the final baseline model. The previous variable selection steps yielded a final baseline model. Cadmus compared this model to other candidate models (including the EVT's model) to assess model performance. For the selected model, we made assessments using several different model-performance metrics, examining individual and joint statistical significance of the independent variables (using *t* and *F* statistics), the model R^2, and collinearity diagnostics. We verified that coefficients had the expected signs and that independent variables could explain most variability in energy use. To avoid omitting relevant variables, we carefully reviewed the final model specification selected by the automated procedure and added variables that we concluded, based on knowledge of the site type modeled and the site's energy consumption, should have been included.

Cadmus selected the final model based on the following criteria:

- ***Accuracy of within-sample prediction:*** Cadmus verified that the model accurately predicted consumption during intervals included in the baseline period.
- ***Expected signs and statistical significance of the coefficients:*** Cadmus verified that the regression coefficients had the expected signs and were statistically significant using standard *t* tests and *F* tests.
- ***Overall explanatory power:*** Cadmus checked the adjusted R^2 of the regression. A high adjusted R^2 indicated that the explanatory variables in the model explained most of the variation in consumption. Regression models with adjusted R^2 values of less than 0.6 were considered inadequate.

Appendix C. Facility Descriptions

This appendix provides detailed descriptions of each facility listed in Table 7:

- Facility F1, a hospital and medical center, provides 24-hour emergency care, along with a multitude of inpatient and outpatient services.[14] The facility has been involved in a number of energy efficiency programs during the last five years, seeking to lower its high energy costs. Facility F1 begin its engagement on February 13, 2014 and has been very proactive in seeking energy-savings opportunities through its participation in CEI and other programs.
- Facility F2 chose to not engage with CEI efforts in 2016.
- Facility F3 did not actively engage in CEI efforts in 2016, but it did continue to perform operational and behavioral changes established in 2015.
- Facility F4 is a manufacturing facility, with production accounting for a large portion of the facility's energy consumption. Facility F4's engagement mostly was driven by a plate line machine optimization program, though a regression could not be run in 2016, as much new equipment was installed during the year, making the baseline no longer accurate.
- Facility F5 is a manufacturing facility, with production accounting for a large portion of the facility's energy consumption. Its engagement began in 2014, but, due to data restrictions and progress delays, the baseline was defined in 2016, meaning all savings claimed for 2016 were attribute to incentivized capital projects and calculated using engineering analyses.
- Facility F6 is a manufacturing facility, with production accounting for a large portion of the facility's energy consumption. The facility has worked extensively with EVT over the past 10 years to improve energy efficiency, although its efforts have largely focused on implementing incentivized capital projects. It began engaging with CEI on February 1, 2014.
- Facility F7 is a ski resort—operates almost exclusively during winter months. Operations at participating buildings slow significantly once the ski season closes for summer. Cadmus evaluated electric, propane, and oil savings at this facility. All plants began participating in the CEI on February 1, 2015. Facility F7 implemented several incentivized capital projects during the reporting period that affected all fuel types. Three buildings at this facility were part of the CEI Pilot program:
    - Facility F7–E1, primarily a lodging building at the resort. Along with hotel rooms, this building provides dining and conference rooms, and this is the only building in the CEI pilot with fuel oil consumption.
    - Facility F7–E2, a private club for events and dining, implemented a major kitchen and bar upgrade in 2014. This included the addition of kitchen equipment.
    - Facility F7–E3 is a fitness center containing a fitness room, pool, and indoor tennis courts. Steam provided to the spa treatment rooms had not functioned since the

[14] F1 Efficiency Vermont report reference.

beginning of the 2015 heating season, according to the report. The implementer expected this event to affect propane consumption. Additionally, an error occurred in the data collection that caused three months of data during the performance period to be unavailable. Due to this Cadmus did not estimate savings during this time period.

Facility F8 is a manufacturing facility, producing board insulation materials, fabricated complements, and insulation systems for electrical transformers. Production accounts for a large portion of the facility's energy consumption. Both production buildings were included in the CEI Pilot. Facility F8 began engaging with CEI on February 13th, 2014. This facility focused on low- or no-cost behavioral and operational improvement measures rather than pursuing most of energy savings through capital projects.

- Facility F9 is a dairy agricultural marketing cooperative. Three plants from Facility F9 participated in the CEI program. Cadmus evaluated electric savings for two of these plants. All plants began participating in the CEI on November 11th, 2015. Facility F9 implemented several incentivized capital projects during the reporting period that affected all plants.
    - Facility F9–E1 main purpose is to rapidly cool down blocks of cheese and cut and wrap aged cheese for retail distribution. Efficiency Vermont was not able to obtain a production variable that was considered a key driver in energy consumption. Due to this, no baseline model was developed for 2016. Engineering estimates were used to estimate savings for 2016.
    - Facility F9–E2 produces a variety of cheeses, Greek yogurt, and sour cream. The facility also serves as the Visitor Center, containing a small gift shop.
    - Facility F9–E3 produces cheese, dries whey, and stores cheese. It makes cheese and whey 24 hours a day, seven days a week.
- Facility F10 is a company that manufactures ice cream, frozen yogurt, and sorbet. Two plants from Facility F10 participated in the CEI program. Cadmus evaluated electric savings for both plants. All plants began participating in the CEI on November 11th, 2015.
    - Facility F10-E1 produces a variety of dairy products. It engaged in one capital project in 2016 which savings were evaluated using engineering techniques. This site had changes in production during 2015, including a shutdown and Cadmus deemed it as unevaluable.
    - Facility F10-E2 produces a variety of dairy products. It did not engage in any capital projects in 2016. Additionally, Facility F10-E2 was not able to provide reliable data during 2015 and therefore 2014 was chosen as the baseline period.
- Facility F11 uses straight-line manufacturing to separate milk, process cream, skim condensed milk, and dry milk to powder. Additionally, Facility F11 receives milk every day. The Facility began participation in CEI on November 11th, 2015. It completed one capital project in 2016.

Facility F12 is a creamery and makes artisanal cheese and butter using both cows' and goats' milk. The Facility began participation in CEI on November 11th, 2015. It did not participate in any capital projects in 2016. Efficiency Vermont was not able to establish a reliable regression model so an engineering estimate was used to report savings.

Appendix D. Model Descriptions

The following sections describe the final models selected for each facility fuel types.

Electricity Models

EVT enrolled 11 facilities in the 2016 CEI Pilot program, Cadmus found three of the facilities unevaluable, and extended Cadmus evaluated electricity savings for eight facilities (four in each cohort). Table 13 only presents facilities evaluable within Cohort 1 savings. Only facility F7–E2 evaluated CEI savings. Facility F16, with the highest CEI saving facility of 669 MWh accounted for 52% of overall evaluated savings of 1,284 MWh.

Table 13. 2016 Reported and Evaluated Electric Energy Savings Cohort 1

Facility ID	Evaluated Facility Savings (MWh)	Lower Bound 90% Confidence Interval	Upper Bound 90% Confidence Interval	Evaluated Capital Project Savings (MWh)	Evaluated CEI Savings (MWh)	Reported CEI Savings (MWh)	Realization Rate	CEI Percent Savings
F1	793	757	828	526	267	274	97%	4%
F6	669	579	760	0	669	630	106%	19%
F7–E1	16	7	24	0	16	60	27%	2%
F7–E2	-53	-74	-31	0	-53	-30	177%	-10%
F7–E3	32	24	41	0	32	58	56%	15%
F8	382	306	458	30	404	352	87%	3%
Total	**1,840**	**1,714**	**1,965**	**556**	**1,284**	**1,397**	**92%**	**5%**

Table 14 presents Cohort 2 savings. All facilities evaluated positive CEI savings. Facility F9-E3 was the highest CEI saving facility of 699 MWh which accounted for 44% of the overall evaluated savings of 1,591 MWh.

Table 14. 2016 Reported and Evaluated Electric Energy Savings Cohort 2

Facility ID	Evaluated Facility Savings (MWh)	Lower Bound 90% Confidence Interval	Upper Bound 90% Confidence Interval	Evaluated Capital Project Savings (MWh)	Evaluated CEI Savings (MWh)	Reported CEI Savings (MWh)	Realization Rate	CEI Percent Savings
F9-E2	149	80	218	21	128	182	70%	2%
F9-E3	1,148	999	1,297	449	699	474	148%	3%
F10-E2	491	132	850	0	491	601	82%	7%
F11	283	226	339	34	249	251	99%	4%
F12	25	-48	98	0	25	23	110%	1%
Total	**2,095**	**1,690**	**2,500**	**504**	**1,591**	**2,928**	**104%**	**3%**

Facility 1

EVT defined Facility 6's baseline period 6 as January 1, 2014, to December 31, 2014. Pilot engagement began on February 13, 2014. The facility's baseline overlapped with the engagement's beginning, which could cause savings to be less accurate than the baseline prior to engagement; this should be considered in reviewing the results. Upon request, EVT provided daily site data that covered the full baseline period. Table 15 shows the reported baseline model, which achieved an adjusted R^2 of 0.8, indicating the model captured 80% of the variability in baseline consumption. All variables statistically differed from zero at the 5% significance level.

Table 15. Efficiency Vermont's Facility 1 Reported Electric Model

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Intercept	14489.2	172.9	83.8	< 0.0001
Weekend	2092.9	188.5	11.1	< 0.0001
CDD 45°F	345.8	9.5	36.3	< 0.0001

*Adjusted R^2 of 0.800

Table 16 shows the final evaluated baseline model for this facility. Both evaluated and reported models included a CDD temperature measure and a weekend indicator. Unlike the reported model, the evaluated model controlled for quadratic effects of HDD and CDD, and interaction effects between the weekend indicator and an average temperature variable. The final evaluated model accounted for 90% of the variability in baseline consumption, explaining 10% more of the variability than the reported model. The model was selected using a LASSO approach. Despite the increase in adjusted R^2, Cadmus evaluated a 97% realization. Additionally, reported savings fell within the evaluated confidence interval.

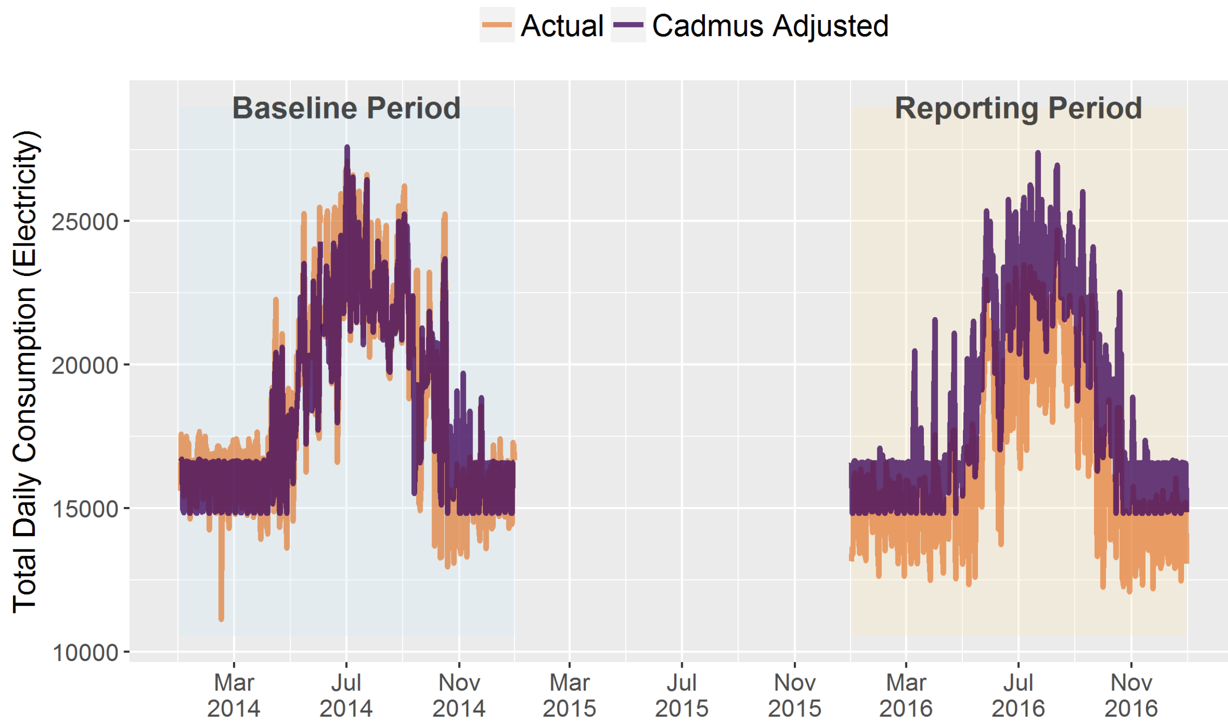
Table 16. Cadmus' Facility 1 Evaluated Electricity Model

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Intercept	16574.14	NA	NA	NA
CDD 41°F	240.75	NA	NA	NA
Weekend	-1756.83	NA	NA	NA
HDD 41°F x HDD 41°F	0.06	NA	NA	NA
CDD 41°F x CDD 41°F	1.52	NA	NA	NA
Weekend x Avg Daily Tmp	-0.01	NA	NA	NA

*Adjusted R^2 of 0.899. Cadmus used bootstrapping to calculate the standard error of the Facility 1 savings estimate. Standard errors for the model coefficients were not reported since there is not agreement about the analytical approach for calculating the standard errors.

Figure 10 shows metered and adjusted baseline consumption across the baseline and reporting period. During the baseline period (light blue), the adjusted baseline consumption (purple) closely aligns with metered consumption (orange), as expected for a well-fitting model. Differences in metered and adjusted baseline consumption during the reporting period (light yellow) represent savings, which are positive when the adjusted baseline consumption is greater than the metered consumption.

Figure 10. Metered and Adjusted Baseline Electricity Consumption



Facility 6

EVT defined the baseline period for Facility 6 as January 1, 2013, to December 31, 2013—a full year prior to the beginning of pilot engagement on February 1, 2014—well-defined for the purposes of the evaluation. Upon request EVT provided weekly production data that covered the full baseline period. Table 17 shows the reported baseline model, which achieved an adjusted R^2 over 0.7, indicating that the model captured more than 70% of the variability in baseline consumption. All variables differed significantly from zero at the 5% significance level.

Table 17. Efficiency Vermont's Facility 6 Reported Electric Model

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Intercept	71,393.8	3,569.6	20.0	< 0.0001
Average Temperature	-467.5	46.6	10.0	< 0.0001
Production	0.6	0.07	8.1	< 0.0001

*Adjusted R^2 of 0.739

Table 18 shows the final evaluated baseline model for this facility. Both evaluated and reported models included production and controlled for changes in weather—the reported model controlled for weather with average temperatures, while the evaluated model included CDDs with a base temperature of 22°F. Unlike the reported model, the evaluated model controlled for holidays, when the facility would likely close. The final evaluated model accounted for 86% of the variability in baseline consumption, explaining 13% more of the variability than the reported model. Despite the large difference in adjusted R^2, Cadmus evaluated a 106% realization rate. Additionally, reported savings fell within the evaluated confidence interval.

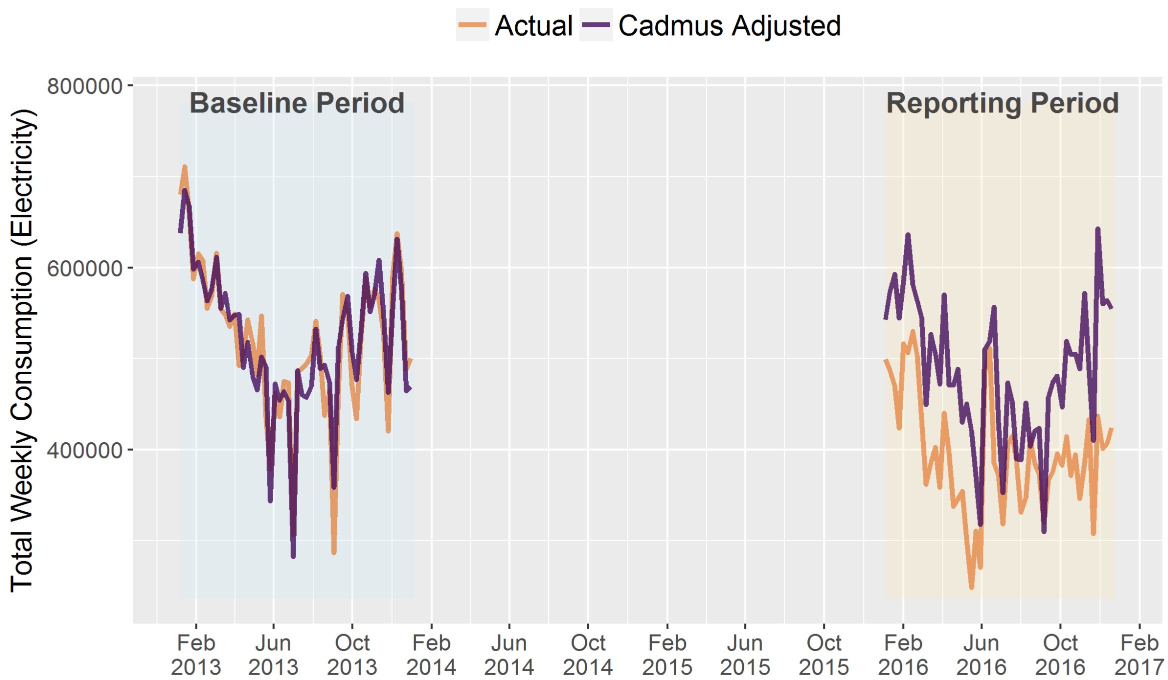
Table 18. Cadmus' Facility 6 Evaluated Electricity Model

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Intercept	71,132	2,717.8	26.17	< 0.0001
CDD 22°F	-73	5.3	-13.70	< 0.0001
Closed	-13,190	2,139.8	-6.16	< 0.0001
Production	0.42	0.1	6.98	< 0.0001

*Adjusted R^2 of 0.863

Figure 11 shows the metered and adjusted baseline consumption across the baseline and reporting period. During the baseline period (light blue), the adjusted baseline consumption (purple) closely aligns with metered consumption (orange), as expected for a well-fitting model. Differences in metered and adjusted baseline consumption during the reporting period (light yellow) represent savings, which are positive when the adjusted baseline consumption is greater than the metered consumption.

Figure 11. Metered and Adjusted Baseline Electricity Consumption



Facility 7: Building 1

EVT defined the baseline period for Facility 7, Site 1, as February 1, 2013, to December 31, 2013, an 11-month period, prior to the beginning of pilot engagement on February2/1/2014. The baseline does not contain a full year and therefore could be missing some weather variation which could cause savings to be less accurate. Upon request, EVT provided daily site data that covered the full baseline period. Table 19 shows the reported baseline model, which achieved an adjusted R^2 of 0.9, indicating that the model captured more than 90% of the variability in baseline consumption. All variables significantly differed from zero at the 5% significance level.

Table 19. Efficiency Vermont's Facility 7 Building 1 Reported Electric Model

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Intercept	-614.4	111.9	-5.5	< 0.0001
Heating SPt (50)	92.8	3.1	30.2	< 0.0001
Daily Temps	29.4	1.8	16.1	< 0.0001
Occupancy	635.1	42.1	15.1	< 0.0001

*Adjusted R^2 of 0.904

Table 20 shows the final evaluated baseline model for this facility. Both evaluated and reported models included temperature measures—the reported model controlled for weather with average temperature and a heating measure while the evaluated model included HDD and CDD measures with base temperatures of 44°F and 64° F, respectively. Unlike the reported model, the evaluated model controlled for quadratic effects of CDD. The final evaluated model accounted for 89% of the variability in baseline consumption. Though, Cadmus did not improve upon the implementers' adjusted R^2, Cadmus utilized LASSO regression analysis which utilizing cross validation. The differences in regression techniques most likely account for the low realization rate of 27%.

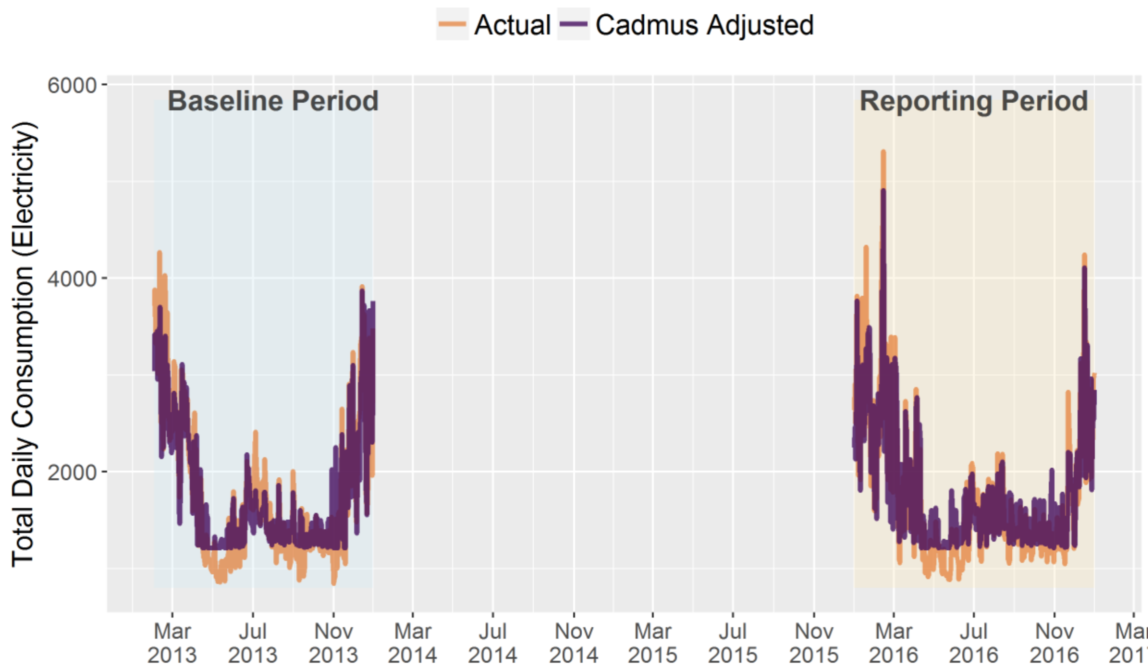
Table 20. Cadmus' Facility 7 Building 1 Evaluated Electricity Model

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Intercept	1,209.3	NA	NA	NA
HDD 44°F	59.26	NA	NA	NA
CDD 64°F	30.65	NA	NA	NA
Occupancy	518.6	NA	NA	NA
CDD 64°F x CDD 64°F	0.096	NA	NA	NA

*Adjusted R^2 of 0.892

Figure 12 shows metered and adjusted baseline consumption across the baseline and reporting period. During the baseline period (light blue), the adjusted baseline consumption (purple) closely aligns with metered consumption (orange), as expected for a well-fitting model. Differences in metered and adjusted baseline consumption during the reporting period (light yellow) represent savings, which are positive when the adjusted baseline consumption is greater than the metered consumption.

Figure 12. Facility 7 Building 1 Metered and Adjusted Baseline Electricity Consumption



Facility 7: Building 2

EVT defined the baseline period for Facility 7, Site 2, as February 1, 2013, to December 31, 2013, an 11-month period prior to the beginning of pilot engagement on February 1, 2014., it could be missing some weather variation which could cause savings to be less accurate. Upon request, EVT provided weekly site data that covered the full baseline period. Table 21 shows the reported baseline model, which achieved an adjusted R^2 over 0.65, indicating that the model captured more than 65% of the variability in baseline consumption. All variables were significantly different from zero at the 5% significance level.

Table 21. Efficiency Vermont's Facility 7 Building 2 Reported Electric Model

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Intercept	7,513.6	345.7	21.7	< 0.0001
Heating Delta (@ 50 SPt, Weekly Average)	262.8	27.8	9.5	< 0.0001

*Adjusted R^2 of 0.658

Table 22 shows the final evaluated baseline model for this facility. Both reported and evaluated models included weather variables—the reported model, controlled for weather with a measure of heating delta, while the evaluated model included HDD and CDD measures with base temperatures of 45°F and 66°F, respectively. Unlike the reported model, the evaluated model controlled for occupancy and site closures. The final evaluated model accounted for over 84% of the variability in baseline consumption, explaining 19% more of the variability than the reported model. Differences in variable selections could account for the large realization rate of 177%. Both models evaluated negative facility savings. Despite the high realization rate, the reported savings fell within the evaluated confidence interval.

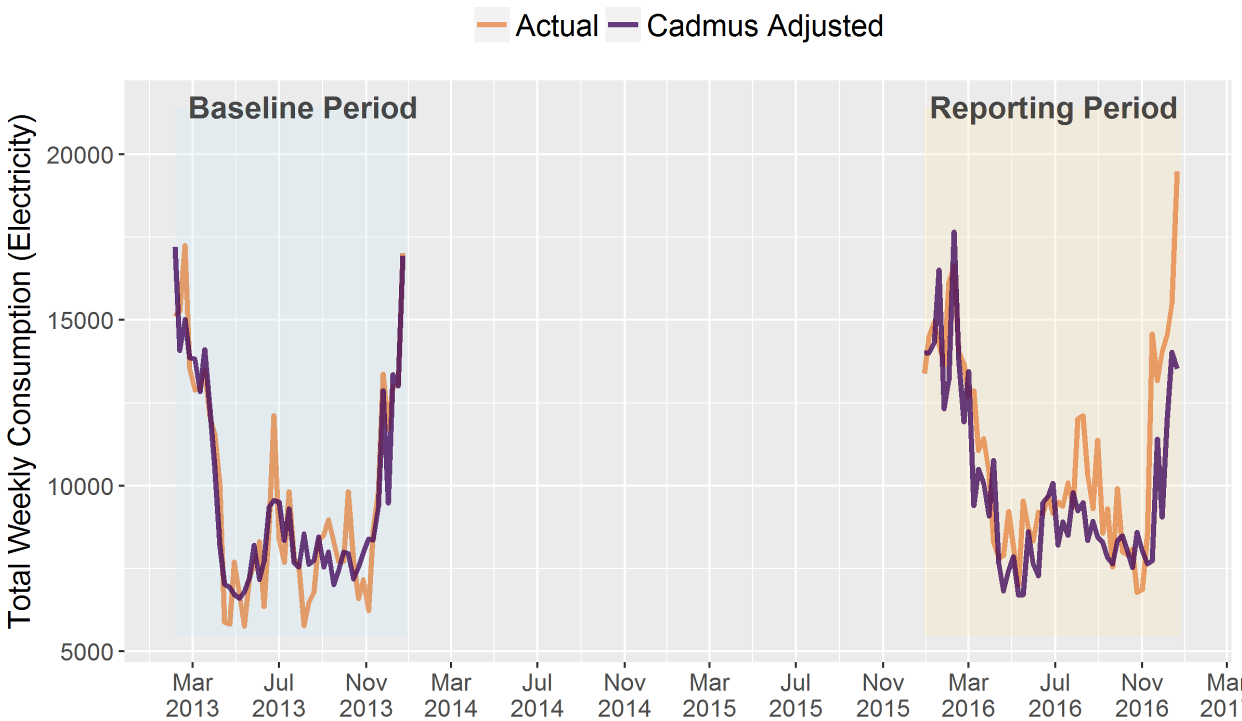
Table 22. Cadmus' Facility 7 Building 2 Evaluated Electricity Model

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Intercept	6,527.0	287.7	22.7	< 0.0001
HDD 45°F	32.8	4.3	7.6	< 0.0001
CDD 66°F	31.9	13.3	2.4	0.0214
Closed	335.0	212.0	1.6	0.1216
Occupancy	4,588.2	760.8	6.0	< 0.0001

*Adjusted R^2 of 0.847

Figure 13 shows metered and adjusted baseline consumption across the baseline and reporting period. During the baseline period (light blue), the adjusted baseline consumption (purple) closely aligned with metered consumption (orange), as expected for a well-fitting model. Differences in metered and adjusted baseline consumption during the reporting period (light yellow) represent savings, which are positive when the adjusted baseline consumption is greater than the metered consumption.

Figure 13. Facility 7 Building 2 Metered and Adjusted Baseline Electricity Consumption



Facility 7: Building 3

EVT defined the baseline period for Facility 7, Site 3, as February 1, 2013, to December 31, 2013, an 11-month period prior to the beginning of pilot engagement on February 1, 2014. Upon request, EVT provided weekly site data that covered the full baseline period. Table 23 shows the reported baseline model, which achieved an adjusted R^2 over 0.97, indicating that the model captured more than 97% of the variability in baseline consumption. All variables were significantly different from zero at the 5% significance level.

Table 23. Efficiency Vermont's Facility 7 Building 3 Reported Electric Model

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Heating Delta (@ 50F SPt Weekly Avg)	29.7	0.9	33.0	< 0.0001
Weather Data (Weekly Average)	84.8	1.5	55.9	< 0.0001

*Adjusted R^2 of 0.971

Table 24 shows the final evaluated baseline model for this facility. Both the evaluated and reported models included weather controls—the reported model controlled for weather with weekly average temperatures, while the evaluated model included HDD and CDD measures with base temperatures of 50°F and 51°F, respectively. Unlike the reported model, the evaluated model controlled for occupancy. The final evaluated model accounted for 79% of the variability in baseline consumption. The adjusted R^2s are difficult to compare as Efficiency Vermont suppressed the intercept. Cadmus does not recommend suppressing an intercept without rational behind it, as it does not allow any baseline usage beyond the variables. Cadmus evaluated a realization rate of 56%.

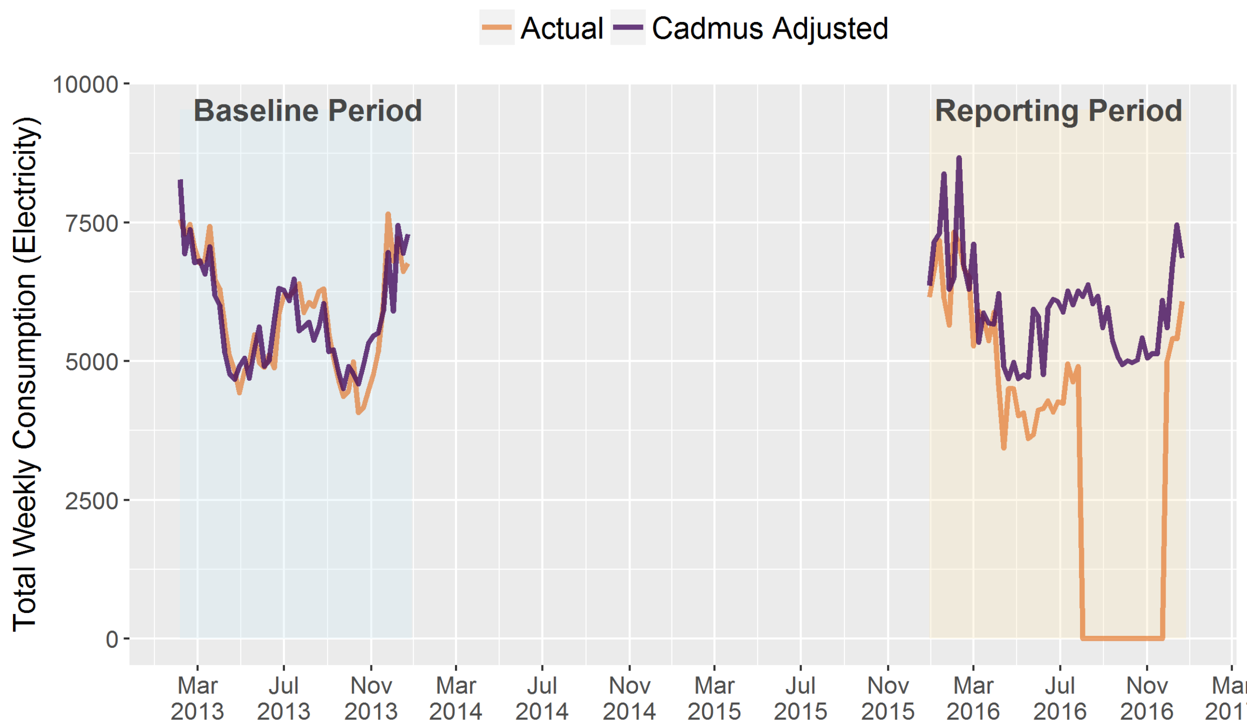
Table 24. Cadmus' Facility 7 Building 3 Evaluated Electricity Model

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Intercept	4,176.7	158.8	26.3	< 0.0001
HDD 50°F	14.60	1.58	9.26	< 0.0001
CDD 51°F	12.83	1.87	6.86	< 0.0001
Occupancy	724.5	291.7	2.48	0.0170

*Adjusted R^2 of 0.789

Figure 14 shows metered and adjusted baseline consumption across the baseline and reporting periods. During the baseline period (light blue), the adjusted baseline consumption (purple) closely aligns with metered consumption (orange), as expected for a well-fitting model. Differences in metered and adjusted baseline consumption during the reporting period (light yellow) represent savings, which are positive when the adjusted baseline consumption is greater than the metered consumption.

Figure 14. Facility 7 Building 3 Metered and Adjusted Baseline Electricity Consumption



Facility 8

EVT defined the baseline period for Facility 8 as February 28, 2014, to December 31, 2014, and began pilot engagement on February 13, 2014. This facility's baseline overlapped with the beginning of the engagement, which could cause savings to become less accurate than those of the baseline prior to engagement, which should be considered when reviewing the results. Upon request, EVT provided daily production data that covered the full baseline period. Table 25 shows the reported baseline model, which achieved an adjusted R^2 of 0.98, indicating the model captured 98% of the variability in baseline consumption. All variables were significantly different from zero at the 5% significance level.

Table 25. Efficiency Vermont's Facility 8 Reported Electric Model

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Intercept	7952.2	593.2	13.4	< 0.0001
Sqrt(BM1 (tons))	5606.7	123.5	45.4	< 0.0001
Sqrt(BM2 (tons))	4527.5	97.9	46.3	< 0.0001
Event	561.3	279.2	2.0	0.0454
Avg. Daily Temp (F)	34.6	9.0	3.9	< 0.0001
Running Production?	-3571.7	656.0	-5.4	< 0.0001

*Adjusted R^2 of 0.980

Table 26 shows the final evaluated baseline model for this facility. Both evaluated and reported models included production and weather variables – the reported model controlled for weather with a daily average temperature measure, while the evaluated model included a series of average temperature interactions and a quadratic HDD term (6°F base temperature). Unlike the reported model, the evaluated model controlled for weekends and closures. The evaluated model also included a suite of additional interaction effects capturing a range of production disruptions. The final evaluated model accounted for 98.4% of the variability in baseline consumption. Cadmus slightly improved the adjusted R^2 and evaluated a realization rate of 87%. Additionally, the reported savings are within the evaluated confidence interval.

Table 26. Cadmus' Facility 8 Evaluated Electricity Model

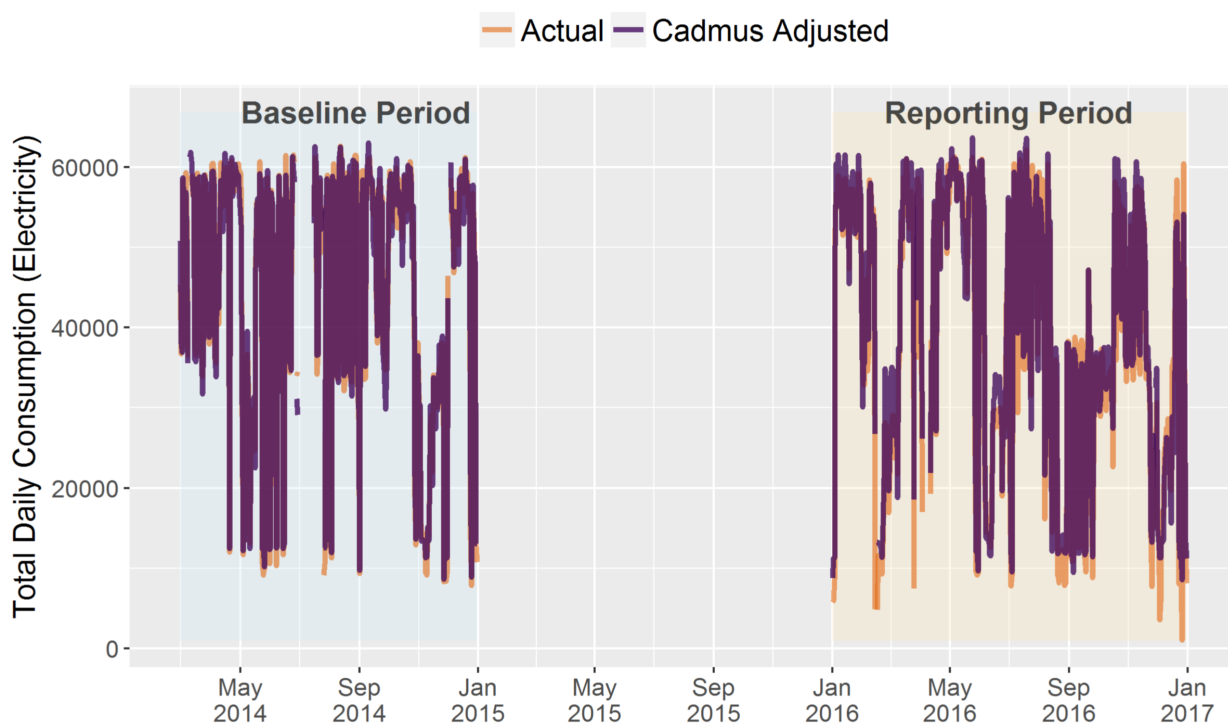
Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Intercept	12,975.4	NA	NA	NA
Closed	-4206.0	NA	NA	NA
BM1	1,493.1	NA	NA	NA
BM2	889.6	NA	NA	NA
Weekend	-1,039.9	NA	NA	NA
HDD 6°F x HDD 6°F	34.5	NA	NA	NA
Closed x Event	-296.8	NA	NA	NA
Avg Daily Tmp x Avg Daily Tmp	0.23	NA	NA	NA
Avg Daily Tmp x Running Production	9.06	NA	NA	NA
Avg Daily Tmp x Weekend	-6.05	NA	NA	NA
Running Production x Weekend	163.5	NA	NA	NA
BM1 x BM1	-18.4	NA	NA	NA
BM1 x BM2	-2.74	NA	NA	NA

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
BM1 x Event	8.98	NA	NA	NA
BM2 x BM2	-6.03	NA	NA	NA
BM2 x Event	34.7	NA	NA	NA
Weekend x Event	-714.4	NA	NA	NA

*Adjusted R^2 of 0.984. Cadmus used bootstrapping to calculate the standard error of the Facility 8 savings estimate. Standard errors for the model coefficients were not reported since there is not agreement about the analytical approach for calculating the standard errors.

Figure 15 shows the metered and adjusted baseline consumption across the baseline and reporting period. During the baseline period (light blue), the adjusted baseline consumption (purple) closely aligns with metered consumption (orange), as expected for a well-fitting model. Differences in metered and adjusted baseline consumption during the reporting period (light yellow) represent savings, which are positive when the adjusted baseline consumption is greater than the metered consumption.

Figure 15. Facility 8 Metered and Adjusted Baseline Electricity Consumption



Facility 9: Building 2

EVT defined the baseline period for Facility 9 Site 2 as 1/1/2015 to 12/31/2015 and began pilot engagement on 11/11/2015. The baseline does overlap slightly with the kickoff if the CEI program, but as it is only about six it should not greatly impact savings. The baseline period is well-defined for the purposes of the evaluation. Upon request, EVT provided weekly production data that covered the full baseline period. Table 27 shows the reported baseline model, which achieved an adjusted R^2 of 0.78, indicating that the model captured 78% of the variability in baseline consumption. All variables were significantly different from zero at the 5% significance level.

Table 27. Efficiency Vermont's Facility 9 Building 2 Reported Electric Model

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Intercept	65,606.7	14747.9	4.4	< 0.0001
Avg Temp F	514.7	44.2	11.6	< 0.0001
Cheese	0.1	0.0	4.4	< 0.0001
Cultured	0.0	0.0	3.1	0.0037

*Adjusted R^2 of 0.784

Table 28 shows the final evaluated baseline model for this facility. Both the evaluated and reported models included production and weather controls – the reported model controlled for weather with average temperature while the evaluated model included HDD and CDD measures with base temperature of 49°F. The final evaluated model accounted for 83% of the variability in baseline consumption, explaining 5% more of the variability than the reported model and evaluated a realization rate of 70%. The reported savings are within the evaluated confidence interval.

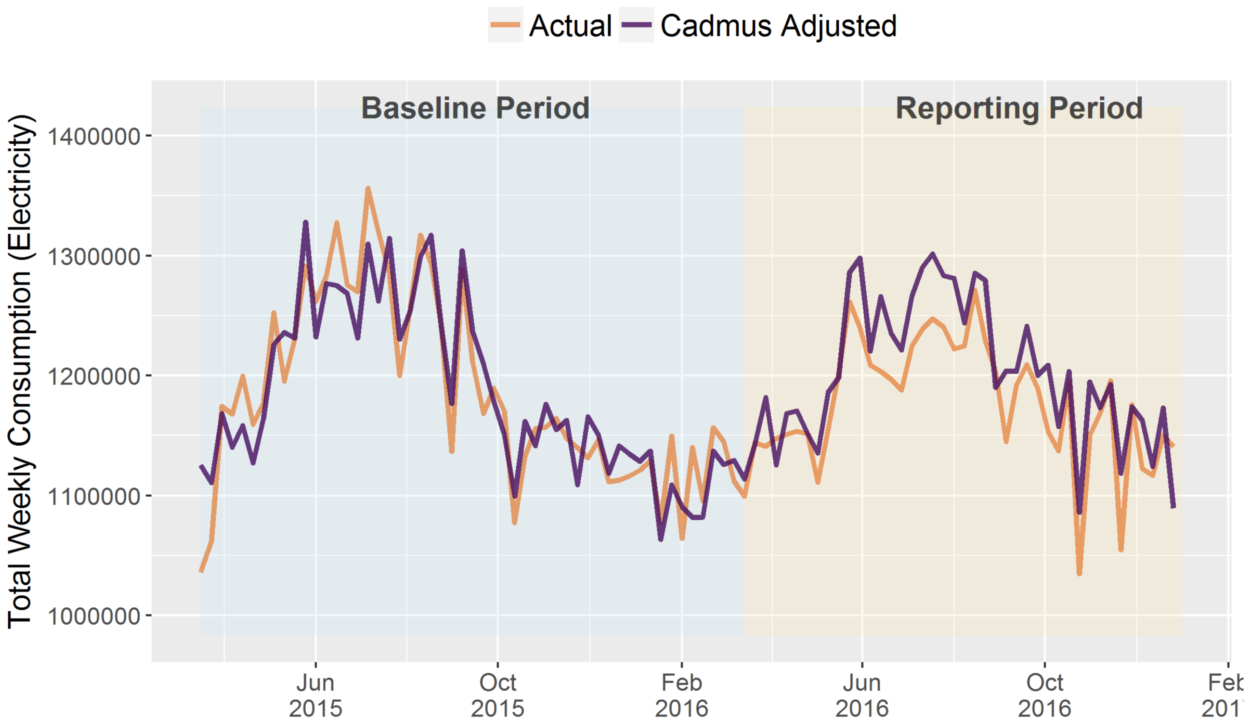
Table 28. Cadmus' Facility 9 Building 2 Evaluated Electricity Model

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Intercept	84,180.3	13,019.9	6.47	< 0.0001
HDD 49°F	-34.07	11.59	-2.94	0.0051
CDD 49°F	130.3	15.82	8.24	< 0.0001
Cheese	0.095	0.018	5.39	< 0.0001
Cultured	0.022	0.009	2.55	0.0140

*Adjusted R^2 of 0.829

Figure 16 shows the metered and adjusted baseline consumption across the baseline and reporting period. During the baseline period (light blue), the adjusted baseline consumption (purple) closely aligns with metered consumption (orange), as expected for a well-fitting model. Differences in metered and adjusted baseline consumption during the reporting period (light yellow) represent savings, which are positive when the adjusted baseline consumption is greater than the metered consumption.

Figure 16. Facility 9 Building 2 Metered and Adjusted Baseline Electricity Consumption



Facility 9: Building 3

EVT defined the baseline period for Facility 9 Site 3 as 1/1/2015 to 12/31/2015 and began pilot engagement on 11/11/2015. The baseline does overlap slightly with the kickoff if the CEI program, but as it is only about six it should not greatly impact savings. The baseline period is well-defined for the purposes of the evaluation. Upon request, EVT provided weekly production data that covered the full baseline period. Table 29 shows the reported baseline model, which achieved an adjusted R^2 of 0.82, indicating that the model captured 82% of the variability in baseline consumption. The production and temperature variables were significantly different from zero at the 5% significance level.

Table 29. Efficiency Vermont's Facility 9 Building 3 Reported Electric Model

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Intercept	-18,370.0	43618.1	-0.4	0.6767
Cheese (lbs)	0.3	0.0	9.7	< 0.0001
Avg Temp F	1,422.4	125.9	11.3	< 0.0001

*Adjusted R^2 of 0.816

Table 30 shows the final evaluated baseline model for this facility. Both the evaluated and reported models included production and weather variables – the reported model controlled for weather with average temperature while Cadmus included HDD and CDD measures with base temperatures of 48°F and 60°F respectively. Unlike the reported model, the evaluated model controlled for facility closures. The final evaluated model accounted for 92% of the variability in baseline consumption, explaining 10% more of the variability than the reported model. Cadmus evaluated a realization rate of 148% most likely driven by differences in model specifications.

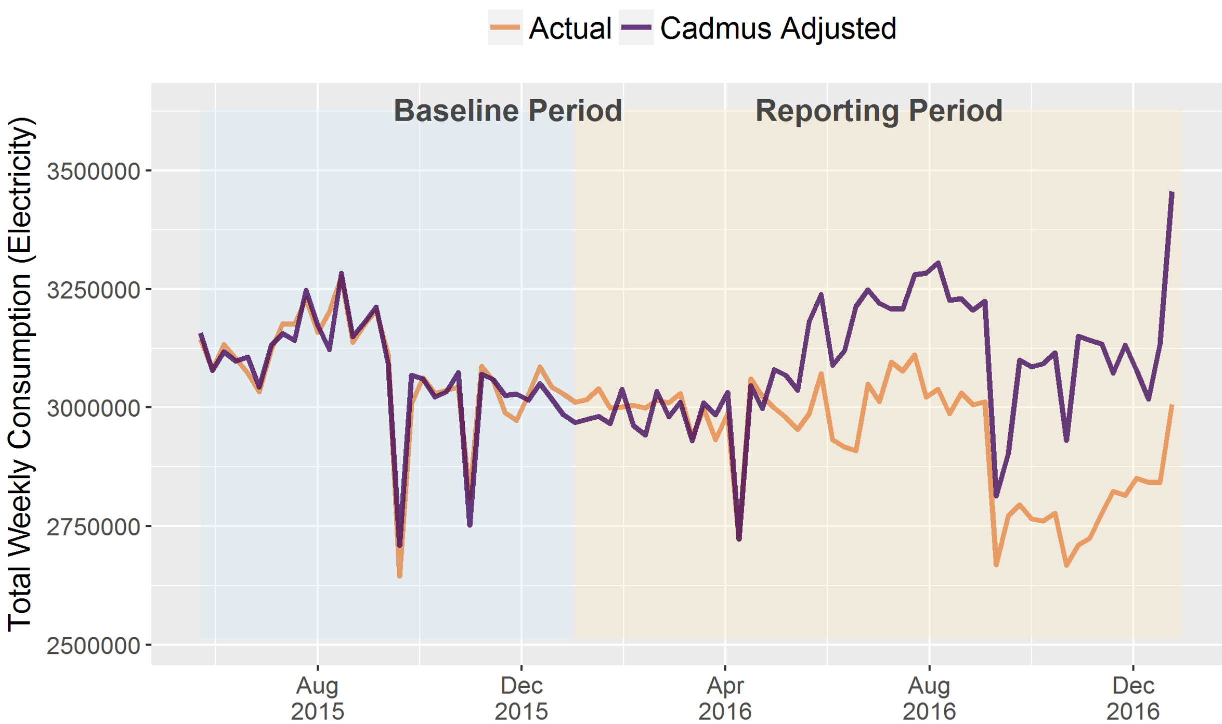
Table 30. Cadmus' Facility 9 Building 3 Evaluated Electricity Model

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Intercept	80,511.9	26004.1	3.1	0.0045
HDD 48°F	-97.6	42.3	-2.3	0.0288
CDD 60°F	432.6	30.2	14.3	< 0.0001
Closed	-5,326.6	2475.1	-2.2	0.0405
Cheese (lbs)	0.310	0.023	13.3	< 0.0001

*Adjusted R^2 of 0.917

Figure 17 shows the metered and adjusted baseline consumption across the baseline and reporting period. During the baseline period (light blue), the adjusted baseline consumption (purple) closely aligns with metered consumption (orange), as expected for a well-fitting model. Differences in metered and adjusted baseline consumption during the reporting period (light yellow) represent savings, which are positive when the adjusted baseline consumption is greater than the metered consumption.

Figure 17. Facility 9 Building 3 Metered and Adjusted Baseline Electricity Consumption



Facility 10: Building 2

EVT defined the baseline period for Facility 8 as 1/1/2014 to 12/31/2014 and began pilot engagement on 11/11/2015. The baseline does overlap slightly with the kickoff if the CEI program, but as it is only about six it should not greatly impact savings. The baseline period is well-defined for the purposes of the evaluation. Upon request, EVT provided monthly production data that covered the full baseline period. Table 31 shows the reported baseline model, which achieved an adjusted R^2 of 0.90, indicating that the model captured 90% of the variability in baseline consumption.

Table 31. Efficiency Vermont's Facility 10 Building 2 Reported Electric Model

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Intercept	272,054.8	41,924.3	6.5	<0.0001
CDD 30°F	124.72	39.8	3.6	0.0056
Litons	144.21	36.1	3.5	0.0072

* Adjusted R^2 of 0.901

Table 32 shows the final evaluated baseline model for this facility. Both the evaluated and reported models included production and temperature controls – the reported and evaluated models used CDD measures with base temperatures of 30°F and 37°F respectively. Unlike the reported model, the evaluated model controlled for facility closures. The final evaluated model accounted for 92% of the variability in baseline consumption, slightly improving upon the EVT model. Cadmus evaluated very similar savings, with a realization rate of 82%, additionally the reported savings are within the evaluated confidence interval.

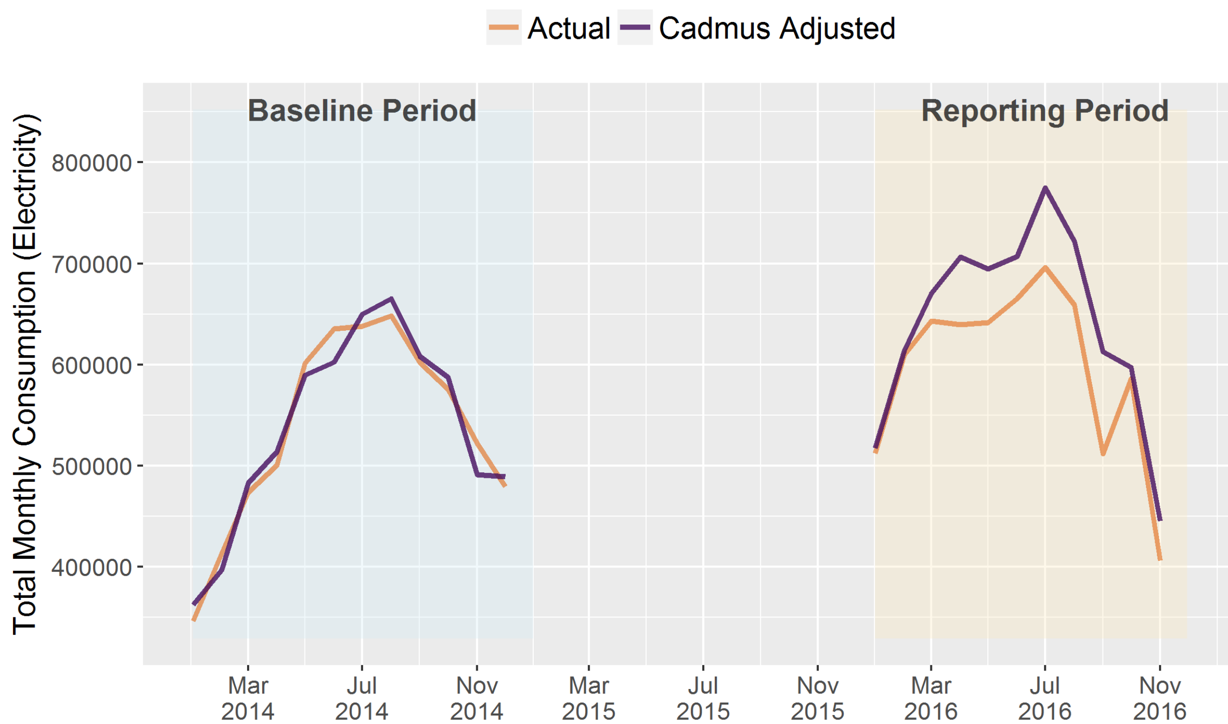
Table 32. Cadmus' Facility 10 Building 2 Evaluated Electricity Model

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Intercept	10,323.1	1069.6	9.7	< 0.0001
CDD 37°F	162.1	26.3	6.2	0.0003
Closed	-755.5	452.4	-1.7	0.1335
Average Daily Litons	128.1	25.8	5.0	0.0011

*Adjusted R^2 of 0.917

Figure 18 shows the metered and adjusted baseline consumption across the baseline and reporting period. During the baseline period (light blue), the adjusted baseline consumption (purple) closely aligns with metered consumption (orange), as expected for a well-fitting model. Differences in metered and adjusted baseline consumption during the reporting period (light yellow) represent savings, which are positive when the adjusted baseline consumption is greater than the metered consumption.

Figure 18. Facility 10 Building 2 Metered and Adjusted Baseline Electricity Consumption



Facility 11

EVT defined the baseline period for Facility 11 as 1/1/2015 to 12/31/2015 and began pilot engagement on 11/11/2015. The baseline does overlap slightly with the kickoff if the CEI program, but as it is only about six it should not greatly impact savings. The baseline period is well-defined for the purposes of the evaluation. Upon request, EVT provided weekly production data that covered the full baseline period. Table 33 shows the reported baseline model, which achieved an adjusted R^2 of 0.84, indicating that the model captured 84% of the variability in baseline consumption. All variables were significantly different from zero at the 5% significance level.

Table 33. Efficiency Vermont's Facility 11 Reported Electric Model

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Intercept	34135.5	10530.2	3.2	0.0022
Powder (qty)	0.995	0.241	4.1	0.0001
Sewer (gal)	0.036	0.007	5.2	< 0.0001
Cream (lbs)	0.041	0.015	2.7	0.0090
Temperature (WB) (°F)	335.4	33.6	10.0	< 0.0001

*Adjusted R^2 of 0.844

Table 34 shows the final evaluated baseline model for this facility. Both the evaluated and reported models included production and weather variables – the reported model controlled for weather with average temperature while Cadmus included a CDD measure with a base temperature of 52°F. The final evaluated model accounted for 91% of the variability in baseline consumption, explaining 7% more of the variability than the reported model. The reported savings were very similar to the evaluated savings with a realization rate of 99%, with the reported savings within the evaluated confidence interval.

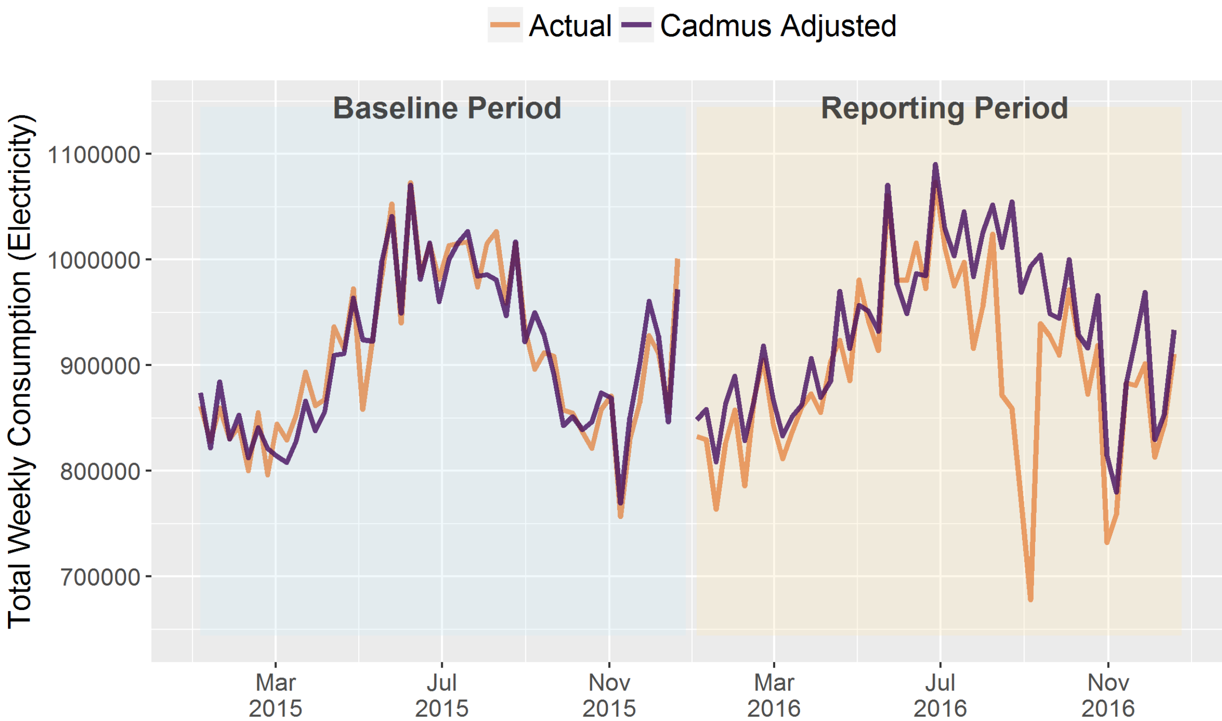
Table 34. Cadmus' Facility 11 Evaluated Electricity Model

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Intercept	37,450.3	7613.6	4.9	< 0.0001
CDD 52°F	118.0	7.836	15.1	< 0.0001
Sewer (gal)	0.040	0.005	8.5	< 0.0001
Powder (qty)	1.555	0.191	8.2	< 0.0001

*Adjusted R^2 of 0.914

Figure 19 shows the metered and adjusted baseline consumption across the baseline and reporting period. During the baseline period (light blue), the adjusted baseline consumption (purple) closely aligns with metered consumption (orange), as expected for a well-fitting model. Differences in metered and adjusted baseline consumption during the reporting period (light yellow) represent savings, which are positive when the adjusted baseline consumption is greater than the metered consumption.

Figure 19. Facility 11 Metered and Adjusted Baseline Electricity Consumption



Facility 12

EVT defined the baseline period for Facility 12 as 12/1/2014 to 1/1/2015 and began pilot engagement on 11/11/2015. The baseline does overlap slightly with the kickoff if the CEI program, but as it is only about six it should not greatly impact savings. EVT provided monthly production data upon request that covered the full baseline period. Due to prior data availability issues, EVT did not provide a reported baseline model that captured a sufficient share of the variability in baseline consumption.

Table 35 shows the final evaluated model for this facility. The evaluated model includes a temperature control, index which a linear trend in the baseline period that controlled for changes at the facility that increased usage over time, and a closure indicator. The final evaluated model accounted for 92% of the variability in baseline consumption. Despite, the differences in evaluation techniques Cadmus evaluated a realization rate of 110%, additionally the reported savings are within the evaluated confidence interval.

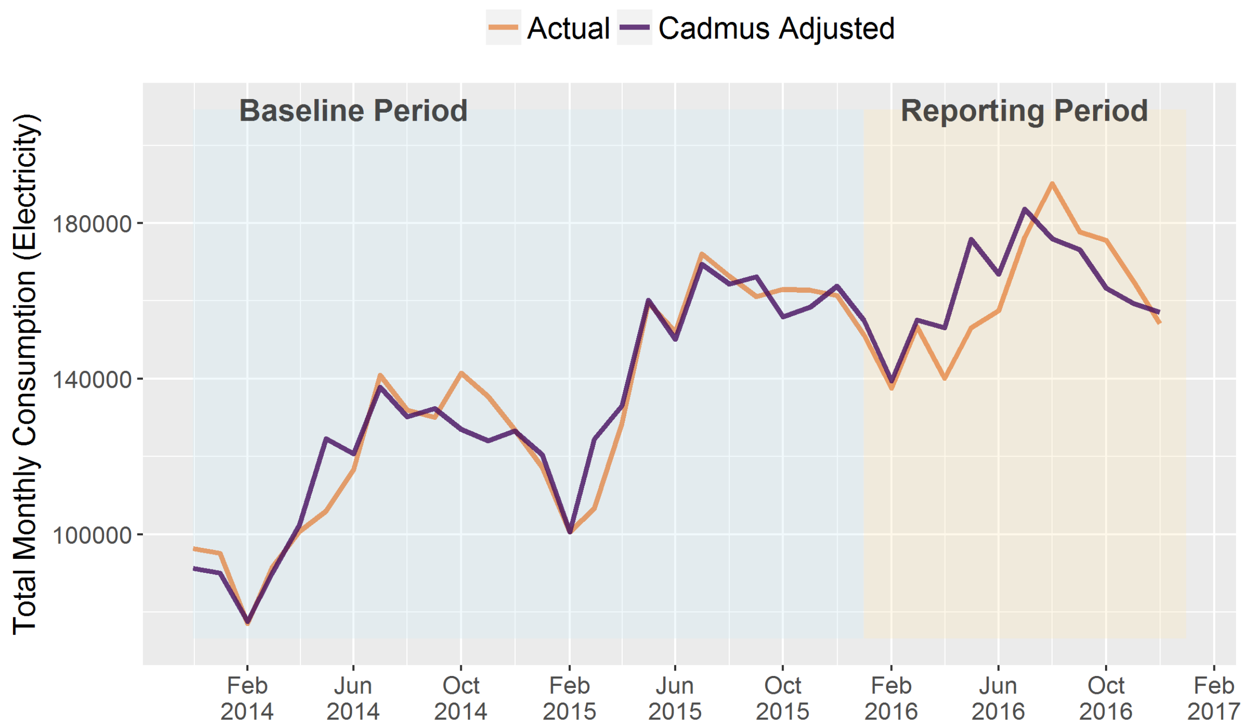
Table 35. Cadmus' Facility 12 Evaluated Electricity Model

Variable	Estimated Average Daily kWh	Standard Error	T-Statistic	P-Value
Intercept	2,178.3	140.9	15.5	< 0.0001
Closed	254.2	100.2	2.5	0.0191
Index	86.4	7.2	11.9	< 0.0001
Avg Daily Temp	19.7	2.7	7.3	< 0.0001

*Adjusted R^2 of 0.921

Figure 20 shows the metered and adjusted baseline consumption across the baseline and reporting period. During the baseline period (light blue), the adjusted baseline consumption (purple) closely aligns with metered consumption (orange), as expected for a well-fitting model. Differences in metered and adjusted baseline consumption during the reporting period (light yellow) represent savings, which are positive when the adjusted baseline consumption is greater than the metered consumption.

Figure 20. Facility 12 Metered and Adjusted Baseline Electricity Consumption



Oil and Propane Models

Cadmus evaluated electricity savings for one facilities (five total models within facility F7). Table 36 presents oil propane savings. Both facility F7-E2 and F7-E3 evaluated CEI savings. Facility F7-E1 oil was the highest CEI saving facility of 946 MWh, due to the negative evaluated savings the overall CEI savings are much lower than 946 MWh. Facilities F7-E2, F7-E3, and the overall saving's confidence intervals contain 0 and therefore the savings are not different than 0.

Table 36. 2016 Reported and Evaluated Oil and Propane Energy Savings

Facility ID	Evaluated Facility Savings (MMBtu)	Lower Bound 90% Confidence Interval	Upper Bound 90% Confidence Interval	Evaluated Capital Project Savings (MMBtu)	Evaluated CEI Savings (MMBtu)	Reported CEI Savings (MMBtu)	Realization Rate	CEI Percent Savings
F7-E1[1]	946	371	1,521	0	946	1452	65%	24%
F7-E1[2]	738	434	1,042	0	738	152	486%	40%
F7-E2[2]	-1,449	-3,760	861	0	-1,449	132	-1,098%	-23%
F7-E3[2]	-10	-177	157	0	-10	71	-15%	-2%
Total	**224**	**-2,182**	**2,630**	**0**	**224**	**1,807**	**12%**	**2%**

[1] Oil Model

[2] Propane Model

Facility 7: Building 1

Oil

EVT defined the baseline period for Facility 7 as 2/1/2013 to 12/31/2013 and began pilot engagement on 2/1/2014. The baseline is not a full year and therefore could be missing some weather variation which could cause savings to be less accurate. Upon request, EVT provided weekly production data that covered the full baseline period. Table 37 shows the reported baseline model, which achieved an adjusted R^2 of 0.89, indicating that the model captured 89% of the variability in baseline consumption. The intercept and temperature variable were significantly different from zero at the XX% significance level.

Table 37. Efficiency Vermont's Facility 7 Building 1 Reported Oil Model

Variable	Monthly Oil Consumption (gal)	Standard Error	T-Statistic	P-Value
Intercept	6632.9	872.9	7.6	< 0.0001
Avg. Monthly Temp	-91.6	13.8	-6.6	< 0.0001
Occupancy	0.04	0.10	0.37	0.7230

*Adjusted R^2 of 0.885

Table 38 shows the final evaluated baseline model for this facility. Both the evaluated and reported models included weather variables – the reported model controlled for weather with average monthly temperature while the evaluated model included an HDD measure with a base temperature of 76°F. The reported model included an occupancy measure that was excluded from the evaluated model. The final evaluated model accounted for 92% of the variability in baseline consumption, explaining 3% more of the variability than the reported model. Cadmus evaluated a realization rate of 65% however, the reported savings are within the evaluated saving's confidence interval.

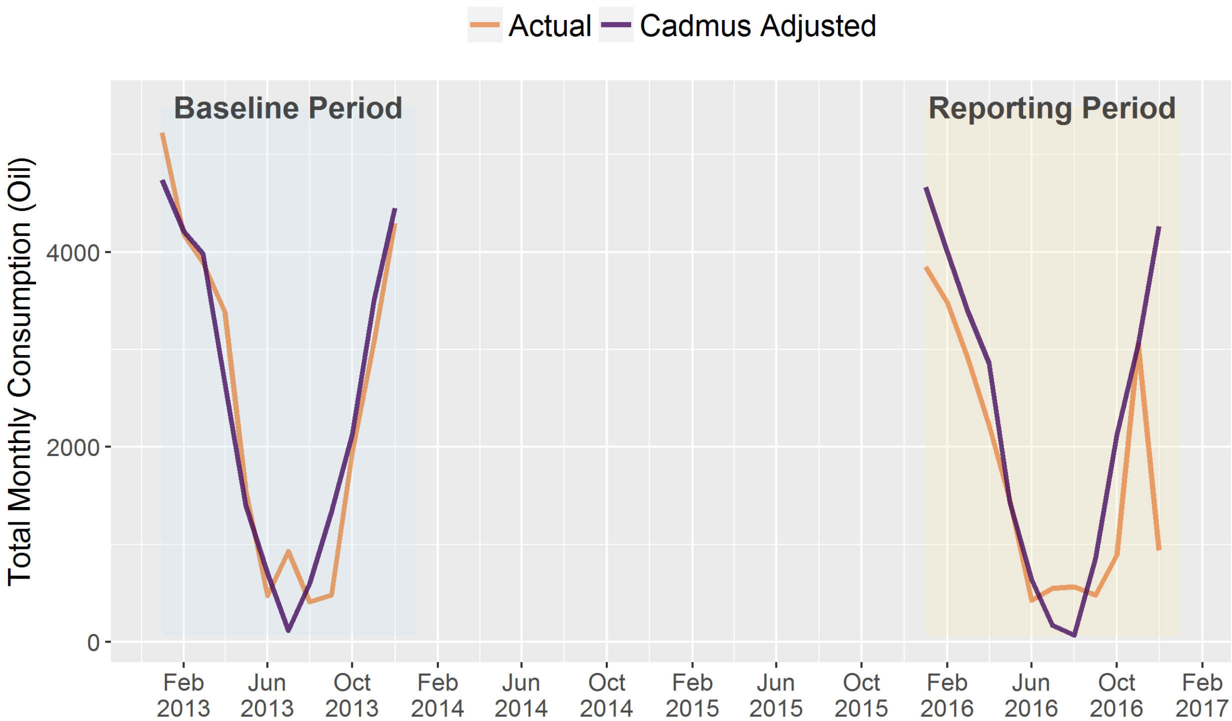
Table 38. Cadmus' Facility 7 Building 1 Evaluated Oil Model

Variable	Monthly Oil Consumption (gal)	Standard Error	T-Statistic	P-Value
Intercept	-13.95	9.92	-1.41	0.1899
HDD 76°F	3.16	0.29	11.05	< 0.0001

*Adjusted R^2 of 0.917

Figure 21 shows the metered and adjusted baseline consumption across the baseline and reporting period. During the baseline period (light blue), the adjusted baseline consumption (purple) closely aligns with metered consumption (orange), as expected for a well-fitting model. Differences in metered and adjusted baseline consumption during the reporting period (light yellow) represent savings, which are positive when the adjusted baseline consumption is greater than the metered consumption.

Figure 21. Facility 7 Building 1 Metered and Adjusted Baseline Oil Consumption



Propane

EVT provided monthly site data for propane use modeling. Table 39 shows the reported baseline propane model for Facility 7 Site 1. The baseline model achieved an adjusted R^2 of 0.36, indicating that the model captured 36% of the variability in baseline consumption. None of the estimated effects were statistically different from zero at the 5% significance level.

Table 39. Efficiency Vermont's Facility 7 Building 1 Reported Propane Model

Variable	Monthly Propane Consumption (gal)	Standard Error	T-Statistic	P-Value
Intercept	1189.4	931.05	1.28	0.23
Occupancy	0.19	0.10	1.84	0.10
Avg. Monthly Temp	-5.32	14.73	-0.36	0.73

*Adjusted R^2 of 0.358

Table 40 shows the final evaluated baseline model for this facility. Both the evaluated and reported models included weather variables – the reported model controlled for weather with average temperature while Cadmus included an additional HDD measure with a base temperature of 16°F. The evaluated model also included a closure indicator and quadratic occupancy term. The final evaluated model accounted for 73% of the variability in baseline consumption, explaining 37% more of the variability than the reported model. However, two of the estimated effects are not statistically different from zero at the 5% significance level. Cadmus evaluated a realization rate of 486% which is high but the difference in adjusted R^2 is very large.

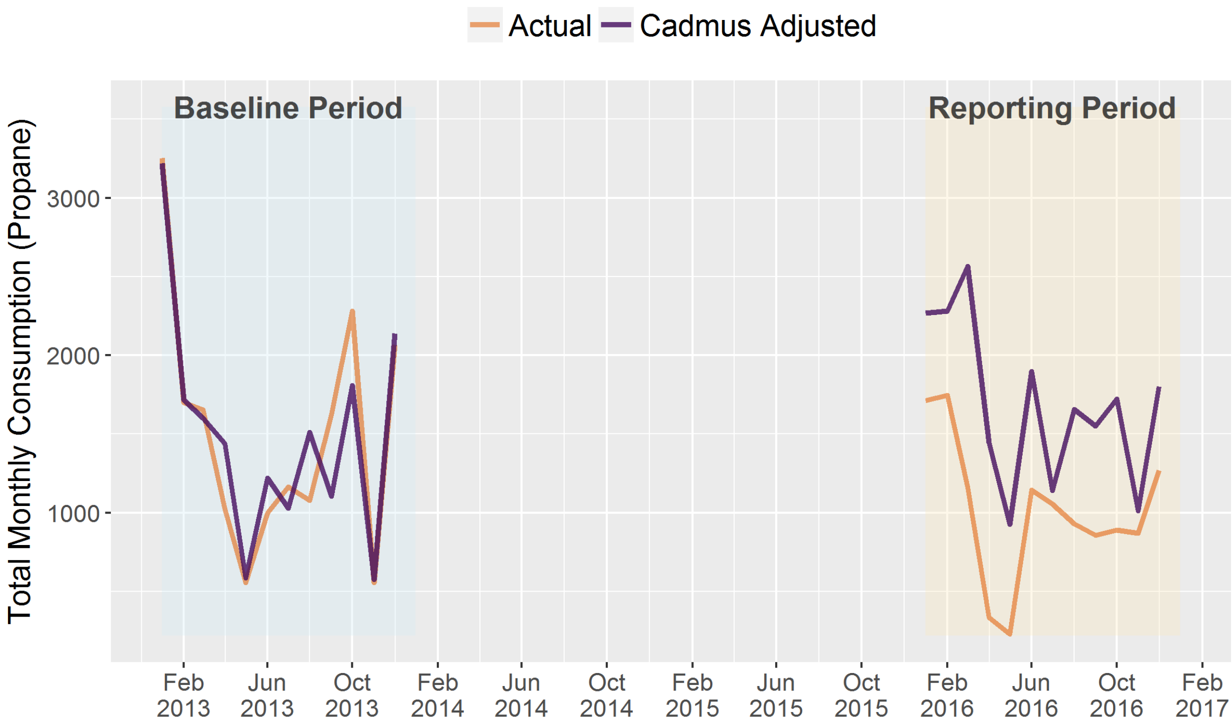
Table 40. Cadmus' Facility 7 Building 1 Evaluated Propane Model

Variable	Monthly Propane Consumption (gal)	Standard Error	T-Statistic	P-Value
Intercept	109.06	44.87	2.43	0.051
HDD 16°F	17.33	6.34	2.73	0.034
Occupancy	0.81	0.29	2.80	0.031
Avg. Daily Temp	-0.69	0.47	-1.47	0.191
Closed	-6.51	3.26	-2.00	0.093
(Occupancy)^2	-0.0032	0.0013	-2.47	0.049

*Adjusted R^2 of 0.734

Figure 22 shows the metered and adjusted baseline consumption across the baseline and reporting period. During the baseline period (light blue), the adjusted baseline consumption (purple) closely aligns with metered consumption (orange), as expected for a well-fitting model. Differences in metered and adjusted baseline consumption during the reporting period (light yellow) represent savings, which are positive when the adjusted baseline consumption is greater than the metered consumption.

Figure 22. Facility 7 Building 1 Metered and Adjusted Baseline Propane Consumption



Facility 7: Building 2

EVT provided monthly site data for propane use modeling. Table 41 shows the reported baseline propane model for Facility 7 Site 2. The baseline model achieved an adjusted R^2 of 0.55, indicating that the model captured 55% of the variability in baseline consumption. The heating delta variable was statistically different from zero at the 5% significance level.

Table 41. Efficiency Vermont's Facility 7 Building 2 Reported Propane Model

Variable	Monthly Propane Consumption (gal)	Standard Error	T-Statistic	P-Value
Intercept	1254.8	2008.1	0.62	0.55
Delta from 50	542.2	143.1	3.79	0.0035

*Adjusted R^2 of 0.548

Table 42 shows the final evaluated baseline model for this facility. Both the evaluated and reported models included weather variables – the reported model controlled for weather with a heating delta measure while Cadmus included an HDD measure with a base temperature of 44°F. The reported model also includes a closure indicator. The final evaluated model accounted for 85% of the variability in baseline consumption, explaining 30% more of the variability than the reported model. Cadmus evaluated a realization rate of -1,098% however, the reported savings are within the evaluated saving's confidence interval.

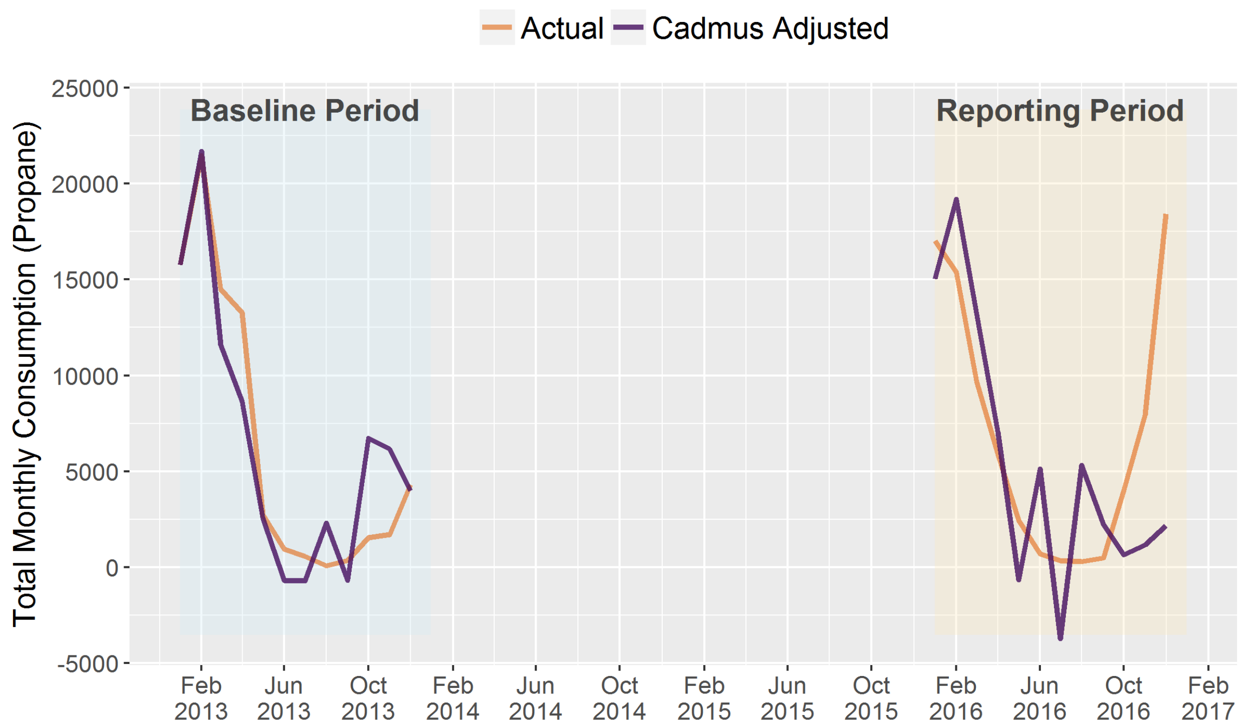
Table 42. Cadmus' Facility 7 Building 2 Evaluated Propane Model

Variable	Monthly Propane Consumption (gal)	Standard Error	T-Statistic	P-Value
Intercept	948.2	188.3	5.0	0.0007
HDD 44°F	30.2	4.0	7.6	< 0.0001
Closed	-97.1	20.0	-4.9	0.0009

*Adjusted R^2 of 0.845

Figure 23 shows the metered and adjusted baseline consumption across the baseline and reporting period. During the baseline period (light blue), the adjusted baseline consumption (purple) closely aligns with metered consumption (orange), as expected for a well-fitting model. Differences in metered and adjusted baseline consumption during the reporting period (light yellow) represent savings, which are positive when the adjusted baseline consumption is greater than the metered consumption.

Figure 23. Facility 7 Building 2 Metered and Adjusted Baseline Propane Consumption



Facility 7: Building 3

EVT provided monthly site data for propane use modeling. Table 43 shows the reported baseline propane model for Facility 7 Site 3. The baseline model achieved an adjusted R^2 of 0.80, indicating that the model captured 80% of the variability in baseline consumption. All variables were statistically different from zero at the 5% significance level.

Table 43. Efficiency Vermont's Facility 7 Building 3 Reported Propane Model

Variable	Monthly Propane Consumption (gal)	Standard Error	T-Statistic	P-Value
Intercept	338.5	108.6	3.1	0.0109
Delta from 50	52.5	7.7	6.8	< 0.0001

*Adjusted R^2 of 0.804

Table 44 shows the final evaluated baseline model for this facility. Both the evaluated and reported models included weather variables – the reported model controlled for weather with a heating delta measure while Cadmus included an HDD measure with a base temperature of 57°F. The reported model also included a closure indicator. The final evaluated model accounted for 88% of the variability in baseline consumption, explaining 8% more of the variability than the reported model. Cadmus evaluated a realization rate of -15% however, the reported savings are within the evaluated saving's confidence interval.

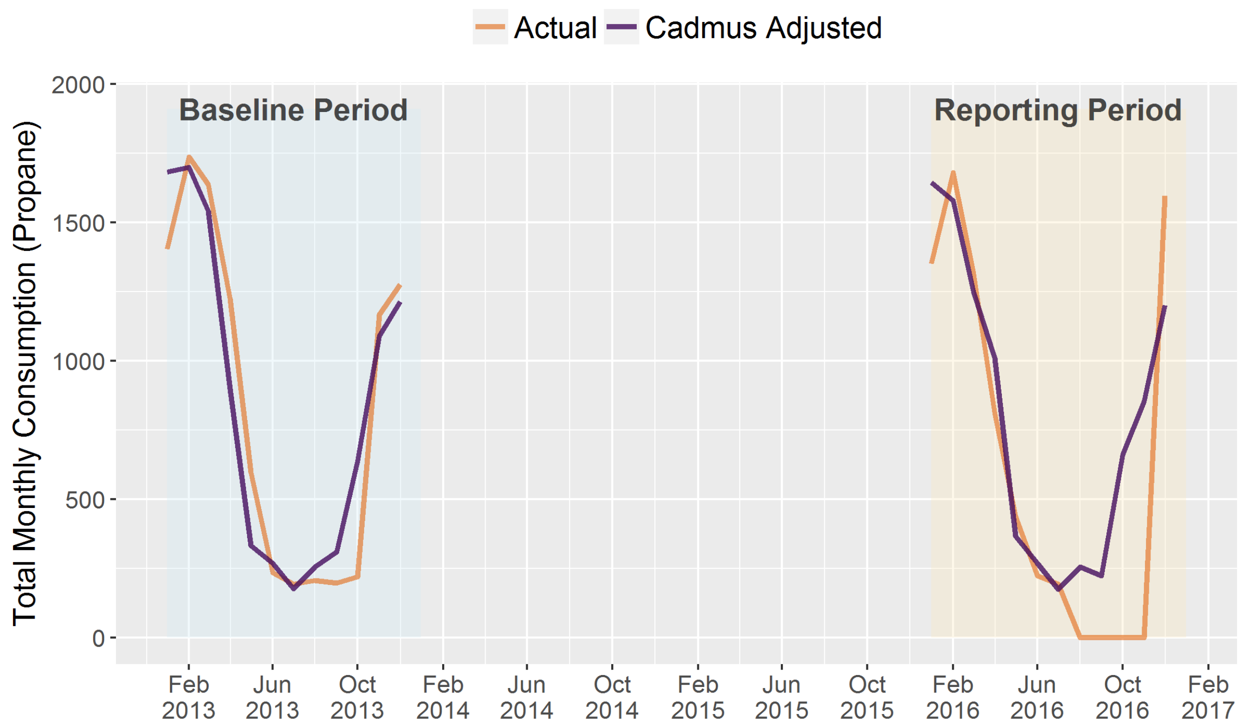
Table 44. Cadmus' Facility 7 Building 3 Evaluated Propane Model

Variable	Monthly Propane Consumption (gal)	Standard Error	T-Statistic	P-Value
Intercept	8.22	3.19	2.58	0.0297
HDD 57°F	1.59	0.19	8.56	< 0.0001
Closed	-2.59	1.22	-2.12	0.0634

*Adjusted R^2 of 0.875

Figure 24 shows the metered and adjusted baseline consumption across the baseline and reporting period. During the baseline period (light blue), the adjusted baseline consumption (purple) closely aligns with metered consumption (orange), as expected for a well-fitting model. Differences in metered and adjusted baseline consumption during the reporting period (light yellow) represent savings, which are positive when the adjusted baseline consumption is greater than the metered consumption.

Figure 24. Facility 7 Building 3 Metered and Adjusted Baseline Propane Consumption



Appendix E. Pilot Goals

EVT's goals for Cohort 1 include the following:

- Demonstrate an M&V approach to quantify savings from these behavioral changes; quantify the relative magnitude of project-based savings vs. and behavior-based energy savings from energy management and conservation. (Setting a participation goal of eight to 10 organizations, EVT achieved eight participants for the Pilot's first year.)
- Provide opportunities for enhanced engagement with customers looking to improve their energy management and for Efficiency Vermont staff to engage more fully with these customers.
- Test the ability for Efficiency Vermont's Account Management staff to cost-effectively affect customers' energy management strategies. This includes developing processes to assess and track costs related to the initiative.
- Increase the identification of additional capital projects from each customer per CEI on-site activities, workshops, and trainings; assess this outreach's incremental effect on projects and other program participation (program lift).
- Determine the pilot's ability to enhance customers' relationships by increasing the number of company contacts Efficiency Vermont works within each customer facility.
- Inform the type and cost of system enhancements (e.g., improved data reporting or permanent sub-metering, required to undertake a successful CEI program with customers).
- Test the EVT's Engineering staff's ability to collect customer energy usage data, generate reliable baseline models, track deviation of actual usage from the model, and estimate savings.
- Develop a system to capture program-related costs, including customer and program costs.
- Gain experience in applying analysis concepts outlined in the SEP M&V Protocol.
- Increase the per-customer value commensurate with the EEC investment made by this customer group.
- Establish effective metrics to deliver the CEI approach to nonindustrial C&I customers, such as large institutions or commercial buildings; share these protocols with other program administrators across the country.