PUGET SOUND ENERGY

Evaluation and Evaluation Report Response

Program:

- Schedule 258, Large Power User Program

Program Year:

- 2018-2019

Contents:

- Evaluation Report
- PSE Evaluation Report Response

This document contains the final 2018-2019 Large Power User Program Evaluation Report, prepared by Opinion Dynamics, PSE's independent evaluation contractor. In accordance with WUTC conditions, all PSE energy efficiency programs are evaluated by an independent, third party evaluator.[1] Evaluations are planned, conducted and reported in a transparent manner, affording opportunities for Commission and stakeholder review through the Conservation Resource Advisory Group (CRAG) and reported to the UTC.[2] Evaluations are conducted using best-practice approaches and techniques.[3]

PSE program managers and evaluation staff prepare an Evaluation Report Response (ERR) upon completion of an evaluation of their program. The ERR addresses and documents pertinent adjustments in program metrics or processes subsequent to the evaluation.

Please not that this is an evaluation of the program as it operated during the 2018-2019 program years.

This and all PSE evaluations are posted to *Conduit Northwest*. To view an electronic copy and to leave comments, visit https://conduitnw.org/Pages/File.aspx?rid=5054, or search words "PSE Commercial and Industrial Retrofit Program Evaluation Report."

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1. (6)(c.) Approved Strategies for Selecting and Evaluating Energy Conservation Savings, Proposed Conditions for the 2016-2017 PSE Electric Conservation.
2. PSE 2016-2017 Biennial Plan, Exhibit 8: Evaluation, Measurement & Verification (EM&V) Framework, Revised August 6, 2015
3. Ibid.

Opinion Dynamics

Boston | Headquarters

617 492 1400 tel
617 497 7944 fax
800 966 1254 toll free

1000 Winter St
Waltham, MA 02451

Puget Sound Energy

2018-2019 Large Power User Compliance Program Evaluation Report – FINAL

April 24, 2020

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1. Executive Summary

This reports details impact and limited process evaluation results for the Large Power User (LPU) compliance program for the 2018-2019 biennium. Process evaluation results for the program were limited to program staff interviews and review of program tracking data and materials.

The LPU Program provides funding support for large non-residential customers receiving electric service under schedules 40, 46, and 49, to implement self-directed custom electric energy-efficient upgrades. These customers are eligible for a funding allocation from PSE based on their electric usage and submit proposals for energy efficiency projects to PSE that take advantage of their allocation. Examples of potential upgrades include HVAC, refrigeration, operational improvements, building thermal improvements, building envelopes, controls, lighting improvements, water heating, and strategic energy management.

PSE hired Opinion Dynamics Corporation to evaluate the program's performance throughout the biennium. The primary objective was to evaluate the electric savings associated with the program. Additionally, we documented any key program changes, as well as the program's success and challenges, from the perspective of key program management staff. We derived evaluation findings in this report from in-depth interviews with key program management staff, a review of program materials and tracking data, and an engineering analysis of energy savings based on a desk review of 24 projects and site visits to 19 participating customers.

Over the biennium, 24 customers[1] completed 43 projects resulting in 19,196 MWH electric savings. The 24 customers who participated in the program over the course of 2018 and 2019 represent 15% of all eligible customer accounts, and their ex post savings represent 1.7% of the eligible population's 2018 energy consumption.

Energy savings and participation are the key indicators of program performance when compared to the program's goals for this biennium. Based on these indicators, the program slightly underperformed both in terms of savings as well as customer participation. Table 1 below summarizes program performance across the key metrics. Notably, the LPU program runs on a four-year cycle giving the participants two years to plan out and spend their funding allocation and an additional two years to implement and install the proposed energy-saving measures. The 2018-2019 biennium covered the last year of the 2015-2018 LPU program cycle and the first year of the 2019-2022 LPU program cycle.

Table 1. LPU Program Performance Across Key Performance Indicators

Metric	Definition	Success Criteria	Ex Ante	Ex Post	KPI Status
Electric savings	Amount of MWh savings for 2018-2019	35,600 MWh[a]	19,196 MWh	17,376 MWh	The program achieved 49% of the goal
Customer Participation	Number of customers taking part in the program	32 sites[b]	24	24	The program achieved 75% of the goal

a Source: Exhibit 1. PSE Conservation Rider. Savings Goals and Budgets.

b Source: 2019 Annual Conservation Plan (page 83).

We evaluated the energy savings via site visits and engineering desk reviews. The realization rate between ex ante and ex post savings provides a sense of how accurate the ex ante savings were. A 100% realization rate indicates that we found no reason to change PSE's estimates of energy savings based on the engineering

[1] Defined as unique accounts.

review. A rate less than 100% indicates we found discrepancies that led to lower savings than PSE's estimates, while a rate higher than 100% indicates we found discrepancies that led to larger savings than PSE's estimates.

Overall, the realization rate for the LPU Program is 91%. Realization rate for lighting enduse is 102% and is primarily due to upward adjustments in the facility operating hours. Realization rate for non-lighting enduse is 79%. The key driver of the realization rate is overrides to condenser water resets and adjustments to the engineering calculations for a large project.[2]

Over the course of the biennium, program staff worked closely with qualifying customers to maximize program reach and ensure customer support and satisfaction with their program participation experiences. PSE staff do not anticipate making changes to the LPU program in the coming program cycles.

Overall Conclusions & Recommendations

Given the strong realization rates savings for this program and the minimal number of issues found in the impact evaluation, PSE's approach to both calculating ex ante energy savings is sound, and PSE's internal verification does an exemplary job of mitigating risk, verifying installation and persistence, and keeping project documentation and savings updated.

While the realization rate for non-lighting projects is somewhat low, it is largely driven by significant changes for one large project that occurred after project completion and were outside of PSE's control. Those changes are not indicative of a systemic ex ante savings calculation or tracking errors.

The LPU program draws savings from relatively few projects. Those projects, however, tend to be large and custom in nature. Participation in the program is also self-directed. External influences that are out of the program's immediate control, such as building demolition and program equipment removal after successful project completion and closeout can have large impact on the evaluated savings. Anticipating such changes can be difficult, yet identifying them ahead of time can help better position the program in terms of anticipated performance.

The LPU program is administered on a four-year cycle giving the participants two years to plan out and spend their funding allocation and an additional two years to implement and install the proposed energy-saving measures. The end of 2018 marked the end of the 2015-2018 program cycle, and the beginning of 2019 marked the start of the 2019-2022 cycle. The 2018-2019 biennium therefore captured portions of two cycles. Such misalignment of the evaluation cycle with the implementation cycle presents certain challenges in terms of assessing program performance against participation and savings goals. More specifically, while the program met its goal for the 2015-2018 cycle, it was too early for program staff to gauge program performance based on 2019 alone and with three more years remaining in the cycle.

Based on the evaluation findings, we recommend that the program continue smooth program implementation and thorough verification processes to ensure continued customer engagement and program success.

We also offer the following considerations for future programmatic enhancements:

- To the degree possible, the program should consider flagging and monitoring particularly large or especially risky projects based on past experience and other indicators upon project completion, as this can help identify changes to building conditions or project measures that can negatively impact

[2] The project accounted for 40% of all non-lighting ex ante savings and 14% of all LPU ex ante savings achieved over the course of the biennium.

the savings. This information can help program staff make appropriate adjustments to assist in better alignment of ex post savings with ex ante, thus minimizing negative shocks for the program at the evaluation stage. Such monitoring, however, should not be detrimental to program cost-effectiveness or overly burdensome for program staff to implement. Such monitoring could be done via follow-on outreach to the participating facility staff and/or follow-on review of the facility consumption data.

- Program staff should consider aligning the evaluation cycle with the program cycle as a way to allow for more effective assessment of program performance and providing timely recommendations to inform planning of the new cycle.

2. Introduction

This report details the impact and limited process evaluation results for the Large Power User (LPU) program for the 2018-2019 biennium. Process evaluation results for the program were limited to program staff interviews and review of program tracking data.

2.1 Program Description

The LPU program provides funding support for large non-residential customers receiving electric service under schedules 40, 46, and 49 to implement self-directed custom electric energy-efficient upgrades. These customers are eligible for a funding allocation from PSE based on their electric usage and submit proposals for energy efficiency projects to PSE that take advantage of their allocation. Examples of potential upgrades include HVAC, refrigeration, operational improvements, building thermal improvements, building envelope, controls, lighting improvements, water heating, and strategic energy management.

PSE awards grants for specific projects in two phases. In the non-competitive request for proposals (RFP) phase, eligible customers have approximately two years to propose projects that exhaust their funding allocations. A competitive RFP phase follows this first phase, where customers submit proposals to compete for any remaining funds that eligible customers did not use during the non-competitive phase. PSE evaluates each proposal for cost-effectiveness, technical soundness, regulatory compliance, timeliness of project completion, and persistence of savings. Participants receive custom incentives in the form of grants after PSE verifies project savings. The customer has four years in total to complete the project.

As part of the application process, eligible customers submit a proposal with the following program requirements:

- Documentation of baseline energy use
- Project savings analysis
- Measure costs
- Funding analysis
- Energy savings verification plan
- Lighting retrofit projects that achieve energy savings exceeding 300,000 kWh/year also require one of the following forms of documentation:
- 15-minute interval data from metered facility electrical use that clearly demonstrate lighting usage for a period of at least seven consecutive days during normal facility operation
- Data logging of lighting fixture use in at least two lighting control zones, representative of overall usage of fixtures, that are to be upgraded by the project
- Lighting schedule printouts from energy management and control systems

Similar to other custom retrofit projects, LPU program staff develop an internal write-up called the “Scope of Work” that includes measurement and verification plans, and details on how to calculate savings for each project. Prior to issuing pre-approval for each project, PSE staff review the Scope of Work document, conduct a pre-installation inspection to verify existing equipment conditions, review the proposed efficiency upgrades, and evaluate the verification plan to ensure that the proposed strategy will accurately quantify energy savings. For all projects, a PSE EME conducts a post-installation site inspection to review installed equipment and

confirm the implementation of the verification plan. The inspection is conducted after the measures are installed and before project funds are distributed.

The design and implementation of the LPU program remained largely unchanged during the 2018-2019 biennium.

2.2 Summary of Program Achievements

Over the 2018-2019 biennium, 43 projects were completed as part of the program by 24 unique customers,[3] resulting in 19,196 MWH savings (Table 2).

Table 2. Summary of Program Achievements

Year	Total Projects	Total Customers	Total Ex Ante Savings (MWH)
2018	42	24	18,750
2019	1	1	446
Total	**43**	**24[a]**	**19,196**

a One customer completed two different LPU projects.

As seen in Table 3, lighting projects accounted for half of Large Power Users program ex ante savings (50%), while motors projects accounted for the smallest share of savings (8%).

Table 3. Summary of Program Achievements by Enduse

Enduse	Count of Projects	Ex Ante Savings (MWH)	% of Ex Ante Savings
Lighting	21	9,595	50%
Controls	12	4,549	24%
HVAC	5	3,468	18%
Motors	6	1,584	8%
Total	**43[a]**	**19,196**	**100%**

a One project consisted of multiple enduses.

3. Evaluation Methodology

This section summarizes the research objectives as well as the data sources and methodologies used to conduct this evaluation of the Large Power Users program.

3.1 Research Questions

The primary objective of the 2018-2019 evaluation of the Large Power Users program was to provide estimates of electric savings associated with the program. This program has not been evaluated since 2015 and those results were the first provided for this program.

The evaluation focused on answering the following impact and process research questions:

[3] Customers are defined as unique statement accounts.

Impact Questions

- What are the energy impacts from the program?

Process Questions

- How many projects were completed? By how many different customers? What types of projects?
- What percentage of eligible customers are participating in the program? Has there been any change in the participation rate since the last evaluation of this program in 2015?
- Did the program's implementation change from 2015? If so, how and why, and was this an advantageous change?
- Did the program experience any implementation challenges in 2018/2019? If so, what were they, and how were they overcome?
- What changes could the program make to improve the customer experience and generate greater energy savings?

3.2 Evaluation Activities

Based on the objectives outlined above, the evaluation team completed impact evaluation focused activities on characterizing and understanding the Large Power Users program performance (see Table 4).

Table 4. Summary of Large Power Users Program Evaluation Activities for 2018-2019

Activity	Impact	Process	Summary
Program Staff Interviews	✓	✓	Confirm key details about the program's implementation and explore how the program has performed against its goals, and any program changes over time. Identify any uncertainty over savings.
Data Requests and Program Data Review	✓	✓	Request data needed for the evaluation (e.g., program tracking data extracts, project specific documentation including invoices, energy savings calculations and assumptions, customer applications, billing data, project details and background, post-inspection reports, etc.); review materials to assess program design, implementation, and operations.
Engineering Analysis	✓		Review and assess the reasonableness of custom savings estimates. Review project documentation for consistency, reasonableness, and applicability. Conduct desk reviews for a sample of projects to verify project-specific data provided in the tracking database, document inconsistencies (if any), and adjust savings estimates as needed. Gather data on-site for a sample of projects selected as part of the on-site visit sample to calculate custom savings estimates for measures with higher uncertainty.
Consumption Analysis	✓		Compare actual pre- and post- energy consumption data to estimate the reduction in energy usage after participation.

Below we describe each of the evaluation activities in greater detail.

Program Staff Interviews

Opinion Dynamics completed interviews with all PSE non-residential program managers for a total of 25 interviews across two phases – one in the spring of 2018 and the other in the fall of 2019. Of those, we completed two interviews with the LPU program manager specifically. The interviews covered a range of topics, including program implementation and design, recent and planned program changes, and program performance during the 2018-2019 biennium. The process evaluation results presented in this report build directly on the interviews with the LPU program manager.

Data Requests and Program Data Review

Opinion Dynamics conducted a review of program materials and data for each program, including marketing materials, program planning documents, program theory and logic models, and past evaluation reports and studies.

Engineering Analysis

Engineering analysis for the LPU program consisted of engineering desk reviews and on-site visits. The desk reviews consisted of a thorough examination of all available program documentation for the projects, including applications, invoices, and specification sheets. Our team also performed on-site visits to confirm measure quantities and other key project parameters of incented projects.

To select projects for desk reviews, we used a stratified random sampling approach, stratifying by technology and project savings. We relied on the Dalenius-Hodges method to strata boundary selection and Neyman allocation method to developing an optimal allocation of sample points in each stratum. Appendix A details the Dalenius Hodges and Neyman allocation methods.

The projects selected for on-site visits were a subset of the 24 desk review projects (nested sample), selected at random. We targeted a precision level of 10% at 90% confidence by technology (lighting vs. non-lighting).

Table 5 provides a summary of the desk review and site visit sample for the program. Note that the counts of projects and sum of savings values in the table reflect participant population at the time when the sample was developed, as opposed to the final population as of the end of 2019. As a result, the numbers in those two columns differ from what is presented in Table 3 above. Overall, the sample of 24 desk reviews accounted for 55% of all projects and 71% of total ex ante savings as of the end of 2019.

Table 5. Summary of Desk Reviews and Site Visit Sample

Enduse	Count of Projects	Sum of Savings (kWh)	% of Savings	Total Sample of Projects for Desk Reviews	Total Sample of Projects for Site Visits
Lighting	20	9,148,638	49%	12	10
HVAC	5	3,468,341	18%	12	10
Controls	12	4,549,392	24%		
Motors	6	1,583,668	8%		
Total	**42**	**18,750,039**	**100%**	**24**	**19[a]**

a One site visit included lighting and non-lighting enduses and was sampled as part of both strata.

Following the completion of the engineering analysis, Opinion Dynamics calculated a project realization rate for each project, by taking the ratio of verified savings to the ex ante savings from the program tracking data.

Equation 1. Project Realization Rate

$$Project\ Realization\ Rate = \frac{Ex\ Post\ Energy\ Savings}{Ex\ Ante\ Energy\ Savings}$$

We used the stratified ratio estimator adjustment method[4] to extrapolate results for the sampled projects back to the overall population. Appendix A details the method.

4. Impact Evaluation Findings

This section contains detailed findings from the impact evaluation activities.

Through the review of the program tracking data, we found that the databases are clean and well-maintained. PSE keeps detailed track of participants and projects that they complete through the program, including information about businesses that complete program-supported projects, energy-efficient improvements that participants adopt through the program, dates, savings, and incentives. Our review, however, identified a gap in the program tracking data, namely, measure quantity. The measure quantity field was provided as part of the program tracking data but was blank. Having this information included in the program tracking data, especially for projects such as lighting can be helpful for program evaluation through providing ready project detail without the need to access and review project documentation.

The evaluation team completed a total of 24 desk reviews and 19 onsite visits (Table 6).

Table 6. Lighting End-use Desk Review and Site Visit Summary

Phase	Number of Projects				
	Population	Planned Desk Reviews	Completed Desk Reviews	Planned Site Visits	Completed Site Visits
Lighting	20	12	12	10	10
Non-Lighting	23	12	12	10	9

As part of the desk reviews, we completed the following:

- Reviewed all project documentation, including PSE's savings calculations worksheets, implementation inspection photos, invoices, and savings calculations.
- Reviewed PSE reported savings methodologies and calculations, including an assessment of the reasonableness of claimed savings as a percentage of annual baseline energy consumption given the facility type.
- Reviewed baseline regression model type, inputs, and outputs for reasonableness given facility type for projects that relied on whole-facility billing data.
- Checked the data for data entry errors, omissions, or inconsistencies by comparing project documentation to the program-tracking data extract.
- Ensured equipment models entered into PSE's savings calculation worksheets are consistent with product specifications and invoices.

[4] Levy, P.S. & S. Lemeshow. 2008. Sampling of Populations: Methods and Applications (4th Ed). Wiley: Hoboken, New Jersey.

- Identified project scope and confirmed that it aligns with what is provided in invoice and project documentation, where applicable.
- Confirmed that project-specific baseline and performance periods are appropriately defined, such that they align with project completion dates.
- Examined analysis files for formula and calculation errors for all projects regardless of the savings methodology.

As part of the onsite verification visits, we completed the following:

- Completed a walk-through of each facility to identify installed measure quantity, type, efficiency, and location (e.g., interior or exterior).
- Recorded project characteristics such as business and systems operating hours, HVAC system type, motor horsepower, and efficiency, direct digital control (DDC) energy management system control strategies and settings, overridden/manual set temperatures, or fan speeds.
- Gathered additional facility information that impact savings estimates (i.e., facility shift schedules, change in occupancy).

LPU Lighting Impact Results

Based on the sample of 12 desk reviews and 10 onsite verification visits for lighting enduse projects, we found the following:

- Small differences in operating hours: The evaluation team confirmed operating hours with onsite personnel and applied them when calculating evaluated savings. Across all 10 projects receiving an onsite visit, the evaluation team found that the majority (64%) of installed measures had operating hours identical to those in the program tracking database. However, the evaluation team confirmed that 36% of measures had operating hours that differed from the program tracking database. We found that 27% of these measures had much longer operating hours[5], and 9% of measures had much shorter operating hours[6] compared to the program tracking database.
- Nearly all tracked measures are installed and operating: Through onsite verification visits, we confirmed that nearly all (99.5%) of LPU lighting measures were in place and operating.
- Claimed savings were inconsistent for one project across multiple sources of project documentation: We identified an inconsistency in claimed kWh savings (accounting for 8% of the sampled savings) while comparing project documentation to the tracking database. The tracking database identifies claimed savings as 556,264 kWh, but project documentation instead confirms that claimed savings should have been 566,264 kWh. Ex post savings reflect those presented in project documentation, resulting in an increase of 1.8% in savings.

Table 7 shows the realization rate and precision resulting from the analysis, along with the gross impact results following the application of the realization rate. As can be seen in the table, the gross realization rate is 102%, with a relative precision of 4.5% at 90% confidence.

[5] The average verified annual hours increased by more than 250% for the 27% of lighting measures with higher operating hours. The average verified hours of use was 8,472 hours per fixture annually compared to the ex ante average of 3,177 hours per fixture.
[6] The average verified annual hours decreased by less than 50% for the 9% of lighting measures with lower operating hours. The average verified hours of use was 2,481 hours per fixture annually compared to the ex ante average of 4,572 hours per fixture.

Table 7. LPU Lighting – Realization Rate and Relative Precision at 90% Confidence

End-Use	Ex Ante Savings (kWh)	Realization Rate	Relative Precision at 90% Confidence	Ex Post Savings (kWh)
LPU Lighting	9,594,698	102%	4.5%	9,791,988

LPU Non-Lighting Impact Results

Based on the sample of 12 desk reviews and 9 onsite verification visits, we found the following:

- VFD setpoints: For one project, the onsite engineer found the VFD in hand at 30 Hz for all hours of the day (8,760 hours) for a fountain pump, which differed from the initial schedule of running at 45 Hz during occupied hours and 24 Hz during unoccupied hours. Energy savings increased by 24% for this project. This project accounted for 0.8% of the sampled savings.
- Exhaust fan VFD counts: One project consisted of VFDs installed on exhaust fans across multiple buildings on a campus. The onsite engineer found several of the exhaust fans removed from service due to a remodel and several others removed due to a building being demolished. The evaluation team probed the onsite contact for the reasons for building demolition but was not able to obtain that information. Energy savings for this project decreased by 21.5%. The project accounted for 10% of the sampled savings.
- VFD operating limit: The evaluation team identified changes in the post-retrofit conditions for one exhaust fan EF-4. Project documentation indicated after the retrofit, the VFD limit for EF-4 is 51 Hz, and the maximum CFM achieved is 5,515 CFM. However, the reported savings are based on modeled the max flow rate as the nameplate value, or 6,476 CFM, in the post-retrofit conditions. Ex post savings are based on the 5,515 CFM documented in project files and savings are reduced by 4.5% as a result. The project accounted for 1% of the sampled savings.
- Demolished building: One project consisted of multiple central plant and HVAC measures implemented across nine different buildings. The evaluation team verified on-site that one of these buildings had been demolished since installing the chiller backflow prevention valve (BPV) intended to reduce energy consumption. We removed reported savings for this measure, and the project savings are reduced by 11.2%. The project accounted for 16% of sampled savings.
- Control overrides and engineering adjustments. One project consisted of adding condenser water reset controls and variable speed drives to cooling towers and condenser water pumps for thirteen different buildings on a large corporate campus. The evaluation team learned that the condenser water reset controls were overridden in at least one building. Finally, the evaluation team determined that another building in the project was operating at a lower overall central plant efficiency (kw/ton) than assumed in the original ex ante calculations, and the savings for this building were reduced by 48% based on the updated data provided to PSE by the program participant. The above-described adjustments to these two buildings resulted in the overall realization rate of 39% for this project. This project accounts for 40% of the sampled LPU non-lighting projects savings.

Table 8 shows the realization rate and precision resulting from the analysis, along with the gross impact results following the application of the realization rate. As can be seen in the table, the gross realization rate is 79%, with a relative precision of 5.7% at 90% confidence. Notably, if the engineering adjustments described in the last bullet point above were not required, the realization rate for the non-lighting component of the LPU program would have been 96%. The LPU program draws savings from relatively few projects. Those projects, however, tend to be large and custom in nature. External influences that are out of the program's immediate control, such as building demolition and program equipment removal after successful projects completion and

closeout can have large impact on the evaluated savings. Anticipating such changes can be difficult, yet to the degree that the program can flag and monitor particularly large projects or especially risky projects based on past experience and other indicators for some time after project completion without such monitoring being detrimental to program cost-effectiveness or overly burdensome, it can help identify and make appropriate adjustments to better align ex post savings with ex ante and minimize negative shocks to the program.

Table 8. LPU Non-Lighting Realization Rate and Relative Precision at 90% Confidence

End-Use	Ex Ante Savings (kWh)	Realization Rate	Relative Precision at 90% Confidence	Ex Post Savings (kWh)
LPU Non-Lighting	9,601,401	79%	5.7%	7,584,491

Table 9 details gross impact results following the application of the lighting and non-lighting realization rates. The final realization rate is 91% at the program level.

Table 9. LPU Combined Gross Impact Results

End-Use	Ex Ante Savings (kWh)	Realization Rate	Relative Precision at 90% Confidence	Ex Post Savings (kWh)
Lighting	9,594,698	102%	4.5%	9,791,988
Non-Lighting	9,601,401	79%	5.7%	7,584,491
Total	**19,196,099**	**91%**	**3.6%**	**17,376,479**

Appendix B contains individual project realization rates, alongside ex ante and ex post savings for each.

5. Process Evaluation Findings

The evaluation team leveraged an initial interview and a follow-up interview with the LPU program manager to explore and document the key program successes and the challenges program staff faced during the 2018-2019 biennium. We also explored key planned programmatic changes as part of the interviews.

The population of qualifying customers consists of 158 unique customer accounts. In 2018, those customer accounts collectively consumed over 1,136 GWH in electricity. The 24 program participants in the 2018 and 2019 biennium represent 15% of all eligible customer accounts, and their ex post savings represent 1.7% of the eligible population's 2018 energy consumption.

PSE has a goal of engaging all qualifying customers through the program. To-date, however, program staff have fallen short of the goal. The goal of 100% customer engagement is ambitious and commendable, yet it is may be hard to reach given limited opportunities for efficiency and lack of interest in pursuing energy efficiency among some customers.

The LPU program is administered on a four-year cycle giving the participants two years to plan out and spend their funding allocation and an additional two years to implement and install the proposed energy-saving measures. The end of 2018 marked the end of the 2015-2018 program cycle, and the beginning of 2019 marked the start of the 2019-2022 cycle. The 2018-2019 biennium therefore captured portions of two cycles. Such misalignment of the evaluation cycle with the implementation cycle presents certain challenges in terms of assessing program performance against participation and savings goals. More specifically, while the program met its goal for the 2015-2018 cycle, it was too early for program staff to gauge program performance based on 2019 alone and with three more years remaining in the cycle.

One of the internal program goals is to encourage the LPU customers to use their entire budget allocation. Program engineers are assigned and proactively engage with individual customers to assist them with energy efficiency project planning and development. The program manager praised the program engineers for the amount of effort and attention that they dedicate to each customer, despite the fact that sometimes their efforts do not result in meaningful projects. Collectively, LPU participants used nearly all the budget allocated to them during the program cycle that ended in 2018 and program staff identified this as the biggest program success of the 2018-2019 biennium.

Another internal goal that the program continuously works toward is maximizing spending during the non-competitive phase of the program. However, program staff faced ongoing challenges encouraging customers to fully use their funding allocation during the non-competitive phase of the program. Despite their efforts, the program manager reported not seeing much overall change in the 2015-2018 program cycle, though some individual customers made progress towards using more of their allocation during the non-competitive phase. Consequently, in 2019, PSE made some program design changes to help customers make better use of funds during the non-competitive phase of the program. More specifically, PSE changed the program requirements to allow participants to use a share of their project funds, up to 15% or $150,000 of the total funding allocation, to complete a comprehensive energy audit of their facility. In addition, PSE gave large customers the option to choose between using their funding allocation for a specific project through the LPU program or applying for a rebate through another PSE program. It is too early in the 2019-2022 cycle to assess the effect of these changes.

Appendix A. Detailed Sample Design and Results Extrapolation Methodology

Determination of Strata Boundaries Using the Dalenius-Hodges Method

The Dalenius-Hodges method begins with the creation of numerous and narrow strata. Within each stratum, the frequency of coupons, f(y), is calculated. Next, the square root of f(y), $\sqrt{f(y)}$, is calculated and the cumulative of $\sqrt{f(y)}$ is formed. The total cumulative $\sqrt{f(y)}$ is then divided by the number of desired strata to determine the division points on the cumulative $\sqrt{f(y)}$ scale.

The above rule assumes equal widths, d, for the class intervals, and it must be modified when the class intervals have variable widths dy. The approach recommended by Kish[7] is to multiply the f(y) by the width of the interval, take the square root of this value, and cumulate the values $\sqrt{d_y f(y)}$. Finally, as in the above case, the total of cumulative $\sqrt{d_y f(y)}$ is then divided by the number of desired strata to determine the division points on the cumulative $\sqrt{d_y f(y)}$ scale.

Optimal Allocation Using the Neyman Allocation Method

Once strata boundaries have been determined, an allocation scheme is used to estimate the population mean with the lowest variance for a fixed total sample size n under stratified random sampling. Such a scheme is the Neyman allocation, as described in Cochran.[8]

$$n_h = n \frac{N_h s_h}{\sum N_h s_h}$$

where:

Nh = the total number of units in stratum h

nh = the number of units in the sample of stratum h

n = the total number of units in the sample across all strata

sh = the variance within stratum h

This formula for optimal allocation may produce an nh in some stratum that is larger than the corresponding Nh. This problem can arise in the plan for the verification of rebate program savings since the overall sampling fraction is large, and some strata are much more variable than others. If the original allocation gives, for example, a n1 that is greater than N1, then equation 1 is revised as follows:

$$n_h = (n - N_1) \frac{N_h s_h}{\sum_2^L N_h s_h}$$

If the original allocation gives, for example, an n1 that is greater than N1 and an n2 that is greater than N2, then equation 2 is revised as follows:

[7] Kish, L. (1995). *Survey Sampling.* Wiley Classics Library Edition.
[8] Cochran, W. G. (1977). *Sampling Techniques.* Hoboken: John Wiley & Sons, Inc.

$$n_h = (n - N_1 - N_2)\frac{N_h s_h}{\sum_3^L N_h s_h}$$

Using the approach just described, the sample design for all of our samples was expected to provide statistically valid impact results, at least at the 90% confidence level ±10% for the projects overall based on demand.

Stratified Ratio Estimator Adjustment Method

We used the following approach to extrapolate results from the sampled projects back to the overall population. We applied this method to each of the two technology samples (lighting and non-lighting)

$$r_{strc} = \frac{\bar{y}_{str}}{\bar{x}_{str}}$$

Where:

$r_{strc} =$ stratified-combined ratio of ex-post to ex-ante sample estimates, or realization rate

$\bar{y}_{str} =$ stratified sample ex post mean

$\bar{x}_{str} =$ stratified sample ex ante mean

The variance of the ratio is given by:

$$Var(r_{strc}) = \left(\frac{1}{N^2\overline{X}^2}\right)\sum_{h=1}^{L}\frac{N_h^2(N_h - n_h)}{n_h(N_h - 1)}\sigma_{hz}^2$$

$N_h =$ Number of participants in population of stratum h

$n_h =$ Number of participants in sample of stratum h

$\bar{y}_h =$ Estimated ex post sample mean in stratum h

$\bar{x}_h =$ Estimated ex ante sample mean in stratum h

And

$$\sigma_{hz}^2 = \sigma_{hy}^2 + R^2\sigma_{hx}^2 - 2R\rho_{hxy}\sigma_{hy}\sigma_{hx}$$

Where:

R = Ratio or realization rate

$\hat{\sigma}_{hy}^2 =$ Estimated variance of the ex post savings in stratum h

$\hat{\sigma}_{hx}^2 =$ Estimated variance of the ex ante savings in stratum h

$\hat{\rho}_{hxy} =$ Estimated correlation between X and Y in stratum h

The standard error is calculated as the square root of the variance.

Appendix B. Verified Savings by Sampled Project

This appendix provides realization rates for each sampled project, alongside ex ante and ex post savings associated with each project.

Table 10. Verified Savings by Sampled Project

#	Project Number	Project Type	Evaluation Scope	Ex Ante Savings (kWh)	Ex Post Savings (kWh)	Realization Rate	Summary of Findings
1	P_643672	Lighting	Desk Review and Onsite Verification	479,242	479,245	100.0%	Confirmed ex ante savings
2	P_545068	Lighting		834,662	1,172,020	140.4%	Increase in hours of use by 274% for ~30% of project lighting measures; 6 fewer 2x2 troffers verified onsite
3	P_664682	Lighting		2,623,209	2,623,209	100.0%	Confirmed ex ante savings
4	P_545092	Lighting		136,751	144,108	105.4%	Increase in hours of use by ~6% for 100% of project lighting measures
5	P_600675	Lighting		41,568	30,862	74.2%	Decrease in hours of use by ~30% for 98% of project lighting measures; 2 fewer LED lamps verified onsite
6	P_612208	Lighting		216,850	216,850	100.0%	Confirmed ex ante savings
7	P_612215	Lighting		257,170	257,170	100.0%	Confirmed ex ante savings
8	P_549993	Lighting		311,111	141,743	45.6%	Decrease in hours of use by ~60% for ~95% of measures
9	P_545099	Lighting		408,395	376,039	92.1%	34 fewer LED pole fixtures verified onsite
10	P_545111	Lighting		599,263	599,263	100.0%	Confirmed ex ante savings
11	P_645370	Lighting	Desk Review Only	556,264	566,264	101.8%	Difference in 10,000 kWh savings between tracking database and project documentation.
12	P_545103	Lighting		556,682	556,682	100.0%	Confirmed ex ante savings
13	P_625380	Non-Lighting	Desk Review Only	766,775	766,775	100.0%	Confirmed ex ante savings
14	P_545084	Non-Lighting	Desk Review and Onsite Verification	179,746	179,746	100.0%	Confirmed ex ante savings
15	P_545100	Non-Lighting		55,411	68,564	123.7%	VFD found in hand at 30 Hz
16	P_545112	Non-Lighting		2,654,872	1,035,733	39.0%	Adjusted engineering assumptions, accounted for control overrides, and made adjustments for overall central plant efficiency
17	P_545064	Non-Lighting		84,330	84,330	100.0%	Confirmed ex ante savings
18	P_545094	Non-Lighting		640,233	502,519	78.5%	Buildings and exhaust fans part of retrofit were demolished
19	P_545097	Non-Lighting		1,070,633	950,558	88.8%	Building and central plant part of retrofit was demolished
20	P_545091	Non-Lighting		311,612	311,612	100.0%	Confirmed ex ante savings

Verified Savings by Sampled Project

#	Project Number	Project Type	Evaluation Scope	Ex Ante Savings (kWh)	Ex Post Savings (kWh)	Realization Rate	Summary of Findings
21	P_545069	Non-Lighting		193,316	193,316	100.0%	Confirmed ex ante savings
22	P_545104	Non-Lighting		68,832	65,712	95.5%	Slight difference in max operational CFM for one of the exhaust fans
23	P_643672	Non-Lighting		25,920	25,920	100.0%	Confirmed ex ante savings
24	P_600116	Non-Lighting	Desk Review Only	644,768	644,768	100.0%	Confirmed ex ante savings

For more information, please contact:

Kessie Avseikova
Director

617-301-4632 tel
617-497-7944 Fax
kavseikova@opiniondynamics.com

1000 Winter Street
Waltham, MA 02451

PUGET SOUND ENERGY

Evaluation Report Response

Large Power User Program, 2018-19

A. Overview

Puget Sound Energy's (PSE's) Large Power User (LPU) Program provides funding support for large non-residential customers receiving electric service under schedules 40, 46, and 49, to implement self-directed custom electric energy-efficient upgrades. These customers are eligible for a funding allocation from PSE based on their electric usage and submit proposals for energy efficiency projects to PSE that take advantage of their allocation. Examples of potential upgrades include HVAC, refrigeration, operational improvements, building thermal improvements, building envelopes, controls, lighting improvements, water heating, and strategic energy management.

PSE hired Opinion Dynamics Corporation (ODC) to evaluate the program's performance throughout the biennium. The primary objective was to evaluate the electric savings associated with the program, document any key program changes, and document the program's success and challenges from the perspective of key program management staff. ODC derived evaluation findings in this report from in-depth interviews with key program management staff, a review of program materials and tracking data, and an engineering analysis of energy savings based on a desk review of 24 projects and site visits to 19 participating customers.

Over the biennium, 24 customers[1] completed 43 projects resulting in 19,196 MWH electric savings. The 24 customers who participated in the program over the course of 2018 and 2019 represent 15% of all eligible customer accounts, and their ex post savings represent 1.7% of the eligible population's 2018 energy consumption.

Summary of Evaluation Results

Overall, the realization rate for the LPU Program is 91%. Realization rate for lighting enduse is 102% and is primarily due to upward adjustments in the facility operating hours. Realization rate for non-lighting enduse is 79%. The key driver of the realization rate is overrides to condenser water resets and adjustments to the engineering calculations for a large project.

Evaluation Considerations and Recommendations and Program Responses

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Consideration #1*: Increase monitoring of projects with disproportionate impacts on savings.*

"To the degree possible, the program should consider flagging and monitoring particularly large or especially risky projects based on past experience and other indicators upon project completion, as this can help identify changes to building conditions or project measures that can negatively impact the

[1] Defined as unique accounts.

savings. This information can help program staff make appropriate adjustments to assist in better alignment of ex post savings with ex ante, thus minimizing negative shocks for the program at the evaluation stage. Such monitoring however should not be detrimental to program cost-effectiveness or overly burdensome for program staff to implement. Such monitoring could be done via follow-on outreach to the participating facility staff and/or follow-on review of the facility consumption data." *P. 7*

***PSE Response** (From Jeff Petersen):* In the Large Power User (LPU) program, PSE evaluates customer-supplied energy efficiency projects, validates energy savings claims prior to construction, and verifies project performance during the verification and closeout phases truing up savings claims when necessary. During the verification and closeout phases, PSE will use site visit information and collected data to verify the grant payment conditions were met. When all projects requirements for verification are satisfied, PSE pays the incentive with the expectation that resulting energy savings will persist. Occasionally due to circumstances beyond PSE's control, efficiency measures are overridden or cease to deliver expected energy savings.

Post-closeout follow-on monitoring often involves additional resources and time commitments that can be burdensome to customer facility staff. Also, specific measure energy savings may not be apparent through facility consumption data review.

PSE will continue to review submitted projects focusing on supporting data, standard engineering calculations, past experience and post-installation documentation to validate energy savings. For projects with a high savings uncertainty, PSE may require additional measure-specific data or an extended verification period prior to grant payment.

***Consideration #2:** Align evaluation cycles with program cycles*

"The LPU program is administered on a four-year cycle giving the participants two years to plan out and spend their funding allocation and an additional two years to implement and install the proposed energy-saving measures. The end of 2018 marked the end of the 2015-2018 program cycle, and the beginning of 2019 marked the start of the 2019-2022 cycle. The 2018-2019 biennium therefore captured portions of two cycles. Such misalignment of the evaluation cycle with the implementation cycle presents certain challenges in terms of assessing program performance against participation and savings goals. More specifically, while the program met its goal for the 2015-2018 cycle, it was too early for program staff to gauge program performance based on 2019 alone and with three more years remaining in the cycle." *P. 6*

"Program staff should consider aligning the evaluation cycle with the program cycle as a way to allow for more effective assessment of program performance and providing timely recommendations to inform planning of the new cycle." *P. 7*

***PSE Response (**From Kasey Curtis, Senior Market Analyst):*

We understand the challenge of evaluating programs with multi-year cycles, and will in the future attempt to align the program cycles with the evaluation cycle, starting with the next LPU evaluation in 2024.
