Impact Evaluation Report for:

2016 – 2017 Production Efficiency Program, Final

Energy Trust of Oregon

July 24, 2020

Energy Trust of Oregon

421 SW Oak St #300

Portland | Oregon 97204

Michaels No.: E9219AAN

Contents

Acronyms

- ATAC - Allied Technical Assistance Contractor
- CFL – Compact Fluorescent
- EISA – Expert Imaging and Sound Association
- EUL – End of Useful Life
- FSR – Final Site Report
- HPS – High Pressure Sodium
- LPD - Light Power Density
- M&V – Measurement & Verification
- O&M – Operations and Maintenance
- OOB – Out of Business
- PDC - Program Delivery Contractors
- PE - Production Efficiency
- RR – Realization Rate
- SEM – Strategic Energy Management
- SSMVP – Site Specific Measurement and Verification Plan
- VFD – Variable Frequency Drive

Acknowledgements

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

Executive Summary

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

This report documents the impact evaluation of the Production Efficiency (PE) program for program years 2016 and 2017 conducted by Michaels Energy and Evergreen Economics (the Michaels Team). The Michaels Team evaluated each PE program sub-track, or specific track, as well as cannabis projects[1] by year and by fuel type.

Realization Rates Summary

The overall program realization rates (RR), along with confidence (C) and precision (P), by fuel type for the PE program are provided in Table 1.

Table 1 |
Production Efficiency Program Realization Rates by Year and Fuel Type

	2016			2017			Combined Years		
Fuel Type	**RR**	**C**	**P**	**RR**	**C**	**P**	**RR**	**C**	**P**
Electric	86%	90%	3.1%	90%	90%	1.8%	88%	90%	1.8%
Gas	98%	90%	3.8%	94%	90%	4.1%	96%	90%	3.3%

The achieved realization rates by year, track, sub-track and fuel type are summarized in Table 2 and Table 3.

[1] The subsequent sections of this report provide more detail and information about the program and the impact evaluation methodology and results.

Table 2 |
Production Efficiency Program Realization Rates by Sub-Track, Electric Savings

Track	Sub-track	2016			2017			Combined Years		
		RR	C	P	RR	C	P	RR	C	P
Custom	***Total Custom***	***75%***	***90%***	***3.5%***	***95%***	***90%***	***1.0%***	***84%***	***90%***	***1.6%***
	Custom Capital	71%	90%	3.1%	93%	90%	1.3%	81%	90%	1.5%
	Custom O&M	94%	90%	5.4%	100%	90%	0.0%	97%	90%	2.0%
Streamlined Industrial	***Total Small Industrial***	***88%***	***90%***	***2.6%***	***85%***	***90%***	***2.5%***	***87%***	***90%***	***2.0%***
	Green Rewind	66%	80%	20.6%	74%	80%	27.3%	71%	80%	17.3%
	Lighting	91%	80%	1.6%	88%	80%	2.2%	89%	80%	1.6%
	Prescriptive	92%	80%	3.8%	100%	80%	0.0%	96%	80%	1.9%
	Small Industrial	78%	90%	4.5%	71%	90%	4.4%	75%	90%	3.3%
SEM	***SEM***	***135%***	***90%***	***7.3%***	***93%***	***90%***	***2.0%***	***112%***	***90%***	***3.9%***
	Total	**86%**	**90%**	**3.1%**	**90%**	**90%**	**1.8%**	**88%**	**90%**	**1.8%**
	Cannabis	95%	90%	2.7%	81%	90%	3.5%	82%	90%	3.3%

Table 3 |
Production Efficiency Program Realization Rates by Sub-Track, Gas Savings

Track	Sub-track	2016			2017			Combined Years		
		RR	C	P	RR	C	P	RR	C	P
Custom	***Total Custom***	***98%***	***90%***	***4.9%***	***97%***	***90%***	***2.4%***	***97%***	***90%***	***2.2%***
	Custom Capital	97%	90%	5.4%	97%	90%	2.5%	97%	90%	2.4%
	Custom O&M	100%	90%	0.0%	100%	90%	0.0%	100%	90%	0.0%
Streamlined Industrial	***Total Small Industrial***	***99%***	***90%***	***0.5%***	***72%***	***90%***	***15.7%***	***89%***	***90%***	***7.8%***
	Green Rewind	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Lighting	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Prescriptive	100%	80%	0.0%	70%	80%	14.4%	90%	80%	7.3%
	Small Industrial	64%	90%	17.2%	81%	90%	24.4%	76%	90%	15.0%
SEM	***SEM***	***97%***	***90%***	***17.5%***	***100%***	***90%***	***0.0%***	***98%***	***90%***	***13.9%***
	Total	**98%**	**90%**	**3.8%**	**94%**	**90%**	**4.1%**	**96%**	**90%**	**3.3%**
	Cannabis	NA	NA	NA	NA	NA	NA	NA	NA	NA

The adjustments to savings were categorized into the following categories:

- Operated or Installed Differently: Different operating hours than what is specified in the ex ante savings calculations; includes equipment not installed or shutdown (back-up equipment).
- Inappropriate Assumption: Assumptions include any assumed values or conditions that are used in the calculation of baseline and/or measure savings. Inappropriate assumptions could be an assumption of idealized conditions that are not representative of actual conditions. Examples of assumptions that may be inappropriate include power factor assumptions, ideal heat transfer assumptions, assumptions of weather dependency, or assumptions of ideal flow conditions.
- Inappropriate Baseline: Examples include building types misclassified for baseline determination, using efficiencies of existing equipment when code-minimum efficiencies should instead be used (or vice-versa), or using a baseline that does not align with code or industry standard practice.
- Calculation or Engineering Error: Errors in the savings calculations that are not attributable to the categorizations described above. This covers anything from spreadsheet cell reference errors, to missing or double-counting adjustment factors, to misplaced decimal points.

- Tracking Error: This covers situations where a piece of equipment was incorrectly categorized for a prescriptive measure.

The drivers for savings adjustments are summarized in Table 4.[2] "Operated or Installed Differently" was the number one issue found for both gas and electric projects, and resulted in the largest adjustments to the estimated savings. Sometimes these issues are outside of the control of the program, such as when a business changes operation parameters after the project is completed, or a customer is no longer in business.

Table 4 | Production Efficiency Program Savings Adjustment Category Summary*

Electric Savings Adjustments	**2016**, n=45	**2017**, n=47	**Total**, n=92	**Absolute Adjusted Savings, kWh**	**% of Savings Adjusted (Category Adjusted Savings/ Total Adjusted Savings)**
Operated or Installed Differently	23	23	46	7,415,352	62%
Inappropriate Assumptions	10	15	25	1,600,304	13%
Inappropriate Baseline	8	5	13	1,726,079	14%
Calculation or Engineering Error	7	6	13	1,269,396	11%
Tracking Error	1	0	1	22,240	0%
Total	**49**	**49**	**98**	**12,033,371**	**100%**
Gas Savings Adjustments	**2016**, n=11	**2017**, n=9	**Total**, n=20	**Absolute Adjusted Savings, therms**	**% of Savings Adjusted (Category Adjusted Savings/ Total Adjusted Savings)**
Operated or Installed Differently	4	2	6	47,300	62%
Inappropriate Assumptions	3	3	6	16,470	22%
Inappropriate Baseline	0	0	0	-	0%
Calculation or Engineering Error	2	3	5	12,608	17%
Tracking Error	0	0	0	-	0%
Total	**9**	**8**	**17**	**76,378**	**100%**

* The total number of projects evaluated was 255, 117 from 2016 and 138 from 2017. More than one adjustment type per project is possible; 'n' reflects the number of projects with adjustments in each year. The categorized Adjusted Savings are all inclusive of adjustments made as a result of the impact evaluation and are presented here in absolute value to demonstrate the magnitude of the adjustments in part and in total.

Overall Key Findings and Recommendations

The findings and recommendations below are for the PE program overall. Section 4 provides additional findings and recommendations for each sub-track and for the cannabis projects.

Finding 1: The PE program was successful at limiting savings adjustments for those things largely within the program's control. However, there is some opportunity for improvement.

Recommendation 1a: Provide robust review of key energy savings assumptions and the baseline condition. Ensure that these factors are based on supporting information from the customer and PDC. These issues were found in every track and sub-track, except for SEM projects.

Recommendation 1b: To limit the adjustments made based on equipment being operated or installed differently, ensure that detailed information is collected from customers about the operation of their equipment via interviews/questionnaires or

[2] See section 4 for more detail on each sub-track.

metered data, so that the operating characteristics used in the ex ante savings calculations are representative of the actual operation of the equipment. Verify descriptions of the equipment locations and pertinent operating parameters ahead of final incentive payments. This issue was found across every track, with the Custom Capital projects accounting for 68% of the adjusted savings within the “Operated or Installed Differently” adjustment category.

Finding 2: The PE program project files were largely complete, providing the necessary project documentation needed for effective impact evaluation. In some cases, the final savings calculation files were not clearly identified, leading to ineffective use of the evaluation team and Energy Trust program staff time.

Recommendation 2a: For Custom track projects, ensure project files are clearly labeled, particularly the final versions of files.

Recommendation 2b: For Custom track projects, add comments in the workbook and a “ReadMe” tab explaining which inputs are metered, trended, and assumed default values. Such a tab could be designed to capture the necessary information in a form format.

Finding 3: As was found in the 2013 and 2014 PE impact evaluation, it was difficult at times to verify information and baseline conditions due to the large timeframe between project completion and the impact evaluation. Changes in customer personnel and operating conditions make it challenging to fully understand changes to projects – both why they occurred and when they occurred. This affects the effectiveness of the evaluation as assumptions must be made that may or may not reflect reality.

Recommendation 3: The 2013 and 2014 impact evaluation recommended consideration of faster or real-time evaluation. Michaels agrees that faster, more real-time evaluation would benefit the program and make for a more efficient and effective impact evaluation.

Memo

To: Board of Directors

From: Erika Kociolek, Evaluation Sr. Project Manager
Eric Braddock, Sr. Technical Manager – Industry and Agriculture

Date: August 27, 2020

Re: Staff Response to 2016-2017 Production Efficiency Impact Evaluation

The 2016-2017 Production Efficiency impact evaluation, conducted by Michaels Energy, demonstrates that the program generated substantial energy savings, and accurately estimated the majority of these savings, as evidenced by relatively high realization rates.

The evaluator found that many of the recommendations from the 2013-2014 Production Efficiency impact evaluation have been addressed. The evaluator made two recommendations related to increasing the reliability of savings and improving program documentation: (1) collecting detailed information from customers about the operation of their equipment via forms or metering to ensure the savings calculations are presentative of equipment operation and (2) ensuring final versions of analysis files for custom projects are clearly labeled and the source of values in analysis files are well documented and clearly explained. Regarding the first recommendation, the program strives for accuracy when collecting information from customers. Depending on the size or complexity of the project, different levels of information are collected from customers. Program staff has developed a standard questionnaire for streamlined industrial that is included in most of the tools for this program track. Program staff is also investigating if the Green Motors program track needs to include additional information on forms. Regarding the second recommendation, starting in 2019 the custom program delivery contractors (PDCs) took on the role of generating all technical analysis studies. In the past, these studies were produced by a large pool of allied technical assistance contractors (ATACs). The program expects to see less variance in terms of the quality and content of analysis files now that only the custom PDCs are conducting technical analysis studies.

The evaluator also made one recommendation related to future evaluations: shifting to faster or real-time evaluation to ensure faster delivery of evaluation results. Faster delivery of evaluation results is important because it provides program staff with more useful and timely information to improve program delivery, allows measures with shorter lifetimes to be evaluated closer to the time they are installed or completed, and reduces the likelihood of changes in customer personnel and operating conditions. The 2018-2019 Production Efficiency impact evaluation is already underway; projects sampled for that evaluation are being evaluated between one and three years after project completion. For the 2020-2021 Production Efficiency impact evaluation, Energy Trust evaluation staff is exploring the possibility of transitioning to real-time evaluation. This would likely involve sampling projects and measures and evaluating sampled projects and measures quarterly or semi-annually. In addition, Energy Trust is evaluating very large or complex projects outside of program impact evaluations and through a separate and ongoing process, which is more similar to the evaluation process for mega-projects and the process for evaluating large New Buildings projects. To date, one Production Efficiency project has been selected to go through this process. This greatly reduces the amount of time between project completion and evaluation.

Unique to this impact evaluation, projects and measures completed at licensed cannabis growing facilities were oversampled due to the substantial savings claimed at these facilities in 2016 and 2017; these facilities represented a new market segment for the Production Efficiency program. The evaluator found a high percentage (26%) of these facilities were out of business at the time of the evaluation (a year or two after project completion). This was driven by significant change and consolidation in the cannabis industry in 2018 and 2019, driven by a product surplus. The evaluator noted the assumed 15-year measure life may not be appropriate for these facilities. With some exceptions (namely water and wastewater facilities), Energy Trust does not use different measure life assumptions for different facility types; the assumption is that the 15-year measure life is an average and accounts for differences in measure life across different facility types. However, Energy Trust evaluation and program staff will monitor the incidence of out of business licensed cannabis growing facilities in the 2018-2019 Production Efficiency impact evaluation. If high percentages of licensed cannabis growing facilities are observed, this may lend support for using a different measure life.

1. Introduction

Energy Trust contracted with Michaels Energy, in partnership with Evergreen Economics (collectively the Michaels Team or Michaels) to complete the impact evaluation of the 2016 and 2017 Production Efficiency (PE) program.

1.1 2016 and 2017 Program Savings

The PE program began in 2003. It is currently comprised of three main program tracks:

- **Custom**: Allows for a comprehensive approach to gas and electric process efficiency projects, retrofits and operations and maintenance (O&M).
- **Streamlined Industrial** (prescriptive and calculated measures): Focus is on simpler, more common equipment measures such as lighting, irrigation, small compressed air, variable frequency drives, and other prescriptive and calculated measures.
- **Strategic Energy Management (SEM)**: Provides training, tools and technical support to enable customers to save energy by establishing or improving energy management practices in the workplace.

Table 5 and Table 6 summarize the projects implemented through the PE program in 2016 and 2017, respectively.

Table 5 | Production Efficiency Program Completed Projects and Reported Savings, 2016[3]

Track	Sub-Track	Sites	Projects	Measures	Electric Savings (kWh)	Gas Savings (Therms)	Preliminary Sample Points	Estimated On-Sites
Custom	Custom Capital	128	164	239	48,564,041	1,134,207	42	30
	Custom O&M	38	44	72	11,215,000	114,992	25	18
Streamlined Industrial	Green Rewind	35	56	70	174,656	-	7	3
	Lighting	339	430	1211	37,608,090	-	9	4
	Prescriptive	374	437	889	4,798,329	396,521	9	4
	Small Industrial	232	263	265	14,459,851	10,709	31	16
SEM	SEM	19	19	19	10,693,215	57,245	15	15
Total		**1,165**	**1,413**	**2,765**	**127,513,182**	**1,713,674**	**138**	**90**

[3] Source: Request for Proposals: Impact Evaluation of the 2016-2017 Production Efficiency Program, Appendix C – Engineering estimates of production efficiency program efficiency savings, page 17 of 26.

Table 6 |

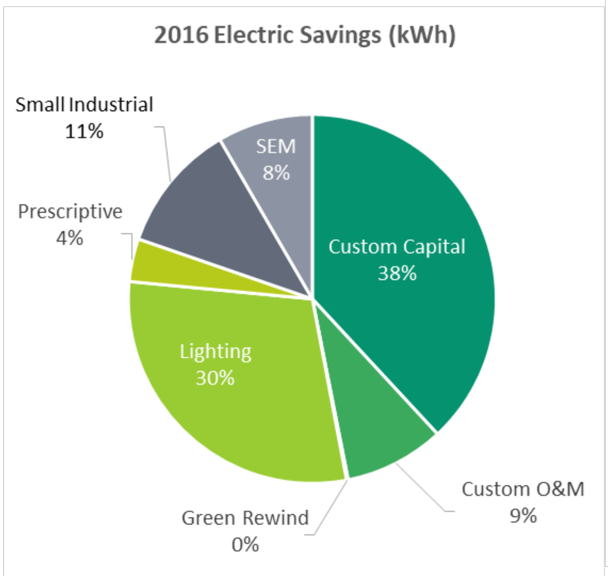
Production Efficiency Program Completed Projects and Reported Savings, 2017[4]

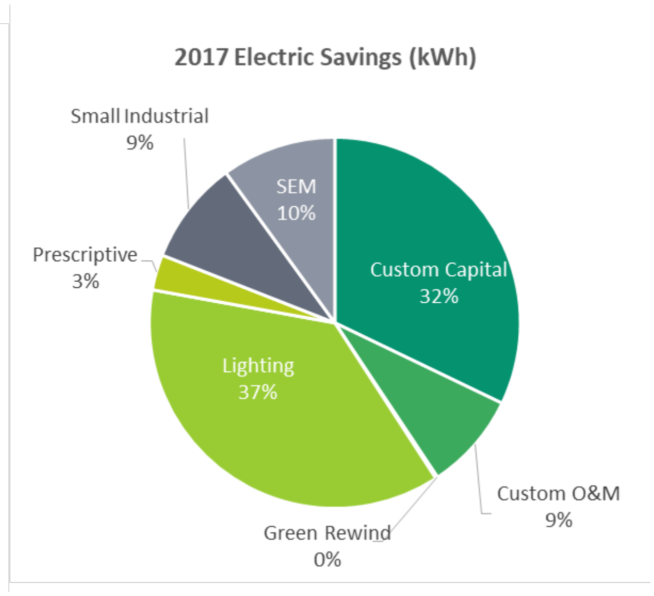
Track	Sub-Track	Sites	Projects	Measures	Electric Savings (kWh)	Gas Savings (Therms)	Preliminary Sample Points	Estimated On-Sites
Custom	Custom Capital	113	144	214	41,003,212	1,408,921	40	28
	Custom O&M	41	46	68	10,882,643	58,939	26	18
Streamlined Industrial	Green Rewind	26	38	46	220,587	-	6	2
	Lighting	429	578	1622	47,236,898	-	9	4
	Prescriptive	335	375	738	3,947,910	190,626	9	4
	Small Industrial	248	268	268	11,561,929	28,792	31	17
SEM	SEM	21	24	24	12,752,782	8,685	17	17
Total		**1,213**	**1,473**	**2,980**	**127,605,961**	**1,695,963**	**138**	**90**

The Custom Capital and Lighting sub-tracks contributed the most electric savings in 2016 (38% and 29%, respectively) and 2017 (32% and 37%, respectively).

Figure 1 |

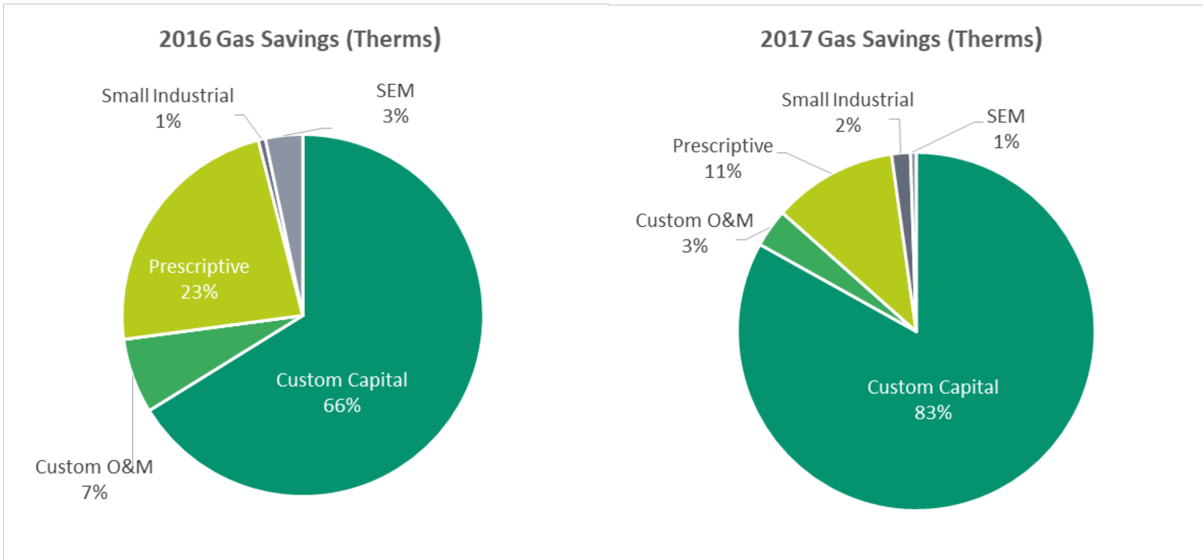
Production Efficiency Electric Savings by Sub-Track, 2016 and 2017





[4] Source: Request for Proposals: Impact Evaluation of the 2016-2017 Production Efficiency Program, Appendix C – Engineering estimates of production efficiency program efficiency savings, page 17 of 26.

Figure 2 |
Production Efficiency Therm Savings by Sub-Track, 2016 and 2017



As shown in Figure 3 and Figure 4 below, in 2016 and 2017 combined, 80% of electric savings (working kWh) came from lighting, compressed air, refrigeration, SEM, irrigation, and chillers. For gas (working therms), 80% of the savings came from air abatement, primary processes, steam, and process heating.

Figure 3 |
Production Efficiency Electric Savings by Measure Type, 2016 and 2017

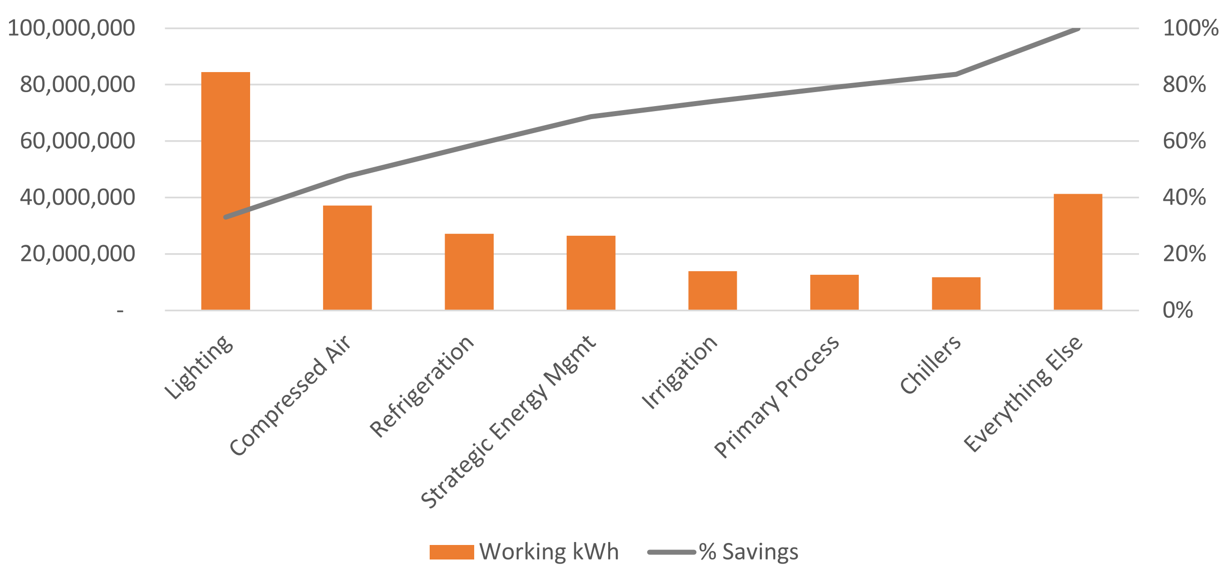
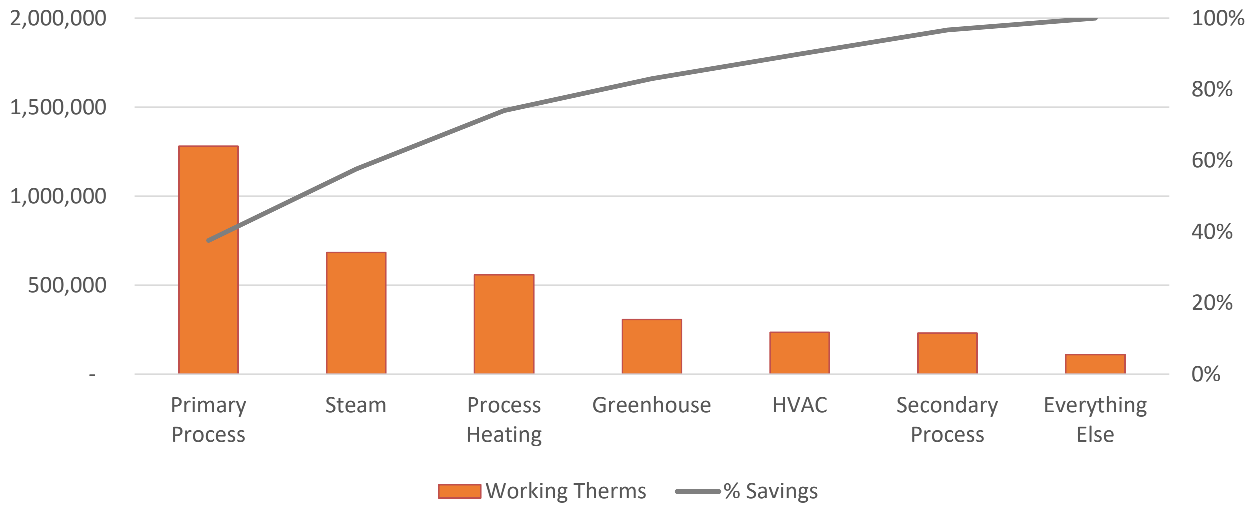


Figure 4 |
Production Efficiency Gas Savings by Measure Type, 2016 and 2017



1.2 Report Organization

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

- Section 2: Impact Evaluation Description: This section provides discussion on the impact evaluation objectives, the evaluation methodology (including sampling), and the impact analysis.
- Section 3: Impact Evaluation Results, Findings, and Recommendations: This section provides discussion on the realization rates, types of impact evaluation adjustments made (categorized adjustments), findings and recommendations for each sub-track and cannabis projects, and an assessment of the recommendations made in the 2013-2014 PE impact evaluation[5]. It should be noted that the 2013-2014 impact evaluation wasn't complete until after the 2016 and 2017 program year; therefore, recommendations from the 2013-2014 impact evaluation report would not have been available for action in the 2016 and 2017 program years.
- Appendices: The appendices provide supporting information for this impact evaluation.

[5] SBW Consulting, Impact Evaluation of 2013-2014 Production Efficiency Program Final Report, March 19, 2019, https://www.energytrust.org/wp-content/uploads/2019/07/20132014PEImpactEvaluation-w-SR.pdf

2. Impact Evaluation Description

2.1 Objectives

The Michaels Team designed the impact evaluation to address the evaluation and research objectives summarized below:

- Develop reliable estimates of Production Efficiency gas and electric program savings for 2016 and 2017, and gas and electric savings for one large project completed in 2015[6], to establish realization rates.
- Report observations and make recommendations to help Energy Trust improve the effectiveness of its estimates of energy savings.
- Investigate SEM projects in more depth.
- Investigate projects completed at licensed cannabis grow facilities in more depth.

In addition to these objectives, the Michaels Team collected data to answer the following questions.

- Are there any aspects of the energy savings analyses by Program Delivery Contractors (PDCs), trade allies, Allied Technical Assistance Contractors (ATACs), or SEM implementers that may be of concern to Energy Trust?
- Are there obvious errors in any of the assumptions used in energy savings analyses, either in the original savings estimates or in verification of energy savings?
- What are the factors that result in large variances in measure savings (e.g., assumptions too conservative, incorrect hours of operation, etc.)?
- Were recommendations made in previous impact evaluations implemented, and if so, how have these changes affected the program? It should be noted that the 2013-2014 impact evaluation wasn't complete until after the 2016 and 2017 program year; therefore, recommendations from the 2013-2014 impact evaluation report would not have been available for action in the 2016 and 2017 program years.
- Are there any 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?
- Are there economic or other trends that are impacting the program's ability to forecast and estimate savings?

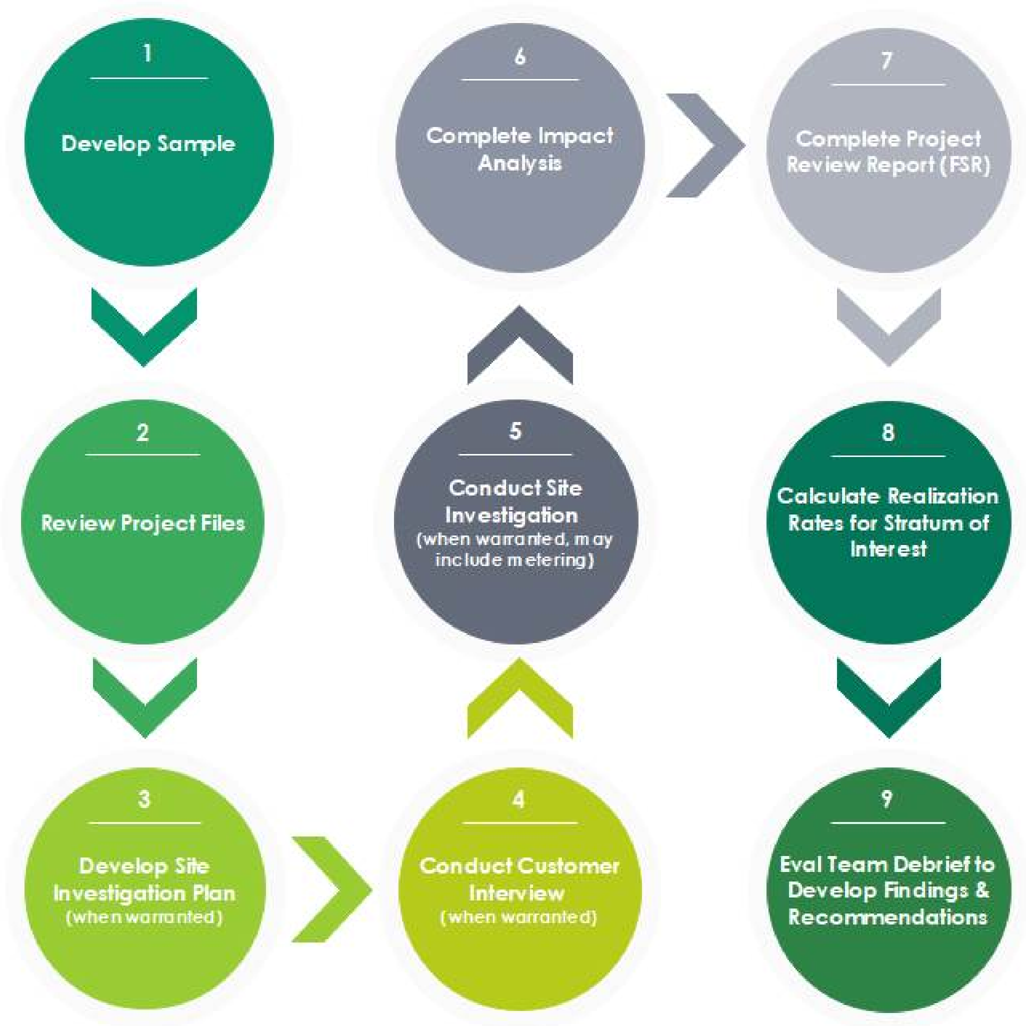
The following sub-sections provide the methodology, including the sampling, for this impact evaluation.

2.2 Impact Evaluation Methodology

The impact evaluation methodology is depicted in Figure 5. Please note that these primary activities include sub-activities not depicted in this figure. The sections following Figure 5 provide more information about each primary activity.

[6] The results of the 2015 large project impact evaluation are provided in a separate report and are not included within the realization rates or other analysis presented within this report.

Figure 5 |
Impact Evaluation Process Flow



2.2.1 Develop Evaluation Sample

Energy Trust staff provided a participant file titled *2016_2017_PEData.txt* on July 30, 2018. This was used to develop a summary of the population working savings (reported in program tracking system) and evaluated working savings, presented in Table 7 and Table 8. The projects included in the evaluated working savings represent those projects sampled for the impact evaluation.

Table 7 |

Population Savings and Savings Evaluated by Program Track, 2016

Track	Sub-track	Electric		
		Population Working kWh	Working kWh Evaluated	Percent kWh Evaluated
Custom	***Custom***	***59,779,041***	***23,515,699***	***39.3%***
	Custom	48,564,041	17,528,508	36.1%
	Custom O&M	11,215,000	5,987,191	53.4%
Streamlined Industrial	***Streamlined Industrial***	***57,040,926***	***15,724,387***	***27.6%***
	Green Rewind	174,656	76,323	43.7%
	Lighting	37,608,090	11,552,700	30.7%
	Prescriptive	4,798,329	2,382,822	49.7%
	Small Industrial	14,459,851	1,712,542	11.8%
SEM	Strategic Energy	10,693,215	5,365,390	50.2%
	Total	**127,513,182**	**44,605,476**	**35.0%**
Cannabis	Cannabis	1,219,426	508,241	41.7%

Track	Sub-track	Gas		
		Population Working Therms	Working Therms Evaluated	Percent Therms Evaluated
Custom	***Custom***	***1,249,199***	***916,602***	***73.4%***
	Custom	1,134,207	802,819	70.8%
	Custom O&M	114,992	113,783	98.9%
Streamlined Industrial	***Streamlined Industrial***	***407,230***	***286,030***	***70.2%***
	Green Rewind	NA	NA	NA
	Lighting	NA	NA	NA
	Prescriptive	396,521	279,075	70.4%
	Small Industrial	10,709	6,955	64.9%
SEM	Strategic Energy	57,245	57,245	100.0%
	Total	**1,713,674**	**1,259,877**	**73.5%**
Cannabis	Cannabis	-	-	NA

NOTE: Cannabis projects are not mutually exclusive of other tracks

Table 8 |
Population Savings and Savings Evaluated by Program Track, 2017

Track	Sub-track	Electric Population Working kWh	Working kWh Evaluated	Percent kWh Evaluated
Custom	***Custom***	***51,885,855***	***17,206,743***	***33.2%***
	Custom	41,003,212	14,708,096	35.9%
	Custom O&M	10,882,643	2,498,647	23.0%
Streamlined Industrial	***Streamlined Industrial***	***62,543,622***	***13,642,286***	***21.8%***
	Green Rewind	220,587	124,524	56.5%
	Lighting	46,813,197	10,577,096	22.6%
	Prescriptive	3,947,910	232,810	5.9%
	Small Industrial	11,561,929	2,707,856	23.4%
SEM	Strategic Energy	12,752,782	8,014,930	62.8%
	Total	**127,182,259**	**38,863,959**	**30.6%**
Cannabis	Cannabis	7,512,248	5,637,998	75.1%

Track	Sub-track	Gas Population Working Therms	Working Therms Evaluated	Percent Therms Evaluated
Custom	***Custom***	***1,469,585***	***1,311,921***	***89.3%***
	Custom Capital	1,408,921	1,251,257	88.8%
	Custom O&M	60,664	60,664	100.0%
Streamlined Industrial	***Streamlined Industrial***	***219,418***	***34,000***	***15.5%***
	Green Rewind	NA	NA	NA
	Lighting	NA	NA	NA
	Prescriptive	190,626	5,208	2.7%
	Small Industrial	28,792	28,792	100.0%
SEM	Strategic Energy	8,685	6,931	79.8%
	Total	**1,697,688**	**1,352,852**	**79.7%**
Cannabis	Cannabis	-	-	NA

NOTE: Cannabis projects are not mutually exclusive of other tracks

2.2.1.1 Sample Design

The sample design was developed to target a 90/10 level of confidence and precision for the Custom Capital, Custom O&M, and SEM tracks. The Streamlined Lighting and Green Rewind tracks have had stable realization rates; therefore, the sample design had a lower standard of confidence and precision for these tracks (80/20). The sample design also sampled cannabis projects as a stand-alone group at the 90/10 level of confidence and precision.

The evaluation achieved the levels of confidence and precision by track and by year, as shown in Table 9 and Table 10. There are two reasons the impact evaluation did not hit the precision targets for natural gas for the Prescriptive (2017) and Small Industrial (2016 and 2017) program tracks, and the Green Rewind for electric (2016 and 2017). First, the sample sizes were very small for these program tracks. Second, each of these two program tracks had projects that deviated substantially from a realization rate of 1.0. Note that program weight is a function of the ex ante savings of projects within a stratum relative to ex ante savings within the program track. More detail for those not meeting the precision target can be found below:

- Green Rewind 2016 Electric: There were only (10) projects evaluated with electric savings – (8) had realization rates of 100% and (2) had realization rates of 0%.
- Green Rewind 2017 Electric: There were only (10) projects evaluated with electric savings – (6) had realization rates of 100%, (1) had a realization rate of 35%, and (3) had realization rates of 0%.
- Small Industrial 2016 Gas: There were only (2) projects with gas savings – (1) had a realization rate of 100% and (1) had a realization rate of 34%.
- Streamlined Industrial 2017 Gas: The lower precision is the result of the lower precision levels for each of the sub-tracks, with the Prescriptive track more heavily weighted due to it comprising 70% of the gas savings.
    - Small Industrial 2017 Gas: There were only (3) projects with gas savings – (2) had realization rates of 46% and (1) had a realization rate of 100%.
    - Prescriptive 2017 Gas: There were only (8) projects with gas savings – (6) had realization rates of 100%, (1) had a realization rate of 50%, and (1) had a realization rate of 2%.
- SEM 2016 Gas: There were only (7) projects evaluated with gas savings – (5) had realization rates of 100%, (1) had a realization rate of 101%, and (1) had a realization rates of 4%.

Table 9 |

Achieved Levels of Confidence and Precision by Program Track 2016

Program Track and Sub-track	-----------Electricity-----------				-----------Gas-----------			
	Confidence		Precision		Confidence		Precision	
	Target	Actual	Target	Actual	Target	Actual	Target	Actual
Custom	**90%**	**90%**	**Better than 10%**	**3.5%**	**90%**	**90%**	**Better than 10%**	**4.9%**
Custom Capital	90%	90%	10%	3.1%	90%	90%	10%	5.4%
Custom O&M	90%	90%	10%	5.4%	90%	90%	10%	0.0%
Streamlined Industrial	**90%**	**90%**	**10%**	**2.6%**	**90%**	**90%**	**10%**	**0.5%**
Green Rewind	80%	80%	15%	20.6%	NA	NA	NA	NA
Lighting	80%	80%	15%	1.6%	NA	NA	NA	NA
Prescriptive	80%	80%	15%	3.8%	80%	80%	15%	0.0%
Small Industrial	90%	90%	10%	4.5%	90%	90%	10%	17.2%
SEM	**90%**	**90%**	**10%**	**7.3%**	**90%**	**90%**	**10%**	**17.5%**
Cannabis	**90%**	**90%**	**10%**	**2.7%**	**NA**	**NA**	**NA**	**NA**

Table 10 |

Achieved Levels of Confidence and Precision by Program Track 2017

Program Track and Sub-track	----------Electricity----------				----------Gas----------			
	Confidence		Precision		Confidence		Precision	
	Target	Actual	Target	Actual	Target	Actual	Target	Actual
Custom	**90%**	**90%**	**Better than 10%**	**1.0%**	**90%**	**90%**	**Better than 10%**	**2.4%**
Custom Capital	90%	90%	10%	1.3%	90%	90%	10%	2.5%
Custom O&M	90%	90%	10%	0.0%	90%	90%	10%	0.0%
Streamlined Industrial	**90%**	**90%**	**10%**	**2.5%**	**90%**	**90%**	**10%**	**15.7%**
Green Rewind	80%	80%	15%	27.3%	NA	NA	NA	NA
Lighting	80%	80%	15%	2.2%	NA	NA	NA	NA
Prescriptive	80%	80%	15%	0.0%	80%	80%	15%	14.4%
Small Industrial	90%	90%	10%	4.4%	90%	90%	10%	24.4%
SEM	**90%**	**90%**	**10%**	**2.0%**	**90%**	**90%**	**10%**	**0.0%**
Cannabis	**90%**	**90%**	**10%**	**3.5%**	**NA**	**NA**	**NA**	**NA**

2.2.1.1.1 Probability Sample and Stratification

The Dalenius-Hodges stratification process is based on the quantiles of the distribution of projects in the population. The population of projects are first ordered from largest to smallest based on estimated savings and then projects are assigned to their respective strata. For electric, there are four strata with each strata consisting of approximately 25% of ex ante kWh savings. For gas, there are three strata with each strata consisting of approximately 33% of ex ante gas savings.

For each year, fuel, and specific track, the Michaels Team used the Dalenius-Hodges method to stratify projects by ex ante savings in order to optimize the efficacy of the sample design, given the allowable budget and the evaluation time constraints.[7] This approach assigns sampling units into strata based on one or more characteristics (e.g., ex ante energy savings). By segmenting the projects into strata based on ex ante savings, within-strata variation is reduced, which in turn reduces the sample necessary to meet the levels of confidence and precision.

There were 235 probability projects randomly selected and stratified per below using the Dalenius-Hodges stratification method:

- Strata kWh: 1 = Large, 2 = Medium, 3 = Small, 4 = Extra Small
- Strata therm: 1 = Large, 2 = Medium, 3 = Small

2.2.1.1.2 Certainty Project Selection

In addition to stratified random sampling, Michaels selected projects that met specific size criteria as certainty sites. Choosing some projects as certainty sites eliminates the possibility that these larger projects would not be selected through random sampling. In addition, particularly large projects are often very different from other projects within a program; therefore, the findings from the evaluation of such projects may not be well suited for extrapolation to the

[7] For more information on the Dalenius-Hodges method, see Section 5A.7 of Sampling Techniques, 3rd Edition, by William G. Cochran.

overall population of projects. For this reason, evaluation results from certainty projects are not applied beyond that project.

The 22 certainty projects within the sample were selected based on the following criteria:

- For non-cannabis electricity projects, the criteria for selection as a certainty project was that the project constituted 10% or more of ex ante electricity savings for the program track or sub-track and ex ante electricity savings were at least 250,000 kWh.
- For gas projects, the criteria for selection as a certainty project was that the project constituted 10% or more of ex ante gas savings for the program track or sub-track and ex ante gas savings were at least 40,000 therms.
- For cannabis projects, the criteria for selection as a certainty project was that the project constituted 5% or more of ex ante electricity savings for all cannabis projects and ex ante electricity savings were at least 25,000 kWh.

2.2.1.2 Sample Frame and Sample

Energy Trust staff provided a participant sample frame file titled *2016_2017_PEData.txt* on July 30, 2018. Table 11 shows the distribution of sample points—projects—by program year, fuel, specific track, and strata. There are many more sample points allocated to electricity than to gas because there are many more electricity projects.

Cannabis projects are shown in the sampling tables as an individual track, but this is for evaluation purposes only. Cannabis is not a specific track or sub-track in the Production Efficiency program. The sample frame file included a 'cannabisflag' field to identify projects completed at licensed cannabis growing facilities.

Table 11 |
Distribution of Sample Points by Program Year, Fuel, Specific Track, and Strata

2016 Program---kWh								2016 Program Year---Therms							2016	2016
Track	Sub-track	Certainty	Stratum 1	Stratum 2	Stratum 3	Stratum 4	10.5	Track	Sub-track	Certainty	Stratum 1	Stratum 2	Stratum 3	Dropped	Total Projects Sampled	Total Projects Evaluated
Custom	Custom Capital	0	6	4	5	4	0	Custom	Custom Capital	1	1	0	10	0	31	31
	Custom O&M	2	1	3	3	1	0		Custom O&M	1	0	1	0	0	12	12
Streamlined Industrial	Green Rewind	0	2	3	2	3	0	Streamlined Industrial	Green Rewind	NA	NA	NA	NA	0	10	10
	Lighting	0	4	4	4	3	0		Lighting	NA	NA	NA	NA	0	15	15
	Prescriptive	1	1	4	3	3	0		Prescriptive	2	1	2	6	0	23	23
	Small Industrial	0	3	2	2	2	0		Small Industrial	0	0	1	1	0	11	11
SEM	SEM	3	0	0	0	4	1	SEM	SEM	0	0	0	5	0	12	11
Cannabis		0	0	1	1	2	0	Cannabis		NA	NA	NA	NA	0	4	4
Total		6	17	21	20	22	1	Total		4	2	4	22	0	118	117
% of Savings in Sample Ffame		0.2%	1.0%	3.1%	11.4%	84.2%				3.5%	1.8%	7.0%	87.7%			

2017 Program Year---kWh								2017 Program Year---Therms							2017	2017
Track	Sub-track	Certainty	Stratum 1	Stratum 2	Stratum 3	Stratum 4	Dropped	Track	Sub-track	Certainty	Stratum 1	Stratum 2	Stratum 3	Dropped	Total Projects Sampled	Total Projects Evaluated
Custom	Custom Capital	0	5	6	6	6	0	Custom	Custom Capital	4	1	0	6	0	34	34
	Custom O&M	1	0	2	3	2	0		Custom O&M	0	1	1	2	0	12	12
Streamlined Industrial	Green Rewind	0	1	3	2	4	0	Streamlined Industrial	Green Rewind	NA	NA	NA	NA	0	10	10
	Lighting	0	5	4	3	5	0		Lighting	NA	NA	NA	NA	0	17	17
	Prescriptive	1	0	4	3	3	0		Prescriptive	0	3	3	2	0	19	19
	Small Industrial	0	5	4	3	3	0		Small Industrial	0	0	1	2	0	18	18
SEM	SEM	3	1	0	2	2	1	SEM	SEM	0	0	1	1	0	10	9
Cannabis		3	0	6	6	4	0	Cannabis		NA	NA	NA	NA	0	19	19
Total		8	17	29	28	29	1	Total		4	5	6	13	0	139	138
% of Savings in Sample Ffame		0.2%	1.1%	3.7%	10.8%	84.3%				3.8%	5.7%	10.5%	80.0%			
Total 2016 and 2017 Projects Evaluated															257	255

Two SEM projects in the sample were dropped from the evaluation due to unresponsive customers: Project-00027016 and Project-00027122[8]. Without the ability to discuss these projects with a knowledgeable site representative, evaluating these projects was not possible. These projects were from the 2016 Strategic Energy Management Strata – Certainty and 2017 Strategic Energy Management Strata – 3, respectively. Table 12 shows the impact to the realization rates for the SEM track, if these projects had been included, with realization rates set at zero and set at 100%. Dropping these projects from the evaluation had no impact on the SEM track gas realization rates.

Table 12 |
Effect of SEM Projects Dropped from Evaluation Sample on SEM Track Electric Realization Rates

Year	Projects Dropped from Sample	Projects Included in Sample with RR=0%	Projects Included in Sample with RR=100%
2016	135%	94%	124%
2017	93%	84%	94%
Combined Years	112%	89%	108%

2.2.2 Review Project Files (Desk Reviews)

The Michaels Team reviewed project files for each sampled project. This review included a review of measure documentation and savings calculations to verify savings claimed. Project file reviews were also used to identify projects for which a site investigation would be beneficial and to develop the customer interview guides for each sub-track and for cannabis projects. The information gathered through the interviews was used to inform the impact evaluation and provided data to explain adjustments to reported savings. Michaels completed project file reviews for all projects sampled for this impact evaluation.

2.2.2.1 Custom and Streamlined Industrial

The interview guides for the Custom track and Streamlined Industrial track participants assessed changes in facility operation and key facility personnel since project completion. The facility personnel were asked about current and anticipated operating hours, production levels, production lines, processes, and building renovations.

2.2.2.2 SEM

The interview guides for SEM track participants included questions focused on SEM-specific project characterizations.

[8] Please note that all project identification numbers reflect those in the Michaels Energy tracking system to project to anonymity of the customer.

2.2.2.3 Cannabis

The interview guides for cannabis participants focused on establishing proper baselines. The quickly changing horticultural lighting technologies and the turnover of grow facility ownership and operations were explored through questions in the interview guide, which asked about plans for future upgrades as well as past ownership and expected future consolidation.

2.2.3 Develop Site Investigation Plans (Site-Specific Measurement and Verification Plan, or SSMVP)

For those projects for which a site visit was deemed appropriate, a site-specific measurement and verification plan (SSMVP) was developed to outline the data and information to be gathered. Critical parameters to be monitored or verified, such as measures and operating conditions with significant impact on savings and those with a high level of uncertainty, were identified.

Each SSMVP included:

- Equipment to be inspected
- Parameters, assumptions, and operating conditions to be verified
- Data to be collected from energy management systems, when warranted
- Metering or loggers to be installed, when warranted
- A proposed analysis methodology and data to be collected to complete the impact analysis
- Participant interview questions

2.2.4 Conduct Customer Interview

Interviews were completed for all certainty projects and for probability sites where interviews were determined to be useful in the evaluation. For sites with multiple projects completed and/or multiple measures installed, Michaels ensured the interviews focused on those measures with higher savings, calculation accuracy risk, and/or specific interest to Energy Trust.

Table 13 |
Number of Interviews Planned and Completed

			Total Interviews Planned 2016 & 2017			Total Interviews Actual 2016 & 2017		
Fuel	Track	Sub-Track	non-Cannabis	Cannabis		non-Cannabis	Cannabis	
Electric	Custom	Custom O&M	18	0	18	18	0	18
		Custom Capital	42	2	44	37	2	39
	Streamlined Industrial	Green Rewind	16	0	16	18	0	18
		Lighting	20	21	41	26	17	43
		Prescriptive	16	0	16	18	0	18
		Small Industrial	18	0	18	21	0	21
	SEM	SEM	16	0	16	15	0	15
	Total		146	23	169	153	19	172
Gas	Custom	Custom O&M	4		4	6		6
		Custom Capital	20		20	21		21
	Streamlined Industrial	Prescriptive	12		12	17		17
		Small Industrial	2		2	5		5
	SEM	SEM	9		9	6		6
	Total		47		47	55		55
Total Electric and Gas			193	23	216	208	19	227

2.2.5 Conduct Site Visits

Michaels conducted site visits in accordance with the site-specific evaluation plans approved by Energy Trust's Evaluation Project Manager and program staff. To facilitate the site investigation, Energy Trust staff and PDCs assisted with the customer recruitment though initial outreach.

There were six projects (Project-00026939, Project-00027198, Project-00027138, Project-00027195, Project-00027007 and Project-00027122) for which the customer refused a site visit. For five of these cases, Michaels conducted a thorough project file review to estimate evaluated savings and to establish realization rates. The remaining project (Project-00027122) was dropped due to insufficient information available to conduct a reliable impact evaluation.

There were also eight customers that are no longer in business. The evaluated savings for these projects were determined based on when the customer went out of business, how long the program equipment was installed and operational, if the equipment was currently installed, and the future plans for the site and equipment. Michaels included a description of each project approach and the reasoning for the impact evaluation results in the Final Site Report submitted and reviewed by Energy Trust staff.

Table 14 |
Number of Site Investigations Planned and Completed

Fuel	Track	Sub-Track	Total Site Visits Planned 2016 & 2017			Total Site Visits Actual 2016 & 2017		
			non-Cannabis	Cannabis	Total	non-Cannabis	Cannabis	Total
Electric	Custom	Custom O&M	18	0	**18**	18	0	**18**
		Custom Capital	42	2	**44**	34	2	**36**
	Streamlined Industrial	Green Rewind	6	0	**6**	2	0	**2**
		Lighting	8	15	**23**	15	13	**28**
		Prescriptive	8	0	**8**	4	0	**4**
		Small Industrial	18	0	**18**	15	0	**15**
	SEM	SEM	16	0	**16**	13	0	**13**
	Total		**116**	**17**	**133**	**101**	**15**	**116**
Gas	Custom	Custom O&M	4		**4**	6		**6**
		Custom Capital	20		**20**	20		**20**
	Streamlined Industrial	Prescriptive	12		**12**	10		**10**
		Small Industrial	2		**2**	2		**2**
	SEM	SEM	9		**9**	6		**6**
	Total		**47**		**47**	**44**		**44**
Total Electric and Gas			**163**	**17**	**180**	**145**	**15**	**160**

2.2.5.1 Data Logging

Michaels leveraged utility data and customer metering systems already in place to form the basis of our data collection efforts, when available. In some cases, data was best collected through the installation of metering or logging equipment. During the site visits, meters or logging equipment were installed as specified in the site-specific measurement and verification plan, or as identified during a deeper file review, customer interviews, and the site investigation. Table 15 shows the number of sites where meters were planned to be installed and were actually installed. The primary reason for meters not installed is because we were able to obtain information from interviews and/or site visits.

Table 15 |
Number of Meter Installations Planned and Completed

Fuel	Track	Sub-Track	Total Meter Installs Planned 2016 & 2017			Total Meter Installs Actual 2016 & 2017		
			non-Cannabis	Cannabis	Total	non-Cannabis	Cannabis	Total
Electric	Custom	Custom O&M	2	0	**2**	1	0	**1**
		Custom Capital	6	1	**7**	4	0	**4**
	Streamlined Industrial	Green Rewind	0	0	**0**	2	0	**2**
		Lighting	3	0	**3**	1	2	**3**
		Prescriptive	0	0	**0**	1	0	**1**
		Small Industrial	7	0	**7**	2	0	**2**
	SEM	SEM	0	0	**0**	0	0	**0**
	Total		**18**	**1**	**19**	**11**	**2**	**13**
Gas	Custom	Custom O&M	0		**0**	2		**2**
		Custom Capital	2		**2**	1		**1**
	Streamlined Industrial	Prescriptive	0		**0**	1		**1**
		Small Industrial	0		**0**	0		**0**
	SEM	SEM	0		**0**	0		**0**
	Total		**2**		**2**	**4**		**4**
Total Electric and Gas			**20**	**1**	**21**	**15**	**2**	**17**

2.3 Impact Analysis

The impact analysis first determined the individual measure and project evaluated savings. Next, the individual project evaluated savings were aggregated to the track and sub-track level, and then to the program level for each year (2016 and 2017) and by fuel type.

2.3.1 Streamlined Industrial and Custom Projects

The Michaels Team used our extensive library of energy models, custom built calculations, and system simulations to determine evaluated savings.

2.3.2 SEM Projects

Evaluated savings estimates for each SEM project were calculated based on the billed regression analyses used for the original working (ex ante) savings estimates. When deemed necessary, adjustments were made to the original regression models using information collected as part of the customer interview and the site inspections.

Michaels also used the customer interview to verify which measures from the opportunity register were completed and to gather details on any capital measures installed during the SEM analysis period. This information was used to verify the savings regression analysis.

3. Impact Evaluation Results, Findings, and Recommendations

This section provides discussion on the types of impact evaluation adjustments made (categorized adjustments), findings and recommendations for each sub-track and for cannabis projects, and an assessment of the recommendations made in the 2013-2014 PE impact evaluation[9].

Each section begins on a new page to allow for easy distribution to interested parties.

[9] SBW Consulting, Impact Evaluation of 2013-2014 Production Efficiency Program Final Report, March 19, 2019, https://www.energytrust.org/wp-content/uploads/2019/07/20132014PEImpactEvaluation-w-SR.pdf

3.1 Realization Rates

Electric realization rates for the 2016 and 2017 Production Efficiency program overall were 86% and 90%, respectively.

Gas realization rates for the 2016 and 2017 sub-tracks were 98% and 94%, respectively.

Table 16 |
Production Efficiency Program Realization Rate by Year and Fuel Type

	2016			2017			Combined Years		
Fuel Type	RR	C	P	RR	C	P	RR	C	P
Electric	86%	90%	3.1%	90%	90%	1.8%	88%	90%	1.8%
Gas	98%	90%	3.8%	94%	90%	4.1%	96%	90%	3.3%

Table 17 and Table 18 provide a summary of the realization rates by track and sub-track for each year evaluated and combined. Explanations for what led to each realization rate are provided in the following specific program track and sub-track sub-sections.

Table 17 |
Electric Realization Rates by Track, Sub-Track, and Year

		2016			2017			2016 & 2017 Combined		
Track	Sub-track	Realization Rate	Lower 90%	Upper 90%	Realization Rate	Lower 90%	Upper 90%	Realization Rate	Lower 90%	Upper 90%
Custom	***Custom Total***	***75%***	***72%***	***79%***	***95%***	***94%***	***96%***	***84%***	***83%***	***86%***
	Custom Capital	71%	68%	74%	93%	92%	94%	81%	80%	83%
	Custom O&M	94%	88%	99%	100%	100%	100%	97%	95%	99%
Streamlined Industrial	***Streamlined Industrial Total***	***88%***	***85%***	***90%***	***85%***	***83%***	***88%***	***87%***	***84%***	***89%***
	Green Rewind	66%	41%	83%	74%	46%	101%	71%	52%	87%
	Lighting	91%	89%	92%	88%	86%	90%	89%	88%	91%
	Prescriptive	92%	88%	96%	100%	100%	100%	96%	94%	97%
	Small Industrial	78%	74%	83%	71%	66%	75%	75%	71%	78%
SEM	Strategic Energy	135%	128%	142%	93%	91%	95%	112%	109%	116%
	Total	**86%**	**84%**	**88%**	**90%**	**89%**	**91%**	**88%**	**87%**	**89%**
Cannabis	Cannabis	95%	92%	98%	81%	77%	84%	82%	78%	85%

Table 18 |
Gas Realization Rates by Track, Sub-Track, and Year

		2016			2017			2016 & 2017 Combined		
Track	Sub-track	Realization Rate	Lower 90%	Upper 90%	Realization Rate	Lower 90%	Upper 90%	Realization Rate	Lower 90%	Upper 90%
Custom	***Custom Total***	***98%***	***92%***	***102%***	***97%***	***95%***	***99%***	***97%***	***95%***	***99%***
	Custom Capital	97%	91%	102%	97%	94%	99%	97%	95%	99%
	Custom O&M	100%	100%	100%	100%	100%	100%	100%	100%	100%
Streamlined Industrial	***Streamlined Industrial Total***	***99%***	***99%***	***100%***	***72%***	***55%***	***87%***	***89%***	***81%***	***97%***
	Green Rewind	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Lighting	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Prescriptive	100%	100%	100%	70%	55%	84%	90%	83%	97%
	Small Industrial	64%	47%	81%	81%	55%	104%	76%	61%	91%
SEM	Strategic Energy	97%	74%	109%	100%	100%	100%	98%	79%	107%
	Total	**98%**	**94%**	**101%**	**94%**	**90%**	**97%**	**96%**	**94%**	**98%**
Cannabis	Cannabis	NA	NA	NA	NA	NA	NA	NA	NA	NA

For the 2016 and 2017 impact evaluation, the primary reasons for electric savings adjustments were due to "equipment found to be operated or installed differently". Sometimes these issues are outside of the control of the program, such as when a business changes operation parameters or the way the project is completed. More discussion on the drivers for lower realization rates is included in the specific sub-track sections.

In the 2013 and 2014 impact evaluation, adjustments are not categorized by the type of adjustment, but based on the report recommendations it appears that working savings estimate issues were mostly related to overly optimistic operating conditions or errors in the engineering calculations. These issues are largely within the program's control. See Section 3.2 for an analysis of savings adjustment categories.

A comparison of the realization rates for 2016 and 2017 program years are compared below to the prior impact evaluation for program years 2013 and 2014[10].

Table 19 |
Production Efficiency Program Realization Rates for 2013, 2014, 2016, and 2017 by Fuel Type

Fuel Type	2013	2014	2016	2017
Electric	96%	91%	86%	90%
Gas	97%	100%	98%	94%

[10] The 2013 and 2014 realization rates are from the SBW Consulting, Impact Evaluation of 2013-2014 Production Efficiency Program Final Report, March 19, 2019, https://www.energytrust.org/wp-content/uploads/2019/07/20132014PEImpactEvaluation-w-SR.pdf

3.2 Categorized Adjustments

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

- Operated or Installed Differently: Different operating hours than what is specified in the ex ante savings calculations; includes equipment not installed or shutdown (back-up equipment).
- Inappropriate Assumption: Assumptions include any assumed values or conditions that are used in the calculation of baseline and/or measure savings. Inappropriate assumptions could be an assumption of idealized conditions that are not representative of actual conditions. Examples of assumptions that may be inappropriate include power factor assumptions, ideal heat transfer assumptions, assumptions of weather dependency, or assumptions of ideal flow conditions.
- Inappropriate Baseline: Examples include building types misclassified for baseline determination, using efficiencies of existing equipment when code-minimum efficiencies should instead be used (or vice-versa), or using a baseline that does not align with code or industry standard practice.
- Calculation or Engineering Error: Errors in the savings calculations that are not attributable to the categorizations described above. This covers anything from spreadsheet cell reference errors, to missing or double-counting adjustment factors, to misplaced decimal points.
- Tracking Error: This covers situations where a piece of equipment was incorrectly categorized for a prescriptive measure.

Table 20 summarizes the number of categorized adjustments by fuel type and by year. Figure 6 and Figure 7 illustrate the associated energy savings adjustment for each adjustment category. "Operated or Installed Differently" was the number one issue found for both gas and electric projects and produced the largest adjustments to the estimated savings.

Table 20 |
Production Efficiency Program Savings Adjustment Category Summary*

Electric Savings Adjustments	2016, n=45	2017, n=47	Total, n=92	Absolute Adjusted Savings, kWh	% of Savings Adjusted (Category Adjusted Savings/ Total Adjusted Savings)
Operated or Installed Differently	23	23	46	7,415,352	62%
Inappropriate Assumptions	10	15	25	1,600,304	13%
Inappropriate Baseline	8	5	13	1,726,079	14%
Calculation or Engineering Error	7	6	13	1,269,396	11%
Tracking Error	1	0	1	22,240	0%
Total	**49**	**49**	**98**	**12,033,371**	**100%**
Gas Savings Adjustments	**2016, n=11**	**2017, n=9**	**Total, n=20**	**Absolute Adjusted Savings, therms**	**% of Savings Adjusted (Category Adjusted Savings/ Total Adjusted Savings)**
Operated or Installed Differently	4	2	6	47,300	62%
Inappropriate Assumptions	3	3	6	16,470	22%
Inappropriate Baseline	0	0	0	-	0%
Calculation or Engineering Error	2	3	5	12,608	17%
Tracking Error	0	0	0	-	0%
Total	**9**	**8**	**17**	**76,378**	**100%**

* The total number of projects evaluated was 255, 117 from 2016 and 138 from 2017. More than one adjustment type per project is possible; 'n' reflects the number of projects with adjustments in each year. The categorized Adjusted Savings are all inclusive of adjustments made as a result of the impact evaluation and are presented here in absolute value to demonstrate the magnitude of the adjustments in part and in total.

Figure 6 |
Production Efficiency Electric Savings Impact Evaluation Adjustments

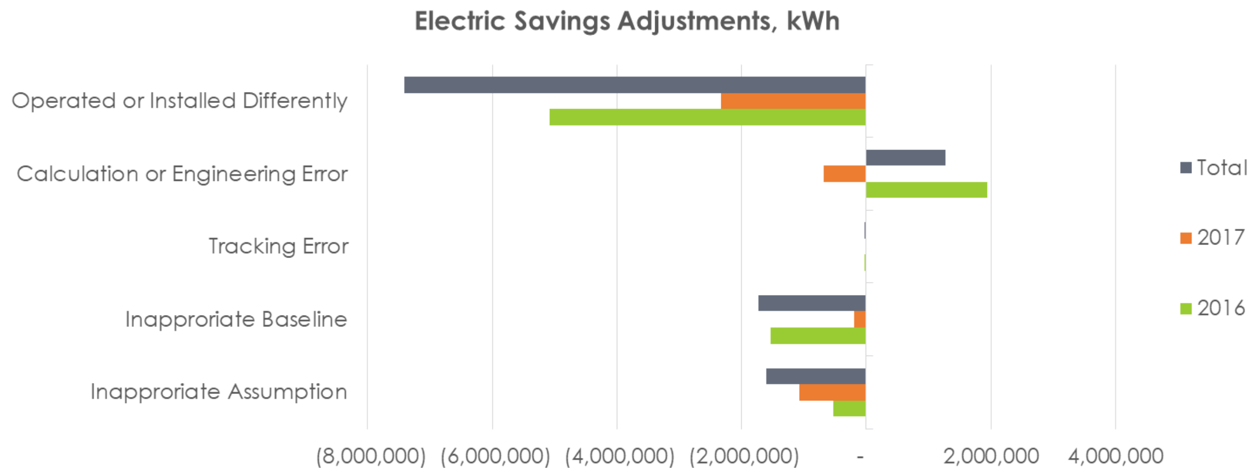
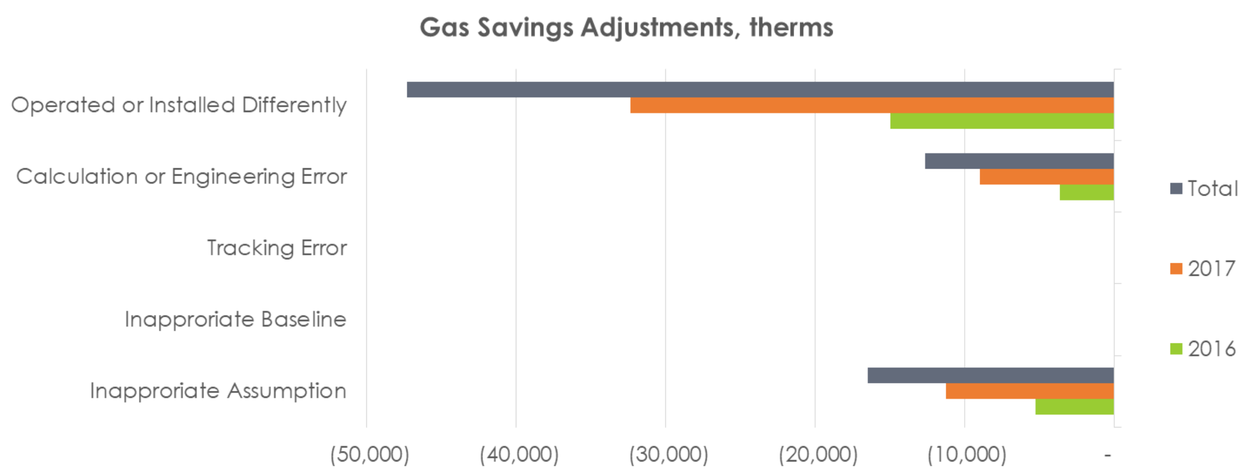


Figure 7 |
Production Efficiency Gas Savings Impact Evaluation Adjustments



3.3 Custom Capital Projects

Custom projects cover a wide range of process and equipment improvements to increase energy efficiency at a variety of facility types. Examples of custom projects include:

- Variable frequency drives (VFDs) on pump, fan, and compressor motors
- HVAC upgrades, such as installation of variable speed fans and equipment with higher efficiency ratings
- Regenerative thermal oxidizer installation
- Lumber dying kiln moisture controls and VFDs
- Compressor and condenser upgrades in large refrigeration systems
- Heat exchangers for the capture of process waste heat

3.3.1 Findings

Custom Capital realization rates are provided in Table 21.

Table 21 |
Custom Capital Realization Rates Summary for 2016, 2017 and Combined

Sub-track	2016		2017		Combined Years	
	Electric, n=19	Gas, n=12	Electric, n=23	Gas, n=11	Electric, n=42	Gas, n=23
Custom Capital	71%	97%	93%	97%	81%	97%

3.3.1.1 Realization Rate Adjustments Summary Findings

The realization rates (RR) for the Custom Capital projects ranged from 0% to better than 100%.

Some causes of low realization rates are described below. Please note that not every finding results in a recommendation, as some issues may be outside of the control of Energy Trust and PDCs, or issues are not pervasive enough to warrant action, but are catalogued here should issues become more prevalent. Some example projects are referenced for each finding, but may not represent the entire universe of projects with this issue.

1. HVAC projects in spaces with strict temperature and/or humidity requirements were sometimes not able to meet the parameters defined in the project scope. These projects included changes from constant volume to variable volume systems, free cooling on chillers, and VFDs with minimum speed reductions. Examples: Project-00026929 and Project-00026931.
2. Some VFDs installed on dust collection or ventilation systems suffered from dirty environments and filters that became clogged faster than anticipated in the original savings calculation. The clogged filters increased the system pressure drop and degraded savings from the VFD installation. Example: Project-00027034.
3. In some cases actual operating hours were estimated incorrectly, or they were adjusted since the project was completed due to changes in production. Examples: Project-00026934, and Project-00026927.
4. Some process heating (gas and electric) projects received low realization rates due to overly ambitious assumptions of idealized heat transfer. Most of the adjustments from these projects were corrected using a billed data regression. These projects would have performed better if the savings had been based on metered energy use of the heater rather than a model of expected heat transfer performance. Examples: Project-00027133, and Project-00027172.

3.3.1.2 Savings Calculation Inputs and Assumptions

1. Although most savings calculation workbooks for Custom Capital projects were well documented and easy to follow, in some cases values were hardcoded and the source of the value was not provided or explained.
2. The final versions of the calculation workbooks in the project files were not always easily identified.

3.3.2 Recommendations

1. To improve the accuracy of the savings estimates for Custom Capital projects:
    a. Savings for process heating projects are better estimated using the metered energy use of the heater rather than a model of expected heat transfer performance.
2. To improve the effectiveness of the evaluation (for Energy Trust staff, as well as the evaluation team):
    a. Ensure that final versions of calculation workbooks are clearly labeled - e.g., using file names like, “project name_Final”.
    b. Add comments in the workbook and a “ReadMe” tab explaining which inputs are metered, trended, and assumed defaults values. Such a tab could be designed to capture the necessary information in a form format.

3.4 Custom O&M Projects

Custom O&M projects cover changes to operating conditions that do not involve equipment. These projects can include:

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

3.4.1 Findings

Custom O&M realization rates are provided in Table 22.

Table 22 | Custom O&M Realization Rates Summary

Sub-track	2016		2017		Combined Years	
	Electric, n=10	Gas, n=2	Electric, n=8	Gas, n=4	Electric, n=18	Gas, n=6
Custom O&M	94%	100%	100%	100%	97%	100%

3.4.1.1 Realization Rate Adjustments Summary Findings

1. The Custom O&M projects generally received high realization rates when the operating conditions defined in the project were maintained by the facility. When the facility did not have proper training or when the operating conditions were too aggressive to be applied in all production or weather conditions, the project savings decreased.
2. In general, the projects that did not maintain the setpoints prescribed in the projects were most frequently in facilities where the operators did not have a strong understanding of their equipment and controls. When the project was led by an outside contractor rather than an onsite manager, the savings were less likely to persist.
3. Many of the Custom O&M projects involved equipment that was directly metered for energy consumption before and after the setpoint change. The metered data helped ensure energy savings estimates were reasonable.

3.4.1.2 Savings Calculation Inputs and Assumptions

1. Although most savings calculation workbooks for Custom O&M projects were well documented and easy to follow, in some cases values were hard coded and the source of the value was not provided or explained.
2. The final versions of the calculation workbooks in the project files were not always easily identified.
3. In some cases, the calculations were performed by the Allied Technical Assistance Contractors, and were not provided for review during the evaluation timeframe, or the third party contractor used a proprietary model. These projects were not fully evaluable. Examples: Project-00027055 and Project-00026949.[11]

[11] These examples may not represent the universe of projects that had this issue.

3.4.2 Recommendations

1. To improve the effectiveness of the evaluation for Energy Trust staff as well as the evaluation team:
    a. Ensure that final versions of calculation workbooks are clearly labeled – e.g., using file names like, "project name_Final".
    b. Add comments in the workbook and a "ReadMe" tab explaining which inputs are metered, trended, and assumed defaults values. Such a tab could be designed to capture the necessary information in a form format.
    c. Require third party contractors to use non-proprietary models for energy savings estimation.

3.5 Streamlined Industrial Green Rewind Projects

Green Rewind projects receive incentives for disassembly and refurbishment of electric induction motors, including re-winding and testing the stators in order to restore or maintain a motor's original efficiency.

3.5.1 Findings

Green Rewind realization rates are provided in Table 23.

Table 23 |
Green Rewind Realization Rates Summary

Sub-track	2016		2017		Combined Years	
	Electric, n=10	Gas, n=0	Electric, n=10	Gas, n=0	Electric, n=20	Gas, n=0
Green Rewind	66%	NA	74%	NA	71%	NA

3.5.1.1 Realization Rate Adjustments Summary Findings

1. For five projects evaluated, the savings were set to zero because the motor was not in use due to the motor being a spare, or because the facility was no longer in operation.
2. One project had the savings reduced due to the motor being installed in an agricultural application rather than an industrial setting as claimed. Agricultural motors have lower savings levels due to fewer hours per year of operation.

3.5.2 Recommendations

1. To improve the accuracy of the savings estimates for Green Rewind projects:
    a. Ensure that motors approved for incentives are reinstalled and operational rather than placed into storage.
    b. Ensure that the program application and database reflect the applicable industry.

3.6 Streamlined Industrial Lighting Projects

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

3.6.1 Findings

The Lighting realization rates are provided in Table 24.

Table 24 |
Streamlined Industrial Lighting Realization Rates Summary

Sub-track	2016		2017		Combined Years	
	Electric, n=15	Gas, n=0	Electric, n=17	Gas, n=0	Electric, n=32	Gas, n=0
Lighting	91%	NA	88%	NA	89%	NA

3.6.1.1 Realization Rate Adjustments Summary Findings

1. The most common adjustment made was to the operating hours of the lights involved in a project. This caused the savings for some projects to increase, and others to decrease. The hours adjustments were sometimes made using data collected with installed lighting loggers, and sometimes were based on information provided by the customer.
2. Some projects included savings from occupancy sensors that reduced operating hours of the lights. The operating hour reduction was an assumed value provided by the customer that ranged from 25% to 75% based on the space and facility type. In some warehouses, light loggers were installed and confirmed high operating hour reductions consistent with the 75% reduction assumption.
3. In warehouse spaces, many projects assumed a 75% reduction from occupancy sensors in the warehouse and the loading dock. Based on collected light logger data, this assumption was reasonable for the warehouse but not appropriate for the loading dock. The loading dock has consistently higher activity than the warehouse so the lighting operation reduction was less than the assumed 75%. Examples: Project-00026979 and Project-00027078[12].
4. Re-lamping projects:
    a. One project erroneously used an incandescent baseline. This baseline was corrected to an EISA-compliant equivalent compact fluorescent (CFL) baseline.
    b. Two projects incorrectly stated the wattage of replacement TLED lamps with ballasts. The ballast includes a wattage penalty that was frequently excluded from the estimate of post project energy consumption.
5. More specific new construction space types should be used when calculating the baseline. Any space larger than 10,000 square feet should be classified distinctly. This issue was most relevant to spaces with a mixed warehouse and manufacturing space. In these projects, large spaces were defined as manufacturing when they were actually a warehouse. The code-allowed lighting power density (LPD) for a warehouse is much lower than the LPD for a manufacturing space. This issue was identified for one project,

[12] These examples may not represent the universe of projects that had this issue.

P00001211983 but mentioned here as this can have large implications when not handled correctly.

3.6.1.2 Savings Calculation Inputs and Assumptions

1. Savings Calculation Workbooks
    a. New Construction Workbook:
        i. The new construction savings calculation workbook has multiple tabs that link to each other. The workbook could be easier to use and the savings estimate would take less time if it was streamlined and the assumptions were more clearly organized.
    b. Program Lighting Tool:
        i. The program lighting tool calculation workbook does not include the identification number of the measures for each fixture. This makes the review of the estimated savings time-consuming and inefficient because each fixture must be matched to a loosely defined measure in order to review savings at the measure level.

3.6.2 Recommendations

1. To improve the accuracy of the savings estimates for Lighting projects:
    a. Ensure re-lamping projects are using the correct baseline by updating the program lighting tool workbook to reflect the current baseline each year (for example, do not use incandescent baselines).
    b. Ensure projects correctly state the wattage of replacement TLED lamps with ballasts.
    c. Ensure new construction projects correctly define the space types included to accurately estimate the savings.
2. To improve the effectiveness of the evaluation for Energy Trust staff as well as the evaluation team:
    a. For the program lighting tool workbook, add a column to indicate the identification number of the measure for each fixture.
    b. Ensure reasons for adjustments to energy savings workbooks are clearly identified in project documentation (for example, changing user-defined values to standard values).
    c. Consider streamlining the new construction lighting workbook, organizing and identifying the project assumptions according to the inputs into the model.

3.7 Streamlined Industrial Prescriptive Projects

Prescriptive projects cover equipment replacements and equipment installations. These projects can include:

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

3.7.1 Findings

Prescriptive realization rates are provided in Table 25.

Table 25 | Streamlined Industrial Prescriptive Realization Rates Summary

Sub-track	2016		2017		Combined Years	
	Electric, n=12	Gas, n=11	Electric, n=11	Gas, n=8	Electric, n=23	Gas, n=19
Prescriptive	92%	100%	100%	70%	96%	90%

3.7.1.1 Realization Rate Adjustments Summary Findings

1. The projects generally received high realization rates because most equipment was found to be program-qualifying and used as expected.
2. For one of the reviewed projects that involved the installation of several high efficiency boilers, the savings were adjusted to 50% of the ex ante savings because half of the installed boilers were used as backup units and therefore almost never ran.

3.7.1.2 Savings Calculation Inputs and Assumptions

1. The prescriptive savings for steam pipe insulation and hot water pipe insulation are based strictly on the temperature of the material inside the piping, and are not dependent on the size (i.e., diameter) of the piping. Multiple projects were identified for which the savings would have drastically changed if the size of the piping being insulated was taken into account.

3.7.2 Recommendations

1. To improve the accuracy of the savings estimates for Prescriptive projects:
    a. Savings for irrigation system seal and gasket replacements should be adjusted to account for irrigation pumps that are not powered via the grid. It is recommended that this be done by applying adjustment factors to the prescriptive savings, with the adjustment factors being the percent of time that grid power is used for irrigation pumping.
    b. Add size classifications to the prescriptive savings for hot water and steam piping insulation. Possible size classifications could be 2” diameter or less, 2-6” diameter, 6-10” diameter, 10-16” diameter, and greater than 16” diameter. Note that comprehensive data on pipe diameters was not collected through this evaluation.
    c. Ensure that all boilers meet minimum operating requirements.

3.8 Streamlined Industrial Small Industrial Projects

The Small Industrial projects cover equipment replacements and equipment installations. These projects can include:

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

3.8.1 Findings

Small Industrial realization rates are provided in Table 26.

Table 26 | Streamlined Industrial Small Industrial Realization Rates Summary

Sub-track	2016		2017		Combined Years	
	Electric, n=9	Gas, n=2	Electric, n=15	Gas, n=3	Electric, n=24	Gas, n=5
Small Industrial	78%	64%	71%	81%	75%	76%

3.8.1.1 Realization Rate Adjustments Summary Findings

1. Many significant adjustments were made to projects, yielding realization rates ranging from 0% to 229%. Out of the 29 Small Industrial projects that were reviewed, 20 projects received adjustments to savings.
2. One project received a realization rate of 0% because the installed control system on a farm was only used to monitor conditions, and the control capabilities of the system were not actually being utilized.

3.8.1.2 Savings Calculation Inputs and Assumptions

1. Compressed air projects were commonly adjusted due to the compressor loading being different than what is specified in the ex ante savings calculations.
2. The inputs used to characterize the use of high speed doors in refrigerated areas and the operation of the baseline doors were often found to be inconsistent with the operation determined during the site visit and conversations with the customer. This led to adjustments to the values used in the savings calculations which resulted in a reduction in savings.
3. The information used in the savings calculations to characterize the operation of defrost controls for refrigeration systems was found to be atypical in multiple instances, causing the baseline defrost energy use to be significantly higher than what was deemed appropriate during the evaluation. Adjusting these to values more typical of commercial/industrial refrigeration systems caused the savings for multiple refrigeration controls projects to decrease.

3.8.2 Recommendations

1. To improve the accuracy of the savings estimates for Small Industrial projects:

a. Ensure that detailed information is collected from customers about the operation of their equipment via interviews/questionnaires or metered data, so that the operating characteristics used in the ex ante savings calculations are representative of the actual operation of the equipment.
b. In situations where baselines are not wholly dictated by code (such as refrigeration system controls) and there is not a functioning existing system that can be used to establish a baseline, additional checks should be made to ensure the baseline system details align with what is considered industry standard practice, to ensure the baseline is reasonable and appropriate.
c. Savings for large projects should be checked against the typical energy use of the facility to ensure the claimed savings make sense.

3.9 Strategic Energy Management Projects

Strategic Energy Management (SEM) projects include training, tools, and technical support for 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. These actions can include:

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

Savings are estimated using various energy savings models developed by the customer or implementation provider.

3.9.1 Findings

SEM realization rates are provided in Table 27.

Table 27 |
SEM Realization Rates Summary

Sub-track	2016		2017		Combined Years	
	Electric, n=6	Gas, n=5	Electric, n=7	Gas, n=2	Electric, n=13	Gas, n=7
SEM	135%	97%	93%	100%	112%	98%

3.9.1.1 Realization Rate Adjustments Summary Findings

1. Energy Savings Regression Models
    a. The energy models included checks to identify atypical data that could skew the regressions. Such data points could stem from the facility being shut down for a holiday, the facility halting production temporarily while maintenance or re-tooling is done, or simply from a short period of extremely hot or extremely cold weather. These data checks were generally found to be well-documented and made sense for the energy models.
    b. The SEM regression models were found to accurately characterize the energy use of the facilities, supporting high realization rates for most projects. Most of the regressions used production information as one of the variables in the model, and most models also used weather data as a variable in the model.
    c. Although most energy models were found to be sound, several projects reported annual savings estimates based on just a few months of reporting period energy use data[13]. Small variations in a reporting period energy use can potentially have a significant impact on the reported savings. For example, weather-dependent savings estimates could be skewed higher or lower depending on the nature of the savings and the time of year covered by the reporting period. If a SEM project

[13] The program's minimum reporting period requirement is 3 months and is common to require a longer reporting period for models where seasonality is a factor.

yields heating energy savings through heat recovery from an industrial process, it will produce savings during the winter but not the summer. If the SEM model looks at savings from November through March and then extrapolates out to a full year, savings for that measure will be exaggerated.

   d. Some customers were unable to provide details about the SEM initiatives at their facility due to the employee turnover, and some customers were unsure about the completion or presence of some SEM opportunities due to the amount of time that had elapsed between the SEM engagement period and the time of the evaluation. This created challenges in gathering information from some customers to support the evaluation of savings for SEM projects and adjustments made to the savings analysis.

2. Energy Savings Regression Models Adjustment Specifics: Given the structure of the SEM program and the way that SEM savings are determined, adjustments were primarily due to changes to the energy model based on collected data and site observations that made a clear improvement to the model. The most common adjustment made during Michaels' evaluation of the SEM projects was to the weather data used in the energy model regressions.
   a. In the savings calculations for Project-00027017, the regression developed in the energy model resulted in a single atypical reporting period energy use value, and the result was a significant drop in the estimated savings for the project. The variables used in the model were reviewed, and there was nothing especially atypical about the operation of the facility during that time, and it was concluded that the atypical data point was simply due to the sensitivity of the regression model and a combination of variables that were outside of normal values just enough to have a significant impact on the expected energy use. Removing that one data point from the savings calculations caused the estimated annual savings for the project to increase by over 2 million kWh.
   b. There were several instances where modifications could be made to how the weather data was used in the model to result in a better regression result. These modifications varied:
      i. Some projects used average daily or weekly temperature data and were switched to heating degree days and cooling degree days for the evaluation to ensure a better fit.
      ii. Some projects used heating degree days and cooling degree days, but adjusting the balance point temperature improved the model.

3.9.1.2 Other Observations

1. Anecdotally, it was observed that some sites lack staff qualifications for performing maintenance (such as for compressed air systems). One example of this is having a person on staff that is trained in the use of ultrasonic detectors for finding compressed air leaks. This was an observation about some sites, and it is recommended that this be a research question for future evaluations of SEM.
2. Opportunity Registers: SEM participants were pleased with the opportunity register developed as part of the SEM engagement and felt that it provided valuable information about ways to save energy with little to no capital cost.

a. Since the end of the SEM engagement period, (11) of the (20) evaluated customers have stopped updating the opportunity register. There are several reasons contributing to this, including a gradual disengagement of staff from the energy-saving initiatives, or the customer has a separate central system for tracking work orders and task priorities.
b. Anecdotally, some facility personnel mentioned that it would be helpful if the opportunity registers developed during the SEM engagement included a rough estimate of the savings and benefits expected from each action item as this would help prioritize actions and provide a sense of how big of an impact certain simple actions can have on energy use. This was not a specific research question for this project, but may be a useful research question for future evaluations of SEM.

3.9.2 Recommendations

1. To improve the accuracy of the savings estimates for SEM projects:
    a. When appropriate, use heating and cooling degree-days in energy models rather than average temperature. Energy use tends to correlate better to heating and cooling degree-days, especially when a high percentage of facility energy use is for space and/or process heating and cooling.
    b. For projects that use weather as a variable or facilities that have seasonality of production, it is recommended that ASHRAE Guideline 14, Section 5.2.4 be used as guidance for the post-retrofit measurement period:

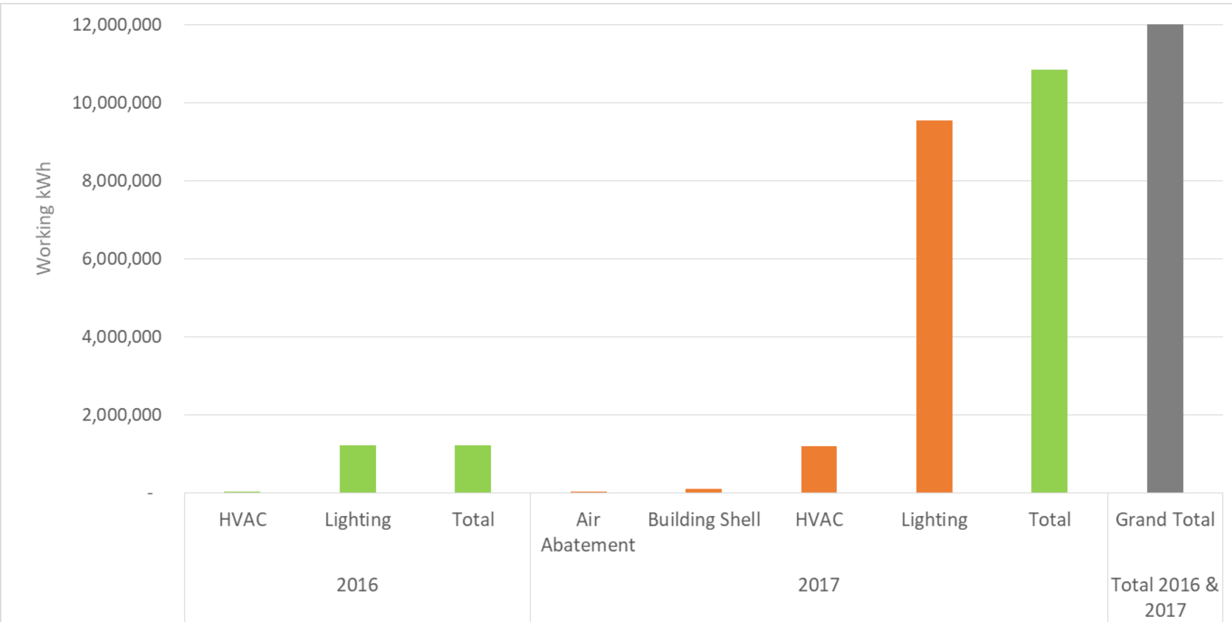
    ASHRAE Guideline 14, 5.2.4 Setting the Duration of the Post-Retrofit Measurement Period. Variables used in computing savings shall be measured over a period of time that is long enough to:
    1. Encompass all operating modes of the retrofitted system(s),
    2. Span the full range of independent variables normally expected for the post retrofit period, and
    3. Provide the intended level of certainty in the reported savings.

    One year of data post-retrofit is the ideal to more accurately capture seasonal and weather-based variations in energy usage. However, it is recognized that this guideline can be cumbersome. Therefore, we recommend a minimum time period of 6 months provided ASHRAE items above are covered for these types of projects. For projects that are not affected by weather or seasonality, the current minimum of 3 months is sufficient.
    c. Reduce the time between the completion of SEM initiatives and when they are evaluated. This will result in more timely feedback, will allow evaluators to collect information from customers when details of the SEM initiatives and engagement are relatively fresh in their minds, and will minimize the risk of not being able to collect sufficient data to support the evaluation due to employee turnover or facility operational changes.
    d. Carefully consider variables used in the regression models for establishing the best fit based on the type of project.
    e. Consider adding an estimate of savings or description of other benefits for each action item in the opportunity register to help SEM participants prioritize actions to complete.

3.10 Cannabis Projects

The projects completed at licensed cannabis grow facilities were primarily based on lighting measures with nearly 11 MWh in lighting savings comprising the total 12 MWhs in program savings for 2016 and 2017. The number of projects and associated savings in 2017 is eight times greater than in 2016.

Figure 8 |
Cannabis Project Electric Savings by Measure Type



3.10.1 Findings

The Cannabis realization rates are provided in Table 28.

Table 28 |
Cannabis Realization Rates Summary

Sub-track	2016		2017		Combined Years	
	Electric, n=4	Gas, n=0	Electric, n=19	Gas, n=0	Electric, n=23	Gas, n=0
Cannabis	95%	NA	81%	NA	82%	NA

3.10.1.1 Realization Rate Adjustments

1. Out-of-Business (OOB) Sites: It is possible for OOB sites to introduce bias into the evaluated sample. To mitigate this concern, Michaels applied the following rules for the impact evaluation of projects implemented at sites that are no longer in business.
    a. OOB site projects received a 100% installation rate when the equipment was installed and used more than a year. The reasoning is that savings associated with equipment removed after a year becomes a measure life issue.

b. OOB site projects received a 0% realization rate, when the equipment was used for less than one year after installation. This was the primary driver for the realization rates.

2. Measure Life: The EUL for most commonly observed LED type installed (SPYDRx)[14], if used continuously in a vegetation or clone room, is 11.2 years, per expected lifetime of this product as stated by Fluence, the manufacturer[15]. Additionally, given that 26% of sites evaluated are out of business, using a cannabis LED measure life less than 11 years could be appropriate. Currently, Energy Trust is using a 15-year measure life.

3.10.1.2 Operations

1. LED Bulb Concern: Anecdotally, some growers who have retrofitted from high pressure sodium bulbs to LEDs expressed concerns about the LEDs. The LEDs that are supposed to be 1-to-1 replacements are not strong enough to grow the same yield and quality of plant. To compensate, growers are adding more LEDs and/or are lowering the LEDs so they are closer to the plants (this is only possible due to the decreased heat output of LEDs compared to HPS). Lowering the lights increases the light intensity on the plants directly below the lights, but decreases the overlap area and overall lighted area covered by each light. This was not a specific research question, so it was not explored across all projects evaluated. This may be a good research question for future evaluations.
2. LED Benefits: The biggest advantage of LEDs is the heat decrease. The overall cooling load decreases dramatically, causing less evaporation of water from the soil and transpiration from the plants, thereby decreasing the dehumidification load - which also decreases the heat output. Overall, the LEDs and the decreased necessity for dehumidification decreases cooling load in the space.
3. Life Cycle Energy Usage: The life cycle of the plants plays a big part in energy usage. Cannabis plants will continue to grow naturally as long as they are exposed to over 14 hours of light per day. Therefore, for the mothers, seeds, clones, and vegetative phase plants, most growers set their lights for 18 to 24 hours of exposure each day. Once they reach the proper size to bloom, they are placed in a room set for 12 to14 hours of light exposure each day. This triggers the flowering phase of the plants. The plant phases also take differing amounts of time (for example – clone = 2 weeks, vegetation = 3 weeks, and flower = 7-8 weeks), therefore there are usually more plants in the flowering phase than any other.

3.10.1.3 Cannabis Growth Operations Business Trends

1. Out-of-Business (OOB) Issues Reported by Interviewed Customers: It must be noted that program participants implementing projects at licensed cannabis grow facilities were often hesitant to respond to many questions, particularly when businesses had closed

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[14] Please note that the collection of baseline equipment was not an objective of this study. Therefore, the most commonly observed LED type installed (SPYDRxis) an anecdotal observation.
[15] See manufacturer website for more information on this, https://shop.fluence.science/store/spydr-series/spydrx-plus/.

operations. Therefore, the information presented below should be considered anecdotal. Additional research is recommended if deemed important to the program.

a. Currently, a product surplus in Oregon has resulted in cannabis grow facility closures and/or halted production. This is supported by the online article, *Oregon Is Producing Twice As Much Cannabis As People Are Using*[16]. Of the 23 evaluated projects, 6 sites, representing 6 projects and 12 measures, have closed operations. Some of these customers have sold their equipment to other grow facilities, others are trying to sell, and in the case of one grower, the equipment was stolen, forcing the site to close.
b. There is a shift to larger investment groups for long-term stability, suffocating smaller "Mom and Pop" grow farms. This could lead to program efficiencies of delivery, but could also reduce available savings over time as industrial growers perfect the growth operations and/or more efficient systems
c. There is a need to learn how to store mature plants and product before processing. This might allow for some growers to remain in business and could be a possible program addition to ensure storage facilities are energy efficient.

3.10.2 Recommendations

1. To offer more energy savings opportunities for cannabis projects
    a. Consider incentives for the following measures:
        i. CO_2 tanks (rather than burning natural gas) are safer to use and reduce the cooling load requirement as there is no free-burning open flame.
        ii. Automatic feeder (rhythm auto feeder) can save on water. It can recycle dehumidifier water for feeding.
        iii. Newer dehumidifiers produce less heat, saving energy and reducing cooling load.
    b. Promote building shell insulation
2. To align measure life with measure installations due to sites closing operations should the trend to close continue, the program could consider reducing the assumed measure life. For example, if the trend continues with approximately 25% of sites going out of business, measure life for each measure could be reduced by 25%. Future evaluations could explore this issue.

[16] Kristian Foden-Vencil, OPB, January 31, 2019. https://www.opb.org/news/article/oregon-cannabis-surplus-2019/

3.11 Status of Recommendations from Prior Impact Evaluation Report

This impact evaluation assessed whether or not recommendations from the last impact evaluation were implemented. The last impact evaluation[17] of the Production Efficiency program was done for the 2013 and 2014 program years. The key recommendations are listed below.

1. Consider faster or real-time evaluation. We found that this evaluation was hampered by the long duration from project completion to evaluation. Evaluation delays prevent timely implementation of any recommendations resulting from the evaluation for future improvements to the program. There were also significant delays evaluating some specific projects due to problems with obtaining customer cooperation in a timely fashion.

   2016-2017 PE Impact Evaluation Finding: This recommendation has not been implemented. Michaels experienced these same issues during this evaluation project and agrees that faster, more real-time evaluation would benefit the program and make for a more efficient and effective evaluation.

2. Clarify M&V protocols related to savings duration. Energy Trust's M&V protocols are not clear about whether evaluation savings estimates should be based on as observed conditions, conditions in the first year after measure implementation, or a combination of conditions prorated over the measure life cycle. We recommend that Energy Trust determine which savings estimates best serve the programs and define that protocol. Future evaluation requests for proposals should then clearly state the protocol on how to appropriately handle all parameters in the savings models to achieve the required evaluation savings estimates. This will ensure methodological consistency over future years. This evaluation was based on typical savings as the average of historical production/operating hours and the working analysis. If we had used first year only or as observed conditions, then savings for some of the large projects would have been significantly lower, resulting in lower realization rates.

   2016-2017 PE Impact Evaluation Finding: This was not a finding for this evaluation; therefore, it appears to be implemented.

3. More pre- and post-installation metering. Many projects are developed using baseline schedules provided by the customer and kW loads based on equipment nameplate data. We found several projects where the customer (at the time of the evaluation) stated different baseline conditions than used in the working analysis. Therefore, the baseline conditions may have been simply assumed by the analyst. Also, we found post-installation kW equipment loads based on nameplate data, for which our metered results revealed substantial differences. Additional metering to determine schedule and kW

[17] SBW Consulting, Impact Evaluation of 2013-2014 Production Efficiency Program Final Report, March 19, 2019, https://www.energytrust.org/wp-content/uploads/2019/07/20132014PEImpactEvaluation-w-SR.pdf

profiles, or even one-time measurements to confirm nameplate kW, would improve the accuracy of some working savings estimates significantly.

<u>2016-2017 PE Impact Evaluation Finding</u>: The recommendation to install more metering was addressed well. For most custom projects, equipment was metered pre- and post-period where appropriate based on load variance and the impact on savings.

4. <u>Consider maximum (design) capacity and realistic loads</u>. We found multiple projects that based savings on maximum equipment capacity or future expected loads, when in fact, the equipment was operating at significantly reduced loads. Realistic loading should be the analysis goal. This is also justification for post-installation metering. There are some cases of this that result from unforeseen market conditions, which cannot be anticipated and are beyond the control of the Program, but due diligence with customer interviews during the site visit is warranted.

   <u>2016-2017 PE Impact Evaluation Finding</u>: Michaels observed some issues with maximum design capacity and realistic load assumptions, but these were primarily due to unforeseen significant decreases in production that could not have been predicted at the time of the analysis. Therefore, this recommendation appears to be implemented.

5. <u>Better QC of working analysis models.</u> We found errors in the working analysis calculations of 11 projects. About half the errors were significant (greater than 10% impact on savings) while the remaining errors were minor with little impact. The errors appeared randomly across most of the sample domains. Additional QC would be beneficial to identify and correct such errors. This would also help ensure well documented analyses. Consider enlisting the efforts of an independent third-party QC contractor to improve analytical quality.

   <u>2016-2017 PE Impact Evaluation Finding</u>: Although "engineering or calculation" adjustments were a common finding, the savings adjustments related to this issue were minor.

Appendix A: Customer Introduction Letter

421 SW Oak St., Suite 300

Portland, OR 97204

February 14, 2019

Dear Customer:

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

We have contracted with Michaels Energy, an independent research consulting firm, to help determine the actual performance of energy efficiency projects that received support through the Production Efficiency program in 2016 and 2017. If applicable, Michaels Energy will also discuss operations and maintenance practices associated with projects supported by Energy Trust between 2010 and 2015, to help Energy Trust learn how changes over time have impacted the projects previously supported.

An evaluation engineer from Michaels Energy will be contacting you to complete a short phone interview. The engineer may also request a visit to your facility. This representative **will not** request any personal information and will display a company identification badge.

What to Expect if Selected for a Site Visit

An evaluation engineer will request to schedule a site visit at a time that is convenient for you between January and March 2019. During that visit, the engineer will require access to all equipment that received incentive support. The engineer will gather information on the facility and operations, and may install metering on some equipment. If an energy management system is available at the facility, the engineer may request data to be used in analyzing the energy savings associated with your project. The amount of time required depends on the scale of the project to be analyzed. Every attempt will be made to reduce the impact on your operations.

If you have questions or if another person is the appropriate contact for this study, please feel free to contact Paige Markegard, Project Coordinator at Michaels Energy (608.792.3686 or plmarkegard@michaelsenergy.com). You may also contact me directly at my phone number or email below.

Thank you for being a leader in energy efficiency, and for your participation in this study to help Energy Trust further energy efficiency in Oregon.

Sincerely,

Erika Kociolek, Evaluation Sr. Project Manager, Energy Trust of Oregon
503.445.0578 or erika.kociolek@energytrust.org

Appendix B: Customer Interview Guides

The interview guides will be shared as a stand-alone document.

Appendix C: Confidential - Completed Customer Interview Dataset

The data and information collected through the customer interviews was entered into an interview response tracker file. This confidential file will be shared as a stand-alone document.

Appendix D: Confidential - Final Site Reports

The confidential final site reports will be shared as a stand-alone document.