Impact Evaluation of the 2015–2016 Existing Buildings Program

Energy Trust of Oregon

Date: 6/25/2018

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0 EXECUTIVE SUMMARY

Energy Trust of Oregon (Energy Trust) hired DNV GL to complete an impact evaluation of Energy Trust's 2015–2016 Existing Buildings Program. This report presents the methods, results, and findings of the evaluation. The goal of the evaluation was to improve savings estimates and enhance the Existing Buildings Program's effectiveness in delivering savings to customers. In addition, the report also provides insights regarding strategic energy management (SEM) and current market penetration of tubular light-emitting diode (TLED) lamps.

0.1 Program overview

The Existing Buildings program began in March 2004 and is implemented by a program management contractor. ICF International has been the PMC since January 1, 2013. The program has four main tracks: Custom, Lighting (including standard, direct-install, and street lighting measures), Standard (prescriptive), and Strategic Energy Management (SEM). This program acquired 24% of the electric energy savings[1] and 25% of the gas savings[2,3] acquired by all Energy Trust efficiency programs.

- In 2018, this program is expected to provide 26% of all electricity savings and 24% of all gas savings acquired by Energy Trust in the program year.[4]

0.2 Savings claimed

Table 1 shows the gross claimed program savings by track, years, and fuel included in the program tracking data provided to DNV GL. The values shown are the site-level "working" savings listed in the data provided. These savings do not include adjustments for prior realization rates, net-to-gross, or transmission and distribution.

Table 1: Claimed energy savings, by year, fuel, and track

	Data Lines		Electricity Savings (kWh)		Gas Savings (therms)	
Program Track	2015	2016	2015	2016	2015	2016
Custom	263	252	26,045,331	25,840,900	789,124	654,306
Standard Lighting	7,976	7,268	66,159,552	77,678,006	0	0
Standard Non-Lighting	1,393	1,461	6,515,821	10,590,409	559,703	753,615
Capital Measures Only	9,632	8,981	98,720,704	114,109,315	1,348,827	1,407,921
Strategic Energy Management	114	168	10,330,780	9,806,709	539,194	481,771
Grand Total	9,746	9,149	109,051,484	123,916,024	1,888,021	1,889,692

[1] Evergreen Economics, Report to Legislative Assembly on Public Purpose Expenditures, January 2015 – December 2016, FINAL 2 Year Report May 25, 2017. https://www.energytrust.org/wp-content/uploads/2017/08/2017_2-Year-PPC-Report_Final_Revised_05-25-17.pdf

[2] 2015 Annual Report to the Oregon Public Utility Commission & Energy Trust Board of Directors, ENERGY TRUST OF OREGON APRIL 15, 2016, UPDATED OCTOBER 24, 2016 https://www.energytrust.org/wp-content/uploads/2016/12/2015.Annual.Report.OPUC_.with_.NEEA_.pdf

[3] 2016 Annual Report to the Oregon Public Utility Commission & Energy Trust Board of Directors, ENERGY TRUST OF OREGON APRIL 14, 2017, UPDATED DECEMBER 15, 2017 https://www.energytrust.org/wp-content/uploads/2017/04/Energy.Trust_.2016.Annual.Report.OPUC_.pdf

[4] Excludes "Existing Multifamily". Energy Trust 2018 Budget and Action Plan. https://www.energytrust.org/wp-content/uploads/2017/12/APPROVED_Budget_and_Action_Plan_2018_web.pdf

0.3 Evaluation results

Table 2 shows the evaluated savings by track and program year. Table 3 provides the final program and track level realization rates achieved.

Table 2: Evaluated energy savings, by year, fuel, and track

	Electricity Savings (kWh)		Gas Savings (therms)	
Program Track	2015	2016	2015	2016
Custom	24,525,378	22,222,244	637,221	678,824
Standard Lighting	65,497,956	73,017,326	N/A	N/A
Standard Non-Lighting	4,980,109	10,032,315	423,695	572,747
Capital Measures Only	94,618,760	104,828,006	1,061,256	1,224,990
Strategic Energy Management	9,216,657	9,038,775	446,946	546,458
Grand Total	103,823,011	113,872,754	1,506,080	1,790,532

Table 3: Program realization rates, by year, fuel, and track

	Electricity Realization Rates			Gas Realization Rates		
tracks	2015	2016	Total	2015	2016	Total
Custom	94%	86%	90%	81%	104%	91%
Standard Lighting	99%	94%	96%	N/A	N/A	N/A
Standard Non-Lighting	76%	95%	88%	76%	76%	76%
Capital Measures Only	96%	92%	94%	79%	87%	83%
Strategic Energy Management	89%	92%	91%	83%	113%	100%
Existing Buildings Program	95%	92%	93%	80%	95%	88%

0.4 Historic capital measure performance

Table 4 and the charts on the following page show historic program performance. The table and charts do not include the SEM track which was added to the Existing Buildings program in 2015.

Table 4: Historic program performance, excluding SEM

Program Year	Verified Electric Savings (MWh)	Electric Realization Rate	Verified Gas Savings (therms)	Gas Realization Rate
2008	41,887	99%	746,564	87%
2009	63,537	85%	705,644	75%
2010	91,884	107%	1,486,729	86%
2011	98,776	91%	2,148,020	101%
2012	86,911	95%	1,174,676	79%
2013	79,612	88%	911,922	67%
2014	82,699	81%	973,143	72%
2015	94,992	96%	1,061,316	79%
2016	104,962	92%	1,228,416	87%

Figure 1: Historic Non-SEM program electric savings and realization rates

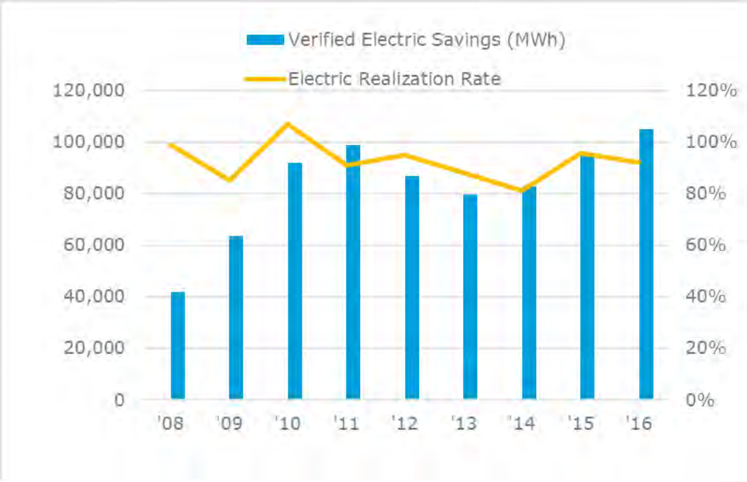
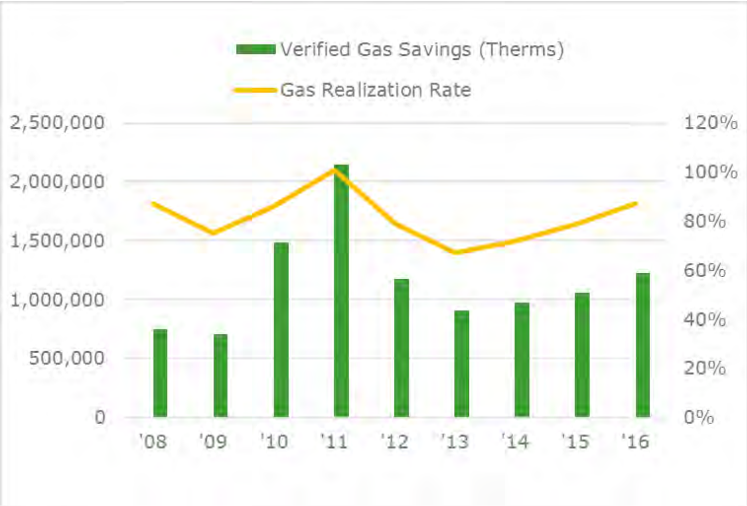


Figure 2: Historic Non-SEM program gas savings and realization rates



0.5 Historic SEM performance

Table 5 and the charts that follow show historic SEM performance over time.

Table 5: Historic SEM program performance

Program Year	Verified Electric Savings (MWh)	Electric Realization Rate	Verified Gas Savings (therms)	Gas Realization Rate
2012	7,351	139%	-18,452	-15%
2013	8,988	103%	174,390	47%
2014	11,514	89%	690,639	160%
2015	9,217	89%	446,946	83%
2016	9,039	92%	546,458	113%

Figure 3: Historic SEM program electric savings and realization rates

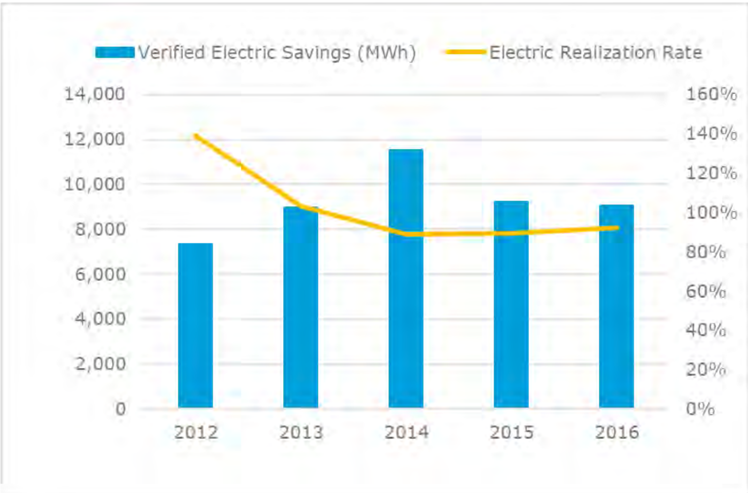
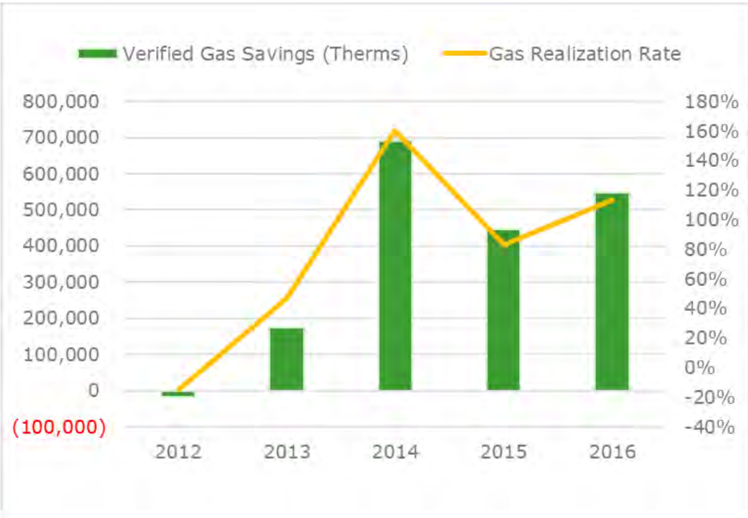


Figure 4: Historic SEM program gas savings and realization rates



0.6 Evaluation findings and recommendations

0.6.1 Lighting recommendations

- Finding – In a limited number of cases, the evaluation estimated significantly different savings from the program, at retail buildings more often than other building types. The difference in savings was due primarily to differences in the annual hours of use estimated by the evaluation and those estimated by the program.
  - Recommendation – Given the frequency of over- and under-estimating operating hours, program staff should emphasize the importance of accurate estimates of operating hours during training for trade allies. DNV GL does not recommend any structural program change to address this. Any change would likely increase program complexity with no assurance that it would improve estimates of savings.
- Finding – The Existing Buildings program did not account for the effect of reduced lighting power on building HVAC systems. This has the potential to result in an overestimation of the societal value delivered by the program. The conclusions of the previous evaluation report[5] are supported by DNV GL. Across the projects evaluated, DNV GL estimates that interactive effects reduce interior lighting electricity savings by 1% (approximately 146,000 kWh) and increase gas consumption at a rate of 2.5 therms per MWh of lighting energy saved (approximately 36,400 therms).
  - Recommendation – Energy Trust should include estimates of interactive effects when calculating the societal value of this program. Energy Trust should consider changes to its savings calculation workbook, but weigh the changes against the added workbook complexity required. Future impact evaluations should continue to estimate the impact of lighting projects on all building systems.

0.6.2 TLED lighting specific recommendations

- Finding – General satisfaction with TLEDs is high and performance issues are minimal. Out of 44 survey participants, 43 gave their TLEDs a 4 out of 5 rating; one participant gave a 3 rating. There was only one report of buzzing and flickering (which started after a fire at a local substation caused a power surge) and one report of ballast failure. Over 90% have not removed any lamps or fixtures since the retrofit, another indication of satisfaction with lighting system performance.
  - Recommendation – Continue supporting the installation of TLEDs. No systematic concerns were identified that require a program change to address.

0.6.3 Measure Approval Documents recommendations

- Finding – The measure approval documents (MADs) reviewed do not provide sufficient transparency and traceability to support reliable savings estimates. Energy Trust has been updating the format and content of these documents over time and the documents reviewed for this evaluation cover multiple stages of development.
  - Recommendation – DNV GL discusses this finding further and provides multiple recommendations to address it within the standard track evaluation section. The recommendations focus on increasing transparency and traceability within the documents. Additionally, DNV GL recommends that Energy Trust develop and implement a plan to transition from a system with supporting documentation

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[5] Energy Trust of Oregon, Impact Evaluation of the 2013-2014 Existing Buildings Program, Prepared by ADM Associates Inc., 02/09/17. Available at: https://www.energytrust.org/wp-content/uploads/2017/02/EB_Impact_Evaluation_2013_2014.pdf

stored on internal servers to one that makes the methodologies, assumptions, and values used readily available to the public on the Energy Trust website.

0.6.4 Standard measure recommendations

- Finding – DNV GL identified multiple opportunities to improve the accuracy and reliability of savings estimates for multiple standard measures. DNV GL discusses these findings further and provides multiple recommendations to address them within the standard track evaluation section. Below is a summary of the reccommendations.
  - Power Strips – Energy Trust should adjust the assumptions for leave-behind power strips and initiate research on purchased power strips. Leave behind power strip savings are unreliable.
  - ENERGY STAR – Energy Trust should consider using the ENERGY STAR calculators more directly and reduce use of program-specific assumptions. The assumptions used by the program are not sufficiently documented.
  - Refrigeration – Energy Trust should review the assumptions and methods used to estimate refrigeration measure savings. Energy Trust should confirm that the correct savings are used in the tracking database for the measures installed.
  - Food Equipment – Energy Trust should assume the standard gas fryer vat size instead of the large fryer vat size when estimating savings. Additionally, Energy Trust should consider standard practice research to document the current baseline for lost opportunity kitchen equipment purchases.
  - Boilers – Energy Trust should update the savings assumptions for condensing boilers to account for back-up capacity that is installed, but rarely operated. Energy Trust should consider future research to assess the efficiency of lost opportunity baseline equipment.

0.6.5 Custom recommendations

- Finding – DNV GL found the models developed by the program to be robust. DNV GL did not identify any systemic errors in the energy savings analysis, but errors did exist in the projects reviewed.
  - Recommendation – Final reported savings based on eQuest simulation models should use parametric runs to estimate the impact of measure combinations. Final reported savings based on Trane Trace simulation models should use a modelling alternative that includes all measures installed. DNV GL recommends using standard weather files and providing the weather files along with the energy model files.
  - Recommendation – DNV GL believes the following adjustments will improve Energy Trust's program: increase documentation of changes to building controls, avoid overly complex calculations, and avoid non-live calculations.

0.6.6 Strategic Energy Management recommendations

- Finding – Participants value energy coaches and peer-to-peer learning. Participants cite benefits from the insights provided by working closely with energy coaches to identify and execute operational and capital improvement opportunities.
  - Recommendation – Energy Trust should continue to identify program improvements that allow energy coaches to spend more time working with participant staff to support energy conservation opportunities. Additionally, DNV GL recommends that Energy Trust looks to further support interorganizational learning opportunities, such as is provided by the peer-to-peer learning sessions.

- Finding - Energy Champions & Executive Leadership are key. DNV GL finds that the participant's level of program engagement corresponds to the organization's level of buy-in by executive leadership and level of continuity of energy champion staff.
  - Recommendation – Based on this finding, DNV GL recommends to Energy Trust that participants exhibiting low engagement be classified under an inactive status, and the program not report savings from those participants. Reclassification as an active program participant could occur when the entity demonstrates their willingness to actively engage and support fully participating in the process.
- Finding - Many model baselines have or will soon expire. DNV GL observes that many enrolled facilities have baseline measurement periods that have already or will soon elapse the five-year baseline term stated in the program guidelines. Additionally, many facilities are using non-standard 'baseline adjustments.'
  - Recommendation - The evaluation team recommends updating expired baseline measurement periods ahead of the 2019 program year, if this is not already being performed. This will have the added benefit of reducing the quantity of older models that do not conform to the current modeling guidelines (e.g. do not use degree days) as well as eliminate complication from legacy capital projects.
- Finding - Measurement periods are inconsistent. The evaluation team observes inconsistency in measurement periods across participating facilities. While the measurement periods generally span from the Fall to the following Fall, the initial and final measurement months are not consistent across the program. This creates complications and uncertainty in assessing annual savings values for both the program and the evaluation teams.
  - Recommendation - To address this issue, DNV GL recommends that Energy Trust create a measurement schedule for current and future participants that defines when each year's period will start and stop, use this schedule across the program, and thoroughly document justifications for any deviations from the schedule that are deemed necessary.

Energy Trust of Oregon

MEMO

To: Board of Directors
From: Jay Olson, Sr. Program Manager – Commercial
Kathleen Belkhayat, Program Manager – Commercial Energy Performance Management
Sarah Castor, Evaluation Sr. Project Manager
Date: June 28, 2018
Re: Staff Response to the Impact Evaluation of the 2015-2016 Existing Buildings Program

The evaluation of Energy Trust of Oregon's Existing Buildings program savings in 2015 and 2016, conducted by DNV GL, determined that the program saved substantial amounts of electricity and natural gas. The achieved savings are also very close to what the program estimated it would save, reinforcing the reliability of program savings estimates.

The Existing Buildings program continually strives to improve the accuracy of its savings estimates. As such, staff agree with the evaluation's recommendations to review standard measures for foodservice equipment, refrigeration and boilers to assess whether improvements of the savings estimates are possible. The program will also work with Allied Technical Assistance Contractors to ensure high quality, thorough energy simulation models and to implement parametric runs when applicable.

Given the newness of tubular light emitting diode (TLED) technology, staff is pleased to see a high level of satisfaction among participants installing the lighting measure. The positive experiences and reliable performance of TLEDs support their retention and expanded adoption in a variety of commercial building applications. Energy Trust will continue to monitor customer experience with TLEDs in the 2017 Existing Buildings impact evaluation.

The commercial Strategic Energy Management offering continues to demonstrate high value for both energy savings and customer engagement and education. The program is in the process of updating a large number of models to conform with program guidelines and reflect adjusted baseline periods. Staff expect this effort to improve the consistency and accuracy of models, as well as the ease of evaluating energy savings.

1 BACKGROUND

Energy Trust performs evaluations of its programs on a regular basis. DNV GL was selected to conduct an impact evaluation of Energy Trust's Existing Buildings program offering. This program offering is designed to deliver comprehensive energy efficiency options and services to commercial customers with existing buildings. The program offers incentives and technical support for the installation and operation of cost effective energy efficiency measures for all major building end uses. This evaluation covers program years 2015 through 2016. The goals of this evaluation are to:

- Develop estimates of Existing Buildings program gas and electric savings to establish realization rates for the 2015 and 2016 program years individually. Information will be used for future program savings projections and budget developments and will be incorporated into Energy Trust's annual true-up of program savings.
- Report observations from the evaluation and make recommendations to help Energy Trust understand substantial deviations from claimed savings and to improve ex ante savings estimates and the effectiveness of future engineering studies and impact evaluations of Existing Buildings projects.

1.1 Energy Trust background

Energy Trust is an independent nonprofit organization, selected and overseen by the Oregon Public Utility Commission, to lead Oregon utility customers in benefiting from saving energy and generating renewable power. The services, cash incentives and solutions have helped participating customers of Portland General Electric, Pacific Power, NW Natural, Cascade Natural Gas, and Avista save more than $2.3 billion on their energy bills since 2002. The cumulative impact of their programs since 2002 has been a contributing factor in the region's low energy costs and in building a sustainable energy future. More information about Energy Trust's background, funding sources, strategic and action plans, policies and programs are available on their website at www.energytrust.org/about.

1.2 Program description

The Existing Buildings (EB) program began in March 2004 and is implemented by a program management contractor (PMC). ICF International has been the PMC since January 1, 2013. The program has four main tracks: Custom, Lighting (including standard, direct-install, and street lighting measures), Standard (prescriptive), and Strategic Energy Management (SEM). The program also maintains a few other tracks and pilots, which represent a small portion of program participants and savings, and are excluded from this evaluation. Custom track projects have their savings estimated through energy studies conducted by Allied Technical Assistance Contractors (ATACs). These studies may involve engineering calculations or energy simulation modeling. Standard Lighting track measures are installed directly by trade allies, while direct-install lighting measures are installed by a trade ally subcontractor to SmartWatt, under subcontract to the PMC. Standard track measures use savings estimates from reliable sources (including the Regional Technical Forum, ENERGY STAR, and others), as documented in Energy Trust measure approval documents (MADs). SEM savings are estimated based on a top-down analysis of building-level energy use and do not include savings from capital measures completed at the site through other program tracks during the SEM engagement. After completing a first year of SEM, participants have the option of participating in Continuous SEM, where they can claim additional savings and incentives for furthering their SEM activities.

1.3 Evaluation objectives

This evaluation was designed and completed to achieve the following primary objectives:

- Estimate the gas and electric savings achieved by program years 2015 (PY2015) and 2016 (PY2016).
- Calculate gas and electric realization rates for PY2015 and PY2016.
- Provide savings and realization rates separately for SEM and non-SEM measures by program year and fuel type.
- Provide realization rates to serve future program savings projections and budget developments.
- Report observations from the evaluation regarding program implementation and documentation, and compare assumptions regarding measure performance to actual performance.
- Provide recommendations to:
  - Understand substantial deviations from reported savings
  - Improve reported savings estimates
  - Improve effectiveness of future engineering studies and impact evaluations

2 EVALUATION OVERVIEW

This section provides an overview of DNV GL’s technical approach for the impact evaluation of this program. This section only describes the tasks used to determine the evaluated savings. Track-specific evaluation sections are provided following the overview. The track specific sections discuss the actual activities and results for the program tracks.

2.1 Program database review

DNV GL reviewed the program tracking data provided by Energy Trust. This task helped DNV GL understand the measures and projects completed during the two program years and begin to plan for the impact evaluation.

During this task, DNV GL and Energy Trust identified the measure codes that should be considered TLED codes during this evaluation.

2.2 Sample design

DNV GL utilized stratified random sampling with certainty selection across 82 unique strata to identify the sample for this impact evaluation. Table 6 summarizes the final sample design implemented and the associated expected relative precision of the results. The full sample design is discussed in Appendix A. The design for each track is discussed in the track specific sections.

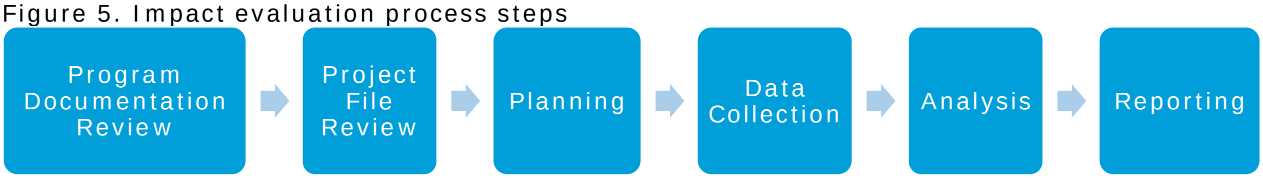
Table 6: Sample summary

		2015				2016			
Measure Type	Fuel	% of Reported Savings in Draft Sample	N Frame	n Sample	Relative Precision (90% CI)	% of Reported Savings in Draft Sample	N Frame	n Sample	Relative Precision (90% CI)
Capital (Non-SEM)	Electric	21%	3,851	124	10%	19%	4,455	128	9%
	Gas	23%	676	52	14%	28%	727	59	12%
SEM	Electric	28%	89	20	17%	45%	135	28	20%
	Gas	23%	50	15	19%	22%	69	17	18%
ALL (Capital + SEM)	Electric	22%	3,940	144	9%	21%	4,590	156	9%
	Gas	23%	726	67	11%	26%	796	76	10%

2.3 Site specific evaluation

Site specific impact evaluation was initiated after the final primary sample was identified. The site specific impact evaluation process steps used for this project is illustrated in Figure 5.

Figure 5. Impact evaluation process steps



The steps in this process will be primarily applied at the track level and are discussed in the track specific sections. A brief description of each step is provided below:

- Program Documentation Review: DNV GL reviewed a sample of project documentation to identify and understand what information is retained by Energy Trust to support compliance with the program's requirements and inform the estimate of savings for the project or measures. For sampled prescriptive measures, DNV GL also reviewed the measure approval documents.
- Project File Review: Our engineering team then conducted a thorough review of the project files, focused on the energy savings calculations and assumptions, feasibility study reports, and other supporting documentation. The review identified provided documentation, original calculation methodology, key uncertainty parameters and any concerns with the original savings estimation methods.
- Planning: Upon the completion of project document review and file review, DNV GL created a track, measure or site data collection and analysis plan based on the measures completed at each sampled site. This plan documented the project: the expected installed conditions, the data to be collected through the evaluation process, and the anticipated analysis method. In general, our plans followed the framework provided in the International Performance Measurement & Verification Protocol (IPMVP). However, there were times when the best evaluation approach is outside of the IPMVP framework. The following are the key elements that supplement the preparation of project EM&V plans:
  - Evaluating Standard/Prescriptive Measures. The M&V plan for prescriptive measures was the same across each measure selected for evaluation. The same information was gathered across all projects and the same analysis methodology employed, unless project-specific circumstances require an alternative analysis method.
  - Evaluating Complex Projects. For projects with multiple interactive measures, the evaluation team reviewed all measures as one interactive system and estimate the achieved savings across all measures.
- Data Collection: Data collection occured through phone interviews and site visits. The need for a site visit was determined based on the results of the program and project documentation review. Data collection activities verified equipment installation, verified operating conditions, and collected the information necessary to determine evaluated savings.
- Analysis: The ex-post savings analysis followed the M&V plan. DNV GL utilized the ex-ante savings estimation tools or their methodologies, unless the evaluators determine that there were major flaws in the ex-ante savings methodologies or determined that an alternative method provided a more reliable estiamte of savings. For each sampled project, DNV GL produced estimates of evaluated electric and/or gas savings. DNV GL engineers also noted any opportunities for improvement in the accuracy of tracked savings estimates determined during the course of our analysis.

2.4 Sample extrapolation to track and program

DNV GL used a separate ratio estimator to obtain unbiased estimates of the total evaluated savings (either kWh or therms) for any group of interest. This estimator will yield, by design, unbiased estimates of some outcome measure, and is particularly beneficial when the outcome measure is correlated with something known for all members of the sample frame. In this case, the evaluated savings are logically correlated with claimed savings as listed in the tracking database. In general, the separate ratio estimator works as follows.

Suppose the indices:

g	=	Application domains which are defined by track, year and fuel type (kWh or therms). For some outcome measures and domains of interest, strata had to be collapsed with one another during the estimation process. This occurred with $Y_g \neq 0$ but $\sum_{i \in Sample} w_{ig} y_{ig} = 0$ (these terms are defined below).
i	=	Site.

And suppose:

x_{ig}	=	Evaluated savings for site i in group g.
y_{ig}	=	Claimed savings for site i in group g.
w_{ig}	=	Sample weight for site i in group g. This reflects the sample selection process that was used at the beginning of the study to select the 86 sites.
Y_g	=	Population total claimed savings in group g. So $Y_g = \sum_{i \in Frame} y_{ig}$

$\hat{R}_g = \dfrac{\sum_{i \in Sample} w_{ig} x_{ig}}{\sum_{i \in Sample} w_{ig} y_{ig}}$ is the Ratio estimate for group g.

Then the separate ratio estimator that will yield the total evaluated savings is:

$$\hat{T} = \sum_g \left(Y_g \cdot \hat{R}_g \right)$$

And the ratio estimate of total modeled savings to total claimed savings is:

$$\hat{R} = \frac{\hat{T}}{\sum_g Y_g}$$

The procedure used for calculating ratio estimation by domains provides the correct standard error of the estimate for each domain and overall. The procedure also takes into account defined clusters of observations (customers) and stratification. The standard error is calculated using two methods.

The standard error is calculated as drawn from a finite population: the measures completed within the analysis period with associated energy impacts in the program-tracking database. This calculation uses the Finite Population Correction (FPC) factor. This factor is a reduction to the calculated variance that accounts for the fact that a relatively large fraction of the population of interest has been observed directly and is not subject to uncertainty. It is appropriate to apply precision statistics, such as confidence intervals, based on the standard error calculated in this manner when quantifying the results of the program during the study period only. The FPC factor reduces the calculated sampling error around the estimate more for smaller populations than for large.

3 LIGHTING TRACK EVALUATION

The evaluation lighting track includes three lighting delivery groups: Standard lighting, Direct Install lighting, and Street lighting. Table 7 shows the reported savings for lighting by delivery track and program year. Table 8 shows the population frame for lighting measures. These measures represent over 60% of the electricity savings reported by the program in each program year. Note that Table 7 shows a doubling of energy savings from 2015 to 2016 that are attributed to standard TLED measures. No natural gas savings are reported.

Table 7: Reported lighting track energy savings by delivery and program year

Program	Reported kWh		Reported therms	
Track	2015	2016	2015	2016
Standard (except TLED)	45,596,198	45,334,044	0	0
Standard (TLED)	6,001,286	12,927,930	0	0
Direct Install	4,120,570	4,615,837	0	0
Street Lighting	10,441,498	14,800,195	0	0
Lighting Total	66,159,552	77,678,006	0	0
Existing Buildings program total	109,051,484	123,916,024	1,888,021	1,889,692
Percent of Existing Buildings program savings	61%	63%	0%	0%

3.1 Sample design

DNV GL used stratified random sampling to select an efficient representative sample of projects for evaluation designed to provide reliable savings estimates across program years and provide Energy Trust with requested TLED participant feedback. Key elements of the design are:

- Creation of a technology domain for identified TLED measures to ensure a sufficient number of TLEDs were sampled for participant feedback. Further stratification within the TLED domain based on TLED ballast/driver type: Remote Driver, Existing Fluorescent Ballast, At Line Voltage (no ballast), New T8 Ballast, and Multiple/Unknown. TLED measures and the ballast type were identified using a measure code list provided by Energy Trust staff.
- Creation of a technology domain for Street Lighting due to the unique attributes of these projects and the magnitude of savings reported per project. Further stratification within Street Lighting to separate one city's projects from all other projects.
- Creation of a Non-TLED technology domain for all other lighting projects. Further stratification within this domain by Direct Install and Standard to ensure that both were respresented in the evaluation sample.
- Stratification by size of savings reported (up to four size strata were used) and use of a certainty stratum to increase the magnitude of savings evaluated and minimize the expected relative precision of evaluated savings.

Sampling occurred at the project level (Project ID) after separation of TLED measures from Non-TLED measures. Table 8 summarizes the sample design for the lighting track. This design was expected to provide program year savings estimates with 15% relative precision at the 90% confidence interval. Further detail on sample design is available in Appendix A.

Table 8: Lighting track sample design

Program Year	Technology Domain	Sub-Domain	Size Stratum	Population (N)	Sample Target (n)
2015	TLED	Remote Driver	1	119	6
			2	55	5
			3	25	5
			Certainty	1	1
		Existing Fluorescent Ballast	1	31	3
		At Line Voltage	1	46	5
		New T8 Ballast	1	38	3
		Multiple/Unknown TLED Types	1	71	7
	Non-TLED	Direct Install	1	338	4
		Standard	1	1,772	4
			2	268	4
	Street Lighting	City A	1	4	1
		Other Cities	1	6	1
2016	TLED	Remote Driver	1	31	2
		Existing Fluorescent Ballast	1	147	5
		At Line Voltage	1	295	6
			2	93	5
			3	28	5
		New T8 Ballast	1	190	4
			2	29	4
		Multiple/Unknown TLED Types	1	81	4
	Non-TLED	Direct Install	1	526	6
		Standard	1	1,698	4
			2	235	4
	Street Lighting	City A	1	4	1
		Other Cities	1	14	1

3.2 Lighting track evaluation methods

This section discusses the activities completed and associated findings of the impact evaluation.

3.2.1 Summary of approach

DNV GL completed these steps to evaluate this track:

- Documentation and file review: Review tracking data to identify savings reported, units reported, and measure codes used. Review of standard lighting calculator. File review to verify reported information through invoices and other provided documentation.
- Data Collection Planning: Identification of the key input parameters for impact evaluation. Identification of data collection method, site visit or interview, for each site based on expected uncertainty. Creation of an impact evaluation data collection tool. Creation of a TLED interview guide.
- Data Collection: Phone interview and/or onsite verification of sampled participants using the instruments developed.
- Analysis: Estimate evaluated savings using the data collected to update key parameters. Analyze responses to TLED interview questions.

3.2.2 Documentation and file review

DNV GL reviewed the project documentation provided for all of the projects included in the original sample design. There were three key findings from this review.

- Documentation was sufficient. The documentation for the majority of lighting projects was comprehensive and included all relevant files. Direct install project documentation differed from standard lighting project documentation. The direct install files did not include 120L/140L forms or the standard calculation spreadsheet, but did include an inventory of the equipment installed by space. In most cases the implementers provided sufficient documentation to verify claims.
- Calculation methodology reviewed. The program used a standard calculator (Excel workbook) to estimate project savings. No custom savings calculation workbooks were identified. The standard calculation tool is similar to other commercial calculators we have reviewed, is easy to understand and easy to use. There are calculations for some things like LED case lighting and federal minimum baseline weighting that are not straightforward and are computed in the background, but the tool appears to be accurate and not in need of any major changes.
- Non-TLED controls that were sampled as TLED: During sample design, the "BECUSTLIGHT" and "CUSTLEDLAMP" measures were flagged as possible TLEDs and sampled with the TLED oversample as "Multiple/Unknown TLED Types". The file review showed that 10 of the 11 "Multiple/Unknown TLED Types" projects sampled were not TLEDs. DNV GL moved these ten projects into the Non-TLED technology domain.

3.2.3 Data collection planning

DNV GL developed data collection plans and tools to achieve both the impact evaluation and participant feedback objectives of this evaluation. The TLED interview guide is available in Appendix B, the objectives of the interview along with the results are discussed in section 3.4 TLED interview results.

The impact evaluation data collection plan focused on acquiring information to validate the accuracy of the following key parameters used to estimate lighting energy savings.

1. Annual hours of use (*$Hours_{annual}$*) is the most uncertain savings parameter. Reducing uncertainty around this parameter is often the most beneficial outcome of lighting impact evaluations. The evaluation gathered information on:
    a. Self-reported facility or fixture schedules (by space)
    b. Lighting fixture controls by space (occupancy sensors, timers, photocell controllers, combination of controls)
    c. Behavioral changes due to change in lighting fixture or lighting controls

2. Delta watts (*ΔW*) is the difference between the pre-existing lighting fixture wattage and the installed lighting fixture wattage. Verification of ΔW included examination of:
    a. Pre-existing fixture types (including ballast type)
    b. Pre-existing fixture/lamp conditions (e.g., 4 lamp T8 fixtures but 20% of fixtures had 1 or more failed lamps)
    c. Pre-existing fixture wiring or behavioral usage (e.g., 3-lamp T8 fixture wired to turn on 1 lamp, 2 lamps, or all 3 lamps; users turned off half of the bay lights in the afternoons)
    d. Installed fixture types
    e. Installed fixture wiring and replacement strategy (e.g., were installed fixture wired the same as the pre-existing; were they installed on a 1:1 ratio)

3. Quantity
    a. Pre-existing fixture quantities (by space and/or fixture type)
    b. Installed fixture quantities (by space and/or fixture type)
    c. Quantity of fixtures added or removed since the original install date

Interactive effects: Current Energy Trust policy does not account for heating and cooling interactive effects on lighting measures.[6] DNV GL agrees with previous program evaluators[7] that interactive effects should be included to accurately estimate the value of the program. For this study, DNV GL collected high-level HVAC system information, what locations they serve, and the locations of claimed fixture retrofits. The evaluation estimated the impact of lighting measures on HVAC consumption using the collected information and Regional Technical Forum-based interactive factors.[8]

3.2.4 Data collection

Lighting data collection occurred primarily via telephone interview. DNV GL engineers spoke with facility owners or operators to collect the identified key parameter information. During the file reviews and initial recruitment, DNV GL flagged participants for possible site visits based on combinations of the following:

- Site contact, tenant, or ownership change. If the recruitment effort determined that the facility had changed owner or tenant, and the contact was not familiar with the incentivized project, the site might have been flagged for a site visit;
- The site was a high-priority data point for the stratum;
- Major renovation occurred or occupancy type changed; and
- Complex or custom lighting project that involved multiple measures or multiple space types.

Interviews, either on-site or via telephone, with TLED measure participants included additional questions specific to TLEDs. The TLED interview guide developed for this evaluation is available in Appendix B.

3.2.5 Project level analysis

DNV GL developed a savings calculation workbook template that follows the methodology (flow and function) of Energy Trust’s standard savings tool (Tab: Form 103L) used in the lighting program. Savings that were claimed by Energy Trust and sampled by the evaluation were first re-created in the savings calculation workbook. Evaluated energy savings were calculated in the same workbook by adjusting the key savings parameters. The values used were determined from the most valid data source available.

Key Savings Parameters - The key savings parameters researched were:

- Annual hours of use ($Hours_{annual}$)
- Delta wattage (difference between pre-existing lighting fixture wattage and the installed lighting fixture wattage, ΔW)
- Quantity

Using these key savings parameters, direct annual energy (kWh) savings are very generally described as:

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[6] Heat is a byproduct of lighting. As lighting efficiency increases, the heat it gives off tends to decrease. This has an interactive effect on HVAC costs. During heating months, HVAC typically has to work harder to make up the heat that used to be generated by the lighting. In cooling months, the HVAC typically consumes less energy.

[7] Energy Trust of Oregon, Impact Evaluation of the 2013-2014 Existing Buildings Program, Prepared by ADM Associates Inc., 02/09/17. Available at: https://www.energytrust.org/wp-content/uploads/2017/02/EB_Impact_Evaluation_2013_2014.pdf

[8] STANDARD PROTOCOL FOR ESTIMATING ENERGY SAVINGS OF NON-RESIDENTIAL LIGHTING RETROFITS V2.4, REGIONAL TECHNICAL FORUM, Release date: December 6, 2016. Available at: https://rtf.nwcouncil.org/standard-protocol/non-residential-lighting-retrofits

$$kWh_{savings} = \sum_{measures} \Delta W \times Hours_{annual} \times Quantity$$

As described in Section 3.2.3, we also included an interactive factor to estimate total evaluated savings for each project.

3.3 Lighting track evaluation results

This section presents the results of DNV GL's impact evaluation for this track.

3.3.1 Achieved sample

Table 9 shows the final sample achieved across the entire lighting track. The final achieved evaluation sample differed from the sample design due to the following:

- Power Strip Sample Points: Five projects sampled in the 2016 Non-TLED technology domain were power strip measures. All power strip measure savings were moved to the Standard track. Evaluation results for these devices are reported in the Standard Track section.
- Non-TLED controls that were sampled as TLED: DNV GL moved ten of eleven projects originally classified as "Multiple/Unknown TLED Types" into the Non-TLED technology domain.
- Refusals, Non-Responses, Replacements: The balance of the incomplete sample was primarily those participants that could not be reached after exhausting our phone call protocol, and 16 who refused to participate in the evaluation. Our protocol required calling up to 5 times at different times of the day. We also tried contacting the participant by email if they did not respond to phone calls.

Table 9: Final lighting track sample summary

<table>
<tr><th>Year</th><th>Technology</th><th>Delivery / TLED Type</th><th>Sample Target</th><th>Achieved Sample</th><th>% Complete</th></tr>
<tr><td rowspan="8">2015</td><td rowspan="5">TLED</td><td>Remote Driver</td><td>17</td><td>10</td><td>59%</td></tr>
<tr><td>Existing Fluorescent Ballast</td><td>3</td><td>2</td><td>67%</td></tr>
<tr><td>At Line Voltage</td><td>5</td><td>6</td><td>120%</td></tr>
<tr><td>New T8 Ballast</td><td>3</td><td>2</td><td>67%</td></tr>
<tr><td>Multiple/Unknown TLED Types</td><td>7</td><td>N/A</td><td></td></tr>
<tr><td rowspan="2">Non-TLED</td><td>Direct Install</td><td>4</td><td>4</td><td>100%</td></tr>
<tr><td>Standard</td><td>8</td><td>12</td><td>150%</td></tr>
<tr><td>Street Lighting</td><td>All Cities</td><td>2</td><td>2</td><td>100%</td></tr>
<tr><td>2015 Subtotal</td><td></td><td></td><td>49</td><td>38</td><td>78%</td></tr>
<tr><td rowspan="8">2016</td><td rowspan="5">TLED</td><td>Remote Driver</td><td>2</td><td>1</td><td>50%</td></tr>
<tr><td>Existing Fluorescent Ballast</td><td>5</td><td>3</td><td>60%</td></tr>
<tr><td>At Line Voltage</td><td>16</td><td>13</td><td>81%</td></tr>
<tr><td>New T8 Ballast</td><td>8</td><td>6</td><td>75%</td></tr>
<tr><td>Multiple/Unknown TLED Types</td><td>4</td><td>N/A</td><td></td></tr>
<tr><td rowspan="2">Non-TLED</td><td>Direct Install</td><td>6</td><td>4</td><td>67%</td></tr>
<tr><td>Standard</td><td>8</td><td>8</td><td>100%</td></tr>
<tr><td>Street Lighting</td><td>All Cities</td><td>2</td><td>2</td><td>100%</td></tr>
<tr><td>2016 Subtotal</td><td></td><td></td><td>51</td><td>37</td><td>73%</td></tr>
<tr><td>Grand Total</td><td></td><td></td><td>100</td><td>75</td><td>75%</td></tr>
</table>

3.3.2 Evaluated savings

Expansion from the sample to track level results follows the methodology discussed in in Section 2.4. Table 10 shows the overall lighting realization rates for the track by program year. Realization rates by technology are presented in Table 11. Overall, DNV GL estimates the evaluated lighting savings across both program years to be 96% of the reported savings with a relative precision of 6% at the 90% confidence interval.

Table 10: Lighting track electric impact evaluation results by program year

Year	Projects Evaluated	Realization Rate[9]	Standard Error	Rel. Precision @ 90% Confidence	Evaluated Savings (kWh)
Lighting-2015	38	99%	0.06	10%	65,486,643
Lighting-2016	37	94%	0.04	6%	72,321,730
Lighting-15/16	75	96%	0.03	6%	137,808,373

Table 11: Lighting track electric impact evaluation results by technology

Technology	Projects Evaluated	Realization Rate	Standard Error	Rel. Precision @ 90% Confidence
Non-TLED	28	98%	0.05	8%
TLED	43	77%	0.06	12%
Street Lighting	4	100%	0	0%
Lighting-15/16	75	96%	0.03	6%

3.3.3 Savings variance

The assumptions used to estimate reported savings were reasonable for most projects: 90% of the 162 individual measures evaluated had realization rates above 80%. Of the 17 measures that did not achieve 80% or greater realization rates, our engineers found that thirteen measures had shorter operating hours than assumed by the program. Five of these thirteen were retail business, three were warehouse/storage, and the remainder were spread among other building types as shown. In four of these cases, the reduction in hours of use was due to the existence of controls that were not accounted for in the reported savings estimate. Table 12 shows number of measures with realization rates (RR) less than 80% by building type.

Table 12: Lighting measures variance summary by building type

Building Type	Measures with RR < 80%	Reason
Retail	5	Hours of use
Warehousing and Storage	3	Hours of use (2); controls not accounted for (1)
Other Types, Hours of Use	6	Hours of use
Other Types, Controls	3	Controls not accounted for
Totals	17	

9 In this report "Realization Rate" refers to the ratio of "Evaluated Savings" to "Reported Savings". Reported savings are the "working savings" shown in the Energy Trust database provided to DNV GL. Evaluated Savings are the savings estimated by DNV GL to have been achieved by the program. Program attribution was not considered in this study and is researched and reported separately by Energy Trust.

3.4 TLED interview results

The program provides incentives for the three types of TLEDs.[10] As part of the impact evaluation effort, DNV GL addressed numerous TLED research questions related to four broad topics:

- General measure performance
- TLED removal and replacement after the initial installation
- Controls
- Participant decision-making regarding program participation
- Table 13 provides a description of the different TLED installation types and some of the key differences between them. Table 14 links these research topics to specific research questions. The full interview guide is available in Appendix B.

Table 13: TLED types

Type	Description	Key Differences
Type A	Uses either an existing or a new fluorescent-lamp ballast	Lowest installation cost of the three, but is susceptible to ballast failure.
Type B	Requires that the fixture be modified to connect the TLED directly to 120/277V sources	No fluorescent-lamp ballast results in line voltage (120-227V) across the lamp. Although this type avoids issues with ballasts, it increases the safety risk.
Type C	Requires that the existing fluorescent ballast be replaced with a low-voltage driver in the fixture to supply power to the TLED	Installation costs are highest for this type, but lamp efficiency is higher, hazards are minimized, and ballast failure is not a concern.

Table 14. TLED research topics and survey questions

Topic	Research Question
General Performance	Are the TLEDs installed through the program in 2015 and 2016 operating well? Are participants satisfied with their performance?
	Are there any differences in satisfaction by TLED installation type (Type A, B, or C), space use or customer type?
	Are participants experiencing any issues with TLEDs, like buzzing, flickering, early failure, etc.?
	For participants who changed the quantity and/or placement of lighting fixtures, are they satisfied with their overall lighting system design?
Removal and Replacement	Have any participants removed any of the incentivized TLEDs installed in 2015 and 2016?
	If a participant removed any incentivized TLEDs, when did they remove them?
	If a participant removed any TLEDs, why did they remove them?
	If a participant removed any TLEDs, with what type of lighting did they replace them?
Controls	What control strategies are being used with TLEDs?
	For participants who installed TLED products and controls,[11] were the controls installed before, at the same time as, or after the TLEDs were installed?

[10] KNOW BEFORE YOU BUY: TLED BASICS, https://www.energytrust.org/wp-content/uploads/2017/05/EB_FS_TLED.pdf

[11] In this context, "controls" means any control scheme other than a simple on/off switch.

Topic	Research Question
	For participants who installed TLED products and controls, are they satisfied with how the controls are operating, or are there issues to be addressed?
	Do participants intend to install new or additional controls for TLEDs within the next 12 months? If so, what type(s)?
Participant Decision-Making[12]	Was the interview participant involved in the decision to install the incentivized TLEDs?
	Did the participant consider other TLED types in addition to the incentivized type(s)?
	What motivated the participant to install the specific type(s) of incentivized TLEDs (A, B, C)?

We addressed these research questions using telephone surveys with 44 program participants who received incentives for TLED measures. The subsections that follow provide detailed survey results. Table 15 shows the number of survey participants for each major TLED type and the program participation and savings by program year. Of the 44 survey participants, only 7 changed the quantity and/or placement of lighting fixtures as part of their TLED retrofits. As such, the majority of survey responses represent participants who replaced fixtures and/or lamps but did not redesign their lighting systems.

Table 15. TLED survey participation by type and year

TLED Type	Number of Respondents	Number of Projects		Reported Savings (kWh)	
		2015	2016	2015	2016
Type A (existing fluorescent ballast)	5	31	147	673,801	3,790,378
Type A (new T8 ballast)	7	38	219	232,457	1,583,551
Type B (line voltage / no ballast)	17	46	416	390,750	5,099,482
Type C (remote driver)	11	200	31	3,788,981	1,429,698
More than one type of TLED	4	71	81	915,297	1,024,821
Total	44	386	894	6,001,286	12,927,930

3.4.1 TLED measure performance

General satisfaction. Participants rated their general satisfaction with TLED measures on a scale of 1 to 5 where 1 means "not at all satisfied" and 5 means "very satisfied." Nearly nine out of ten participants reported that they were "very satisfied" with their TLED measures (a rating of 5) and all but one provided ratings of 4 or higher (n=44). One respondent with Type A TLEDs provided a rating of 3 (moderate satisfaction). This respondent received incentives for TLEDs while keeping their existing fluorescent ballasts and cited dissatisfaction with the maintenance time required when a unit's ballast fails. There were no noteworthy patterns in satisfaction based on TLED type, space usage, or customer type—not surprising given the high satisfaction overall.

Equipment performance. When asked directly whether they had experienced any performance issues with their TLEDs (such as buzzing, flickering, early failure, and so on), more than 90% of the TLED participants we surveyed reported no such issues (n=42). Only three reported performance issues:

[12] Note that research questions regarding decision-making were not in the original scope of work for this study, but we added questions on this topic for instances in which the interview respondent was the decision-maker—i.e., we did not attempt to find a separate contact to address these questions.

- One received incentives for TLEDs replacing existing fluorescent ballasts and reported “buzzing” and “flickering” of the units and noted that they had already replaced the offending fixtures as a result.
- One received incentives for TLEDs with remote drivers and reported “burning out and physical smoking of fixtures.” This respondent reported that an electrician or contractor inspected the relevant TLED fixtures’ ballasts and replaced them.
- The third respondent who reported performance issues did not provide specifics regarding the issues experienced.

Type B TLEDs. Of the 44 TLED survey participants, 17 received incentives for Type B TLEDs. Type B TLEDs require installers to remove ballasts and directly wire sockets to line voltage. Our concern with Type B TLED measures is that if someone were to replace a TLED with a fluorescent lamp, the fluorescent tube would not light due to the lack of ballast-provided strike voltage. Maintenance staff is not exposed to any increased risk, but ensuring they are aware of the difference between a ballasted fixture and a Type B fixture could improve program satisfaction.

3.4.2 TLED removal and replacement

Interviewers asked TLED survey participants whether they removed any of the incentivized TLED fixtures or lamps since participating in the program. Of the 41 survey respondents who answered the question, nearly 9 out of 10 reported that they had not removed any incentivized TLED fixtures or bulbs (36 respondents). These results underscore the high levels of satisfaction with program-incentivized TLED measures among participants.

Of the five survey respondents who reported having removed program-incentivized TLED measures, three reported having removed fixtures and two reported having removed lamps.

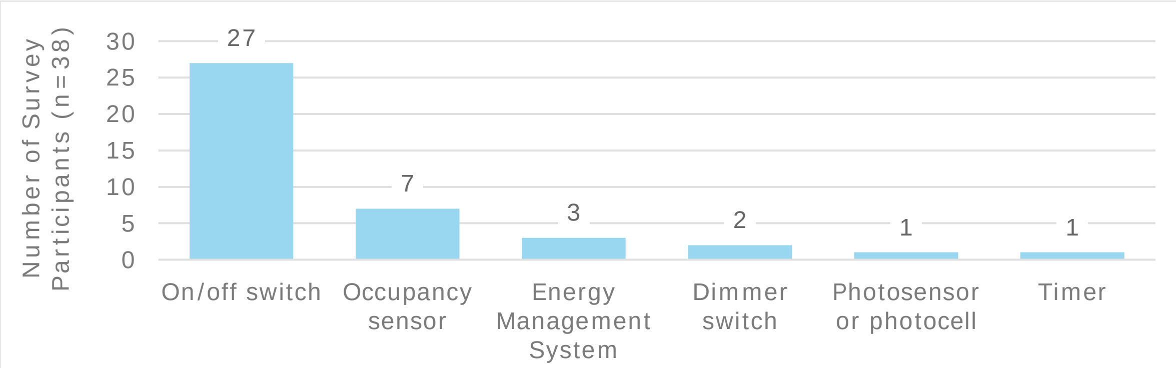
- The respondents who removed fixtures did not comment on why they did so.
- The two who removed lamps each gave a different reason: one because of issues with flickering, and one stated the lamps were too bright. One of these respondents reported replacing the TLED lamps they removed with other TLED lamps.

3.4.3 TLED controls

Interviewers read TLED participants a list of control types and asked which types they used. Of the 38 TLED survey participants who answered the question, nearly three-quarters reported that they controlled their TLEDs with on/off switches (27 survey participants; see Figure 6).

- Seven survey participants reported that they control their TLEDs with occupancy sensors.
- Only a handful of respondents mentioned using energy management systems or building management systems; dimmer switches; photosensors or photocells; or timers to control their TLEDs.
- Five of the seven TLED survey participants who reported controlling their program-incentivized TLEDs with occupancy sensors reported that they received incentives for the sensors through the Existing Buildings program. The participants who received incentives both for TLEDs and occupancy sensors represented the full range of TLED types (A, B, and C).

Figure 6. TLED control strategies



* Note: Survey question allowed multiple responses from each participant.

Installation timing and satisfaction. Of the eleven TLED survey respondents who reported that they used control strategies other than on/off switches, we asked:

- How satisfied they are with the performance their TLED controls (on a scale of 1 to 5 where 1 means "not at all satisfied" and 5 means "very satisfied")
- Whether they installed the controls before, during or after they installed the TLEDs

Ten of the eleven respondents who used control strategies other than on/off switches reported that they were "very satisfied" with their controls' performance (ratings of 5), and the eleventh reported a rating of 4 (satisfied). Five reported that they installed the controls before installing the TLEDs, four reported that they installed the controls at the same time, and one reported installing the controls after installing the TLEDs (the eleventh was not sure of the timing). All four of the respondents who reported that they installed the TLED controls at the same time as the TLEDs were among the five who received Existing Buildings program incentives for occupancy sensors in addition to their TLEDs.

Installation plans. We asked TLED survey participants whether they plan to install any new or additional controls for their TLEDs within the next 12 months. Of the 38 who answered the question, only one planned to install additional controls. This participant reported planning to install photosensors or photocells.

3.4.4 TLED participant decision-making

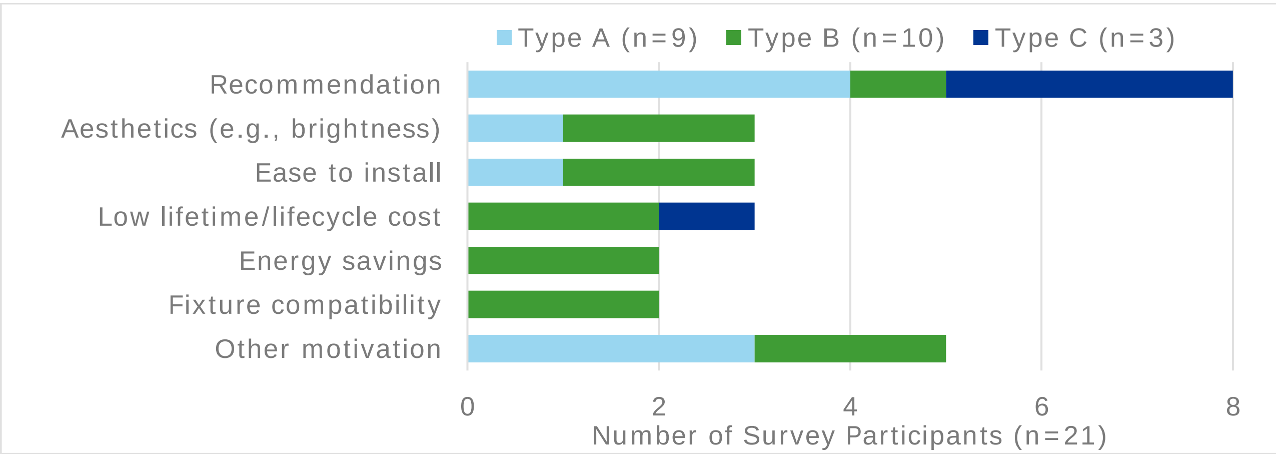
Thirty-three of the TLED survey participants reported that they were involved in the decision to install the TLEDs for which they received incentives through the Existing Buildings program (n=44). We asked these participants:

- Whether they considered other TLED types in addition to the type(s) they installed
- What motivated them to install the specific type(s) they installed (A, B, C)

Only three of the survey participants who were involved in the decision to install the TLEDs for which they received program incentives reported that they considered other TLED types in addition to the type or types they installed. Two of these participants installed Type C TLEDs. The third installed more than one type of TLED. None of these respondents were able to identify the other TLED types they considered in addition to the ones for which they ultimately received Existing Buildings program incentives.

Thirty-three TLED survey participants reported that they were involved in the decision to install program TLEDs. We asked them what motivated them to select the type or types of TLEDs they selected, "don't know" was the most common response (12 respondents). Among the 21 that were able to cite a reason, motivations varied. They most commonly mentioned recommendations from contractors, electricians, or others, followed by aesthetics, ease of installation, and lifecycle costs Figure 7).

Figure 7. Motivations for purchasing TLEDs by TLED type



* Note: This survey question allowed multiple responses from each participant. Twenty-one TLED survey participants responded to the question, and one provided responses related to two TLED types.

3.5 Lighting track findings and recommendations

Our evaluation findings and recommendations specific to the lighting track are presented in this section.

3.5.1 Track recommendations

- Finding – In a limited number of cases, the evaluation estimated significantly different savings from the program, at retail buildings more often than other builing types. The difference in savings was due primarily to differences in the annual hours of use estimated by the evaluation and those estimated by the program.
    - Recommendation – Given the frequency of over- and under-estimating operating hours, program staff should emphasize the importance of accurate estimates of operating hours during training for trade allies. DNV GL does not recommend any structural program change to address this. Any change would likely increase program complexity with no assurance that it would improve estimates of savings.
- Finding – The Existing Buildings program did not account for the effect of reduced lighting power on building HVAC systems. This has the potential to result in an overestimation of the societal value delivered by the program. The conclusions of the previous evaluation report[13] are supported by DNV GL. Across the projects evaluated, DNV GL estimates that interactive effects reduce interior lighting electricity savings by 1% (approximately 146,000 kWh) and increase gas consumption at a rate of 2.5 therms per MWh of lighting energy saved (approximately 36,400 therms). There was anecdotal evidence that the removal of fluorescent ballasts from high rise buildings significantly reduced the return air temperature.
    - Recommendation – Energy Trust should include estimates of interactive effects when calculating the societal value of this program. Energy Trust should consider changes to its savings calculation workbook, but weigh the changes against the added workbook complexity required. Future impact evaluations should continue to estimate the impact of lighting projects on all building systems.

3.5.2 TLED specific recommendations

- Finding – General satisfaction with TLEDs is high and performance issues are minimal. Out of 44 survey participants, 43 gave their TLEDs a 4 out of 5 rating; one participant gave a 3 rating. There was only one report of buzzing and flickering (which started after a fire at a local substation caused a power surge) and one report of ballast failure. Over 90% have not removed any lamps or fixtures since the retrofit, another indication of satisfaction with lighting system performance.
    - Recommendation – Continue supporting the installation of TLEDs. No systematic concerns were identified that require a program change to address.
- Finding – One Type A TLED site using existing fluorescent ballasts reported "burning out and physical smoking of fixtures", potentially resulting from a ballast compatibility issue. Compatibility with installed ballasts varies depending on manufacturers and models.
    - Recommendation – Review Type A measure participation and consider eliminating program support for Type A lamps that rely on existing ballasts or limiting support to those with manufacturer-recommended lamp/ballast combinations.

[13] Energy Trust of Oregon, Impact Evaluation of the 2013-2014 Existing Buildings Program, Prepared by ADM Associates Inc., 02/09/17. Available at: https://www.energytrust.org/wp-content/uploads/2017/02/EB_Impact_Evaluation_2013_2014.pdf

- Finding – Facility staff knowledge of Type B lamp operation may be an issue. Our surveys showed that only about a third of customers installing Type B lamps remember that their contractor warned them not to replace these lamps with flourescent tubes. (Our field staff did observe warning labels inside Type B fixtures at sites visted.)
  - Recommendation – Review and enhance Type B communication. Even if contractors are trying to communicate the risks, those warnings may not be understood. The program could adopt existing handouts or develop their own, providing them to trade allies to pass on to their clients. Stickers on fixtures containing Type B lamps warning that fluorescent replacements will not operate should be a requirement (if they're not already).
- Finding – "Recommendation from another user" was the leading reason participants selected the TLED type they installed.
  - Recommendation – The program should prioritize contractor education and communication if changes to measure mix are desired. For example, if the program would like a higher percentage of projects to be TLED Type C, educating contractors to make this recommendation will be required.
  -

4 STANDARD TRACK NON-LIGHTING EVALUATION

This section documents DNV GL's impact evaluation of non-lighting savings acquired through the standard non-lighting track (standard track). The standard track offered non-lighting prescriptive incentives for a large variety of electric and natural gas energy efficiency measures including refrigeration, cooking, HVAC, building shell, and office equipment.

The standard track also included occupancy-sensor controlled power strips, referred to as Power Strips or Smart Strips, which were typically "left-behind" with participants by the implementer rather than purchased by the participant.

The program estimates measure energy savings in this track using per-unit energy savings (UES) values that were either *stipulated values*, or *calculated values* using a standard formula and equipment or site-specific measure characteristics. The standard track measures accounted for about 7% of the 2015-2016 Existing Buildings program's reported electricity savings and 35% of the reported gas savings. Table 16 presents the energy use for the standard track measures and the overall Existing Buildings program by program year. The 2016 program year savings are significantly higher in 2016 than 2015; 2016 electric savings are about 60% higher than 2015, and 2016 gas savings are about 35% higher than 2015.

Table 16: Reported standard track energy savings by program year

Program Track	Reported Electric Savings (kWh)		Reported Gas Savings (therms)	
	2015	2016	2015	2016
Standard Non-Lighting	6,515,821	10,590,409	559,703	753,615
Existing Buildings program total	109,051,484	123,916,024	1,888,021	1,889,692
Percent of Existing Buildings program savings	*6%*	*9%*	*30%*	*40%*

4.1 Sample design

DNV GL used stratified random sampling to select an efficient representative sample of projects for evaluation designed to provide reliable savings estimates across program years and program fuels. DNV GL sampled at the measure level, using unique Measure IDs in the data. The sample design target included 142 points, consisting of 72 food service equipment projects and 70 non-food service equipment projects. The evaluation divided the track into food service and non-food service measure groups to ensure representation across both food and non-food measures in the track. Additional strata used include program year, primary fuel type, and size of savings claim (up to three size strata were used). The final sample design included 23 unique strata and selected 15 different food service equipment measures and 30 different non-food service measures for evaluation. This design was expected to provide program year savings estimates with 15% relative precision at the 90% confidence interval. Table 17 summarizes the sample design. Further detail on sample design is available in Appendix A.

Table 17: Standard track sample design

Program Year	Technology Domain	Primary Fuel	Size Stratum	Population (N)	Sample Target (n)
2015	Food	Electric	1	147	5
			2	36	4
			3	23	4
		Gas	1	213	8
			2	173	7
			3	90	7
	Non Food	Electric	1	508	8
			2	83	7
			3	27	7
		Gas	1	72	5
			2	13	4
			3	8	4
2016	Food	Electric	1	150	6
			2	36	6
		Gas	1	221	9
			2	174	8
			3	95	8
	Non Food	Electric	1	531	7
			2	86	7
			3	19	7
		Gas	1	116	5
			2	21	5
			3	12	4

4.2 Standard track evaluation methods

This section discusses the activities completed to evaluate this track.

4.2.1 Summary of approach

DNV GL used two approaches for the evaluation of standard track measures: *measure-specific* and *project-specific*. The following steps were completed in both approaches:

- Documentation and file review: Reviewed tracking data to identify savings reported, units reported, and measure code used. Review of Measure Approval Documents (MAD) to understand the eligibility requirements, savings algorithms, and savings values used to support reported savings. File review to verify reported information through invoices and other provided documentation.
- Data Collection Planning: Identified the key input parameters and stipulated values to research and how they should be verified (i.e. file review, phone interview, internet lookup, etc.). Then, created a list of interview questions.
- Data Collection: Phone interview of sampled participants using the survey instruments developed.
- Analysis: Estimated evaluated savings using the data collected to update key parameters and or map to the most correct MAD value.

The two approaches created to complete the evaluation were:

- *Measure-specific:* DNV GL used a more systematic and standardized *measure-specific* approach for entity codes[14] that occur five or more times in the sample. For each of these measures, we created an

[14] Entity code is a specific field in the Existing Buildings program database that is used to identify similar measures.

Excel workbook that contains the relevant tracking data extract, and sequentially documents each phase of our analysis including the file review, phone verification questions and responses, analysis of all the collected data, and the final evaluated results and dispositions. There is typically one workbook for each type of measure and some workbooks encompass multiple entity codes.

- *Project-specific:* A more customized, *project-specific* approach was used for entity codes occurring less than five times in the sample, which were referred to as *low-frequency measures*. For each of these measures, a single Word document was used for a more free-form review of the available information, logging of verification questions and responses, and evaluation analysis results and findings. Additional materials and calculations were also used as needed to support the analysis. However, summarized findings for the file review, phone verification, analysis, and the final numeric evaluated results for all of these measures were also tabulated in an Excel workbook.

Table 18 shows all of the entity codes in the standard track, notes which were sampled and not sampled in this evaluation, and notes the evaluation approach type implemented.

Table 18: Standard track sample design by entity code

Entity Code	Percent of Track Savings[15]		Measure ID Count		Evaluation Approach
	%kWh	%therms	Population (N)	Sample Target (n)	
FOODEQUIP[16]	9.1%	54.3%	1,152	64	Measure Specific Approach
FRIDGE	33.5%	7.4%	110	12	
BOILER	-	22.3%	47	11	
CEILINGINSULATE	2.2%	9.8%	68	10	
LIGHTING	18.8%	-	204	10	
POWERSTRIP	1.7%	-	598	10	
ICEMAKER	1.1%	-	206	8	
MOTOR	6.6%	-	76	4	Project Specific Approach
VIRTUALIZATION	8.8%	-	20	2	
CONTROLS	8.6%	-	86	2	
CUSTOMFRIDGE	4.0%	-	11	2	
TANKDHW	-	1.1%	30	2	
SHOWERHEAD	0.1%	0.7%	9	2	
HEATPUMP	4.0%	-	92	1	
RADIANTHEAT	0.1%	1.2%	7	1	
HVAC	0.9%	-	41	1	
STEAMTRAP	-	1.0%	5	0	Not Sampled for Evaluation
WALLINSULATE	0.3%	0.6%	20	0	
GASFURNACE	-	0.7%	33	0	
TANKLESS	-	0.4%	10	0	
AERATOR	0.1%	0.2%	12	0	
CLOTHWASH	0.0%	0.1%	4	0	
GASUNITHEAT	-	0.1%	2	0	
LIGHTCONTROL	0.0%	-	2	0	
DISHWASH	0.0%	0.0%	5	0	
PEOTHER	0.0%	-	1	0	
ACMINISERVER	0.0%	-	1	0	
COMPRESSEDAIR	0.0%	-	1	0	
FREEZER	0.0%	-	1	0	

15 Percent savings values shown as 0.0% are non-zero but less than 0.05%. Cells with no values are zero.

16 The FOODEQUIP entity code includes the following measure types: Fryers, Commercial Ovens, Steam Cookers, Holding Cabinets, Commercial Dishwashers, Griddles, and Ventilation Hoods

4.2.2 Documentation and file review

DNV GL reviewed the applicable Measure Approval Documents (MAD), as well as site-specific project file documentation for all of the sampled measures. This section discusses the results of our review.

4.2.2.1 Measure Approval Documents

For Standard track measures, savings approaches and values are provided in the MAD files. We received and reviewed MADs for all sampled measures. We were provided with one to three MAD files for each measure, due to the revision cycle of each measure. We also reviewed any additional files, such as calculators or calculation workbooks that were provided as supporting savings documentation. However, for many of the MAD docs, the supporting documentation was only available from links to an internal drive that could not be accessed by DNV GL. The following documents DNV GL's review process and findings:

- File identification: DNV GL typically identified the corresponding MAD file for each measure by the file name, since we were not provided with a direct link from measures to MAD file, and there was no such link in the tracking data. Most MAD filenames corresponded to the measures discussed within, however, some file names did not contain the measure name. For example, the MAD file for fryers was "food service cooking" and contained multiple food service measures.
- File structure: The structure and format for presentation of the information in the MADs varied across the measures, which sometimes made it difficult to review the measures and identify the key assumptions. Some of the MADs were copies of emails with a long narrative. However, even though the MAD structure across measures was inconsistent, we were able to identify the key parameters and assumptions and line up the tracking data values with MAD values. Most of the MADs did identify the responsible engineers so that they could be contacted should any questions about the approach and references arise.
- Assumption sources: Sources for assumptions and savings were discussed in the MAD files, but often without proper and complete citation. There was often no way for the evaluation to validate the references used to generate the savings shown in the MAD. However, the scope of this effort was primarily to make sure that the MAD assumptions were being applied correctly, and to evaluate the assumed values versus actual participant operation.
- Measure identification: The measure names used within each MAD generally differed from the measure names used in the tracking data. We identified the correct measure by looking at the unit energy savings (UES) values. However, because the UES values are not recorded in the tracking data – only total kWh, total therms, and "quantity" are provided – we reverse engineered the UES values from the tracking data, and for some measures we also needed supplemental information from the site-specific project files.
- Measure baseline condition: The measure baseline condition is either Common Practice[17] or Pre-Conditions[18]. The assumed baseline condition was not clearly identified in the MAD and evaluators need to understand the assumed baseline condition in order to assess the reliability of measure savings.
- Measure units: The unit basis for for each measure is the denominator for each UES value. For example, boiler savings are expressed as kBtu saved per kBtuh of boiler heating capacity, and LED case lighting is kWh per linear foot of case. The unit basis was not clearly identified in the MAD and

[17] Cost-Effectiveness Policy and General Methodology for Energy Trust of Oregon, December 16, 2011, https://www.energytrust.org/wp-content/uploads/2016/11/4.06.000.pdf

[18] ROADMAP FOR THE ASSESSMENT OF ENERGY EFFICIENCY MEASURES REGIONAL TECHNICAL FORUM, Release Date: December 8, 2015, https://nwcouncil.app.box.com/v/20151208CompleteGuidelines

evaluators need to understand the unit basis in order to assess the reliability of measure savings. For all measures, we were able to determine the unit basis and correct MAD file and measure by reverse engineering the UES values from the tracking data values. However, the UES unit basis should be clearly defined in MAD tables, and both the UES and unit basis should be reported as part of the tracking data. This was further challenged by the inconsistency in unit reporting observed in the tracking data provided.

4.2.2.2 Project file review

Project documentation for standard track projects was typically complete and extensive and included the application form, invoice, technical performance specification sheet, and ENERGY STAR (ES) documentation for ES measures. Overall, DNV GL found the project file documentation for the standard track was well organized, easy to access, consistent with the tracking data, and sufficient for independent verification. File names were an issue for a small number of projects; most projects were identified by a descriptive name, but some had long alpha-numeric names. It is believed that the files were automatically renamed when transferred from the PMC to Energy Trust's document retention system.[19]

The file review for smart power strips was different than other measures because the power strips are purchased in bulk. The only information available at the project-site level was the application form which showed the quantity left behind and an acknowledgement of training on how and where to install the power strip (see Figure 8). The application form did not contain the smart strip make and model, which we needed to validate the equipment eligibility, but we obtained a copy of the invoice for the mass purchase of power strips by the implementer which contained this information.

Figure 8. Example of advanced power strip participant receipt block from program application

Advanced Power Strip Survey Log			
Type	Quantity Given	Provided Instructions?	Verified Office Setting?
Occupancy Sensing Power Strip	1	Yes	Yes

4.2.3 Data collection

The primary data collection method for standard track measures was a phone interview. In a few cases, data was collected for standard track measures when DNV GL was already on site for a measure sampled in a different track. DNV GL followed a recruitment and communication protocol approved by Energy Trust for this project. The questions and overall evaluation approach for each measure were guided by the measure eligibility requirements, size and performance characteristics, complexity, available tracking data, and MAD savings approach (stipulated or calculated values). For all measures, as a minimum we verified installation and active operation, confirmed the business type, reviewed business hours, and asked about pre-retrofit conditions. All measures also included measure-specific parameter or condition questions.

4.2.4 Measure analysis

DNV GL estimated evaluated savings for all sampled measures with completed data collection. Inputs for the evaluated savings calculations were determined from the most valid data source including the phone interview, tracking data, MAD file review, project file review, and other independent research. We did not

[19] The file naming issues did not prevent DNV GL from evaluating the projects sampled. However, Energy Trust should determine what caused the renaming and prevent it from occurring in the future.

typically revise the MAD algorithms, but would use the collected data to either calculate a revised value or more typically, map to a more correct MAD value. For ENERGY STAR equipment, we used the latest version of the ENERGY STAR appliance calculator and combined that with our primary data. Excel workbooks were used to process and document the analysis and evaluated savings results and assumptions. Measure results are presented in Appendix C.

4.3 Standard track evaluation results

This section presents the track-level results of DNV GL's impact evaluation of this track.

4.3.1 Achieved sample

Table 19 shows the final sample achieved across the entire standard track. DNV GL estimated evaluated savings for 84% of the measures sampled. Participants associated with 6 food measures (10% of food measures completed) were confirmed to be out of business. These were considered a completion. The final achieved evaluation sample differed from the sample design due to the following.

- Power Strips: During file review, we discovered that the POWERSTRIP entity code measures were also distributed under the Lighting track. To ensure a consistent evaluation approach for this measure, the five sampled projects from the Lighting track were added to the Standard track evaluation effort, bringing the total POWERSTRIP target quota to 15. The evaluation also created a new technology category for these measures. Based on the typical delivery method for this measure, DNV GL concluded that the evaluation results for this measure should not effect other standard measures.
- Refusals and Non-Responses: The balance of the incomplete sample was primarily those participants that could not be reached after exhausting our phone call protocol, and a small number who refused to participate in the call. Our protocol required calling up to 5 times at different times of the day. We also tried contacting the participant by email if they did not respond to phone calls.

Table 19: Final standard track sample summary

Program Year	Technology	Sample Target	Achieved Sample	% Complete
2015	Power Strip	5	3	60%
	Food	35	27	77%
	Non-Food	30	26	87%
2016	Power Strip	10	10	100%
	Food	37	34	92%
	Non-Food	30	23	77%
Total	Overall	147	123	84%

4.3.2 Evaluated savings

Expansion from the sample to track-level results follows the methodology discussed in Section 2.4. Table 20 shows the overall electric standard track realization rates for the track by program year. The electric realization rates are driven primarily by the evaluation results for refrigeration measures. Refrigeration measures account for 71% of the total standard track measure savings and therefore are a large part of the sample. However, there is a difference for the two years: for 2015 the realization rate is driven by results for the LED refrigerated case lighting measure, and for 2016 the realization rate is driven by results for the measure to add doors to open refrigerated cases. The overall realization rate is closer to the 2016 value because the 2016 electric savings were significantly higher than 2015 savings.

Table 20: Standard track electric impact evaluation results by program year

Tracks by Year	Completed Sample	Realization Rate	Standard Error	Relative Precision at 90 % Confidence	Evaluated Savings (kWh)
Smart Strip-2015	3	47%	0.38	131%	109,684
Smart Strip-2016	10	20%	0.13	109%	18,868
Standard Non-Lighting-2015	32	78%	0.06	13%	4,870,431
Standard Non-Lighting-2016	28	95%	0.08	15%	10,041,281
Overall	73	88%	0.03	5%	15,040,264

Table 21 shows the overall gas standard track realization rates for the track by program year. The gas realization rates are driven primarily by the evaluation results for gas fryer, space heating boiler, and roof/attic insulation measures.

Table 21: Standard track natural gas impact evaluation results by program year

Tracks by Year	Completed Sample	Realization Rate	Standard Error	Relative Precision at 90 % Confidence	Evaluated Savings (therms)
Standard Non-Lighting-2015	28	76%	0.15	33%	424,095
Standard Non-Lighting-2016	34	76%	0.07	16%	572,927
Overall	62	76%	0.07	16%	997,022

4.4 Standard track findings and recommendations

Our evaluation findings and recommendations specific to the standard track are presented in two sections, one to address overarching tracking data and MAD file review and the other to address measure-specific findings.

4.4.1 Measure Approval Document (MAD) and tracking data recommendations

Findings and recommendations for the tracking data and MAD files are discussed in this section. We also address a key research question from the RFP in regards to the MAD files.

Do the measure approval documents used by the program include sufficient information to estimate reliable savings, and if not, what specific changes should be made to improve them?

Evaluation Response: Overall, the measure approval documents (MADs) reviewed do not provide sufficient transparency and traceability to support reliable savings estimates. Energy Trust has been updating the format and content of these documents over time and the documents reviewed for this evaluation cover multiple stages of development.

DNV GL understands that creating, maintaining, and updating prescriptive measure assumption documentation is a time-consuming process with no perfect solution. No measure database, technical reference manual, or work paper library solution created has proven to be the best for all program administrators. DNV GL finds the Energy Trust's library of MADs to be confusing and lacking sufficient information. DNV GL recommends that Energy Trust explore opportunities to improve the transparency, content, and application of its prescriptive measure supporting documentation system. Below are our thoughts on what should exist in each MAD to ensure sufficient information for reliable savings estimation. Some of these exist in the MADs reviewed.

The MAD should clearly specify the unit basis for the unit energy savings (UES). For example, boiler savings are expressed as kBtu saved per kBtuh of boiler heating capacity. Similarly, LED case lighting is kWh per linear foot of case. For all measures, we were typically able to determine this by review and reverse engineering the UES values from the tracking data values (total savings and quantity). However, the UES unit basis clearly defined in MAD tables and should be reported as part of the tracking data.

- Whenever possible, the MADs should show the method and/or assumptions used to estimate savings in a simplified form, such as a one-line calculation or table. In cases when inputs vary by application, the one line calculation should name the parameters, such as "pounds of food per day". In cases when simulations are used and combined, key inputs and outputs to the simulations should be provided. If possible, a one-line calculation should be provided showing the average values or range of values calculated. When the input assumption varies based on application, the MAD should include the look-up table used. If including the tables or assumptions in the document is deemed too difficult, then an Excel file should be embedded in the Word file (as is currently done in some cases).
- The MAD should clearly specify the baseline condition for the measure, either pre-existing conditions (retrofit measures) or current practice (lost opportunity measures). The MAD should then provide the assumed efficiency of the baseline and the basis for the assumption.
- In all cases, the MAD should document what research supports the assumptions used or document what industry standards support the assumed value. This applies to both inputs to savings calculations, the baseline and installed equipment assumed, the measure life, and measure costs (cost does not impact reliability).
- When possible, the MAD or referenced supporting documentation should document the confidence interval and relative precision of the input assumption or savings estimation used. These values provide a clear indication of savings reliability.

Below are additional findings based on this evaluation:

- Finding – There is no direct link to the MAD file used for each measure in the tracking data, nor to the measure names used in the MAD file. To identify the correct MAD file was a multistage effort, first finding the files with a similar measure name, then calculating the unit energy savings (UES) values from the tracking data from the total kWh or therms and the quantity, then finding the best match in the MAD doc to the tracking data measure name and the calculated UES value.

- Recommendation A – Create consistent and traceable file names. The MAD file and tracking data should use the same measure names and/or use unique measure codes so that there is direct traceability to the source of the savings approach and UES values for every measure in the tracking data. If new measure codes are created, then the MAD should be updated.
- Recommendation B – Create a way to directly identify the applicable MAD file used for each measure. This options we have thought of are a mapping table of Measure Code to MAD file name, or a MAD file name field could be added to the tracking data.
- Recommendation C – Include program years and programs that the savings documented in the file are approved to be used in. Include a measure history table similar to the table in policy documents that shows the last revision date, revisions made, and date of next review. Do not update the measure savings within a program year unless absolutely necessary. These changes should improve the transparency of the MAD update process and traceability of savings claims to supporting documentation.
- Recommendation D – Include the UES value, the units according to the unit basis for the measure, and the physical count of units installed in the tracking data. Future impact evaluation should research the accuracy of these values in the tracking data.

- Finding – Many of the MAD savings estimation approaches for food service measures were based on the ENERGY STAR calculators, but did not use the calculators directly, and modified many of the assumptions.
  - Recommendation – Use the ENERGY STAR calculators and default assumptions as-is, but use realistic estimates of business and equipment operation for participants. The best approach would be to use the ES calculator with parameters for the actual installed equipment and operation for the business receiving the incentive.
- Finding – For many MAD files, the supplemental-supporting references for assumed values and approaches were not properly referenced (title, author, date) and only a link to an internal server location for the studies was provided.
  - Recommendation – For supplemental-supporting documents, studies, reports or calculators, consider embedding those files in the Word doc, attaching to a created PDF file, and/or provide a proper and complete reference so that wherever possible an internal or web search can easily find the reference. Reference sources should ideally be publicly and readily available, and the savings values and methods used in the MAD files should be traceable and transparent.
- Finding – The MAD files use a variety of structures and formats, including some that appear to be long narratives from emails. The variety of formats used makes it difficult to ensure that the information for a measure is completely and consistently documented across measures.
  - Recommendation – Create a template with the structure that can encompass all the measures and all the information needed to characterize a prescriptive measure, then phase that template in as measures are updated (targeting high-impact measures) or complete a separate project to update all MAD files.
- Finding **–** The savings methodologies and assumptions are not easily available to the public and should be. In February 2018, Oregon is ranked 5th in states rankings and Portland, OR is ranked 4th in city rankings by the American Council for an Energy-Efficient Economy (ACEEE).[20] Of the 11 states ranked in

[20] American Council for an Energy-Efficient Economy (ACEEE), State Rankings: https://database.aceee.org/state-scorecard-rank, City Rankings: https://database.aceee.org/city-scorecard-rank

the top 10, only two do not have readily available measure databases or reference manuals: Oregon and Washington (7th). In Washington, the measures and protocols approved by the Regional Technical Forum are readily available and often applied. A public reference manual, measure database, or work paper library improves the transparency program assumptions, methods, and savings estimations.

- Recommendation – Energy Trust should develop and implement a plan to transition from a system with supporting documentation stored on internal servers to one that makes the methodologies, assumptions, and values used readily available to the public on the Energy Trust website.

4.4.2 Measure-level recommendations

Findings and recommendations for the measures with the largest impact on the overall electric and gas realization rates are listed below. Findings and recommendations for all measures reviewed under the measure-type approach are provided in Appendix EAppendix A.

- Finding – *Smart Power Strips.* Findings for all sites are uncertain due to reliability of remote smart strip verificiation, especially use of the motion sensor feature. For 10 of 13 sites, the savings were zeroed out because participants could not recall receiving it or did not receive it, were unsure it was being used, received it but had not installed it, or the unit was not functional. Even for the confirmed users, one indicated the motion sensor was not used, and another used it at home. In a separate but related retail-focused delivery effort, large quantities of smart strips were purchased at retail by some participants who intended to install them, but those participants were not sampled in this evaluation.
  - Recommendation – Leave the smart strips behind as a participant reward, but do not claim savings as there is too much uncertainty in their actual use. Also, do not require the participant to sign an agreement to install and use as that does not guarantee use. Finally, consider doing a follow-up study or survey of all participants who received incentives for purchasing large quantities of smart strips to verify the installation rate and active use.
- Finding – *ENERGY STAR measures.* The ENERGY STAR calculators are readily available, relatively easy to use and defaults are very transparent, citable, and version controlled. For many of the measures, Energy Trust uses the basic ENERGY STAR algorithms, but makes adjustments to some of the parameters that reference sources that could not always be validated. In addition, some of the assumptions were found to be incorrect, for example a "Large" fryer vat is assumed, but all but one of the verified units were "Standard" size vats.
  - Recommendation A – Consider using the ENERGY STAR calculator directly and as part of the MAD documentation. Furthermore, consider using the ENERGY STAR calculator for every participant, but use realistic operating hours to reflect each business. One alternative to consider is the creation of a measure for non-restaurant business types that incorporates lower usage. If created, the measure should be tested for cost-effectiveness.
  - Recommendation B – Review the measure-level results in the Appendix C and consider revising key assumptions like the fryer vat size, or collecting that information for the incentivized equipment, to provide more accurate savings estimates.
  - Recommendation C – Conduct research on current practice to validate the baseline assumptions for incentivized equipment in Oregon.
- Finding – *Refrigerated case LED lighting.* There were several issues for this measure. The verified projects were predominantly retrofit projects, though the measure is also applicable for new cases. One of the verified sites had motion sensor control which was not reported for the project. The quantity unit

basis is supposed to be linear feet of case, but half of the sample had a reported quantity of one in the database (total savings was correct). DNV GL believes this is due to who entered the information or when the information was entered. Finally, three vintages of MAD were available for this measure – 2010, 2015, and 2016 – but the savings values and measure descriptions in the tracking data appeared to line up best with the 2010 vintage MAD file.

- Recommendation A – Update or review program processes to ensure that correct measure units are added to the database for all standard measures. Future evaluations should report on reliability of this field.
- Recommendation B - Review the MAD files for this measure and decide which one is the most recent and valid, then review program processes to ensure that current program is using the valid MAD-supported savings.

▪ Finding – *Refrigerated case LED lighting.* There were a few cooler case lighting projects that had multiple fixture replacements of various types. The application only shows the total linear feet replaced; ideally, an itemized list of fixture types and quantities should be available. We had to dig into invoices, drawings/prints of the cases, etc. to try to make sense of things. This is not ideal as invoices don't always show things in a consistent way and the linear footage of existing fixtures do not always match 1-to-1 with the new fixtures.

- Recommendation – Project documentation should include a detailed matrix and sketch that directly maps the invoice information and case lengths to MAD measures.

▪ Finding – *New cooler cases w/multiple individual measures.* There were a few projects that appear to claim multiple measures (glass doors on open cases and LED case lighting) for new cooler cases, and most refrigerated case measures allow both a retrofit or new case configuration. However, a majority of the verified measures were retrofit situations, and the baseline should be significantly different for a retrofit versus a new case. Interactive HVAC savings are claimed for gas heating systems but not for electric heating systems, and the reported HVAC system was incorrect for three of the seven verified sites.

- Recommendation A – Review measure requirements and determine if new cases can receive incentives for this measure. If not, update measure eligibility requirements in the MAD. If so, a new measure should be developed for new cases that include all energy efficiency features, and the existing measure should only be used for retrofit situations. The baseline for new measures should be current practice.
- Recommendation B - Improve identification of the space heating system type, adjust the electric savings for electric space heating systems, or consider dropping the interactive gas savings and only claiming the direct kWh savings. DNV GL believes the full benefits and costs of the measure should be considered, but recognizes that tracking interactive effects adds complexity. At minimum, interactive effects should be accounted for consistently across the Existing Buildings program.

▪ Finding – *Gas Fryers.* There is an ENERGY STAR calculator for this measure. Energy Trust did not use the calculator directly, it used the calculation approach, some of the defaults, and some revised parameters. DNV GL used the current ES calculator for the evaluation of all ENERGY STAR measures. The MAD for fryers assumed a large vat but almost all of the verfied sites were standard vat, and this is a key feature for the savings estimate. Phone response values for verified pounds of food and hours of fryer operation tended to be lower than assumed in Energy Trust's calculations. Four sites were out of business, and one did not use fryers at all.

- Recommendation – Use the ENERGY STAR calculator for traceability and transparency. Assume standard vat size instead of large for the calculations. Review and consider revising the assumed pounds of food and fryer hours per day; using participant estimates would be best. Consider stopping incentives to fast-food chains or other 7/24/365 sites where ENERGY STAR equipment is already common practice.

- Finding – *Space Heating Boilers and Boiler Controls.* A realization rate less than one was primarily due to adjusted savings for sites where one of the installed boilers was reported as being used for backup. For one site, the savings was zeroed out completely because the new unit replaced an existing condensing boiler; the MAD file savings are based on a standard efficiency boiler baseline and we presumed that condensing boilers were standard practice for this site. One site had a database reported "quantity" of one, but should have been the total boiler capacity in kBtuh. The unit basis for quantity is kBtu saved per kBtuh of boiler capacity, so only the total boiler capacity is tracked.
  - Recommendation A – Update program tracking and reporting to account for boilers installed as backups. Consider identifying the quantity of incentivized boilers that will be primary versus backup on the application. Add a field to the tracking data to capture the physical quantity of boilers. The MAD already states that backup boilers should not be counted in the incentive, so a mechanism is needed to ensure this requirement. Regarding the baseline, the eligibility criteria should clearly state the baseline condition for existing buildings. Energy Trust should not support the installation of high efficiency equipment that replaces existing high efficiency equipment.
  - Recommendation B – Consider completing research on current practice for space heating boilers in Oregon. DNV GL believes that the current practice baseline efficiency for boilers is higher than the 80% assumed in the MAD. Recent research completed by our Massachusetts C&I evaluation team recommended increasing the assumed baseline for lost opportunity measures based on market activity in Massachusetts and recent Department of Energy rulemaking.[21,22]
  - Recommendation C – Consider completing a whole building degree day regression analysis (similar to the Strategic Energy Management analysis) on recent or current boiler measure participants to identify the gas usage sensitive to changes in temperature. The results of this analysis and outputs from the simulation models referenced in the MAD could be used to more accurately estimate savings for this measure.

[21] Gas Boiler Market Characterization Study Phase II - Final Report, Massachusetts Program Administrators and Energy Efficiency Advisory Council, March 1, 2017. http://ma-eeac.org/wordpress/wp-content/uploads/Gas-Boiler-Market-Characterization-Study-Phase-II-Final-Report.pdf

[22] Department of Energy, Commercial Packaged Boilers, final rule: https://energy.gov/sites/prod/files/2016/12/f34/CPB_ECS_Final_Rule.pdf
CPB webpage: https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=8

5 CUSTOM TRACK EVALUATION

The custom track reported 515 unique measures providing 51,886,231 kWh and 1,443,430 therms in annual energy savings across the two program years. These savings account for 22% of the program's reported electricity savings and 38% of the program's reported gas savings. Table 22 shows the reported savings for custom by program year. Table 23 shows the population frame for custom.

Table 22: Reported custom track energy savings by delivery and program year

Program	Reported kWh		Reported therms	
Track	2015	2016	2015	2016
Custom	26,045,331	25,840,900	789,124	654,306
Existing Buildings program total	109,051,484	123,916,024	1,888,021	1,889,692
Percent of Existing Buildings program savings	24%	21%	42%	35%

5.1 Sample design

DNV GL used stratified random sampling to select an efficient representative sample of projects for evaluation designed to provide reliable savings estimates across program years. Key design elements were:

- Creation of domains based on the primary fuel saved, electricity or gas. This helped ensure sufficient results for both fuels.
- Stratification by size of savings reported (up to four size strata were used) and use of a certainty stratum to increase the magnitude of savings evaluated and minimize the expected relative precision of evaluated savings.

Sampling occurred at the project level (Project ID). DNV GL sample design included 80 custom projects at 79 sites that include 110 unique measures. Table 23 summarizes the sample design for the custom track. This design was expected to provide program year savings estimates with 15% relative precision at the 90% confidence interval. Further detail on sample design is available in Appendix A.

Table 23: Custom track sample design

Program Year	Fuel Stratum	Size Stratum	Population (Projects)	Sample Target
2015	Electric	1	103	9
		2	24	8
		3	11	8
		Certainty	5	5
	Gas	1	71	5
		2	15	5
2016	Electric	1	120	9
		2	21	9
		3	13	9
		Certainty	3	3
	Gas	1	45	5
		2	10	4
		Certainty	1	1
2015 Subtotal			229	40
2016 Subtotal			213	40
EVALUATION TOTAL			442	80
Percent of Reported kWh in sample				54%
Percent of Reported therms in sample				34%

5.2 Custom track evaluation methods

5.2.1 Summary of approach

DNV GL completed the following steps for the custom track impact evaluation:

- Project file review: Review of project files provided by Energy Trust.
- Data collection planning: Creation of project-specific measurement and verification plans.
- Data collection: Sites visits and phone interviews with sampled participants.
- Analysis: Estimated evaluated savings using the data collected to update key input parameters.

5.2.2 Project file review

DNV GL reviewed each sampled project file for sufficient documentation, program savings methodology, and accurate savings reporting. This review included:

- Verification of the existence of signed application or end-user agreement
- Identification of the Building Type
- Determination if the file folder contained enough information for evaluation
- Verification of the existence of engineering calculations and/or energy simulation models with outputs that match the reported savings
- Assessment of the completeness of documentation

5.2.3 Measurement and verification planning

DNV GL created project-specific M&V plans to guide the onsite data collection effort. These site-level M&V plans were created for each sampled site using DNV GL's project-specific M&V Plan template. These plans focused on the collection of information specific to the key research parameters identified. The study did not collect information on all drivers of end-use energy consumption.

5.2.4 Data collection

The evaluation team made onsite verification at 45 project sites and conducted interviews by phone with the facility personnel at 23 project sites. Seven sites were dropped because of no response received from the facility contact or the facilities did not have a suitable person who could answer the evaluator's queries. For the remaining five sites that were completely identical to one of the verified or interviewed sites, the evaluator utilized the data collected from the identical site to evaluate the measure savings.

5.2.5 Project analysis

DNV GL estimated evaluated savings for 73 of the 80 projects originally sampled. DNV GL used the same calculation tool used by the program to estimate savings with revised inputs where necessary. Inputs for the evaluated savings calculations were determined from the most valid data source including participant interviews, site observations, site EMS data, schedules, or setpoints, program project files, and utility meter data. Typically, adjustments were made to the post installation analysis in order to model the conditions observed by the evaluation. However, in some cases the evaluation did adjust the pre-existing or baseline inputs based on interviews with the participants. Project specific results were provided to Energy Trust separately.

5.3 Custom track evaluation results

5.3.1 Achieved sample

Table 24 shows the final sample achieved across the entire standard track. DNV GL estimated evaluated savings for 91% of the projects sampled. The final achieved evaluation sample differed from the sample design due to the following.

- Refusals and Non-Responses: The incomplete sample was primarily those participants that could not be reached after exhausting our phone call protocol, and a small number who refused to participate in the call. Our protocol required calling up to five times at different times of the day. We also tried contacting the participant by email if they did not respond to phone calls.

Table 24: Final standard track sample summary

Program Year	Primary Fuel	Sample Target	Achieved Sample	% Complete
2015	Electric	30	28	93%
	Gas	10	9	90%
2016	Electric	30	27	90%
	Gas	10	9	90%
Total	Overall	80	73	91%

5.3.2 Evaluated savings

Expansion from the sample to track-level results follows the methodology discussed in Section 2.4. Table 25 shows the overall electric standard track realization rates for the track by program year. The electric realization rates are driven by numerous factors, including changes to building operation or use, errors in the program analysis, and adjustments to simulation inputs. DNV GL captures our findings and recommendations in the sections that follow.

Table 25: Custom track electric impact evaluation results by program year

Tracks by Year	Completed Sample	Realization Rate	Standard Error	Relative Precision at 90 % Confidence	Evaluated Savings (kWh)
Custom-2015	34	94%	0.11	19%	24,525,378
Custom-2016	33	86%	0.07	12%	22,222,244
Overall	67	90%	0.06	11%	46,715,664

Table 26 shows the overall gas standard track realization rates for the track by program year. The gas realization rates are driven by numerous factors, including changes to building operation or use, errors in the program analysis, and adjustments to simulation inputs. DNV GL captures our findings and recommendations in the sections that follow.

Table 26: Custom track natural gas impact evaluation results by program year

Tracks by Year	Completed Sample	Realization Rate	Standard Error	Relative Precision at 90 % Confidence	Evaluated Savings (therms)
Custom-2015	14	81%	0.12	25%	637,221
Custom-2016	18	104%	0.12	19%	655,489
Overall	32	91%	0.09	17%	1,292,548

5.3.3 Custom track findings and recommendations

Our evaluation findings and recommendations specific to the custom track are presented in two sections, one to address key research questions and the other to address track-specific findings.

5.3.3.1 Energy Trust questions

This section provides responses to Energy Trust's custom track research questions.

Are there any aspects of the models used in the energy savings analyses by the PMC or program allies that may be of concern to Energy Trust?

Evaluation Response: Overall, the evaluation found the models developed by the program to be robust. We identified the following opportunities for improvement in model development that should increase the accuracy of individual project estimates.

- Final reported savings based on eQuest simulation models should use parametric runs to estimate the impact of measure combinations. The evaluation found that most program eQuest models used individual measure runs and did not utilize the parametric modelling option. In some cases, lack of parametric modeling inflated the reported savings estimate.
- Final reported savings based on Trane Trace simulation models should use a modeling alternative that includes all measures installed. This alternative will estimate the annual consumption of the final proposed case and can be subtracted from the baseline model output to estiamate annual savings. There were multiple cases when savings estimates for each measure were provided, but it was unclear how the final reported savings estimate for measures installed was determined.
- DNV GL recommends using standard weather files and to provide the weather files along with the energy model files. The program models did not follow any uniform guideline for consistent use of weather file, such as TMY2 or TMY3. Some project used TMY2 or TMY3 while few models used custom weather files.

Are there any obvious errors in any of the assumptions used in energy savings analyses, either in the original savings estimates or in verification of energy savings?

Evaluation Response: DNV GL did not identify any systemic errors in the energy savings analysis, but errors did exist in the projects reviewed.

- One project incorrectly assumed that elevator motors would run 8,760 hours per year fully loaded. The hours of operation and load on elevator motors is highly variable throughout the year.
- One project incorrectly calibrated a simulation model to two utility meters, when only one of the meters serves the building.
- Two projects included significantly overestimated compressor annual operating hours.
- One project used two unique simulation runs to estimate savings for what really was one measure. By dividing the measure into two pieces, the simulation model overestimated savings.

What factors result in large variances in measures savings (assumptions too conservative, incorrect hours of operation, loads differ from expectations, etc.)?

Evaluation Response: The errors listed above all resulted in large variances in measures savings. DNV GL also identified the following common parameters that resulted large savings variances:

- *Changes in operating schedule*: The evaluation updated building operating schedules based on data gathered during the evaluation. In many cases, these schedules differed from the operating schedules used in the reported savings analysis. The source of the operating schedules used to estimate reported savings are unknown as the program files or TAS do not report the sources of these schedules.
- *Changes in operating setpoints*: The majority of the ex post revisions made were related to the control setpoints used in simulation models. The evaluation updated setpoints based on the data gathered during the evaluation. Most of the changes were related to: occupied/un-occupied cooling setpoints, occupied/un-occupied heating setpoints, economizer high limit setpoint, chilled water and HHW plant operating setpoints and reset range, cooling and heating supply air temperature setpoints and reset range, and cooling and heating lock-out temperatures. The source of the original setpoints assumed was typically unknown. The evaluation cannot therefore conclude if the setpoints were changed since the project was completed.
- *Capacity Expansion or Reduction*: There were two instances, one project at a data center and one project at a research facility, where the evaluation found that the capacity or the system load played the major determinant for the estimated savings. The ex post savings were decided based on the as-found facility load and that either increased or decreased the project savings drastically.
- *Significant drop of IT load*: The evaluation found three data center and telecom facilities where the ex post IT load changed significantly from what was used in the reported analysis. In one such instance, the ex post facility IT load was found to be almost one fourth of its reporting period load. However, it was not clear to the evaluator if the reported IT loads were based on the observed data or were based on the design IT loads. However, it is usual to see IT load variation in such facilities. Thus, the unpredictability exists with the reported energy savings because of load changes.

How can Energy Trust most effectively evaluate projects that involve multiple phases or commissioning that takes place over multiple years?

Evaluation Response: DNV GL suggests the following procedures be adopted for large projects with multiple phases and commissioning:

- Evaluation Timing: DNV GL recommends waiting to estimate evaluated savings of phased projects until the projects are complete. Phased projects often involve multiple interactive measures and any attempt to estimate savings from a single phase of the project would introduce unnecessary error and accounting challenges. However, Energy Trust should also include an independent review of the project plan and savings estimation at the start of the project. This independent review would improve the evaluation's effectiveness and mitigate the evaluation savings risk.
- Baseline Documentation: Effective evaluation requires a thorough understanding of the baseline condition and assumptions. Given the length of these projects, it is essential to fully document facility operation before the project begins as there are many risks to losing this information as the project develops. For projects that involve control setpoint or sequence modification, collect the baseline system performance data and document them to establish the baseline condition. These can include either collecting the EMS screenshots or by creating plots from the baseline trends to show the baseline setpoints, their variation over the baseline period. Furthermore, the project documentation should include the baseline operation details, such as the system parameters information collected, the period of data collection, interval along with the final observation baseline operating conditions.

- Post-project Documentation: DNV GL recommends that all phased projects include post-project commissioning reports that document the final measures installed and adjust the reported energy savings if necessary. The documentation should also capture the final post installation operation, including the list of operating parameters revised and their validation either through the facility EMS screenshots or plots of operating trends.

Do you have 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 or evaluating its programs in the future?

Evaluation Response: DNV GL believes the following adjustments will improve Energy Trust's program:

- *Increase documentation of changes to building controls*: For many control upgrade or modification measures, the evaluation team found little or no information available to support the measure changes and the inputs used in simulation modeling. DNV GL recommends that pre- and post-project control setpoints be documented either through facility EMS screenshots, plots of EMS trends, or a text narrative.
- *Avoid overly complex calculations:* The evaluation team found that some of the reported calculations were very complex and involved a large number of spreadsheet tabs along with hundreds of variables. Even though there are no technical issues associated with these complex calculations, the evaluator believes that for the calculations could have been made simpler given the commonly found measures. DNV GL recommends that Energy Trust either avoid complex calculations that are difficult to trace, require contractors to provide additional documentation of the calculation completed and key parameters, or increase the budget available to evaluate them.
- *Avoid non-live calculations:* The evaluation team came across many instances where the reported spreadsheet calculations were not live, meaning that at some point a macro is run. One of the possible reasons for this can be the proprietary nature of these savings calculations. However, the use of these calculators does not improve the reliability of the program since independent verification of savings is both prohibitively time consuming and often introduces additional error due to the use of a different calculation methodology.

5.3.3.2 Additional Custom Track Recommendations

This section provides additional findings and recommendations from the custom track evaluation.

- Finding – Multple eQuest models were generated for each implemented measures and baseline instead of using eQuest "parametric run" option. This required additional time to verify that each successive measure is built on preceding measure to avoid double counting of savings.
  - Recommendation – Use "parametric run" option when multiple measures were modeled using eQuest. This gives the opportunity to the customer and implementer to either select or deselect any given measure based on measure feasibility, its preference or its ranking in overall cost-benefit analysis. Similarly, when the measures are modeled using the eQuest "parametric run" option, it gives opportunity to the evaluator to deselect any given measure if any specific measure was found not working or not implemented. This reduces the evaluation time significantly and ensures that the measure interactive effects have been captured.

- **Finding** – Many Trace 700 models were not complete and were not consistent with TAS reported savings. Even though the final reported savings were based the combined effect of proposed measures, the program Trace models provided did contain the the final alternatives.
  - **Recommendation** – The ATAC should prepare Trace alternatives to represent the baseline, the individual measures and the final alternative that represents the actual measures implemented. The project documentation should provide the annual energy consumption estimated by each model and the reported energy savings should be the difference between the consumption of the baseline and final alternatives. The PMC should confirm that they have received a model that contains the baseline and final alternatives. These models should be stored to be available to Energy Trust should the project be evaluated. Additionally, model output screenshots should be included in an appendix to the TAS besides documenting the baseline and measure parameter values.
- **Finding** – Some of the reported savings calculations used baseline assumptions that were not documented and beyond engineering judgement. One such example was assuming the baseline chiller efficiency at 1.8 kw/ton, given the baseline chillers were water cooled. These undocumented assumptions resulted in inflated baseline energy consumption and overestimates of energy savings.
  - **Recommendation** – Prepare adequate baseline documentation that can be used in the evaluation analysis. Since the evaluation team does not get the opportunity to verify the baseline operation onsite (except what the facility personnel can recall), it is essential to document the baseline operation.
- **Finding** – Demand control ventilation measure savings were estimated through Trace 700 model without any documenation on the space occupancy density details, actual CO2 concentration observed or design condition, and CO2 setpoints. While the DCV systems were found to be installed and recording CO2 levels, many were not generating savings due to the setpoints in place and occupancy patterns.
  - **Recommendation** – The program should only support DCV installations in spaces where the conditions are right, such as: the HVAC ventilation system is designed for high density occupancy and the occupancy level in the space is variable. Gymnasiums that require significant ventilation during events are a perfect candidate for this measure. However, there are many instances in which no savings will be achieved. The program should ensure that projects with proposed DCV measures are good candidates for the application and that the setpoints used are appropriate for the space.

6 STRATEGIC ENERGY MANAGEMENT EVALUATION

The SEM track reported 280 unique measures providing 20,137,489 kWh and 1,020,965 therms in annual energy savings across the two program years. These savings account for 17% of the program's reported electricity savings and 54% of the program's reported gas savings. Table 27 shows the reported savings for SEM by program year.

Table 27: Reported SEM track energy savings by delivery and program year

Program	Reported kWh		Reported therms	
Track	2015	2016	2015	2016
SEM	10,330,780	9,806,709	539,194	481,771
Existing Buildings program total	109,051,484	123,916,024	1,888,021	1,889,692
Percent of Existing Buildings program savings	9%	8%	29%	25%

6.1 Sample design

DNV GL used stratified random sampling to select an efficient representative sample of projects for evaluation designed to provide reliable savings estimates across program years. Key design elements were:

- Temporal stratification of sample points based on the year of initial program engagement, providing sufficient coverage of both early (Continuing) and later (2015 or 2016 Year 1) program participants.
- Creation of domains based on the primarily fuel saved, electricity or gas. This helped ensure sufficient results for both fuels.
- Stratification by size of savings reported (up to two size strata were used) and use of a certainty stratum to increase the magnitude of savings evaluated and minimize the expected relative precision of evaluated savings.

Sampling occurred at the site level (CRM site number). DNV GL's sample design included 63 unique measures. Table 28 summarizes the sample design for the SEM track. This design was expected to provide program year savings estimates with 20% relative precision at the 90% confidence interval. Further detail on sample design is available in Appendix A.

Table 28: SEM track sample design

Program Year	Year 1 / Continuation	Fuel Stratum	Size Stratum	Program Sites	Sample Target
2015	2015 Year 1	Electric	1	34	6
			Certainty	1	1
		Gas	1	11	3
			Certainty	3	3
	Continuation	Electric	1	33	6
			Certainty	1	1
		Gas	1	28	6
			Certainty	1	1
2016	2015 Year 1	Electric	1	11	3
			Certainty	3	3
			Certainty	2	2
		Gas	1	6	1
			Certainty	1	1
	2016 Year 1	Electric	1	38	6
		Gas	1	23	3
	Continuation	Electric	1	47	4
			2	8	4
		Gas	1	23	3
			Certainty	3	3
			Certainty	3	3
2015 Subtotal				112	27
2016 Subtotal				168	36
EVALUATION TOTAL				280	63
Percent of Reported kWh in sample					38%
Percent of Reported therms in sample					55%

6.2 SEM track evaluation methods

6.2.1 Summary of approach

DNV GL completed the following steps for the SEM track impact evaluation:

- Doumentation review: Review of project files provided by Energy Trust for sufficient documentation.
- Project file review: Review of project files provided by Energy Trust for program savings methodology and accurate savings reporting.
- Data collection planning: Creation of project-specific measurement and verification plans.
- Data collection: Sites visits and phone interview with sampled participants.
- Measure analysis: Estimated evaluated savings using the data collected to update key modeling parameters.

6.2.2 Documentation review

DNV GL reviewed each sampled project file for sufficient documentation. This review included:

- Verification of the existence of signed application or end-user agreement
- Identification of the building type
- Determination if the file folder contained enough information for evaluation

- Verification of the existence of engineering calculations and/or energy simulation models with outputs that match the reported savings
- Assessment of the completeness of documentation

6.2.3 Project file review

DNV GL reviewed each sampled project file for program savings methodology and accurate savings reporting. This review included the following steps:

- Verifying stated meter numbers and/or account numbers.
- Identifying how many years the site has participated in the program.
- Identifying if the site was previously evaluated or reviewed.
- Identifying use of non-weather variables, polynomials, or multiple degree-day variables.
- Identifying what, if any, capital projects were completed during the program years.
- Determining if the energy savings reported in the database is supported by a single or multiple regression models.
- Extraction of the monthly utility consumption data, and non-weather independent variables (if used) for each facility and identify if additional data is needed from Energy Trust.
- Extraction of the independent variables used in the facility regression model, HDD, CDD, OAT, etc.
- Determining if any baseline adjustments occur in the model.
- Identifying what capital projects are included in the model and extract the associated savings values applicable to the sampled fuel and program year.

6.2.4 Measurement and verification planning

Project specific M&V plans were created using a DNV GL SEM M&V Plan template. M&V Plans focused on documenting the facility being evaluated, its consumption, reported SEM actions, and identified capital projects. The plans were then used as part of the data collection interview process.

6.2.5 Data collection

Data collection was executed per the site M&V plan through an in-depth interview completed on-site or via telephone. The evaluation team completed interviews onsite at 22 project sites and performed phone interviews with the facility personnel at 31 project sites. Eleven sites were dropped because of no response received from the facility contact or the facilities did not have a suitable person who could answer the evaluator’s queries. Through the in-depth interview, DNV GL staff captured information to:

- Verify participation in the program during the sampled program year.
- Verify the actions taken during the sampled program year to reduce energy consumption.
- Determine if the standard modeling approach is sufficient for the site and what changes are required if not.
- Determine what capital improvements or non-SEM activities impacted energy consumption during the sampled program year.
- Identify any operating conditions or changes to the facility that may have affected the energy savings or the validity of the MT&R model. This includes capital projects installed during SEM engagement.
- Identify known seasonal changes in facility use that might prevent modeling using weather only.

- Understand basic occupancy, cooling, heating, process schedules and associated control sequences that should be reflected in consumption data, such as typical start and stop to heating and cooling seasons and use of free cooling.

6.2.6 Measure analysis

DNV GL estimated evaluated savings for 64 measures. The data collected through the interviews was be used to develop an estimate of evaluated savings achieved during the program year. To estimate savings, DNV GL developed independent standard regression models using monthly utility meter data, weather data, and provided or collected data for other independent variables determined to be necessary.

Model development followed Energy Trust's "Commercial O&M Measurement and Verification Guideline For Energy Trust of Oregon's Commercial Strategic Energy Management (SEM) and Pay for Performance (PfP) offerings. Version 1.0 2017" provided in the RFP for this project. Model validity was tested per the Statistical Criteria for Model Fitness.

6.3 SEM track evaluation results

6.3.1 Achieved sample

Table 29 shows the final sample achieved across the entire SEM track. DNV GL estimated evaluated savings for 102% of the measures sampled. The final achieved evaluation sample differed from the sample design due to the following:

- Multiple models combined under one sampled program site: Some oversampling in sample strata was due to the discovery of multiple facilities and models being combined into one program site and CRM#. In these instances, the individual facilities were modeled separately.
- Estimating evaluated savings across both 2015 and 2016 program years: Most oversampling in sample stata was due to estimated evaluated savings for sampled sites across both years, even if they were only sampled for one year.
- Refusals and Non-Responses: Incomplete sample strata were primarily due to those participants that could not be reached after exhausting our phone call protocol, and a small number who refused to participate in the call. Our protocol required calling up to five times at different times of the day. We also tried contacting the participant by email if they did not respond to phone calls.

Table 29: Final SEM track sample summary

Program Year	Year 1 / Continuation	Primary Fuel	Sample Target	Achieved Sample	% Complete
2015	2015 Year 1	Electric	7	10	143%
		Gas	6	5	83%
	Continuation	Electric	7	9	129%
		Gas	7	9	129%
2016	2015 Year 1	Electric	8	8	100%
		Gas	2	2	100%
	2016 Year 1	Electric	6	4	67%
		Gas	3	3	100%
	Continuation	Electric	8	9	113%
		Gas	9	5	56%
Total	Overall		63	64	102%

6.3.2 Evaluated savings

Expansion from the sample to track-level results follows the methodology discussed in Section 2.4. Table 30 shows the overall electric SEM track realization rates by program year. The electric realization rates are driven primarily by the change to baseline models that comply with the modeling guidance document. It is also likely that some of the savings variance is due to the program's use of measurement periods less than 12 months long to estimate annual savings compared to the evaluations program year assignment schedule.

Table 30: SEM track electric impact evaluation results by program year

Tracks by Year	Completed Sample	Gross Realization Rate	Standard Error	Relative Precision at 90 % Confidence	Evaluated Savings (kWh)
SEM-2015	17	89%	0.11	20%	9,216,657
SEM-2016	18	92%	0.24	43%	9,038,775
Overall	35	91%	0.14	25%	18,280,470

Table 31 shows the overall gas SEM track realization rates by program year. The gas realization rates are driven primarily by the same reasons given above for electric savings.

Table 31: SEM track natural gas impact evaluation results by program year

Tracks by Year	Completed Sample	Gross Realization Rate	Standard Error	Relative Precision at 90 % Confidence	Evaluated Savings (therms)
SEM-2015	17	83%	0.21	42%	446,946
SEM-2016	14	113%	0.11	16%	546,458
Overall	31	100%	0.11	18%	1,023,282

6.4 SEM track findings and recommendations

Our evaluation findings and recommendations specific to the SEM track are presented in this section.

- Finding – Participants value energy coaches and peer-to-peer learning. Participants cite benefits from the insights provided by working closely with energy coaches to identify and execute operational and capital improvement opportunities. Participants also commented on perceiving value from the peer-to-peer information exchanges with participants of a similar facility type. These learning exchanges provide participants with practical 'case study' examples to draw upon, as well as benchmarking and competitive motivation across organizations with similar facilities.
  - Recommendation – DNV GL recommends that Energy Trust continue to identify program improvements that allow energy coaches to spend more time working with participant staff to support energy conservation opportunities. Additionally, DNV GL recommends that Energy Trust looks to further support interorganizational learning opportunities, such as is provided by the peer-to-peer learning sessions.
- Finding - Energy Champions & Executive Leadership are key. DNV GL finds that the participant's level of program engagement corresponds to the organizations level of buy-in by executive leadership and level of continuity of energy champion staff. Program participants with lower engagement levels typically have experienced a personnel transition or lack significant authorization and support from their leadership. The corollary is that participants with staff continuity and strong leadership support demonstrate high levels of program engagement. DNV GL finds it challenging to attribute calculated

savings to the influence of the program for participants with low engagement as they generally lacked evidence of significant activity that would drive savings.

- Recommendation – Based on this finding, DNV GL recommends to Energy Trust that participants exhibiting low engagement be classified under an inactive status, and the program not report savings from those participants. Reclassification as an active program participant could occur when the entity demonstrates their willingness to actively engage and support fully participating in the process.

- Finding - The level of activity documentation varies broadly across participants in the program. Through the documentation review and data collection process, DNV GL observes a broad variation in the level of activity documentation in the tracking tool provided by the program. Some participants frequently document activities performed in the tracking tool, while others lack any considerable documentation of SEM-related activities.
  - Recommendation – To address this inconsistency, DNV GL recommends to Energy Trust the following:
    - Consider updating program documentation requirements to necessitate a minimum level of tracked activity to receive incentive payments or continued program enrollment
    - Update documentation requirements to include greater details of activity, especially one-time activities and capital projects
    - Exclude repetitive entries of O&M activities once they have been initiated, instead listing them as an expected ongoing activity unless otherwise noted.
- Finding - Portfolio operators have a large burden. The evaluation team finds that participants with multiple facilities enrolled in the program find updating the MTRs to be a significant time burden, unless each facility update is assigned to a specific team member, which appears uncommon.
  - Recommendation – To reduce this obstacle, DNV GL suggests Energy Trust help facilitate identification of opportunities to track activities at the participant level, instead of only at the individual facility level.
- Finding - Many model baselines have or will soon expire. DNV GL observes that many enrolled facilities have baseline measurement periods that have already or will soon elapse the five-year baseline term stated in the program guidelines. Additionally, many facilities are using non-standard 'baseline adjustments.'
  - Recommendation - The evaluation team recommends updating expired baseline measurement periods ahead of the 2019 program year, if this is not already being performed. This will have the added benefit of reducing the quantity of older models that do not conform to the current modeling guidelines (e.g. do not use degree days) as well as eliminate complication from legacy capital projects.
- Finding - Measurement periods are inconsistent. The evaluation team observes inconsistency in measurement periods across participating facilities. While the measurement periods generally span from the Fall to the following Fall, the initial and final measurement months are not consistent across the program. This creates complications and uncertainty in assessing annual savings values for both the program and the evaluation teams.
  - Recommendation - To address this issue, DNV GL recommends that Energy Trust creates a measurement schedule for current and future participants that defines when each year's period will start and stop, use this schedule across the program, and thoroughly document justifications for any deviations from the schedule that are deemed necessary.

APPENDIX A. EVALUATION SAMPLE DESIGN MEMO

Memo to:		Memo No.:	002
Sarah Castor, Energy Trust of Oregon		From:	Andrew Wood, DNV GL
		Date:	6/25/2018
Copied to:		Prep. by:	Andrew Wood, DNV GL
Jennifer Barnes, DNV GL			Ben Jones, DNV GL

Commercial Existing Buildings Impact Evaluation Sampling Plan

This memorandum summarizes DNV GL's proposed sampling plan for the impact evaluation of the Energy Trust of Oregon's Commercial Existing Buildings program.

Evaluation objectives

Existing buildings program actions may target a site's electricity consumption, natural gas consumption, or both. The objectives of this evaluation considered in the development of this sampling plan are:

- Estimate achieved gas and electric savings for PY2015 and PY2016
- Develop separate gas and electric realization rates for PY2015 and PY2016 to be used for program true-up.
- Develop separate gas and electric realization rates for PY2015 and PY2016 SEM savings
- Develop separate gas and electric realization rates for PY2015 and PY2016 Non-SEM savings
- Develop separate gas and electric realization rates for future program planning.
- Provide Energy Trust with feedback on participants' experience with installed Tubular LEDs (TLED).

Sample Summary

This proposed sample is summarized in the two tables below. DNV GL believes the proposed sample and expected relative precision values are reasonable for this program and the results will achieve the study's objectives. In general, 20% - 25% of the savings installed will be directly evaluated based on this sample. The expected relative precision values are based on error ratios determined in previous Energy Trust studies of the same program.

Table 32: Sample summary

		2015				2016			
Measure Type	Fuel	% of Reported Savings in Draft Sample	N Frame	n Sample	Relative Precision (@ 90% CI)	% of Reported Savings in Draft Sample	N Frame	n Sample	Relative Precision (@ 90% CI)
Capital (Non-SEM)	Electric	21%	3851	124	10%	19%	4455	128	9%
	Gas	23%	676	52	14%	28%	727	59	12%
SEM	Electric	28%	89	20	17%	45%	135	28	20%
	Gas	23%	50	15	19%	22%	69	17	18%
ALL (Capital + SEM)	Electric	22%	3940	144	9%	21%	4590	156	9%
	Gas	23%	726	67	11%	26%	796	76	10%

Sample frame

Energy Trust provided DNV GL with the file "Measures 2015 2016 v2.xlsx" on 05/23/2017 which shows energy efficiency measures completed during PY2015 and PY2016 through the Existing Buildings program. All pilot initiative measures were removed from the dataset by Energy Trust. The information in this file is considered the sample frame for this study and the savings listed under "working kWh" and "working therms" are considered the gross site-level savings reported by the program.

DNV GL reviewed the sample frame file to confirm consistent measure classification. We made one change to the data with Energy Trust's approval. Project P00001123990 was listed as Custom, but the measure description, incentive and savings recorded matched the Standard Gas Fryer values. DNV GL changed the measure track classification to Standard.

Tubular LEDs (TLEDs) are a key measure of interest for this study. DNV GL identified all TLED measures installed through the program based on a measure code list provided by Energy Trust. The table below summarizes the program achievements shown in the tracking data.

Table 33: Sample frame summary by year and fuel

Measure of Interest	Program	Unique Measure Lines		Working kWh		Working therms	
	track	2015	2016	2015	2016	2015	2016
Capital, TLEDs	Lighting	454	747	5,664,100	11,435,282		
	Direct Install	376	1,090	546,264	2,909,654		
	Subtotal	830	1,837	6,210,364	14,344,936		
Capital, Non-TLED	Lighting	4,601	4,452	45,933,384	46,826,692		
	Direct Install	2,535	960	3,574,306	1,706,183		
	Street Lighting	10	19	10,441,498	14,800,195		
	Custom	263	252	26,045,331	25,840,900	789,124	654,306
	Standard	1,393	1,461	6,515,821	10,590,409	559,703	753,615
	Subtotal	8,802	7,144	92,510,340	99,764,379	1,348,827	1,407,921
Capital Total		9,632	8,981	98,720,704	114,109,315	1,348,827	1,407,921
SEM	SEM Cohort	114	168	10,330,780	9,806,709	539,194	481,771
Grand Total		9,746	9,149	109,051,484	123,916,024	1,888,021	1,889,692

DNV GL converted the "working kWh" and "working therms" in the tracking file to "site btu's". This conversion creates a single savings value to simplify stratification and the calculation of evaluation result weights. All aggregated evaluation results will be presented in kWh and therms. Only sampled electric measures will contribute to kWh results and only sampled gas measures will contribute to gas results. Tables in the appendix summarize the population.

kwh_btu = 3412 * working_kwh

therms_btu = 99,976 * working_therms

Table 34: Sample frame summary by mmbtu and year

Measure of Interest	Program track	Unique Measure Lines 2015	Unique Measure Lines 2016	Sum of mmbtu 2015	Sum of mmbtu 2016
TLEDs	Lighting	454	747	19,327	39,019
	Direct Install	376	1,090	1,864	9,928
	Subtotal	830	1,837	21,191	48,947
Non-TLED Capital	Lighting	4,601	4,452	156,731	159,779
	Direct Install	2,535	960	12,196	5,822
	Street Lighting	10	19	35,628	50,500
	Custom	263	252	167,764	153,588
	Standard	1,393	1,461	78,190	111,479
	Subtotal	8,802	7,144	450,509	481,168
Capital Total		9,632	8,981	471,699	530,115
SEM	SEM Cohort	114	168	89,157	81,627
Grand Total		9,746	9,149	560,856	611,743

Sampling Unit, Unit of Analysis

Measures were initially classified into the six program tracks listed below. The sampling unit will vary based on the track the project was completed under. The sampling unit recommendations are based on DNV GL's review of the program tracking data, specifically what types of measures are typically classified by project and site once initial track classifications are completed. Reported savings will be aggregated at the sampling unit level before size stratification and sample selection.

- Custom – The sampling unit is the Project ID.
- TLED Lighting – The sampling unit is the Project ID
- Street Lighting – The sampling unit is the Project ID
- Direct Install – The sampling unit is the Project ID
- Standard Lighting – The sampling unit is the Project ID
- Standard Non-Lighting – The sampling unit is the Measure ID
- SEM – The sampling unit is the CRM Site Number

Stratification

Stratification is an important and commonly used design feature in most data collection efforts. Stratification refers to the process of partitioning the sample frame into distinct domains (or strata) and sampling is done independently within each domain. Stratification is often used to (1) improve precision of the final estimates and (2) control the sample size by subgroups of interest during the analysis. Precision is improved if strata are formed so that the population is relatively homogeneous within each stratum and relatively heterogeneous between strata.

Studies that involve analyzing data that could be highly variable between units often benefit by creating what is referred to as a certainty stratum. In this case projects or measures with the highest savings were placed in this stratum. This stratum is referred to as "certainty" because all frame units are selected for the data collection effort from this stratum. So the sampling variance associated with estimates created from this stratum is zero (since a census is being taken). A certainty stratum is suggested for this study. For this study, the sample will be selected independently within domains defined by the following:

- Program Year: 2015 and 2016.
- Fuel: Electric and Gas classifications were used throughout the design. If an aggregated sampling unit saved both electric and gas, then the fuel classification was based on which fuel provided the majority of the site btu savings.
- Measure of Interest: Capital TLED Measures, Capital non-TLED Measures, SEM Measures
- Program Track: Custom, Lighting, Standard Non-Lighting, and SEM.
- Program Sub-Category: Additional categorization was used within tracks.
    - Within lighting, the following sub-categories were used: Street Lighting, Direct Install, Standard Lighting .
    - Standard Non-Lighting was further categorized into Food Equipment and Non-Food Equipment.
    - SEM was further categorized into SEM Year 1 and SEM Continuation.
- Measure Type or Project Savings: Additional fuel specific, measure specific, location, and size stratification was used within each track to minimize the expected relative precision, ensure sample representation, and align with the evaluation's objectives.
- Certainty: 26 projects were selected at certainty.

Sample Allocation to Strata

After the strata are formed, the next step was to allocate the sample of respondents to each stratum. The final sample allocation, the number of sites and the number of customers by stratum are presented in tables in the appendix.

Table 35: Stratification summary

Year	Track	Technology	Type / Primary Fuel	Size	N	n	Working kWh	Working therms
2015	Lighting	TLED	Remote Driver	1	119	6	906,041	0
				2	55	5	1,072,603	0
				3	25	5	1,348,243	0
				Certainty	1	1	462,094	0
			Existing Fluorescent Ballast	1	31	3	673,801	0
			At Line Voltage	1	46	5	390,750	0
			New T8 Ballast	1	38	3	232,457	0
			Multiple/Unknown TLED Types	1	71	7	915,297	0
		Non-TLED	Direct Install	1	338	4	3,783,384	0
			Standard	1	1772	4	17,645,674	0
				2	268	4	28,287,710	0
		Street Lighting	Portland	1	4	1	6,853,130	0
			Non-Portland	1	6	1	3,588,368	0
	Custom		Electric	1	103	9	3,928,900	297
				2	24	8	5,099,391	15,214
				3	11	8	6,050,901	18,118
				Certainty	5	5	7,731,694	15,906
			Gas	1	71	5	1,031,236	314,700
				2	15	5	2,203,209	424,889
	Standard Non-Lighting	Food	Electric	1	147	5	175,243	0
				2	36	4	236,616	0
				3	23	4	283,247	0
			Gas	1	213	8	65,178	106,219
				2	173	7	109,546	110,697
				3	90	7	91,630	132,976
		Non Food	Electric	1	508	8	1,179,546	9
				2	83	7	1,601,226	0
				3	27	7	2,244,311	0
			Gas	1	72	5	6,870	54,374
				2	13	4	209,172	68,178
				3	8	4	313,236	87,250
	SEM	2015 Year 1	Electric	1	34	6	4,170,512	12,044
				Certainty	1	1	1,180,595	17,269
			Gas	1	11	3	455,375	40,656
				Certainty	3	3	854,735	134,983
		Continuation	Electric	1	33	6	2,259,119	1,038
				Certainty	1	1	539,961	0
			Gas	1	28	6	870,483	265,691
				Certainty	1	1	0	67,513

Year	Track	Technology	Type / Primary Fuel	Size	N	n	Working kWh	Working therms
2016	Lighting	TLED	Remote Driver	1	31	2	1,429,698	0
			Existing Fluorescent Ballast	1	147	5	3,790,378	0
			At Line Voltage	1	295	6	1,230,752	0
				2	93	5	1,568,025	0
				3	28	5	2,300,705	0
			New T8 Ballast	1	190	4	596,786	0
				2	29	4	986,765	0
			Multiple/Unknown TLED Types	1	81	4	1,024,821	0
		Non-TLED	Direct Install	1	526	6	3,123,189	0
			Standard	1	1698	4	17,797,861	0
				2	235	4	29,028,831	0
		Street Lighting	Portland	1	4	1	13,747,190	0
			Non-Portland	1	14	1	1,053,005	0
	Custom		Electric	1	120	9	4,349,202	7,264
				2	21	9	5,151,111	36,494
				3	13	9	6,931,649	37,649
				Certainty	3	3	4,181,486	24,572
			Gas	1	45	5	1,205,065	203,818
				2	10	4	2,623,070	283,370
				Certainty	1	1	1,399,317	61,139
	Standard Non-Lighting	Food	Electric	1	150	6	230,090	0
				2	36	6	332,494	0
			Gas	1	221	9	48,240	109,869
				2	174	8	89,595	115,229
				3	95	8	77,886	137,611
		Non Food	Electric	1	531	7	1,851,790	0
				2	86	7	2,444,921	0
				3	19	7	3,807,350	0
			Gas	1	116	5	215,087	105,307
				2	21	5	772,920	131,733
				3	12	4	720,036	153,866
	SEM	2015 Year 1	Electric	1	11	3	256,554	742
				Certainty	3	3	463,291	0
				Certainty	2	2	517,076	10,219
			Gas	1	6	1	135,770	16,000
				Certainty	1	1	0	42,228
		2016 Year 1	Electric	1	38	6	2,142,993	2,863
			Gas	1	23	3	1,297,447	118,024
		Continuation	Electric	1	47	4	1,703,319	815
				2	8	4	2,749,688	1,379
			Gas	1	23	3	54,657	49,901
				Certainty	3	3	225,549	71,807
				Certainty	3	3	260,365	167,793

Sample Selection

Within each non-certainty strata, the measures or projects included in the evaluation were selected at random by assigning a random number to the sampling unit and sorting each strata by this random number. Back-up sample points were also selected using these sorted lists.

Expected Precision

DNV GL used the error ratios reported in the recent 2013/14 Existing Buildings and SEM evaluations with small adjustments.[23] Table 36 shows the error ratios assumed.

Table 36: Assumed error ratios

Track	Groups	ER Assumed
Lighting	TLED	0.45
	Non-TLED	0.29
	Street Lighting	0.10
Custom		0.55
Standard		0.56
SEM		0.44

Table 37 and Table 38 summarize the sample design and expected relative precision for various groups of interest. The anticipated relative precision estimates are based on error ratios and results reported in the recent 2013/14 Existing Buildings and SEM evaluations and the distribution of savings within each stratum. All "N" and "n" values are counts of the unique sampling units within each group. Note, of the 70 TLED projects sampled, 13 are Direct Install and 57 are Standard. The total number of Direct Installed projects proposed to be evaluated is 23 when TLED and Non-TLED projects are combined.

Table 37: Expected mmBtu Precision by Track

	2015				2016			
Program Track	MMBTU	N	n	Relative Precision (@ 90% CI)	MMBTU	N	n	Relative Precision (@ 90% CI)
Lighting - Street Lighting	35,626	10	2	15%	50,498	18	2	14%
Lighting - TLED	20,476	386	35	17%	44,110	894	35	25%
Lighting - Non-TLED	169,634	2378	12	20%	170,429	2459	14	20%
Lighting - Total	225,736	2774	49	15%	265,037	3371	51	14%
Custom - Total	167,760	229	40	14%	153,584	213	40	13%
Standard Non-Lighting - Food	38,261	682	35	20%	38,918	676	37	19%
Standard Non-Lighting - Non-Food	39,928	711	35	18%	72,560	785	35	19%
Standard Non-Lighting - Total	78,189	1393	70	13%	111,478	1461	72	14%
SEM - Total	89,155	112	27	16%	81,626	168	36	14%
Grand Total	560,840	4508	186	8%	611,725	5213	199	8%

[23] We increased the TLED error ratio above that of other standard lighting (to 0.45, from 0.35) to reflect a higher uncertainty for the newer technologies and reduced the gas ER for the Standard track (to 0.60 from 0.70) as the ER found was higher than we have seen elsewhere and was based on a unusual small sample size (n=5).

Table 38: Expected Precision Summary, by program code

Measure Type	Fuel	2015 % of Reported Savings in Draft Sample	2015 N	2015 n	2015 Relative Precision (@ 90% CI)	2016 % of Reported Savings in Draft Sample	2016 N	2016 n	2016 Relative Precision (@ 90% CI)
Capital (Non-SEM)	Electric	21%	3851	124	10%	19%	4455	128	9%
	Gas	23%	676	52	14%	28%	727	59	12%
SEM	Electric	28%	89	20	17%	45%	135	28	20%
	Gas	23%	50	15	19%	22%	69	17	18%
ALL	Electric	22%	3940	144	9%	21%	4590	156	9%
	Gas	23%	726	67	11%	26%	796	76	10%

TLEDs

Unique sampling domains were created for the different types of TLEDs being installed through the program. Creation of these domains ensures that feedback is collected on all technology types. If the program data showed that a project installed multiple TLED types or if the TLED is unknown, then the project was classified into the Multiple/Unknown category. This category ensures that all TLED projects have a potential for selection. The table below shows the reported savings, population (N), and sampled size (n) by year and TLED type. The table also shows the TLED sample by the two program tracks installing this technology.

Table 39: TLED sample summary

TLED TYPE	2015			2016		
	Working kWh	N	n	Working kWh	N	n
Remote Driver	3,788,981	200	17	1,429,698	31	2
New T8 Ballast	232,457	38	3	1,583,551	219	8
Existing Fluorescent Ballast	673,801	31	3	3,790,378	147	5
At Line Voltage	390,750	46	5	5,099,482	416	16
Multiple/Unknown TLED Types	915,297	71	7	1,024,821	81	4
Grand Total	6,001,286	386	35	12,927,930	894	35
Direct Install TLED	337,186	34	3	1,492,648	176	10
Standard Lighting TLED	5,664,100	333	32	11,435,282	610	25

APPENDIX B. TLED INTERVIEW GUIDE

Energy Trust of Oregon 2017 Tubular LEDs (TLED) Telephone Interview

Final:10/9/2017

Key Research Questions

The interview will capture information on participants' operations, controls, and satisfaction with rebated TLED products. The table below links the key research questions for this effort to the specific interview questions that address them.

Topic	Research Question	Relevant Interview Question(s)
General Performance	Are the TLEDs installed through the program in 2015 and 2016 operating well? Are participants satisfied with their performance?	P1, P1A, W1, W1A
	Are there any differences in satisfaction by TLED installation type (at line voltage, with existing or new ballast, etc.), space use or customer type?	N/A[1]
	Are participants experiencing any issues with TLEDs, like buzzing, flickering, early failure, etc.?	P2, P2A, P3, P4, P4A, P4B, P5, P5A, P5B, P6, P6A, P7, P8
	[For participants who changed the quantity and/or placement of lighting fixtures] Are participants satisfied with their overall lighting system design?	P9, P9A, P9B, P10, P10A
Removal and Replacement	Have any participants removed any of the rebated TLEDs installed in 2015 and 2016?	R1, R2
	[If participant removed any rebated TLEDs] When did participants remove the rebated TLEDs?	R3
	[If participant removed any TLEDs] Why did they remove the rebated TLEDs?	R4A, R4B
	[If participant removed any TLEDs] With what type of lighting did participants replace the rebated TLEDs?	R5, R5A
Controls	What control strategies are being used with TLEDs?	C1
	[For participants who installed TLED products and controls[2]] Did these controls receive incentives from the EB program? If not, why not?	C2, C2A
	[For participants who installed TLED products and controls[2]] Were the controls installed before, at the same time as, or after the TLEDs were installed?	C3
	[For participants who installed TLED products and controls[2]] Are participants satisfied with how the controls are operating, or are there issues to be addressed?	C4, C4A
	Do participants intend to install new or additional controls for their TLEDs within the next 12 months? If so, what type(s)?	C5, C5A
Decision-making[3]	Was interview participant involved in decision to install the rebated TLEDs?	D1
	Did participant consider other TLED types in addition to the rebated type(s)?	D2, D2A
	What motivated participant to install the specific type(s) of rebated TLEDs (A, B, C)?	D3A, D3B, D3C

[1] Installation type and customer type are tracking data variables, and the verification interview will determine space usage. DNV GL will compare interview results regarding satisfaction by each of these variables.
[2] Note that "controls" in this context refers to any control type other than an on/off switch.
[3] Note that research questions regarding decision-making are not in the original scope of work for this study, but we added questions on this topic for instances in which the interview respondent is the decision-maker—i.e., we will not attempt to find a separate contact to address these questions.

Database Variable Definitions

Variable Name	Definition[1]
Customer_Name	Respondent contact name
Installeddt	Date on which equipment was installed
Measuredesc	Measure name (brief description)
Program	Terms the program the contact is likely to recognize Most likely: "Energy Trust Incentives" Also: "Energy Trust Existing Buildings" For Direct Install: "Small Business Energy Savings" or "SmartWatt". SmartWatt is the Direct Install contractor.
Site_Address	Equipment installation address

[1] Unless otherwise noted, the database can contain more than one value for each variable for each respondent.

Instructions to Interviewers

- Do not read response options unless instructed to do so in questionnaire (["READ LIST"]). Never read response options for don't know (98) or refused (99).
- If more than one TLED installation type occurred at the site, prioritize the type with higher reported savings in the instructions regarding which measure(s) should be the focus of the interview.
- Responses must be recorded in Excel response file.
- Commence interviewing once you have identified the appropriate respondent. This should be someone familiar with the rebated equipment and its operation.
- Prioritize your impact questions. Then complete this interview. If respondent asks how much time, estimate 15 extra minutes.
- If asked what the purpose of the interview is, state something like:
    - "Linear of Tube LEDs are being installed and incentive more and more. Energy Trust wants to know if participants like you are satisfied with the technology, if you've had any issues, and understand more about how you are controlling the lights."
- If asked, have others had issues:
    - "I am not aware of issues. Asking you questions today is part of Energy Trust's effort to make sure there aren't issues"

Technology Information for Interviewers

Name	Definition
TLEDS Drivers	Tubular (or Troffer) Light Emitting Diode (TLED)s A "driver" is used when the FL lamp and ballast are removed (type C lamps)
TLED Type A lamp	Retrofitted to existing fixtures. These types of tubes replace T12, T8, and T5 lamps and operate using an internal driver that is powered directly from an existing linear fluorescent ballast. Type A installations do not require any modifications to the existing fixture and many people refer to this type of lamp as 'plug-and-play.' Type A tubes have reduced efficiency due to power loss from the existing ballast and limited dimming and controllability capabilities.
TLED Type B lamp	Wired directly to the line voltage. These types of tubes operate using an internal driver and are powered directly from the main voltage that is supplying the fixture. The existing fixture must be modified for these tubes, fixture, which has led to calling this type of lamp as 'ballast bypass.' These lamps require installation by a certified electrician and have limited dimming and controllability capabilities.
TLED Type C lamp	Supplied with dedicated LED drivers. These types of tubes operate using a remote driver, which replaces the existing fixture's ballast. These types of tubes require modifying the existing fixture, but the power being directed to the sockets are low-voltage, not AC Mains. Type C tubes are more efficient than the other types.
Links for more info:	http://cltc.ucdavis.edu/sites/default/files/files/publication/LED_Retrofit_Options_Linear_Fluorescent_FINAL.pdf https://www.energytrust.org/wp-content/uploads/2017/05/EB_FS_TLED.pdf http://www.lutron.com/TechnicalDocumentLibrary/TLED_Lighting_Scenarios_for_Retro_App_Whitepaper.pdf

Introduction

I'd like to ask you a few questions regarding the TLED lighting equipment that was rebated through the <Program> program on or around <Installeddt>.

General Performance

P1. On a scale of 1 to 5 where 1 means "not at all satisfied" and 5 means "very satisfied," how satisfied are you with the general performance of the <Measuredesc>?

1	1 – not at all satisfied
2	2
3	3
4	4
5	5 – very satisfied
98	Don't know
99	Refused

P1A. [IF SATISFACTION IS NOT LOW (IF P1 ≠ 1, 2, OR 3), SKIP TO P2] Why do you say that? [IF NECESSARY: What could be improved?]

[RECORD VERBATIM RESPONSE]

P2. Since installing <Measuredesc> have you observed any performance issues such as buzzing, flickering while dimming, or any light quality issues?

1	Yes
2	No
98	Don't know
99	Refused

P2A. [IF NO PERFORMANCE ISSUES (IF P2 ≠ 1), SKIP TO P9] What performance issues have you observed? [ACCEPT MULTIPLE RESPONSES]

1	Buzzing
2	Flickering
3	Poor dimming
4	Incompatibility with dimming controls
5	Poor/low light level
6	Poor light quality
7	Fixture failure
8	Ballast failure
9	Lamp failure (burned out)
10	Failure (unspecified)
97	Other [SPECIFY]
98	Don't know
99	Refused

[IF SATISFACTION IS NOT LOW (IF P1 ≠ 1, 2, OR 3) AND NO PERFORMANCE ISSUES (P2 ≠ 1), SKIP TO P6 for Type B, P9 for Type A and C]

[IF <Measuredesc> ≠ TYPE A FIXTURE, SKIP TO P6 for Type B, P9 for Type A and C]]

Type A Questions Only

P3. Did an electrician or contractor inspect any of the ballasts for any of the rebated TLED fixtures where your satisfaction was low or you experienced poor performance?

1 Yes
2 No
98 Don't know
99 Refused

P4. Did an electrician or contractor replace any of the ballasts for any of the rebated TLED fixtures where your satisfaction was low or you experienced poor performance?

1 Yes
2 No
98 Don't know
99 Refused

P4A. [IF ELECTRICIAN OR CONTRACTOR DID NOT REPLACE BALLASTS (P4 ≠ 1) SKIP TO P5] Did replacing the ballast(s) correct the performance issues?

1 Yes
2 No
98 Don't know
99 Refused

P4B. [IF BALLAST REPLACEMENT FIXED THE ISSUE (P4A = 1), SKIP TO P5] What was the problem after the electrician or contractor replaced the ballast(s)?

[RECORD VERBATIM RESPONSE]

P5. Did your electrician or contractor tell you anything regarding what to expect about ballast performance?

1 Yes
2 No
98 Don't know
99 Refused

P5A. [IF ELECTRICIAN OR CONTRACTOR DID NOT SAY ANYTHING ABOUT BALLAST PERFORMANCE (P5 ≠ 1) SKIP TO P5B] What did the electrician or contractor say about ballast performance?

[RECORD VERBATIM RESPONSE]

P5B. [IF P5A RESPONSE MENTIONS EARLY FAILURE, SKIP TO P6] Did your electrician or contractor tell you that the ballasts may fail before the lamps fail or burn out?

1 Yes
2 No
98 Don't know
99 Refused
99 Refused

[IF <Measuredesc> ≠ TYPE B, SKIP TO P9]

Type B Questions Only

P6. Did your electrician or contractor mention anything about safety when he or she installed the rebated TLEDs? [IF NECESSARY, SPECIFY TYPE B TLED]

1 Yes
2 No
98 Don't know
99 Refused

P6A. [IF ELECTRICIAN OR CONTRACTOR DID NOT MENTION SAFETY (P6 ≠ 1), SKIP TO P7] What did your electrician or contractor mention about safety?

[RECORD VERBATIM RESPONSE]

P7. [IF P6A RESPONSE DOES NOT MENTION HIGH VOLTAGE WIRING] Did your electrician or contractor mention the potential shock hazard that may exist with the type of rebated TLEDs you installed? [IF NECESSARY, SPECIFY TYPE B TLED]

1 Yes
2 No
98 Don't know
99 Refused

P8. Are there any safety labels on the rebated TLED fixtures?

1 Yes
2 No
98 Don't know

If respondent is unaware of safety concerns, shock hazard, or does not have safety labels, notify Data Collection Lead and Project Manager after the interview. Inform respondent that we will notify Energy Trust so they can follow up.

All Types Questions

P9. When the rebated <Measuredesc> were installed, did you change the quantity or placement of the lighting fixtures?

1 Yes, changed quantity of fixtures
2 Yes, changed placement of fixtures
3 Yes, changed quantity and placement of fixtures
4 No
98 Don't know
99 Refused

P10. [IF NO CHANGE TO QUANTITY/PLACEMENT (P9 ≠ 1, 2, or 3), SKIP TO R1] On a scale of 1 to 5 where 1 means "not at all satisfied" and 5 means "very satisfied," how satisfied are you with the overall design of your new lighting system?

1 1 – not at all satisfied
2 2
3 3
4 4
5 5 – very satisfied
98 Don't know
99 Refused

P10A. [IF SATISFACTION IS NOT LOW (P10 ≠ 1, 2, or 3), SKIP TO R1] Why do you say that? [IF NECESSARY: What could be improved?]
[RECORD VERBATIM RESPONSE]

Since Installation, Removal and Replacement (All Types)

R1. Since installing the TLED lighting equipment, have you removed any of the rebated TLED fixtures or bulbs?

1 Yes, removed bulbs
2 Yes, removed fixtures
3 Yes, removed fixtures and bulbs
4 No
98 Don't know
99 Refused

R2. [IF DID NOT REMOVE ANY TLEDs (R1 ≠ 1, 2, OR 3), SKIP TO C1] In total, how many did you remove?
[RECORD QUANTITY OF PROGRAM-DISCOUNTED FIXTURES]
[RECORD TOTAL QUANTITY OF PROGRAM-DISCOUNTED BULBS]

R3. In what month and year did you remove them?
[RECORD MONTH AND YEAR FOR FIXTURES]
[RECORD MONTH AND YEAR FOR BULBS]

R4A. [IF DID NOT REMOVE ANY FIXTURES (R1 ≠ 2 OR 3), SKIP TO R4B] Why did you remove the rebated fixtures?

1 Flickering
2 Poor dimming
3 Incompatibility with dimming controls
4 Poor/low light level
5 Poor light quality
6 Fixture failure
7 Ballast failure
97 Other [SPECIFY]
98 Don't know
99 Refused

R4B. [IF DID NOT REMOVE ANY BULBS (R1 ≠ 1 OR 3), SKIP TO R5] Why did you remove the rebated bulbs?

0 Because I removed the fixtures
1 Flickering
2 Poor dimming
3 Incompatibility with dimming controls
4 Poor/low light level
5 Poor light quality
6 Fixture failure
7 Ballast failure
8 Lamp failure (burned out)

97 Other [SPECIFY]
98 Don't know
99 Refused

R5. Did you replace the rebated TLED lighting you removed?
1 Yes
2 No
98 Don't know
99 Refused

R5a. [IF DID NOT REPLACE (R5 ≠ 1), SKIP TO C1] What type of lighting did you use to replace the rebated TLEDs? [ACCEPT MULTIPLE RESPONSES]
1 New/different TLEDs
2 LEDs
3 Linear fluorescent
4 Compact fluorescent
5 Incandescent
6 Halogen
97 Other [SPECIFY]
98 Don't know
99 Refused

Controls (All Types)

Next I would like to ask a few questions about the lighting controls you use for the for the TLED fixtures in your facility. I'd like to talk about <u>ALL</u> the controls you have associated with TLEDs in your facility, not just the rebated TLEDs.

C1. I'd like to read you a short list of control types. Can you tell me which of these you use to control the TLED fixtures in your facility? If you're not familiar with something I mention, it's no problem. [READ LIST]
1 On/off switch
2 Dimmer switch
3 Photosensor or photocell
4 Occupancy sensor
5 Daylighting controls
6 Energy Management System
7 Timer
97 Something else? [SPECIFY]
98 [DO NOT READ] Don't know
99 [DO NOT READ] Refused

C2. [IF ONLY CONTROL IS ON/OFF SWITCH (C1 = 1 ONLY), SKIP TO C5] Did you receive incentives for these TLED controls through <Program>?
1 Yes
2 No
98 Don't know
99 Refused

C2A. [IF YES, D/K, or Refused, SKIP TO C3] Why did you not receive an incentive?
[RECORD VERBATIM RESPONSE]

C3. Did you install the TLED controls before, at the same time as, or after you installed the rebated TLEDs?

1	Before
2	Same time
3	After
98	Don't know
99	Refused

C4. On a scale of 1 to 5 where 1 means "not at all satisfied" and 5 means "very satisfied," how satisfied are you with the performance of your controls for the TLEDs?

1	1 – not at all satisfied
2	2
3	3
4	4
5	5 – very satisfied
98	Don't know
99	Refused

C4A. [IF SATISFACTION IS NOT LOW (IF C4 ≠ 1, 2, OR 3), SKIP TO C5] Why do you say that? [IF NECESSARY: What could be improved?]

[RECORD VERBATIM RESPONSE]

C5.

1	Yes
2	No
98	Don't know
99	Refused

C5A. [IF NO PLANS TO INSTALL CONTROLS (IF C5 ≠ 1), SKIP TO D1] What type(s) of controls do you plan to install [within the next 12 months to control your TLEDs]?

1	On/off switch
2	Dimmer switch
3	Photosensor or photocell
4	Occupancy sensor
5	Daylighting controls
6	Energy Management System
7	Timer
97	Other [SPECIFY]
98	Don't know
99	Refused

Decision-Making

D1. Did you have any role in the decision to install the rebated TLEDs?

1 Yes
2 No
98 Don't know
99 Refused

[IF NO ROLE IN DECISION (IF D1 ≠ 1), SKIP TO D3A]
[IF INSTALLED MULTIPLE TYPES OF TLEDS (TYPE A, B, C), SKIP TO D3A]

D2. Did you consider any other types of TLEDs in addition to the rebated TLEDs?

1 Yes
2 No
98 Don't know
99 Refused

D2A. [IF DID NOT CONSIDER OTHERS (IF D1 ≠ 1), SKIP TO D3A] What type or types did you consider? [ACCEPT MULTIPLE RESPONSES]

1 Type A
2 Type B
3 Type C
97 Other [SPECIFY]
98 Don't know
99 Refused

D3A. [IF <Measuredesc> ≠ TYPE A, SKIP TO D3B] What motivated you to select Type A TLEDs? [ACCEPT MULTIPLE RESPONSES]

1 Recommendation from electrician or contractor/electrician or contractor
2 Low first cost
3 Low lifetime/lifecycle cost
4 Ease to install
5 Building limitations/requirements
6 Compatibility with existing light fixtures
7 Compatibility with existing lighting controls
97 Other [SPECIFY]
98 Don't know
99 Refused

D3B. [IF <Measuredesc> ≠ TYPE B, SKIP TO D3C] What motivated you to select Type B TLEDs? [ACCEPT MULTIPLE RESPONSES]

1 Recommendation from electrician or contractor/electrician or contractor
2 Low first cost
3 Low lifetime/lifecycle cost
4 Ease to install
5 Building limitations/requirements
6 Compatibility with existing light fixtures
7 Compatibility with existing lighting controls
97 Other [SPECIFY]
98 Don't know
99 Refused

D3C. [IF <Measuredesc> ≠ TYPE C, SKIP TO W1] What motivated you to select Type C TLEDs? [ACCEPT MULTIPLE RESPONSES]

1 Recommendation from electrician or contractor/electrician or contractor
2 Low first cost
3 Low lifetime/lifecycle cost
4 Ease to install
5 Building limitations/requirements
6 Compatibility with existing light fixtures
7 Compatibility with existing lighting controls
97 Other [SPECIFY]
98 Don't know
99 Refused

Wrap-Up

W1. On a scale of 1 to 5 where 1 means "not at all likely" and 5 means "very likely," how likely would you be to recommend TLEDs like the ones you received rebates for to another business owner?

1 1 – not at all likely
2 2
3 3
4 4
5 5 – very likely
98 Don't know
99 Refused

W1A. [IF LIKELIHOOD IS <u>NOT</u> LOW (IF W1 ≠ 1, 2, OR 3), SKIP TO W2] Why do you say that? [IF NECESSARY: Why would you be unlikely to recommend TLEDs to another business owner?]
[RECORD VERBATIM RESPONSE]

W2. Energy Trust is currently working on new web based tools to help businesses in the state. Can Energy Trust contact you directly to get feedback on the tools they are developing?

1 Yes
2 No
98 Don't know
99 Refused

Those are all the question I have for you today. Thank you for your time.

APPENDIX C. SEM ANALYSIS METHODOLOGY

This appendix presents the methods used in this evaluation to develop gross savings, followed by a discussion of the results.

The gross savings analysis relied on statistical energy consumption modeling using available historic energy consumption, weather data, and non-weather dependent variables expected to influence consumption at a sampled site. DNV GL primarily copied monthly facility energy consumption from the MT&R files for the analysis. In some cases, Energy Trust provided the monthly consumption directly.

DNV GL applied one methodology to develop savings estimates for comparison with the claimed program achievements. DNV GL followed version 1.0 of Energy Trust's Commercial O&M Measurement and Verification Guideline For Energy Trust of Oregon's Commercial Strategic Energy Management (SEM) and Pay for Performance (PfP) offerings. This guideline was provided in Energy Trust's request for proposal. This methodology primarily utilizes degree day calculations to estimate baseline building performance during the program measurement period.

Modeling background

Modeling criteria

DNV GL considers statistical criteria and the appropriateness of the model when developing models for use in evaluation. In general, the strength of a model follows from its ability to tell a concise, consistent, and compelling story.

- *Concise* models are able to explain the appropriate amount of variation in the dependent variable under conditions experienced most frequently. There can be a large amount of variation in factors outside of weather that drive energy consumption. The intent of the energy consumption model is to best explain energy consumption as a function of weather and other predictor variables when those values are in the most common regions of their respective ranges.
- *Consistent* models have coefficient values with logical relationships. For example, a model should typically yield higher estimates of energy consumption as weather conditions become extreme or building occupancy or activity levels increase.
- *Compelling* models have a strong statistical fit. The probability that the coefficients are different than zero should generally be greater than 90%. Further, the overall model should account for a large amount of the observed variation in energy consumption. The adjusted R-squared statistic captures how much variation in the dependent variable (energy consumption) the model explains. Values greater than 0.8 denote a very strong statistical fit. Models that have an adjusted R-squared less than 0.5 are unable to explain half the variation in energy consumption.

To assess whether the models are consistent and concise, DNV GL assessed the available data on the drivers of energy consumption at SEM sites. Often, we did not have sufficient visibility into the energy drivers to assess if the models were well defined. For example, hospitals likely have factors other than weather that drive energy consumption. However, we did consider if the models made sense overall, adapting appropriately to the known variables:

- Was energy consumption predicted to change appropriately in response to the weather conditions?
- Were the predicted savings reasonable for the actions and measures implemented?

Modeling vs. Fitting

One significant risk in statistical modeling is the trap of "over-fitting" to the available data when developing regression models. Curve-fitting tries to find an equation that fits well with the present data, while modeling tries to find an equation that represents the underlying data generator. Curve-fitting can be misleading and can lead to over-fitting in the sense that the fitted curve may not accurately represent periods of time outside of what was used to create the curve; the classic example is always being able to fit an (n-1)th-degree polynomial to n data points. For these regression models, the energy consumption should be directly correlated with what actually drives usage. The DNV GL models are independent of any curve-fitting.

For this evaluation, DNV GL used adjusted R-squared values to assess the statistical fit. Adjusted R-squared is reduced when the model includes too many predictor variables. Increasing the number of variables may lead to a high R-squared value, but also can lead to interpretation issues, especially when the predictor variable is seemingly unrelated to energy consumption. The evaluation therefore limited the independent variables to weather-based variables and one non-weather variable.

Site Baseline Modeling Approach

DNV GL utilized a standardized regression modeling approach for gas and electric usage to estimate annual energy consumption for each sampled site (or associated meter if multiple meters serve one site). DNV GL utilized HDD and/or CDD, rather than average temperature as used in many of the MT&Rs, to capture the underlying physical heating and cooling processes. This standardized modeling approach serves to independently verify the claimed program savings. DNV GL developed the best model for each site based on the standard modeling criteria. In order to find the best model for each site, DNV GL tested several different models using various reference temperatures:

- Heating only - uses HDD term only. This model was used for all gas models.
- Cooling only – uses CDD term only.
- Single reference temperature – uses HDD and CDD calculated using the same reference temperature.
- Dual reference temperatures – uses HDD and CDD, where unique reference temperatures are calculated separately for cooling and heating.

Model selection & development

DNV GL developed the models using site-specific data from the baseline period (consumption prior to the start of the program). DNV GL used the same months as the program for the baseline period unless sufficient data was unavailable or a large capital project occurred during the baseline period. Model development for each site occurred in two stages:

Stage 1, Determination of optimal model type reference temperatures: The first stage determines the optimal reference temperature for each potential site model type. The temperature value that produced the highest adjusted R-squared value for a type was chosen to represent that type.

Stage 2, Model type selection: The best site model type of the four types listed above was the model type with the highest adjusted R-squared value. Table 40 shows the model types used for the evaluation models developed.

Table 40: Selected evaluation model types

Fuel	Temperature Response Model Type	Model Count
Electric	CDD Only	10
Electric	CDD & HDD, Single Reference Temperature	17
Electric	CDD & HDD, Dual Reference Temperature	2
Electric	HDD Only	8
Electric	Subtotal	
Gas	HDD Only	30
All	Total	

Monthly Residuals

Energy savings for each month during the program are estimated as the difference between the modeled baseline energy and the actual energy consumption. This is referred to as the "monthly residual". This value is an estimate of the energy use avoided during the month due to all changes at the site. If the project installed a capital project after the baseline period, then any savings due to the capital project are included in the monthly residual.

Program Year Savings

This section discusses how incremental program year savings are determined from monthly residuals.

Program Year Assignment

Total program year energy savings are based on the sum of monthly residuals during the program year. Prior to 2016, the SEM program would often estimate annual first-year savings from a measurement period less than 12 months. The second-year energy savings (or first continuation year) would then "true-up" savings by measuring 12-months starting from the end of the previous measurement period. DNV GL created a program year assignment schedule to determine which program year each monthly residual should be assigned to. The cohort schedule is based on the date of the participant's original cohort kick-off meeting. For each cohort analysis schedule, where applicable, the following logic was applied to generate the schedule:

- SEM Year 1 – This is the first year for a participating facility and it contains 12 reads starting with the month following the Cohort Kick-Off workshop.
- SEM Year 2 – This is the second year for a participating facility and starts after Year 1 and ends after the following October. In most cases, this period contains less than 12 monthly reads.
- **SEM Year 3+ or "Standard Year"** – The Standard year contains the 12 reads from November – October. Every year except Year 1 and Year 2 is on the Standard Year schedule.

The standard eight analysis schedules are shown in Table 34 at the end of this appendix. If participant enrolled additional sites in the program after the date of the kick-off meeting, the additional sites are assigned to a later cohort analysis schedule based on their enrollment date. The assignments are selected to most closely aligned with their program participation and ensure the kick-off meeting occurred after the facility initiated program participation. Table 41 shows the cohort to which the additional sites were typically assigned, based on the participant's original cohort.

Table 41: Program year assignment schedule for sites added after kick-off meeting

Original Participant Cohort	Cohort for program year assignment
1	2
2	3
3	5
4	5
5	7
6	7

Five sampled facilities have baseline and measurement periods that do not fit well into any of the standard eight analysis schedules. These sample points are assessed using schedules specific to their program involvement.

Program year capital project savings

Individual capital measures associated with a sampled facility and fuel combination installed during the baseline or program year periods are included in this analysis. Concurrent capital project measure savings are accounted for by prorating the annual savings value per the measure installation date and cohort analysis schedule. For the program year under which the measure was initially installed, the measure savings are prorated by the number of days between the measure installation date and the end date for that program year, relative to 365 days for the full annual savings. For subsequent program years, the measure savings are prorated based on the number of days between the program year start and end dates, relative to 365 days for the full annual savings. Individual capital measure savings are then aggregated together for each facility to produce facility-level capital measures savings by program year and fuel type.

- If the capital project occurred during PY15 or PY16, then DNV GL independently estimated an evaluated annual savings for the project and subtracted the prorated savings from the modeled SEM savings.

Program year SEM savings

Capital measure saving values are subtracted from the program year summation of monthly model residual savings values to arrive at the total SEM program savings achieved by program year and fuel type. Following the program's guidelines, incremental savings are calculated as any SEM program savings that are greater than the SEM program savings claimed in previous years of program participation.

Savings calculation summary

The following is a summary of the steps taken to estimate evaluated program year SEM savings:

1. Monthly Residuals: DNV GL calculated meter-level monthly energy savings as the difference between the estimated baseline consumption (using the regression model) and actual meter consumption. All calculations used monthly utility meter reads and daily weather data aggregated to each utility meter read period.
2. Program Year Assignment: DNV GL assigned each monthly residual to a program year based on schedules created for this evaluation.
3. Total Program Year Savings: DNV GL calculated the total savings achieved at each site by program year as the sum of monthly residuals assigned to each program year.

4. Program Year Capital Project Savings: DNV GL calculated program year capital savings based on the evaluation's estimate of annual capital project savings and the number of days in the assigned program year that the measure was installed.

5. Total Program Year SEM Savings: DNV GL calculated the total SEM savings achieved in a program year as the difference between the Total Program Year Savings and the Program Year Capital Project Savings.

6. Incremental Program Year SEM Savings: DNV GL calculated Incremental Program Year SEM Savings as the difference between the Total Program Year SEM Savings for the program year and the maximum Total Program Year SEM Savings estimated for a previous program year.

Table 42: SEM program year assignment, standard cohort schedule

Month	Cohort 1	Cohort 2	Cohort 3	Cohort 4	Cohort 5	Cohort 6	Cohort 7	Cohort 8
Kick Off	Nov-11	Jan-13	Oct-13	Jan-14	Oct-14	Jan-15	Oct-15	Oct-15
Oct-11	-	-	-	-	-	-	-	-
Nov-11	-	-	-	-	-	-	-	-
Dec-11	PY12	-	-	-	-	-	-	-
Jan-12	PY12	-	-	-	-	-	-	-
Feb-12	PY12	-	-	-	-	-	-	-
Mar-12	PY12	-	-	-	-	-	-	-
Apr-12	PY12	-	-	-	-	-	-	-
May-12	PY12	-	-	-	-	-	-	-
Jun-12	PY12	-	-	-	-	-	-	-
Jul-12	PY12	-	-	-	-	-	-	-
Aug-12	PY12	-	-	-	-	-	-	-
Sep-12	PY12	-	-	-	-	-	-	-
Oct-12	PY12	-	-	-	-	-	-	-
Nov-12	PY12	-	-	-	-	-	-	-
Dec-12	PY13	-	-	-	-	-	-	-
Jan-13	PY13	-	-	-	-	-	-	-
Feb-13	PY13	PY13	-	-	-	-	-	-
Mar-13	PY13	PY13	-	-	-	-	-	-
Apr-13	PY13	PY13	-	-	-	-	-	-
May-13	PY13	PY13	-	-	-	-	-	-
Jun-13	PY13	PY13	-	-	-	-	-	-
Jul-13	PY13	PY13	-	-	-	-	-	-
Aug-13	PY13	PY13	-	-	-	-	-	-
Sep-13	PY13	PY13	-	-	-	-	-	-
Oct-13	PY13	PY13	-	-	-	-	-	-
Nov-13	PY14	PY13	PY14	-	-	-	-	-
Dec-13	PY14	PY13	PY14	-	-	-	-	-
Jan-14	PY14	PY13	PY14	-	-	-	-	-
Feb-14	PY14	PY14	PY14	PY14	-	-	-	-
Mar-14	PY14	PY14	PY14	PY14	-	-	-	-
Apr-14	PY14	PY14	PY14	PY14	-	-	-	-
May-14	PY14	PY14	PY14	PY14	-	-	-	-
Jun-14	PY14	PY14	PY14	PY14	-	-	-	-
Jul-14	PY14	PY14	PY14	PY14	-	-	-	-
Aug-14	PY14	PY14	PY14	PY14	-	-	-	-
Sep-14	PY14	PY14	PY14	PY14	-	-	-	-
Oct-14	PY14	PY14	PY14	PY14	-	-	-	-
Nov-14	PY15	PY15	PY15	PY14	PY15	-	-	-
Dec-14	PY15	PY15	PY15	PY14	PY15	-	-	-
Jan-15	PY15	PY15	PY15	PY14	PY15	-	-	-
Feb-15	PY15	PY15	PY15	PY15	PY15	PY15	-	-
Mar-15	PY15	PY15	PY15	PY15	PY15	PY15	-	-
Apr-15	PY15	PY15	PY15	PY15	PY15	PY15	-	-
May-15	PY15	PY15	PY15	PY15	PY15	PY15	-	-
Jun-15	PY15	PY15	PY15	PY15	PY15	PY15	-	-
Jul-15	PY15	PY15	PY15	PY15	PY15	PY15	-	-
Aug-15	PY15	PY15	PY15	PY15	PY15	PY15	-	-
Sep-15	PY15	PY15	PY15	PY15	PY15	PY15	-	-
Oct-15	PY15	PY15	PY15	PY15	PY15	PY15	-	-
Nov-15	PY16	PY16	PY16	PY16	PY16	PY15	PY16	PY16
Dec-15	PY16	PY16	PY16	PY16	PY16	PY15	PY16	PY16
Jan-16	PY16	PY16	PY16	PY16	PY16	PY15	PY16	PY16
Feb-16	PY16	PY16	PY16	PY16	PY16	PY16	PY16	PY16
Mar-16	PY16	PY16	PY16	PY16	PY16	PY16	PY16	PY16
Apr-16	PY16	PY16	PY16	PY16	PY16	PY16	PY16	PY16
May-16	PY16	PY16	PY16	PY16	PY16	PY16	PY16	PY16
Jun-16	PY16	PY16	PY16	PY16	PY16	PY16	PY16	PY16
Jul-16	PY16	PY16	PY16	PY16	PY16	PY16	PY16	PY16
Aug-16	PY16	PY16	PY16	PY16	PY16	PY16	PY16	PY16
Sep-16	PY16	PY16	PY16	PY16	PY16	PY16	PY16	PY16
Oct-16	PY16	PY16	PY16	PY16	PY16	PY16	PY16	PY16

APPENDIX D. CUSTOM MEASURE RESULTS

This appendix provides summaries of the custom track evaluation results by measure category. Realization rates shown are unweighted simple averages of unique measure results. DNV GL provided measure specific results to Energy Trust separately.

Table 43: Custom track evaluation results by measure Category

Custom Evaluation Category & Measure Description	# Evaluated Electric Measures	# Evaluated Gas Measures	Unweighted, Average Electric GRR (%)	Unweighted, Average Gas GRR (%)
Controls				
Custom Building Controls	33	21	81%	71%
Custom EMS	1		100%	
EMS for BPTaC	2		100%	
Controls Total	36	21	83%	71%
HVAC				
Custom Boiler	1	2	100%	98%
Custom Chillers	8	1	127%	109%
Custom Demand Control Ventilation	1	1	7%	269%
Custom Economizers	2		87%	
Custom HVAC	17	7	83%	74%
HVAC Total	29	11	93%	99%
Miscellaneous - Custom				
Custom Other	7	5	81%	130%
Miscellaneous - Custom Total	7	5	81%	130%
Motor				
Custom VFD Pump	3		58%	
Custom VFDs	12	1	69%	1,201%
Motor Total	15	1	67%	1,201%
Grand Total	87	38	83%	116%

APPENDIX E. STANDARD MEASURE RESULTS

This appendix provides summaries of the standard track evaluation results by measure.

Measure specific approach: The initial pages contain tables summarizing the evaluation activities and documenting recommendations associated with specific measures sampled for evaluation.

Project specific approach: A single table follows the measure specific tables for the project specific approach measures. These are measures with 4 or less measures sampled for evaluation.

DNV GL Measure Description	Smart (Motion Sensor) Power Strips	
Track: Entity Code	Standard: POWERSTRIP	
Measure Code(s)	OCCPLUGSTRIPSI[24], OCCPLUGSTRIP	
The smart strip was a TrickleStar 183SS-US-8XX Motion Sensor Power Strip. Key evaluation parameters were the installation and operation of the power strip plus the use of the motion sensing feature of the equipment.	RR: Avg. (Min-Max)	38%
	Sample Target	15
	Survey Completes	13

Measure Information

Program Data Review: 2,673 units were claimed across 807 installations for 325,896 kWh in savings. Measure quantities of 1 through 9 per project were most common, but 8 sites had quantities ranging from 15 to 80 per site. For two Department of Corrections locations (an office and a prison), a total of 60 smart strips were left at the two sites.

Program Delivery: These devices were "left behind" with the customers along with a *signed agreement* that they install them in office spaces.

Evaluation Summary

- The evaluation sample included 15 sites for verification: 10 were from the Standard track, and 5 sites came from the DI-Lighting track[25].
- Telephone interviews were completed for data collection: Findings were generally indefinite and uncertain because it was difficult to remotely verify both deployment and use of the motion sensor feature.
- Site-level realization rates were either 0% or 100%.
  - Savings were zeroed out for 10 of 13 completed surveys because customers could not recall receiving the smart strips, reported that they did not receive them, were unsure they were being used, received but had not installed them, or they were received but not functional.
  - For the customers who confirmed receipt and installation, only one indicated they were being used as designed; one indicated the motion sensor function was not used, and one used it at home.

Evaluation Recommendations

Measure installation and use is highly uncertain. Savings are non-existent or unreliable. Specific recommendations include:

24 Only the OCCPLUGSTRIPSI measure code was sampled

25 Smart strips were also left behind at some Lighting track participant sites, and a sample of these was drawn. The phone verification for the Lighting track sample was conducted as part of the Standard track evaluation effort.

- Discontinue measure if savings is the primary reason for distribution.
- Do not claim savings for these devices.
- If distribution continues and savings are claimed:
  - Only leave behind if at least one actual installation can be done (to demonstrate functionality).
  - Do not make customers sign an agreement about how and where they will use the device. Signing an agreement does not guarantee the smart strips will be installed, nor installed correctly.
  - Do not provide large quantities without an installation verification plan in place.
  - Complete additional research to determine the installation rate for this measure.

Adjustment to evaluation plan

DNV GL concluded that the power strip measure's evaluated savings compared to claims is unique in the program and should not represent the results of other non-sampled standard measures. We therefore made the following adjustments.

- Created two strata for all power strips installed through the program, one in the Standard track and one in Lighting. Power strips were originally sampled in:
  - 2016LightingNon-TLEDDirect Install Non-TLEDElectricSize1
  - 2015StandardNon Food EquipmentAllElectricSize1
  - 2016StandardNon Food EquipmentAllElectricSize1
- The sample of power strips reviewed for this evaluation served as the sample for these new strata.
- DNV GL adjusted the weighting in the original Lighting and Standard track samples to account for the change in sample. Power strips were selected in three strata. Standard: DNV GL combined the Size1 and Size2 strata in each year to create one stratum. Lighting: DNV GL re-weighted the *2016LightingNon-TLEDDirect Install Non-TLEDElectricSize1* stratum.

DNV GL Measure Description	Gas Fryers		
Track: Entity Code	Standard: FOODEQUIP		
Measure Code(s)	NCIRGASFRY2014		
This measure covers the installation of new ENERGY STAR-compliant gas fryers. Fryers account for the largest percentage of gas savings. Key evaluation parameters include number of vats, vat capacity-size (Large or Standard), cooking energy efficiency, business hours, equipment operating hours, and pounds of food cooked per day.	RR: Avg. (Min-Max)	88% (0% - 170%)	
	Sample Target	34	
	Survey Completes	29	

Measure Information

Program Data Review: 729 unique measure lines were reported over the two program years. These lines accounted for 0% of electricity savings and 45.5% of gas savings reported for the Standard track.

Program Delivery: This is a standard prescriptive measure. Incentives are paid when the application, invoice/receipt, and ENERGY STAR certification are submitted.

Evaluation Summary

The evaluation sample included 34 sites for verification, 29 interviews were complete (4 of these were confirmed to be out-of-business), 5 non-response

- Telephone interviews were completed for data collection
- Large vat assumed by MAD, but all but one project was Standard size vat
- Verified pounds of food and hours of fryer operation were lower than assumed in MAD
- 4 sites were confirmed to be out-of-business, and one site did not use the fryers at all

Evaluation Recommendations

- Use the ENERGY STAR calculator for traceability and transparency
- Assume Standard vat size instead of Large
- Change assumed lbs of food and fryer hours per day
- Consider ending incentives to fast-food chains or other 7/24/365 (ENERGY STAR is already the standard practice)

Adjustment to evaluation plan

None

DNV GL Measure Description	Dishwashers	
Track: Entity Code	Standard: FOODEQUIP	
Measure Code(s)	UCHITEMPELE, STDRUPLOTEMPELE, UCHITEMPGAS, STCONHITEMPGPE, STDRUPLOTEMPGAS, STDRUPHITEMPELE	
This measure covers the installation of dishwashers in restaurant spaces. Key evaluation parameters include ENERGY STAR dishwasher type (high temp/low temp, Under Counter, Stationary Single Tank Door, Single Tank Conveyor, or Multi-Tank Conveyor), Racks washed per day, building hot water fuel type, annual operating days and operating hours.	RR: Avg. (Min-Max)	23% (elec.) 19% (gas) (0% - 132%, elec.) (0% - 13%, gas)
	Sample Target	16
	Survey Completes	13

Measure Information

Program Data Review: 133 unique measure lines were reported over the two program years. These lines accounted for 3.88% of electricity savings and 2.01% of gas savings reported for the standard track.

Program Delivery: Standard

Evaluation Summary

The evaluation sample included 16 sites for verification. 13 interviews were complete, 3 sites were non-responsive.

Telephone interviews were completed for data collection. Measure Information:

- Low RR mostly due to overestimation of racks washed per day. Some lower rates are due to actual operating hours varying from assumed hours.
- MAD assumes a constant number of racks washed per day based on dishwasher type, and appears to assume high-activity restaurants.

Evaluation Recommendations

Use the ENERGY STAR calculator for traceability and transparency.

Perform additional studies to update the assumed number of racks washed per day and hours per day of operation.

Adjustment to evaluation plan

None

DNV GL Measure Description	Convection Oven (Electric and Gas)
Track: Entity Code	Standard: FOODEQUIP
Measure Code(s)	NCCONVOVEN, ELECONVOVFULL

This measure covers convection ovens in restaurants and other commercial/institutional spaces. Full-size convection ovens can be either single deck or double deck. Key evaluation parameters include oven production capacity, cooking energy efficiency, idle energy rate, business/operating hours and average pounds of food cooked per day.	RR: Avg. (Min-Max)	69% (Elec. Only 1 site) 70% (Gas) (13% - 144%)
	Sample Target	9
	Survey Completes	7

Measure Information

Program Data Review: 148 unique measure lines were reported over the two program years. These lines accounted for 0.73 % of electricity savings and 3.17 % of gas savings reported for the standard track.

Program Delivery: Standard

Evaluation Summary

The evaluation sample included 9 sites for verification. 7 interviews were completed; there were 2 non-responsive sites.

Telephone interviews were completed for data collection. Measure Information:

- Low RR due to actual operating hours which vary considerably by business type
- MAD appears to assume high-activity/constant operation restaurants
- Half of verified sites were non-restaurants (community center, hospital, caterer) with lower or more sporadic operating hours
- MAD did not use the ENERGY STAR calculator but used the calculation approach

Evaluation Recommendations

- Use the ENERGY STAR calculator for traceability and transparency.
- Add a low-use measure to address non-restaurant business types.

Perform additional studies to update the assumed number of pounds of food cooked per day and hours per day of operation.

Adjustment to evaluation plan

None

DNV GL Measure Description	Ice Makers (Ice machines)	
Track: Entity Code	Standard: ICEMAKER	
Measure Code(s)	BEICEIMHSMES, BEICESCUSMT3	

This measure covers the installation of commercial ice makers. Incentives are offered for two tiers and three types of ice makers: Ice Making Head (IMH), Self-Contained Units (SCU), and Remote Condensing Units (RCU). Key evaluation parameters include ice machine type, ice harvest rate, energy consumption rate, business hours, holidays, and replacement practice.	RR: Avg. (Min-Max)	77% (0% - 113%)
	Sample Target	8
	Survey Completes	7

Measure Information

Program Data Review: 108 unique measure lines were reported over the two program years. These lines accounted for 0.45% of electricity savings and 0% of gas savings reported for the standard track.

Program Delivery: Standard

Evaluation Summary

The evaluation sample included 8 sites for verification. 7 interviews were completed and 1 was non-responsive.

Telephone interviews were completed for data collection. Measure Information:

- MAD assumed 8760 hrs versus actual site operating hours and 50% duty cycle
- Actual installed equipment performance values (energy consumption rate, annual days of operation, and ice harvest rate) were different from MAD values
- The MAD uses the ENERGY STAR calculator approach but modified the assumptions

Evaluation Recommendations

- Use the ENERGY STAR calculator for traceability and transparency
- If the ENERGY STAR calculator defaults are revised, provide references for changes

Perform additional studies to update the key evaluation parameters listed above.

Adjustment to evaluation plan

None

DNV GL Measure Description	Space Heating Boilers & Controls	
Track: Entity Code	Standard: BOILER	
Measure Code(s)	GFBOIL2500, GFBOIL3002500, MODBOILBURN	

This measure covers the installation of space heating boilers and controls. These measures account for a large percent of HVAC measure gas savings. Three different measure codes were verified. Key evaluation parameters include boiler specifications, standard replacement practice, boiler end-uses, boiler mode during operation (condensing or others), and primary/backup information.	RR: Avg. (Min-Max)	77% (0% - 132%)
	Sample Target	11
	Survey Completes	9

Measure Information

Program Data Review: 47 unique measure lines were reported over the two program years. These lines accounted for 0% of electricity savings and 22% of gas savings reported for the standard track.

Program Delivery: Standard

Evaluation Summary

The evaluation sample included 11 sites for verification. 9 interviews were completed and 2 sites were non-responsive.

Telephone interviews were completed for data collection. Measure Information:

- 0 savings at 1 site because the new unit replaced an existing condensing boiler
- One site had 132% RR due to update to 2015 MAD estimate
- Majority of sites had 2-3 boilers incentivized, many had 1 for backup
- 1 site reported "quantity" as 1 but should be total boiler capacity in kBtuh
  - Unit basis for quantity is kBtu saved per kBtuh of boiler capacity

Evaluation Recommendations

- Identify quantity of incentivized boilers that will be used primarily for backup
- Add a field to the tracking data to capture the physical quantity of boilers
- Consider a way to adjust savings to account for backup boilers
- Consider researching the standard market practice for condensing boilers

Adjustment to evaluation plan

None

DNV GL Measure Description	Roof/Attic Insulation	
Track: Entity Code	Standard: CEILINGINSULATE	
Measure Code(s)	INSATTICEHP, BEGROOF, BEGATTIC, INSROOFGR5R20, INSROOFER, INSATTICER, BEGROOF	
This measure covers the installation of roof or attic insulation. Two basic measures are considered: no existing insulation and some existing insulation. Different heating system types are covered: gas, electric resistance, and heat pump. Key evaluation parameters include building area, building vintage, roof/attic, existing insulation verification, and space heating/space cooling verification.	RR: Avg. (Min-Max)	55%(elec.) 97%(gas) (0% - 100%, elec.) (0% - 100%, gas)
	Sample Target	10
	Survey Completes	8 (3 elec., 5 gas)

Measure Information

Program Data Review: 68 unique measure lines were reported over the two program years. These lines accounted for 2.24% of electricity savings and 9.77% of gas savings reported for the standard track.

Program Delivery: Standard

Evaluation Summary

The evaluation sample included 10 sites for verification. 8 interviews were completed and 2 sites were non-responsive.

Telephone interviews were completed for data collection. Measure Information:

- Low electric RR due to zeroed-out savings for 2 projects considered new construction: major remodel-rehab of the building reported by customer
- MAD measure names are inconsistent: "Insulation Roof…" and "Roof Insulation…"
- Complex measure to get correct: Roof or Attic, existing R-value, heating type

Evaluation Recommendations

- Ensure that projects are true retrofits, not complete remodel-rehab (i.e. new construction)
- Fix the measure names and consider using either only Roof or Attic values

Adjustment to evaluation plan

None

DNV GL Measure Description	LED Case Lighting (Retrofit or New Case)	
Track: Entity Code	Standard: LIGHTING	
Measure Code(s)	LEDCLT84W, LEDCLT84W75W, LEDCLT124W, LEDCLTNEW4W, LEDCLT124W75W	

This measure covers the retrofit of existing refrigerator cases to, or purchase of new refrigerated cases that have, LED case lighting. Key evaluation parameters include linear feet of casing, baseline fixture type/wattage, new fixture type/wattage, and installed quantity.	RR: Avg. (Min-Max)	75% (41% - 100%)
	Sample Target	10
	Survey Completes	9

Measure Information

Program Data Review: 137 unique measure lines were reported over the two program years. These lines accounted for 12.19% of electricity savings and 0% of gas savings reported for the standard track.

Program Delivery: Standard

Evaluation Summary

The evaluation sample included 10 sites for verification. 9 interviews were completed and 1 was non-responsive.

Telephone interviews were completed for data collection. Measure Information:

- Predominantly retrofit projects, but 3 projects were new cases
- Majority of projects verified as reported but with 2010 MAD savings
- Three sites had a low RR due to motion sensor, incorrect quantity, retrofit instead of new case
- Incorrect quantity (=1) entered for almost ½ the sample
- Includes gas savings due to HVAC interactive effects (for gas heating)

Evaluation Recommendations

- Clean up the MAD docs: 3 different versions were provided but most cases used the oldest
- Add unit basis (linear feet of case) to clarify quantity units
- Use tracking data measure names (or IDs) that match MAD
- Drop the interactive gas heating savings to simplify approach

Adjustment to evaluation plan

None

DNV GL Measure Description	Cooler Doors (Add doors to open cases)	
Track: Entity Code	Standard: FRIDGE	
Measure Code(s)	COOLDRETFIT, COOLDRETFITE	
This measure covers the retrofit of open refrigerated cases to include doors or the replacement of open cases with closed door cases. The measure has electric & gas (interactive HVAC) savings. Key evaluation parameters include number of doors, linear feet of casing, retrofit type, and HVAC heating and cooling type.	RR: Avg. (Min-Max)	100% (elec.), 92.5% (gas). (gas: 0% - 100%)
	Sample Target	8
	Survey Completes	7

Measure Information

Program Data Review: 38 unique measure lines were reported over the two program years. These lines accounted for 29.94% of electricity savings and 7.44% of gas savings reported for the standard track.

Program Delivery: Standard

Evaluation Summary

The evaluation sample included 8 sites for verification. 7 interviews were completed and one site was 1 non-responsive

- Telephone interviews were completed for data collection
- Predominantly retrofit projects, only one new case project
- Interactive HVAC savings were claimed for gas but not for electric space heating
- Reported HVAC heating system type was incorrect for 3 of 7 projects
- Only one set of savings was used for both retrofit and new cases

Evaluation Recommendations

- Drop interactive HVAC gas savings or revise for electric space heating
- Improve identification of HVAC heating system type
- Limit measure to retrofit: New cases are likely installed only when old units fail
- Best way to truly verify installed lengths is with onsite inspection

Adjustment to evaluation plan

None

DNV GL Measure Description	Strip Curtains	
Track: Entity Code	Standard: FRIDGE	
Measure Code(s)	STRIPCURTLTWFS	
This measure covers the retrofit/replacement of strip curtains for walk-in freezers. Key evaluation parameters include square-feet verification, replacement/add-on verification, replacement practices, and average daily operating hours.	RR: Avg. (Min-Max)	52% (0% - 100%)
	Sample Target	4
	Survey Completes	2

Measure Information

Program Data Review: 19 unique measure lines were reported over the two program years. These lines accounted for 2.14% of electricity savings and 0% of gas savings reported for the standard track.

Program Delivery: Standard

Evaluation Summary

The evaluation sample included 4 sites for verification. 2 interviews were completed and 2 were non-responsive

Telephone interviews were completed for data collection. Measure Information:

- Almost all sampled sites involved the changing of ownership, therefore it was difficult to gather useful information about the installed strip curtains, as new owners have no knowledge of them
- Only able to confirm 1 site with strip curtains intact. The other site indicated worn-out curtains without confirming fully intact curtains
- MAD categorizes savings only based on building type and freezer/cooler install

Evaluation Recommendations

- Add a parameter to indicate free-riders (i.e. grocery stores that do this regardless)
- Use a calculator to verify savings for more traceability and transparency

Adjustment to evaluation plan

None

Evaluated Standard measures, project specific results.

Entity Code	Measure Description	Measure Code(s)	GRR	Evaluated Sites	Findings	Recommendations
CONTROLS	Anti-sweat Heater Controls	BEREFANTISWTM, BEREFANTISWTL	Elec: 50% (only 2 sites, one is 0%, one is 100%)	2 out of 2 sampled	Site with zero realization rate stated the cases with the rebated anti-sweat heater controls are no longer on site. The other site has the reported equipment verified and installed. Savings adopted into the MAD are reasonable, since they were derived from RTF.	Review both tracking data and MAD document. Make sure savings in MAD doc is well sourced. (RTF, TRM, etc.)
CUSTOM FRIDGE	Floating Head Pressure Control / Floating Suction Pressure Control	FSPCFHPC, FSPCFHPCZ2AIR	Elec: 100%	1 out of 2 sampled	DEER savings found in READI_v.2.4.7 (DEER data base) were used to estimate evaluated savings, as described by the MAD. Savings are categorized by Climate Zones, FHPC/FSPC, Evap cooled/Air cooled, and with/without interactions. Evaluated site was air cooled with compressor system HP verified. No standard practices for this type of measure for the site.	Provide the eQuest model that MAD doc used to calculate savings for more traceability.
FOODEQUIP	Energy Star Electric Steam Cookers	BEELESTEAM	Elec: 863%	1 out of 1 sampled	One site only. Extreme realization rate due to assumption differences. Energy Star calculator uses a per pan basis for savings, while the estimated savings does not account for per pan basis. Also, actual specs are different than assumed specs.	Use the Energy Star calculator with actual performance specifications and operating hours; and most importantly standardize the unit and quantity basis during calculation.
FOOD EQUIP	Vent Hood - Gas Heat	BEVENTHOOD	Gas: 100% Elec: 100%	1 out of 1 sampled	New control system for dedicated commercial kitchen exhaust hood and make-up air system. It works with VFD to modulate fan speed. Verified the system is installed and operating, but cannot revise savings since measure was installed in an airport space, with complex system and interactions. Savings calculation method is based on New Jersy 2016 TRM.	Use a standardized food service calculator like Energy Star for more traceability.
FOOD EQUIP	Energy Star Hot Food Holding Cabinets	HOTFOODCABHALF; BEHOTCAB	Elec: 23%	3 out of 3 sampled	Two sites are half-size; one site is full-size. Half-size cabinets are only used partially during business hours. Low realization rate due to actual cabinet volume and idle energy rate lower than assumptions.	Use the Energy Star calculator with actual performance specifications and operating hours.
HEATPUMP	Packaged Terminal Heat Pump	BEPTHEATPUMP	Elec: 100%	1 out of 1 sampled	MAD savings are categorized by building type (multi-family, dorms, hotel/motels), and appears to be based on a BIN analysis. Verified baseline unit as packaged terminal AC with AC electric heating, no discrepancy found.	Provide traceable sources for savings method for better transparency. Some of the parameters for this MAD savings method was unclear (i.e. 100% load supplemental heater temperature).

Entity Code	Measure Description	Measure Code(s)	GRR	Evaluated Sites	Findings	Recommendations
HVAC	HVAC In-room Cooling Sensor	BEHVACINROOM	Elec: 147%	1 out of 1 sampled	Measure savings is estimated per room basis, and only include electric cooling savings. Savings from MAD is based on High realization rate due to higher occupancy rate of the evaluated hotel site: 88% verified, 60% assumed by MAD, with ratio adjustments for savings per room.	Measure savings should be varied based on room size, cooling/heating setpoints, climate zones, efficiencies, occupancy type, and building type. MAD savings should address all of these factors.
MOTOR	ECM Motors	BEMOTREF, ECMWIU	Elec: 100%	4 out of 4 sampled	All are ECMs retrofit to very old cooler/freezer units. For building type, 3 sites are supermarkets, 1 site is restaurant. Savings are evaluated with MAD document's prescriptive savings, depending on whether if the measure is new install/retrofit, as well as reach-in/walk-in cooler and freezers. The savings method is from an RTF, which uses reasonable inputs and assumptions	None
RADIANT HEAT	Radiant Infrared Heater	RADHEATMOD	Gas: 100% Elec: 100%	1 out of 1 sampled	Measure is installed in a mostly open auto-repair garage/service bay. Techincally this measure is applicable for high bay space as specified by the measure definition, but the application is okay (replaced gas furnace), so MAD savings is used.	Provide MAD savings analysis to allow for better evaluation of details behind the measure savings estimate.
SHOWER-HEAD	Low-Flow Showerheads	SHRHDG15	Gas: 48% Elec:51%	2 out of 2 sampled	We used the unit energy savings (elec and gas) from the MAD doc provided to us, but these values are significantly different from the reported values, which do not even appear in the 2016 MAD doc. Water-energy savings are also claimed, so even gas WH shows electric savings (unusual). Both sites used gas water heating.	Review the tracking data and MAD doc and determine if there is an issue as values do not line up. Make the use of water-energy savings more visible in the MAD doc, consider listing it separately: Claiming kWh savings for a gas water heating measure could look like an error when reviewing the tracking data.
TANKDHW	Condensing Storage Water Heater	NCDHWCOND	Gas: 100%	1 out of 2 sampled	Used MAD unit energy savings to verify based on building type. For the evaluated site, verified building type, occupancy rate, condensing water heater quantity.	MAD document need to describe the baseline water heating system and its efficiency used for the savings analysis.
VIRTUAL-IZATION	Data Virtualization	BEVIRTUAL	Elec: 46%	1 out of 2 sampled	2 sites sampled, only 1 interview was completed. Low realization rate due to observed consolidation ratio (# of old servers/# of new servers for VMs) is much less than assumed value for reported savings. Reported UES was higher than values in the MAD doc. This measure has been discontinued.	Double check number of servers before and after based on invoices. Verify consolidation ratio with MAD doc. Consider using standardized calculator to be more traceable. Require customer to provide disposal document and Virtual software invoices as a standard practice.

About DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter and greener.