CADMUS

Impact Evaluation Report for 2020 Production Efficiency Program

April 1, 2022

Prepared for:

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Acronyms

CDD	Cooling Degree Day
CAGI	Compressed Air and Gas Institute
EMS	Emergency Management System
HDD	Heating Degree Day
IPMVP	International Performance Measurement and Verification Protocol
LPD	Lighting Power Density
M&V	Measurement and Verification
MAD	Measure Approval Document
O&M	Operations and Maintenance
PDCs	Program Delivery Contractors
PE	Production Efficiency
PGE	Portland General Electric
PPS	Probability Proportional to Size
RTF	Regional Technical Forum
SEM	Strategic Energy Management
TAS	Technical Analysis Study
UMP	Uniform Methods Project

Acknowledgements

The impact evaluation of the Production Efficiency program was made possible through the significant support of Energy Trust evaluation and program staff, along with staff from the program delivery contractors. Their collective assistance with customer outreach, ensuring the evaluation team had the necessary data and information to verify and measure project savings, and the review of project evaluation reports was a tremendous help with this evaluation. We sincerely thank each and all for their support.

Executive Summary

Energy Trust of Oregon (Energy Trust) is an independent nonprofit organization governed by a volunteer board of directors and accountable to the Oregon Public Utility Commission. Energy Trust delivers energy savings programs to Oregon customers of Portland General Electric, Pacific Power, NW Natural, Cascade Natural Gas, and Avista, and customers of NW Natural in southwest Washington. As part of Energy Trust's ongoing efforts to improve program performance, it regularly completes process and impact evaluations of its programs.

This report documents the impact evaluation Cadmus conducted of the Production Efficiency (PE) program for program year 2020. We evaluated each PE program track by year and by fuel type. The PE program includes the following offerings:

- Standard
- Business lighting
- Custom
- Strategic energy management

For the purposes of this impact evaluation, we used the following categories (program tracks) which is consistent with prior impact evaluations, and more closely aligns with how project and measure data is captured in Energy Trust systems:

- Streamlined (prescriptive, small industrial, lighting, and green motor rewind)
- Custom (custom capital and custom O&M)
- Strategic energy management (SEM)

Eligible customers can participate in one, two, or all three program tracks.

For the evaluation of the 2020 program, Cadmus sampled 110 distinct projects at 103 sites to provide a mix of measure types. At those sites we also evaluated electricity savings for four additional projects and gas savings for one additional project as convenience measures. For each program year, we estimated the total program electricity and natural gas savings with 90% confidence and ±10% precision. We based these estimates on a representative sample of the project population, stratified by program year, fuel type, and track, as well as track substratification to target custom capital and custom operations and maintenance (O&M) projects for more robust evaluation.

Cadmus sampled projects using probability proportional to size (PPS) within each stratum. As shown in Table 1 and Table 2, the final sample represented 35% of electric savings and 77% of gas savings for the program's total reported savings.

Table 1. 2020 Program and Sample Total Electricity Project Quantities and Reported Savings

Program Year	Program Projects[a]	Sampled Projects[a]	Electric Savings (kWh)			
			Program	Sampled	Convenience	Percent Sampled
2020	1,320	82	128,599,882	44,420,400	97,246	35%
Total	**1,320**	**82**	**128,599,882**	**44,420,400**	**97,246**	**35%**

[a] project is defined as a unique project ID within a program year.

Table 2. 2020 Program and Sample Total Natural Gas Project Quantities and Reported Savings

Program Year	Program Projects[a]	Sampled Projects[a]	Natural Gas Savings (therms)			
			Program	Sampled	Convenience	Percent Sampled
2020	1,320	28	1,294,068	996,394	559	77%
Total	**1,320**	**28**	**1,294,068**	**996,394**	**559**	**77%**

[a] project is defined as a unique project ID within a program year.

Cadmus performed the 2020 evaluation during a challenging year. The continuing COVID-19 pandemic prolonged the recovery to normal facility operations and resulted in increased uncertainty about future facility operations. The supply chain challenges and delays experienced throughout the market also impacted hours of operations and production levels. This complicated the impact evaluation and required additional considerations for savings adjustments using the *Energy Trust Industrial Impact Evaluation Policies* as a reference to guide adjustments and ensure uniformity.

As a result, Cadmus worked with Energy Trust to discuss unique scenarios to account for external impacts on energy savings. Evaluation activities included a mix of desk reviews, in-depth interviews, virtual site visits, and on-site visits. During virtual and on-site visits, we observed the status and operating parameters for energy efficiency measures receiving Energy Trust incentives. We measured or recorded operational characteristics to support engineering analysis. Cadmus evaluated lighting, prescriptive, and streamlined measures primarily through industry-standard algorithms and deemed measure savings. We analyzed custom measures using algorithms, detailed calculation spreadsheet reviews, power metering data, and/or energy management system (EMS) trend data. We analyzed SEM projects through participant interviews and a review of the statistical regression models.

Realization Rates Summary

Table 3 lists the overall program realization rates, along with confidence and precision by fuel type for the PE program. In general, the program demonstrated consistently strong realization rates.

Table 3. Production Efficiency Program Realization Rates by Fuel Type

Fuel Type	2020			
	Reported Savings	Evaluated Savings	Realization Rate	Relative Precision[a]
Electricity (kWh)	128,599,882	126,240,680	98%	2.3%
Natural Gas (therms)	1,294,068	1,251,440	97%	4.3%

[a] Relative precision is calculated at the 90% confidence level.

Table 4 and Table 5 summarize the achieved realization rates by year, track, subtrack, and fuel type.

Table 4. Production Efficiency Program Realization Rates by Subtrack, Electric Savings

Track	Subtrack	Electricity			
		Reported (kWh)	Evaluated (kWh)	Realization Rate	Relative Precision [a]
Custom	Custom Capital	34,489,403	33,967,834	98%	5.6%
	Custom O&M	3,025,849	3,033,229	100%	3.7%
	Total	37,515,252	37,001,063	99%	5.0%
SEM	SEM	33,566,222	33,540,410	100%	1.9%
	Total	33,566,222	33,540,410	100%	1.9%
Streamlined Industrial	Green Rewind	111,666	96,142	86%	29.0%
	Lighting	35,504,469	33,700,793	95%	7.1%
	Prescriptive	9,825,086	9,825,084	100%	0.0%
	Small Industrial	12,077,187	12,077,187	100%	0.0%
	Total	57,518,408	55,699,207	97%	4.1%
Total		**128,599,882**	**126,240,680**	**98%**	**2.3%**

[a] Relative precision is calculated at the 90% confidence level.

Table 5. Production Efficiency Program Realization Rates by Subtrack, Gas Savings

Track	Subtrack	Natural Gas			
		Reported (therms)	Evaluated (therms)	Realization Rate	Relative Precision[a]
Custom	Custom Capital	512,643	454,386	89%	10.7%
	Custom O&M	1,492	173	12%	0.0%
	Total	514,135	454,559	88%	10.6%
SEM[b]	SEM	243,683	268,052	110%	N/A
	Total	243,683	268,052	110%	N/A
Streamlined Industrial	Prescriptive	463,493	445,157	96%	6.6%
	Small Industrial	72,757	83,672	115%	8.4%
	Total	536,250	528,829	99%	5.5%
Total		**1,294,068**	**1,251,440**	**97%**	**4.3%**

[a] Relative precision is the calculated at 90% confidence level.

[b] Precision could not be calculated because the sample size is 1.

Peak Demand Savings

Since the Program Delivery Contractors (PDCs) do not calculate demand savings for the program, Cadmus calculated summer and winter peak demand savings using electric load profiles and peak demand factors provided by Energy Trust. We reviewed the reported load profiles for each measure in the sample and revised them where necessary to better align with the measure type and hours of operation. We then multiplied the reported and evaluated savings for each measure by the applicable peak demand factor. We calculated realization rates for each program track and subtrack and applied them to the reported savings for the program population to determine total peak demand reduction for each building type, shown in Table 6.

Table 6. 2020 Evaluated Coincident Peak Demand Savings by Subtrack

Track	Subtrack	Winter Demand Savings (kW)	Summer Demand Savings (kW)
Custom	Custom Capital	4,081	4,859
	Custom O&M	388	433
	Total	4,469	5,292
Streamlined Industrial	Green Rewind	13	15
	Lighting	6,993	7,290
	Prescriptive	1,262	1,966
	Small Industrial	1,285	2,065
	Total	9,552	11,336
Total		**14,022**	**16,628**

Electricity and Gas Adjustments

Cadmus organized savings adjustments into the following categories:

- **Different operating hours:** Equipment operating hours differed from what was specified in the *ex ante* savings calculations.
- **Different equipment setpoints:** Different equipment setpoints from those used in the *ex ante* savings calculations. This included different temperature and pressure setpoints.
- **Incorrect equipment specifications or quantities:** This included incorrect equipment capacity, wattage, efficiency, and quantity.
- **Incorrect/Different analysis methodology:** We used a different analysis methodology from the *ex ante* savings, such as using EMS trend data to build a new regression analysis, normalizing baseline and installed periods, applying a day type methodology to air compressors, or using a different Measure Approval Document (MAD) to calculate savings.
- **Measure removal:** This involved the removal of a measure at a closed or operational facility.
- **Inappropriate baseline:** This involved baseline equipment specifications that did not align with code or industry standard practice.
- **Inappropriate assumption:** Any assumed values or conditions that were used in the calculation of baseline or measure savings. This included cooling and heating efficiencies, fan affinity exponents, and theoretical performance values.
- **Calculation or engineering error:** Situations where values in the *ex ante* savings calculation workbook, invoices, or verification report did not match values used in the analysis; this included spreadsheet formula errors or hard coded values that were not updated.
- **SEM adjustment:** Some SEM projects had adjustments to savings due to observations during the site visits, interviews, or during the review of the energy intensity models.

Table 7 shows the number of projects with adjustments and the absolute value of adjusted savings for each category. For the electric fuel type, different operating hours was the most prevalent adjustment category, and for the gas fuel type, incorrect analysis methodology was the most prevalent adjustment category.

Where multiple categories applied to one project, Cadmus assigned the project to the single category that had the greatest impact on its realization rate.

Table 7. Production Efficiency Program Savings Adjustment Category Summary

Electric Savings Adjustments	2020 (n=82)[a]	Absolute Adjusted Savings[b] (kWh)	% of Savings Adjusted (Category Adjusted Savings/Total Adjusted Savings)
Different operating hours	11	527,222	26.7%
Different equipment setpoints	7	57,963	2.9%
Incorrect equipment specifications or quantities	6	189,507	9.6%
Incorrect/different analysis methodology	3	129,066	6.5%
Measure removal	1	37,641	1.9%
Inappropriate baseline	1	83,871	4.3%
Inappropriate assumption	4	612,667	31.1%
Calculation or engineering error	2	182,338	9.2%
SEM adjustment	3	151,503	7.7%
Total	**38**	**1,971,778**	**100%**
Gas Savings Adjustments	**2020 (n=28)**	**Absolute Adjusted Savings (therms)**	**% of Savings Adjusted (Category Adjusted Savings/Total Adjusted Savings)**
Different operating hours	2	1,584	2.2%
Different equipment setpoints	4	24,528	34.2%
Incorrect equipment specifications or quantities	1	1,200	1.7%
Incorrect/different analysis methodology	1	8,882	12.4%
Inappropriate assumption	6	9,827	13.7%
Calculation or engineering error	1	1,346	1.9%
SEM adjustment	1	24,270	33.9%
Total	**16**	**71,637**	**100%**

[a] n reflects the number of unique of project IDs evaluated for each year and fuel type. Only one adjustment category was assigned per project; if multiple categories applied to one project, the project was assigned to the category with the largest impact on the realization rate.

[b] The absolute value of adjusted savings are cumulatively shown to demonstrate positive and negative impacts.

The program achieved high realization rates for electricity streamlined and custom measure projects, as well as gas streamlined projects. Cadmus found comparatively lower realization rates for gas custom and custom O&M projects. Overall, the PDCs performed a reasonable level of review and quality control to achieve high average project savings realization rates. The PDCs proved extremely knowledgeable about the facilities with which they worked and were receptive to supporting evaluation efforts. Cadmus worked directly with the PDCs on a few occasions to contact facilities and acquire analysis files and data. We found that most PDCs quickly provided any documentation they could access, identified appropriate facility contacts, and went out of their way to assist with recruitment efforts.

We also found that Energy Trust implementation staff maintained a thorough understanding of project details and participant sensibilities. Cadmus developed a large number of measurement and verification (M&V) plans for Energy Trust staff review. Even though the PDCs were more directly involved with project review and approval, senior Energy Trust staff for the PE program had a strong knowledge of project and analysis details and could provide significant feedback to improve M&V efforts. This was especially helpful when the ongoing COVID-19 and supply chain disruptions required Cadmus, in many cases, to rely on Energy Trust staff for additional data requests and project files. Energy Trust staff were responsive and supportive of all evaluation activities, which contributed to the success of the 2020 impact evaluation.

Recommendations

Based on our evaluation findings, Cadmus recommends the following opportunities for program improvements. We divided our recommendations into their respective tracks. If a recommendation applies to multiple tracks, we included it in the *Other Recommendations* section.

Custom Capital

- For compressed air savings analysis, we recommend the program use the day-type analysis methodology. This methodology looks at energy savings for each day type, accounting for differences in air demand across weekdays and weekends. This is particularly useful when developing 8,760 load shapes and is beneficial when calculating air leak and air dryer savings. We recommend avoiding averaging data across entire metering or trend data periods as this eliminates some of the important and intricate changes over a metered period that should be considered in the savings analysis. The day-type methodology is referenced in the Uniform Methods Project (UMP) Compressed Air Evaluation protocol[1] and also used by the Department of Energy's Air Master Tool to estimate savings.[2]
- For projects where system level data are not available, but utility data are available from the customer and the measure represents more than 10 to 20% of the site's total monthly metered energy use we recommend incorporating these data into the analysis to calculate savings. This could take the form of an International Performance Measurement and Verification Protocol (IPMVP) Option C Whole Building analysis or as a reference to benchmark results or calibrate savings models. When used appropriately, billing data, along with weather or production data, can be used to calculate a weather/production-normalized regression for baseline and post-period energy use—this provides a simplified analysis approach that results in more robust energy savings estimates versus those from a building modeling software tool, such as eQuest.

[1] National Renewable Energy Laboratory. (NREL; Benton, Nathanael; Patrick Burns, and Joel Zahlan). 2021. *Chapter 22: Compressed Air Evaluation Protocol. The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. NREL/SR-7A40-77820. https://www.nrel.gov/docs/fy21osti/77820.pdf.

[2] Office of Energy Efficiency & Renewable Energy. 2014. "Advanced Manufacturing: AIRMaster+". https://www.energy.gov/eere/amo/articles/airmaster.

Custom O&M

- For compressed air leak savings projects, we recommend using the system leak-down test as highlighted in the UMP Compressed Air Protocol to estimate the combined loss (cfm) of compressed air leaks. The PDC can use this approach in the pre- and post-case to estimate the effect of leak fixes in the system. In cases were the system leak-down test is impractical, The PDC should estimate flow by measuring compressor power and correlating this to flow using Compressed Air and Gas Institute (CAGI) sheets or standard flow tables. Compressor power should be measured during nonproduction periods and all non-leak air consumption should be discounted from the data to determine actual leak volume. Lastly, the most accurate approach is to measure actual flow rate in the pre- and post-nonproduction periods and discount for any non-leak air users. Installing flow meters can sometimes be invasive and prove impractical and, hence, the two prior methods are more common approaches. Ultrasonic leak detectors are good for identifying leaks and estimating savings at a high level; however, the three approaches detailed above provide a more accurate way of estimating leak loss.
- We recommend Energy Trust standardize the approach used to determine air-leak savings for the program. Our analysis found that the PDCs used different methodologies to adjust leak rates and to calculate savings for each of these projects, which resulted in different savings estimates. In some cases, the PDCs derated leak savings by 50% from the ultrasonic leak detectors and in other cases they did not. If pre- and post-metered data are not available, standardize the approach to using findings from the ultrasonic leak detector and adjust accordingly to reflect compressor flow during nonproduction periods.
- We recommend the program require the PDCs use nonproprietary models for energy savings estimation or alternatively provide any data collected and used in the energy savings analysis.

Streamlined Industrial

- **Lighting:** We recommend the program use light loggers more frequently to determine lighting hours of use and occupancy sensor savings for projects with significant electricity savings (i.e., greater than 500,000 kWh) and those projects that also have occupancy sensors. This will provide more accurate energy savings estimates.
- **Lighting:** If light loggers cannot be installed at a project or in sensitive spaces due to customer concerns, location, or space use, we recommend the project documentation include clear hours of use calculations and the source of information (i.e., Monday through Friday, 6:00 a.m. to 5:00 p.m., based on an interview with the site contact).
- **Lighting:** We recommend the program apply a uniform approach to calculate HVAC interactive effects across all lighting projects. Upgrades to LED lights generally result in an increase in electricity savings through cooling savings and an increase in gas or electric consumption due to additional heating requirements. Energy Trust should apply a standardized approach to calculate interactive effects across all lighting projects in the program to ensure these effects are

accounted for appropriately. Lighting-related HVAC interactive effects are also covered in the UMP Commercial and Industrial Lighting Evaluation Protocol.[3]

- **Lighting:** We recommend the program require proof of space-use change or alteration and light levels for retrofit projects that use a light power density (LPD) methodology. Documentation could include pre- and post-retrofit space photos, calculations of lumens per square foot, narrative background on the need for increased or decreased lighting levels, and existing and as-built electrical drawings.
- **Small Industrial:** We recommend following a uniform approach to calculate gas savings using the virtual grower calculator. For some projects, the PDC claimed the full savings amount resulting from the virtual grower, and for some greenhouse projects, the PDC adjusted savings down by 20%. The calculator should be used uniformly across all projects. If there is a concern about the calculator overestimating savings, we recommend adjusting the assumptions and inputs within the calculator rather than making a universal adjustment to the final savings values.
- **Small Industrial:** For some large irrigation projects involving gasket replacements, Cadmus observed that Energy Trust adjusted savings down to account for a cap on the maximum incentive that can be offered. Savings were therefore reduced by 90% to reflect the approved incentive value. This adjustment was done after the project was approved and added to the database. As such, Energy Trust adjusted savings by applying a negative savings value in the database to reduce the original savings that were input in the database. We recommend developing a uniform process to make these adjustments during the project review to avoid having to adjust the database once projects are finalized. This will also allow for consistencies in the application of the adjustment. Furthermore, if the deemed savings values used are overestimating savings at larger gasket quantities, we recommend reviewing the assumptions that go into the calculation of the deemed savings values and adjusting accordingly the assumptions and inputs to fix the issue rather than making an adjustment to savings values in the database.
- **Small Industrial:** For small industrial projects that rely on MADs for estimating savings, we recommend including all project files used to develop savings estimates. These files should not include hardcoded numbers for savings results.
- **Small Industrial:** MAD 200 v2 states "steam systems must operate year-round, at all hours" but does not specify if allows for idling or turndown. The incentive application only has a field for "operates year-round". Cadmus recommends adding language to clarify year-round operation requirements.

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3 National Renewable Energy Laboratory (NREL; Gowans, Dakers). 2013. *Chapter 2: Commercial and Industrial Lighting Evaluation Protocol. The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. . NREL/SR-7A30-53827. https://www.energy.gov/sites/prod/files/2013/11/f5/53827-2.pdf

Strategic Energy Management

- The in-depth interviews with site contacts confirmed that the COVID-19 pandemic affected facilities participating in SEM in a variety of ways. Some of these impacts may be long-lasting, and many of the energy intensity models, as they stand now, could provide inaccurate forecasts of baseline energy consumption in future program years. We recommend reviewing the effects of COVID-19 at each facility to determine if projects require re-baselining and new energy intensity models once normal operations resume post pandemic.
- The Energy Trust SEM M&V Guidelines recommend sites use a 90-day or 12-month reporting period for claiming annual program savings. Energy Trust should consider formally testing how changes to the reporting period definition (months covered and length of the period) impacts the annual savings claimed for a variety of facility types. Savings rates may remain consistent across all 12 months for certain production sectors, but a formal investigation would provide guidance on which facilities may suffer from greater inaccuracies under this assumption. Additionally, Energy Trust should consider increasing the minimum reporting period length (90 days) for sites that have only monthly energy consumption observations.
- When higher-frequency energy consumption data, such as daily data, are available for building the energy intensity models, we recommend interacting production variables with indicators at known change points to reduce modeling error and improve observed nonlinearity between energy drivers and energy consumption. Change points should be driven by knowledge of the facility to avoid overfitting.
- In addition to the plots of model residuals over time and against fitted values, Energy Trust should require that projects provide plots of model residuals versus each independent variable included in the model. These plots will aid in verification of energy models and enable the evaluator to provide more specific recommendations to improve modeling.
- Energy Trust should work with implementers to improve and standardize documentation of any savings adjustments made due to capital projects occurring during baseline and engagement periods. Project workbooks or reports should clearly describe how any adjustments are made and show these calculations in one standardized location within these documents (preferably during the final savings calculation for capital projects occurring during the engagement period).
- When SEM facilities diverge from IPMVP Option C for claiming energy savings due to their SEM engagement and Energy Trust uses a bottom-up approach to estimate savings, we recommend improving the process by providing some additional detail on measures to more closely align with the approach used for custom projects. Providing more substantial supporting documentation such as trend data, photos, and specification sheets can help in determining energy savings of the measures.
- To assist with future qualitative assessments of SEM savings, we recommend requiring sites to include the expected energy savings generated from major SEM projects as part of the

opportunity register to increase the accuracy of realization rate adjustments based on these activities.

- We recommend Energy Trust add additional clarification to the *Energy Trust Industrial Impact Evaluation Policies* to address SEM facility closures. Energy Trust should treat each SEM facility closure on an individual basis and consider savings based on the measure list in the opportunity register. For instance, if the measures in the register are related to capital measures, then Energy Trust should follow a similar approach to how custom project facility closures are handled. However, if measures are predominantly behavioral, Cadmus recommends that these projects are addressed as measure removals considering the unlikelihood of behavioral measures saving energy if the facility resumes operation.

Other Recommendations

This section covers recommendations that apply to the overall program and not to a specific track. These recommendations focus on overarching opportunities to improve the program.

Metering Periods

We recommend the program use a minimum metering period of two weeks. Two weeks is typically enough to capture a full production cycle, but this is also dependent on the type of equipment, production schedule, seasonality, weather, and other factors. For example, HVAC systems may require longer intervals or multiple metering periods to characterize operation in the shoulder months. The PDCs should take these dependencies into consideration whenever metering.

Demand Savings Calculations

- **Develop Demand Methodology to Report Savings**

  The peak multiplier method currently employed by Energy Trust to estimate demand savings is not sufficiently rigorous to accurately account for demand impacts. Cadmus recommends that Energy Trust develop methods to report peak demand savings for each custom and prescriptive project in future program years. Utilities throughout the country have already performed extensive work to characterize peak demand savings estimates. We recommend that Energy Trust examine demand savings methods employed in technical reference manuals for comparable states and utilities. Energy Trust can use this information to begin developing a database of peak coincidence factors for prescriptive measures and identify more rigorous methods to calculate demand impacts from custom measures.

  The effort to characterize peak demand savings is made even more urgent by recent events—a record-breaking heat wave in June 2021 that resulted in heavy air conditioning loads on the electric grid as well as Oregon House Bill 2021 to decarbonize the electric grid by 2040. At the same time, there are local and national efforts to decarbonize transportation and space and water heating that will result in continued increases in electric demand. Reliable estimates of peak demand savings achieved through Energy Trust's programs will be critical to future integrated resource planning efforts.

Operations

- For Energy Trust projects with multiple program tracks, we recommend Energy Trust assign one PE number for each program track. For example, PE16768 had two measures: one in the custom capital track and another in the custom O&M track. Cadmus sampled at the project and track level, and in this case, sampled the measure associated with the custom O&M track. Cadmus evaluated the savings of the measure in the custom capital track as part of the convenience sample. Assigning one PE number for each program track will help distinguish between the savings associated with the two tracks, aiding with sampling at the track level and confidence and precision calculations.
- We recommend Energy Trust clearly specify program projects that are located on the same site by assigning unique site IDs for each site. In the 2020 program data, projects located at the same address did not always have the same site ID. In some cases, this resulted in contacting sites on different occasions for the impact evaluation. Assigning a clear and unique ID per site will allow Energy Trust to filter for all projects at a specific site and reduce the amount of outreach to sites with multiple projects.
- We recommend creating a protocol that addresses projects that do not receive an incentive but still claim savings if the measure was influenced by the PDC. In some cases, the PDC may be supporting a customer with the implementation of projects, through this process it is possible for the customer to identify projects that did not go through the incentive process but were still implemented. Energy Trust could potentially claim savings for these projects if they are within a defined protocol and meet Energy Trust's criteria (for example: PE16768).
- We recommend updating the *Energy Trust Industrial Impact Evaluation Policies* (see Appendix C) to include guidance on how to address facility closures where SEM and custom O&M measures are implemented. Since these projects generally include behavioral measures, facility closures can significantly impact lifetime measure savings and revert energy savings achieved through SEM programs, additional training, and maintenance. For SEM and more behavior-related custom O&M projects, we recommend the evaluator determine when the facility was shut down and prorate the savings relative to the measure lifetime.
- We recommend that Energy Trust develop guidelines for the PDCs to compile and save all relevant project files for Energy Trust and the evaluators to use during the evaluation process. For the 2020 PE impact evaluation, Cadmus experienced an uptick in data requests and coordination with Energy Trust due to incomplete project files, incorrect or out-of-date files, or proprietary analysis files. Energy Trust staff did a great job coordinating with the PDCs to request all relevant files for the evaluation and were able to satisfy all data requests in a timely manner. This was a significant effort on the part of Energy Trust staff to support these data requests and moving forward it will be helpful to create guidelines for the PDCs to review and provide relevant project files.

Memo

To: Board of Directors

From: Erika Kociolek, Sr. Data & Business Intelligence Analyst
Eric Braddock, Sr. Technical Manager – Industry and Agriculture

Date: April 4, 2022

Re: Staff Response to 2020 Production Efficiency Impact Evaluation

The 2020 Production Efficiency impact evaluation demonstrates the program generated substantial energy savings and accurately estimated the majority of these savings, as evidenced by high realization rates.

Similar to the 2018-2019 Production Efficiency impact evaluation, for the 2020 Production Efficiency impact evaluation, the majority of data collection was done virtually due to the COVID-19 pandemic, although a few on-site visits took place as restrictions eased in the latter part of 2021.

The evaluator made a large number of program track-specific recommendations, along with several overall recommendations. Energy Trust program staff reviewed the recommendations and responded to each one in detail. For the custom and custom O&M tracks, Energy Trust program staff adjusted the program guide for these tracks in response to the evaluator's recommendations. For the SEM track, Energy Trust program staff is developing a performance tracking tool platform (energy modeling software), which will be used starting in 2023. This energy modeling software will make it easier for the program to implement some of the evaluator's recommendations, including providing plots to aid in verification of energy models and standardizing documentation of any energy savings adjustments made due to capital projects. Two of the evaluator's recommendations apply to Energy Trust planning and evaluation staff. In 2019, Energy Trust program staff and evaluation staff (with input from evaluators) developed impact evaluation guidelines, which ensure consistency in how evaluators handle issues such as production changes, measure removal, facility closures, customer non-participation in impact evaluations, and broad social and economic changes such as the 2009 recession and the COVID-19 pandemic. The evaluator recommended some small changes to these impact evaluation guidelines. Energy Trust evaluation staff agrees with the suggested changes and plan to update the guidelines. In addition, the evaluator recommended Energy Trust develop more rigorous methods to estimate demand savings. Energy Trust planning staff agree with this recommendation, but note that using more rigorous methods would require a number of organizational process and system updates. For now, Energy Trust planning staff is continuing to use more straightforward methods to estimate demand savings given the complexity of the required updates.

Energy Trust will not conduct a 2021 Production Efficiency impact evaluation. The main driver of this decision is that Energy Trust's business planning process identified that the Energy Trust evaluation team was projected to exceed its estimated capacity for work in 2022. In response, Energy Trust evaluation staff proposed cutting several projects, including the 2021 Production Efficiency impact evaluation. Energy Trust evaluation staff believes it is reasonable to not conduct a 2021 Production Efficiency impact evaluation given the program design and program offerings for the 2021 program year are extremely similar to those in prior years, the program implementers have remained the same, all prior program years (with the exception of 2015) have been evaluated, and overall program realization rates have been high and relatively stable. Any large / complex Production Efficiency project recognized in 2021 will be evaluated as part of the ongoing large / complex project impact evaluation process.

Introduction

Energy Trust of Oregon (Energy Trust) retained Cadmus to complete an impact evaluation of the 2020 Production Efficiency (PE) program, which seeks to achieve energy savings in the industrial and agricultural sectors through capital, behavioral, and operations and management (O&M) measures.

2020 Program Savings

On behalf of Energy Trust, multiple program delivery contractors (PDC) implemented the 2020 PE program. The program includes the following offerings:

- Standard
- Business lighting
- Custom
- Strategic energy management

For the purposes of this impact evaluation, we used the following categories (program tracks) which is consistent with prior impact evaluations, and more closely aligns with how project and measure data is captured in Energy Trust systems:

- **Streamlined (prescriptive, small industrial, lighting, and green motor rewind):** This track focuses on simpler, more common equipment measures such as lighting, irrigation, small compressed air, variable frequency drives, and other prescriptive and calculated measures.
- **Custom (custom capital and custom O&M):** This track allows for a comprehensive approach to gas and electric process efficiency projects, retrofits, and O&M.
- **Strategic energy management (SEM):** This track provides training, tools, and technical support to enable customers to save energy by establishing or improving energy management practices in the workplace.

Eligible customers can participate in one, two, or all three program tracks. Table 8 summarizes the projects implemented through the PE program in 2020 by track. Cadmus sampled and verified 109 primary projects and five convenience projects.

We included projects in multiple strata as they generated both electricity and natural gas savings or included measures that belonged to multiple subtracks. To maintain sampling independence between fuel-type strata and subtracks, we included these projects in the sample frame as if they were distinct projects so they could be sampled separately. As a result, projects could be included in the sample for one fuel type or subtrack but not the other, included in the random sample for both fuel types and subtracks separately, or not included in the random sample for either fuel type or subtrack. This is discussed further in the *Sample Design* section.

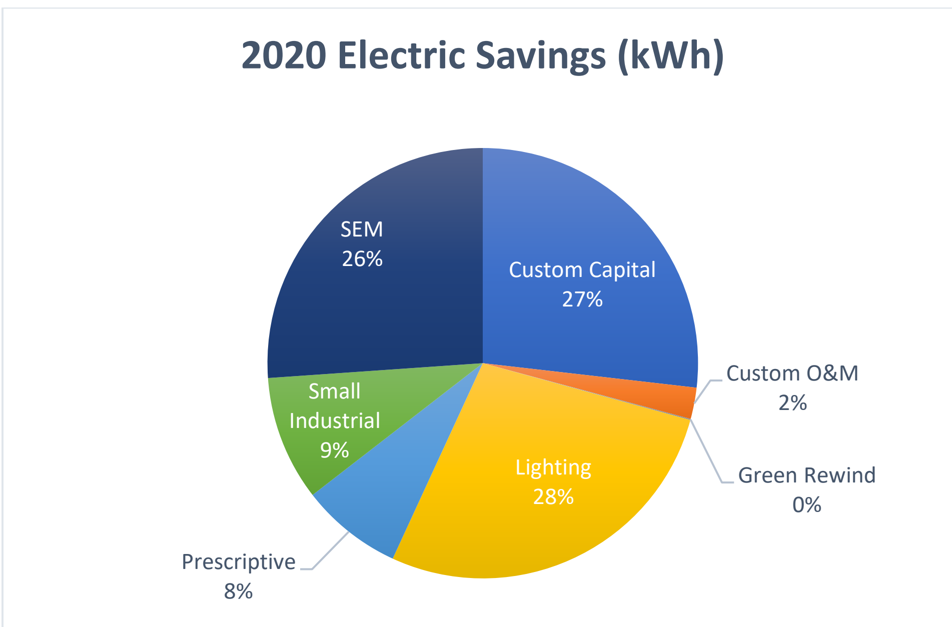
Table 8. Production Efficiency Program Completed Projects and Reported Savings, 2020

Program Year	Track	Subtrack	Sites[a]	Projects[a]	Measures[a]	Electricity Savings (kWh)	Gas Savings (therms)	Total Evaluated Projects[b]
2020	Custom	Custom Capital	64	119	161	34,489,403	512,643	30
		Custom O&M	15	25	30	3,025,849	1,492	12
	Custom Subtotal		79	144	191	37,515,252	514,135	42
	Streamlined Industrial	Green Rewind	17	29	31	111,666	-	6
		Lighting	342	458	1,366	35,504,469	-	15
		Prescriptive	305	401	860	9,825,086	463,493	22
		Small Industrial	203	246	244	12,077,187	72,757	16
	Streamlined Industrial Subtotal		867	1,134	2,501	57,518,408	536,250	59
	SEM	SEM	28	42	42	33,566,222.00	243,683	13
Total			**974**	**1,320**	**2,734**	**128,599,882**	**1,294,068**	**114**

[a] Sites, projects, and measures are defined as the number of unique site IDs, unique project IDs, and unique measure IDs per subtrack, respectively.
[b] Total sampled projects included 110 primary electricity and gas projects and four convenience projects, all of which were in Custom Capital track.

The custom capital, SEM, and lighting subtracks contributed the most electric savings in 2020 (27%, 26%, and 28%, respectively), as shown in Figure 1.

Figure 1. Production Efficiency Electric Savings by Subtrack, 2020



The custom capital and prescriptive subtracks collectively represented over 75% of natural gas savings in 2020, as shown in Figure 2.

Figure 2. Production Efficiency Gas Savings by Subtrack, 2020

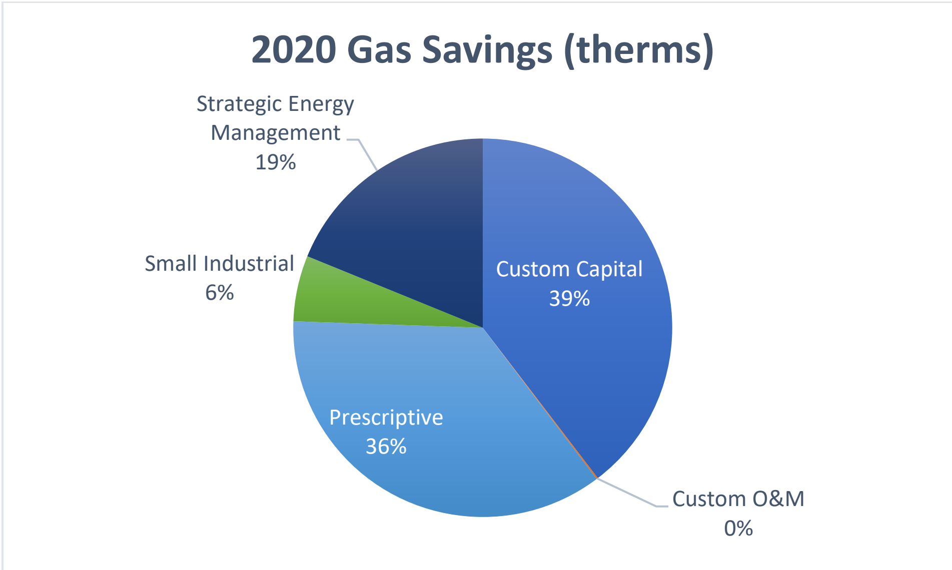


Figure 3 and Figure 4 show electric and gas program savings, respectively, for the 2020 program year. As shown in Figure 3, the majority of program electric savings in the 2020 program year were in the lighting subtrack, followed by the custom capital subtrack.

Figure 3. Production Efficiency Electric Savings by Subtrack, 2020

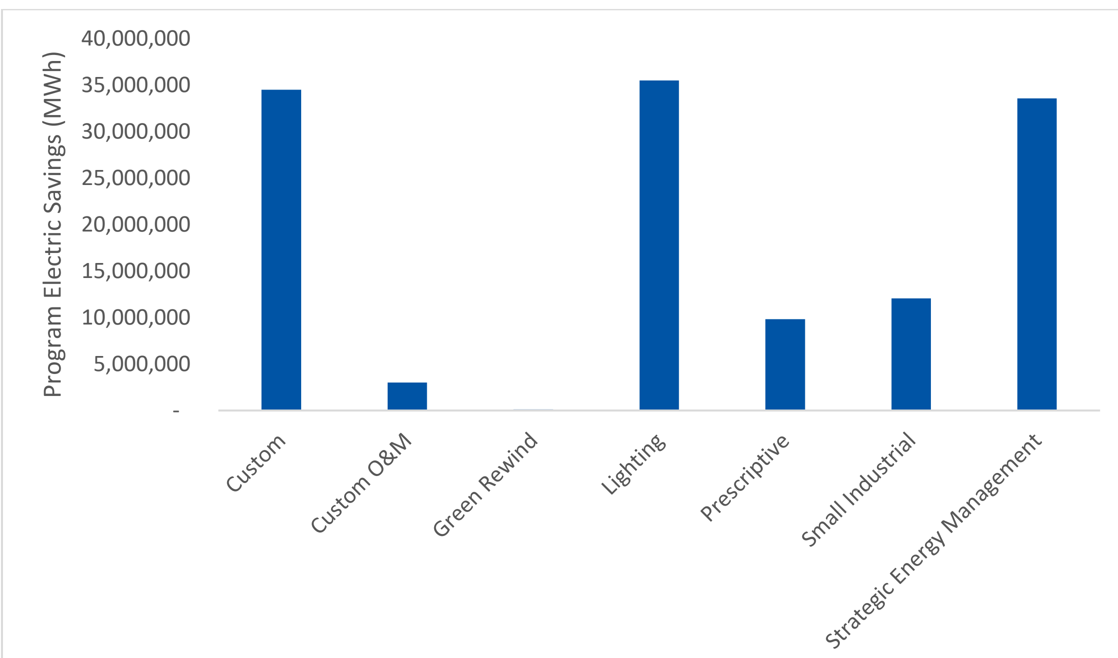
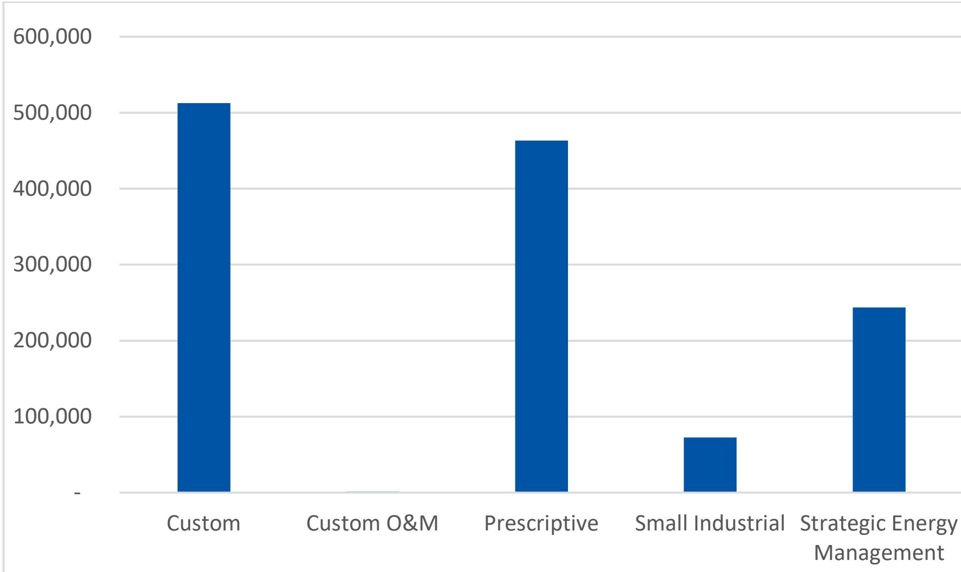


Figure 4. Production Efficiency Gas Savings by Subtrack, 2020



Report Organization

The remainder of this report is organized into the following sections:

- **Impact Evaluation Overview:** This section provides the impact evaluation objectives, methodology (including sampling), and analysis.
- **Impact Evaluation Results, Findings, and Recommendations:** This section provides the realization rates, types of impact evaluation adjustments made (categorized adjustments), findings and recommendations for each subtrack, and an assessment of the recommendations made in the 2018-2019 PE impact evaluation. Note that the 2018-2019 impact evaluation was not completed until after the 2020 program year; therefore, recommendations from the 2018-2019 impact evaluation report were not available for action by PE program staff or the PDCs in the 2020 program year.
- **Appendices:** The appendices provide supporting information for this impact evaluation.

Impact Evaluation Overview

Evaluation Goals and Key Research Objectives

Cadmus' evaluation goals for the PE program included the following:

- Develop reliable estimates of the gross electricity and natural gas savings directly attributable to each program track. For both fuel types, estimates will achieve a statistical level of at least 90% confidence and ±10% precision through a stratified sampling of the population of 2020 projects, and we will extrapolate the results by major measure category.
- Estimate electricity demand reduction at the measure level and for the program overall.
- Report observations and make recommendations to help Energy Trust improve the effectiveness of its estimates of energy savings and demand reduction.

In addition to these objectives, Cadmus collected data and reviewed project files to provide feedback on the following:

- Appropriateness of energy savings analysis by the trade allies, Program Delivery Contractors, and SEM implementers.
- Errors in any of the assumptions used in energy savings analyses, either in the original savings estimates or in verification of energy savings.
- Factors that result in large variances in measure savings (e.g., assumptions too conservative, incorrect hours of operation).
- Recommendations regarding energy savings analysis approaches and assumptions or customer behavior or decision-making that would be helpful to Energy Trust in designing, implementing, and evaluating its programs in the future.

Impact Evaluation Methodology

To verify reported program participation and to estimate gross energy savings in the impact evaluation, Cadmus estimated changes in gross energy consumption using data collected through phone verification, virtual site visits, program tracking data, and engineering calculation models. We used the following approaches to determine gross energy savings attributable to the program:

- Sample development
- Data collection
- Engineering analysis

Cadmus calculated savings based on changes between baseline and installed efficiency measures, using program tracking data and assessing the assumptions and accuracy in the calculations. We shared with Energy Trust site-level savings for review and approval before initiating program-level analysis and incorporated staff feedback into these results. Once Energy Trust reviewed and approved the savings, we estimated total program-level savings using a savings-weighted extrapolation process. Energy Trust has provided the peak-period definition to estimate electricity demand savings based on the total electric savings, as well as load coincidence factors (at the measure end-use level), which we used to calculate demand savings

Evaluation Sample

Energy Trust staff provided 2020 population data for sample development. We developed a summary of the population savings from values reported in the program tracking system and sampled savings, as shown in Table 9. The sampled savings resulted from those projects sampled for the impact evaluation. Sampled electricity savings represented 35% of the total program electricity savings in 2020. Sampled gas savings represented 77% of total program gas savings for 2020.

Table 9. Program and Sampled Savings by Program Track, 2020

Program Year	Track	Subtrack	Electricity			
			Program Savings (kWh)	Sampled Savings (kWh)	Convenience Savings (kWh)	Percent Evaluated (kWh)
2020	**Custom**	Custom Capital	34,489,403	13,913,249	96,996	40%
		Custom O&M	3,025,849	1,959,202	-	65%
	Custom Subtotal		37,515,252	15,872,451	96,996	42%
	Streamlined Industrial	Green Rewind	111,666	49,848	-	45%
		Lighting	35,504,469	8,350,212	-	24%
		Prescriptive	9,825,086	1,249,461	250	13%
		Small Industrial	12,077,187	2,157,608	-	18%
	Streamlined Industrial Subtotal		57,518,408	11,807,129	250	21%
	SEM	SEM	33,566,222	16,740,820	-	50%
	Total		**128,599,882**	**44,420,400**	**97,246**	**35%**
	Track	**Subtrack**	**Natural Gas**			
			Program Savings (therms)	**Sample Savings (therms)**	**Convenience Savings (therms)**	**Percent Evaluated (therms)**
	Custom	Custom Capital	512,643	394,947	559	77%
		Custom O&M	1,492	1,492	-	100%
	Custom Subtotal		514,135	396,439	559	77%
	Streamlined Industrial	Prescriptive	463,493	304,316	-	66%
		Small Industrial	72,757	52,942	-	73%
	Streamlined Industrial Subtotal		536,250	357,258	-	67%
	SEM	SEM	243,683	242,697	-	100%
	Total		**1,294,068**	**996,394**	**559**	**77%**

Sample Design

For the 2020 program year, Cadmus estimated the total program electricity and natural gas savings with 90% confidence and ±10% precision. We based these estimates on a representative sample of the project population, stratified by fuel type, and track (custom, streamlined, and SEM), as well as track substratification to target custom capital and custom O&M projects for more robust evaluation, which were of particular interest to Energy Trust.

Cadmus sampled projects using probability proportional to size within each stratum and then evaluated these sampled projects using a combination of engineering desk reviews, interviews, virtual, and on-site M&V. We sampled sites with probabilities proportional to the reported electricity and natural gas savings associated with each project, where projects with larger reported savings had a higher probability of being sampled. This sampling method led to efficient samples and population estimates and provided an effective alternative to using a certainty stratum (which can lead to incomplete evaluations of certainty strata and subsequent complications with weighting and estimation). For the evaluation, Cadmus allocated resources to strata and substrata with respect to evaluation rigor requirements so that fewer sample points were needed to evaluate strata with lower rigor requirements and larger sample sizes were used to evaluate strata and substrata with higher rigor requirements.

Cadmus determined the evaluation methodology within tracks based on the rigor requirements for each sampled project. We primarily relied on desk reviews for projects where historical data provided robust estimates that had not changed over time (such as lighting and green motor rewind projects) and for projects where interviews provided robust data for evaluation purposes (such as certain types of O&M projects). We conducted virtual and on-site visits for projects requiring direct observation of measures and equipment to determine the persistence of SEM activities (such as SEM projects with capital measures installed during the same period as the SEM engagement).

Table 10 provides the targeted and achieved confidence and precision around gas and electricity savings. Based on our experience, we estimated the expected coefficients of variation within each stratum and used these to determine the target number of completed projects. The achieved precision was generally lower (more precise) than our expected target.

Table 10. Achieved Levels of Confidence and Precision by Program Track

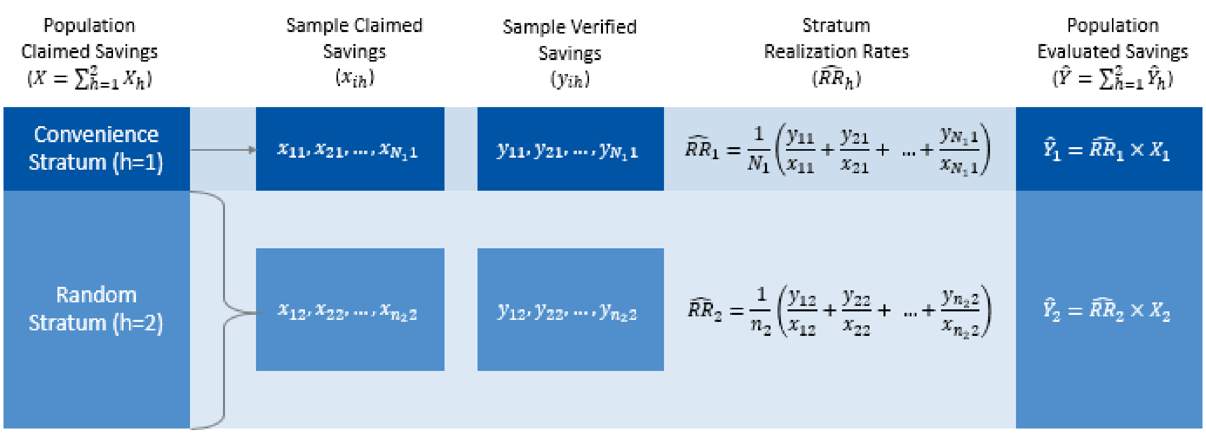
Track	Subtrack	Target Precision (90% Confidence Level)	Achieved Precision (90% Confidence Level)	
			Electricity	Natural Gas
			2020	2020
Custom	Custom Capital	±20%	5.6%	10.7%
Custom	Custom O&M	±20%	3.7%	0.0%
Custom	Total	±20%	5.0%	10.6%
SEM	SEM	±20%	1.9%	N/A
SEM	Total	±20%	1.9%	N/A
Streamlined Industrial	Green Rewind	±20%	29.0%	N/A
Streamlined Industrial	Lighting	±20%	7.1%	N/A
Streamlined Industrial	Prescriptive	±20%	0.0%	6.6%
Streamlined Industrial	Small Industrial	±20%	0.0%	8.4%
Streamlined Industrial	Total	±20%	4.1%	5.5%
Total	**Total**	**±10%**	**2.3%**	**4.3%**

We included some projects in multiple strata as they generated both electricity and natural gas savings. To maintain the sampling independence between fuel-type strata, we included dual-fuel projects in both strata as if they were distinct projects so they could be sampled separately. As a result, projects could be included in the random sample for one fuel type but not the other, included in the random sample for both fuel types separately, or not included in the random sample for either fuel type.

If a project was included in any random sample, we verified savings for both fuel types. However, because of the stratified random sampling approach, we only assumed that the sampled project represented all projects in the fuel-type strata from which it was actually selected in the random sample. For example, evaluated gas savings of a dual-fuel project sampled for electricity will not necessarily represent other gas savings if it was not selected as part of the gas random sample. In this situation, we called the project a primary sampled project in the electricity stratum and a convenience sampled project in the gas stratum.

Figure 5 depicts how Cadmus calculated realization rates and evaluated population claimed savings in this scenario. We divided each fuel-type and project track substratum into two additional substrata: one comprised convenience projects and the other comprised all randomly sampled projects (primary and remaining non-convenience, non-sampled projects). Within these substrata, we calculated sample realization rates ($\widehat{RR}_h$) and population evaluation savings ($\hat{Y}_h$). Savings from convenience projects did not impact the realization rates for non-convenience sampled projects; they do contribute to the subtrack- and population-level savings.

Figure 5. Realization Rate Calculations for Convenience and Randomly Sampled Projects



Review Project Files

Cadmus reviewed the available documentation (e.g., verification reports, analysis workbooks, monitoring, reporting, and tracking workbooks) for the sampled projects, paying attention to the calculation procedures and documentation for savings estimates. The methods applied for documentation review varied according to whether the project involved a capital measure or an SEM engagement. For any missing project files and calculation models, Cadmus worked with Energy Trust and the PDCs to collect these. Cadmus kept a running list of data requests that it shared with Energy

Trust on a weekly basis. Due to the effects of the COVID-19 pandemic and the shift to doing more desk reviews and virtual site visits, acquiring all available files to support the analysis was critical and Energy Trust and the PDCs were extremely supportive with our requests.

Streamlined Industrial

Cadmus reviewed all project files, analysis workbooks, and MAD's documentation to verify energy savings estimates. Our review generally included the following:

- Project checklist
- Incentive application
- Measure calculator
- Invoices and receipts
- Additional documentation such as emails, summaries, calculations, equipment spec sheets, etc.
- Any applicable MADs

Custom

To the extent possible, Cadmus reviewed analyses originally used to calculate reported savings and operating parameters. We reviewed all technical analysis study (TAS) and verification reports and analysis. Cadmus worked with Energy Trust and the PDCs to acquire any missing documentation. This was especially important due to the shift to virtual site visits where additional emphasis was placed on the file reviews and existing baseline and installed data.

To evaluate each sampled project, we began by reviewing relevant documentation and other program materials from Energy Trust, and the PDCs. Cadmus reviewed information including program application forms, the tracking database extract, and project reports for each program measure (if applicable). We examined each project file for the following information:

- Documentation on equipment installed or O&M measures performed
  - Descriptions
  - Schematics
  - Performance data
  - Other supporting information
- Information about savings calculation methodologies
  - Methodologies used
  - Assumption on specifications and the sources for these specifications

SEM

For each sampled SEM project, Energy Trust provided the energy intensity model workbooks and final annual savings reports for the energy savings evaluation. Cadmus reviewed the annual savings reports and engineering calculations used to estimate SEM savings for errors and reasonableness to qualitatively assess the energy models and savings calculations using the following rubric:

- Check for errors in modeling methods
  - Missing capital measures
  - Incorrect accounting of capital measure savings
  - Incorrect accounting for other factors affecting energy use
  - Unexplained data excluded from regression model
  - Major energy drivers excluded from regression model
  - Failed goodness-of-fit criteria
- Check for trends in baseline model residuals based on data in annual savings report and models
  - Residuals equal the difference between actual metered energy and predicted energy use for the baseline regression model
  - A trend in residuals against fitted values or over time indicates that the model systematically underpredicts or overpredicts energy consumption and savings and suggests than an important energy driver has been omitted from the model
- Examine time period dates
  - Baseline and reporting periods are distinct
  - Baseline and reporting periods are the standard length of either 12 months or three months, and those different than the standard are explained and justified
- Check savings calculations
  - Reporting period savings annualization errors

Develop Site Investigation Plans (Site-Specific M&V Plans)

For all custom and SEM track projects, Cadmus developed a site-specific M&V plan to outline the data and information to be gathered. We also identified critical parameters to be monitored or verified, such as measures and operating conditions with significant impact on savings and those with a high level of uncertainty.

Site-Specific Evaluation Plan Development for Custom Projects

Cadmus engineers developed comprehensive evaluation plans for each custom project using guidelines outlined in the International Performance Measurement and Verification Protocol (IPMVP). This technique allowed us to develop evaluation plans that conform to Energy Trust protocols and to each project's unique needs. Upon completing the evaluation plans, Cadmus provided a draft to Energy Trust technical staff for review and further discussion.

The evaluation plan followed a three-part format:

- **Project summary**. The summary provided an overview of the facility and the efficiency measures implemented through the project.
- **Savings analysis methodology**. This section outlined the methods and assumptions the PDC employed to estimate energy savings.
- **M&V methodology**. This section provided several details:
  - The M&V methodology Cadmus proposed (whether IPMVP options or other M&V guidelines)
  - A complete list of parameters for collection or monitoring on the site
  - The monitoring duration and frequency.
  - Data logging equipment (quantities and type) for use during monitoring (if applicable) and the site-specific sampling plan, if required

Site-Specific Evaluation Plan Development for SEM Projects

After reviewing the opportunity register and the annual savings report associated with each sampled SEM project, Cadmus developed site-specific evaluation plans that included the following:

- Basic information about the facility, such as the baseline, engagement, reporting period dates, and claimed energy savings
- Details of the methodology used to claim energy savings at each site (IPMVP Option C or a bottom-up engineering approach)
- A list of the major projects completed at the site that were verified during the in-depth interview
- An outline of the major verification activities required for the site, which typically included a file review, interview with the site contact, model review and savings analysis, and a bottom-up savings analysis when necessary

Conduct Facility Operator Interviews and Site Visits

To achieve Energy Trust's impact evaluation objectives, Cadmus deployed a range of methods and tools and adopted a consistent, integrated, and transparent approach to collecting primary program and participant data. We sought participant data for three primary reasons:

- To perform rigorous investigations during our site visits
- To fully explain discrepancies between expected and evaluated impacts
- To provide insights that help Energy Trust improve *ex ante* estimates

Cadmus scheduled all interviews and virtual and on-site visits in coordination with the PDCs and Energy Trust, in accordance with the customer recruitment and communications plan. We clearly relayed our expectations for interviews and virtual and on-site visits by providing day-of-visit timelines to each participant, as well as an overview of the project and M&V plans for review ahead of the interview or visit. We adjusted our schedules as needed to accommodate participants' schedules and were considerate of availability, especially considering the ongoing COVID-19 pandemic.

Conducting Customer Interviews

Non-SEM Participant Interviews

Cadmus completed interviews for all custom capital, custom O&M, and SEM sites, as well as several streamlined industrial sites where we determined interviews would be useful to the evaluation. Additional emphasis was placed on interviews during this evaluation cycle due to the ongoing COVID-19 pandemic and the lack of access to facilities. The purpose of the customer interviews was to confirm several factors:

- Installation and functionality of all equipment
- Current occupancy or facility use
- Adjustments in control schemes
- Other items significantly impacting energy consumption

The interviews helped to further verify the accuracy of assumptions relating to energy-savings calculations and to recalculate savings, as needed. Cadmus interviewed staff at each sampled site, including facility operators, energy team members, and energy champions. The interview guide Cadmus used during interviews is included as *Appendix B. Customer Interview Guides*. We supplemented information in the interview guides with project-specific information and project-specific M&V plans. For projects not warranting a virtual visit, Cadmus conducted the interviews via phone.

Strategic Energy Management Participant Interviews

Cadmus updated the most recent SEM participant interview guide (developed for the 2018-2019 PE impact evaluation) according to Energy Trust's objectives for the evaluation. Cadmus gathered the following information about each site's engagement with the SEM program through participant interviews:

- The site contact's role at the facility and with the SEM engagement
- Challenges with implementing SEM and changes in their engagements
- Descriptions of the energy champion, energy champion, and executive sponsor roles
- The facility's energy policies or goals
- The extent to which the facility used energy management tools such as the energy management assessment, energy map, and opportunity register
- Employee engagement activities
- The energy intensity model developed for the facility
- The plan for future SEM engagement or changes to tracking energy use
- Facility operations since the SEM engagement

Cadmus used the interview responses to confirm that major projects listed in the annual savings reports were completed and remained operational, verify specific inputs to bottom-up savings calculations (when necessary), and gauge qualitatively whether the energy intensity models produced sensible results given the facility operations.

Before conducting the interviews, Cadmus thoroughly reviewed project files and regression models to ensure that the interviews covered the relevant SEM activities and facility information specific to each site and required for the qualitative evaluation. Cadmus engineers and evaluators with SEM expertise conducted the SEM participant interviews.

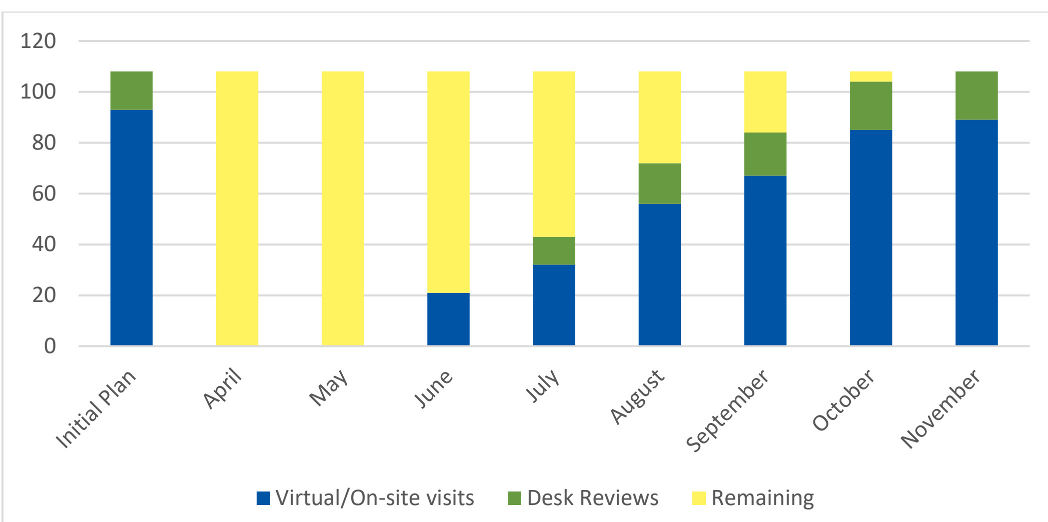
Cadmus provided participants with interview questions ahead of time, giving them adequate time to prepare for the interview. Participants for the most part found this option amenable, given their busy schedules and the ongoing COVID-19 pandemic. Each completed interview required significant recruiting and explanation to engage participants and to provide them with information. Cadmus coordinated the initial outreach via the PDCs and begun scheduling outreach after all sites were initially contacted and informed. This approach shortened the interview times and decreased costs associated with recruitment and interviews.

Conducting Desk Reviews, Virtual and On-Site Visits

Cadmus originally planned to conduct 15 desk reviews (that included customer interviews) and interviews and 93 virtual and on-site visits for the 2020 evaluation year. Cadmus completed 19 desk reviews and interviews and 89 virtual and on-site visits. A few projects were shifted from a virtual or site visit to a desk review due to considerations for customer preference and availability, and in one case, a facility closure.

Figure 6 shows the monthly progression of M&V activities throughout the duration of the evaluation period (2021) and the distribution of desk reviews and virtual and on-site visits.

Figure 6. Verification Methods Selection



For desk reviews, Cadmus primarily relied on historical data, as well as workbooks, invoices, and other project files provided by Energy Trust, to verify savings. We conducted virtual and on-site visits for projects requiring direct observation of measures and equipment and projects that required additional data collection and verification.

To successfully complete the virtual site visits, Cadmus developed and followed guidelines for site visits and site selection for the 2018-2019 PE impact evaluation. These guidelines are documented in a memo included in *Appendix D. Virtual Site Visit Memorandum.*

When scheduling a virtual or on-site visit, we sent customers an introduction letter (included in *Appendix A. Customer Introduction Letter*) as well as a data collection checklist specific to the measure of interest.

Impact Analysis

Across the three tracks, Cadmus verified evaluation methods ranging from simple verifications to statistical regression analyses. We used straightforward, well understood M&V analysis methods that are based on verifiable inputs and—most importantly—that align with methods that utility program staff and the PDCs use during program planning and project development.

The impact analysis included multiple components:

- Site-level savings, realization rates, and descriptions of adjusted parameters, along with rationales for adjustments
- Program, stratum, and measure categories
- Savings and realization rates
- Observations and recommendations for program improvements

Streamlined Industrial and Custom Projects

Cadmus completed site-level analyses, as outlined in the approved site-specific evaluation plans. For each project, we determined evaluated savings by means of simple verification, engineering calculation models, metering analysis, and utility billing analysis. We used a mix of provided analysis files, along with our library of tools and custom spreadsheets, to determine appropriate savings. For streamlined industrial projects, we followed the appropriate MADs provided by Energy Trust.

Cadmus verified savings for each project and calculated a corresponding realization rate. We developed a realization rate summary that covered all streamlined projects with variances and provided commentary on the reasons for adjustments. We reviewed and discussed these with Energy Trust. As needed, we discussed specific projects with larger variations (generally above ±10% variance) with Energy Trust and the PDCs. We requested additional data and project files to support the evaluation and worked with the PDCs where appropriate to achieve consensus on the evaluated savings results. This helped to ensure alignment on any program issues and reduce iterations on the evaluation reports.

Strategic Energy Management Analysis

Cadmus reviewed the project files and interviewed the site contacts to verify savings at each site. We did not build independent baseline models, but qualitatively verified energy savings by confirming that baseline, engagement, and reporting period definitions met Energy Trust's requirements. Cadmus also confirmed that the site implemented the major projects included in the opportunity register, reviewed the energy savings reported model specification, assessed whether capital projects were appropriately prorated and deducted from SEM, and verified that reporting period savings were correctly annualized.

Cadmus directly calculated realization rates when we found computational errors in the capital project savings or annualization of reporting period savings. However, when our qualitative review found problems with other components of the SEM engagement, we assigned realization rates of 90% or 110% depending on whether these problems likely resulted in overestimated or underestimated energy savings. When we did not find any problems, or if the problems were likely to have small or negligible impacts on energy savings, or if we could not determine how savings might be impacted, we assigned a realization rate of 100%. Cadmus assumed that the claimed savings were adequate by default and assigned non-100% realization rates only with sufficient evidence against that assumption.

As part of the in-depth interviews with site contacts, Cadmus verified whether the major projects listed in the annual savings report that contributed to the SEM savings were implemented and remained operational. We did not estimate savings for the major projects completed at sites that claimed savings using an energy intensity model following IPMVP Option C. However, if the site contact indicated that a major project contributing to SEM savings was dismantled after the reporting period, we applied our engineering expertise to gauge whether the relative size of the project would significantly impact overall savings. Cadmus assigned a 90% realization rate to the claimed savings in cases where it could.

When sites claimed savings using a bottom-up approach we verified savings by documenting the major SEM projects included in the impact analysis and the specific inputs gathered during the interviews and virtual visits to conduct a rigorous analysis of claimed savings. Savings analysis of bottom-up projects follows a similar methodology to custom projects. This includes the review of baseline, engagement, and reporting period requirements, as well as project status similarly to modelled SEM projects. We also confirmed the status of all major projects included in the opportunity register, reviewed the energy savings reported, assessed whether capital projects were appropriately prorated and deducted from any relevant bottom-up SEM savings, and verified that the measures defined in the bottom-up calculation were still operational and implemented.

Demand Savings Analysis

Energy Trust does not currently report demand savings for individual measures, projects, or programs. For the impact evaluation, Cadmus calculated summer and winter peak demand savings using prescriptive peak multiplier factors provided by Energy Trust. These factors were based on regional load profiles for sectors, building types, and end uses, adjusted for the expectation of peak demand. Energy Trust calculated the summer and winter peak factors for each load profile as shown in the calculation below:

$$PeakMultiplier = \frac{Coincidence\ Factor}{8{,}760\ hours\ x\ Load\ Factor}$$

Energy Trust calculated the summer and winter coincidence factors as the weighted average load during the respective peak periods as defined by Portland General Electric (PGE) and Pacific Power with 60% and 40% weights, respectively:

- PGE Summer: August, 12:00–22:00
- PGE Winter: December and January, 06:00–12:00 and 16:00–22:00
- Pacific Power Summer: August, 14:00–21:00
- Pacific Power Winter: December and January, 07:00–09:00 and 18:00–20:00

Cadmus reviewed the electric load profile assigned to each measure and site to ensure it appropriately reflected the expected hours of operation for that measure and was consistent with similar measures. We updated the profiles where necessary. We then multiplied each measure's evaluated energy savings by the peak multiplier (based on the assigned load profile) to calculate summer and winter peak demand savings for each measure. After calculating the demand savings for each measure, we combined the measure-specific peak demand savings in various combinations to determine the total peak demand savings by building type, track, and measure for each program year.

Impact Evaluation Results and Findings

This section presents track-level realization rates and provides discussion on the types of impact evaluation adjustments Cadmus made (categorized adjustments), as well as findings. The section also includes general observations regarding discrepancies and other factors influencing measure-level realization rates. Cadmus used the site measure ID for each facility to maintain participant anonymity.

Realization Rates

As shown in Table 11, electric realization rates for the 2020 program overall were 98%. Gas realization rates for the 2020 program overall were 97%.

Table 11. Production Efficiency Program Realization Rate by Fuel Type

Fuel Type	2020			
	Reported Savings	Evaluated Savings	Realization Rate	Relative Precision[a]
Electricity (kWh)	128,599,882	126,240,680	98%	2.3%
Natural Gas (therms)	1,294,068	1,251,440	97%	4.3%

[a] Relative precision is calculated at the 90% confidence level.

Table 12 and Table 13 provide a summary of the realization rates by track and subtrack for each year evaluated and overall. Explanations for what led to each realization rate are provided in the following specific program track and subtrack subsections.

Table 12. Electric Realization Rates by Track and Subtrack

Track	Subtrack	Electricity			
		Reported (kWh)	Evaluated (kWh)	Realization Rate	Relative Precision [a]
Custom	Custom Capital	34,489,403	33,967,834	98%	5.6%
	Custom O&M	3,025,849	3,033,229	100%	3.7%
	Total	37,515,252	37,001,063	99%	5.0%
SEM	SEM	33,566,222	33,540,410	100%	1.9%
	Total	33,566,222	33,540,410	100%	1.9%
Streamlined Industrial	Green Rewind	111,666	96,142	86%	29.0%
	Lighting	35,504,469	33,700,793	95%	7.1%
	Prescriptive	9,825,086	9,825,084	100%	0.0%
	Small Industrial	12,077,187	12,077,187	100%	0.0%
	Total	57,518,408	55,699,207	97%	4.1%
Total		**128,599,882**	**126,240,680**	**98%**	**2.3%**

[a] Relative precision is calculated at the 90% confidence level.

Table 13. Gas Realization Rates by Track and Subtrack

Track	Subtrack	Natural Gas			
		Reported (therms)	Evaluated (therms)	Realization Rate	Relative Precision[a]
Custom	Custom Capital	512,643	454,386	89%	10.7%
	Custom O&M	1,492	173	12%	0.0%
	Total	514,135	454,559	88%	10.6%
Streamlined Industrial	SEM	243,683	268,052	110%	N/A
	Total	243,683	268,052	110%	N/A
	Prescriptive	463,493	445,157	96%	6.6%
	Small Industrial	72,757	83,672	115%	8.4%
	Total	536,250	528,829	99%	5.5%
Total		**1,294,068**	**1,251,440**	**97%**	**4.3%**

[a] Relative precision is calculated at the 90% confidence level.

Overall, the program achieved high realization rates for electric and gas savings. The primary reason for the lower custom O&M gas realization rate was one project that used incorrect hours of use assumptions and an incorrect assumption around boiler firing rates. Custom capital gas savings achieved a lower realization rate relative to other tracks due to adjustments made to a few projects, which are discussed further in the sections below.

Table 14 shows the realization rates for the PE program by fuel type for program years 2016 through 2020. Both electricity and natural gas fuel types for the 2020 program achieved a slightly lower realization rate than in 2019. Reasons for the lower realization rates are discussed in the corresponding sections.

Table 14. Production Efficiency Program Realization Rates for 2016 through 2020 by Fuel Type

Fuel Type	2016	2017	2018	2019	2020
Electricity	86%	90%	101%	101%	98%
Natural Gas	98%	94%	78%	104%	97%

Categorized Adjustments

To better understand why projects are adjusted, Cadmus categorized each adjustment at the project level into one of the following categories:

- **Different operating hours:** Equipment operating hours differed from what was specified in the *ex ante* savings calculations.
- **Different equipment setpoints:** Different equipment setpoints from those used in the *ex ante* savings calculations. This included different temperature and pressure setpoints.
- **Incorrect equipment specifications or quantities:** This included incorrect equipment capacity, wattage, efficiency, and quantity.
- **Incorrect/different analysis methodology:** We used a different analysis methodology from the *ex ante* savings such as using EMS trend data to build a new regression analysis, normalizing

baseline and installed periods, applying a day type methodology to air compressors, or using a different Measure Approval Document (MAD) to calculate savings.

- **Measure removal:** This involved the removal of a measure at a closed or operational facility.
- **Inappropriate baseline:** This involved baseline equipment specifications that did not align with code or industry standard practice.
- **Inappropriate assumption:** Any assumed values or conditions that were used in the calculation of baseline or measure savings. This included cooling and heating efficiencies, fan affinity exponents, and theoretical performance values.
- **Calculation or engineering error:** Situations where values in the *ex ante* savings calculation workbook, invoices, or verification report did not match values used in the analysis; this included spreadsheet formula errors or hard coded values that were not updated.
- **SEM adjustment:** Some SEM projects had adjustments to savings due to observations during the site visits, interviews or during the review of the energy intensity models.

Where multiple categories applied to one project, Cadmus assigned the project to the single category that had the greatest impact on its realization rate.

Table 15 summarizes the number of categorized adjustments by fuel type and by year.

Table 15. Production Efficiency Program Savings Adjustment Category Summary

Electric Savings Adjustments	2020 (n=xyz)[a]	Absolute Adjusted Savings (kWh)	% of Savings Adjusted (Category Adjusted Savings/Total Adjusted Savings)
Different operating hours	11	527,222	26.7%
Different equipment setpoints	7	57,963	2.9%
Incorrect equipment specifications or quantities	6	189,507	9.6%
Incorrect/different analysis methodology	3	129,066	6.5%
Measure removal	1	37,641	1.9%
Inappropriate baseline	1	83,871	4.3%
Inappropriate assumption	4	612,667	31.1%
Calculation or engineering error	2	182,338	9.2%
SEM adjustment	3	151,503	7.7%
Total	**38**	**1,971,778**	**100%**
Gas Savings Adjustments	**2020 (n=xyz)**	**Absolute Adjusted Savings (therms)**	**% of Savings Adjusted (Category Adjusted Savings/Total Adjusted Savings)**
Different operating hours	2	1,584	2.2%
Different equipment setpoints	4	24,528	34.2%
Incorrect equipment specifications or quantities	1	1,200	1.7%
Incorrect/different analysis methodology	1	8,882	12.4%
Inappropriate assumption	6	9,827	13.7%
Calculation or engineering error	1	1,346	1.9%
SEM adjustment	1	24,270	33.9%
Total	**16**	**71,637**	**100%**

[a] n reflects the number of unique of project IDs evaluated for each year and fuel type. Only one adjustment category was assigned per project; if multiple categories applied to one project, the project was assigned to the category with the largest impact on the realization rate.

[b] The absolute value of adjusted savings are cumulatively shown to demonstrate positive and negative impacts.

Figure 7 and Figure 8 illustrate the cumulative energy savings adjustments for each adjustment category. Inappropriate assumptions was the number one issue found for electric projects and produced the largest adjustments to the estimated savings. On the gas side, different equipment setpoints cumulated to be the largest adjustment to estimated savings.

Figure 7. Production Efficiency Electric Savings Impact Evaluation Adjustments

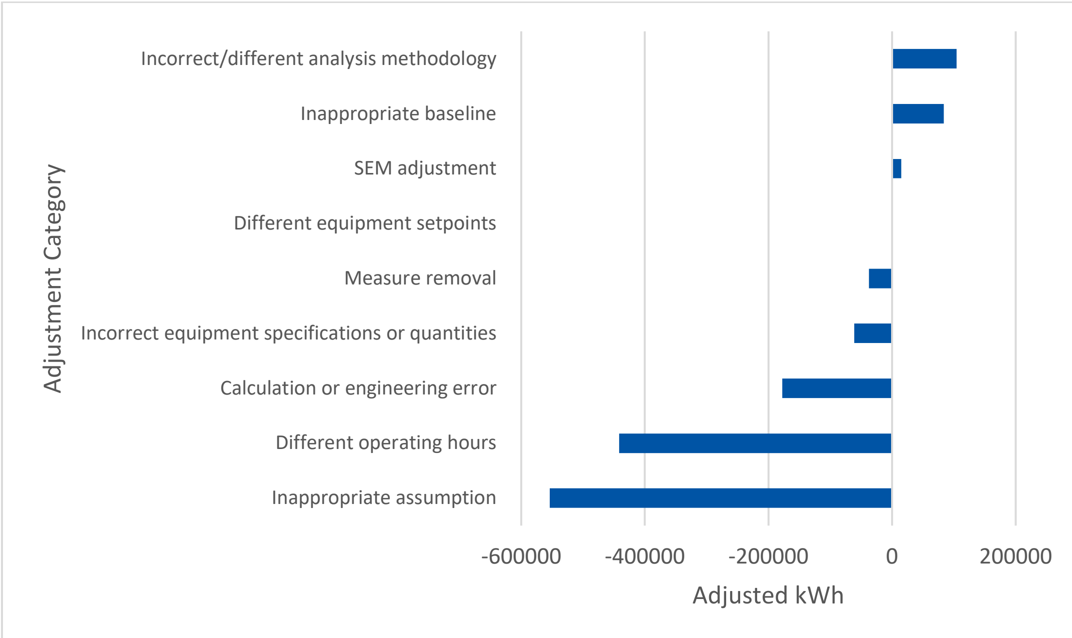
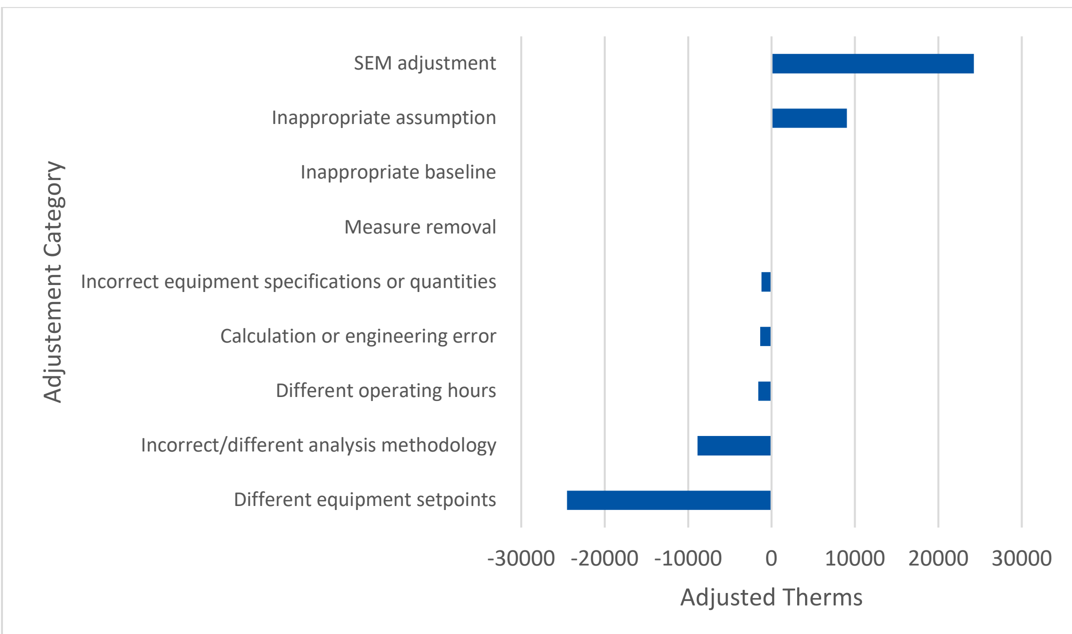


Figure 8. Production Efficiency Gas Savings Cumulative Impact Evaluation Adjustments



Custom Capital Projects

Custom capital projects represented the most complex projects (and those reporting the largest energy savings). These included a range of measures, from regenerative thermal oxidizers to industrial refrigeration system upgrades. Cadmus evaluated 30 custom capital projects, of which 26 were primary projects and four were convenience projects. For each custom project, we performed a virtual or on-site visit or interview to verify correct installations of equipment rebated through the program and to confirm quantities and operating characteristics. In many cases, we also obtained EMS trend data on critical operational parameters or used existing power meter or trend data. This allowed us to determine if the initial analysis approach proved reasonable, and, if necessary, to apply a revised calculation approach. For projects with provided analysis workbooks, Cadmus adjusted calculations to update operating parameters confirmed through site visits and interviews with facility operations staff. For each custom capital project, we also developed evaluation reports highlighting findings, assumptions, and analysis methodology.

Custom capital projects included a variety of subcategories based on the following measure types:

- Air abatement
- Compressed air
- Fan
- Heat recovery
- HVAC
- Irrigation
- Motors
- Primary process
- Secondary process
- Pumping
- Refrigeration
- Wastewater

Findings

Table 16 lists the custom capital realization rates by year and combined.

Table 16. Custom Capital Realization Rates Summary for 2020

Fuel Type	2020	
	Realization Rate	Relative Precision[a]
Electricity	98%	5.6%
Natural Gas	89%	10.7%

[a] Relative precision is calculated at the 90% confidence level.

Realization Rate Adjustments Summary Findings

The realization rates for the custom capital projects ranged from 26.8% to 112.9%. The custom capital track achieved an electric realization rate of 98% and gas realization rate of 89%. Cadmus adjusted savings for 24 custom capital projects. Most adjustments were minor and out of the control of Energy Trust and the PDC. These include updated hours of use and changes in setpoints that occurred after the projects were implemented. There were a few projects that had a larger impact on realization rates, and these generally included changes to assumptions and calculation methodology. On the electric side there was one large chiller project (PE17393) that used incorrect assumptions for full load tonnage and chiller sequencing. On the gas side, there were a few projects (PE13180, PE16389, and PE17098) that received low realization rates.

- For PE13180, Cadmus found that collected data showed a lower runtime of 41% per year instead of the originally calculated 43.07% per year. The site contact also confirmed that the average variable frequency drive was 50 Hz instead of 45 Hz. Both of these changes resulted in lower savings.
- For PE16389, the custom PDC used an eQuest model that overestimated savings. Cadmus obtained daily heating degree day (HDD) values using hourly PRISM data for Pendleton, Oregon, between 2015 and 2021 and correlated natural gas consumption to HDD using a variable base temperature for each year to optimize the correlation. We then used the data to calculate a regression for weather-normalized baseline consumption for each year between 2015 and 2019 and subtracted the consumption for the regression for 2021 data to evaluate total annual gas savings. This resulted in lower savings.
- For PE17098, which was a project to increase condensate return, Cadmus found that the facility had switched to using an older boiler that operates at a lower efficiency than the new boiler. The older boiler has a combustion efficiency of approximately 84.5% at the most common operating settings. The new boiler has an efficiency of 86.4%. Factoring in this lower boiler efficiency resulted in lower savings.

During the evaluation, Energy Trust noted that there were two projects (PE16389 and PE17178) in the custom capital track that were misclassified and should have been in the custom O&M track. Considering these projects were sampled in the custom capital track and appear as such in the data set, Cadmus maintained the originally sampled custom capital track.

The following list highlights more specific adjustments to projects and provides some examples:

- In some cases, operating hours were estimated incorrectly, or they were adjusted since the project was completed due to changes in production. Cadmus confirmed with the site contacts that these were not temporary changes and were unrelated to COVID-19. Operating hour changes affected both gas and electric savings across several measure types. Project examples: PE15150, PE15664, and PE16586.
- For some projects, the PDC used the incorrect setpoints to calculate savings or setpoints that were changed since the project was complete. Cadmus used trend data, existing sensors and gauges readings, review of the control panels, and discussions with site contacts to update setpoints. This affected both gas and electric savings across several measure types. Examples of adjustments included temperature setpoint changes, flow rate changes, and process changes resulting in setpoint adjustments. Project examples: PE13180, PE17840, PE12534, PE17178, PE17542, and PE17453.
- For some projects, the PDC used the incorrect or different calculation methodologies to calculate savings. This included issues with overestimating savings using an eQuest model, and adjusting savings using more recent data collected that excludes COVID-19 downtime. Project examples: PE15658 and PE16389.

- For some projects, the PDC used incorrect equipment specifications, which resulted in differences in savings. For one project, the PDC used the incorrect power factor to calculate savings, a second project used an older chiller efficiency that is not reflective of current operation, and a third project Cadmus observed a lower boiler efficiency during the site visit. Projects examples: PE16778, PE17110, and PE17098.
- For some projects, the PDC used incorrect assumptions, which resulted in adjustments to savings. These included adjustments to assumptions on efficiencies, load profiles, temperature setpoints, and infiltration rates. Project examples: PE16861, PE14690, PE16768, PE17393, PE16381, and PE17772.
- For some projects, Cadmus identified an engineering or calculation error. This was generally a result of spreadsheet errors. This included one project in which the PDC incorrectly calculated the total kW and cfm Demand for an air compressor project, one project that did not use power factor in the energy savings calculations, and a third project in which the PDC did not include condensate losses in their analysis. These projects resulted in adjustments to savings. Project examples: PE9053, PE17535, and PE16710.
- For one project (PE13413) the PDC used the incorrect baseline to calculate savings. Cadmus modified the baseline aeration flow rate to include two basins instead of one. This was observed by our team and also verified by the site contact.

Other Findings

- Although most savings calculation workbooks for custom capital projects were well documented and easy to follow, in some cases values were hard-coded and the source of the value was not provided or explained. We used workbooks, alongside the verification and TAS reports, to get a complete understanding and overview.
- Some trend data collected by third-party installers were not available to Cadmus. Though we found screen shots and data summaries in the TAS and verification reports, they did not include data and the analysis methodology. For all projects where this was an issue, Cadmus requested the data, and this was subsequently provided by the PDC.

Custom O&M Projects

Custom O&M projects represented adjustments to control settings and equipment operating parameters that could be very sensitive to facility changes. Cadmus evaluated 12 custom O&M projects, of which all 12 were primary projects. The types of O&M projects implemented through the PE program could be calculated in the spreadsheets developed by the PDCs.

As with the custom capital projects, Cadmus performed virtual site visits or interviews to verify whether the proposed O&M measures remained in operation. We reviewed trend data when available to obtain the current operating parameters for each measure. We updated the calculation workbooks for projects with data available. These projects included the following measures:

- Compressed air leak repairs
- HVAC scheduling

- Turning down set points on process heating
- Turning off equipment that was redundant or not in use

Findings

Custom O&M realization rates are provided in Table 17.

Table 17. Custom O&M Realization Rates Summary

Fuel Type	2020	
	Realization Rate	Relative Precision[a]
Electricity	100%	3.7%
Natural Gas	12%	0.0%

[a] Relative precision is calculated at the 90% confidence level.

Realization Rate Adjustments Summary Findings

The realization rates for the Custom O&M projects ranged from 11.6% to 123%. The custom O&M track achieved an electric realization rate of 100% and gas realization rate of 11.6%. Most custom O&M projects received a 100% realization rate. Energy savings estimates were generally calculated using appropriate methodologies, assumptions, inputs, and metered or trend data. Cadmus adjusted nine custom O&M projects. The follow list highlights more specific adjustments to projects and provides some examples:

- For some projects, the PDC used the incorrect *equipment* setpoints to calculate savings. This included one project that the PDC used the lower compressor pressure setpoint to calculate energy savings. For a second project, the evaluator adjusted the average speed of the pump based on one year of data. Project examples: PE16252 and PE16468.
- For some projects, the PDC used inappropriate assumptions to calculate savings. In one case the assumptions on hours of operations for the lead/lag boiler was adjusted based on site visit verification and discussion with the facility, in a second case, the PDC used an inappropriate air compressor efficiency to calculate savings. Project examples: PE17612.
- For some projects, the PDC used the inappropriate or different calculation methodologies to calculate savings. For one project the evaluation team determined that the regression equation used by the PDC was not reflective of equipment performance and adjusted this accordingly based on post data. For a second project the PDC used a proprietary model to calculate savings. The evaluation team did not have access to this model and used the provided raw data along with a day type analysis to calculate savings. Project examples: PE17037 and PE18108.
- For one project (PE18217), the condenser approach and maximum fan-speed setpoints, which were reverted to baseline conditions. (12°F approach and 100% max condenser fan speed). Therefore, savings for this measure were eliminated, which resulted in 0% realization rate for this measure.
- For one project (PE16768), operating hours were estimated incorrectly, or they were adjusted since the project was completed due to changes in production. Cadmus confirmed with the site contacts that these were not temporary changes and were unrelated to COVID-19.

Other Findings

- The custom O&M projects generally received high realization rates when the facility maintained operating conditions defined in the project. We found the project savings decreased when the facility did not have proper training or when the operating conditions were too aggressive to be applied in all production or weather conditions.
- In general, the projects that did not maintain the setpoints prescribed were most frequently in facilities where there were production changes, or where setpoints caused changes that did not successfully improve operations and were changed back to the original setpoints.
- Many of the custom O&M projects involved equipment that was directly metered or where trend data were available to determine energy consumption before and after the setpoint change or maintenance fixes. The metered data helped ensure energy savings estimates were reasonable and that sufficient data were collected to calculate resulting savings.
- Although most savings calculation workbooks for custom O&M projects were well documented and easy to follow, in some cases values were hard coded and the source of the value was not provided or explained.
- The PDCs used different methodologies to adjust leak rates and to calculate savings for each of these projects, which resulted in different savings estimates. In some cases, the PDCs derated leak savings by 50% from the ultrasonic leak detectors and in other cases they did not derate leak savings. In one case the contractor used actual pre and post meter data to calculate savings.

Streamlined Industrial Projects (Green Motor Rewind, Lighting, Prescriptive, and Small Industrial)

The streamlined industrial projects generally include projects that are well established and use prescriptive or standardized calculation methodologies and spreadsheets developed over the years from best practices and MADs. These generally included smaller electric and gas projects that were easier to verify and required fewer inputs. For these projects, Cadmus conducted a mix of virtual or on-site visits, interviews, and desk reviews. We verified that the appropriate calculation methodology was used, the appropriate inputs and assumptions were applied, and that the project was installed and operational. The tracks for the streamlined industrial projects are outlined below.

Green Motor Rewind

Green Rewind projects received incentives for disassembly and refurbishment of electric induction motors, including rewinding and testing the stators to restore or maintain a motor’s original efficiency. Cadmus evaluated six green motor rewind projects.

Lighting

Lighting projects included new construction spaces with a space-by-space code baseline and watt-reduction retrofits or fixture replacements in existing spaces. Cadmus evaluated 15 lighting projects.

Prescriptive

Prescriptive projects covered equipment replacements and equipment installations. Cadmus evaluated 21 prescriptive projects that included the following:

- Irrigation system seals, gaskets, and nozzles
- Pipe insulation for hot water and steam lines
- Roof insulation
- High-efficiency boilers

Small Industrial

The small industrial projects covered equipment replacements and equipment installations. Cadmus evaluated 16 small industrial projects that included the following:

- Air compressor replacements
- Refrigeration system equipment and controls
- Irrigation pump variable frequency drives
- Fast-acting doors in refrigerated warehouses
- Heating systems for greenhouses

Findings

Streamlined industrial realization rates are provided in Table 18.

Table 18. Streamlined Industrial Realization Rates Summary

Fuel	Track	2020	
		Realization Rate	Relative Precision [a]
Electric	Green Rewind	86%	29.0%
	Lighting	95%	7.1%
	Prescriptive	100%	0.0%
	Small Industrial	100%	0.0%
	Total	97%	4.1%
Gas	Prescriptive	96%	6.6%
	Small Industrial	115%	8.4%
	Total	99%	5.5%

[a] Relative precision is calculated at the 90% confidence level.

Realization Rate Adjustments Summary Findings

Green Motor Rewind

The realization rates for the green motor rewind projects ranged from 16.6% to 100%. The track performed well in 2020, and most projects received a 100% realization rate. The overall electric realization rate of 86%, as shown in Table 18. Cadmus made adjustments to one project in the sample. For PE18837, the PDC used the incorrect motor size to calculate savings, which resulted in a significant overestimation of savings. Cadmus verified the correct motor size through the invoices and application and adjusted saving resulting in a reduction in realization rate. Energy Trust discovered the issue with PE18837 in 2021 and reversed savings for the project, re-issuing it with the correct motor size and incentive value. Since the reversal was done in 2021, the incorrect savings still appeared in the 2020 data set and Cadmus evaluated it as such.

In some cases, Cadmus noted that the rewound motors were in storage and not reinstalled. We deemed this appropriate considering that it is reasonable to expect a facility to install a backup motor while motors are rewound and not stop production lines to reinstall rewound motors when received. We do expect, however, that a facility would install these motors in the future and achieve savings over the expected measure life.

Lighting

The realization rates for the lighting projects ranged from 50.7% to 118.7%. The track performed well in 2020, with most projects receiving a 100% realization rate; overall, the track received an electric realization rate of 95%. During the 2020 evaluation, Cadmus installed light loggers at eight lighting projects to get a deeper understanding of hours of use and provide Energy Trust with some additional feedback on the hours-of-use estimations. We based the following recommendations on our logger data findings, including adjustments to five lighting projects. The following list highlights the specific adjustments made to projects and provides some examples:

- Cadmus adjusted operating hours of the lights involved in a project. This increased the evaluated savings for some projects decreased it for others. In general, we based the hourly adjustments on additional findings from the installed light loggers. Project examples: PE16752, PE16813, PE16825, PE17132, PE16981, PE17309, PE18064, PE18092, and PE18281.
- For PE14815, Cadmus found the reported light fixture wattage to be slightly higher than the evaluated wattage. This reduced savings.
- For PE17155, Cadmus found fewer fixtures than reported. This reduced savings.
- For PE15760, 16 green houses were built instead of 22, which reduced the total square footage built and the function of the spaces also changed which also resulted in an adjustment to the reported lighting power density (LPD) values.
- In a few evaluated retrofit projects the PDC calculated the baseline lighting energy use using the LPD method rather than using the existing lighting fixture quantity and wattage. The project documentation included notes that indicated increased light levels for various manufacturing purposes, but we did not find documentation to support these notes.

Prescriptive

The realization rates for the prescriptive projects ranged from 60.4% to 100%. Most projects received a 100% realization rate. In general, Cadmus received the appropriate data, specification sheets, and calculation methodologies for these projects. Cadmus made adjustments to one prescriptive project, detailed below:

- For PE18204, Cadmus identified a different steam pressure setpoint which reduced savings for the project. We confirmed with the site contact that steam pressure was less than 15 psi at the site and, therefore, adjusted prescriptive savings to use a low-pressure steam savings value. Steam pressure was 70 psi but had a restrictor that stepped it down below 15 psi.

Small Industrial

The realization rates for the small industrial projects ranged from 100% to 125%. The track performed well in 2020, and most projects received a 100% realization rate. The overall electric realization rate of 100% and gas realization rate of 115%, as shown in Table 18. Cadmus made adjustments to three small industrial projects, detailed below:

- For three greenhouse projects (PE16909, PE17606, and PE18112) the PDC adjusted the final savings output of the calculator down 20%. The adjustment was done by the PDC to be conservative, however this was not done consistently across all greenhouse projects that use the Virtual Grower calculator. Further, regarding the adjustment to be conservative, the evaluator recommends that if there is a concern about the calculator overestimating savings, we recommend adjusting the assumptions and inputs within the calculator and not to the final savings values. Cadmus adjusted savings to claim the full savings of the projects without any adjustments.

Strategic Energy Management Projects

SEM includes training, tools, and technical support from SEM coaches to help customers save energy by establishing or improving energy management practices in the workplace. Savings for SEM projects come from low- and no-cost actions completed at a facility to reduce energy use. Typical SEM actions included the following for the 2020 PE program:

- Turning off production equipment via automatic or manual controls when possible during down-time
- Fixing compressed air system leaks
- Reducing motor speeds when possible
- Adjusting space temperature setpoints and/or schedules
- Fine-tuning equipment controls to increase operating efficiency
- Turning off lights when appropriate

To estimate evaluated savings, Cadmus used various energy savings models developed by the customer or the PDC. We also evaluated some bottoms-up SEM projects by reviewing project specific data and analysis similar to what we would do on a custom project.

Findings

SEM realization rates are provided in Table 19. Only one SEM site claimed natural gas savings, and that site realized 110% of its claimed savings due to its baseline model's underprediction of gas consumption in summer months. Realization rates assigned to claimed electricity savings ranged between 89.8% to 112.2%. Deviations from 100% resulted from a variety of factors. This included failure in verification of key Energy Trust criteria, such as model fractional savings uncertainty or reporting period length, and differences in savings calculations for one project that used a bottom-up approach, but did not generally result from site energy modeling concerns.

Table 19. SEM Rates Summary

Fuel Type	2020	
	Realization Rate	Relative Precision[a]
Electricity	100%	1.9%
Natural Gas	110%	N/A

[a] Relative precision is calculated at the 90% confidence level.

Summary Findings

Baseline, Engagement, and Reporting Period Definitions

- In the annual savings reports, for nearly every project, the PDC clearly justified the baseline, engagement, and reporting period definitions. In particular, most projects that deviated from the standard of three- or 12-month reporting periods, the PDC justified this decision. Most often, the PDC increased the length of the reporting periods to six months to capture some of the summer and winter months or to avoid including a significant nonroutine event that was unrelated to the SEM engagement.

Opportunity Register

- Some participants were unable to provide details about the SEM initiatives at their facilities due to the employee turnover, and some customers were unsure about the completion or presence of some SEM opportunities due to the amount of time that had elapsed between the SEM engagement period and the time of the evaluation. As such, in some cases, Cadmus was unable to gather adequate information to support the evaluation of savings for SEM projects.

Energy Intensity Models

- In general, the SEM regression models seemed to accurately characterize the energy use of the facilities, supporting high realization rates for most projects. Most of the regressions used production information as one of the variables in the model, and most models also used weather data as a variable in the model.
- In all cases, the coefficient estimates for the energy drivers included in the models were reasonable. For example, increases in units produced were associated with increases in energy consumption, as expected.
- Most models passed all of the goodness-of-fit criteria as outlined in Energy Trust's M&V SEM Model Guidelines documentation. When models did not pass all criteria, most often they failed the fractional savings uncertainty threshold. Across projects, participants handled these situations differently. In some cases, the facility continued using the energy intensity model to claim energy savings. Other participants switched to a bottom-up approach for their projects or simply did not claim SEM savings if they had not implemented major SEM projects at the facility.
- Cadmus observed nonlinearity in the relationships between independent variables and energy consumption at many of the sites. Often, the nonlinearity appeared to be driven by a change in this relationship for the highest- or lowest-production observations. As an example, a facility may reach peak efficiency at a certain production threshold, after which the marginal change in consumption for additional units produced is near zero. Treating these relationships as linear can systematically under- or overpredict observations with high or low production. This is particularly important in considering the future viability of existing baseline models at sites that experienced changes in production output towards the end, or after, their 2020 reporting periods.
- The in-depth interviews with site contacts confirmed that the COVID-19 pandemic affected SEM participating facilities in a variety of ways. Some of these impacts may be long-lasting, and many of the energy intensity models, as they stand now, could provide inaccurate forecasts of baseline energy consumption in future program years.
- Several energy intensity models included weather in their models, as appropriate. Most facilities included weather in the models as HDD and cooling degree days (CDD). In the 2018-2019 PE impact evaluation report, Cadmus had recommended that energy models use HDD or CDD when appropriate, instead of average temperature or higher-order polynomials. In 2020, sites using energy models were more likely to use HDD and CDD, as Cadmus had recommended previously, though notably the one gas model included in the 2020 evaluation did not (and as a result, underpredicted consumption in summer months).

- Model residuals (as shown in plots of residuals vs. fitted values and residuals over time) were typically reasonably well behaved, leading Cadmus to verify residual diagnostics overall. However, we noted at least some non-linearity in these plots for around half of the projects that used energy models. The most common issue were clusters or nonconstant spread in residuals vs. fitted values plots. In many instances, these issues likely resulted from poor model precision on nonproduction or site shutdown days. All sites that experienced regular nonproduction days included variables to at least partially control for these days, but these models typically were much less precise during nonproduction periods, suggesting that the models could still be improved by controlling for additional variables that determined energy consumption on these days.
- All annual savings reports documented statistical outliers produced by the energy intensity models. In many cases, the site investigated the observations and left the outliers in the analysis when they found no justification for removal. When observations were removed, they were often few in number and well documented in the annual savings report. However, in one case, removal of an outlier from the reporting period resulted in a reporting period well below the 90-day minimum length recommended by Energy Trust.

Capital Projects

- Projects correctly accounted for and adjusted consumption for capital projects that received incentives through Energy Trust's other tracks. However, Cadmus found that few projects clearly described and documented their approach to adjusting consumption for capital projects. In most cases, these adjustments were not sufficiently documented and were buried within energy modeling workbooks, complicating the verification process. For example, Cadmus found that many projects adjusted the daily energy values before they applied the model and calculated the model prediction, instead of making one line item adjustment at the end during the final savings calculation.

Savings Estimation Methods

- There were no major errors in scaling the reporting period savings rate to a full 12 months of engagement; in one case, Cadmus found minor errors (amounting to less than 0.01% in the savings rate), but these were too small to affect the site's overall realization rate.
- The PDC based reported annual savings estimates for several projects on just a few months of reporting period energy use data.[4] However, small variations in reporting period energy use can potentially have a significant impact on the reported savings, even when energy use at the site is not expected to be seasonally driven. This is especially important for sites that do not have daily energy data, as their reporting period may be based on just three monthly observations (in the example of a 90-day reporting period with a monthly energy intensity model). Cadmus did not investigate how such assumptions may have impacted overall savings estimates.

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[4] The program's minimum reporting period requirement is three months, and it is common to require a longer reporting period for models where seasonality is a factor.

- Projects with bottom-up savings had a near 100% realization rate. There were only three projects that Cadmus sampled that claimed savings using the bottom-up approach. Overall, the data provided were sufficient when combined with staff interviews and site visits to verify energy savings. We adjusted one site's individual project savings due to incorrect assumptions and setpoint adjustments. These adjustments resulted in a 97% realization rate because some measures had negative impacts and some had positive impacts on savings.

Demand Analysis Findings

Cadmus calculated summer and winter peak demand savings through electric load profiles and peak demand factors provided by Energy Trust. We first reviewed the reported load profiles for each project. We revised the load profiles where necessary to better align with the measure's expected operation, which often relied on the facility' hours of operation. Load shapes were adjusted for a total of 32 projects out of 69 unique electric projects and 44 out of 123 electric measures in the evaluation sample. The areas where the evaluation team saw the largest change in load shapes were: 3-Shift Industrial to 1-Shift Industrial on eleven projects and 2-Shift Industrial to 1-Shift Industrial on eight projects. Cadmus verified actual hours of operation for all but three projects in the evaluation sample. We assigned evaluated load profiles for those measures where shift profiles were most appropriate based on hours of operation using the following ranges:

- 1-Shift Industrial: 0 to 4,159 hours
- 2-Shift Industrial: 4,160 to 6,239 hours
- 3-Shift Industrial: 6,239 to 7,999 hours
- Flat-ele: 8,000 to 8,760 hours

Cadmus calculated demand realization rates to extrapolate to the non-evaluated population due to the variance in load profiles assigned to measures in each track. First, we multiplied the reported electricity savings by the peak multiplier for the reported load profile to determine a value for the "reported" demand savings for winter and summer. The program did not actually report demand savings, but this value was critical for the extrapolation process due to the variety of load profiles assigned within tracks. We then multiplied the evaluated electricity savings for each project by the applicable demand factor to determine the evaluated demand savings for winter and summer. We calculated demand savings realization rates for each project based on the ratio of evaluated to reported demand savings. We extrapolated these realization rates from the sample to the population in an identical manner as those used to calculate the overall electricity and natural gas savings. The resulting demand savings by track are shown in Table 20.

Table 20. 2020 Evaluated Demand Savings by Track

Track	Subtrack	Winter Demand Savings (kW)	Summer Demand Savings (kW)
Custom	Custom Capital	4,081	4,859
	Custom O&M	388	433
	Total	4,469	5,292
Streamlined Industrial	Green Rewind	13	15
	Lighting	6,993	7,290
	Prescriptive	1,262	1,966
	Small Industrial	1,285	2,065
	Total	9,552	11,336
Total		**14,022**	**16,628**

Conclusions and Recommendations

Cadmus conducted an impact evaluation of the 2020 PE program by analyzing energy savings from 110 projects implemented at 73 sites. At those sites, we evaluated electricity savings for three additional projects and gas savings for one additional project as convenience measures. The measures belonged to six different program tracks and represented a variety of subcategories.

Cadmus performed verification through site visits, virtual site visits, interviews, and desk reviews for each project in the sample. We evaluated energy savings based on verified equipment counts, operating parameters, metering data, EMS trend data, and assumptions derived from engineering experience and secondary sources. For each measure, these data informed prescriptive algorithms and calculation spreadsheets.

The PDCs generally applied appropriate methodologies and assumptions. Overall, Cadmus' evaluated savings differed from reported energy savings across the following main categories:

- Different operating hours
- Different equipment setpoints at the facility
- Incorrect equipment specifications or quantities
- Incorrect analysis methodology
- Measure removal
- Inappropriate assumption
- Calculation or engineering error
- SEM adjustment

Combined, these combined factors led to an electric realization rate of 98% and a gas realization rate of 97%.

Overall, the PDCs performed a reasonable level of review and quality control to achieve a high average of project savings and realization rates. The PDCs often proved extremely knowledgeable about the facilities with which they worked and were generally receptive to supporting evaluation efforts. Cadmus worked directly with the PDCs on a few occasions to contact facilities and acquire analysis files and data. We found most PDCs quickly provided any documentation they could access, identified the appropriate facility contacts, and went out of their way to assist with recruitment efforts.

We also found that Energy Trust implementation staff maintained a thorough understanding of project details and participant sensibilities. Cadmus developed a large number of M&V plans for Energy Trust staff to review. Even though PDCs were more directly involved with project review and approval, senior PE program staff had strong knowledge of project and analysis details and provided significant feedback to improve M&V efforts. This was especially helpful given the ongoing COIVD-19 pandemic and supply chain disruptions where, in many cases, Cadmus had to rely on Energy Trust staff for additional data requests and project files. Energy Trust staff were responsive and supportive of all evaluation activities, which contributed to the success of the 2020 impact evaluation.

Based on its evaluation, Cadmus recommends the following opportunities for program improvements. Recommendations are divided into their respective tracks. If a recommendation applies to multiple tracks, we included it each respective track below.

Custom Capital

- For compressed air savings analysis, we recommend the program use the day-type analysis methodology. This methodology looks at energy savings for each day type, accounting for differences in air demand across weekdays and weekends. This is particularly useful when developing 8,760 load shapes and is beneficial when calculating air leak and air dryer savings. We recommend avoiding averaging data across entire metering or trend data periods as this eliminates some of the important and intricate changes over a metered period that should be considered in the savings analysis. The day-type methodology is referenced in the UMP Compressed Air Evaluation protocol[5] and also used by the Department of Energy's Air Master Tool to estimate savings.[6]
- For projects where system level data are not available, but utility data are available from the customer and the measure represents more than 10 to 20% of the site's total monthly metered energy use, we recommend incorporating these data into the analysis to calculate savings. This could take the form of an IPMVP Option C Whole Building analysis or as a reference to benchmark results or calibrate savings models. When used appropriately, billing data, along with weather or production data, can be used to calculate a weather/production-normalized regression for baseline and post-period energy use—this provides a simplified analysis approach that results in more robust energy savings estimates versus those from a building modeling software tool, such as eQuest.

Custom O&M

- For compressed air leak savings projects, we recommend using the system leak-down test as highlighted in the UMP Compressed Air Protocol to estimate the combined loss (cfm) of compressed air leaks. The PDC can use this approach in the pre- and post-case to estimate the effect of leak fixes in the system. In cases were the system leak-down test is impractical, The PDC should estimate flow by measuring compressor power and correlating this to flow using CAGI sheets or standard flow tables. Compressor power should be measured during nonproduction periods and all non-leak air consumption should be discounted from the data to determine actual leak volume. Lastly, the most accurate approach is to measure actual flow rate in the pre- and post-nonproduction periods and discount for any non-leak air users. Installing flow meters can sometimes be invasive and prove impractical and, hence, the two prior methods are more common approaches. Ultrasonic leak detectors are good for identifying leaks

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5 National Renewable Energy Laboratory. (NREL; Benton, Nathanael; Patrick Burns, and Joel Zahlan). 2021. *Chapter 22: Compressed Air Evaluation Protocol. The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. NREL/SR-7A40-77820. https://www.nrel.gov/docs/fy21osti/77820.pdf.

6 Office of Energy Efficiency & Renewable Energy. 2014. "Advanced Manufacturing: AIRMaster+". https://www.energy.gov/eere/amo/articles/airmaster.

and estimating savings at a high level; however, the three approaches detailed above provide a more accurate way of estimating leak loss.

- We recommend Energy Trust standardize the approach used to determine air-leak savings for the program. Our analysis found that the PDCs used different methodologies to adjust leak rates and to calculate savings for each of these projects, which resulted in different savings estimates. In some cases, the PDCs derated leak savings by 50% from the ultrasonic leak detectors and in other cases they did not. If pre- and post-metered data are not available, standardize the approach to using findings from the ultrasonic leak detector and adjust accordingly to reflect compressor flow during nonproduction periods.
- We recommend the program require the PDCs use nonproprietary models for energy savings estimation or alternatively provide any data collected and used in the energy savings analysis.

Streamlined Industrial

- **Lighting:** We recommend the program use light loggers more frequently to determine lighting hours of use and occupancy sensor savings for projects with significant electricity savings (i.e., greater than 500,000 kWh) and those projects that also have occupancy sensors. This will provide more accurate energy savings estimates.
- **Lighting:** If light loggers cannot be installed at a project or in sensitive spaces due to customer concerns, location, or space use, we recommend the project documentation include clear hours of use calculations and the source of information (i.e., Monday through Friday, 6:00 a.m. to 5:00 p.m., based on an interview with the site contact).
- **Lighting:** We recommend the program apply a uniform approach to calculate HVAC interactive effects across all lighting projects. Upgrades to LED lights generally result in an increase in electricity savings through cooling savings and an increase in gas or electric consumption due to additional heating requirements. Energy Trust should apply a standardized approach to calculate interactive effects across all lighting projects in the program to ensure these effects are accounted for appropriately. Lighting-related HVAC interactive effects are also covered in the UMP Commercial and Industrial Lighting Evaluation Protocol.[7]
- **Lighting:** We recommend the program require proof of space-use change or alteration and light levels for retrofit projects that use a LPD methodology. Documentation could include pre- and post-retrofit space photos, calculations of lumens per square foot, narrative background on the need for increased or decreased lighting levels, and existing and as-built electrical drawings.
- **Small Industrial:** We recommend following a uniform approach to calculate gas savings using the virtual grower calculator. For some projects, the PDC claimed the full savings amount resulting from the virtual grower, and for some greenhouse projects, the PDC adjusted savings down by 20%. The calculator should be used uniformly across all projects. If there is a concern

[7] National Renewable Energy Laboratory (NREL; Gowans, Dakers). 2013. *Chapter 2: Commercial and Industrial Lighting Evaluation Protocol. The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. . NREL/SR-7A30-53827. https://www.energy.gov/sites/prod/files/2013/11/f5/53827-2.pdf

about the calculator overestimating savings, we recommend adjusting the assumptions and inputs within the calculator rather than making a universal adjustment to the final savings values.

- **Small Industrial:** For some large irrigation projects involving gasket replacements, Cadmus observed that Energy Trust adjusted savings down to account for a cap on the maximum incentive that can be offered. Savings were therefore reduced by 90% to reflect the approved incentive value. This adjustment was done after the project was approved and added to the database. As such, Energy Trust adjusted savings by applying a negative savings value in the database to reduce the original savings that were input in the database. We recommend developing a uniform process to make these adjustments during the project review to avoid having to adjust the database once projects are finalized. This will also allow for consistencies in the application of the adjustment. Furthermore, if the deemed savings values used are overestimating savings at larger gasket quantities, we recommend reviewing the assumptions that go into the calculation of the deemed savings values and adjusting accordingly to fix the issue rather than making an adjustment to savings values in the database.
- **Small Industrial:** For small industrial projects that rely on MADs for estimating savings, we recommend including all project files used to develop savings estimates. These files should not include hardcoded numbers for savings results.
- **Small Industrial:** MAD 200 v2 states "steam systems must operate year-round, at all hours" but does not specify if allows for idling or turndown. The incentive application only has a field for "operates year-round". Cadmus recommends adding language to clarify year-round operation requirements.

Strategic Energy Management

- The in-depth interviews with site contacts confirmed that the COVID-19 pandemic affected facilities participating in SEM in a variety of ways. Some of these impacts may be long-lasting, and many of the energy intensity models, as they stand now, could provide inaccurate forecasts of baseline energy consumption in future program years. We recommend reviewing the effects of COVID-19 at each facility to determine if projects require re-baselining and new energy intensity models once normal operations resume post pandemic.
- The Energy Trust SEM M&V Guidelines recommend sites use a 90-day or 12-month reporting period for claiming annual program savings. Energy Trust should consider formally testing how changes to the reporting period definition (months covered and length of the period) impacts the annual savings claimed for a variety of facility types. Savings rates may remain consistent across all 12 months for certain production sectors, but a formal investigation would provide guidance on which facilities may suffer from greater inaccuracies under this assumption. Additionally, Energy Trust should consider increasing the minimum reporting period length (90 days) for sites that have only monthly energy consumption observations.
- When higher-frequency energy consumption data, such as daily data, are available for building the energy intensity models, we recommend interacting production variables with indicators at known change points to reduce modeling error and improve observed nonlinearity between

energy drivers and energy consumption. Change points should be driven by knowledge of the facility to avoid overfitting.

- In addition to the plots of model residuals over time and against fitted values, Energy Trust should require that projects provide plots of model residuals versus each independent variable included in the model. These plots will aid in verification of energy models and enable the evaluator to provide more specific recommendations to improve modeling.
- Energy Trust should work with implementers to improve and standardize documentation of any savings adjustments made due to capital projects occurring during baseline and engagement periods. Project workbooks or reports should clearly describe how any adjustments are made and show these calculations in one standardized location within these documents (preferably during the final savings calculation for capital projects occurring during the engagement period).
- When SEM facilities diverge from IPMVP Option C for claiming energy savings due to their SEM engagement and Energy Trust uses a bottom-up approach to estimate savings, we recommend improving the process by providing some additional detail on measures to more closely align with the approach used for custom projects. Providing more substantial supporting documentation such as trend data, photos, and specification sheets can help in determining energy savings of the measures. To assist with future qualitative assessments of SEM savings, we recommend requiring sites to include the expected energy savings generated from major SEM projects as part of the opportunity register to increase the accuracy of realization rate adjustments based on these activities.
- We recommend Energy Trust add additional clarification to the *Energy Trust Industrial Impact Evaluation Policies* to address SEM facility closures. Energy Trust should treat each SEM facility closure on an individual basis and consider savings based on the measure list in the opportunity register. For instance, if the measures in the register are related to capital measures, then Energy Trust should follow a similar approach to how custom project facility closures are handled. However, if measures are predominantly behavioral, Cadmus recommends that these projects are addressed as measure removals considering the unlikelihood of behavioral measures saving energy if the facility resumes operation.

Other Recommendations

This section covers recommendations that apply to the overall program and not to a specific track. These recommendations focus on overarching opportunities to improve the program.

Metering Periods

- We recommend the program use a minimum metering period of two weeks. Two weeks is typically enough to capture a full production cycle, but this is also dependent on the type of equipment, production schedule, seasonality, weather, and other factors. For example, HVAC systems may require longer intervals or multiple metering periods to characterize operation in the shoulder months. The PDCs should take these dependencies into consideration whenever metering.

Demand Savings Calculations

- **Develop Demand Methodology to Report Savings**

  The peak multiplier method currently employed by Energy Trust to estimate demand savings is not sufficiently rigorous to accurately account for demand impacts. Cadmus recommends that Energy Trust develop methods to report peak demand savings for each custom and prescriptive project in future program years. Utilities throughout the country have already performed extensive work to characterize peak demand savings estimates. We recommend that Energy Trust examine demand savings methods employed in technical reference manuals for comparable states and utilities. Energy Trust can use this information to begin developing a database of peak coincidence factors for prescriptive measures and identify more rigorous methods to calculate demand impacts from custom measures.

  The effort to characterize peak demand savings is made even more urgent by recent events—a record-breaking heat wave in June 2021 that resulted in heavy air conditioning loads on the electric grid as well as Oregon House Bill 2021 to decarbonize the electric grid by 2040. At the same time, there are local and national efforts to decarbonize transportation and space and water heating that will result in continued increases in electric demand. Reliable estimates of peak demand savings achieved through Energy Trust's programs will be critical to future integrated resource planning efforts.

Operations

- For Energy Trust projects with multiple program tracks, we recommend Energy Trust assign one PE number for each program track. For example, PE16768 had two measures: one in the custom capital track and another in the custom O&M track. Cadmus sampled at the project and track level, and in this case, sampled the measure associated with the custom O&M track. Cadmus evaluated the savings of the measure in the custom capital track as part of the convenience sample. Assigning one PE number for each program track will help distinguish between the savings associated with the two tracks, aiding with sampling at the track level and confidence and precision calculations.
- We recommend Energy Trust clearly specify program projects that are located on the same site by assigning unique site IDs for each site. In the 2020 program data, projects located at the same address did not always have the same site ID. In some cases, this resulted in contacting sites on different occasions for the impact evaluation. Assigning a clear and unique ID per site will allow Energy Trust to filter for all projects at a specific site and reduce the amount of outreach to sites with multiple projects.
- We recommend creating a protocol that addresses projects that do not receive an incentive but still claim savings if the measure was influenced by the PDC. In some cases, the PDC may be supporting a customer with the implementation of projects, through this process it is possible for the customer to identify projects that did not go through the incentive process but were still implemented. Energy Trust could potentially claim savings for these projects if they are within a defined protocol and meet Energy Trust's criteria (for example: PE16768).

- We recommend updating the *Energy Trust Industrial Impact Evaluation Policies* (see Appendix C) to include guidance on how to address facility closures where SEM and custom O&M measures are implemented. Since these projects generally include behavioral measures, facility closures can significantly impact lifetime measure savings and revert energy savings achieved through SEM programs, additional training, and maintenance. For SEM and more behavior-related custom O&M projects, we recommend the evaluator determine when the facility was shut down and prorate the savings relative to the measure lifetime.
- We recommend that Energy Trust develop guidelines for the PDCs to compile and save all relevant project files for Energy Trust and the evaluators to use during the evaluation process. For the 2020 PE impact evaluation, Cadmus experienced an uptick in data requests and coordination with Energy Trust due to incomplete project files, incorrect or out-of-date files, or proprietary analysis files. Energy Trust staff did a great job coordinating with the PDCs to request all relevant files for the evaluation and were able to satisfy all data requests in a timely manner. This was a significant effort on the part of Energy Trust staff to support these data requests and moving forward it will be helpful to create guidelines for the PDCs to review and provide relevant project files.

Status of Recommendations from Prior Impact Evaluation Report

This impact evaluation assessed whether recommendations from the last impact evaluation were implemented. The last impact evaluation covered the 2018-2019 program years. Table 21 highlights the recommendations provided in the 2018-2019 PE impact evaluation and Cadmus' observations into the status of these recommendations.

Table 21. Status of Recommendations from Prior Impact Evaluation

Program Track	2018-2019 Recommendation	Cadmus Observations
Custom Capital	For compressed air savings analysis, we recommend the program use the day type analysis methodology. This methodology looks at energy savings for each day type accounting for differences in air demand across weekdays and weekends. This is particularly useful when developing 8,760 load shapes and is beneficial when calculating air leak and air dryer savings. We recommend avoiding averaging data across entire metering/trend data periods as this eliminates some of the important and intricate changes over a metered period that should be considered in the savings analysis. The day type methodology is referenced in the Uniform Methods Protocol (UMP) Compressed Air Evaluation protocol and also used by the Department of Energy's Air Master Tool to estimate savings	Partially Implemented: Cadmus observed some projects where the day type analysis was used to estimate savings. However, for most compressed air projects a different analysis approach was used.
Custom O&M	For compressed air leak savings projects, we recommend using the system leak-down test as highlighted in the UMP Compressed Air Protocol to estimate the combined loss (CFM) of compressed air leaks. This approached can be used in the pre and post case to estimate the effect of leak fixes in the system. In cases were the system leak-down test is impractical, flow should be estimated by measuring compressor power and correlating to flow using CAGI sheets or standard flow tables. This compressor power be measured during non-production periods and all non-leak users of air should be discounted from the data to determine actual leak volume. Lastly, the most accurate approach is to measure actual flow rate in the pre and post non-production periods and discount for any non-leak air users. Installing flow meters can sometimes be invasive and prove impractical and hence the two prior methods are more common approaches. Ultrasonic leak detectors are good for identifying leaks and estimating savings at a high level; however, the three approaches detailed above provide a more accurate way of estimating leak loss.	Partially Implemented: Cadmus observed some projects where metered data was used during non-production periods to estimate leak savings. This was not universal across the project sites and in most cases the ultrasonic leak detectors was used to estimate savings. It should be noted that in most cases leak savings were derated to be more conservative.
	We recommend the program standardize the approach used to determine air-leak savings. Our analysis found that there were a few leak projects that claimed more savings than available air flow during nonproduction periods. This generally meant that the ultrasonic leak detector was overestimating savings. Contractors used different methodologies to adjust leak rates and to calculate	Partially Implemented: The calculations used to determine air-leak savings was not always consistent. In some cases, the ultra-sonic leak detector savings were derated by 50% and in other cases the full air leak

Program Track	2018-2019 Recommendation	Cadmus Observations
	savings for each of these projects, which resulted in different savings estimates. If pre- and post-metered data are not available, standardize the approach to using findings from the ultrasonic leak detector and adjust accordingly to reflect compressor flow during nonproduction periods.	cfm identified was used. For one project the PDC used non-production meter data to calculate savings.
Streamlined Industrial Lighting Projects	We recommend the program use light loggers more frequently to determine lighting hours of use and occupancy sensor savings for projects with significant electricity savings (i.e., greater than 500,000 kWh) and those projects that also have occupancy sensors. This will provide more accurate energy savings estimates.	In Progress: For the 2020 PE Impact Evaluation, Energy Trust requested that light loggers be installed at sites to provide more feedback on the deviation between customer reported hours and hours collected through the loggers. Cadmus installed light loggers at eight sites to that effect.
	We recommend the program apply a uniform approach to calculating HVAC interactive effects across all lighting projects. Upgrades to LED lights generally result in an increase in electricity savings through cooling savings and an increase in gas or electric consumption due to additional heating requirements. The program should apply a standardized approach to calculate interactive effects across all lighting projects to ensure these effects are accounted for appropriately	Not Implemented: This was not implemented for the 2020 program year. We observed that the only spaces where this was implemented were refrigerated spaces.
Other Recommendations	Virtual Site Visits: Cadmus recommends Energy Trust maintain the use of virtual site visits as an evaluation tool for verifying savings moving forward, especially for straight-forward measures that do not require additional metering or spot measurements. Cadmus developed a memo for Energy Trust titled, Virtual Site Visit Memorandum, which details considerations for virtual site selection and recommendations for measures that should be considered. A copy of this memo is included in Appendix D. Virtual Site Visit Memorandum.	Implemented: This was fully implemented, and the evaluation team was able to conduct virtual site visits whenever deemed appropriate.
	Metering Periods: We recommend the program use a minimum metering period of two weeks. Two weeks is typically enough to capture a full production cycle, but this is also dependent on the type of equipment, production schedule, seasonality, weather, and other factors. For example, HVAC systems may require months of data at longer intervals or multiple metering periods to characterize operation in the shoulder months. PDCs should take these dependencies into consideration whenever metering.	Partially Implemented: For some projects the metering periods observed exceed the recommended two-week minimum recommended. However, there were still a few projects observed during the evaluation that used metering periods of less than one week in the analysis.
	Project Classifications: For Energy Trust projects with multiple program tracks, we recommend the program assign one PE number for each program track. For example, PE14040 had two measures, one in the Custom Capital track and another in the Custom O&M track. Cadmus sampled at the project and track level, and in this case, sampled the measure associated with the Custom O&M track. Cadmus evaluated the savings of the measure in the Custom Capital track as part of the convenience sample. Assigning one PE number for each program	Not Implemented: For the sampled projects in 2020, Cadmus observed two projects that had two different track classifications (Custom Capital and Custom O&M) within the project reference number. This resulted in the sampled track being evaluated as a primary measure and the related non-sampled track evaluated as a convenience measure.

Program Track	2018-2019 Recommendation	Cadmus Observations
	track will help distinguish between the savings associated with the two tracks, aiding with sampling at the track level and confidence and precision calculations	
	Multiple Projects at Site: We recommend the program clearly specify projects that are located on the same site by assigning unique site IDs for each site. In the 2018-2019 program data, projects located at the same address did not always have the same site ID. In some cases, this resulted in contacting sites on different occasions for the impact evaluation. Assigning a clear and unique ID per site will allow Energy Trust to filter for all projects at a specific site and reduce the amount of outreach to sites with multiple projects	Implemented: The Energy Trust team provided feedback and support to identify projects that were located at the same facility. This alleviated the issue of having multiple projects at a specific site for customer outreach.
SEM	The in-depth interviews with site contacts confirmed that the COVID-19 pandemic affected facilities participating in SEM in a variety of ways. Some of these impacts may be long-lasting, and many of the energy intensity models, as they stand now, could provide inaccurate forecasts of baseline energy consumption in future program years. We recommend reviewing the effects of COVID-19 at each facility to determine if projects require re-baselining and new energy intensity models once normal operations resume post-pandemic.	Partially Implemented: For some sites, it was clearly documented through the SEM reports and confirmed during interviews that there were no COVID related impacts to facility's operations. However, for 2020 evaluation, in-depth interviews with site contacts confirmed that the COVID-19 pandemic affected SEM participating facilities in a variety of ways. Some of these impacts may be long-lasting, and many of the energy intensity models, as they stand now, could provide inaccurate forecasts of baseline energy consumption in future program years.
	The Energy Trust SEM M&V Guidelines recommend sites use a 90-day or 12-month reporting period for claiming annual program savings. Energy Trust should consider formally testing how changes to the reporting period definition (months covered and length of the period) impacts the annual savings claimed for a variety of facility types. Savings rates may remain consistent across all 12 months for certain production sectors, but a formal investigation would provide guidance on which facilities may suffer from greater inaccuracies under this assumption.	Not Implemented: There was no formal investigation conducted, however, in the annual savings reports, for nearly every project, the PDC clearly justified the baseline, engagement, and reporting period definitions. In particular, most projects that deviated from the standard of three- or 12-month reporting periods, the PDC justified this decision. Most often, the PDC increased the length of the reporting periods to six months to capture some of the summer and winter months or to avoid including a significant nonroutine event that was unrelated to the SEM engagement.
	When higher-frequency energy consumption data, such as daily data, are available for building the energy intensity models, we recommend interacting production variables with indicators at known change points to reduce modeling error and improve observed nonlinearity between energy drivers and energy consumption. Change points should be driven by knowledge of the facility to avoid overfitting.	Not Implemented: Cadmus observed nonlinearity in the relationships between independent variables and energy consumption at many of the sites. Often, the nonlinearity appeared to be driven by a change in this relationship for the highest- or lowest-production observations. As an example, a facility may reach peak efficiency at a certain production threshold, after which the marginal change in consumption for additional units produced is near zero. Treating these relationships as linear can systematically under- or

Program Track	2018-2019 Recommendation	Cadmus Observations
		overpredict observations with high or low production. This is particularly important in considering the future viability of existing baseline models at sites that experienced changes in production output towards the end, or after, their 2020 reporting periods.
	When appropriate, we recommend using heating and cooling degree-days in energy models rather than average temperature and higher-order polynomials. Energy consumption tends to correlate better to heating and cooling degree-days, especially when a high percentage of facility energy use is for space and process heating and cooling.	Partially Implemented: Several energy intensity models included weather in their models, as appropriate. Most facilities included weather in the models as HDD and cooling degree days (CDD). In its 2019 evaluation report, Cadmus had recommended that energy models use HDD or CDD when appropriate, instead of average temperature or higher-order polynomials. In 2020, sites using energy models were more likely to use HDD and CDD, as Cadmus had recommended previously, though notably the one gas model included in the 2020 evaluation did not (and as a result, underpredicted consumption in summer months).
	When SEM facilities diverge from IPMVP Option C for claiming energy savings due to their SEM engagement, Energy Trust should consider treating these projects like separate custom track projects requiring a distinct impact evaluation approach and interview or site visit with a different site contact – specifically, one most familiar with the major projects implemented.	Implemented: For projects where sufficient data was not available to conduct an Option C analysis, Energy Trust used a bottom-up approach like a custom analysis to calculate savings.
	To assist with future qualitative assessments of SEM savings, we recommend requiring sites to include the expected energy savings generated from major SEM projects as part of the opportunity register to increase the accuracy of realization rate adjustments based on these activities.	Partially Implemented: For SEM projects using an energy intensity model this was not implemented. However, for the bottoms-up SEM projects expected energy savings was provided for measures in the opportunity register.

Appendix A. Customer Introduction Letter

May 2021

Dear Customer,

I am writing to ask for your help with a study of projects that received support through Energy Trust's Production Efficiency program in 2020. As part of our commitment to continuous improvement, Energy Trust regularly evaluates our programs to ensure that they are meeting our expectations for energy savings, generation, and cost-effectiveness. The study's results will be used to inform Energy Trust on how much energy our programs save. The study's results **will not** be used to recalculate incentive payments, and will not divulge information that identifies a site. Your participation in this study will enable Energy Trust to improve our programs and the offerings available to businesses like yours.

Energy Trust has contracted with Cadmus, an independent research consulting firm, to confirm the energy efficiency measures installed in 2020, including the measure(s) installed at your facility. An engineer from Cadmus will be contacting you within the next few weeks to complete a short phone interview about your project. The engineer may also request to conduct a virtual or on-site visit to confirm the energy efficiency measures installed at your facility.

What to Expect if Selected for a Virtual or On-Site Site Visit:

With your permission, an engineer from Cadmus will:

- Schedule an on-site visit or video call with the appropriate project contact at your site
- View the equipment related to the program incentive and ask the contact a few questions
- Take or request additional photos or trend data
- For on-site visits, the Cadmus engineer may request to take spot measurements, install power meters or light loggers, depending on the energy efficiency measure installed. Any additional data collection will be non-invasive and will not interrupt facility operations. If preferred, the Cadmus engineer can work with the site contact to have facility staff install the data loggers.

For selected projects, the Cadmus engineer will provide you with the objectives of the video call or site visit and key points to be verified. For video calls the engineer will also confirm the software you prefer and any additional support documents. During the on-site visit or call, the Cadmus engineer will discuss and verify the key details and operating parameters of the energy efficiency project. Video calls may be recorded for reference and review by the engineer. Please be assured that any information or data gathered during the virtual visit will be treated as strictly confidential.

If you have any questions, please contact Joel Zahlan of Cadmus at 703.247.6140 or by email at joel.zahlan@cadmusgroup.com. We look forward to working with you on this important study. Thank you in advance for your cooperation.

Sincerely,

Erika Kociolek, Evaluation Sr. Project Manager

erika.kociolek@energytrust.org

503.445.0578

Appendix B. Customer Interview Guides

The interview guides will be shared as a standalone document.

Appendix C. Energy Trust Industrial Impact Evaluation Policies

Production Changes

- If evaluators find that production **levels** have changed significantly (more than ±10%) relative to the assumptions feeding into the *ex ante* savings, Energy Trust expects evaluators to capture the current production levels, and ask about the facility's expectations regarding production levels in the next six months.
  - If production levels have changed less than ±10%, then the assumptions feeding into the *ex ante* savings should be used.
  - If production levels have changed more than ±10% . . .
    - . . . and current production levels are expected to remain constant in the future, current production levels should be used to calculate *ex post* savings.
    - . . . and expected production levels in the next six months align with the assumptions feeding into the *ex ante* savings (regardless of current production levels), then the assumptions feeding into the *ex ante* savings should be used.
    - . . . and expected production levels in the next six months are expected to change relative to current production levels (and they differ from the assumptions feeding into the *ex ante* savings), then an average of current production levels and expected production levels in the next six months should be used to calculate *ex post* savings.
  - If evaluators are not able to capture current production levels, ask about the facility's expectations regarding production levels in the next six months, or obtain any other relevant information about the status of the facility or project, then the assumptions feeding into the *ex ante* savings should be used.
- If evaluators find that production **lines** have changed, evaluators should assess if the baseline used for the *ex ante* savings is appropriate, and assess how the changes affect the baseline.
  - Energy Trust and evaluators will discuss if a new baseline should be developed to calculate *ex post* savings.

Measure Removal in Operational Facilities

- If evaluators find that a measure has been removed, Energy Trust expects evaluators to determine when the measure was removed, and prorate the savings relative to the measure lifetime.
  - For example, if an O&M measure with *ex ante* savings of 15,000 kWh was in place for only the first year, then the *ex post* savings would be one-third of the *ex ante* savings (5,000 kWh).
  - For example, if a capital measure (a motor) with *ex ante* savings of 15,000 kWh was in place for only the first year, then the *ex post* savings would be 1/15 of the *ex ante* savings (1,000 kWh).

SEM

- Evaluators will review the final reports and energy models for errors and reasonableness, assessing the following:
    - Check for errors in modeling methods
        - Failure to account for capital measures
        - Incorrect accounting of capital measure savings
        - Incorrect accounting of other factors affecting facility energy use
        - Unexplained data excluded from regression model
    - Check for trends in baseline model residuals based on data in final reports and energy models
        - Residuals equal the difference between actual metered energy and predicted energy use for the baseline regression model; trends in residuals against fitted values or over time indicates that the model systematically underpredicts or overpredicts energy consumption and savings and suggests that important energy drivers have been omitted from the model
    - Check baseline and reporting periods
        - Baseline and reporting periods should be distinct
        - Baseline and reporting periods different than the standard of 12 months and 3 months, respectively, should be explained and justified
    - Verify capital projects and SEM activities as part of site visits and/or interviews
        - Verify the status of the capital projects documented in the final reports and opportunity registers. If they were implemented, determine if they are still in place, and if not, why not
        - Verify the status of the most impactful SEM activities documented in the final reports and opportunity registers. If were implemented, determine if they are still in place, and if not, why not
        - Gather information about additional activities and/or capital measures implemented since the SEM engagement, including when they were implemented
- Using the information gathered from the file review and the site visits and/or interview, evaluators will assign realization rates to reflect whether ex ante savings were likely underestimated, estimated accurately, or overestimated, as follows:
    - 90% to indicate that the claimed energy savings seemed unreliable or were likely overestimated
    - 100% to indicate that the claimed energy savings appears reasonable
    - 110% to indicate that the claimed energy savings were likely underestimated
- If evaluators determine that more rigorous quantitative evaluation of the energy models for specific projects are warranted, Energy Trust and evaluators will discuss how to proceed. In general, Energy Trust expects that more rigorous quantitative evaluation of the energy models

would only be used if there were significant changes at the site, or if evaluators were not able to contact customers to verify capital projects and SEM activities.

Facility Closures

- In 2011, Energy Trust completed a study of measures installed in industrial facilities between 2002 and 2009.
- Prior to 2011, Energy Trust utilized a measure lifetime of 10 years for the majority of capital industrial measures to address the issues of plant closures and process line changes over time.
- The study found that the vast majority of measures (98%) were still in place, and concluded that the measure lifetime of ten years was very conservative.
- In response, Energy Trust began using a measure lifetime of 15 years.
- Evaluators may determine that a facility is permanently closed or temporarily inactive based on information provided by the site contact, by Energy Trust and/or the PDCs, by publicly available information, and/or by information collected in the course of data collection – e.g., voicemail messages or e-mail bouncebacks.
- A facility closure is defined as a facility that is permanently closed or temporarily inactive at the time of the evaluation
- For **permanently closed facilities**, Energy Trust believes that facility closures are accounted for in the measure lifetime *for capital measures* used by Energy Trust, and expects evaluators to calculate *ex post* savings for capital measures installed in closed facilities similarly to how they would normally – the key is that the facility closure does not, as a matter of course, mean that the capital measure receives a realization rate of zero. Unlike the case of measure removal, for permanently closed facilities, the savings will not be prorated relative to the measure lifetime.
- For **temporarily inactive facilities** (to be determined based on information provided by the site contact, by Energy trust and/or the PDCs, by publicly available information, and/or by information collected in the course of data collection – e.g., voicemail messages or e-mail bouncebacks):
  - If the facility has projects not sampled for certainty strata, evaluators may drop the projects and replace them with back-up projects.
  - If the facility has projects sampled for certainty strata, evaluators will need to perform desk reviews. If evaluators do not feel comfortable performing desk reviews to assign realization rates, Energy Trust and evaluators will discuss how to proceed.
- A facility that has curtailed shifts or furloughed employees temporarily is not permanently closed. It *may* be considered temporarily inactive, depending on the specific circumstances of the facility. Either way, evaluators should reference the Production Changes section, above.
- Since Energy Trust does not regularly undertake studies to assess measure persistence, impact evaluations are an important source of information, and insights gained from impact evaluations may be used to adjust measure lifetimes for the program at large, for certain measures, and/or certain types of customers.

Customer Non-Participation in Impact Evaluations

- In general, Energy Trust expects most customers to participate in impact evaluations.
- In prior years, only a handful of customers (1) refuse to participate or (2) do not participate because evaluators are not able to contact customers due to, for example, a facility closure (addressed above), or lack of response to repeated attempts to make contact.
  - For projects not sampled for certainty strata, evaluators may drop the projects and replace them with back-up projects.
  - For projects sampled for certainty strata, evaluators will need to perform desk reviews. If evaluators do not feel comfortable performing desk reviews to assign realization rates, Energy Trust and evaluators will discuss how to proceed.

A Note About Broad Social and Economic Changes

- Over the past 15 years, Energy Trust has seen several events, including the 2008 recession and COVID-19 pandemic, which have resulted in relatively rapid changes to facility operations and significant uncertainty about the future.
- These events, and the resulting changes to facility operations, complicate impact evaluation, due to uncertainty about the duration of these events and the durability of the resulting changes to facility operations.
- In all cases, Energy Trust and evaluators will discuss how to proceed
  - If Energy Trust and evaluators are both in agreement, evaluators will not use production, billing, or operational data in the evaluation – the event will essentially be considered a blackout period.

Evaluators should consult with Energy Trust staff if they are uncertain how to apply the above policies to a given project, or if there are situations that are not addressed above.

Appendix D. Virtual Site Visit Memorandum

To: Erika Kociolek; Energy Trust of Oregon

From: Cadmus EM&V team

Subject: Virtual Site Visits

Date: July 30, 2020

The COVID-19 pandemic has resulted in significant and rapid changes to facility operations and caused uncertainty about future operations. This has complicated impact evaluations and especially affected on-site project verifications. Energy Trust of Oregon has provided guidance for impact evaluation activity, including updating its industrial impact policies and providing alternative approaches to project verification. Specifically, this guidance provides virtual site visits as an option for savings verification across the portfolio. This memo reviews the considerations that influence the successful implementation of this methodology and identifies some considerations and limitations.

A virtual site visit involves web-based audio and video to facilitate face-to-face interaction with a project-specific site contact. This allows the evaluation team to verify projects and observe performance parameters remotely in real time. The evaluator may use a combination of the following to verify savings:

- Virtual site-visit observations (for example, a video recording, interview with the site contact, or photos taken during the virtual tour)
- Additional submitted project documentation, such as invoices, specification sheets, calculation models, and site-provided meter or trend data.

When physical access to a customer site is not feasible, a virtual site visit is a useful tool to gather the site-specific conditions and data needed to determine measure savings.

Careful selection of sites, projects, and technology for virtual verification is of vital importance. Table 1 shows the criteria for determining potentially eligible sites. These selection criteria may evolve as we implement the virtual site visit methodology and gather additional information.

Table 1. Virtual Site Selection

Consideration		Selection Criteria
1	Safety	• The sites and measures selected must be deemed safe for verification by a site contact. This method relies on site contact accessing equipment for verification. Sometimes the equipment may be located in spaces that are not easy to access or may involve operating equipment that requires professional training. • For example, it's preferable to select sites that do not require the site contact to climb ladders or access electrical panels for a virtual site visit.

Consideration		Selection Criteria
2	Data security, privacy, and participant operational policies	• We follow participant operational policies and address their privacy concerns. • A virtual site visit is not feasible if the customer's policies explicitly forbid virtual access to their location. For example, video or photos may not be allowed in research and development facilities. • A virtual site visit is also not possible if the customer refuses access due to privacy and data security concerns. These concerns could be mitigated through the following procedures: • Use of universally accepted virtual tools with tested security provisions and protocols, such as Microsoft Teams, FaceTime, or other tools. • Ensure that all recorded video calls, photos, and requested materials will be saved and uploaded to a secure location accessible only to key personnel. • All the customer's operational policies (e.g., data security, safety policies) must be carefully followed to ensure confidence and trust in the virtual process. Therefore, it is important to have experienced site inspection staff conduct the virtual site visits to access project data.
3	Site or project characteristics	• Sites that involve a large number of projects may be not be good candidates for virtual verification. • For example, it is not efficient for the site contact to attempt to walk the evaluator through a site with 5 dissimilar projects, which would involve a significant amount of time and effort for the customer to verify each one. • Additionally, sites that involve a significant number of measures that are similar in nature can be difficult for the site contact to validate appropriately (for instance, projects involving the same lighting or refrigeration equipment installed in different parts of facility during different periods in a program year will need to be identified, recorded, and verified separately). • Similarly, a lighting project with 1,000 light fixtures to verify is not a good candidate for virtual inspection as it will require significant effort from the customer. The site contact will need to verify and record the quantity, make and model of the equipment, the location and operating conditions, and other inputs that inform the savings calculation. • Some projects and measures are not easy to verify virtually due to their size, complexity, and other characteristics. • Extremely large projects or projects involving complex measures, such as combined heat and power, large multi-air compressor systems, and unique process-related projects, may not be good candidates for virtual site visits. This is because verification of these projects may involve metering and will require detailed information on operating parameters as well as additional data collection (production, indoor and outdoor temperature, process temperature, and run times of production equipment). • In contrast, projects involving boilers, process heaters, small air compressor projects and measures (air dryers and no-loss drains), small HVAC equipment, small lighting projects, or controls may be good candidates because they can typically be verified efficiently and directly at the unit. • Projects that cannot be clearly visually verified may not be ideal for virtual site visits. • For example, air leak repairs are not ideal because they are difficult to verify visually and will be more difficult over a virtual call. In addition to detailed leak repair logs and accessibility issues, inspections may require ultrasonic detection equipment that might not be available on site (or the site contact is not trained to use). • Projects where trend data or metered data are available may be good candidates for virtual site visits. • For example, a project involving an air compressor or chiller that has trending capability or metered data is a good candidate because the virtual site visit can focus on verifying specific data points, such as setpoints, hours of operation, nameplate information, and the analysis can incorporate these inputs with the available data.

Consideration		Selection Criteria
4	Site contact knowledge and time requirement	• Site contacts must have sufficient knowledge of the project and equipment and be able to perform the virtual visit and gather data required for verification. • Time requirement for site contact. • The site contact will possibly need to participate in a pre-site call and provide supporting documentation such as images and video. The contact may need to be available for follow-up questions as well, potentially requiring more time and effort than is typical with an on-site visit.
5	Data collection quality and input assumptions	• Virtual site visits rely on data collection by site contacts who may not have the appropriate background and training needed to gather savings calculation inputs. • The evaluator may need to provide training through clear communication with the site contact such as video call guidance support, measurement and verification plan support, and data request details prior to virtual site visit. • Site contacts will participate in an interview with the evaluator. The interview will determine the site contact's ability to capture inputs such as production data, hours of operations, impacts due to COVID-19, willingness to complete a virtual site visit, etc. • A suitable site contact must demonstrate he or she is knowledgeable about the projects and business contexts and can safely gather the necessary data without undue burden.
6	Technology	• Possible technical limitations, such as internet connectivity, cell phone reception, and lack of video or photo technology, could prevent virtual site visits. • For example, connectivity issues may prevent live videos if equipment is located in basement locations. • Energy Trust could mitigate this issue by accepting non-live video recordings and photos of nameplates for reference and review.

Specific Examples

This section outlines specific examples of measure types and their suitability for a virtual site visit.

Suitable Measures for Virtual Site Visits

Projects that Use Measure Approval Documents (MADs): These projects—such as inverter-driven welders, forklift battery chargers, process hot water boilers, industrial green motor rewinds, commercial insulation, and pipe insulation—are strong candidates for virtual site visits. The calculation methodologies for these measures are clearly defined, with a protocol the evaluator can follow during the verification process. The main verification points are typically equipment installation, operation, nameplates, quantities, operating parameters, and hours of operations.

Boiler Projects. This type of project is a good candidate for a virtual site visit because the calculation methodology is clearly defined, and operating parameters are easy to verify. The main verification points are the boiler nameplate data, heat input and output, efficiency, hours of operation, boiler load, specification sheets, invoices, pressures, and temperatures. The evaluator can generally verify performance by first confirming that the boiler is installed and operational and then visually verify that the system is operating correctly. A walk-through with the site contact is safe as this project is usually found in in a separate boiler room away from facility activities.

Projects with Trend Data: Projects with trend data—such as chillers, air compressors, and pumps and fans with variable frequency drives—are good candidates for virtual site visits. The evaluator can focus the virtual site visit on verifying equipment installation, operating parameters, and operating status. The evaluator can also discus production-related questions and request trend data during the virtual visit to verify savings.

Challenging Measures for Virtual Site Visits

Large Lighting Projects: Large lighting projects with large fixture quantities, typically more than 100 fixtures, are not good candidates for virtual verification as these require significant effort from the site contact to walk through the facility, verify counts, and verify wattages. These projects could also pose a safety risk to the site contact as they typically require the use of a ladder to confirm lamp nameplate data.

Large and Complex Custom Projects (with electric metering): In general, any custom projects that require metered data not already available—such as large combined heat and power projects, air compressors, and unique process improvement measures—are not an ideal candidates for virtual site visits. Metering a project requires specific training and could pose a safety risk if the correct safety measures, typically involving a licensed electrician, are not followed. Large and complex projects also add an additional layer of difficulty as there may be additional data streams—such as indoor and outdoor temperature, production levels, process temperatures, pressure, and flow data–that need to be captured for verification.

Appendix E. Confidential – Non-SEM Final Site Reports

The confidential Final Site Reports will be shared as a standalone document.

Appendix F. Confidential – SEM Final Site Reports

The confidential Final Site Reports will be shared as a standalone document.