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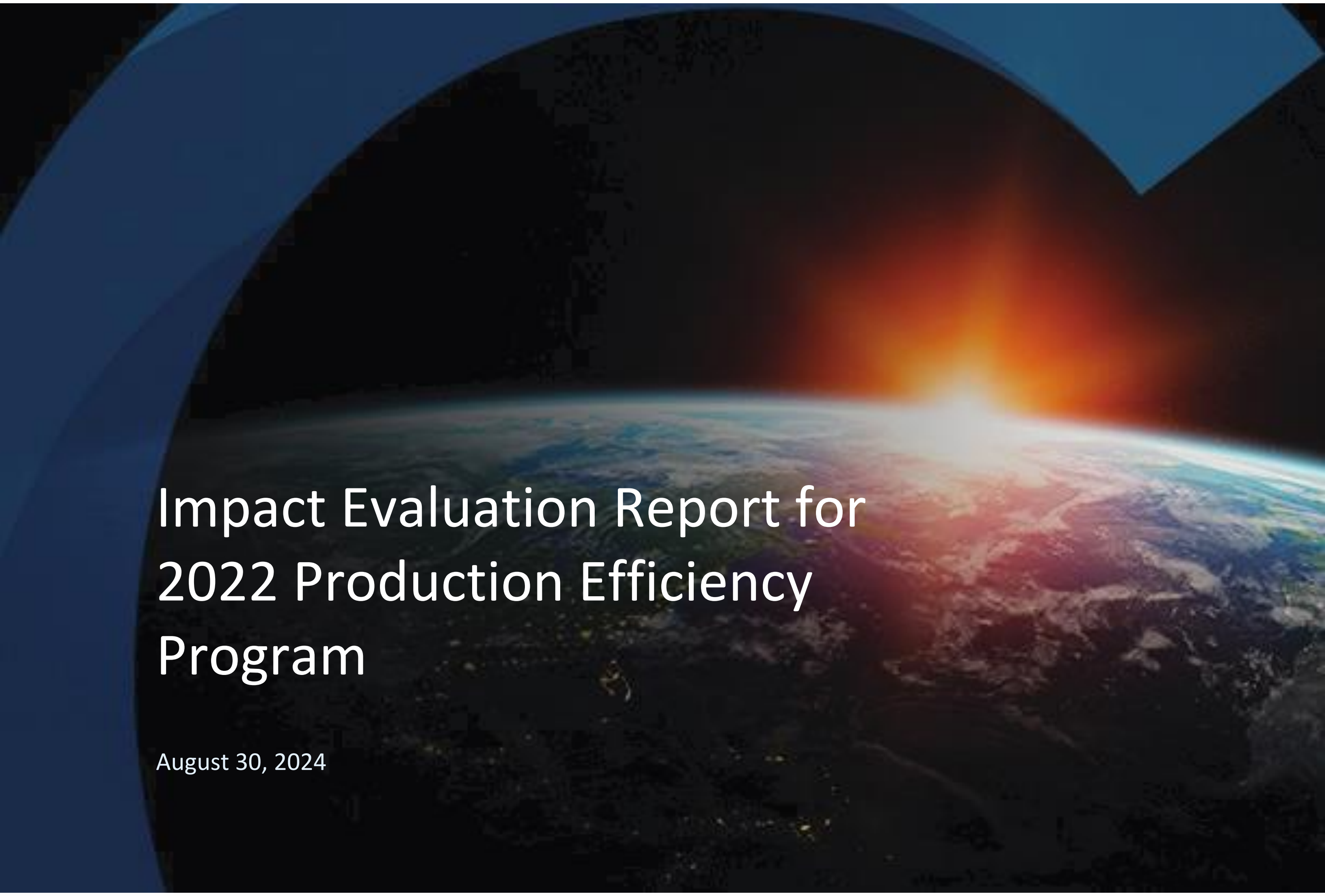

Impact Evaluation Report for 2022 Production Efficiency Program

August 30, 2024

Prepared for:

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Acronyms

BML	Balance of measure life
CDD	Cooling degree day
CAGI	Compressed Air and Gas Institute
EMS	Energy Management System
EUL	Expected Useful Life
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
PDC	Program Delivery Contractor
PMC	Program Management Contractor
PE	Production Efficiency
PGE	Portland General Electric
PPS	Probability proportional to size
RTF	Regional Technical Forum
RUL	Remaining useful life
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 management contractors and program delivery contractors. Their collective assistance with customer outreach, ensuring that the evaluation team had the necessary data and information to verify and measure project savings, and their 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 to 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.

The Production Efficiency Program provides energy efficiency services and incentives to industrial and agricultural businesses through a single program. Production Efficiency provides a robust set of custom, standard and downstream lighting offerings that have been designed to help energy intensive and complex organizations achieve cost-effective savings on an ongoing basis. Through engaging with Energy Trust, industrial and agricultural businesses in Oregon invest in and manage their energy use, improving their profitability, productivity, and sustainability. This report documents the impact evaluation Cadmus conducted of the Production Efficiency (PE) program for program year 2022 with the following objectives completed:

1. We developed reliable estimates of the gross electricity and natural gas savings directly attributable to each program track. We achieved a statistical level of 96.3% confidence with ±4.3% precision for electric savings and 98.8% with ±3.5% precision for gas savings, which was within the 90% confidence with ±10% precision objective.
2. We performed an electric demand savings analysis comparing measure specific demand savings to load shapes. We did not perform natural gas demand savings analysis.
3. We report observations and make recommendations to help Energy Trust improve the effectiveness of its estimates of energy savings and demand reduction in this report.

The PE program's delivery structure is comprised of two program tracks: Standard Industrial and Custom. Eligible customers can participate in one or both tracks. The Standard Industrial track includes prescriptive rebates and calculated incentives, as well as lighting offered through Downstream, Midstream and Direct Install delivery channels. The Midstream and Direct Install Lighting delivery channels are managed by a PDC, CLEAResult, under Energy Trust's Business Lighting program. Starting in 2024, industrial sites participating in Downstream lighting are managed by the Production Efficiency PMC, Energy 350. The Custom track provides comprehensive capital upgrades and operations and maintenance (O&M) improvements, as well as industrial Strategic Energy Management (SEM).

For the purposes of this impact evaluation, we evaluated based on the following four tracks. These differ from the program track definitions described above, but align with prior impact evaluations:

- Streamlined Industrial (prescriptive, standard calculated)
- Lighting (direct install, downstream, and midstream/instant discounts)
- Custom (custom capital and custom O&M)
- Strategic energy management (SEM)

For the evaluation of the 2022 program, Cadmus sampled 127 distinct projects at 110 sites to provide a mix of measure types. For the 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 evaluation 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, the final sample represented 62% of electric savings and 49% of natural gas savings for the program's total reported savings.

Table 1. 2022 Program and Sample Total Project Quantities and Reported Savings

Program Year	Fuel Type	Program Projects[a]	Sampled Projects[a]	Electric Savings (kWh)		
				Program	Sampled	Percentage Sampled
2022	Electric	858	112	98,443,700	60,917,399	62%
2022	Natural Gas	44	21	1,441,294	712,502	49%

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

Cadmus used the *Energy Trust Industrial Impact Evaluation Policies* as a reference to guide adjustments and ensure uniformity. 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 standard calculated 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 for top-down models and through analysis of custom measures using algorithms, detailed calculation spreadsheet reviews, power metering data, and/or energy management system (EMS) trend data for bottom-up models.

Realization Rates Summary

Table 2 lists the overall program realization rates with confidence and precision by fuel type for the PE program. In general, the program demonstrated consistently strong realization rates.

Table 2. Production Efficiency Program 2022 Realization Rates by Fuel Type

Fuel Type	Reported Savings	Evaluated Savings	Realization Rate	Relative Precision [a]
Electricity (kWh)	98,389,979	94,753,633	96.3%	4.3%
Natural Gas (therms)	1,441,294	1,423,354	98.8%	3.5%

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

Table 3 and Table 4 summarize the achieved realization rates by year, track, subtrack, and fuel type.

Table 3. Production Efficiency Program Realization Rates by Subtrack, Electric Savings

Track	Subtrack	Electricity			
		Reported (kWh)	Evaluated (kWh)	Realization Rate	Relative Precision[a]
Custom	Custom Capital	35,856,586	33,340,923	93.0%	11.0%
	Custom O&M	2,268,922	2,140,467	94.3%	8.6%
	Total	**38,125,508**	**35,481,390**	**93.1%**	**10.3%**
SEM	SEM	24,194,910	23,828,858	98.5%	3.9%
	Total	**24,194,910**	**23,828,858**	**98.5%**	**3.9%**
Lighting	Lighting Direct Install	811,081	811,081	100.0%	0.0%
	Lighting Downstream	11,695,058	11,327,476	96.9%	3.9%
	Lighting Midstream/Instant Discounts	5,604,553	5,604,553	100.0%	0.0%
	Total	**18,110,692**	**17,743,110**	**98.0%**	**2.5%**
Streamlined Industrial	Green Motor Rewind[b]	N/A	N/A	N/A	N/A
	Prescriptive	11,104,033	11,095,446	99.9%	0.4%
	Standard Calculated	6,854,835	6,604,828	96.4%	28.5%
	Total	**17,958,868**	**17,700,274**	**98.6%**	**9.4%**
Total		**98,389,979**	**94,753,633**	**96.3%**	**4.3%**

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

[b] We did not evaluate the Green Motor Rewind subtrack in 2022 because the measure was retired in Q3, 2023.

Table 4. 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	281,629	254,989	90.5%	21.4%
	Total	**281,629**	**254,989**	**90.5%**	**21.4%**
SEM[b]	SEM	383,273	383,273	100.0%	NA
	Total	**383,273**	**383,273**	**100.0%**	**NA**
Streamlined Industrial	Prescriptive	479,269	491,401	102.5%	1.5%
	Standard Calculated	297,123	293,691	98.8%	0.0%
	Total	**776,392**	**785,092**	**101.1%**	**0.9%**
Total		**1,441,294**	**1,423,354**	**98.8%**	**3.5%**

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

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

The program achieved subtrack realization rates ranging from 93% - 102.5%, as seen in Table 3 and Table 4, which is in line with previous impact evaluations. Custom and custom O&M electricity realization rates were comparatively low, especially Custom capital with a 93% realization rate. The lower realization rates are predominantly due to changes in operation conditions outside of the influence of the program. Custom natural gas savings also had a lower realization rate of 90.5%, but this was a result of a combination of factors, including three similar projects all using inconsistent or incorrect savings calculations methodology, and a measure removal due to a change in heating source.

Table 5. Production Efficiency Program Realization Rates for 2016 through 2022 by Fuel Type

Fuel Type	2016	2017	2018	2019	2020	2022
Electricity	86%	90%	101%	101%	98%	96%
Natural Gas	98%	94%	78%	104%	97%	99%

*An impact evaluation as not performed for PY 2021

Overall, the program achieved high realization rates for electric and natural gas savings. Electric had a slightly lower realization rate in 2022 compared to 2020. Gas achieved a slightly higher realization rate in 2022 than 2020. These results show a high degree of consistency in recent years for both fuel types, as seen in the table above.

Overall, the PDCs performed a reasonable level of review and quality control to achieve high average project savings realization rates. The PMC proved extremely knowledgeable about the facilities with which they worked and were receptive to supporting evaluation efforts. Cadmus worked directly with the PMC on a few occasions to contact facilities and acquire analysis files and data. We found that most PMC staff 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 program 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. Energy Trust staff were responsive and supportive of all evaluation activities, which contributed to the success of the 2022 impact evaluation.

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 project subtrack, shown in Table 6.

Table 6. 2022 Evaluated Coincident Peak Demand Savings by Subtrack

Track	Subtrack	Winter Demand Savings (kW)	Summer Demand Savings (kW)
Custom	Custom Capital	3,468	3,972
	Custom O&M	45	46
	Total	**3,513**	**4,018**
Lighting	Lighting Direct Install	7	6
	Lighting Downstream	486	496
	Lighting Midstream/Instant Discounts	129	106
	Total	**622**	**608**
Streamlined Industrial	Green Motor Rewind	-	-
	Prescriptive	297	699
	Standard Calculated	78	85
	Total	**375**	**784**
SEM	Strategic Energy Management	2,371	3,129
	Total	**2,371**	**3,129**
Total		**6,882**	**8,539**

Electricity and Natural Gas Adjustments

Cadmus organized savings adjustments into the following categories:

- **Different operating hours/conditions:** Equipment operating hours or average operating conditions differed from what was specified in the *ex ante* savings calculations.
- **Different equipment setpoints:** Equipment setpoints differed 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 facility or a discontinued process line.
- **Inappropriate baseline:** This involved baseline equipment specifications that did not align with code or industry standard practice.
- **Inappropriate assumption:** Any adjustments to 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 had not been updated.
- **SEM adjustment:** We adjusted savings for some SEM projects due to observations during site visits, interviews, or review of the energy intensity models. Bottom-up savings received adjustments based on the above categories, while top-down models had more qualitative adjustments considered.

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 natural gas fuel type, incorrect analysis methodology was the most prevalent adjustment category**.**

When 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	Projects Adjusted (n=112)[a]	Absolute Adjusted Savings[b] (kWh)	Percentage of Savings Adjusted (Category Adjusted Savings/ Total Adjusted Savings)
Different operating hours/conditions	16	2,389,939	64.1%
Different equipment setpoints	7	385,220	10.3%
Inappropriate baseline	8	265,358	7.1%
Measure removal	1	247,036	6.6%
Incorrect equipment specifications or quantities	6	175,114	4.7%
Inappropriate assumption	4	122,620	3.5%
Calculation or engineering error	2	96,471	2.6%
Incorrect/different analysis methodology	2	42,082	1.1%
Total	**46**	**3,730,162**	**100%**
Natural Gas Savings Adjustments	**2022 (n=21)[a]**	**Absolute Adjusted Savings (therms)**	**Percentage of Savings Adjusted (Category Adjusted Savings/ Total Adjusted Savings)**
Incorrect/different analysis methodology	4	26,206	68.8%
Different equipment setpoints	1	6,580	17.3%
Inappropriate baseline	1	3,432	9.0%
Measure removal	1	1,867	4.9%
Total	**7**	**38,085**	**100%**

[a] n reflects the number of unique of project IDs evaluated for 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.

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

- For projects where energy consumption is dependent on key parameter data that is outside the influence of the upgrade (such as flow rates, cooling loads, or production variables), we recommend more detail in the persistence plan describing the expected operating range and its impact on performance. For example, a chiller VFD retrofit and controls project energy savings is determined by the cooling load served, typically from 250 tons to 750 tons. Emphasizing that the majority of savings occur from the 250 – 350 ton range although the majority of the time is spent above 350 tons, and that lower the load served, the higher the savings, can help the customer and evaluator easily identify whether the change in savings is to be expected.

- The PDC verification reports frequently used the average input power of two weeks of logged data multiplied by annual operation hours to determine verified energy consumption. This is a sound method to determine annual energy consumption, but we recommend adding additional key parameter monitoring to normalize the savings if appropriate. For example, for a compressed air VFD compressor upgrade, savings are determined based on system flow. In addition to metering compressor power for two weeks, monitor pressure or flow as well to verify the compressor is operating in the same flow range as the analysis.
- For particularly large projects, consider a real-time, in-depth evaluation. A more in-depth evaluation is usually required for larger project, and fluctuations in process or load data can result in differing realization rates when significant time has elapsed since project verification. The specific projects that could have benefited from real-time, in-depth evaluation include: PE19043, PE16927, PE17258, PE17099, PE18916 and PE18320. In addition to each project having savings over 1.25 million kWh, energy savings were largely impacted by a key parameter outside of the project scope. Nitrogen demand and generation, compressed air flow, irrigation flow, and production cooling load were all key parameters that were found different than the verification conditions, impacting evaluated savings.
- Custom O&M measures were a small fraction of overall program savings. Only Territory 2 had sampled O&M projects, all of which were compressed air leak repairs. We recommend moving compressed air leak repair to a streamlined program measure that uses a standardized leak flow estimate developed from verification results. Leak flow calculations vary based on manufacturer of leak detectors, field technician identifying leaks, and implementation tools used. Standardizing to common leak size ranges will reduce time and technical rigor required for this measure, reducing both customer and PMC time required to attain savings.

Lighting

- We recommend the program perform additional verification of lighting schedules and levels for large lighting projects (>150,000 kWh/year) that use controls to verify operating hours and light levels. This can be accomplished through trend data reports or evidence of lighting control schedules from a BMS in the project package.
- We recommend removing references to a federal baseline adjustment if it is no longer applicable.
- We recommend that the program add guidance for baseline lighting determinations and savings calculation methodology for custom grow light projects.
- We recommend providing documented demonstrations of how the lighting tool approach aligns with or connects to a lighting measure's associated MAD as part of the project savings calculation package. Specifically, we recommend highlighting the EUL, RUL, final BML, and Wattage Ratio "current to pre-condition" and “current practice to energy efficient" used to determine the baseline system watts used in the final savings calculation.

Streamlined Industrial

- The largest differences in realization rates were found to be from invoice reviews not matching project application values. We recommend highlighting application inputs from invoices and supporting documentation, such as equipment quantity, baseline costs, specifications, and other relevant factors.

Strategic Energy Management

- Only bottom-up SEM engagements received realization rates different than 100%. These projects are often more difficult to evaluate after subsequent Continuous SEM activities. We recommend more thorough documentation of savings calculations and persistence for bottom-up calculations by using logged or spot-checked data for projects accounting for 25% or more of the engagement savings.
- The Energy Trust SEM M&V Guidelines recommend that 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 (specific months covered and length of the period) impact 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..
- When higher-frequency energy consumption data, such as daily data, are available for building the energy intensity models, we recommend using interacting production variables and 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.
- Energy Trust should work with implementers to improve and standardize documentation of any savings adjustments resulting from 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 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 evaluators determine the 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 that 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 control changes or equipment repairs and automation, then Energy Trust should follow an approach similar to how custom project facility closures are handled. However, if measures are predominantly behavioral, Cadmus recommends that these projects be addressed as measure removals considering the unlikelihood of behavioral measures persisting 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 Parameters

We recommend that the program use a representative metering period with a minimum of two weeks. The metering period should capture a full production cycle, but an optimal length depends on the type of equipment, production schedule, seasonality, weather, and other factors. The key factors impacting equipment energy consumption should be clearly stated, as well as the observation range. For example, a fan VFD upgrade should include input power for a full production schedule, a full speed range, and indicate and meter the variable that dictates fan speed (such as suction pressure).

Demand Savings Calculations

- **Develop Demand Methodology to Report Savings:** The peak multiplier method Energy Trust currently employs 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. In many cases, the PDC has performed a peak demand analysis as a component of the energy calculations. We recommend establishing peak demand windows and reporting peak demand savings based on the difference in baseline and post installation power during those windows.
- **Report Equipment Load Shapes, not Facility Load Shapes:** In many cases, the load shape selected is for the facility rather than the equipment operation. Although most processes follow the production load shape, some auxiliary and support equipment deviate from the load shape (such as air compressors, dust collection, or vacuum pumps), or have significant weather impacts (such as HVAC, chillers and boilers). We recommend that load shapes be reported based on equipment operation rather than facility load shape.

Operations

- We recommend updating the *Energy Trust Industrial Impact Evaluation Policies* (see *Appendix B*) to include guidance on how to account for interactive realizations rates for facilities completing capital projects during SEM engagements.

We recommend setting up the expectation with the customer that it is likely there will be a follow-up evaluation after the project has been claimed. Clearly communicating the persistence strategy or key parameters impacting energy consumption for each project improves realization and reduces the time spent by the customer and evaluators reviewing the project.

MEMO

Date: 1/3/2025
To: Energy Trust Board of Directors
From: Leila Shokat, Project Manager – Evaluation
Eric Braddock, Senior Technical Manager – Industry and Agriculture
Laura Schaefer, SEM Program Manager – Industry and Agriculture
Amanda Potter, Sector Lead – Industry and Agriculture

Subject: Staff Response to Impact Evaluation of the 2022 Production Efficiency Program

The 2022 Production Efficiency Impact Evaluation assessed the performance of projects claimed in the 2022 program year in the Custom and Standard Industrial tracks. The Custom track includes comprehensive capital upgrades, operations and maintenance (O&M) improvements and industrial Strategic Energy Management (SEM). The Standard Industrial track includes prescriptive rebates and calculated incentives, as well as lighting offered through Downstream, Midstream and Direct Install delivery channels. The results of the evaluation show the program performed well in 2022, with overall program realization rates of 96% for electricity and 99% for natural gas.

In 2022, the Production Efficiency program operated with three program delivery contractors (PDCs)—Energy 350, Cascade Energy and RHT Energy—as well as a Business Lighting PDC, CLEAResult. Starting in 2023, the program transitioned to a program management contractor (PMC) model, with Energy 350 as the PMC. This 2022 impact evaluation covers the last year of the program's PDC model. For the purposes of this evaluation, projects were evaluated in the following four categories: Custom, SEM, Standard Industrial and Lighting.

The Custom track saw realization rates of 93% for electric and 91% for natural gas. The evaluation found the majority of projects with savings adjustments resulted from factors outside of the program's control, including changes in operating hours or conditions, equipment setpoints or measure removal. The Production Efficiency program currently provides customers with persistence plans, which describe key parameters that could influence a facility's savings persistence over time. The program will consider the recommendation to provide additional information as to how the savings would change as those key parameters change, which could reduce the incidence of customers making system changes that may impact their realized savings.

SEM projects also saw high realization rates of 99% for electric and 100% for natural gas. Most recommendations for improvement in SEM projects related to documentation of savings calculations and savings adjustments. With the change to SEM projects being managed by a single PMC instead of multiple PDCs, and with the implementation of the Energy Performance Platform (EPP) for SEM projects, the program has already been able to further standardize documentation of these project elements. The 2023 program year impact evaluation, which is currently underway, will include projects that used the EPP platform for the first time.

The Standard Industrial track saw strong realization rates of 99% for electric and 101% for natural gas, with no areas where systematic improvements could be made.

In 2022, Business Lighting (which also serves commercial customers) was delivered by CLEAResult. Lighting projects returned a strong realization rate of 98%, with most adjustments resulting from baseline adjustments or adjusted operating hours for downstream projects. The recommendation to perform additional verification for large downstream lighting projects was considered by the program. For some of these projects, the PMC performs site visits, however with the trade ally-driven delivery model of downstream lighting, additional verification would be difficult to implement. Evaluation staff will consider placing greater emphasis on downstream lighting in future Production Efficiency impact evaluations due to the complexity of these projects.

Program staff agree with the recommendation to move compressed air leak repair to a more streamlined offer and have already begun implementing this in 2024, using standard leak rates and requiring less project-specific documentation from customers.

PMC staff and program staff provided invaluable assistance through their specific project knowledge and ongoing relationships with customers. This helped in the evaluation and is an indication of the successful transition between implementers since the 2022 program year. Evaluation and program staff will continue to collaborate to update the Industrial Impact Evaluation Guidelines and explore ways to improve the customer experience of evaluations while maintaining their rigor and the timeliness of results.

Introduction

Energy Trust of Oregon (Energy Trust) contracted Cadmus to complete an impact evaluation of the 2022 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.

2022 Program Savings

The PE program is comprised of two main program tracks: Standard Industrial and Custom. Eligible customers can participate in one or both tracks. The Standard Industrial track includes prescriptive rebates and calculated incentives with wide-reaching applicability across industrial and agricultural market sectors. This track delivers savings from irrigation, compressed air, greenhouse, HVAC, and other prescriptive and calculated measures. The Standard Industrial track also includes lighting savings from lighting and lighting controls measures, offered through Downstream, Midstream and Direct Install delivery channels. The Midstream and Direct Install Lighting delivery channels are managed by a PDC, CLEAResult, under Energy Trust's Business Lighting program for commercial and industrial customers. Starting in 2024, industrial sites in the Downstream portion of Business Lighting are managed by the Production Efficiency PMC, Energy 350. This evaluation will include industrial downstream lighting customers who participated in 2024. Lighting that is managed under the Business Lighting program is not within the scope of this impact evaluation.

The Custom track provides comprehensive capital upgrades and operations and maintenance (O&M) improvements delivered via one-on-one customer outreach and technical support. The PMC or its subcontractors performs technical analysis studies for custom projects to support customer and program investment decisions. Savings and incentive payments for Custom capital and O&M projects are calculated in the technical analysis study and verified after installation. In 2023, the program developed an O&M Optimization offering, with the goal of removing barriers to completing discrete O&M projects.

The Custom track also includes industrial Strategic Energy Management (SEM). Energy Trust introduced SEM in 2009 to help industrial facilities of all types and sizes implement a holistic approach to energy management. Through SEM, manufacturers can reduce energy use immediately and establish a strong foundation for future continuous energy improvement.

For the purposes of this impact evaluation, we evaluated based on the four following tracks, which is consistent with prior impact evaluations and more closely aligns with how project and measure data are captured in Energy Trust systems:

- Lighting
- Streamlined Industrial (prescriptive and standard calculated)
- Custom (custom capital and custom O&M)
- Strategic energy management (SEM)

Eligible customers can complete multiple projects per year, in any of the tracks.

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.

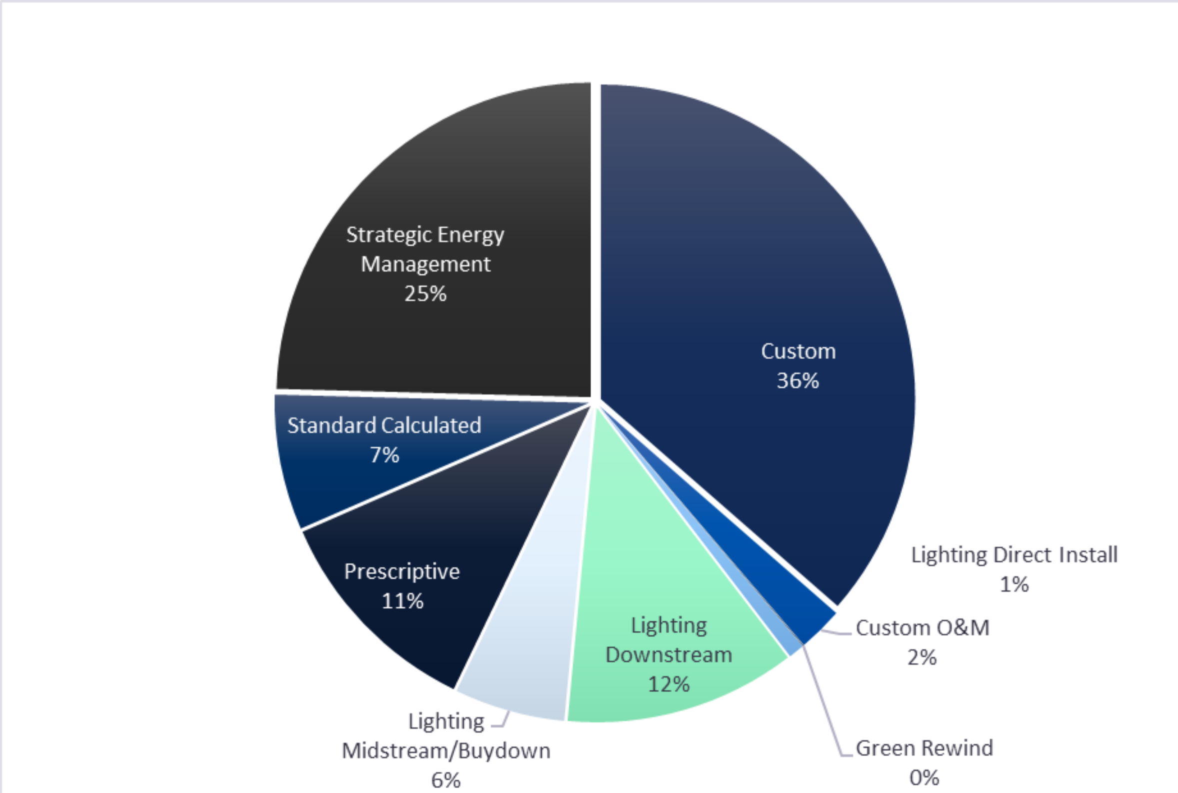
Table 8. Production Efficiency Program Completed Projects and Reported Savings, 2022

Program Year	Track	Sub-Track	Sites[a]	Projects[a]	Measures[a]	Electric Savings (kWh)	Natural Gas Savings (therms)	Total Evaluated Projects[b]	Site Visits
2022	Custom	Custom Capital	72	87	113	35,856,586	281,629	42	18
		Custom O&M	23	23	27	2,268,922	-	3	1
	Custom Subtotal		95	110	140	38,125,508	281,629	45	19
	Streamlined Industrial	Green Motor Rewind	18	27	27	43,722	-	-	-
		Prescriptive	165	206	403	11,104,033	479,269	25	1
		Standard Calculated	161	170	180	6,854,835	297,123	7	-
	Streamlined Industrial Subtotal		344	403	610	18,002,590	776,392	32	1
	Lighting	Lighting Direct Install	40	42	402	811,081	-	2	-
		Lighting Downstream	122	131	270	11,695,058	-	16	1
		Lighting Midstream/Buy down	246	127	661	5,604,553	-	5	-
	Lighting Subtotal		408	300	1,333	18,110,692	-	23	1
	SEM	Strategic Energy Management	50	49	51	24,194,910	383,273	27	4
Total			**807[c]**	**858[c]**	**2,134**	**98,433,700**	**1,441,294**	**127**	**25**

[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 127 primary electricity and natural gas projects.
[c] Total sites and projects are lower than the sum of subtrack subtotals because of overlap.

The custom capital, SEM, and lighting subtracks contributed the most electric savings in 2022 (36%, 25%, and 12%, respectively), as shown in Figure 1Figure 1.

Figure 1. Production Efficiency Electric Savings by Subtrack, 2022



The prescriptive and SEM subtracks collectively represented 60% of natural gas savings in 2022, as shown in Figure 2.

Figure 2. Production Efficiency Natural Gas Savings by Subtrack, 2022

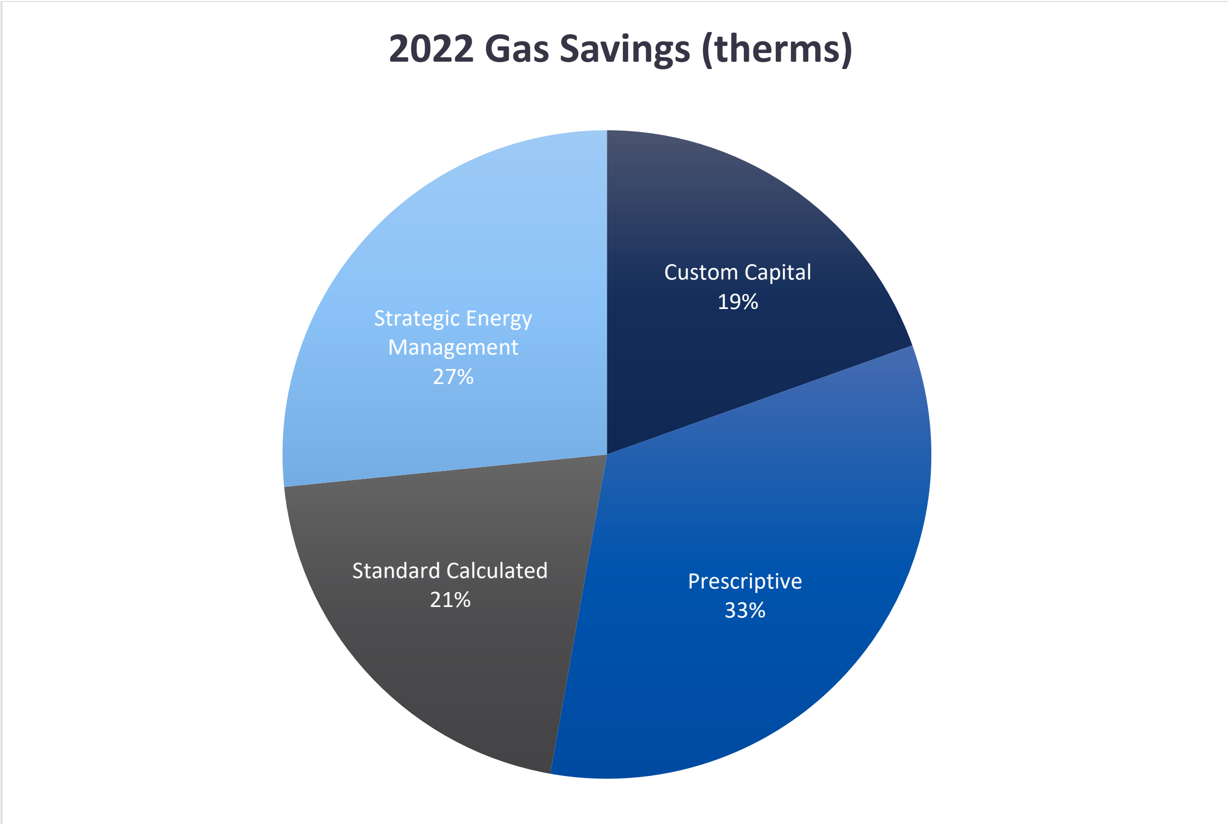
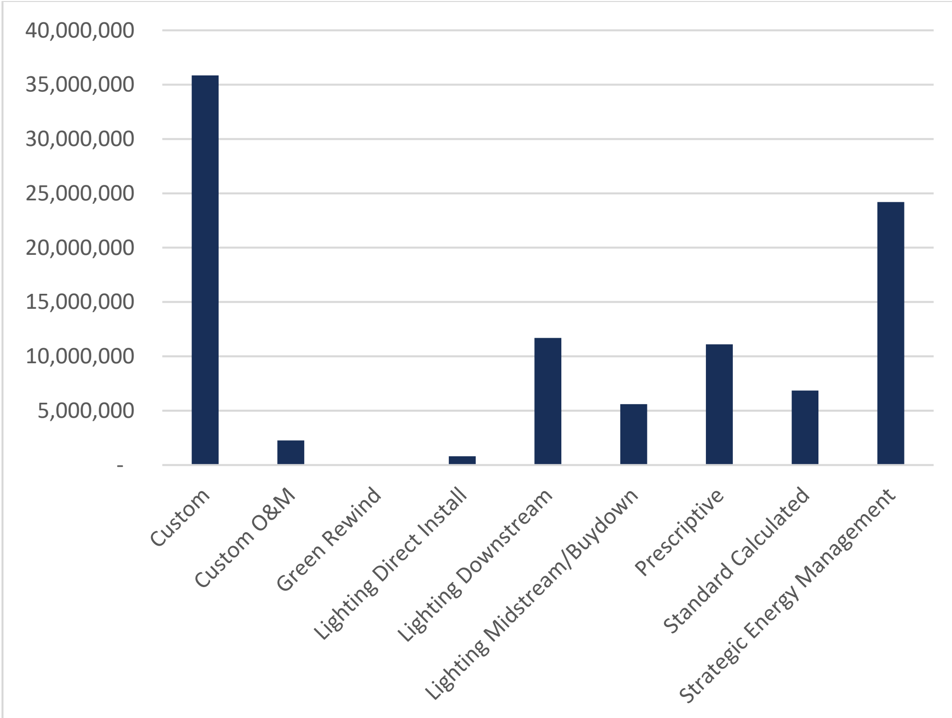


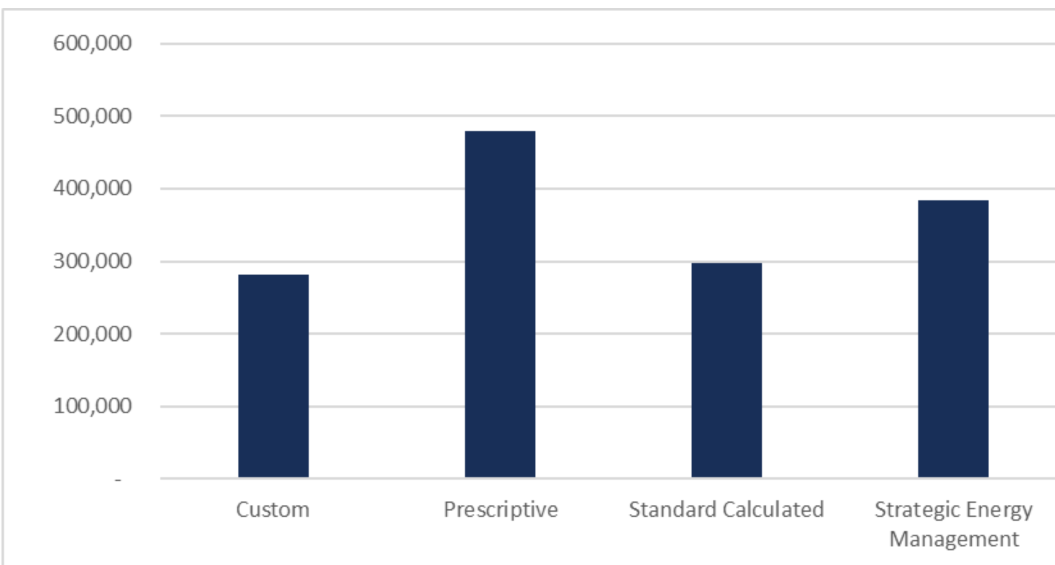
Figure 3 and Figure 4 show electric and natural gas program savings, respectively, for the 2022 program year. As shown in Figure 3, the majority of program electric savings in the 2022 program year were in the custom capital subtrack, followed by the SEM subtrack.

Figure 3. Production Efficiency Electric Savings by Subtrack, 2022



The majority of program natural gas savings in the 2022 program year were in the prescriptive subtrack, followed by the SEM subtrack as shown in Figure 4.

Figure 4. Production Efficiency Natural Gas Savings by Subtrack, 2022



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 2020 PE impact evaluation.
- **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 achieve a statistical level of at least 90% confidence and ±10% precision through a stratified sampling of the population of 2022 projects, and we extrapolated the results by subtrack.
- Estimate electricity and natural gas 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 aspects of the evaluation:

- Appropriateness of energy savings analysis by the trade allies, PDCs, 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 resulted in large variances in measure savings (e.g., assumptions that were 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 2022 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 9Table 9. The sampled savings resulted from those projects sampled for the impact evaluation. Sampled electricity savings represented 62% of the total program electricity savings in 2022. Sampled natural gas savings represented 69% of total program natural gas savings for 2022.

Table 9. Program and Sampled Savings by Program Track, 2022

Program Year	Track	Sub-Track	Electric		
			Program Savings (kWh)	Sample Savings (kWh)	Percentage Sampled (by kWh)
2022	Custom	Custom	35,856,586	30,841,368	86%
		Custom O&M	2,268,922	331,786	15%
	Custom Subtotal		38,125,508	31,173,154	82%
	Streamlined Industrial	Green Motor Rewind	43,722	N/A	0%
		Prescriptive	11,104,033	3,740,759	34%
		Standard Calculated	6,854,835	609,916	9%
	Streamlined Industrial Subtotal		18,002,590	4,350,676	24%
	Lighting	Lighting Direct Install	811,081	46,959	6%
		Lighting Downstream	11,695,058	3,657,172	31%
		Lighting Midstream/Instant Discounts	5,604,553	785,302	14%
	Lighting Subtotal		18,110,692	4,489,433	25%
	SEM	Strategic Energy Management	24,194,910	20,904,137	86%
	Total		**98,433,700**	**60,917,399**	**62%**
	Track	**Sub-Track**	**Natural Gas**		
			Program Savings (therms)	**Sample Savings (therms)**	**Percentage Sampled (by therms)**
	Custom	Custom	281,629	228,008	81%
		Custom O&M	-	-	-
	Custom Subtotal		281,629	228,008	81%
	Streamlined Industrial	Prescriptive	479,269	474,832	99%
		Standard Calculated	297,123	293,690	99%
	Streamlined Industrial Subtotal		776,392	768,522	99%
	SEM	Strategic Energy Management	383,273	4,996	1%
	Total		**1,441,294**	**1,001,526**	**69%**

Sample Design

For the 2022 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). We also used track substratification to achieve a more robust evaluation by targeting custom capital and custom O&M projects, which were of particular interest to Energy Trust.

Cadmus sampled projects using PPS within each stratum and then evaluated these sampled projects using a combination of engineering desk reviews, interviews, and virtual and on-site M&V. We sampled sites with probabilities proportional to the reported electricity and natural gas savings associated with each project, so that 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 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 for which historical data provided robust estimates that had not changed over time (such as lighting and prescriptive projects) and for projects for which 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 across all subtracks, and to determine the persistence of SEM activities (such as SEM projects with capital measures installed during the same period as the SEM engagement). Additional metering was conducted during select on-site visits, and additional trend data collection and analysis was conducted for projects with high savings and changing load characteristics.

Table 10 provides the targeted and achieved confidence and precision for natural 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 in 2022

Track	Subtrack	Target Precision (90% Confidence Level)	Achieved Precision (90% Confidence Level)	
			Electricity	Natural Gas
Custom	Custom Capital	±10%	10.94%	21.35%
Custom	Custom O&M	±10%	8.55%	N/A
Custom	Total	±10%	10.26%	21.35%
SEM	SEM	±10%	3.86%	N/A
SEM	Total	±10%	3.86%	N/A
Streamlined Industrial	Green Motor Rewind	±10%	N/A	N/A
Streamlined Industrial	Lighting	±10%	2.45%	N/A
Streamlined Industrial	Prescriptive	±10%	0.38%	1.51%
Streamlined Industrial	Standard Calculated	±10%	28.50%	0.00%
Streamlined Industrial	Total	±10%	9.4%	0.88%
Total	**Total**	**±10%**	**4.27%**	**3.53%**

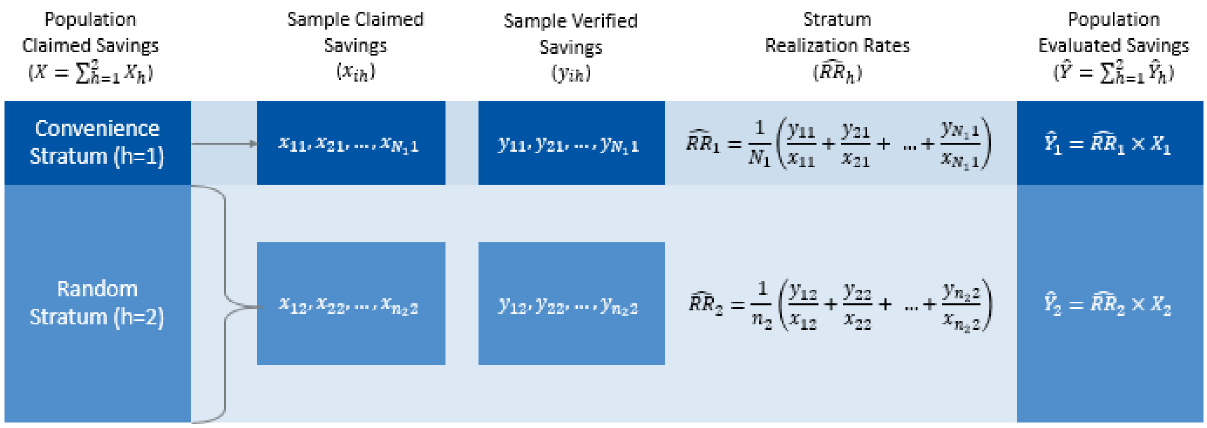
Note: Custom gas and Standard Calculated electric precisions are outside the confidence threshold. This is a result of the wide range of realization rates found and the portion of projects with realizations other than 100%. SEM, Lighting, and Green Motor Rewind had no gas savings evaluated, resulting in N/A.

We included some projects in multiple strata because 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. We included the realization rates for both fuel types in the evaluation sample for these projects.

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 that comprised convenience projects and the other that 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, but those savings 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., project reports and analysis, supporting project documentation, and tracking workbooks) for the sampled projects, paying attention to the calculation procedures and documentation for savings estimates. The methods we applied for documentation review varied according to whether the project involved a capital measure or SEM engagement. Cadmus worked with Energy Trust and the relevant PMC or PDC (in the case of lighting projects) to collect missing project files and calculation models, and kept a running list of data requests that we shared with Energy Trust on an as-needed basis. Energy Trust, as well as the PMC and PDC were extremely supportive with our requests.

Streamlined Industrial

Cadmus reviewed all project files, analysis workbooks, and MAD 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 studies (TAS) and verification reports and analysis. Cadmus worked with Energy Trust and the PMC to acquire any missing documentation. This was especially important when updating analysis with newly collected data was required for evaluation.

To evaluate each sampled project, we began by reviewing relevant documentation and other program materials from Energy Trust, and the PMC. 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
- Assumptions on specifications and the sources for these specifications

SEM

For each sampled SEM project, Energy Trust provided the energy intensity model workbooks, energy tracking 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 and qualitatively assessed the energy models and savings calculations using the following rubric:

- Check for errors in modeling methods
- Check for missing capital measures
- Check for incorrect accounting of capital measure savings and non-routine adjustments
- Check for incorrect accounting or other factors affecting energy use
- Check for unexplained data excluded from regression model
- Check for major energy drivers excluded from regression model
- Check for failed goodness-of-fit criteria
- Check for errors in bottom-up calculations
- Identify methodologies used
- Verify assumptions on specifications and the sources for these specifications
- Check for trends in baseline model residuals based on data in annual savings report and models
- Verify that residuals equal the difference between actual metered energy and predicted energy use for the baseline regression model
- Check for a trend in residuals against fitted values or over time, which 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
- Verify that baseline and reporting periods are distinct

- Verify that baseline and reporting periods are the standard length of either 12 months or three months, and that those different than the standard are explained and justified
- Check savings calculations
- Look for 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 impacts 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 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 information:

- 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 will help Energy Trust improve *ex ante* estimates

Cadmus scheduled all interviews and virtual and on-site visits in coordination with the PMC and Energy Trust, in accordance with the Cadmus developed 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.

Conduct Customer Interviews

Cadmus completed interviews for 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.

Non-SEM Participant Interviews

Interviews were conducted both virtually and in-person. Every effort was made to reduce customer effort by focusing the interview on items required by the evaluation plan and communicating virtually when appropriate. 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 A. Customer Interview Guides*. We supplemented information in the interview guides with project-specific information and project-specific M&V plans. For projects that did not warrant a site visit or 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 2020 PE program 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 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 topics and requests ahead of time, giving them time to prepare for the interview. Each completed interview required significant recruiting and explanation to engage participants and to provide them with information. Cadmus coordinated the initial outreach and scheduled interviews with customers who responded. For sites with little or no response, the PMC aided in providing specific contact information.

A change in the delivery approach from multiple PDCs to one PMC and turnover in site personnel led to more time and effort spent on recruitment than anticipated. In some instances, the site contact was new for the PMC, leading to new relationships. In future impact evaluations, the evaluator should work closely with the PMC early on to determine the right point of contact, assign single evaluation engineers to a site for all project evaluations and communications, and rely on virtual or remote verification techniques where appropriate.

Conducting Desk Reviews, Virtual and On-Site Visits

Cadmus originally planned to conduct 15 desk reviews and interviews and 93 on-site visits (25 with metering), and 14 virtual visits for the 2022 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 on-site visit to a desk review to accommodate customer preference and availability, and in one case, a facility closure.

For desk reviews, Cadmus 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. We made an effort to update analysis files with key parameter trend data for large savings projects.

To successfully complete the virtual site visits, Cadmus developed and followed guidelines for site visits and site selection for the 2022 PE impact evaluation. These guidelines are documented in a memo included in *Appendix C. Virtual Site Visit Memorandum.*

When scheduling a virtual or on-site visit, we sent customers an introduction letter (included in *Appendix A. Customer Interview Guides*).

Impact Analysis

Across the three tracks, Cadmus verified evaluation methods ranging from simple assumption validation 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 Energy Trust staff and the PMC 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 one or more of the following: 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 greater than ±10% variance) with Energy Trust and the PMC. We requested additional data and project files to support the evaluation and worked with the PMC when 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 problems, found problems that were likely to have small or negligible impacts on energy savings, or 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 had been dismantled after the reporting period, we applied our engineering expertise to gauge whether the relative size of the project would significantly impact overall savings. No projects were determined to impact savings, so Cadmus assigned a 100% realization rate to all modeled claimed savings.

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 methodology similar to that of custom projects. This includes a review of baseline, engagement, and reporting period requirements, as well as project status like with modeled 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 that 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 2022 program overall were 96.3%. Natural gas realization rates for the 2022 program overall were 98.7%.

Table 11. Production Efficiency Program Realization Rate by Fuel Type

Fuel Type	2022			
	Reported Savings	Evaluated Savings	Realization Rate	Relative Precision[a]
Electricity (kWh)	98,433,700	94,753,633	96.30%	4.27%
Natural Gas (therms)	1,441,294	1,423,354	98.76%	3.53%

[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. 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	Electric			
		Reported (kWh)	Evaluated (kWh)	Realization Rate	Relative Precision[a]
Custom	Custom Capital	35,856,586	33,340,923	92.98%	10.94%
	Custom O&M	2,268,922	2,140,467	94.34%	8.55%
	Total	38,125,508	35,481,390	93.06%	10.26%
SEM	SEM	24,194,910	23,828,858	98.49%	3.86%
	Total	24,194,910	23,828,858	98.49%	3.86%
Lighting	Lighting Direct Install	811,081	811,081	100.00%	0.00%
	Lighting Downstream	11,695,058	11,327,476	96.86%	3.92%
	Lighting Midstream/Instant Discounts	5,604,553	5,604,553	100.00%	0.00%
	Total	18,110,692	17,743,110	97.97%	2.45%
Streamlined Industrial	Green Motor Rewind[b]	N/A	N/A	N/A	N/A
	Prescriptive	11,104,033	11,095,446	99.92%	0.38%
	Standard Calculated	6,854,835	6,604,828	96.35%	28.50%
	Total	17,958,868	17,700,274	98.56%	9.40%
Total		**98,389,979**	**94,753,633**	**96.30%**	**4.27%**

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

[b] We did not evaluate the Green Motor Rewind subtrack in 2022.

Table 13. Natural Gas Realization Rates by Track and Subtrack

Track	Subtrack	Natural Gas			
		Reported (therms)	Evaluated (therms)	Realization Rate	Relative Precision[a]
Custom	Custom Capital	281,629	254,989	90.54%	21.35%
	Total	**281,629**	**254,989**	**90.54%**	**21.35%**
SEM[b]	SEM	383,273	383,273	100.00%	NA
	Total	**383,273**	**383,273**	**100.00%**	**NA**
Streamlined Industrial	Prescriptive	479,269	491,401	102.53%	1.51%
	Standard Calculated	297,123	293,691	98.84%	0.00%
	Total	776,392	785,092	101.12%	0.88%
Total		**1,441,294**	**1,423,354**	**98.76%**	**3.53%**

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

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

Overall, the program achieved high realization rates for electric and natural gas savings. Standard calculated relative precision for electric evaluated savings is higher (less precise) due to large differences between project realization rates. Custom capital relative precision for natural gas savings is high due to multiple projects receiving low realization rates, three of which were the same measure with all others unique measures. Another project received a very high realization rate, further affecting precision. Standard calculated natural gas realization rates are a result of evaluated project realization rates and the steam trap measure type receiving a 100% realization rate. This pass-through realization for steam traps was given since the sampled projects realization rates did not appropriately represent steam trap savings, which were a significant portion of the population.

Table 14 shows the realization rates for the PE program by fuel type for program years 2016 through 2022. The electricity fuel type achieved a slightly lower realization rate in 2022 than in 2020 and the natural gas fuel type achieved a slightly higher realization rate in 2022 than in 2020. Reasons for the deviation in realization rates are discussed in the corresponding sections.

Table 14. Production Efficiency Program Realization Rates for 2016 through 2022 by Fuel Type

Fuel Type	2016	2017	2018	2019	2020	2022
Electricity	86%	90%	101%	101%	98%	96%
Natural Gas	98%	94%	78%	104%	97%	99%

*An impact evaluation as not performed for PY 2021

Electricity and Natural Gas Adjustments

To better understand why project-level savings were 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.

When 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	Adjusted Projects (n=112)[a]	Absolute Adjusted Savings[b] (kWh)	Percentage of Savings Adjusted (Category Adjusted Savings/ Total Adjusted Savings)
Different operating hours/conditions	16	2,389,939	64.10%
Different equipment setpoints	7	385,220	10.30%
Inappropriate baseline	8	265,358	7.10%
Measure removal	1	247,036	6.60%
Incorrect equipment specifications or quantities	6	175,114	4.70%
Inappropriate assumption	4	122,620	3.50%
Calculation or engineering error	2	96,471	2.60%
Incorrect/different analysis methodology	2	42,082	1.10%
Total	**46**	**3,723,840**	**100%**
Natural Gas Savings Adjustments	**2022 (n=21)[a]**	**Absolute Adjusted Savings (therms)**	**Percentage of Savings Adjusted (Category Adjusted Savings/ Total Adjusted Savings)**
Incorrect/different analysis methodology	4	26,206	68.8%
Different equipment setpoints	1	6,580	17.3%
Inappropriate baseline	1	3,432	9.0%
Measure removal	1	1,867	4.9%
Total	**7**	**38,085**	**100%**

[a] n reflects the number of unique of project IDs evaluated for fuel type. Only one adjustment category was assigned per project; if multiple categories applied to a single 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 6 and Figure 7 illustrate the cumulative energy savings adjustments for each adjustment category. Different operating hours/conditions was the issue found most frequently for electric projects and produced the largest adjustments to estimated savings. On the natural gas side, incorrect/different analysis methodology was the category that caused the largest total adjustment to estimated savings.

Figure 6. Production Efficiency Electric Savings Impact Evaluation Adjustments

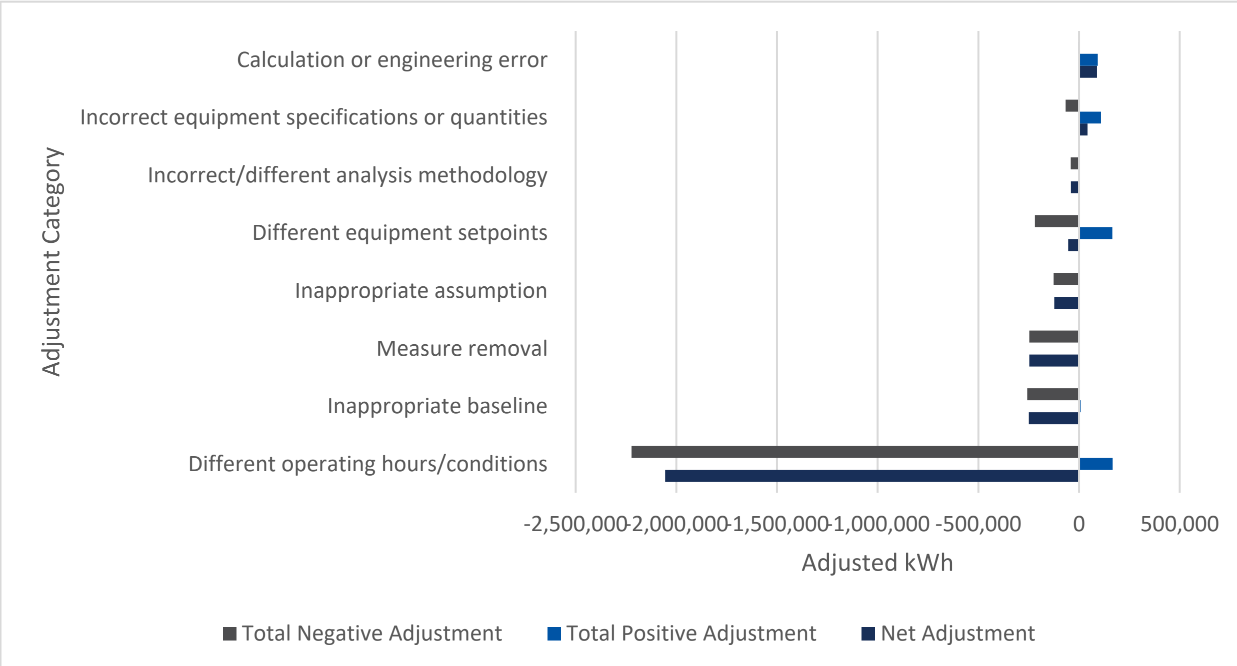
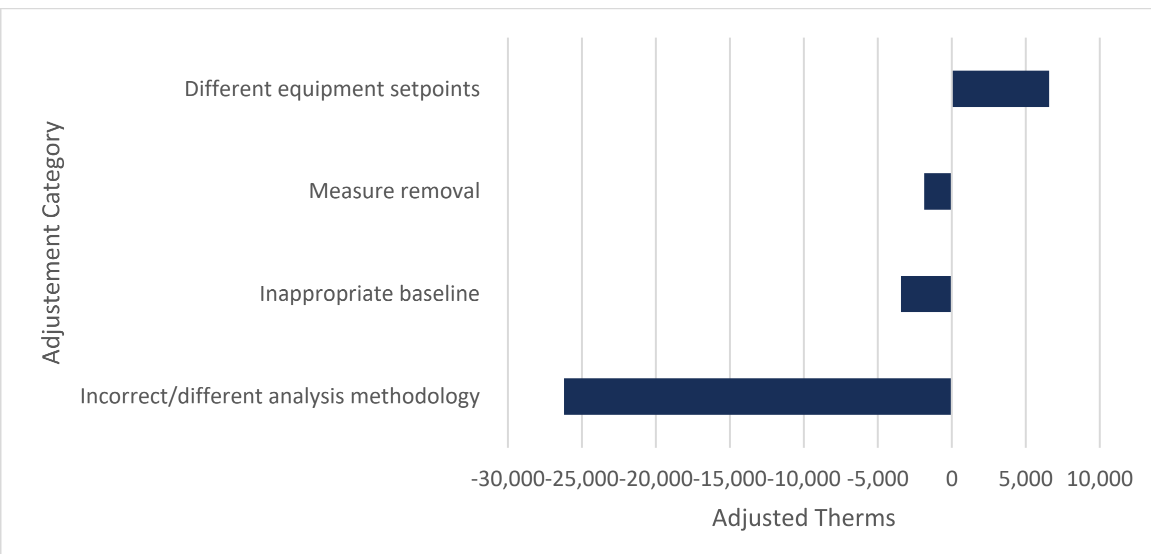


Figure 7. Production Efficiency Natural Gas Savings Cumulative Impact Evaluation Adjustments



Note: There were no multiple adjustment types in the natural gas adjustment categories.

Custom Projects

Custom Capital

Custom capital projects represented the most complex projects (and those reporting the largest energy savings). These included a range of measures, from liquid nitrogen system upgrades to fryer upgrades. Cadmus evaluated 42 custom capital projects, of which 33 were electric, 5 were natural gas and 4 were both. 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 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 was 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:

- Dust Collection
- Chillers
- Compressed air
- Controls and Equipment upgrades
- Fans and Blowers
- HVAC
- Insulation and Shell improvements
- Irrigation
- Primary process
- Secondary process
- Piping and Pumping
- Refrigeration
- Wastewater

Findings

Table 16Table 16 lists the custom capital realization rates by fuel type.

Table 16. Custom Capital Realization Rates Summary for 2022

Fuel Type	Realization Rate	Relative Precision[a]
Electricity	92.98%	10.94%
Natural Gas	90.54%	21.35%

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

Realization Rate Adjustments Summary Findings

The realization rates for the custom capital electric projects ranged from 50.3% to 386.9%, and natural gas projects ranged from 0% to 135.7%. The custom capital track achieved an electric realization rate of 93% and natural gas realization rate of 90.5%. Cadmus adjusted savings for 29 out of 42 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. A few projects that had a larger impact on realization rates generally included updated trend data with new loads or production rates. The high relative precision for natural gas projects is the result of a wide range of realization rates across the majority of sampled projects.

Four electric projects that had the largest deviation in savings were PE14568, PE17099, PE17258, and PE19400. The three natural gas projects that contributed the most to low realization rates are PE16856, PE18104 and PE19192.

- For PE14568, a new VFD chiller had reduced savings as a result of slightly decreased facility production rates and therefore cooling load. The reduced cooling load did not impact the chiller efficiency, but did impact the baseline and proposed annual energy consumption with the reduced load. The facility was unsure whether production loads would increase in the future.
- For PE17099, a cement mortar lining project, 2023 irrigation season data revealed a higher pressure loss for a given flow compared to the 2022 irrigation season. Both seasons were used to develop a new baseline and post-installation flow model. Facility operators are very involved in energy efficiency efforts and are carefully tracking performance of this system. No source of additional pressure loss was identified, but the site continues to investigate.
- For PE17258, a liquid nitrogen production system upgrade project that is supplying liquid nitrogen directly piped to a large customer, saw a 16% decrease in demand on the system. The decreased demand put the baseline and proposed equipment at a lower part load and decreased run time from 4,818 hours to 4,156 hours per year.
- For PE19400, a VFD was added to an anodizing blower to reduce airflow based on process demand. Cadmus logged the amperage for a month and found an average amperage which was greater than the seven days of PDC logged amperage.
- For PE16856, PE16916, and PE19676, all projects added high speed doors to a wood processing facility that keeps spaces conditioned during production times. The method used to calculate savings was different for PE19676, which used an estimated infiltration load calculation, and PE16856 and PE16916, which used weather data and wind speed to calculate infiltration based on door opening duration and length. All methods were updated by Cadmus to a standard door opening airflow exchange formula.
- For PE18104, a metal finishing process controller reduced operation time of auxiliary support equipment for the process. Cadmus found that the boiler runtime reduction that was the source of natural gas savings was described to coincide with the electric heater operation, but was a hard coded value of 27.5%. Cadmus updated the runtime reduction to 18.5%.
- For PE19192, a custom insulation project, energy savings were originally calculated as electric for cooling and natural gas for heating. Before the first heating season with the new insulation, the customer converted the heating system to an electric resistance heated glycol circulation system, which eliminated natural gas savings and increased electric savings.

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

- In many cases, operating hours or key process loads 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 used trend data to verify the new loads used to update energy savings analyses. Operating hour changes affected electric savings across several measure types. Types of conditions that changed operation included cooling load, nitrogen production, compressed air flow, production rates, water flows, and operation time. Project examples: PE14568, PE17099, PE17258, PE18320, PE18473, PE18835, PE18892, PE18916, PE19043, PE19354, and PE18218.

- For some projects, key setpoints used to calculate savings 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 natural gas and electric savings across several measure types. Examples of adjustments included temperature setpoint changes, pressure setpoint changes, and flow adjustments. Project examples: PE13494, PE17392, PE18720, PE19400, PE19471, and PE19482.
- For some projects, the PDC used the incorrect or different calculation methodologies than industry standard to calculate savings. This included the previously mentioned high speed door calculations, and the hard coded boiler operation reduction. Projects varied in measure type and were mostly natural gas, with some electric. Project examples: PE16856, PE16916, PE19676, and PE18104.
- For two projects, PE19092 and PE19192, the PDC used incorrect equipment specifications, which resulted in differences in savings. For one project, the PDC used the incorrect purge flow, and a second project used an incorrect heating type.
- For one project, the PDC used an incorrect equipment quantity, which resulted in adjustments to savings. This changed the number of electric resistance heaters from 12 to 14 on PE19092.
- For two projects, PE17549 and PE19330, Cadmus identified an engineering or calculation error. This was a result of spreadsheet errors. This included one project in which a different fit curve was applied, and another where a forecast function was used instead of a change point regression. These projects resulted in adjustments to electric savings.
- For two projects, the PDC used the inappropriate baselines to calculate savings. Cadmus modified the baseline kiln drying time for an incremental baseline for PE16860, and adjusted baseline offseason cooling load for refrigeration control system calibrated with UCI data for PE17525.
- For one project (PE19192), the measure was removed since the natural gas heating source was replaced with an electric heating source before the first heating season.

Other Findings

- Although most savings calculation workbooks for custom capital projects were well documented and easy to follow, in some cases when there was a turnover in PDC to PMC, original analysis spreadsheets were not available. Savings calculations were updated with new trend data results where applicable.
- Many sites with multiple capital projects also participate in SEM. In some instances, there are interactive effects between the custom capital and SEM projects that can change the forecasted

operation and savings of specific measures. For instance, a compressed air leak reduction performed after a new dryer is installed may reduce the baseline purge flow, which reduces dryer upgrade savings while increasing SEM savings.

- Some verification savings are calculated with average power and operation time without normalizing for other key performance parameters. Although this method is an accurate representation of verified post-installation annual energy consumption, it does not account for changes that occurred in the system that could require a change in baseline energy consumption.

Custom O&M

Cadmus evaluated 3 custom O&M projects, of which all were compressed air leak reduction 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, deployed data loggers, and conducted site inspections to obtain the current operating parameters for each measure. We updated the calculation workbooks for projects with data available. All O&M evaluated projects were compressed air leak repairs.

Findings

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

Table 17. Custom O&M Realization Rates Summary in 2022

Fuel Type	Realization Rate	Relative Precision[a]
Electricity	94.34%	8.55%
Natural Gas	N/A	N/A

[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 91.1% to 100%. The custom O&M track achieved an electric realization rate of 94%, with one of the three projects not receiving a 100% realization rate. Energy savings estimates were calculated using appropriate methodologies, assumptions, inputs, and metered or trend data. Cadmus adjusted one custom O&M project (PE19505). Cadmus found the calculation methodology to be correct, but found one of eleven randomly sampled leaks had a leak tag still attached to a leaking fitting.

Other Findings

- The majority of Custom O&M projects for 2022 were compressed air leak repairs with high realization rates which demonstrated high persistence due to integrated leak programs at the sites.

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 23 lighting projects including 2 direct install, 16 downstream, and 5 midstream/instant discounts.

Findings

Table 18. Lighting Realization Rates Summary, 2022

Fuel	Track	Realization Rate	Relative Precision [a]
Electric	Lighting	98%	2.45%
	Total	**98%**	**2.45%**

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

Realization Rate Adjustments Summary Findings

The realization rates for the lighting projects ranged from 71.5% to 115.5%. The track performed well in 2022, with most projects receiving a 100% realization rate; overall, the track received an electric realization rate of 98%.

Lighting Direct Install

The realization rates for projects in the lighting direct install program were 100% for all 2 sampled projects.

Lighting Downstream

The realization rates for projects in the downstream lighting program ranged from 71.5% to 115.5%. During the 2022 evaluation, Cadmus reviewed calculators and supporting documentation, and met with Energy Trust and the PMC to better understand how adjustments from Regional Technical Forum standards were adjusted to meet site-specific cases. Cadmus made adjustments to a total of 11 of 16 evaluated projects. The following list highlights the specific adjustments made to projects and provides some examples:

- Cadmus adjusted operating hours of the lights involved in two projects based on review of supporting documentation and interviews with site personnel. One project had increased savings while another had decreased. Project examples: EA-0000693381 and EA-0000798700.
- For one project (DSMT116), Cadmus found the differences in hour of use in the MAD and supplied calculations, as well as slightly different measure and remaining useful life values. This reduced savings.
- For five projects, Cadmus found an inappropriate baseline was used based on specific project conditions and applicable MADs. In some cases, savings were reduced and in other cases they were increased. Project examples: EA-0000700536, EA-0000722016, EA-0000722109, EA-0000723187, and EA-0000860920.
- For two projects, incorrect equipment wattages were used as the baseline lights, and in one case, incorrect controls savings value. Cadmus adjusted the savings, resulting in increased

savings for one project and decreased for another. Project examples: EA-0000669194 and EA-0000830892.

Lighting Midstream/Instant Discounts

The realization rates for projects in the lighting midstream program were 100% for all five sampled projects.

Streamlined Industrial Projects (Green Motor Rewind, Prescriptive, and Standard Calculated)

The streamlined industrial projects include projects that are well established and use prescriptive or standardized calculation methodologies and spreadsheet calculators developed over the years from best practices, publicly available research and data sets, and past program data. The assumptions, calculations, and analysis are documented in MADs. These generally included smaller electric and natural 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 Motor Rewind projects were not in the scope of the evaluation because the Green Motor Rewind program was discontinued in Q3, 2023.

Prescriptive

Prescriptive projects covered equipment replacements and equipment installations. Cadmus evaluated 25 prescriptive projects that included the following measures:

- Irrigation system seals, gaskets, and nozzles
- Pipe insulation for hot water and steam lines
- Indoor agriculture dehumidifiers
- Steam trap replacement

Standard Calculated

The standard calculated projects covered equipment replacements and custom insulation. Cadmus evaluated 7 standard calculated projects that included the following measures:

- Air compressor replacements
- Fan Variable Frequency Drives (VFDs)
- Custom insulation

Findings

Streamlined industrial realization rates are provided in Table 19.

Table 19. Streamlined Industrial Realization Rates Summary, 2022

Fuel	Track	Realization Rate	Relative Precision [a]
Electric	Green Motor Rewind	N/A	N/A
	Prescriptive	100%	0.4%
	Standard Calculated	96%	28.5%
	Total	**99%**	**9.4%**
Natural Gas	Prescriptive	103%	1.51%
	Standard Calculated	99%	0.0%
	Total	**99%**	**0.88%**

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

Realization Rate Adjustments Summary Findings

Green Motor Rewind

The Cadmus team did not evaluate any Green Motor Rewind projects in the 2022 PE Program. These projects reflected a very small percentage of savings within the overall PE program.

Prescriptive

The realization rates for the prescriptive projects ranged from 96.4% to 117.5%. Most projects received a 100% realization rate. The overall electric realization rate of 100% and natural gas realization rate of 103%, is shown in Table 19.Table 19 In general, Cadmus received the appropriate data, specification sheets, and calculation methodologies for these projects. Cadmus made adjustments to two prescriptive projects:

- For PE19594, a dehumidifier rating was adjusted based on supplied performance specifications, which reduced savings.
- For PE19603, a greenhouse film replacement project, we found invoices for more square footage than claimed in the calculator. Cadmus updated areas based on customer provided areas, resulting in increased savings.

Standard Calculated

The realization rates for the standard calculated projects ranged from 0% to 105.8%. The track performed well in 2022, and most projects received a 100% realization rate. The overall electric realization rate of 96% and natural gas realization rate of 99%, as shown in Table 19. Cadmus made adjustments to two standard calculated projects, detailed below:

- For PE19250, an incorrect motor efficiency was applied. Cadmus updated the motor efficiency which reduced savings.
- For PE19957, the wall and roof insulation measure was deemed ineligible due to insulation being replaced rather than added.

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 2022 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
- Repairing failed HVAC dampers

To estimate evaluated savings, Cadmus used various energy savings models developed by the PDC. We also evaluated some bottom-up SEM projects by reviewing project-specific data and analysis as we would do for a custom project.

Findings

SEM realization rates are provided in Table 20. Only seven SEM sites claimed natural gas savings, and one of those sites is now closed. The site received a 100% realization in accordance with established protocol. Realization rates assigned to claimed electricity savings ranged between 17.8% to 103.9%. Deviations from 100% resulted from a variety of factors, but were only found on bottom-up projects. Modeled projects all received 100% realization.

Table 20. SEM Rates Summary, 2022

Fuel Type	Realization Rate	Relative Precision[a]
Electricity	98%	3.86%
Natural Gas	100%	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, the PDC clearly justified the baseline, engagement, and reporting period definitions. Sites used either 90 days or 12 months for reporting periods.

Opportunity Register

- In general, participants were able to use the opportunity register to track project completion. Site personnel turnover, insufficient detail, and length of time since project completion in some instances made verifying specific opportunities difficult.

Energy Intensity Models

- In general, the SEM regression models seemed to accurately characterize the energy use of the facilities, supporting 100% realization rates for all modeled 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 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.
- 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 toward the end of, or after, their reporting periods.
- The in-depth interviews with site contacts confirmed that many COVID-19 changes have normalized, but not always to pre-pandemic conditions.
- Several energy intensity models included weather in their models, as appropriate. Most facilities included weather in the models as heating degree days (HDDs) and cooling degree days (CDDs). In the 2018-2019 PE impact evaluation report, Cadmus recommended that energy models use HDDs or CDDs 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 natural gas model included in the 2022 evaluation did not (and as a result, underpredicted consumption in summer months.)
- Model residuals (as shown in plots of residuals versus fitted values and residuals over time) were typically reasonably well behaved, leading Cadmus to verify residual diagnostics overall. However, we noted at least some nonlinearity in these plots for approximately half of the projects that used energy models. The most common issue was clusters or nonconstant spread in residuals versus 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.
- Interactive effects of SEM activities on equipment with capital incentives are not always clearly documented or considered. For cases in which SEM activities would change the baseline condition of a new capital project, those savings may impact evaluated savings for the capital projects.

Savings Estimation Methods

- There were no major errors in scaling the reporting period savings rate to a full 12 months of engagement.
- Projects with bottom-up savings were the only projects with realization rates other than 100%. These projects often represented lower total savings (approximately 25% of evaluated savings), and comprised almost half of the evaluated SEM projects. Three projects had major changes in realization rates: projects PE19044, PE19045 and PE19166.
    - For PE19044, one opportunity had additional heaters found to be locked out compared to the claimed number of heaters, increasing savings. All other major projects received 100% realization rates.
    - For PE19045, each of the four major completed opportunities had changes to the calculations, although all were found to still be implemented. The largest change was due to a power factor adjustment from 0.9 to 0.99 for a VFD control adjustment from manual to automatic. This decreased savings.
    - For PE19166, all opportunities were completed on a process line that was replaced in early 2024. Each opportunity had savings adjusted to the appropriate EUL based on opportunity completion date and process line shutdown date.

Demand Analysis Findings

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's mandate to decarbonize the electric grid by 2040. At the same time, local and national efforts to decarbonize transportation and space and water heating will cause 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.

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's hours of operation. Load shapes were adjusted for a total of 34 projects out of 127 unique electric projects in the evaluation sample. The areas where the evaluation team saw the largest change in load shapes were: 3-Shift Industrial and Flat – electric to more industry-specific load shapes, such as Cold Storage, Wood Products, Food Products, and Primary Metals. Cadmus verified actual hours of operation for all but three projects in the evaluation sample. We assigned evaluated load profiles based on the operation of the impacted equipment. A total of 26 projects changed based on a more specific industry load profile being available, 6 were changed based on better equipment operation profiles compared to facility end-use profile selected, and 2 were changed as a result of updated facility operation.

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 in the same way as we calculated the overall electricity and natural gas savings. The resulting demand savings by track are shown in Table 21.

Table 21. 2022 Evaluated Demand Savings by Track

Track	Subtrack	Winter Demand Savings (kW)	Summer Demand Savings (kW)
Custom	Custom Capital	3,468	3,972
	Custom O&M	45	46
	Total	3,513	4,018
Lighting	Lighting Direct Install	7	6
	Lighting Downstream	486	496
	Lighting Midstream/Instant Discounts	129	106
	Total	622	608
Streamlined Industrial	Green Motor Rewind	-	-
	Prescriptive	297	699
	Standard Calculated	78	85
	Total	375	784
SEM	Strategic Energy Management	2,371	3,129
Total		**6,882**	**8,539**

Conclusions and Recommendations

Cadmus conducted an impact evaluation of the 2022 PE program by analyzing energy savings from 127 projects implemented at 110 sites. 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 factors led to an electric realization rate of 96% and a natural gas realization rate of 98%.

Overall, the PDCs performed a reasonable level of review and quality control to achieve a high average of project savings and realization rates. The PMC often proved extremely knowledgeable about the facilities with which they worked and were generally receptive to supporting evaluation efforts. Cadmus worked directly with the PMC on a few occasions to contact facilities and acquire analysis files and data. We found that the PMC 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 COVID-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 2022 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 in each respective track below.

Custom Capital

- For projects where energy consumption is dependent on key parameter data that is outside the influence of the upgrade (such as flow rates, cooling loads, or production variables), we recommend more detail in the persistence plan describing the expected operating range and its impact on performance. For example, a chiller VFD retrofit and controls project energy savings is determined by the cooling load served, typically from 250 tons to 750 tons. Calling out the majority of savings occur from the 250 – 350 ton range although the majority of the time is spent above 350 tons, and adding the lower the load served, the higher the savings, can help the customer and evaluator easily identify whether the change in savings is to be expected.
- The PDC verification reports frequently used the average input power of two weeks of logged data multiplied by annual operation hours to determine verified energy consumption. This is a sound method to determine annual energy consumption, but we recommend adding additional key parameter monitoring to normalize the savings if appropriate. For example, for a compressed air VFD compressor upgrade, savings are determined based on system flow. In addition to metering compressor power for two weeks, monitor pressure or flow as well to verify the compressor is operating in the same flow range as the analysis.
- For particularly large projects, consider a real-time, in-depth evaluation. A more in-depth evaluation is usually required for larger project, and fluctuations in process or load data can result in differing realization rates when significant time has elapsed since project verification. The specific projects that could have benefited from real-time, in-depth evaluation include: PE19043, PE16927, PE17258, PE17099, PE18916 and PE18320. In addition to each project having savings over 1.25 million kWh, energy savings were largely impacted by a key parameter outside of the project scope. Nitrogen demand and generation, compressed air flow, irrigation flow, and production cooling load were all key parameters that were found different than the verification conditions, impacting evaluated savings.

Custom O&M

- Custom O&M measures were a small fraction of overall program savings. Only Territory 2 had sampled O&M projects, all of which were compressed air leak repairs. We recommend moving compressed air leak repair to a streamlined program measure that uses a standardized leak flow estimate developed from verification results. Leak flow calculations vary based on manufacturer of leak detectors, field technician identifying leaks, and implementation tools used. Standardizing to common leak size ranges will reduce time and technical rigor required for this measure, reducing both customer and PMC time required to attain savings.

Lighting

- We recommend the program perform additional verification of lighting schedules and levels for large lighting projects (>150,000 kWh/year) that use controls to verify operating hours and light levels. This can be accomplished through trend data reports, evidence of lighting control schedules from a BMS in the project package.

- We recommend removing references to a federal baseline adjustment in the Downstream Lighting Tool if it is no longer applicable.
- We recommend that the program add guidance for baseline lighting determinations and savings calculation methodology for custom grow light projects, as provided in form 490HL.
- We recommend providing documented demonstrations of how the lighting tool approach aligns with or connects to a lighting measure's associated MAD as part of the project savings calculation package. Specifically, we recommend highlighting the EUL, RUL, final BML, and Wattage Ratio "current to pre-condition" and “current practice to energy efficient" used to determine the baseline system watts used in the final savings calculation.

Streamlined Industrial

- The largest differences in realization rates were found to be from invoice reviews not matching project application values. We recommend highlighting application inputs from invoices and supporting documentation, such as equipment quantity, baseline costs, specifications, and other relevant factors.

Strategic Energy Management

- Only bottom-up SEM engagements received realization rates different than 100%. These projects are often more difficult to evaluate after subsequent Continuous SEM activities. We recommend more thorough documentation of savings calculations and persistence for bottom-up calculations by using logged or spot-checked data for projects accounting for 25% or more of the engagement savings.
- The Energy Trust SEM M&V Guidelines recommend that 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 (specific months covered and length of the period) impact 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..
- When higher-frequency energy consumption data, such as daily data, are available for building the energy intensity models, we recommend using interacting production variables and 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.
- Energy Trust should work with implementers to improve and standardize documentation of any savings adjustments resulting from 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 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 evaluators determine the 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 that 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 an approach similar to how custom project facility closures are handled. However, if measures are predominantly behavioral, Cadmus recommends that these projects be addressed as measure removals considering the unlikelihood of behavioral measures persisting 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 Parameters

We recommend that the program use a representative metering period with a minimum of two weeks. The metering period should capture a full production cycle, but an optimal length depends on the type of equipment, production schedule, seasonality, weather, and other factors. The key factors impacting equipment energy consumption should be clearly stated, as well as the observation range. For example, a fan VFD upgrade should include input power for a full production schedule, a full speed range, and indicate and meter the variable that dictates fan speed (such as suction pressure).

Demand Savings Calculations

- **Develop Demand Methodology to Report Savings:** The peak multiplier method Energy Trust currently employs 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. In many cases, the PDC has performed a peak demand analysis as a component of the energy calculations. We recommend establishing peak demand windows and reporting peak demand savings based on the difference in baseline and post installation power during those windows.
- **Report Equipment Load Shapes, not Facility Load Shapes:** In many cases, the load shape selected is for the facility rather than the equipment operation. Although most processes follow

the production load shape, some auxiliary and support equipment deviate from the load shape (such as air compressors, dust collection, or vacuum pumps), or have significant weather impacts (such as HVAC, chillers and boilers). We recommend that load shapes be reported based on equipment operation rather than facility load shape.

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 2020 program year. Table 22 highlights the recommendations provided in the 2020 PE impact evaluation and Cadmus' observations into the status of these recommendations.

Table 22. Status of Recommendations from Prior Impact Evaluation

Program Track	2020 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 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[1] and also used by the Department of Energy's Air Master Tool to estimate savings	This recommendation has been partially implemented, with increased number of compressed air projects using this method. It is not universally applied however.

[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.

Program Track	2020 Recommendation	Cadmus Observations
	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	Utility data was used to calibrate custom models in one case, but there were no other projects with significant enough energy savings to meet the recommendation.
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 and estimating savings at a high level; however, the three approaches detailed above provide a more accurate way of estimating leak loss.	This recommendation partially implemented, but leak down tests were largely unable to be conducted.

Program Track	2020 Recommendation	Cadmus Observations
	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.	This recommendation has not been implemented, but may be irrelevant with a single PMC.
	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.	This recommendation is largely implemented with data analysis spreadsheets and unlocked cells available for most projects sampled in evaluation.
Lighting	**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.	This recommendation has not been implemented.
	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).	This recommendation has been implemented.

Program Track	2020 Recommendation	Cadmus Observations
Lighting	**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	This recommendation has been implemented.
	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	This recommendation has been implemented.
Streamlined Industrial	**Standard calculated:** 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	This recommendation has been implemented.

Program Track	2020 Recommendation	Cadmus Observations
Streamlined Industrial	**Standard calculated:** 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	This recommendation has been implemented.
	Standard calculated: For standard calculated 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	This recommendation has largely been implemented with few or no hard-coded values used.
	Standard calculated: 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	This recommendation was implemented.

Program Track	2020 Recommendation	Cadmus Observations
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	This recommendation has been implemented with many SEM sites shifting to a bottom-up approach.

Appendix A. Customer Interview Guides

The interview guides will be shared as a standalone document.

Appendix B. 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 PMC, 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 PMC, 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 C. 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 D. Confidential – Non-SEM Final Site Reports

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

Appendix E. Confidential – SEM Final Site Reports

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