PSE PUGET SOUND ENERGY

Evaluation Report Response

Program: Commercial Programs

Program Manager: Leslie Wright, Commercial Programs Manager

Study Report Name: Final Report 2022-2023 Non-Residential Program Evaluation

Draft Report Date: December 21, 2023

Evaluation Analyst: Kasey Curtis

Date of Final Report Provided to Program Manager: January 2, 2024

Date of Program Manager Response: January 18 – 25, 2024

Overview

The Evaluation Report report summarizes the results of the 2022-2023 biennium impact and process evaluations of six Puget Sound Energy (PSE) non-residential programs for program years (PY) 2021-2022. In the report, the program evaluator (DNV) presents results for the following programs:

Schedule 250

- Custom Lighting Grants (BLi)
- Retrofit Custom Grants (Commercial and Industrial [C&I] Retrofit)
- Industrial Energy Management (IEM)

Schedule 262

- Commercial Heating, Ventilation, and Air Conditioning (HVAC) Rebates (PY2021 only)
- Commercial Midstream HVAC and Water Heating

Schedule 258

- Large Power Users (LPU) 449 and non-449 (2019-2022 program cycle)

These programs offer incentives to C&I customers through downstream rebates, midstream rebates through retailers for high-efficiency HVAC and water heating equipment, and a self-directed program for LPU customers. These programs accounted for approximately 54% of PSE's C&I electricity savings and 76% of C&I natural gas savings during the past four program years, 2019-2022.

Evaluation

The primary evaluation objectives, associated research activities, and researchable issues for the impact and process evaluations are described below:

Impact evaluation: Measure energy savings by independently reviewing savings estimation methodologies and verifying savings achievement through file reviews and interviews, determine ratio of savings achieved to savings tracked, and evaluate other key performance indicators (KPIs) for each evaluated program.

Process evaluation: Provide process findings for the programs from the perspective of the program participants. Assess how well the programs are achieving their objectives, provide information on why programs are over/underperforming, and suggest recommendations for improvements.

Key Findings, Recommendations, and PSE Response

This section provides key findings with recommendations resulting from DNV's evaluation, along with PSE's response to the recommendations. The evaluation contains other key findings which do not include recommendations (generally as they reflected positively upon the program and did not merit recommendations), which for the sake of brevity are omitted from this Evaluation Report Response.

Business Lighting Custom Grants:

Key Finding – DNV found that the provided project files were mostly complete. However, about 20% of evaluated BLi site folders didn't include the final version of the BLi calculator that matched the tracked savings or the paid incentive. In each of these cases, DNV worked with PSE or referred to the final quality control (QC) submittal to collect the final savings analysis.

Recommendation – PSE should include the final savings analysis that supports the reported savings and paid incentive in the project folder.

PSE Response

> *Including the lighting calculators that support the savings is a policy of the Business Lighting Program. In these cases, it would appear that the lighting calculators did not match the final claimed savings. This is apparently a step missed during QA/QC for the projects. The Business Lighting Program will include additional training to program staff on the importance of this step, and will be periodically re-emphasized during team meetings.*

Commercial and Industrial Retrofit Custom Grants:

Key Finding – Errors in savings calculation formulas occurred in two sample projects and resulted in a large variance for one site, which ultimately had a significant impact on the program's realization rate. For this site, the applicant calculated total motor power draw using total current rather than average current which overestimated the baseline energy use by 67%.

Recommendation – Projects going through quality assurance (QA) and QC review should verify that the power draw of the equipment is being calculated.

PSE Response

We acknowledge the error. We investigated the source of the error on the larger variance and discovered that the calculations provided to us by the customer contained a formula error in a spreadsheet, and we missed the step of going through the calculations and verifying the information. The engineers involved have been alerted to this error and we will address this variance with additional training and awareness by the engineering teams.

Key Finding – DNV adjusted the calculation methodology for several sites to account for loads that impact the energy savings of the project based on measure type and intended operation, such as weather, production, infiltration, etc. In some of these cases, when the applicant's analysis did not reflect the facility or incentivized equipment loads, we performed a consumption analysis to determine project savings.

Recommendation – The applicant should normalize project savings based on drivers of energy consumption for the project, including weather and non-weather-related drivers.

PSE Response

When appropriate, PSE performs weather and non-weather-related normalizations. Typically for more complex measures or measures with higher levels of interactive effect (such as Controls, Commissioning and Tune-up measures), we perform a regression analysis using variables relevant to the measures completed and adjust for customer-reported changes in building operations that affect energy consumption. In this case, it was not reported through our Facility Change Form that a tenant change occurred. PSE is in the process of developing M&V guidelines to enhance our post-installation verification routines that is intended to prevent these variances in the future.

Key Finding – Due to a non-routine event, we were unable to evaluate a full year of trend data for the combined heat and power (CHP) system. As a result, we had to assume that operation of the CHP based on 6 months of data would apply to the rest of the year. However, assuming identical system availability adds uncertainty to the evaluated savings. Additional uncertainty was introduced because the facility did not have electric net meter data to assess if the surplus electricity generated returned to the grid.

Recommendation – For future CHP projects, PSE should ask the implementer to develop a detailed measurement and verification (M&V) plan metering all grid and onsite energy (and mass and temperature/enthalpy) streams and agree to provide M&V data for 1 full year.

PSE Response

We acknowledge this variance and we believe the evaluator's recommendation is sound. For unrelated reasons, PSE has decided that we will not be incentivizing any more gas GHP projects in the future, but this recommendation will be implemented should that policy change.

Commercial Midstream HVAC and Water Heating

Key Finding – Based on our review of measure case and savings algorithm documentation, DNV concluded that PSE's algorithms and assumptions used to calculate project savings are reasonable. DNV confirmed changes made to the measure case assumptions between the annually updated measure case documentation and concluded that PSE is making the appropriate effort to update their measure case assumptions.

Key Finding – DNV found that multiple premises did not use the appropriate measure case documentation to determine project savings. Several condensing hot water heater measures were using the outlined baseline efficiency from 2020-2021, rather than using the updated baseline efficiency that was detailed in the 2022 measure case documentation. DNV updated the measure case use based on product sale data in the database.

Recommendation – Communicate the reasoning behind changes to the measure case documentation. Remind implementers to use the measure case document that corresponds to the product sale data which should be input and confirmed by PSE.

PSE Response

> *We acknowledge the error and tracked down the instances where this occurred. Given that measure cases often change from one year to the next, and we depend on program implementers to make these adjustments in their documentation, the program will institute an additional quality control check in the future: At the beginning of each year, program staff will carefully review the first set of documentation that comes to PSE from the implementer, review the measure parameters used, and ensure all changes made in the previous year are active in their documentation. Doing so should help avoid these errors in the future.*

Key Finding – This is a successful program with significant energy savings and participants who are satisfied with the program overall.

Key Finding – Contractors are not being informed of year-to-year program changes to qualifying products.

Key Finding – There is an ongoing administrative burden of providing and verifying physical addresses to approve payment.

PSE Response

> *We acknowledge these findings and although they did not provide any recommendations, we will take steps to ensure contractors are better informed about product changes. We are also aware of the administrative burden, which is the result of our ongoing efforts to balance the need for rigorous verification with the need to keep program participants satisfied and motivated to participate.*

Commercial HVAC Rebates

Key Finding – This program has been successful in meeting energy savings goals, recent participation has been the result of active participation by a handful of contractors, and the digital outreach efforts have increased traffic to the program website.

PSE Response

Noted and acknowledged.

Key Finding – The evaluation team verified the quantity and equipment type installed and in use for all evaluated projects. The measure case savings algorithms for all measures were appropriate. The realization rates reflect adjustments to the measure case savings for incorrect application of unit energy savings (UES). The Commercial HVAC Rebates program is achieving 98% of tracked electricity savings and 12% of tracked natural gas savings.

Recommendation – Review program measure cases with staff approving applications in this program to reduce incorrect UES savings application for these measures in the future.

PSE Response

PSE appreciates the recommendation and will review this finding with program staff to make them aware that UES savings have been missed, and our policy is to correct these inconsistencies during the application review.

Key Finding – Thermostats are not a high profit center for contractors, so unless they are already doing an HVAC installation, they are not likely to take the job of installing a thermostat.

PSE Response

The program recognizes that thermostat-only measures are not profitable for contractors. To remedy this, the program is considering expanding our direct install program for thermostats, as well as combining thermostats with maintenance and tune-up measures, though these expanded offerings may not be implemented through the Commercial HVAC program.

Large Power User Program

Key Finding – Evaluated lighting projects submitted under the LPU program achieved high realization rates. We were able to verify savings inputs and determined that the calculation methodology was reasonable.

Key Finding – DNV identified four instances where the measures were not implemented, had been removed at the time of evaluation, or were not implemented as scoped at the time of the project application, which significantly impacted the project savings.

Recommendation – Increase verification measures and/or change post-inspection protocols if the project is expected to save over a certain threshold.

PSE Response

We acknowledge the changes to customer behavior that resulted in the variances. It is sometimes difficult to predict when unexpected operational changes result in measures being removed or not fully implemented. It can be especially difficult for this program, which is limited *to participation by the largest of PSE's customers, which mean longer term engagements with customers possessing large campuses. It is the program's policy that we do full verification prior to issuing an incentive, but in some cases it is not practical or imposes a burden on customers to verify, for instance, every fixture installed across a wide campus, phased in over a period of time. But these projects did not meet our standards for verification, and the results will be shared with our engineers and use as training to better improve verification. The program will also implement steps to prevent errors in these cases, for example, putting more of the onus on customers to provide more detail, for example, the site plan, as-builts, and maps of installation.*

Key Finding – In evaluating an ongoing, multi-year commissioning project, DNV identified that the measures were not implemented/operating based on evaluation period performance trends. Though savings were present in the comparison of pre- and post-installation periods, we identified that the savings were due to a change in facility operation, not the described measures. Since the scoped measures were not implemented, this project could not claim savings attributable to the program.

Recommendation – Change ongoing commissioning verification protocols.

PSE Response

The evaluation result of this project is one of those rare times when PSE must respectfully disagree with the evaluation team. We've engaged in several discussions with the evaluators and internally among our engineers, and we don't believe that the realization rate for this project (9%) is an accurate estimate of savings. Differences of opinion are common in projects like this, where ongoing commissioning achieves savings from multiple and varied sources of HVAC controls and operations that can be corrected, and indications of fault or improvement can be based on indirect measurements. The reasons we disagree with this finding include:

1) Sample limitations: the evaluators drew a sample of projects and measures which are based on a statistical probability that these measures and projects are representative of the whole. PSE believes that the sample drawn in this project- six buildings out of 62 buildings that were involved in this large and complex project- cannot adequately capture the savings from the project. Moreover, the evaluator analyzed a set of six "measure corrections" that can result in savings, but this was within a field of 151 individually listed measure corrections that were identified and corrected by the implementer.

2) Incomplete analysis: The evaluation included savings measures for five categories of detected faults or inefficiencies, representing approximately 49% of the claimed savings for the measure. However, the evaluation did not consider an additional 31 fault correction categories which can also result in savings.

3) Our own billing analysis of the sites indicate that savings is being achieved at the site, though we understand that that alone doesn't prove that the measures themselves are responsible for the savings.

Broadly speaking, we don't believe the sampling approach or evaluation measurements taken could sufficiently develop a conclusion on the realization rate on a project of this size and *complexity, nor does the evaluation support the conclusion that any savings was due solely to changes in operations or occupancy. We acknowledge that the scope of an evaluation must be scaled to the value it could provide, and evaluations use methods like statistical sampling to mitigate the potential cost to ratepayers of providing a longer, more thorough and costly review.*

PSE stands by the savings estimates we reported, but despite our disagreement, this project and its evaluation provided a valuable learning experience for the program. Since this project is ongoing, we have opportunities to carefully monitor the implementation and mitigate potential risks that DNV has identified.

Key Finding – An error in a savings calculation formula resulted in a large variance for one site. For this site, the applicant calculated total motor power draw using total current rather than average current which overestimated the baseline energy use by 67%.

Recommendation – Projects going through QA/QC review should verify that the power draw of the equipment is being calculated correctly.

PSE Response

The program acknowledges that the calculation error resulted in a variance. In this case the data presented to PSE from the customer was incorrect, which our process would ordinarily capture but was missed. We used this example as a training tool – the EME who missed the error in review presented the project at our Commercial Programs Technical meeting, explaining how the error occurred and alerted all other EMEs to be aware of similar errors in the future.

Key Finding – In the recently completed 4-year LPU program cycle (2019-2022), total energy savings, the percentage of total funding allocation spent, and participation rate by eligible customers all decreased from the previous 4-year cycle (2015-2018). While the COVID-19 pandemic and associated effects likely played a role in those outcomes, most of the nonparticipating customers that DNV spoke with cited difficulty identifying cost-effective, qualifying projects as a barrier, which will make growing and even maintaining program participation and savings difficult.

Recommendation – Given these challenges, work to identify program design and/or delivery changes in the current 4-year cycle specifically intended to increase participation and savings. Based on evaluation work to date, items to consider include:

- Work to align the LPU Program with other (even non-energy efficiency) programs to widen customers' options for reducing energy usage and emissions and provide a more holistic approach (e.g., possibly including electrification).
- Develop and provide case studies to help key staff within eligible customer organizations to better obtain decision-maker support.

PSE Response

This finding matches the Program's experience. We have found that participation has lagged across many of our programs, due to post-covid uncertainty as to how commercial buildings will be occupied based on decisions from leaseholders. In many cases building owners are deferring *improvements until their occupant's plans for the workforce are better understood. The Large Power User program has the additional constraint of having a limited set of customers to draw from, given that the program serves a specific tariff class limited to large users that doesn't tend to grow or shrink substantially. To respond to those challenges, the program has implemented an SEM implementation model for many customers beginning in 2025, which intended to acquire more operational savings and reinforce customer relationships. We've also implemented a grant for customers, which will pay up to $150 or 15% of their allocation as an up-front grant with no savings requirements to conduct engineering studies, responsive to the feedback that customers have difficulty in knowing what projects to undertake.*

Industrial Energy Management Program

Key Finding – DNV found that the Industrial System Optimization Program (ISOP) and Industrial Strategic Energy Management (ISEM) subprograms were both achieving savings and determined that the methods used for calculating savings were reasonable for each project's characteristics.

PSE Response

Noted and appreciated.

Key Finding – Two sites had differences in savings due to adjustments to how production data is used in the analysis. For one site, the applicant's analysis did not normalize or account for the change in production volume between the baseline and installed period. In a second site, the applicant used the whole plant energy use intensity (EUI) rather than the extruder EUI. The plant EUI included the effects of other large power users at the facility, which distorted the savings estimate based on variations in facility operation.

Recommendation – If implemented, measure operation is dependent on production volume or other non-weather drivers, the data should be incorporated into the analysis and used to normalize facility consumption to reflect savings from the measure exclusively.

PSE Response

We acknowledge the variances and note that since these two projects were implement, the Industrial programs have implemented different M&V procedures. We've created a standardized M&V procedure guide, which we had reviewed by the evaluator DNV and is now in use. The projects described in the evaluation relied on the expertise of specific engineers. The program also has a dedicated person reviewing project M&V plans. In addition, for larger or more complex projects, it's our practice to hire an independent consulting independent engineer to conduct M&V and then true-up estimated savings.

Key Finding – Incentives provided by the ISEM offering ($0.02/kWh saved, capped at $25,000 annually) garnered the lowest satisfaction rating among participants (3.9 on the five-point scale), and half of respondents (5 of 10) did not agree that current incentives were adequate to motivate other (new) customers to participate.

PSE Response

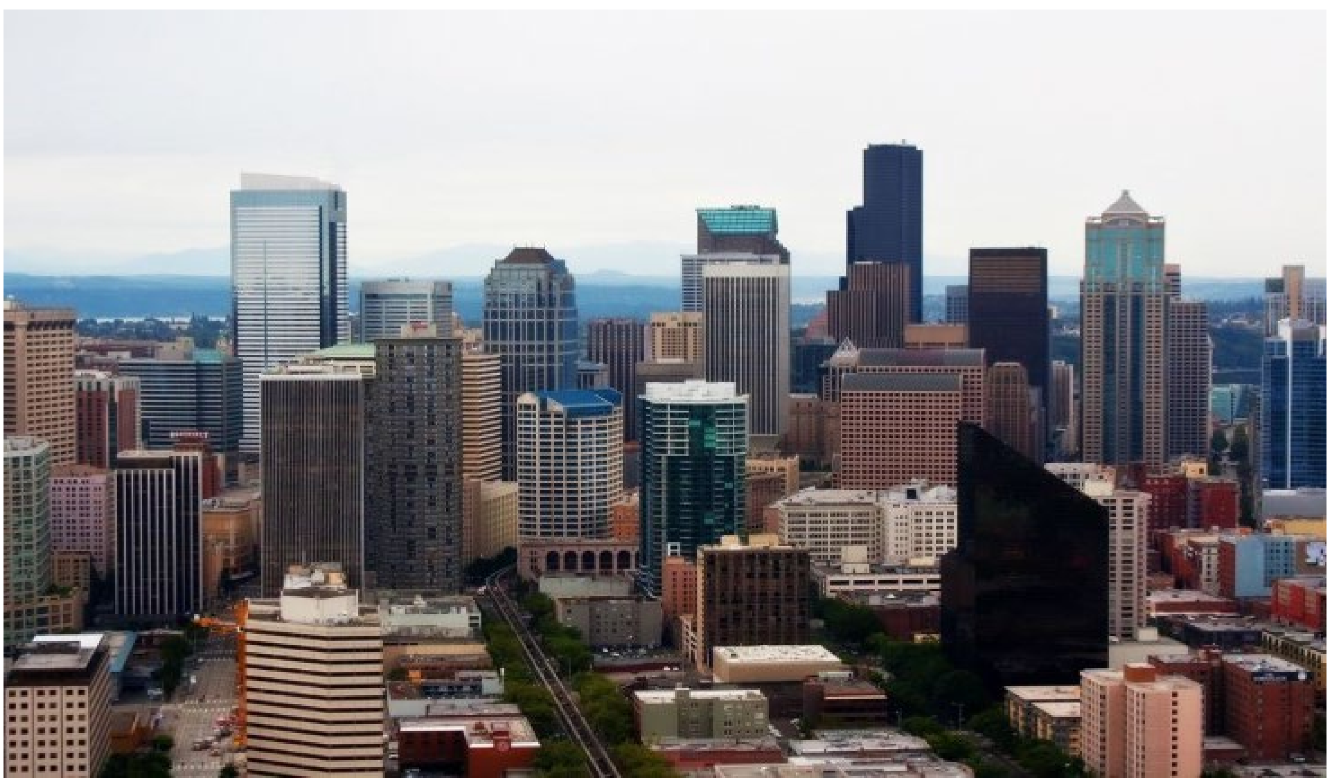
It should be noted that in addition to the direct incentives the program provides, we also provide engineering support in the form of an outside implementation contractor to the customer that provides valuable project support. But to the point of the finding, the program has also heard feedback from participants that the incentives may be inadequate to spur projects, so starting in 2024, we have doubled our incentives to $0.04/kWh, capped at $50,000. We believe this addresses the finding.

NON-RESIDENTIAL

Final Report
2022-2023 Non-Residential Program Evaluation

Puget Sound Energy

Date: December 21, 2023



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1 EXECUTIVE SUMMARY

Puget Sound Energy (PSE) hired DNV to complete an independent evaluation of the program years (PY) 2021-2022 non-residential energy efficiency programs for the 2022-2023 evaluation biennium. This report presents the methods, results, and findings of the evaluation of six non-residential compliance programs. The goal of the evaluation was to independently estimate program savings performance and identify opportunities to improve each of the evaluated programs.

1.1 Background and Approach

DNV completed independent evaluations of six PSE compliance programs delivered under three different Tariff Schedules: Custom Lighting Grants (Business Lighting [BLi], Retrofit Custom Grants (Commercial & Industrial [C&I] Retrofit), Industrial Energy Management (IEM), Commercial Heating, Ventilation, and Air Conditioning (HVAC) Rebates, Commercial Midstream HVAC and Water Heat, and Large Power User (LPU) 449 and Non-449. Each impact evaluation includes an independent estimate of the ratio of energy savings being realized by each program to the energy savings tracked by PSE, referred to as the program realization rate. Impact and process evaluation methods were based on the program design, measures offered, and historic program performance. In general, each program was evaluated based on our review of program documentation and a representative sample of completed projects.

1.2 Evaluation Results

The primary results of our evaluation are program realization rates estimated through our impact evaluation activities (see Table 1-1). These realization rates are an independent estimate of the ratio of achieved savings to tracked savings for the 2022-2023 biennium. The relative precisions are calculated at the 90% confidence interval and represent the relative precision of the resulting energy savings estimated after the realization rate is applied.

Table 1-1. Evaluated program realization rates

Tariff Schedule	PSE Program	Electricity Savings (kWh)		Gas Savings (Therms)	
		Realization Rate	Relative Precision at 90% Confidence Interval	Realization Rate	Relative Precision at 90% Confidence Interval
E/G 250	Custom Lighting Grants (BLi)	94%	5%	N/A	N/A
	Retrofit Custom Grants (C&I Retrofit)	88%	29%	90%	7%
	IEM	121%	24%	98%	4%
E/G 262	Commercial HVAC Rebates	98%	9%	12%	52%
	Commercial Midstream HVAC and Water Heating	97%	8%	91%	7%
E 258	LPU 449 and Non-449	71%	17%	N/A	N/A

1.3 Key Evaluation Findings and Recommendations

This section provides key findings and recommendations resulting from DNV's evaluation. Additional findings are presented within each program-specific section.

1.3.1 Custom Lighting Grants (BLi)

- **Key Finding** – This program is achieving a high realization rate of 94% of tracked electric savings. We found that the calculation methodology used to determine project savings was reasonable and that the submitted project scope accurately reflected the installed projects.
- **Key Finding** – DNV found that the provided project files were mostly complete. However, about 20% of evaluated BLi site folders didn't include the final version of the BLi calculator that matched the tracked savings or the paid incentive. In each of these cases, DNV worked with PSE or referred to the final quality control (QC) submittal to collect the final savings analysis.
    - **Recommendation** – PSE should include the final savings analysis that supports the reported savings and paid incentive in the project folder.
- **Key Finding –** Both customers and participating contractors are largely very satisfied with the BLi program. Of all the program aspects DNV asked about, only one (contractor satisfaction with program application/paperwork) received less than an average of 4.5 on the five-point satisfaction scale. Satisfaction with personal interaction with PSE staff stood out as particularly high, with averages of 5.0 and 4.8 for contractors and customers, respectively. Most contractors thought other utility lighting incentive programs could learn from PSE, and several favorably compared the BLi program to other utility programs in the region.

1.3.2 Retrofit Custom Grants (C&I Retrofit)

- **Key Finding** – Errors in savings calculation formulas occurred in two sample projects and resulted in a large variance for one site, which ultimately had a significant impact on the program's realization rate. For this site, the applicant calculated total motor power draw using total current rather than average current which overestimated the baseline energy use by 67%.
    - **Recommendation** – Projects going through quality assurance (QA) and QC review should verify that the power draw of the equipment is being calculated correctly.
- **Key Finding** – DNV adjusted the calculation methodology for several sites to account for loads that impact the energy savings of the project based on measure type and intended operation, such as weather, production, infiltration, etc. In some of these cases, when the applicant's analysis did not reflect the facility or incentivized equipment loads, we performed a consumption analysis to determine project savings.
    - **Recommendation** – The applicant should normalize project savings based on drivers of energy consumption for the project, including weather and non-weather-related drivers.
- **Key Finding** – Due to a non-routine event, we were unable to evaluate a full year of trend data for the combined heat and power (CHP) system. As a result, we had to assume that operation of the CHP based on 6 months of data would apply to the rest of the year. However, assuming identical system availability adds uncertainty to the evaluated savings. Additional uncertainty was introduced because the facility did not have electric net meter data to assess if the surplus electricity generated returned to the grid.
    - **Recommendation** – For future CHP projects, PSE should ask the implementer to develop a detailed measurement and verification (M&V) plan metering all grid and onsite energy (and mass and temperature/enthalpy) streams and agree to provide M&V data for 1 full year.

- **Key Finding** – Overall, the program is successful and well-run from a process perspective. Goals and key performance indicators (KPIs) are being met, and participants are very satisfied with the program across key aspects.
- **Key Finding** – There is uncertainty from program staff around reasons for program intake slowing down recently.

1.3.3 Industrial Energy Management

- **Key Finding** – DNV found that the Industrial System Optimization Program (ISOP) and Industrial Strategic Energy Management (ISEM) subprograms were both achieving savings and determined that the methods used for calculating savings were reasonable for each project's characteristics.
- **Key Finding** – Two sites had differences in savings due to adjustments to how production data is used in the analysis. For one site, the applicant's analysis did not normalize or account for the change in production volume between the baseline and installed period. In a second site, the applicant used the whole plant energy use intensity (EUI) rather than the extruder EUI. The plant EUI included the effects of other large power users at the facility, which distorted the savings estimate based on variations in facility operation.
    - **Recommendation** – If implemented, measure operation is dependent on production volume or other non-weather drivers, the data should be incorporated into the analysis and used to normalize facility consumption to reflect savings from the measure exclusively.
- **Key Finding** – Incentives provided by the ISEM offering ($0.02/kWh saved, capped at $25,000 annually) garnered the lowest satisfaction rating among participants (3.9 on the five-point scale), and half of respondents (5 of 10) did not agree that current incentives were adequate to motivate other (new) customers to participate.

1.3.4 Commercial HVAC Rebates

- **Key Finding** – This program has been successful in meeting energy savings goals, recent participation has been the result of active participation by a handful of contractors, and the digital outreach efforts have increased traffic to the program website.
- **Key Finding** – The evaluation team verified the quantity and equipment type installed and in use for all evaluated projects. The measure case savings algorithms for all measures were appropriate. The realization rates reflect adjustments to the measure case savings for incorrect application of unit energy savings (UES). The Commercial HVAC Rebates program is achieving 98% of tracked electricity savings and 12% of tracked natural gas savings.
    - **Recommendation** – Review program measure cases with staff approving applications in this program to reduce incorrect UES savings application for these measures in the future.
- **Key Finding** – Thermostats are not a high profit center for contractors, so unless they are already doing an HVAC installation, they are not likely to take the job of installing a thermostat.

1.3.5 Commercial Midstream HVAC and Water Heating

- **Key Finding** – Based on our review of measure case and savings algorithm documentation, DNV concluded that PSE's algorithms and assumptions used to calculate project savings are reasonable. DNV confirmed changes made to the measure case assumptions between the annually updated measure case documentation and concluded that PSE is making the appropriate effort to update their measure case assumptions.
- **Key Finding** – DNV found that multiple premises did not use the appropriate measure case documentation to determine project savings. Several condensing hot water heater measures were using the outlined baseline efficiency from 2020-2021, rather than using the updated baseline efficiency that was detailed in the 2022 measure case documentation. DNV updated the measure case use based on product sale data in the database.

- Recommendation – Communicate the reasoning behind changes to the measure case documentation. Remind implementers to use the measure case document that corresponds to the product sale data which should be input and confirmed by PSE.

- **Key Finding** – This is a successful program with significant energy savings and participants who are satisfied with the program overall.
- **Key Finding** – Contractors are not being informed of year-to-year program changes to qualifying products.
- **Key Finding** – There is an ongoing administrative burden of providing and verifying physical addresses to approve payment.

1.3.6 Large Power User 449 and Non-449

- **Key Finding** – Evaluated lighting projects submitted under the LPU program achieved high realization rates. We were able to verify savings inputs and determined that the calculation methodology was reasonable.
- **Key Finding** – DNV identified four instances where the measures were not implemented, had been removed at the time of evaluation, or were not implemented as scoped at the time of the project application, which significantly impacted the project savings.
  - **Recommendation** – Increase verification measures and/or change post-inspection protocols if the project is expected to save over a certain threshold.
- **Key Finding** – In evaluating an ongoing, multi-year commissioning project, DNV identified that the measures were not implemented/operating based on evaluation period performance trends. Though savings were present in the comparison of pre- and post-installation periods, we identified that the savings were due to a change in facility operation, not the described measures. Since the scoped measures were not implemented, this project could not claim savings attributable to the program.
  - **Recommendation** – Change ongoing commissioning verification protocols.
- **Key Finding** – An error in a savings calculation formula resulted in a large variance for one site. For this site, the applicant calculated total motor power draw using total current rather than average current which overestimated the baseline energy use by 67%.
  - **Recommendation** – Projects going through QA/QC review should verify that the power draw of the equipment is being calculated correctly.
- **Key Finding** – In the recently completed 4-year LPU program cycle (2019-2022), total energy savings, the percentage of total funding allocation spent, and participation rate by eligible customers all decreased from the previous 4-year cycle (2015-2018). While the COVID-19 pandemic and associated effects likely played a role in those outcomes, most of the nonparticipating customers that DNV spoke with cited difficulty identifying cost-effective, qualifying projects as a barrier, which will make growing and even maintaining program participation and savings difficult.
  - **Recommendation** – Given these challenges, work to identify program design and/or delivery changes in the current 4-year cycle specifically intended to increase participation and savings. Based on evaluation work to date, items to consider include:
    - Work to align the LPU Program with other (even non-energy efficiency) programs to widen customers' options for reducing energy usage and emissions and provide a more holistic approach (e.g., possibly including electrification).
    - Develop and provide case studies to help key staff within eligible customer organizations to better obtain decision-maker support.

2 INTRODUCTION

This report summarizes the results of the 2022-2023 biennium impact and process evaluations of six Puget Sound Energy (PSE) non-residential programs for program years (PY) 2021-2022. In this report, the program evaluator (DNV) presents results for the following programs:

- Schedule 250
  - Custom Lighting Grants (BLi)
  - Retrofit Custom Grants (Commercial and Industrial [C&I] Retrofit)
  - Industrial Energy Management (IEM)
- Schedule 262
  - Commercial Heating, Ventilation, and Air Conditioning (HVAC) Rebates *(PY2021 only)*
  - Commercial Midstream HVAC and Water Heating
- Schedule 258
  - Large Power Users (LPU) 449 and non-449 *(2019-2022 program cycle)*

These programs offer incentives to C&I customers through downstream rebates, midstream rebates through retailers for high-efficiency HVAC and water heating equipment, and a self-directed program for LPU customers. Table 2-1 shows the energy savings tracked for the six evaluated programs. These programs accounted for approximately 54% of PSE's C&I electricity savings and 76% of C&I natural gas savings during the past four program years, 2019-2022.

Table 2-1. Tracked PY2019-2022 energy savings

Program	Unique Project Count	Tracked Electricity Savings (kWh)	Percent of Tracked kWh Savings	Tracked Natural Gas Savings (Therms)	Percent of Tracked Therms Savings
Custom Lighting Grants (BLi)	793	62,557,815	32%	N/A	N/A
Retrofit Custom Grants (C&I Retrofit)	188	21,330,124	11%	1,285,052	42%
IEM	22	3,537,411	2%	21,903	1%
Commercial HVAC Rebates	62	1,657,242	1%	214,350	7%
Commercial Midstream HVAC and Water Heating	801	559,609	0%	785,847	26%
LPU 449 and Non-449	35	15,320,581	8%	N/A	N/A
Total	**1,901**	**104,962,782**	**54%**	**2,307,152**	**76%**

2.1 Evaluation Objectives and Researchable Issues

We present the primary evaluation objectives, associated research activities, and researchable issues for the impact and process evaluations below:

- **Impact evaluation:** Measure energy savings by independently reviewing savings estimation methodologies and verifying savings achievement through file reviews and interviews, determine ratio of savings achieved to savings tracked, and evaluate other key performance indicators (KPIs) for each evaluated program.
- **Process evaluation:** Provide process findings for the programs from the perspective of the program participants. Assess how well the programs are achieving their objectives, provide information on why programs are over/underperforming, and suggest recommendations for improvements.

2.2 Evaluated Programs

Each program was assigned a 1-3 value based on the level of rigor needed to achieve satisfactory impact and process results. Table 2-2 outlines the level or rigor used to evaluate each program: a "1" value indicated a mature program with more reliable measures and less variability in results and a "3" indicated a new or inconsistent program with measures which required more thorough analysis. Based on the assigned evaluation rigor, the impact evaluation utilized phone interviews, email verification, and virtual site visits to verify the installation and continued operation, determine the baseline, and collect other key performance parameters to evaluate the measures. For the process evaluation, DNV interviewed program staff, program contractors, and program participants based on the assigned evaluation rigor to collect qualitative information on the programs and to identify program improvement opportunities.

Table 2-2. Evaluation rigor by program

Tariff Schedule	PSE Program	Program Description	Evaluation Rigor (Impact / Process)
E/G 250	Custom Lighting Grants (Business Lighting)	Downstream program supporting high efficiency lighting installations at existing C&I customer locations.	2/2
	Retrofit Custom Grants (C&I Retrofit)	Downstream program supporting non-lighting efficiency installations at existing C&I customer locations.	3/2
	Industrial Energy Management	Downstream program supporting efficiency measures at industrial customer locations. Includes the Industrial Strategic Energy Management (ISEM) subprogram.	3/2
E/G 262	Commercial HVAC Rebates	Downstream program primarily supporting advanced rooftop controllers (ARCs), ductless heat pumps (DHPs), and smart thermostats at C&I customer programs.	1/1
	Commercial Midstream HVAC and Water Heating	Midstream program supporting the selection and installation of high efficiency HVAC and water heating equipment.	1/1
E 258	LPU 449 and Non-449	Self-directed program providing incentives to projects at customer sites on specific PSE rates.	3/2

2.3 Report Overview

We have organized the remainder of this report as follows:

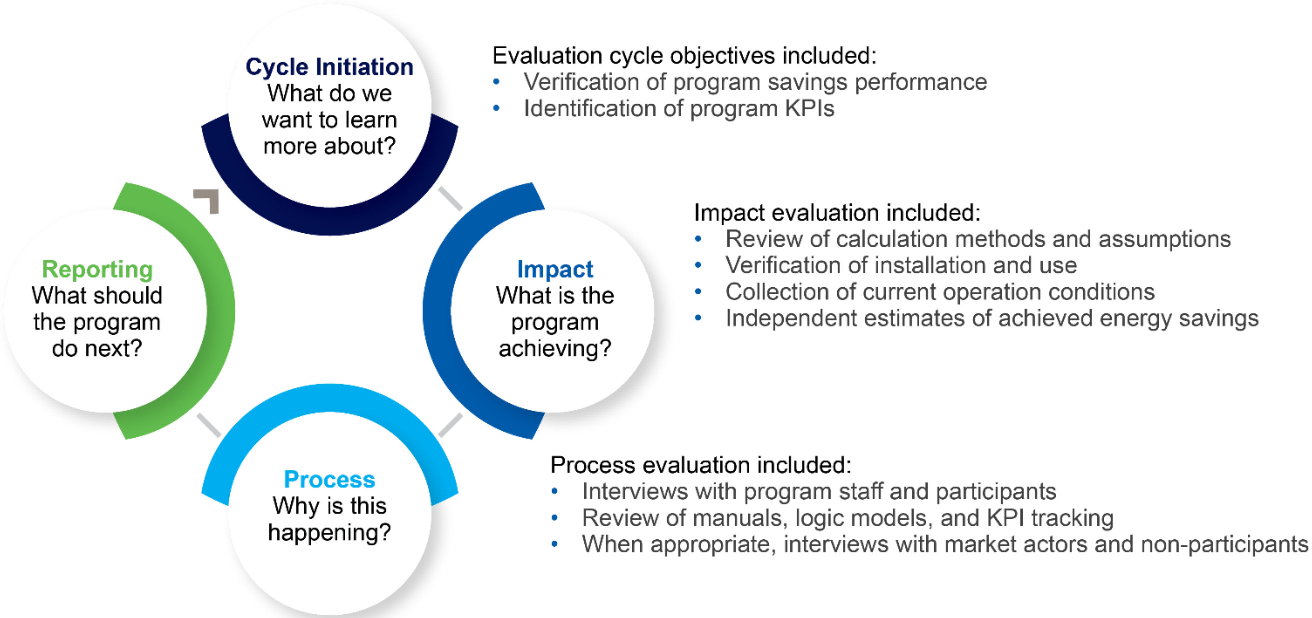
- **Section 3 Evaluation Approach and Methodology** describes the overall evaluation approach and methodology to sample design, data collection, impact evaluation, and process evaluation.
- **Section 4 E/G 250 – Custom Lighting Grants** provides the program savings, impact evaluation results, process evaluation results, and findings and recommendation for the Custom Lighting Grants Program.
- **Section 5 E/G 250 – Retrofit Custom Grants** provides the program savings, impact evaluation results, process evaluation results, and findings and recommendation for the Retrofit Custom Grants Program.
- **Section 6 E/G 250 – Industrial Energy Management Program** provides the program savings, impact evaluation results, process evaluation results, and findings and recommendation for the Industrial Programs.
- **Section 7 E/G 262 – Commercial HVAC Rebates** provides the program savings, impact evaluation results, process evaluation results, and findings and recommendation for the Commercial HVAC Rebates Program.

- **Section 8 E/G 262 – Commercial Midstream HVAC and Water Heating** provides the program savings, impact evaluation results, process evaluation results, and findings and recommendation for the Commercial Midstream HVAC and Water Heating Program.
- **Section 9 E 258 – Large Power User** provides the program savings, impact evaluation results, process evaluation results, and findings and recommendation for the LPU Program.
- **Section 10.1 Appendix A: Sample Design** provides a summary of the sampling approach DNV used for this evaluation.
- **Section 10.2 Appendix B: Project-level Evaluation Results** includes site-specific results for each evaluated site and if applicable, a brief description of primary reason for savings variance.

3 EVALUATION APPROACH AND METHODOLOGY

DNV utilized a dynamic forward-looking developmental evaluation approach. This evaluation approach provided PSE with program feedback structured to help improve savings reliability and program performance. DNV successfully completed two developmental cycles for this biennium. Each cycle started with an objective and concluded with program feedback and recommendations. Figure 3-1 shows the basic steps in each cycle. Each cycle was initiated by seeking to learn more about program savings performance.

Figure 3-1. DNV's development evaluation cycle



3.1 Sample Design

Each impact evaluation step in the development cycle started with a review of program achievements and a sample design. Each sample was designed to provide accurate independent estimates of energy savings achieved by the program and the associated program realization rates. DNV utilized a stratified random sampling approach with certainty selection to identify the sample for each impact evaluation. The sample was selected in two phases, a first phase selected in 2022 and a second phase selected in 2023. The preliminary sample design was based on 2020-2021 program achievements for each program with the goal of achieving 10% relative precision on site energy savings (kBtu) at the 90% confidence interval for each compliance program. All evaluation results present electric and gas realization rates separately.

Table 3-1 summarizes the final impact evaluation sample design implemented and the associated expected relative precision of the results. All relative precisions are shown at the 90% confidence interval for site energy savings (kBtu) which combines electricity and gas savings into one single value with consistent unit of measure for size stratification. The error ratios used in the sample design were based on DNV's experience evaluating similar programs and prior PSE evaluation results. For lighting programs, we chose an error ratio of 0.4, for the C&I Retrofit, Commercial HVAC, and Commercial Midstream programs, we used an error ratio of 0.8, and for the Industrial program and non-lighting High Voltage program projects we used an error ratio of 1.0. The full sample design is discussed in Appendix A: Sample Design. The design and final achieved sample for each program is discussed in the program-specific sections of the report.

Table 3-1. Sample design summary

Tariff Schedule	PSE Program	Phase I	Phase II	Total Sample	Designed kBtu Relative Precision at 90% CI
E/G 250	Custom Lighting Grants (BLi)	15	15	30	13%
	Retrofit Custom Grants (C&I Retrofit)	15	15	30	14%
	IEM	2	7	9	31%
E/G 252	Commercial HVAC Rebates	15	0	15	21%
	Commercial Midstream HVAC and Water Heating	0	15	15	37%
E 258	LPU 449 and Non-449	10	10	20	26%
Total		**57**	**62**	**119**	**10%**

3.2 Data Collection

The evaluation used multiple data sources to evaluate each program. DNV completed all site- or project-specific data collection remotely via telephone, email, or virtual meeting interviews. Table 3-2 shows the data sources used to evaluate each program.

Table 3-2. Evaluation data sources

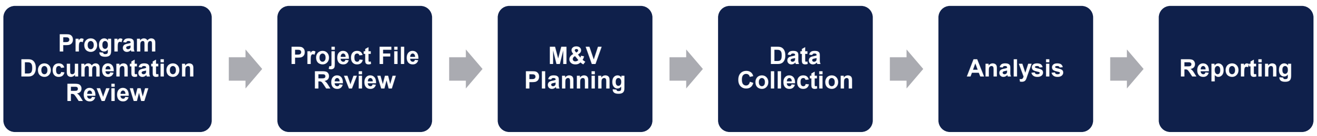
PSE Program	Program Materials	Sampled Project Documentation	Project-Specific Calculations	Utility Consumption Data	EMS/BMS* Trend Data	Participant Interviews	Program Staff Interviews	Market Actor Interviews
Custom Lighting Grants (BLi)	✓	✓		✓		✓	✓	✓
Retrofit Custom Grants (C&I Retrofit)	✓	✓	✓	✓	✓	✓	✓	
IEM	✓	✓	✓	✓	✓	✓	✓	
Commercial HVAC Rebates	✓	✓					✓	
Commercial Midstream HVAC and Water Heating	✓	✓					✓	
LPU 449 and Non-449	✓	✓	✓	✓	✓	✓	✓	

* Energy Management System / Building Management System (EMS/BMS)

3.3 Impact Evaluation Methods

DNV initiated the program impact evaluation after primary and backup sample sites were identified. The impact evaluation steps used for this project are illustrated in Figure 3-2.

Figure 3-2. Impact evaluation steps



The steps in this process were primarily applied at the program level and are discussed in more detail in the program-specific sections. A brief description of each step is provided below:

- **Program Documentation Review:** Review program application forms, program guides, measure savings documentation, and program plans to understand the program design and theory, measures supported by the program, and the assumptions and methods used to estimate energy savings.
- **Project File Review:** A thorough review of the project files for sampled projects, focused on the energy savings calculations, assumptions, and other supporting documentation. The review identified any missing information critical to the evaluation, original calculation methodology, key uncertainty parameters to research, and any concerns with the original savings estimation methods.
- **Measurement and Verification (M&V) Planning:** Upon the completion of program documentation and project file review, DNV created a program, measure, or site data collection and analysis plan. This plan documented the project's expected installed condition, 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).
    - **Evaluating Standard Calculated/Prescriptive Measures:** The M&V plans for standard calculated and prescriptive measures were the same across each evaluated project, meaning the same information was collected and the same analysis methodology was employed across all projects unless project-specific circumstances required an alternative analysis method.
    - **Evaluating Complex Projects:** For projects with custom measures or interactive measures, the evaluation team reviewed all measures as one interactive system and estimated the evaluated savings across all measures. DNV developed a site- or project-specific evaluation plan for these projects.
- **Data Collection:** Data collection primarily occurred through participant phone interviews, virtual meetings, and receipt of data already collected by the customer. DNV verified equipment installation, confirmed the intended operation of the measure, assessed the baseline conditions, and collected key operational parameters necessary to determine evaluated savings. The data and information collected was typically used to adjust operating parameters such as efficiency of equipment, hours of use, setpoints, and operating schedules.
- **Analysis:** The evaluated savings analysis followed the M&V plan. DNV used tracked savings estimation tools/analysis methodologies, unless the evaluator determined that there were major flaws in the original savings methodologies or if an alternative method would provide a significantly more reliable estimate of savings. For each sampled project, DNV produced estimates of evaluated electric and/or gas savings.
- **Reporting:** Analysis results were recorded in measure-specific spreadsheets along with reasons for any variance between the tracked and evaluated savings. DNV also noted any opportunities for improvement in the accuracy of tracked savings estimates determined during the evaluation. This report summarizes the results for each program across all measures evaluated.

3.3.1 Sample Extrapolation to Track and Program

DNV used a separate ratio estimator to obtain unbiased estimates of the total evaluated savings. This estimator yields, 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 tracked 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 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} = Tracked 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 original sample points.

Y_g = Population total tracked savings in group g. So $Y_g = \sum_{i \in Frame} y_{ig}$

$$\hat{R}_g = \frac{\sum_{i \in Sample} w_{ig} x_{ig}}{\sum_{i \in Sample} w_{ig} y_{ig}}$$ 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 tracked 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 considers defined clusters of observations (customers) and stratification.

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.

3.4 Process Evaluation Methods

We conducted a process evaluation for the purpose of identifying program strengths and opportunities for program improvement. DNV's process evaluation relied on interviews with program staff and trade allies, web surveys of program participants, and documentation review. The interviews allowed DNV to compare the PSE's program goals to the participant and/or trade allies' program experience. DNV's process evaluation activities focused on identifying opportunities to improve savings reliability, expand program participation, increase the savings achieved through PSE's program portfolio, and improve the PSE customer experience throughout the program. Details on the process evaluation methods and findings are presented in each program-specific section.

DNV's process evaluation approach generated feedback that enabled adaptive management of PSE's programs. The overarching process evaluation goal was to provide the contextual information necessary to understand how programs are performing, why certain results are occurring, what is working well, and what opportunities for improvement exist. Our evaluation provided PSE with feedback focused on understanding what happened and identifying opportunities to adjust program delivery and achieve program goals.

Our team used a variety of techniques to systematically assess program processes and provided actionable recommendations that address opportunities to improve customer and stakeholder satisfaction and determine the appropriateness of program activities given current market conditions. Table 3-3 summarizes these and some other core process evaluation methods, their value to the evaluation, and the topics we address.

Table 3-3. Process evaluation methods overview

Method	Stakeholders	Topics	Value to the Evaluation
In-depth telephone interviews with PSE program staff	- Program managers - Energy advisors - Outreach staff - Implementation contractors	- Changes to program since the last evaluation cycle - Marketing/outreach activities - Operations - Stakeholder interaction	- Ensures understanding of how specific members of PSE's team plan to use the evaluation results. - Helps ensure we provide results in formats that maximize their usefulness to PSE. - Provides PSE staff with opportunities to contribute to evaluation's content and share perspectives on program performance. - Provides additional basis for data collection instruments.
In-depth telephone interviews with other stakeholders	- Installation contractors, or other vendors, retailers, etc.	- Please refer to specific topics in the program-specific subsections	- Ensures understanding of how entities involved with programs interact with PSE or other implementation staff, with each other, and/or with customers.

Method	Stakeholders	Topics	Value to the Evaluation
Web surveys	- PSE program participants and/or eligible customers	- Customer satisfaction and experience - Some programs may combine verification and satisfaction surveys	- Report salient findings on an ongoing basis to allow PSE to enhance the participant experience or adjust program design to better serve customer need. - Some programs may survey shortly following project completion to increase the probability of getting useful feedback.
Logic model and materials review (including model development for new programs)	- Program managers	- Detailed review/analysis of program theory/ objectives document, program logic models - Program materials e.g., operations and implementation manuals, marketing plans, websites, participant data	- Ensures a thorough understanding of program processes. - Provides the basis for updates to KPIs and logic models and the basis for interview/survey data collection instruments.
Previous evaluation review to evaluate program progress	- Program managers - Implementation contractors	- Past program evaluations - Recommendations - Program responses	- Ensures understanding of program evolution and changes and improvements made based on previous recommendations. - Evaluates program progress in adopting recommendations.

4 E/G 250 – CUSTOM LIGHTING GRANTS

This section summarizes the impact and process evaluation approach, results, and recommendations of PSE's PY2021-2022 Custom Lighting Grants program (also known as the Business Lighting Incentive, or BLi Program).

4.1 Program Overview

The Custom Lighting Grants program, which includes Business Lighting Grants and Business Lighting Express, is also known as the BLi program. This program offers incentives to non-residential customers (those on rate schedules E250 and G250) for installing energy efficient lighting such as LEDs, linear lighting, and lighting controls. This program was created in 2014. Energy savings are typically calculated using a PSE calculator and application that is updated regularly.

PSE manages this program in-house through a program manager, a dedicated BLi team of four, and roughly two dozen engineers who work on all Business Energy Management programs. The program is contractor-driven with approximately 80% of projects completed by lighting contractors. BLi Grants offers custom calculated incentives for the installation of cost-effective high-efficiency lighting projects. BLi Express provides prescriptive incentives for smaller lighting projects that would not "fit" within the BLi Grants program.

4.1.1 Program Savings

Table 4-1 shows the energy savings tracked by the program during PY2021-2022. Lighting – Base measures were the primary contributor to program electricity savings followed by Lighting – Custom measures.

Table 4-1. Tracked PY2021-2022 program savings by measure, BLi

Program	Measure Category	Project Count	Tracked Electricity Savings (kWh)	Percent of Total BLi Tracked Savings
BLi Grants	Lighting – Custom	53	4,853,359	8%
	Lighting – Base – Custom	630	53,208,356	85%
	Lighting – Performance – Custom	59	1,826,126	3%
	Lighting – Street – Custom	21	2,386,072	4%
	Lighting – Tenant Improvement – Custom	2	10,109	0%
BLi Express	BLi Express	29	273,793	0%
Total		**794**	**62,557,815**	**100%**

4.2 Impact Evaluation

This section documents DNV's independent estimate of the program realization rate and review of the program calculation methods. Each element of our evaluation process is discussed below along with relevant findings. The section concludes with our estimate of the program realization rates followed by the primary drivers of variance between PSE's tracked savings estimates and DNV's evaluated savings estimates.

DNV completed the following steps for the BLi program impact evaluation:

- **Sample Selection:** Selection of a representative sample of completed projects for evaluation.
- **Project File and Tool Review:** Review of project files provided by PSE to identify calculation methods and key parameters, and to ensure sufficient information exists to evaluate the project. Review of PSE approved standard application BLi calculator.
- **M&V Planning:** Creation of subprogram-specific M&V plans, adjusted as necessary for each sampled project, to identify key input parameters, stipulate values to research, and determine the data collection methods for verification.
- **Data Collection:** Phone interviews with sampled participants to review each project, baseline assumptions, and current operating parameters.
- **Project Analysis:** Estimated evaluated savings using the data collected to update key input parameters.

4.2.1 Sample Design

This sub-section presents an overview and summary of the sample design used to evaluate PY2021-2022 of the BLi program. DNV used stratified random sampling to select an efficient representative sample of projects for evaluation. The sample was designed to provide a reliable estimate of program performance. Table 4-2 summarizes the planned sample design for this program.

Table 4-2. Preliminary BLi sample design parameters

PSE Program	Sub Domain	Anticipated Population Size	Expected Total Savings (kBtu)	Assumed Error Ratio	Sampling Rounds	Planned Sample	Expected Relative Precision
BLi	All	1,252	330,412,706	0.4	2	30	13%

Sampling occurred at the project level. The sample was selected from BLi projects completed between January 1, 2021, and December 31, 2022. The key design element for the sample was stratification by size of savings reported at the project level and use of a certainty stratum to increase the magnitude of savings evaluated and the accuracy of the estimated savings realization rate.

The sample design resulted in the selection of 30 unique projects for evaluation. Table 4-3 shows the sample design and primary sample counts by stratum.

Table 4-3. Final BLi sample design by stratum

Compliance Program	PSE Subprograms	Sampling Phase	Project Size	Projects in Sample Frame	Savings (kBtu) in Sample Frame	Primary Sample	Probability of Inclusion
Custom Lighting Grants (BLi)	**BLi Grants, BLi Express**	Phase I	Small	475	39,840,287	5	0.011
			Medium	108	54,195,882	5	0.046
			Large	43	71,170,184	5	0.116
		Phase II	Small	396	29,962,373	5	0.013
			Medium	85	40,510,471	5	0.059
			Large	36	52,033,215	5	0.139
Total				**1,143**	**287,712,412**	**30**	**N/A**

4.2.2 Project File and Tool Review

DNV completed structured site-specific reviews of PSE's BLi program application files and calculations that systematically examined and recorded the evaluation team's conclusions on ex ante savings[1] development practices. DNV reviewed each sampled project's files for sufficient documentation, program savings methodology, and accurate savings reporting. These reviews included:

- Assessing completeness of documentation
- Identifying the building type
- Performing a web-based search to determine if the sampled commercial entity was operating normally, operating under modified conditions, or closed
- Verifying the existence of engineering calculations with outputs that match the reported savings
- Identifying key building or system operation parameters contributing to the reported savings
- Verifying building electric meter numbers and assessing building annual electric consumption to determine the percentage of savings resulting from the project

DNV reviewed PSE's approved BLi standard application calculators[2] used to determine project savings for the BLi Grants and BLi Express subprograms. Our review of the engineering calculations identified the use of multiple versions of the calculator through the sampled projects, ranging from 2019 to 2022. DNV evaluated each sampled project using the Business Lighting 2022 – STANDARD V2-1 calculator or the Business Lighting Express 2022 V2.1 calculator depending on the subprogram. We compared the various versions of the calculator dating from 2019 through 2022 to identify any significant changes to the tool's methodology or calculation assumptions that would impact project savings. The primary difference between the 2022 tool and the previous versions was the controls savings factors by facility type, which were updated in 2022 based on recent findings. We found the calculation methodology of the 2022 lighting tools to be reasonable.

4.2.3 M&V Planning

DNV developed an M&V plan for both subprograms, BLi Grants and BLi Express, using our M&V Plan template. The subprogram-specific M&V plans were tailored to each sampled site to guide the data collection effort. These plans focused on the collection of information specific to the key research parameters identified during file review. The study did not collect information on all drivers of end-use energy consumption.

4.2.4 Data Collection

All data collection occurred remotely via telephone or videoconference. No independent data logging or metering was completed for this evaluation. Data collection followed the M&V plan developed for each subprogram. At a minimum, DNV verified installation and active operation, confirmed the business type, reviewed business hours and operating hours of installed equipment, asked about pre-retrofit conditions, and verified the scope of the installed project. During our interview, we determined whether any changes in project operation were due to the impact of the COVID-19 pandemic, and if so, whether or not the operation changes were considered temporary or permanent.

DNV also requested and received utility meter data from PSE detailing the facility's recent consumption. This data was used to validate the percent of savings based on annual facility consumption and in a few cases, this facility meter data was used to conduct a consumption analysis to determine project savings.

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[1] Ex ante savings are the savings claimed by the program before they are independently evaluated. Evaluated savings are also known as ex post savings.

[2] These calculators are updated annually. The most up-to-date version is available on PSE's Business Lighting Incentive Program webpage.

4.2.5 Project Analysis

DNV used the information gathered during data collection to update the key calculation input assumptions. DNV evaluated each sampled project using the Business Lighting 2022 – STANDARD V2-1 calculator or the Business Lighting Express 2022 V2.1 calculator depending on the subprogram. Key inputs for the evaluated savings calculations, such as fixture quantities, wattages, annual hours of use, and controls strategies were determined from the most valid data source including participant interviews, site EMS data, and program project files. If DNV found that the evaluation period's project parameters were different from their respective program modeled values. Any identified difference between the baseline and installed condition that was not part of the implemented improvement were kept energy-neutral and not considered part of the evaluated project savings. This is achieved by using identical values of such parameters in both baseline and installed condition in the project energy analysis.

In rare cases, we were able to confirm the installation and current operation of a lighting measure but were not able to confirm specific project parameters. In each of these instances, we worked with the site contact to determine whether a consumption analysis would be a reasonable determination of project savings. DNV confirmed that a whole facility consumption analysis approach was appropriate if the following conditions were met:

- The existing conditions baseline was legitimate.
- Facility consumption data and other relevant data (e.g., throughput) were available.
- The reported energy savings for the project were greater than 10% of the baseline energy use.
- No other projects that would impact energy use were completed in the pre- or post-installation period.
- The pre- or post-installation period did not include a non-routine event.

If reasonable based on our interview and expected savings magnitude, DNV used a consumption analysis to estimate evaluated savings.

4.2.6 Final Evaluated Sample

Table 4-4 shows the final sample achieved for this impact evaluation alongside the planned sample. The difference between the planned sampled and completed sample is due to challenges recruiting participants for evaluation. These challenges included refusals to participate, being unable to track down the correct contact, and unresponsiveness. To combat unresponsiveness, DNV attempted to call and email each sampled participant up to five times at different times of the day. We requested recruitment assistance from PSE's program implementation staff if customers continued to be non-responsive. For customers that refused to participate or were deemed unresponsive after requesting help from PSE staff, we promptly replaced those sites with backup sites from our sample. The final evaluated count, while smaller than originally planned, is representative of the program.

Table 4-4. BLi evaluated site count summary

Compliance Program	PSE Subprogram	Sampling Frame Q1 2021- Q4 2022	Planned Sample 2022 (Phase I)	Completed Sample 2022 (Phase I)	Planned Sample 2023 (Phase II)	Completed Sample 2023 (Phase II)
Custom Lighting Grants (BLi)	BLi Grants	1,143	15	10	15	11
	BLi Express			2		0
Total		**1,143**	**15**	**12**	**15**	**11**

4.2.7 Program Realization Rates

The project-specific results for the final evaluated sample were extrapolated back to the sampling frame to determine the evaluated savings for the population and the program realization rate. The calculated realization rates should be applied to the final 2022-2023 biennium tracked savings to estimate the evaluated savings for the program over the biennium.
Table 4-5 provides the evaluation results from the evaluation sample of 23 projects that have been expanded to the sample frame of 1,143 projects.

Table 4-5. BLi electric impact evaluation results

Project Count with Electric Savings	Realization Rate	Relative Precision at 90% Confidence Interval
Sample Frame = 1,143 Evaluated = 23	94%	5%

4.2.8 Sources of Variance

The primary driver of savings variance is differences in calculation methodology. For six evaluated projects, DNV updated the applicant's calculation methodology from PSE's Business Lighting calculator to a consumption analysis approach. We selected this method to determine project savings for grocery stores where the site contact could confirm the project installation but not provide additional information on the project. Using a consumption analysis approach, DNV found that the evaluated savings were about 88% of the reported project savings, on average, for retail facilities. This savings reduction was consistent across the six evaluated projects, which could indicate that the self-reported operating hours used in the PSE Business Lighting calculator for these grocery stores are overestimating lighting operation by about 12%. The secondary driver of savings variance was changes to the assumed operating hours used to estimate tracked savings and the self-reported lighting operating hours collected during the evaluation. For two of the evaluated projects, the site contact stated they changed their operating schedule after the project installation was complete due to a tenant switch and changes to production. The identified sources of variance were deemed to be out of the control of PSE's application process. DNV determined that PSE's methods and assumptions for determining energy savings for the BLi program are reasonable.

4.3 Process Evaluation

This section summarizes the key findings for the BLi program process evaluation. It includes results from interviews with trade allies and surveys with customers who participated in the 2022-2023 biennium.

4.3.1 Contractor Interviews

This section summarizes results from interviews conducted with contractors participating in the BLi program. While PSE customers can install measures and claim rebates on their own, most projects are driven primarily by contractors. As such, contractors are best suited to provide informed feedback and relevant suggestions for program improvement.

For these interviews, DNV sought to collect contractor feedback and identify ways in which the program could bolster participation. Broadly, the research topics included:

- Program impacts on business
- Barriers to participation
- Program satisfaction
- Suggestions for improvement

4.3.1.1 Sample Frame

PSE provided DNV with a list of 165 unique contractors that participated in the BLi program in 2021 and 2022. To ensure the selection of informed respondents, and since a "core group" of less than two dozen contractors are responsible for the majority of contractor-completed projects and savings, DNV sought to interview the most "active" contractors. DNV distilled the sample frame down to 18 contractors responsible for at least one million kWh saved across at least five projects in the tracking data, targeting and completing interviews with 10 of these 18 contractors in March 2023. Together, these 10 contractors represented about 35% of BLi program savings in the tracking data provided by PSE.

4.3.1.2 Program Participation and Influence

All 10 respondents said their company has been involved in the program for at least the last 5 years, with a few claiming involvement since the program's inception. Additionally, all 10 respondents indicated they were "very active" in promoting the Business Lighting incentives to their customers, using a five-point scale in which "1" is "not at all active" and "5" is "very active."

DNV asked two questions to elicit the program's influence on these contractors and found that, indeed, most reported the program did have an effect. First, when asked whether the program had influenced the average efficiency level of the lighting equipment their company sells or installs, 7 of 10 said it had. When asked to elaborate on the program's influence, three respondents mentioned their company installs more "additional" efficient equipment along with fixtures and bulbs such as controls (including luminaire level lighting controls [LLLC]) than they would absent the program, and two respondents said their company installs higher quality equipment than they otherwise would.

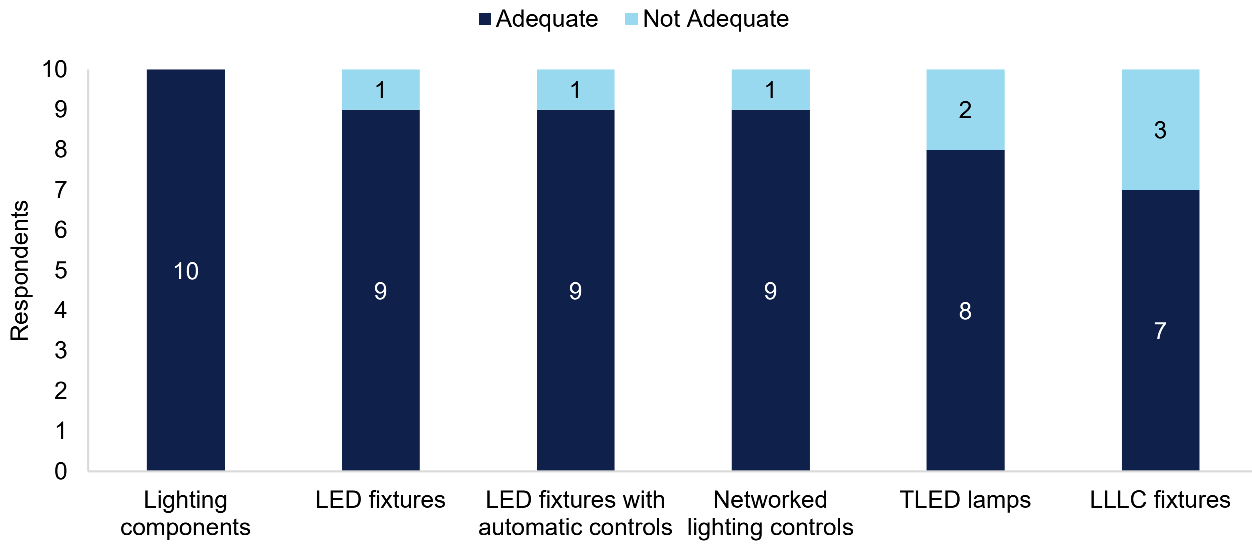
Secondly, when asked whether the program had influenced their company's sales practices, 5 of 10 said it had. Asked to elaborate on the program's influence, three respondents discussed how the BLi program incentives are fully integrated into their company's sales process with every customer, and two mentioned that lighting controls are more integrated into their sales strategy than they otherwise would be absent the program.

4.3.1.3 Incentives

Contractors generally thought that the current (as of March 2023) BLi program rebates for each equipment category were adequate to move customer activity or program equipment sales. Figure 4-1 shows the breakdown of "adequate" and "not adequate" responses for each equipment category.

Notably, the equipment types with the highest number saying the incentives were *inadequate* were LLLC fixtures (3 of 10 respondents) and TLED lamps (2 of 10). We followed up with these respondents by asking what incentive levels would be more adequate to encourage installation. The average suggested increase for LLLC fixtures was $25 (from $75/fixture to $100/fixture), while the average suggested increase for TLED lamps was $1 (from $4/lamp to $5/lamp).

Figure 4-1. BLi contractor assessment of program rebate adequacy



4.3.1.4 Contractor Satisfaction

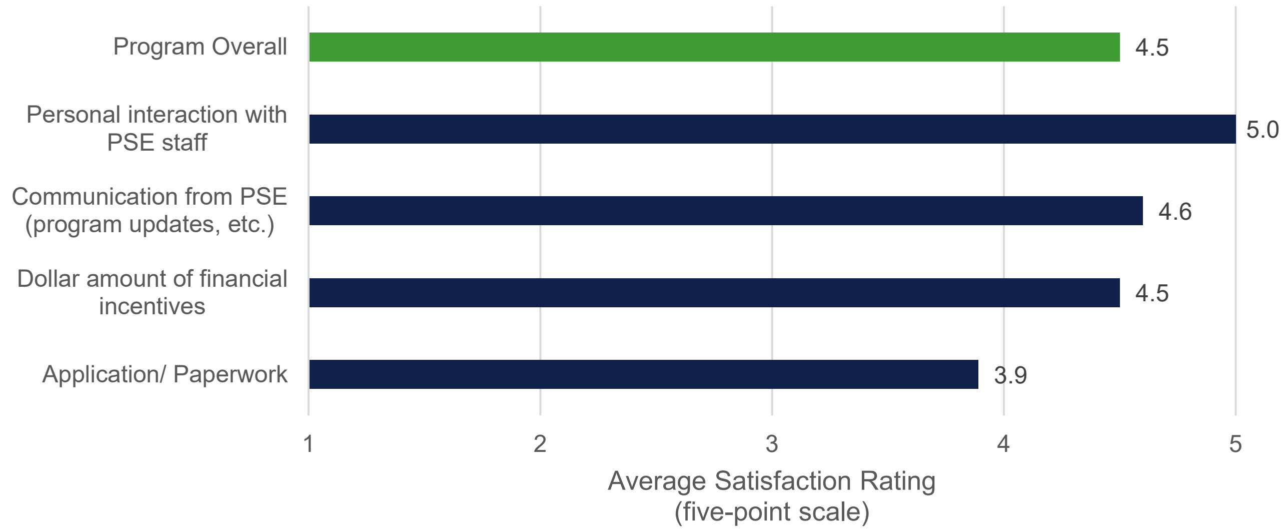
As shown in Figure 4-2, Contractors are broadly satisfied with most program aspects, giving an average rating of at least 4.5 to most, including the program overall (using a five-point scale in which "5" meant "very satisfied" and "1" meant "very dissatisfied"). Notably, all 10 respondents said they were "very satisfied" with their personal interactions with PSE. One contractor gave a particularly representative response when asked about their satisfaction with interactions with PSE:

> "They are willing to help and go out to do site walks. We've developed a great relationship with the Business Lighting team. They work with us to make projects happen."

We followed up by asking whether program staff had given consistent responses and information when requested (which PSE program staff had perceived as a potential problem). All contractors that responded to the question said they had received consistent responses, although one clarified that, earlier in 2022, they had an issue with inconsistent information.

Contractor satisfaction with the required paperwork and application process was somewhat lower, with an average of 3.9 (and four of nine giving a 3 or lower on the 5-point scale). Less-than-satisfied respondents mentioned the time commitment necessary to input all of the required information. In particular, the inability to effectively complete "bulk input" for large projects needing dozens of lines of data was a common sticking point. Satisfaction with the program overall was rated 4.5 (green bar in Figure 4-2).

Figure 4-2. Contractor satisfaction with BLi program



4.3.1.5 Barriers to Participation

During its interview with DNV, PSE program management conveyed a perception that logistical issues (including both the cumbersome program application and participation requirements) may be functioning as a barrier to additional program participation, as contractors may determine that the incentive dollars are not worth the "hassle." In particular, program staff mentioned increased photo and/or video verification requirements for contractors put in place in 2020 as a result of the COVID-19 pandemic. As such, DNV asked the contractors for their perspective on these specific logistical program aspects.

First, the contractors gave their opinion on whether different categories of PSE's program requirements were reasonable:

- Invoicing requirements: 10 of 10 said "reasonable."
- Fixture and lamp qualification: 9 of 10 said "reasonable."
- LLLC requirements: 8 of 10 said "reasonable" (two said they struggled to find equipment meeting these requirements).
- Photo or video verification: 6 of 10 said "reasonable."

As illustrated above, the highest number of trade allies (although still a minority) thought that PSE's photo or video verification requirements were not reasonable. In July 2022, PSE began offering a per-kWh "contractor performance incentive" to compensate contractors for this extra (relative to the "baseline" established before COVID-19) documentation needed. However, just 3 of 10 respondents said this incentive "moved the needle" in terms of their program participation or their satisfaction with the program documentation requirements.

Paired with the fact that four of nine respondents were less-than-satisfied with the application/paperwork process, these responses from contractors confirmed the program staff sentiment that a significant portion of trade allies view logistical program aspects as an issue, and even a barrier to greater participation.

4.3.1.6 Suggestions for Improvement

Most respondents did not have any suggestions to improve the design or delivery of the BLi Program. Among those that did, the suggestions included:

> "Training for the [application] workbook was a barrier and would be nice to have a resource for those workbooks and getting people up to speed on that aspect of the program."

> "Lighting workbook needs to be better for bulk input."

> "Being a contractor that performs large projects, staff stepping up and working with one staff member has really helped relative to the past. It can be overwhelming, so staff is helpful. Larger contractors would benefit from one point of contact."

> "Higher incentive levels will always drive more sales."

4.3.1.7 Comparison to Other Utility Programs

All 10 contractors said they had observed differences in C&I lighting program implementation across different utilities. DNV asked the contractors whether PSE and the BLi Program could learn anything from other programs. Two respondents mentioned PSE's photo verification differing from other utilities. As one of these respondents put it:

> "Requirements for submitting and closing out a project with photos. Other utilities have a basic set up for the photo and don't have to show every fixture."

In a very positive reflection on the BLi Program, 7 of the 10 contractors said there was nothing that PSE could learn from these other programs. Interestingly, calling the BLi Program either the best or among the best programs in the region was a common theme, with several respondents remarking that other utility lighting programs could learn from PSE. For example:

> "PSE is the gold standard when it comes to rebates, and everyone I work with has been super responsive."

4.3.2 Participant Surveys

During the course of the impact evaluation, DNV completed brief surveys (including information relevant to the process evaluation) with 12 unique customers participating in the BLi program. These were knowledgeable respondents, as all said they were involved in their organization's decision to participate in the program. This section summarizes findings collected through those surveys in two topics: program influence and program satisfaction.

4.3.2.1 Program Influence

Eight of 12 participating customers said they first learned about the availability of PSE rebates for the completed lighting project through previous participation. Further, three said they learned of the program through a contractor, and one became familiar through a PSE representative.

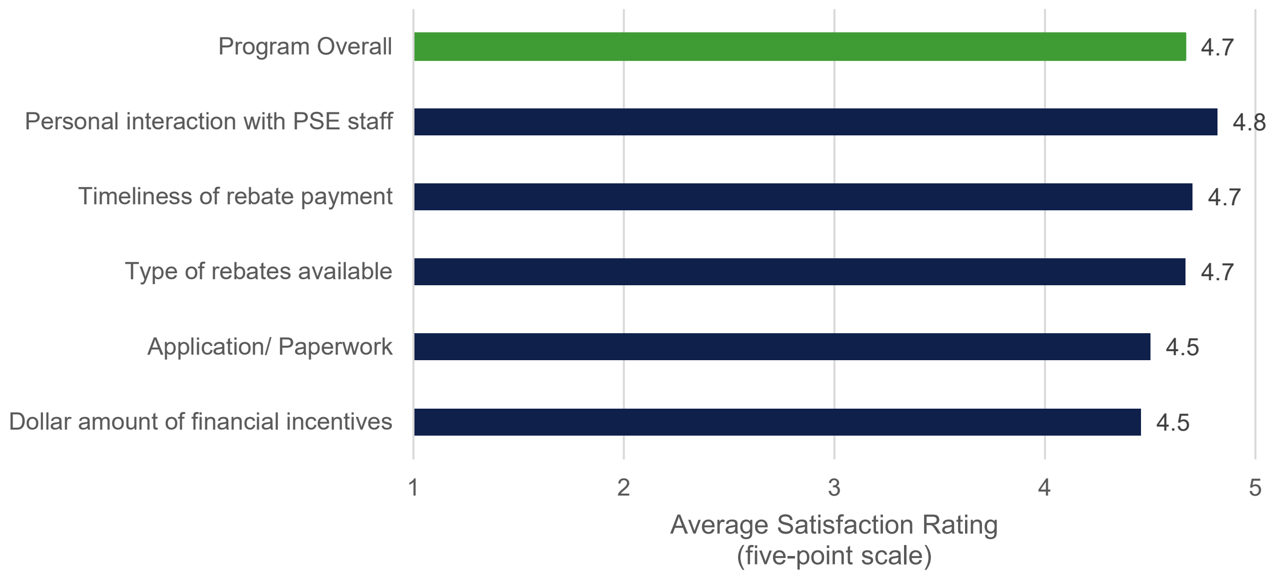
Next, we asked the participants: "The program provides incentives to help offset the cost of going from standard to high performance equipment. How important was the PSE incentive in your decision to make these upgrades?" Respondents rated the importance of PSE incentives using a five-point scale in which "1" is "not at all important" and "5" is "very important." The average rating on the importance of PSE incentives was 4.8, with all 12 participants giving at least a 4 ("somewhat important").

Next, we asked the participants: "If the incentives had not been available, would you have selected any different equipment, or would the timing, or size, of the project be any different?" Ten of 12 respondents said the lighting project they completed would have been different absent the BLi Program. Among the types of impacts, most common was that the project timing would have been impacted without the program (six respondents), followed by the size or scale of the project would have been reduced without the program (four respondents). Additionally, three respondents said they would have installed different equipment in the absence of program incentives.

4.3.2.2 Participant Satisfaction

Customers are generally satisfied with most program aspects, giving an average rating of at least 4.5 to all (using a five-point scale in which "5" meant "very satisfied" and "1" meant "very dissatisfied"). Figure 4-3 shows the full results. None of the 12 customers surveyed gave less than a 3 (indicating neither satisfied nor dissatisfied) to any of the program aspects that DNV asked about.

Figure 4-3. Participant satisfaction with BLi program



Notably, satisfaction with the application(s) or other program-related paperwork was significantly higher for customers (4.5) than for contractors (3.9). This is likely a reflection that, in many cases, contractors fill out the bulk of the paperwork on behalf of customers, lessening the customer burden.

4.3.3 Program Theory Logic Model

PSE does not maintain a program theory logic model (PTLM) specific to the BLi program.

4.4 Findings Recommendations, and Considerations

This section documents DNV's findings, recommendations, and considerations associated with the BLi program.

4.4.1 Impact Key Findings and Recommendations

- **Key Finding** – This program is achieving a high realization rate of 94% of tracked electric savings. We found that the calculation methodology used to determine project savings was reasonable and that the submitted project scope accurately reflected the installed projects.
- **Key Finding** – DNV found that the provided project files were mostly complete. However, about 20% of evaluated BLi site folders didn't include the final version of the BLi calculator that matched the tracked savings or the paid

incentive. In each of these cases, DNV worked with PSE or referred to the final quality control (QC) submittal to collect the final savings analysis.

- **Recommendation** – PSE should include the final savings analysis that supports the reported savings and paid incentive in the project folder.

4.4.2 Impact Findings and Considerations

- **Finding** – Control savings factors are the primary difference between the previous lighting tool used for the sample sites and the current version used by DNV to determine saving (Business Lighting 2022 – STANDARD V2-1). Between the various 2019 and 2020 versions of the Business Lighting tools and the 2022 standard Business Lighting calculator, the controls savings factors were updated for the following controls methods: occupancy sensors, time switches, daylight plus occupancy sensors, and interior LLLC. Between the 2021 and 2022 versions of the tool, PSE updated the interior LLLC control savings factors. DNV concluded that PSE's algorithms and the control savings factor assumptions used to calculate project savings are reasonable. DNV confirmed changes made to the control savings factors were based on new reference information between the annually updated tools and concluded that PSE is making the appropriate effort to update their calculation assumptions.
  - **Consideration** – Consider adding protocols about the version of the Business Lighting tool used by the applicant based on their application approval date and possibly update the Business Lighting calculator version of the tool to the current version if the project is inactive for an extended period of time to account for changes made to the analysis assumptions.
- **Finding** – DNV used a whole building metered consumption analysis approach, rather than the standard PSE Business Lighting calculator, to determine project savings for whole-building LED installations in grocery stores. We selected this analysis methodology because we were able to confirm the installation and current operation of the lighting measure but were not able to confirm specific project parameters. DNV confirmed that a whole facility consumption analysis approach was appropriate since each of the conditions outlined in Section 4.2.5 Project Analysis were met. We found that the average realization rate at the project-level for these facilities was about 88%. Using the whole building consumption analysis method to determine project savings showed that the grocery stores were achieving significant savings as estimated.
  - **Consideration** – Consider adjusting the program savings calculations to reduce estimated savings for grocery store installations to better align with the evaluation result or adjust the program process such that lighting projects expected to reduce facility consumption by more than 10% have savings claimed through the two-step Lighting – Base and Performance application process.

4.4.3 Process Key Findings and Recommendations

- **Key Finding –** Both customers and participating contractors are largely very satisfied with the BLi program. Of all the program aspects DNV asked about, only one (contractor satisfaction with program application/paperwork) received less than an average of 4.5 on the five-point satisfaction scale. Satisfaction with personal interaction with PSE staff stood out as particularly high, with averages of 5.0 and 4.8 for contractors and customers, respectively. Most contractors thought other utility lighting incentive programs could learn from PSE, and several favorably compared the BLi program to other utility programs in the region.

4.4.4 Process Findings and Considerations

- **Finding –** PSE does not maintain a PTLM specific to the BLi program. Not having a PTLM introduces risks, including the inability to properly transfer knowledge about program processes and (perhaps more importantly) desired outcomes if the program experiences a sudden change in staffing.
    - **Consideration** – Given its importance to PSE's overall energy efficiency portfolio (as it accounts for roughly 25% of non-residential electric savings), create a PTLM specific to the BLi program. Establish an annual review of the PTLM to help reflect any program changes.
- **Finding –** Contractors were less satisfied with the required paperwork and application process than for other program aspects, averaging 3.9 on a five-point scale (and four of nine giving a 3 or lower). Less-than-satisfied respondents mentioned the time commitment necessary to input all of the required information.
    - **Consideration** – Look for ways to simplify the application process. In particular, contractors and customers submitting large projects would benefit from easier "bulk" input of project information.
- **Finding –** Nearly half (4 of 10) of contractors said that PSE's photo or video verification requirements were not reasonable, and the contractor performance incentive (introduced to compensate contractors for this extra documentation) did not "move the needle" in terms of program participation or satisfaction for the majority of contractors.
    - **Consideration** – In the next biennium, consider adjustments to the current photo or video verification requirements. This could involve increasing the role of PSE program staff in performing more on-site verification (instead of contractors) or simply increasing the contractor performance incentive such that it better compensates contractors for their time. The goal should be to continue to mitigate risk (by adequately verifying projects) while maintaining or even improving stakeholder satisfaction.
- **Finding –** The BLi program seems to be influencing both customers and participating contractors. For surveyed customers, the average importance of PSE incentives on the project was 4.8 on a five-point scale, and 10 of 12 respondents said the lighting project they completed would have been different absent the program. For interviewed contractors, 7 of 10 said the program had influenced the average efficiency level of the lighting equipment their company sells or installs, and 5 of 10 said the program had influenced their company's sales practices.

5 E/G 250 – RETROFIT CUSTOM GRANTS

This section summarizes the impact and process evaluation approach, results, and recommendations of PSE's PY2021-2022 Retrofit Custom Grants, also known as the C&I Retrofit program.

5.1 Program Overview

The C&I Retrofit program provides incentives for cost-effective energy efficiency upgrades to lighting, equipment, building shell, industrial process, and select O&M improvements. These services are provided on the customer's behalf and, where specified by the customer, are developed in conjunction with design engineers, contractors, and/or vendors.

5.1.1 Program Savings

Table 5-1 shows the energy savings tracked by the program during the biennium. Refrigeration and HVAC controls measures were the primary contributors to program electricity savings and boiler and water heating, HVAC, and refrigeration measures were the primary contributors to program gas savings.

Table 5-1. Tracked PY2021-22 program savings by measure, C&I Retrofit

Measure Categories	Project Count	Tracked Electric Savings (kWh)	Percent of Tracked Electric Savings Contribution	Tracked Gas Savings (Therms)	Percent of Tracked Gas Savings Contribution
Boiler and Water Heater	21	61,965	0%	366,104	28%
Building Tune-up	10	416,558	2%	3,220	0%
CBTU	2	364,248	2%	0	0%
Chiller	1	214,445	1%	0	0%
Commissioning	2	1,336,809	6%	6,737	1%
Compressed Air	7	567,615	3%	0	0%
EBCx	5	64,259	0%	24,808	2%
Energy Recovery System	9	0	0%	45,474	4%
Envelope (Insulation and Windows)	10	23,857	0%	24,855	2%
Fan, Pumps, and Motors	39	1,324,393	6%	0	0%
HVAC	23	1,179,275	6%	297,381	23%
HVAC Controls	68	4,709,967	22%	109,836	9%
Lighting	9	3,267,398	15%	0	0%
Process	6	199,043	1%	15,908	1%
Refrigeration	70	6,033,784	28%	276,377	22%
Other	18	1,566,508	7%	114,352	9%
C&I Retrofit – Total	**300**	**21,330,124**	**100%**	**1,285,052**	**100%**

5.2 Impact Evaluation

This section documents DNV's independent estimate of the program realization rate and review of the calculation methods used by the program. Each element of our evaluation process is discussed below along with relevant findings. The section concludes with our estimate of the program realization rates followed by the primary drivers of variance between PSE's tracked savings estimates and DNV's evaluated savings estimates.

DNV completed the following steps for the impact evaluation of the C&I Retrofit program:

- **Sample Selection:** Selection of a representative sample of completed projects for evaluation.
- **Project Documentation and File Review:** Review of sampled project files and tracking data provided by PSE to identify reported calculation methods and key parameters, ensure sufficient information exists to evaluate the project, and verify reported inputs and supporting information through invoices, applications, and other provided documentation.
- **M&V Planning:** Creation of project-specific M&V plans. The project-specific M&V plans identified the key project-specific input parameters, stipulated values to research and their verification method, and detailed interview question to evaluate the project based on the project file review.
- **Data Collection:** Interviews with sampled participants via telephone or videoconference to review each project, baseline assumptions, and current operating parameters.
- **Project Analysis:** Estimated evaluated savings using the data collected to update key input parameters or conduct a regression analysis using metered energy consumption.

5.2.1 Sample Design

This sub-section presents an overview and summary of the sample design used to evaluate PY2021-2022 of the C&I Retrofit program. DNV used stratified random sampling to select an efficient representative sample of projects for evaluation. The sample was designed to provide a reliable estimate of program performance. Table 5-2 summarizes the planned sample design for this program.

Table 5-2. Preliminary C&I Retrofit sample design parameters

PSE Program	Sub Domain	Anticipated Population Size	Expected Total Savings (kBtu)	Assumed Error Ratio	Sampling Rounds	Planned Sample	Expected Relative Precision
C&I Retrofit	All	140	101,698,837	0.6	2	30	14%

Sampling occurred at the project level. The sample was selected from C&I Retrofit projects completed between January 1, 2021, and December 31, 2022. The key design elements for the sample were:

- Stratification by size of savings reported and use of a certainty stratum to increase the magnitude of savings evaluated and the accuracy of the estimated savings realization rate
- Manual selection of one combined heat and power (CHP) project completed in PSE's previous biennium

The sample design resulted in the selection of 31 unique projects for evaluation. Table 5-3 shows the final sample design and primary sample counts by stratum.

Table 5-3. Final C&I Retrofit sample design by stratum

Compliance Program	Sampling Phase	Project Size	Projects in Sample Frame	Savings (kBtu) in Sample Frame	Primary Sample	Probability of Inclusion
Retrofit Custom Lighting (C&I Retrofit)	**Phase I**	Small	48	9,474,075	4	0.083
		Medium	15	11,728,650	4	0.267
		Large	6	15,741,128	4	0.667
		Certainty	3	15,551,689	3	1.000
		Manual	1	9,570,773	1	1.000
	Phase II	Small	63	16,585,344	4	0.063
		Medium	15	22,515,363	4	0.267
		Large	5	30,338,210	4	0.800
		Certainty	3	56,318,611	3	1.000
Total			**159**	**187,823,843**	**31**	**N/A**

5.2.2 Project File Review

Project file reviews are structured site-specific reviews of PSE's C&I Retrofit program application files and calculations that systematically examine and record the evaluation team's conclusions on ex ante savings development practices. DNV reviewed each sampled project's files for sufficient documentation, program savings methodology, and accurate savings reporting. This review included:

- Assessing completeness of documentation
- Identifying the building type
- Performing a web-based search to determine if the sampled commercial entity was operating normally, operating under modified conditions, or closed
- Verifying the existence of engineering calculations with outputs that match the reported savings
- Identifying key building or system operation parameters contributing to the reported savings
- Verifying building electric meter numbers and assessing building annual electric consumption to determine the percentage of savings resulting from the project

5.2.3 M&V Planning

DNV developed an M&V plan for each sampled project using our M&V Plan template to guide the data collection effort. These plans focused on the collection of information specific to the key research parameters identified during file review. The study did not collect information on all drivers of end-use energy consumption.

5.2.4 Data Collection

All data collection occurred remotely via telephone or videoconference. Data collection followed the M&V plan developed for each project. In many cases, facility EMS screenshots of current setpoints and schedules were captured to document the as-found building controls sequences. No independent data logging or metering was completed for this evaluation. DNV also requested and received utility meter data for each facility to review recent consumption. This data was used to both confirm facility use, calibrate energy models to consumption levels, and, if whole facility analysis was selected as the analysis methodology, determine project savings.

5.2.5 Project Analysis

DNV used the information gathered during data collection to update the key calculation input assumptions. DNV calculated energy savings for each sampled project if we determined that IPMVP Option C whole facility analysis was a feasible and appropriate approach based on various conditions. A whole facility consumption analysis is an accurate estimator of savings because it eliminates all extraneous effects on energy usage to highlight the difference that is primarily due to measure(s) installation by comparing project impacts using a normalized comparison of pre-and-post-project consumption data. DNV confirmed that a whole facility consumption analysis approach was appropriate if the following conditions were met:

- The existing conditions baseline was legitimate.
- Facility consumption data and other relevant data (e.g., throughput) were available.
- The reported energy savings for the project were greater than 5-10% of the baseline energy use.
- No other projects that would impact energy use were completed in the pre- or post-installation period.
- The pre- or post-installation period did not include a non-routine event.

If a consumption analysis was deemed not appropriate to determine savings, DNV 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 EMS data, schedules, setpoints, program project files, and utility meter data. Typically, adjustments were made to the evaluation analysis to model the conditions observed by the evaluation. When DNV found that the evaluation period facility operating parameters (setpoints, schedule and control logics, etc.) were different from their respective program modeled values, the evaluation determined if such parameters were part of the implemented improvement or not. If they were part of the implemented measure improvements, the evaluation energy model implemented those changes to the post-project model only, and those evaluation findings became the basis of having a different modeled evaluation savings compared to program modeled savings. However, if the parameters and setpoints were not part of the implemented measure, the evaluation ensured that such parameters, setpoints, and control logics should act as energy-neutral while determining the evaluation savings. In other words, these parameters are kept identical both in the pre- and post-project models.

5.2.5.1 Combined Heat and Power Analysis

DNV evaluated a CHP project that was installed in the previous biennium (PY 2020-2021). This was the first CHP project completed since the measure offering was created by PSE. In addition to independently evaluating savings, DNV sought to identify areas for improvement in analysis or documentation for future CHP projects incentivized by PSE.

The CHP system was installed at a hospital facility that operates 24/7 year-round with constant steam and hot water requirements. The installed packaged CHP used natural gas to produce electric power and generated waste heat to produce steam and hot water for use throughout the hospital; this recovered steam and hot water from the waste heat of the CHP reduced the steam and hot water loads on three pre-existing natural gas boilers. Energy savings for this measure were based on the efficiency comparison between the proposed CHP system and a PSE baseload combined cycle power plant. The efficiency for these systems was defined as the system's net heat rate (net gas input, Btu per unit electric output, kWh). The assumed baseline heat rate is based on the 2015 Integrated Resource Plan (IRP) value for combined cycle baseload generation. The IRP heat rate is then adjusted for an on-site generation equivalent by considering the transmission losses. The proposed heat rate was determined using the recovered useful heat, total gas input, and total electrical generation of the system from provided trend data.

The primary conclusions from our evaluation are:

- The participant overcame initial installation challenges and now has the system operating under normal conditions. These challenges and other non-routine events at the facility impacted the evaluation timeline.
- The CHP system is operating more efficiently than originally estimated by the applicant resulting in higher annual energy savings.
- The CHP regularly produces more electricity than consumed by the hospital. The evaluation assumed the excess electricity is useful and consumed by other PSE customers. The hospital's natural gas consumption has increased.
- The installed system has reduced the total natural gas combustion required to meet the hospital's electricity, hot water, and steam loads when compared to the assumed baseline combustion turbine. The system wide reduction in gas combustion is reported and valued as electricity savings.

Our evaluation of this measure was limited for the following reasons:

- Due to a non-routine event, we were unable to evaluate a full year of trend data for the CHP system. As a result, we had to assume that operation of the CHP based on 6 months of data would apply to the rest of the year. This increases the uncertainty in our savings estimate. The 6-month trend data exhibited a certain period of CHP unavailability. By assuming a similar operation for the remaining 6 months, we assume identical system availability/unavailability. This assumption may not be correct.
- The facility did not have electric net meter data. As a result, we were unable to assess if the surplus electricity generated returned to the grid. The use of excess electricity is critical to the estimated efficiency of the installed system.
- The documentation provided did not include the source of PSE's estimated baseline heat rate stated to be from the IRP, or the inputs and assumptions used to determine this baseline. The baseline heat rate assumed is a key parameter for the savings analysis as it determines the natural gas consumed and carbon emissions in the counterfactual.

PSE should consider the following when supporting CHP projects in the future. These elements will increase the reliability of savings estimated and improve PSE and regional stakeholders' ability to ensure future CHP project success.

- Project documentation should include information on why the assumed baseline heat rate is the appropriate counterfactual for the project. A statewide policy decision on the baseline assumption for new CHP systems would remove this uncertainty from future project analyses. Further, this policy decision could also identify what savings parameters should be reported for CHP projects.
- PSE should calculate incentives on CHP after a site's specific evaluation of expected electricity, steam, and hot water demands and their annual cost in both existing and post-CHP periods. Facilities considering CHP often have unique utility rates and systems. The participant's financial benefit will be based on their rates which are likely different than those assumed in the standard incentive calculator. A known barrier to CHP system installation is an unfavorable spark spread, the difference between the cost of fuel required to power the CHP system and the cost of grid-provided heat and power to a facility had the CHP system not been installed. PSE may be able to overcome the spark spread barrier with financial incentives.
- PSE should engage with facility personnel during and after installation to help identify their operation challenges and lessons learned from project implementation. This action would help PSE identify necessary changes to the M&V plan or M&V timing, improve its ability to support other customers considering CHP technology, and potentially provide solutions or pathways to solutions to overcome operational challenges. It can be particularly challenging to integrate an installed CHP with an existing steam boiler plant. DNV has observed these challenges

across multiple evaluations across the country. Unlike a CHP system in a new construction facility that allows an integrated process design of the CHP with the designed operating conditions of steam boilers, installing a CHP in an existing steam boiler plant does not allow easy integration of CHP operating temperature, pressure, and flow rates with the operating parameters of the existing boiler plants. Because of this, the installed CHP in an existing boiler plant set-up may not be able to provide the recovered hot water and steam to the boiler loop and can trip when the recovered steam and hot water line temperature and pressure do not align with these parameters of the existing boiler's steam lines.

- PSE should ask the implementer to develop a detailed M&V plan metering all grid and onsite energy (and mass and temperature/enthalpy) streams and agree to provide M&V data for 1 full year. Savings from CHP projects are large enough that final savings should be determined after a performance period (similar to other PSE projects) and independent evaluation should be expected. Evaluators should compare the baseline natural gas consumption with the natural gas consumption of the CHP system to estimate the net increase of natural gas consumption because of the CHP installation. Similarly, the project sites should install a net electric meter to record the net electricity impact on the grid.

5.2.6 Final Evaluated Sample

Table 5-4 shows the final sample achieved for this impact evaluation alongside the planned sample. The difference between the planned sampled and completed sample is due to challenges recruiting participants for evaluation. DNV attempted to call and email each sampled participant up to five times at different times of the day. We requested recruitment assistance from PSE's program implementation staff if customers continued to be non-responsive. We also had seven of our sample and backup sites refusing to participate in the evaluation. If customers refused to participate or were deemed unresponsive after exhausting our attempts to reach them, we promptly replaced those sites with backup sample points. The final sample, while smaller than originally planned, is representative of the program.

Table 5-4. C&I Retrofit evaluated site count summary

PSE Program	Sampling Frame Q1 2021-Q4 2022	Planned Sample 2022 (Phase I)	Completed Sample 2022 (Phase I)	Planned Sample 2023 (Phase II)	Completed Sample 2023 (Phase II)
C&I Retrofit	159	16	12	15	14
Total	**159**	**16**	**12**	**15**	**14**

5.2.7 Program Realization Rates

The project-specific results for the final evaluated sample were extrapolated back to the sampling frame to estimate the evaluated savings for the population and the program realization rate. The calculated realization rates should be applied to the final 2022-2023 biennium tracked savings to estimate the evaluated savings for the program over the biennium. Table 5-5 provides the electric evaluation results from the evaluation sample of 15 projects with electric savings that were expanded to the sample frame of 129 projects with electric savings.

Table 5-5. C&I Retrofit electric impact evaluation results

Project Count with Electric Savings	Realization Rate	Relative Precision at 90% Confidence Interval
Sample Frame = 129 Evaluated = 15	88%	29%

Table 5-6 provides the electric evaluation results from the evaluation sample of 14 projects with electric savings. This value is provided as a reference since the evaluated CHP site was submitted in the previous biennium and may not be reflective of the program in the future.

Table 5-6. C&I Retrofit electric impact evaluation results excluding CHP site

Project Count with Electric Savings	Realization Rate	Relative Precision at 90% Confidence Interval
Sample Frame = 128 Evaluated = 14	71%	20%

Table 5-7 provides the gas evaluation results from the evaluation sample of 16 projects with gas savings that have been expanded to the sample frame of 111 projects with gas savings.

Table 5-7. C&I Retrofit gas impact evaluation results

Project Count with Gas Savings	Realization Rate	Relative Precision at 90% Confidence Interval
Sample Frame = 111 Evaluated = 16	90%	7%

5.2.8 Sources of Variance

Overall, many of the evaluated electric sites had high realization rates. However, four evaluated sites with low realization rates are driving the overall electric realization rate down. One of the primary drivers of savings variance was adjustments to the operation of the equipment or the facility in the as-built condition, which reduced the energy savings resulting from the measure. For one site, the applicant's analysis was conducted assuming that a company with high base loads would occupy the space. However, as the project was installed, the tenant of the space changed to a company with lower base and HVAC loads. Additionally, the applicant analysis used the total building load to determine measure savings. However, the operation of this measure is such that it will only impact weather-dependent loads, so we used the weather-affected consumption to determine project savings. Reducing the facility load in the as built and baseline condition and removing non-weather dependent loads reduced the overall project savings. For another site, the applicant's analysis estimated that the incentivized chiller equipment would operate 5,880 hours per year. However, based on our analysis of the facility's trend data and discussions with the site contact, the incentivized chiller equipment is only operating 3,300 hours per year, which contributed to reduced project savings. Another driver of savings variance is one site that had a calculation error in the analysis file, which resulted in the overestimation of baseline equipment power draw.

Overall, the gas realization rate for this program is 90%. The primary driver of savings variance for evaluated gas projects was a difference in calculation methodology. We changed the calculation methodology for several sites from the applicant analysis method to a consumption analysis approach. For two of these sites, this change in approach significantly reduced the gas savings. In our review of the applicant's calculation methodology, we identified that the original approach did not consider secondary impacts, such as infiltration or ventilation loads and summer lock-out periods, which were captured in the consumption analysis. Another driver of savings variance is one site where the baseline assumption for one site was not realistic based on facility operation.

5.3 Process Evaluation

This section summarizes the key findings for the C&I Retrofit process evaluation. It includes results from interviews with program managers and surveys with customers that participated in PY 2021 through 2023.

5.3.1 Program Manager Interview

DNV conducted an in-depth interview with the managers of the C&I Retrofit program. The interview covered the overall program including delivery, changes, and challenges and barriers.

5.3.1.1 Program Delivery and Changes

When asked how the program is marketed and how outreach is conducted, the program managers explained that historically, contractors have essentially sold the program to customers because they have a vested interest in getting incentives. Recently, however, the program has started to be more proactive with outreach and marketing, implementing search engine optimization, regular email outreach to customers, and have developed some case studies.

DNV also asked the program managers about changes that were expected in PY 2022, if those changes were implemented, and how they think the changes have impacted the program. Noted changes include:

- Creating standardized variable refrigerant flow (VRF) incentives in 2022 to simplify and streamline this measure offering for the market. This change has been implemented and the program managers said it is having a positive impact on the program.
- Increasing the number of small- to medium-size businesses participating in the program. The program managers stated that they have created an alternate route for smaller businesses in regard to controls protocol, and they are working on introducing more energy savings options and incentives for smaller businesses since historically they are an underrepresented group in the C&I program space.
- Improving recruitment with an emphasis on individual account management and a streamlined handoff process. This effort was implemented in early 2022 and the program managers have already seen an improvement in customers' ability to navigate through the program with assistance from their account manager. Program managers noted that beginning in 2023, the program has increased incentives for custom grants, including for controls and VRF.

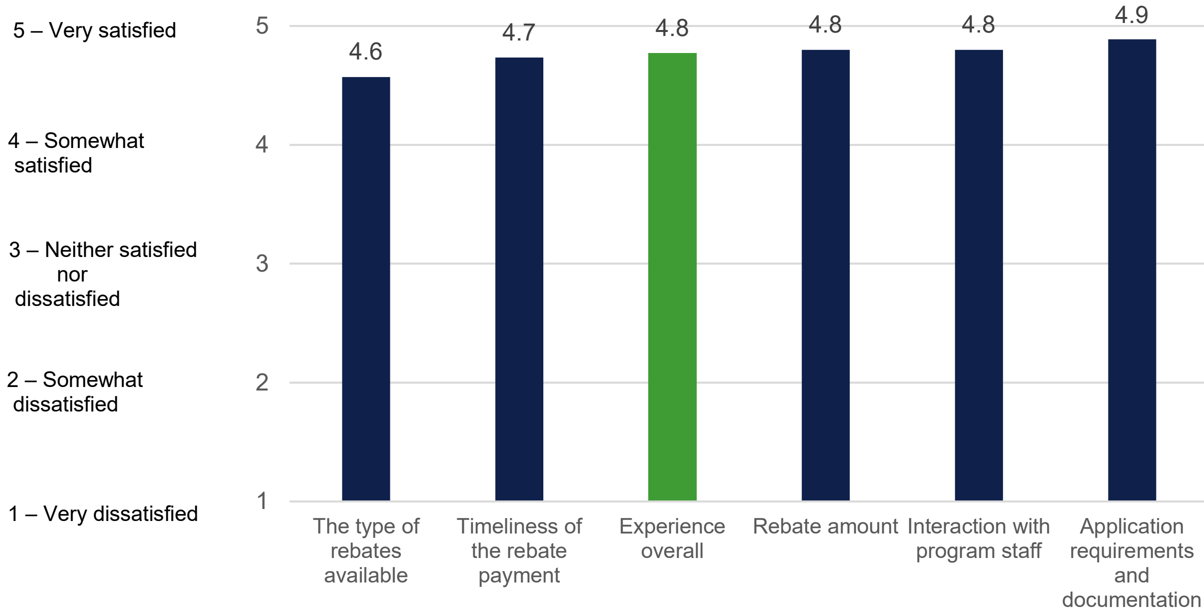
5.3.1.2 Program Challenges and Barriers

DNV asked the program managers about factors or barriers that may prevent customers from participating in the program. They mentioned that, with the exception of commissioning, there has been a slowdown in project intake in the past few years, and there is some uncertainty around the cause of the slowdown. One possible factor mentioned that may have affected program uptake is the COVID-19 pandemic's impact on commercial spaces. There is still uncertainty around tenants returning to the office, so building owners have been pivoting money toward tenant comfort upgrades and away from building upgrades that may come with significant capital spend. Another issue that was mentioned is supply chain and workforce issues. The program has seen a number of projects dropping from the program since 2020 due to the lack of people and material. When asked about any internal challenges being faced, the program managers mentioned one barrier surrounding the training of new engineers. Training engineers in more complex measures, such as controls and commissioning, as well as mentoring newer engineers, tends to land on one more experienced engineer, which takes up a large amount of time.

5.3.2 Participant Survey

As part of the impact evaluation, participants were asked to rate their satisfaction with various aspects of the program on a scale of 1 to 5, where "1" is very dissatisfied and "5" is very satisfied. Figure 5-1 shows how participants responded. The participants on average rated their satisfaction with various aspects of the program as "very satisfied", with the lowest rated aspect being the type of rebates available, at an average of 4.6. Participants rated their experience overall at a 4.8 (green bar in Figure 5-1.

Figure 5-1. Participant satisfaction with various aspects of the program (n=15)



When asked to rate how important the PSE incentive was in their decision to make upgrades on a scale of 1 to 5, where "1" is "not very important" and "5" is "very important", 8 of the 15 respondents said it was very important, five said it was somewhat important, one said it was not very important, and one said they were neutral.

Participants were then asked an optional follow-up question to explain why the rebate was important or not important in their decision to make upgrades. Five respondents said that if the incentive had not been available, the project would be delayed or not completed at all. Six respondents said that the incentive greatly improved the return-on-investment for the project. One respondent said, "One thing that was helpful is that PSE committed to an amount. The firm estimate early on was crucial." The respondent who said "not very important" explained that the existing systems had high maintenance and overhead costs and were resource intensive, so the project would have been completed without the incentive. Participants were asked to provide suggestions or recommendations for program improvement. Below are some direct quotes from respondents:

> "We had a positive experience overall but would have liked to be incentivized for hard-to-quantify savings such as those from controls upgrades. This PSE rebate project only covered a small part of the scope of this project."

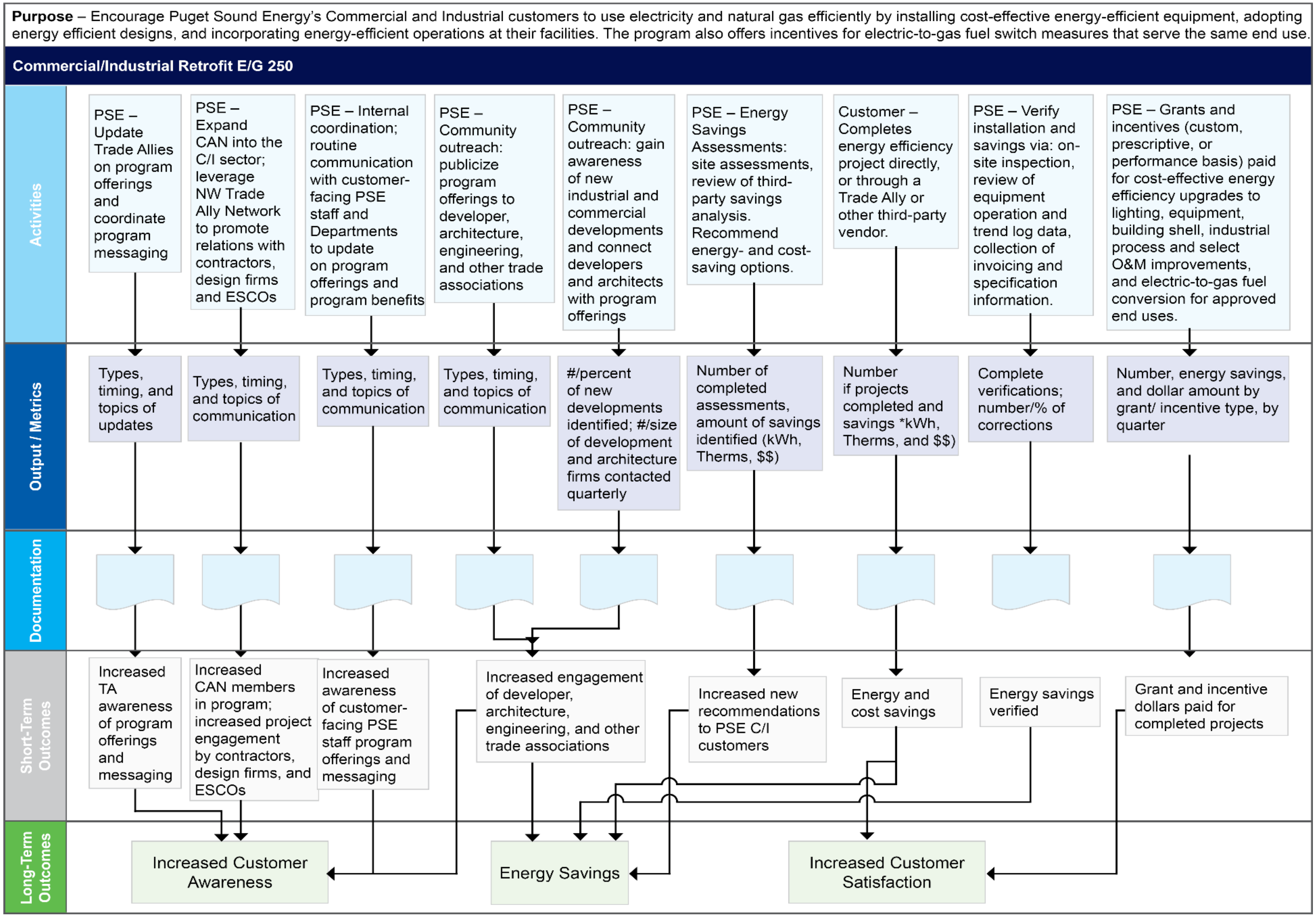
> "Would like more constant contact with an account rep. We have had a few different ones over past few years and would like to continue to see a partnership dynamic."

As noted in Section 5.3.1.1, as of 2023, the program now includes increased incentives for custom grants, including controls. The program managers have also improved the program with embedded individual account representatives, which has already seen a more positive, streamlined program experience for customers.

5.3.3 Program Theory Logic Model

DNV reviewed the PTLM currently used by the C&I Retrofit team to ensure it aligns with program priorities. Logic models are effective tools to assist in program planning, implementation, management, evaluation, and reporting. They help define a program's intended impact and goals, the sequence of intended effects, which activities are to produce which effect, and where to focus outcome and process evaluations. Figure 5-2 shows the existing PTLM.

Figure 5-2. Existing program theory logic model for C&I Retrofit program



While the existing PTLM captures the basic processes of the program, it was created prior to the current program manager taking over the program. Therefore, there is an opportunity to revisit the model and update each row with changes and improvements that have been made since it was created.

5.3.4 Key Performance Indicators

Through our interview with the program managers, we found that the KPIs and goals tracked for this program are energy savings, participation, and program spend. Goals are set using historical data and they are tracked in PSE's program delivery operating system. Additionally, changes in energy codes and other drivers are considered when forecasting and setting program goals. Goals are being met primarily through HVAC, process, and refrigeration measures. The program manager also considers changes in energy codes and other drivers to help inform the energy savings forecasts. In 2022, the program met KPI targets and saw a 90% realization rate.

5.4 Findings, Recommendations, and Considerations

This section documents DNV's findings, recommendations, and considerations associated with the C&I Retrofit program.

5.4.1 Impact Key Findings and Recommendations

- **Key Finding** – Errors in savings calculation formulas occurred in two sample projects and resulted in a large variance for one site, which ultimately had a significant impact on the program's realization rate. For this site, the applicant calculated total motor power draw using total current rather than average current, which overestimated the baseline energy use by 67%.
    - **Recommendation** – Projects going through QA/QC review should verify that the power draw of the equipment is being calculated correctly.
- **Key Finding** – DNV adjusted the calculation methodology for several sites to account for loads that impact the energy savings of the project based on measure type and intended operation, such as weather, production, infiltration, etc. In some of these cases, when the applicant's analysis did not reflect the facility or incentivized equipment loads, we performed a consumption analysis to determine project savings.
    - **Recommendation** – The applicant should normalize project savings based on drivers of energy consumption for the project, including weather and non-weather-related drivers.
- **Key Finding** – Due to a non-routine event, we were unable to evaluate a full year of trend data for the CHP system. As a result, we had to assume that operation of the CHP based on 6 months of data would apply to the rest of the year. However, assuming identical system availability adds uncertainty to the evaluated savings. Additional uncertainty was introduced because the facility did not have electric net meter data to assess if the surplus electricity generated returned to the grid.
    - **Recommendation** – For future CHP projects, PSE should ask the implementer to develop a detailed M&V plan metering all grid and onsite energy (and mass and temperature/enthalpy) streams and agree to provide M&V data for 1 full year.

5.4.2 Impact Findings and Considerations

- **Finding** – Several sites claimed gas savings (and a baseline consumption) that were not realistic based on the measure type and the facility's total baseline gas consumption.
    - **Consideration** – For future projects with savings claims beyond a specific threshold, cross-check claim with annual consumption of the associated meter.

- **Finding** – Through analysis of facility-provided trend data, evaluators found facility operation did not match what was claimed by the program. There were several examples of this, resulting in variance between reported and evaluated savings. For one site, the program claimed 5,880 hours of annual operation. However, the installed chiller was operational at temperatures between 55ºF-74ºF, or about 3,300 hours annually. For another site, the applicant's model did not consider the 5-month summer heating lock-out or the airflow setback for unoccupied periods.
  - **Consideration** – Add guidelines regarding reviewing the implemented control strategies incentivized the program 1 year after installation.
- **Finding** – Evaluators found that the baseline assumption for one site was not realistic based on facility operation. The program claimed that the existing pool cover was too degraded to be effective at trapping heat and claimed the baseline as no pool cover. This is not a realistic assumption since the cover was still being used during the baseline period.
  - **Consideration –** Account for current practice of the facility when approving the baseline used for energy savings.
- **Finding** – The reported and evaluated electric savings for the CHP project were determined by comparing the efficiency of the CHP system to an on-site generation baseline. The applicant estimated that the installed CHP system would operate at an efficiency of about 64%. However, based on the post-installation trend data, the installed system was operating at about 79% efficiency.
  - **Consideration –** Review CHP operating efficiency assumptions for future CHP projects.

5.4.3 Process Key Findings and Recommendations

- **Key Finding** – Overall, the program is successful and well-run from a process perspective. Goals and KPIs are being met, and participants are very satisfied with the program across key aspects.
- **Key Finding –** There is uncertainty from program staff around reasons for program intake slowing down recently.
  - **Consideration –** Consider performing surveys with contractors that have been involved in the program to identify areas for improvement and expansion, and to better understand the reasons behind any slowdown in program uptake.

5.4.4 Process Findings and Considerations

- **Finding –** Program managers are responsible for training more junior engineers on the complex measures, which takes the program manager's focus away from the program and spreads their time thin.
  - **Consideration –** PSE should consider a different approach to training new engineers. Instead of the training and mentoring falling on one person, more senior engineers could be assigned to train and mentor newer engineers. This would give time back to the engineer that has been responsible and would give others experience in mentoring and training.
- **Finding –** The logic model is not updated regularly or utilized by program staff. Not having a PTLM introduces risks, including the inability to properly transfer knowledge about program processes and (perhaps more importantly) desired outcomes if the program experiences a sudden change in staffing.
  - **Consideration –** PSE should regularly revisit program logic models. This tool, if used as intended, can not only help to identify opportunities to grow and continue to improve the program, but it can also be used as training collateral and helps with knowledge transfer for new colleagues.
- **Finding –** Individual account management was implemented in 2023 and has had a positive impact on customer experience.
  - **Consideration –** Continue streamlining and improving account management. Customer satisfaction should be continually monitored to keep this aspect of the program a positive experience for the customer.

6 E/G 250 – INDUSTRIAL ENERGY MANAGEMENT PROGRAM

This section summarizes the impact and process evaluation approach, results, and recommendations for PSE's PY2021-2022 Industrial Energy Management (IEM) program. Our impact evaluation reviewed projects with savings claimed in 2021 and 2022.

6.1 Program Overview

The IEM program provides a comprehensive suite of offerings to improve the energy efficiency of non-residential customers (those on rate schedules E250 and G250) that have also been identified by PSE as industrial. These offerings are classified into four categories, including:

- **Industrial Custom Capital Grants** focus on incentives for energy-efficient upgrades in industrial facilities, such as refrigeration, compressed air, and variable frequency drives (VFDs).
- **Industrial System Optimization Program (ISOP)** helps participating industrial customers identify and implement projects that result in operational and management (O&M) energy improvements for their buildings. The focus of this program is on low-cost energy-saving options, such as set point changes, air leak repairs, installing timers on equipment, and modifying controls for energy-intensive systems.
- **Industrial Strategic Energy Management (ISEM)** establishes cohorts of industrial customers in "like" industries (such as manufacturing or wastewater treatment) which are assisted by a third-party "engineering consultant". Participants establish baseline facility energy usage, implement energy-saving actions (such as behavioral changes, O&M, or capital investments), and measure improvement over a multi-year period. ISEM encourages participating customers to engage all levels of their organization to achieve goals, assigning one or more employees of participating organizations the roles of Energy Champion, Executive Sponsor, and Data Lead.
- **Comprehensive Small Industrial** provides custom grants targeted at "small" industrial customers (defined as an annual usage of less than one million kWh and/or 100,000 therms). The program aims to offset the cost of energy-efficiency capital projects by combining energy savings from the capital project with energy savings from changes to O&M.

PSE manages the IEM program in-house through a team of nine PSE staff, including a program manager (who has been with PSE for nearly a decade), supervisor, and seven engineers. Additionally, the program receives targeted support from third-party contractors (such as the engineering consultants in the ISEM offering). PSE had multiple ISEM cohorts operating in 2022. Year 1 savings from the four-customer wastewater cohort were reported in 2022. Two manufacturing cohorts started in 2022 with Year 1 savings expected to be reported in 2023.

6.1.1 Program Savings

Table 6-1 shows the energy savings tracked by the program during PY 2021 and 2022. Process modification and refrigeration optimization measures were the primary contributors to program electricity savings and the process modification measure was the sole contributors to program gas savings.

Table 6-1. Tracked PY2021-22 program savings by measure, IEM

Measure Category	Project Count	Tracked Electric Savings (kWh)	Percent of Tracked Electric Savings Contribution	Tracked Gas Savings (Therms)	Percent of Tracked Gas Savings Contribution
Compressor or Dryer or Receiver – Custom	3	62,210	2%	-	N/A
ISEM	17	870,001	25%	-	N/A
Optimization – Process Heating – O&M	1	-	N/A	-	N/A
Optimization – Refrigeration – O&M – Custom	3	1,009,164	29%	-	N/A
Process – Modification – Custom	2	1,310,503	37%	21,903	100%
Pump – VFD – Custom	1	26,163	1%	-	N/A
Refrigeration – Custom	3	259,370	7%	-	N/A
Total	**30**	**3,537,411**	**100%**	**21,903**	**100%**

6.2 Impact Evaluation

This section documents DNV's independent estimate of the program realization rate and review of the calculation methods used by the program. Each element of our evaluation process is discussed below along with relevant findings. The section concludes with our estimate of the program realization rates followed by the primary drivers of variance between PSE's tracked savings estimates and DNV's evaluated savings estimates. DNV completed the following steps for the impact evaluation of the IEM program:

- **Sample Selection:** Selection of a representative sample of completed projects for evaluation.
- **Project File Review:** Review of project files provided by PSE to identify calculation methods and key parameters, collect consumption data, and to ensure sufficient information exists to evaluate the project. DNV assessed the evaluability of the ISEM offering through a file review of documentation and analyses associated with the four wastewater ISEM participants that reported Year 1 savings in 2022.
- **M&V Planning:** Creation of project-specific M&V plans to identify key input parameters, stipulate values to research, and determine the data collection methods for verification.
- **Data Collection:** Videoconference or phone interview with sampled participants to review each project, baseline assumptions, consumption/model data, and current operating parameters.
- **Project Analysis:** Estimated evaluated savings using the data collected to update key input parameters.

6.2.1 Sample Design

This sub-section presents an overview and summary of the sample design used to evaluate PY2021-2022 of the IEM program. DNV used stratified random sampling to select an efficient representative sample of projects for evaluation. The sample was designed to provide a reliable estimate of program performance. Table 6-2 summarizes the planned sample design for this program.

Table 6-2. Preliminary IEM sample design parameters

PSE Program	Sub Domain	Anticipated Population Size	Expected Total Savings (kBtu)	Assumed Error Ratio	Sampling Rounds	Planned Sample	Expected Relative Precision
IEM	All	24	18,519,773	1.0	1	9	31%

Sampling occurred at the project level. The sample was selected from IEM projects completed between January 1, 2021, and December 31, 2022. The key design elements for the sample were as follows:

- Manual selection of two projects completed in 2021 that were responsible for 78% of the 2021 reported IEM program savings.
- Stratification by size of savings reported at the project level for projects completed in 2022.

The sample design resulted in the selection of nine unique projects for evaluation. Table 6-3 shows the final sample frame and primary sample counts by stratum. Final PY2022 savings were significantly higher than anticipated at the time of sample design, but no adjustments to the design were necessary to achieve the expected relative precision.

Table 6-3. Final IEM sample design by stratum

Compliance Program	PSE Subprograms	Sampling Phase	Project Size	Projects in Sample Frame	Project Savings (kBtu) in Sample Frame	Primary Sample	Probability of Inclusion
IEM	ISOP, ISEM	Phase I	Manual	2	6,304,932	2	1.000
		Phase II	Small	20	10,073,523	4	0.200
			Medium	5	15,393,837	3	0.600
Total				**27**	**31,772,292**	**9**	**N/A**

6.2.2 Project File Review

Project file reviews are structured site-specific reviews of PSE’s IEM program application files and calculations that systematically examine and record the evaluation team’s conclusions on ex ante savings development practices. DNV reviewed each sampled project’s files for sufficient documentation, program savings methodology, and accurate savings reporting. This review included:

- Assessing completeness of documentation
- Identifying of the building type
- Performing a web-based search to determine if the sampled commercial entity was operating normally, operating under modified conditions, or closed
- Verifying the existence of engineering calculations with outputs that match the reported savings
- Identifying key building or system operation parameters contributing to the reported savings
- Confirming availability of utility consumption data, supporting model data, production data, or other non-weather energy drivers’ data used to support the savings calculations
- Verifying building electric meter numbers and assessing building annual electric consumption to determine the percentage of savings resulting from the project

During Phase 1, DNV conducted a file review of the four-customer wastewater cohort that reported Year 1 savings in 2022. Since ISEM cohorts were not previously evaluated, the objective of the file review was to assess evaluability based on the documentation included in the project files. Our review will be applicable to evaluations of future cohorts. DNV reviewed our initial documentation findings with the program managers and offered recommendations regarding calculation methodology, documentation clarity, and missing supporting documentation.

6.2.3 M&V Planning

DNV developed an M&V plan for each sampled project using our M&V plan template to guide the data collection effort. These plans focused on the collection of information specific to the key research parameters identified during file review. We created project-specific M&V plans for each evaluated ISOP project, which identified measure-specific and facility-specific parameters that impacted project savings. For evaluated ISEM projects, we created one M&V plan for the evaluated wastewater cohort projects, adjusting as needed based on facility specific considerations.

6.2.4 Data Collection

All data collection occurred remotely via telephone or videoconference. Data collection followed the M&V plan developed for each project. In many cases, facility EMS screenshots of current setpoints and schedules were captured to document the as-found building controls sequences. No independent data logging or metering was completed for this evaluation. DNV also requested and received utility meter data for each facility to review recent consumption. This data was used to both confirm facility use, calibrate energy models to consumption levels, and, if consumption analysis was selected as the analysis methodology, determine project savings.

6.2.5 Project Analysis

DNV used the information gathered during data collection to update the key calculation input assumptions. Whenever possible, DNV 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 EMS data, schedules, setpoints, program project files, and utility meter data. Typically, adjustments were made to the evaluation analysis to model the conditions observed by the evaluation. When DNV found that the evaluation period facility operating parameters (setpoints, schedule and control logics, etc.) were different from their respective program modeled values, the evaluation determined if such parameters were part of the implemented improvement or not. If they were part of the implemented measure improvements, the evaluation energy model implemented those changes to the post-project model only, and those evaluation findings became the basis of having a different modeled evaluation savings compared to program modeled savings. However, if the parameters and setpoints were not part of the implemented measure, the evaluation ensured that such parameters, setpoints, and control logics should act as energy-neutral while determining the evaluation savings. In other words, these parameters are kept identical both in the pre- and post-project models. This is achieved by utilizing identical values of such parameters in both baseline and post-project energy analysis.

For evaluated ISEM projects, DNV calculated energy savings by developing a baseline regression model using facility trend data from the on-site EMS and normalized utility consumption data. We applied the baseline regression to the performance period to predict hypothetical baseline consumption and compared that data to the facility's actual consumption data, normalized and accounting for non-routine events and any custom, capital, and prescriptive projects that took place during the performance period that could not be attributed to the IEM program.

6.2.6 Final Evaluated Sample

Table 6-4 shows the final sample achieved for this impact evaluation alongside the planned sample. The difference between the planned sampled and completed sample is due to challenges recruiting participants for evaluation. Two of the originally sampled sites refused to participate in the evaluation, and the backup sites we replaced them with also refused and/or were unresponsive. The final sample, while smaller than originally planned, is representative of the program.

Table 6-4. IEM evaluated site count summary

Compliance Program	PSE Subprograms	Sampling Frame Q1 2021-Q4 2022	Planned Sample 2022 (Phase I)	Completed Sample 2022 (Phase I)	Planned Sample 2023 (Phase II)	Completed Sample 2023 (Phase II)
IEM	ISOP, ISEM	27	2	2	7	5
Total		**27**	**2**	**2**	**7**	**5**

6.2.7 Program Realization Rates

The project-specific results for the final evaluated sample were extrapolated back to the sampling frame to determine the evaluated savings for the population and the program realization rate. The calculated realization rates should be applied to the final 2022-2023 biennium tracked savings to estimate the evaluated savings for the program over the biennium. Table 6-5 provides the electric evaluation results from the evaluation sample of 7 projects with electric savings that have been expanded to the sample frame of 27 projects with electric savings.

Table 6-5. IEM electric impact evaluation results

Project Count with Electric Savings	Realization Rate	Relative Precision at 90% Confidence Interval
Sample Frame = 27 Evaluated = 7	121%	24%

Table 6-6 provides the gas evaluation results from the evaluation sample of 2 projects with gas savings that have been expanded to the sample frame of 3 projects with gas savings.

Table 6-6. IEM gas impact evaluation results

Project Count with Gas Savings	Realization Rate	Relative Precision at 90% Confidence Interval
Sample Frame = 3 Evaluated = 2	98%	4%

6.2.8 Sources of Variance

The primary driver of electric savings variance is how production data was incorporated into the analysis, particularly for one site. The applicant used the whole plant's energy use intensity (EUI) in the analysis, rather than the installed equipment's EUI. Based on the interview with the site contact, the whole plant's EUI was not representative of the installed equipment because there were other large power users at this facility whose consumption distorted the relationship between production data and energy consumption. The installed equipment's EUI was available and was a more accurate predictor of project savings. Additionally, in the post-installed period for this site, the facility was generating production volumes 150% higher than the pre-installation period. DNV normalized the savings based on the post-installed production volume. Using the installed equipment's EUI and post-installation production volumes resulted in a project realization rate of 218%, which drove this program's electric realization rate of over 100%.

The primary driver of gas savings variance was the adjustment of the baseline for one measure and removal of energy savings for several commissioning measures that were identified as no longer intact or modified significantly by operations staff for one evaluated site. The applicant's model leveraged results of a benchmarking survey done for ice arenas by Natural Resources Canada to determine the project baseline. Although the survey accounted for variance due to several independent parameters, DNV ultimately deemed this approach to be invalid as the ice arena that engaged with the program was built much more recently; and therefore, was subject to more stringent energy performance codes than surveyed in the study.

6.3 Process Evaluation

This section summarizes the key findings for the IEM Program process evaluation. It includes results from in-depth interviews and surveys with customers who participated in the 2022-2023 biennium.

6.3.1 ISEM Participant Interviews

While IEM program savings have historically been achieved mostly through traditional custom capital projects and ISOP, going forward, a large proportion of savings are expected to shift to the growing ISEM initiative. As such, DNV focused the process evaluation on conducting interviews with ISEM participants. This section summarizes results from those interviews.

DNV sought to collect ISEM participant feedback on the following topics:

- Program awareness and interest
- Barriers to participation
- Program satisfaction
- Suggestions for improvement

6.3.1.1 Sample Frame

PSE provided DNV with a list of 19 customers participating in one of PSE's three active ISEM cohorts, which included two manufacturing cohorts and one cohort comprised of wastewater treatment plants. DNV targeted and completed interviews with 10 of these 19 participants in March 2023. In all cases, the primary respondent was the Energy Champion for that participant, in some cases accompanied by either the Executive Sponsor or the Data Lead. We completed interviews with at least two respondents from each of the three cohorts.

6.3.1.2 Program Awareness and Participation

Respondents most frequently (5 of 10 respondents) reported learning about PSE's ISEM offering directly from PSE staff (such as key account managers). Other sources of information included other organization staff (3 of 10), typically the respondent's supervisor or manager.

We then asked the respondents for the main reason that their company or organization was interested in participating in ISEM. Most commonly (6 of 10 respondents), participants were attracted to the financial upside, either in terms of the program incentives or the cost savings associated with the potential energy efficiency improvements. Not far behind, however (and confirming PSE program staff experience), internal company or facility sustainability goals that aligned with the ISEM offering was a motivating factor for 4 of the 10 respondents.

At the time of the interviews, most participants were at a similar point in the ISEM process. All 10 respondents described a comparable participation experience, including an initial on-site energy assessment or "treasure hunt." They also described several energy efficiency actions that they had taken in monthly or bi-weekly meetings with the engineering consultant and their ongoing tracking of energy savings. Nearly all (8 of 10) respondents said that, in terms of how they prioritized the list of suggested energy efficiency actions, their company or organization first attempted the lowest-hanging fruit, or "quick wins." Three specifically mentioned utilizing a prioritization matrix, targeting projects in the quadrant corresponding to relatively low effort with relatively high savings.

We then asked the participants what benefits they have observed since they completed the energy efficiency actions. Three of the ten respondents said that they had not seen benefits to date, or that it was too early in the process to tell. Among the seven respondents who had so far experienced benefits, the most common (with five respondents citing) were energy savings or cost savings. Other, less tangible, benefits (mentioned by one respondent each) included:

- Increase in equipment life
- Improvement in employee morale
- Better awareness of their facility

6.3.1.3 Cohorts

One distinguishing aspect of the ISEM program is the cohorts of “like” customers, which meet periodically to discuss progress, provide encouragement, and share ideas. We asked the participants to reflect on their experience, both in terms of what has been most valuable and what has been most challenging about working with their cohort. Most respondents (6 of 10) said they found the opportunity to learn new ideas or approaches from other cohort participants was valuable to them, one stated that the cohort’s value to them was to increase their engagement with the program, and one saw value in what they called “professional venting.” Two respondents said the cohort did not provide any value to them.

While most participants recognized value in the cohorts, most also cited some challenges with their cohort. Most commonly (with 4 of 10 participants interviewed), respondents stated that in general, information shared by other cohort members was not directly applicable to their facility, making the cohort less beneficial than it could have been. All four of these participants were in manufacturing cohorts, meaning half of manufacturing cohort respondents shared this opinion. Interestingly, this opinion was not shared by the two respondents in the wastewater treatment cohort, both of whom said they experienced no challenges at all with respect to the cohort. It is likely that the extremely similar nature of wastewater treatment plants lends itself better to sharing ideas and experiences than manufacturing, which can vary considerably from participant to participant.

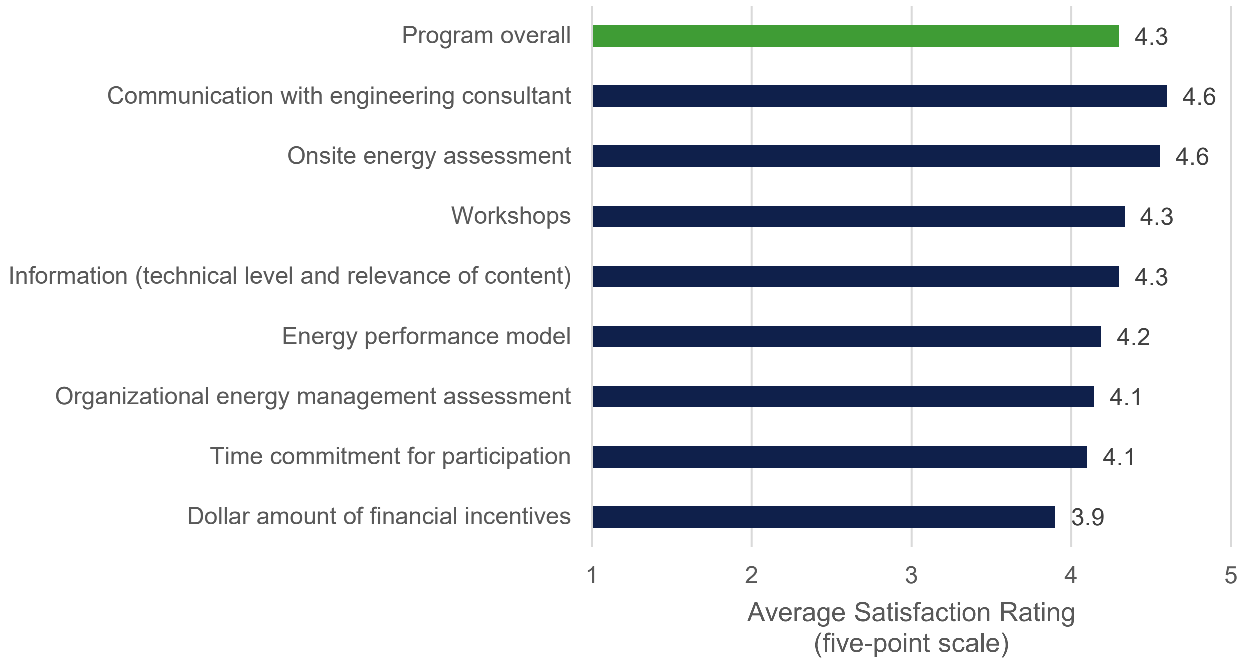
Finally, in terms of challenges with the cohort, 3 of 10 said that the level of engagement, participation, or how talkative the participants are sometimes wanes, which can negatively affect the usefulness of the cohort. As one respondent put it:

> “If nobody talks, it's just a waste of time. Even the people who used to talk aren't saying much anymore. Maybe do them less than monthly - maybe quarterly. Give more time for things to happen.”

6.3.1.4 Satisfaction

Participants are generally satisfied with the ISEM program, giving an average rating of at least 4.2 to most program aspects (using a five-point scale in which “5” meant “very satisfied” and “1” meant “very dissatisfied”). As Figure 6-1 illustrates, communication with the engineering consultant and the onsite energy assessment (“treasure hunt”) received the most positive satisfaction responses, averaging a 4.6 on the five-point scale and no respondents giving less than a 3. Additionally, not included in the figure below, when asked how well the ISEM program met their expectations on a similar five-point scale, responses averaged a 4.6, with just one respondent giving less than a four.

Figure 6-1. Participant satisfaction with ISEM program



As Figure 6-1 shows, satisfaction with the dollar amount of the financial incentives was lowest among all program aspects, averaging 3.9 on the five-point scale (and 4 of 10 giving less than a 4). In response to a separate question, only half (5 of 10) of respondents agreed that the current program financial incentives were high enough to help motivate (new, not already participating) organizations like theirs to participate. As one customer stated, “I wouldn’t change my to-do list based on those incentives.”

While most participants were satisfied (4 or 5 on the five-point scale) with the technical level and relevance of information, two respondents rated that program aspect as a 2. Not coincidentally, both of those respondents’ energy usage profiles relied heavily on refrigeration, and both independently remarked that their engineering consultant lacked refrigeration expertise, limiting learning opportunities and potential energy savings. As one stated, “They haven’t told us anything we didn’t already know.” It is worth noting that, while they described a similar issue, these participants were in different manufacturing cohorts with different engineering consultants.

Despite some of the difficulties detailed above, all 10 ISEM participants interviewed said their organization plans to continue participation throughout the entire 3-year period.

6.3.1.5 Challenges and Suggestions for Program Improvement

We then asked the participants about the biggest challenges to participation in ISEM and suggestions for PSE to mitigate those challenges in the future. The most common responses included:

- **Challenge:** Making adequate time for participation (four respondents)
  - **Suggestion 1:** Conduct one-on-one workshops in shorter (2-3 hours), more frequent sessions.
  - **Suggestion 2:** Shorten cohort meetings to 1 hour, eliminating some or all breaks.
- **Challenge:** Difficulties inputting data into modeling software (four respondents)
  - No suggestions for improvement.

- **Challenge:** Getting other staff, including those at the corporate level, on board (two respondents)
    - **Suggestion 1:** Provide participants with a plan to present information to co-workers, including email templates and program handouts.
    - **Suggestion 2:** Work with primary participants' supervisors to build time needed for ISEM participation into normal job expectations such that participation is not entirely "above and beyond" all existing responsibilities.

6.3.1.6 Barriers to Energy Efficiency

We asked the respondents, outside of the ISEM program, what challenges they face to making more energy efficiency improvements to their facilities. Responses with more than one citation included:

- Time constraints (four respondents)
- General labor shortage (four respondents)
- Organizational culture / people making energy efficient choices (three respondents)
- Production interruptions (two respondents)
- Lack of engineering expertise (two respondents)
- Low-hanging fruit already picked (two respondents)

Finally, we asked the question: "What are the one or two key things your company needs to be able to go further in achieving energy savings?" Participants coalesced around three responses:

- Additional staffing (five respondents)
- Buy-in from executives (four respondents)
- Additional funding (four respondents)

6.3.2 Participant Surveys

During the course of the impact evaluation, DNV completed brief surveys (including information relevant to the process evaluation) with five unique customers participating in the IEM program. These were knowledgeable respondents, as all said they were involved in their organization's decision to participate in the program. This section summarizes findings collected through those surveys in two topics: program influence and program satisfaction.

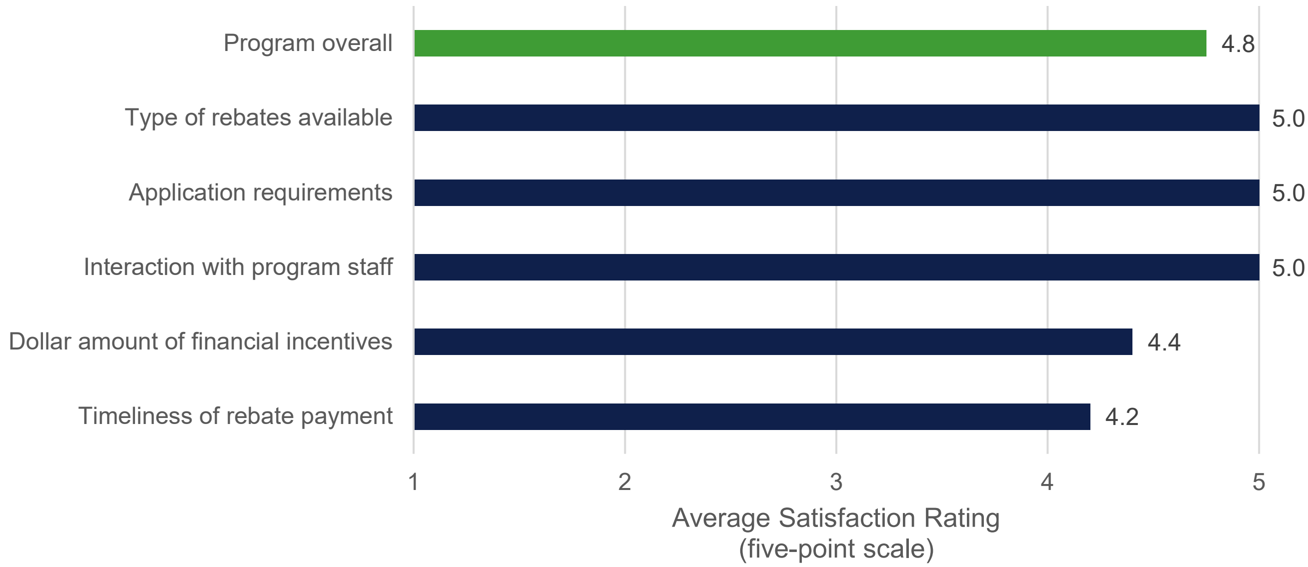
6.3.2.1 Program Influence

DNV asked the participants: "The program provides incentives to help offset the cost of going from standard to high performance equipment. How important was the PSE incentive in your decision to make these upgrades?" Respondents rated the importance of PSE incentives using a five-point scale in which "1" is "not at all important" and "5" is "very important." The average importance of PSE incentives was 4.4, with all five participants giving at least a 4 ("somewhat important").

6.3.2.2 Participant Satisfaction

Customers are generally satisfied with most program aspects, giving an average rating of at least 4.2 to all (using a five-point scale in which "5" meant "very satisfied" and "1" meant "very dissatisfied"). Figure 6-2 shows the average satisfaction ratings for all program aspects. Notably, all respondents giving a numerical rating said they were 'very satisfied' with the types of rebates available, the application requirements, and their interactions with program staff.

Figure 6-2. Participant satisfaction with IEM program



6.3.3 Previous Evaluation Review

DNV found two recommendations from previous evaluations that are applicable to the current biennium, both originating from the Industrial Systems Optimization Program Evaluation (DNV, 2017). PSE has made progress in addressing both recommendations, as both have been incorporated into the program to varying degrees.

The first recommendation centered around reforming savings calculations methods. While the overall realization rate for the 2017 ISOP evaluation was high, the team found that site-level realization rates varied considerably. For the 2021-2022 biennium, DNV found this to still be the case for industrial applications. However, consistency in the realization rate did appear to improve from sampled projects in 2021 to those in 2022 (although small sample sizes make definitive conclusions difficult). As a result, DNV considers this recommendation as in-progress.

The second recommendation was to extend the minimum performance period. In 2017, the team found that the 60-day minimum reduced the accuracy of savings estimates. Since then, PSE modified the minimum standard evaluation period to 6 months, which captures a more representative period in terms of the annual range of conditions. As a result, DNV considers this recommendation as completed.

6.3.4 Program Theory Logic Model

Logic models are effective tools to assist in program planning, implementation, management, evaluation, and reporting. They help define a program's intended impact and goals, the sequence of intended effects, which activities are to produce which effect, and where to focus outcome and process evaluations.

To date, PSE has not developed a full PTLM for the ISEM program. PSE has developed a “program outline,” shown in Figure 6-3. DNV confirmed that the outline effectively captures program activities.

Figure 6-3. ISEM program outline

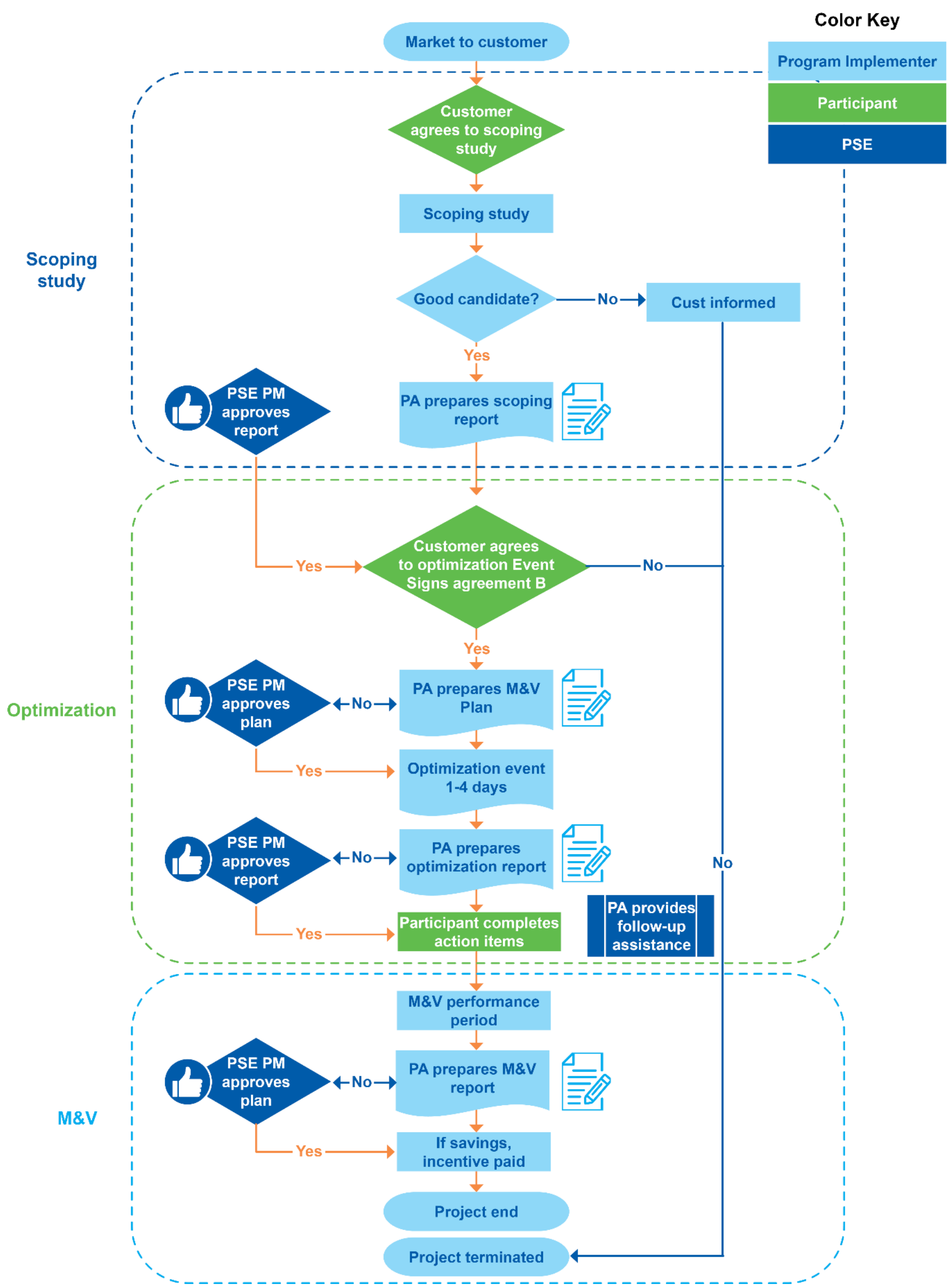
TIMELINE	MONTH 0	MONTH 1	MONTH 2	MONTHS 3-4	MONTH 5	MONTHS 6-7	MONTH 8	MONTHS 9-17	PERF. YEAR 1	PERF. YEAR 2	PERF. YEAR 3
Workshops		**Workshop 1**	**Workshop 2**		**Workshop 3**	**Workshop 4**	**Workshop 5**		**Starts Month 7**	**Starts month 19**	**Starts Month 31**
		Laying Your SEM Foundation	**Finding & Implementing Projects**		**Tracking Energy Performance**	**Engaging Employees**	**Making SEM Stick**				
PSE Activities	Kick-off, Program Intro, & Tour	Site energy & activity monitoring Check-in calls	Site energy & activity monitoring Check-in calls	Site energy & activity monitoring Check-in calls	Site energy & activity monitoring Check-in calls	Site energy & activity monitoring Check-in calls	Site energy & activity monitoring Check-in calls	Site energy & activity monitoring Check-in calls	Site energy & activity monitoring Check-in calls	Site energy & activity monitoring Check-in calls	Site energy & activity monitoring Check-in calls
PSE Responsibilities	Attend Kick-off, Program Intro, & Tour	Create energy models Provide cohort training materials	Create energy models	Create energy models Prepare for Treasure Hunt events Pay milestones when achieved	Finalize site energy models Finalize opportunity registers	Support EE activities Pay milestones when achieved	Support EE activities	Support EE activities	Update energy models Verify energy savings Pay incentives	Update energy models Verify energy savings Pay incentives	Update energy models Verify energy savings Pay incentives
Customer Activities	Kick-off, Program Intro, & Tour	Organizational preparation	E-team engagement and preliminary EE identification	Update & review model Update action items Hold e-team meetings	Update & review model Update action items Hold e-team meetings Complete projects	Update & review model Update action items Hold e-team meetings Complete projects	Update & review model Update action items Hold e-team meetings Complete projects	Update & review model Update action items Hold e-team meetings Complete projects	Update & review model Update action items Hold e-team meetings Complete projects	Update & review model Update action items Hold e-team meetings Complete projects	Update & review model Update action items Hold e-team meetings Complete projects
Customer Responsibilities	Attend Kick-off, Program Intro, & Tour	Provide baseline model data Develop energy policy Set up energy team Develop e-team's meeting agenda & schedule	Milestone 1: Baseline Model Data Deadline Apply principles provided in the workshop	Hold Treasure Hunt event	Review Opportunity Register produced during Treasure Hunt Pursue energy-saving action items Identify new opportunities Support & maintain e-team	Milestone 2: Employee Engagement Efforts Pursue energy-saving action items Identify new opportunities Support & maintain e-team	Pursue energy-saving action items Identify new opportunities Support & maintain e-team	Pursue energy-saving action items Identify new opportunities Support & maintain e-team	Pursue energy-saving action items Identify new opportunities Support & maintain e-team	Pursue energy-saving action items Identify new opportunities Support & maintain e-team	Pursue energy-saving action items Identify new opportunities Support & maintain e-team
Milestones & Incentives			$1,000			$1,000			$0.02/kWh up to $25,000	$0.02/kWh up to $25,000	$0.02/kWh up to $25,000

Source: PSE-provided *Program-outline – ISEM.pdf*

DNV also reviewed the PTLM currently used by the C&I Retrofit team and confirmed that it effectively captures program processes and aligns with program priorities (Figure 6-4). We suggest several additions to further increase its accuracy, including:

- Add a participant action: provide conditional site data (variables that may cause energy usage fluctuations)
- Add a participant action: provide documentation for all incentive-eligible costs
- Timing information (e.g., 6 months for M&V performance period)
- Add ISOP+ (if it moves from pilot to "core" offering)

Figure 6-4. ISOP program theory logic model



6.4 Findings, Recommendations, and Considerations

This section documents DNV's findings, recommendations, and considerations associated with the IEM program.

6.4.1 Impact Key Findings and Recommendations

- **Key Finding** – DNV found that the ISOP and ISEM subprograms were both achieving savings and determined that the methods used for calculating savings were reasonable for each project's characteristics.
- **Key Finding –** Two sites had differences in savings due to adjustments to how production data is used in the analysis. For one site, the applicant's analysis did not normalize or account for the change in production volume between the baseline and installed period. In a second site, the applicant used the whole plant EUI rather than the extruder EUI. The plant EUI included the effects of other large power users at the facility, which distorted the savings estimate based on variations in facility operation.
    - **Recommendation -** If implemented, measure operation is dependent on production volume or other non-weather drivers, the data should be incorporated into the analysis and used to normalize facility consumption to reflect savings from the measure exclusively.

6.4.2 Impact Findings and Considerations

- **Finding –** DNV found that two sites used baselines that could be seen as regressive, regardless of performance code applicability and existing industry standard practice. One site used a research study to determine the baseline rather than applicable performance code. Another site used pre-existing conditions as the baseline, though the pre-existing equipment was beyond its useful life and had experienced maintenance issues. The pre-existing baseline was less efficient than accepted ISP for this measure.
    - **Consideration –** PSE should provide stricter baseline guidelines and provide guidance on ISP for industrial measures.

6.4.3 Process Key Findings and Recommendations

- **Key Finding** – Incentives provided by the ISEM offering ($0.02/kWh saved, capped at $25,000 annually) garnered the lowest satisfaction rating among participants (3.9 on the five-point scale), and half of respondents (5 of 10) did not agree that current incentives were adequate to motivate other (new) customers to participate.
    - **Consideration** – In order to increase ISEM program participation, consider increasing the financial incentives provided to ISEM participants in the 2024-2025 biennium. This could mean increasing the per-kWh incentive, increasing the $25,000 cap, or both. Many of the current participants were primarily motivated to participate by internal sustainability goals, and while customers with these kinds of targets may want to participate in the ISEM program regardless of the level of incentives provided, customers not motivated by sustainability may find participation difficult to justify from a financial perspective.

6.4.4 Process Findings and Considerations

- **Finding** – Half of ISEM participants in manufacturing cohorts (4 of 8) said that a lack of direct applicability to their facility made the cohort aspect less beneficial than it could have been.
    - **Consideration** – As the ISEM offering continues to grow and new cohorts are established, narrow those new cohorts to truly "like" industries to the greatest extent possible to increase the value and benefit of the cohorts to participants. In some cases, customers may be genuinely unique, employing extremely niche equipment and/or processes. For these cases, to provide these customers a similar value that other customers receive via cohorts, consider outside sources or industry groups (either regionally or even

nationally) for these participants to engage in knowledge sharing and end use-specific conversations among peers.

- **Finding** – Two refrigeration-focused ISEM participants (one in each manufacturing cohort) thought their engineering consultant lacked refrigeration expertise, limiting learning opportunities and potential energy savings.
    - **Consideration** – Partner with a refrigeration expert as additional consultants to work with ISEM participants who have refrigeration that dominates energy usage.
- **Finding** – PSE has developed an ISEM "program outline," as well as a PTLM for the ISOP offering. Both charts effectively capture program activities. However, PSE has not developed a full ISEM PTLM, and the ISOP PTLM could use some additions.
    - **Consideration** – Given the increasing importance of the ISEM offering to the IEM program as a whole, expand the ISEM activities chart into a full PTLM, complete with outputs and outcomes. This is especially valuable for programs with external implementation contractors as it assists with the vendors alignment on and focus on program goals and desired outcomes. Review this PTLM annually to ensure that any changes are reflected.
    - **Consideration** – Include some minor additions to the ISOP PTLM. These include the following:
        - Add a participant action: provide conditional site data (variables that may cause energy usage fluctuations)
        - Add a participant action: provide documentation for all incentive-eligible costs
        - Timing information (e.g., 6 months for M&V performance period)
        - Add ISOP+ (if it moves from pilot to "core" offering)
- **Finding** – PSE does not have a comprehensive database of industrial customers in its service territory. Currently, most customers that are marked as industrial within PSE's customer database either identified as such when establishing their account with PSE or they have participated in an industrial energy efficiency program in the past. Additionally, PSE has used a manual process to designate customers as industrial, sometimes including Google searches.
    - **Consideration** – The lack of a thorough list of industrial customers limits potential IEM program reach. Look for additional, more systematic ways to identify industrial customers in PSE's service territory. This may include acquiring lists from third-party data providers, implementing a general online customer survey, or other approaches.

7 E/G 262 – COMMERCIAL HVAC REBATES

This section summarizes the impact and process evaluation approach, results, and recommendations for PSE's PY2021 Commercial HVAC Rebates program.

7.1 Program Overview

The Commercial HVAC Rebates program is a midstream program that offers incentives for the installation of energy saving measures and controls. From 2019 to 2021, PSE's Commercial HVAC Rebates program claimed savings for four different measures: advanced rooftop controls with demand control ventilation (ARC-Full), advanced rooftop controls without demand control ventilation (ARC-Lite), smart thermostats, and DHPs.

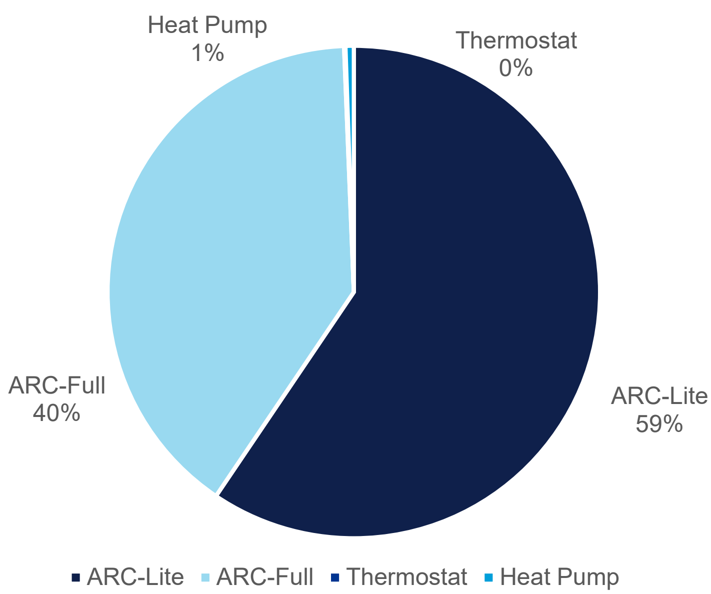
7.1.1 Program Savings

Energy savings are achieved primarily through the installation of ARCs that reduce fan motor use, optimize the use of outside air, and minimize the use of mechanical heating and cooling. The breakdown of claimed program savings by measure is shown in Table 7-1 and Figure 7-1.

Table 7-1. Tracked PY2021-22 program savings by measure, Commercial HVAC

Measure Category	Tracked Electric Savings (kWh)	Tracked Gas Savings (Therms)	Tracked Total Program Savings (kBtu)
ARC-Lite	609,131	-	2,078,440.25
ARC-Full	66,471	11,685	1,395,027.38
Smart Thermostats	928	-	3,166.47
DHPs	5,562	-	18,976.62

Figure 7-1. Total program savings (kBtu) by measure



7.2 Impact Evaluation

This section documents DNV's independent estimate of the program realization rate and review of the calculation methods used by the program. DNV used a measure-specific approach for estimating evaluated savings. The following steps were completed:

- **Sample Selection:** Selection of a representative sample of completed projects for evaluation.
- **Program Measure Review:** Review all measure case documentation and savings calculations to understand the eligibility requirements, savings algorithms, and savings values used to support reported savings. Confirm reasonableness of measure case assumptions, compare historic participation characteristics to the measure assumptions, and identify areas of risk and opportunities for refinement.
- **M&V Planning:** Develop evaluation approach for each measure. Develop an ARC-specific M&V plan to assess the current operation and savings achieved.
- **Data Collection:** Collected data through telephone interviews and email correspondence with sampled participants. When available, DNV utilized data already collected through the installed systems or the facility's existing systems.
- **Analysis:** Determine evaluated savings using the data collected through sampled participants to update key parameters to the savings calculations. DNV calculated savings using the reviewed measure case algorithms. The measure assumptions were replaced with key parameters when available.

7.2.1 Sample Design

This sub-section presents an overview and summary of the sample design used to evaluate PY2021 of the Commercial HVAC program. We evaluated projects completed in 2021 only because we were able to assess the calculation methodology for the incentivized measures for this program during Phase I. There were no significant differences between 2021 and 2022 that required additional sampling.

DNV used stratified random sampling to select an efficient representative sample of projects for evaluation. The sample was designed to provide a reliable estimate of program performance. Table 7-2 summarizes the planned sample design for this program.

Table 7-2. Preliminary Commercial HVAC sample design parameters

PSE Program	Sub Domain	Anticipated Population Size	Expected Total Savings (kBtu)	Assumed Error Ratio	Sampling Rounds	Planned Sample	Expected Relative Precision
Commercial HVAC Rebates	All	102	10,459,489	0.6	1	15	21%

Sampling occurred at the project level. The sample was selected from Commercial HVAC projects completed between January 1, 2021, and December 31, 2021. The key design element for the sample was stratification by size of savings reported at the project level. The sample design resulted in the selection of 15 unique projects for evaluation.

Table 7-3 shows the sample design and primary sample counts by stratum.

Table 7-3. Final Commercial HVAC sample design by stratum

Compliance Program	Sampling Phase	Project Size	Projects in Sample Frame	Savings (kBtu) in Sample Frame	Primary Sample	Probability of Inclusion
Commercial HVAC Rebates	Phase I	Small	33	555,702	4	0.121
		Medium	8	820,825	4	0.500
		Large	6	977,783	3	0.500
		Certainty	4	2,875,396	4	1.000
Total			**51**	**5,229,706**	**15**	**N/A**

7.2.2 Program Measure Review

7.2.2.1 Advanced Rooftop Controls

Both ARC-Full and ARC-Lite measures share the same methodology and are described in this section. The ARC measure involves the installation of aftermarket controls systems on existing rooftop package units (RTU). To qualify for the ARC-Lite measure incentive, the aftermarket controls must enable variable speed fan control. For the ARC-full measure, the systems must also enable digital integrated economizer control and demand control ventilation.

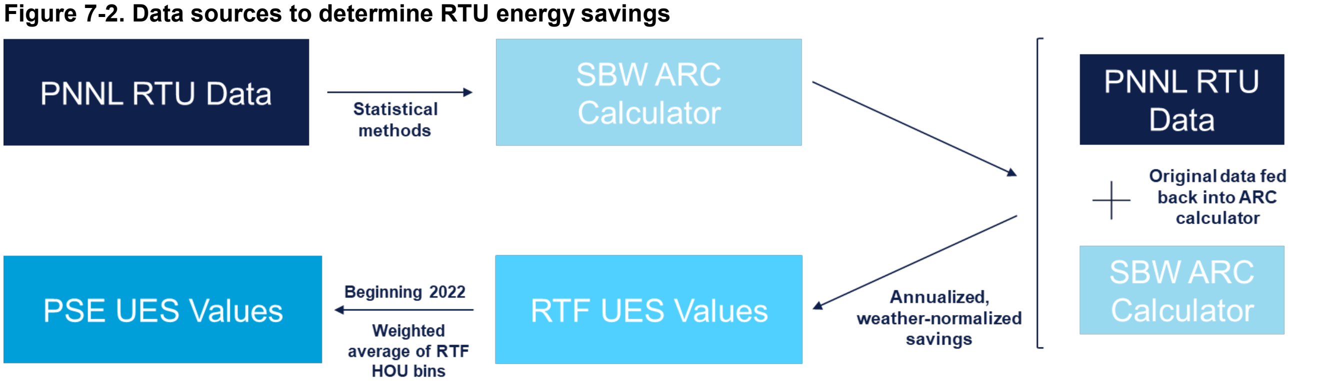
PSE Methodology

Savings for these measures are PSE-deemed, derived from the Regional Technical Forum (RTF), meaning that the savings are based on RTF analysis but modified for improved applicability to PSE service territory.

The origin of the data used to develop these savings values is a Pacific Northwest National Lab (PNNL) field study from 2013. This PNNL study gathered data from 66 retrofitted RTUs at 8 different buildings, 49 units of which were installed at five buildings in the Pacific Northwest. One-minute interval data was collected over a 12-month period during which the controls were alternated between standard and advanced modes daily.

The data collected as part of the PNNL study was then used by SBW Consulting to create an ARC Calculator for Bonneville Power Administration (BPA). The function of this calculator is to estimate annualized, weather-normalized fan energy savings from RTU retrofits. This calculator was then applied to the PNNL study data to develop unit energy savings (UES) used by the RTF. Figure 7-2 outlines the various data sources used to develop the UES that PSE uses to calculate ARC measure savings.

Figure 7-2. Data sources to determine RTU energy savings



The ARC calculator estimates fan power savings by using post-only hourly fan speed and fan power data to generate a power/speed curve which is used to estimate the baseline power at 100% fan speed. Compressor savings are estimated as the difference between total RTU savings (as calculated in PNNL report) and supply fan savings as described above.

Given that these UES values were developed with a statistical approach based on measured energy savings, the baseline and efficient cases for this measure do not have any assumed parameters aside from estimated energy use. This means that evaluating the claimed UES would require measurement of energy use in the same fashion as described above in the PNNL study, where control modes are alternated daily. For estimating fan savings, the ARC calculator developed by SBW Consulting can be used to develop a site-specific fan savings estimate.

Evaluation Approach

The Commercial HVAC program was evaluated at a low rigor (rigor level of 1). Therefore, DNV completed a verification-only approach when RTU data was not available from the customer. If the sampled participant was able to provide fan speed/power data, the ARC calculator was used to develop site-specific estimates for fan savings.

The verification portion (through phone call or email correspondence) of this evaluation approach aimed to confirm the following measure identifiers:

- Age of RTU: According to the RTF, units older than 15 years are ineligible for the measure and newly installed units may be required by code to have some control features incentivized by this measure.
- Capacity of RTU (must be >5 tons)
- Installed control type
- RTU heating fuel
- Annual RTU-served space occupied hours or annual scheduled fan hours

All customers interviewed reported that equipment was still installed and operating properly. However, it is worth noting that one customer mentioned that the ARC measure was installed as an add-on to new RTUs. While the evaluation team successfully verified the installation of the ARC equipment, independent evaluation of the savings values claimed was not possible in the absence of RTU operating data. The evaluation team and PSE sought this data from customers, when possible, but ultimately none of the sampled sites made this information available.

This degree of uncertainty may be acceptable for a measure that accounts for such a small percentage of PSE’s energy efficiency portfolio, but a high-quality evaluation of claimed savings is not possible for this measure without both pre- and post-operating data. In the future, this could be achieved by having a sample of participating customers agree to be metered both before and after the installation of additional controls. Certain customers, such as large chains, may already collect this data themselves. If such customers were willing to share this data, it would help to increase confidence in measure savings.

7.2.2.2 Smart Thermostats

This measure claims savings for the installation of web-enabled smart thermostats with the following features:

- Limited duration occupied period override
- Multiple set-back schedules with energy-saving temperature set- points during unoccupied periods including evenings, holidays, and breaks,
- Capable of scheduling the supply fan to operate continuously during occupied periods, and to operate in “auto” mode during unoccupied periods.
- Remote, web-based monitoring and programming
- Battery and memory back-up to retain settings during power or internet losses.

Multi-family customers and customers with existing EMS/BMS systems are not eligible for this measure.

PSE Methodology

This measure is PSE-deemed and RTF-derived. All RTF values and analysis are utilized except for measure life. PSE assumes an EUL of 10 years instead of the RTF recommended EUL of 5 years. The following reductions are assumed for the installation of thermostats:

- Ten percent of annual fan energy
- Ten percent of annual heating energy
- Two percent of annual cooling energy

EnergyPlus models that were developed for RTF are used to estimate HVAC-specific UES for three climate zones in the Pacific Northwest, and 2014 Commercial Building Stock Assessment (CBSA) data was used to provide total floor area and square foot per ton assumptions for each building type.

Evaluation Approach

The evaluation approach for this measure consisted of a remote phone survey involving verification of equipment installation and questions regarding measure characteristics. DNV used the results of these phone surveys to determine whether the most appropriate UES values were claimed for each project. When provided, actual building square footage and equipment capacity was used to revise annual energy consumption and ton per square footage assumptions.

7.2.2.3 Ductless Heat Pumps

This measure claims savings for the installation of DHPs and is available only to customers with existing electric resistance heating. The claimed savings for this measure account for the difference between electric resistance heating and code minimum baseline DHP. If applicable, any energy savings from installing DHP equipment that exceeds the code minimum baseline is incentivized through the Commercial Midstream HVAC and Water Heating program.

PSE Methodology

This measure is PSE-deemed and based on a calculation method recommended by the Department of Energy's (DOE) Uniform Methods Project (UMP). As discussed above, savings are only claimed for the difference between electric resistance heating and code minimum DHP heating. No cooling savings are claimed for this measure.

The following equation details the savings algorithm used by PSE:

$$\frac{kWh_{heating}}{ton} = \left(\frac{12}{HSPF_{Baseline}} - \frac{12}{HSPF_{Measure}}\right) \times EFLH_{Heat}$$

- $HSPF_{Baseline}$: 3.412 (electric resistance heat, coefficient of performance [COP]=1)
- $HSPF_{Measure}$: 8.2 (code minimum per International Energy Conservation Code [IECC] 2015)
- $EFLH_{Heat}$: 774 (based on PSE modeling and weighted average of Northwest Energy Efficiency Alliance [NEEA] building types)

Evaluation Approach

DNV performed remote phone surveys to confirm installation of equipment and verify measure characteristics. Site contacts were asked to confirm that existing resistance heating was in use before the installation of the DHPs and has since been decommissioned.

The actual installed building type was then used to refine the assumed effective full load hours (EFLH) used in the savings calculation.

7.2.3 Final Sample Design

Table 7-4 shows the final sample achieved for this impact evaluation alongside the planned sample. The difference between the planned sampled and completed sample is due to challenges recruiting participants for evaluation, due to a lack of current contact information and issues identifying participants who were willing to provide the data necessary to evaluate the project. If customers refused to participate or were deemed unresponsive after exhausting our attempts to reach them, we prompted replaced those sites with backup sample points. The final sample, while smaller than originally planned, is representative of the program.

Table 7-4. Commercial HVAC evaluated site count summary

PSE Program	Sampling Frame Q1-Q4 2021	Planned Sample 2022 (Phase I)	Completed Sample 2022 (Phase I)
Commercial HVAC Rebates	51	15	9
Total	**51**	**15**	**9**

7.2.4 Program Realization Rates

Table 7-5 shows the number of evaluated projects for each measure type, along with realization rates for each fuel type. Overall, DNV found the methods used to estimate savings to be reasonable for the measures included in this program. DNV finds the program to be achieving almost all of the energy savings claimed over the evaluated period.

Table 7-5. Commercial HVAC electric and gas impact evaluation results by measure

Measure Category	Evaluated Project Count	Electricity Savings		Gas Savings	
		Tracked Savings (kWh) of Evaluated Sites	Realization Rate	Tracked Savings (Therms) of Evaluated Sites	Realization Rate
DHPs	2	5,562	88%	-	N/A
Smart Thermostats	2	20,910	9%	2,460	9%
ARCs	5	447,531	102%	11,685	12%
Total	**9**	**474,002**	**98%**	**14,145**	**12%**

Table 7-6 provides the electric evaluation results from the evaluation sample of eight projects with electric savings that have been expanded to the sample frame of 54 projects with electric savings.

Table 7-6. Commercial HVAC electric impact evaluation results

Project Count with Electric Savings	Realization Rate	Relative Precision at 90% Confidence Interval
Sample Frame = 54 Evaluated = 8	98%	9%

Table 7-7 provides the gas evaluation results from the evaluation sample of three projects with gas savings that have been expanded to the sample frame of 10 projects with gas savings.

Table 7-7. Commercial HVAC gas impact evaluation results

Project Count with Gas Savings	Realization Rate	Relative Precision at 90% Confidence Interval
Sample Frame = 10 Evaluated = 3	12%	52%

7.2.5 Sources of Variance

The large variance in gas savings is due to issues in reporting savings for two of the nine projects that were evaluated. One smart thermostat project calculated savings using connected tons per thermostat instead of per total connected tons. This accounting error led to significantly inflated savings for the project. Additionally, one ARC project had inflated gas savings because UES were applied per ton instead of per RTU.

7.3 Process Evaluation

7.3.1 Program Manager Interview

DNV conducted an in-depth interview with the managers of the Commercial HVAC program. The interview covered the following topics:

- Program delivery and changes
- Program challenges and barriers
- Overall program assessment

7.3.1.1 Program Delivery and Changes

The program manager stated that commercial customers learn about the program through awareness-building activities. Such activities include targeted messaging delivered directly to selected businesses through email and other digital efforts. Additionally, program awareness is created on PSE's behalf from lighting distributors, trade allies, and contractors when they interact with customers located in its service territory. PSE is building out its commercial business followers on various social media platforms so it can connect with them, share relevant information, such as white papers, and begin to position PSE as a trusted expert in the field of commercial HVAC and water heating.

DNV asked about any expected changes to the program in 2023 and beyond. In 2023, the program manager said that the biggest change is increasing the DHP incentive from $500 a ton to $1000 a ton. The program manager mentioned that in 2024, they would be looking into alternate delivery types for smart thermostats to get more applications. Smart thermostats are not a high profit center for HVAC contractors, so unless they are already performing an HVAC install, they are not going to take a job just to install a thermostat.

7.3.1.2 Program Challenges and Barriers

When asked about barriers to participation, the primary issue mentioned is the smart thermostat adoption. As discussed above, getting HVAC contractors to take a job to install a smart thermostat without a larger HVAC install/repair job is difficult as it is not cost effective from the contractor perspective.

The program manager noted that some smart thermostat applications do not include the measure that was there before the new smart thermostat equipment, which makes savings less accurate. To mitigate this issue, the program staff have started rejecting applications that do not include the old equipment type.

7.3.1.3 Overall Program Assessment

When asked about the biggest success and ways the program is working well, the program manager said that the program is bringing in savings, which is a success seeing as participation has declined across programs in the recent past. The marketing tactics that have been implemented have resulted in increased traffic to the program website.

7.3.2 Previous Evaluation and Document Review

DNV reviewed suggested programs and tactics for the Commercial HVAC program detailed in the 2021-2022 Biennial Conservation Plan to help build program awareness and installation of commercial HVAC solutions. DNV asked the program manager about these suggestions, if they were implemented, and how they think the changes have impacted the program.

The suggested tactics that have been initiated by PSE for the Commercial HVAC program are:

- Provide and manage event kit displays for small-to-medium business-related programs.
- Develop digital and printed copies of program collateral highlighting the lighting program, benefits, and advantages. These materials will be distributed widely during events, presentations, and meetings to wholesalers, distributors, contractors, trade allies, and to business customers.
- Track metrics around event participation and impressions and engagements to drive tactics and strategy in order to remain nimble and ready to serve this unique customer base, including the use of trackable URLs on collateral meant to be used at events.

One suggestion was presentations to various groups, including chambers of commerce, visitors and convention bureaus, restaurant and hospitality associations and other trade associations to publicize program offerings. While program staff have presented at paid trade events, there is still an opportunity to expand outreach to other organizations and associations.

Another suggested tactic was to leverage relationships with key wholesalers, distributors, contractors, and trade allies to gain awareness of new commercial and industrial developments. This effort has not been initiated and could be made easier with a formal trade ally network.

7.3.3 Program Theory Logic Model

The Commercial HVAC program does not currently have a PTLM. We suggest that PSE create a PTLM to track activities and outcomes to help to improve and expand the program. Logic models are effective tools to assist in program planning, implementation, management, evaluation, and reporting. They help define a program's intended impact and goals, the sequence of intended effects, which activities are to produce which effect, and where to focus outcome and process evaluations.

7.3.4 Key Performance Indicators

Currently, the only KPI being tracked for the Commercial HVAC program is energy savings. Energy savings are achieved primarily through the installation of ARCs that reduce fan motor use, optimize the use of outside air, and minimize the use of mechanical heating and cooling. There is an opportunity to track program process KPIs such as customer and contractor satisfaction and impacts from events such as trade shows or presentations for various organizations and associations. Findings from process KPIs can help PSE staff better understand how program outreach is being received by customers and can help PSE identify areas for improvement in marketing and outreach events.

7.4 Findings, Recommendations, and Considerations

This section documents DNV's findings, recommendations, and considerations for the Commercial HVAC program.

7.4.1 Impact Key Findings and Recommendations

- **Key Finding** – The evaluation team verified the quantity and equipment type installed and in use for all of the evaluated projects. The measure case savings algorithms for all measures are appropriate. The realization rates reflect adjustments to the measure case savings for incorrect application of UES savings. The Commercial HVAC Rebates program is achieving 98% of tracked electricity savings and 12% of tracked natural gas savings.
    - **Recommendation** – Review program measure cases with staff approving applications in this program to reduce incorrect UES savings application for these measures in the future.

7.4.2 Impact Findings and Considerations

- **Finding** – Claimed savings are PSE-deemed, RTF-derived. Savings are derived from data gathered by 2013 PNNL field study. Savings were developed with statistical methods, not calculated based on assumed measure parameters.
- **Finding** – ARC measure savings cannot be independently verified without direct pre- and post-installation measurements of the HVAC equipment supported by the program. DNV found that PSE's savings methodology is robust and uses the best available information for the region. However, DNV cannot independently verify that the conditions and sequence of operations required to produce these savings are in place for the participant's equipment.
    - **Consideration –** Consider a more rigorous evaluation of this measure should its relative size in the energy efficiency portfolio increase in the future. A more rigorous evaluation would require direct metering of participant equipment and require significant resources to complete.

7.4.3 Process Key Findings and Recommendations

- **Key Finding** – This program has been successful in meeting energy savings goals, recent participation has been the result of active participation by a handful of contractors, and digital outreach efforts have increased traffic to the program website.
- **Key Finding** – Thermostats are not a high profit center for contractors, so unless they are already doing an HVAC installation, they will not take the job of installing a thermostat.
    - **Consideration** – Further engage existing contractors and consider developing a formal trade ally network. One option is to offer sales performance incentives (SPIFs) to contractors who meet thermostat installation targets to help increase smart thermostat adoption. This will improve and build customer trust and help build PSE's relationship with trade allies. PSE can also use the recent contractor surveys to identify areas for improvement and expansion, and to better understand program successes and participation barriers and challenges.

7.4.4 Process Findings and Considerations

- **Finding** – KPIs are limited to energy savings.
    - **Consideration –** Track additional KPIs. While energy savings is the official KPI for the Commercial HVAC program, additional KPIs can be tracked to help improve and expand the program. These KPIs include program participation and impacts from events such as increased awareness and trade ally engagement. Findings from these program process KPIs can help PSE staff better understand how program outreach is being received by customers and market actors and can help PSE identify areas for improvement in marketing and outreach events.

8 E/G 262 – COMMERCIAL MIDSTREAM HVAC AND WATER HEATING

This section summarizes the impact and process evaluation approach, results, and recommendations for PSE's PY2021-2022 Commercial Midstream HVAC and Water Heating program.

8.1 Program Overview

The Commercial Midstream program provides incentives to distributors and contractors of qualifying high-efficiency HVAC and domestic water heating equipment. Program design, metric analysis, incentive-setting, and program policies are managed in-house via PSE program staff, while all measure rebates are managed through a third-party implementer.

Energy savings are primarily acquired through support of large commercial air conditioners and condensing gas domestic hot water tanks. There are different implementation processes between large commercial projects and small commercial/residential projects:

- **Large Commercial HVAC and Water Heating:** Engages distributors only and is not marketed to contractors or customers. A third-party implementer is used for distributor engagement. Incentivized equipment includes air-cooled air conditioning, water/evaporative-cooled air conditioning, air-cooled heat pumps, water-cooled heat pumps, and condensing gas water heaters.
- **Small Commercial/Residential HVAC and Water Heating:** Includes small residential-sized equipment (below 5.4 tons) for commercial and residential customers. Offers incentives for heat pumps and heat pump water heaters. The distributor is required to pass through the incentive to the contractor, and the contractor is encouraged but not required to pass through to the customer. The program involves distributor and contractor engagement and is not marketed to the end-use customer.

8.1.1 Program Savings

Table 8-1 shows the energy savings tracked by the program during PY 2021 through 2022. Installation of large commercial air conditioners are the primary contributor to program electricity savings. Installation of condensing gas domestic hot water tanks are the primary contributor to the program gas savings.

Table 8-1. Tracked PY2021-2022 energy savings by measure, Commercial Midstream

Measure Categories	Project Count	Tracked kWh Savings	Percent of Tracked kWh Savings Contribution	Tracked Therms Savings	Percent of Tracked Therms Savings Contribution
Air Conditioner – Under 65 kBtuh	8	2,117	0.2%	-	N/A
Air Conditioner – Over 65 kBtuh	130	672,355	75.9%	-	N/A
Heat Pump – Under 65 kBtuh	36	41,444	4.7%	-	N/A
Heat Pump – Over 65 kBtuh	21	61,494	6.9%	-	N/A
DHP – Under 65 kBtuh	95	98,572	11.1%	-	N/A
Domestic Water Heating – Gas Boiler	62	-	N/A	192,308	18.3%
Domestic Water Heater – Gas Water Heater	765	-	N/A	857,235	81.7%
Domestic Water Heater – Heat Pump Water Heater	1	10,407	1.2%	-	N/A
Total	**1,118**	**886,389**	**100%**	**1,049,543**	**100%**

8.2 Impact Evaluation

This section documents DNV's independent estimate of the program realization rate and review of the calculation methods used by the program. Each element of our evaluation process is discussed below along with relevant findings. The section concludes with our estimate of the program realization rates followed by the primary drivers of variance between PSE's tracked savings estimates and DNV's evaluated savings estimates. DNV completed the following steps for the impact evaluation of the Commercial Midstream program:

- **Sample Design:** Selection of a representative sample of completed projects for evaluation.
- **Program Measure Review:** Review all measure case documentation and savings calculations to understand the eligibility requirements, savings algorithms, and savings values used to support reported savings. Confirm reasonableness of measure case assumptions, compare historic participation characteristics to the measure assumptions, and identify areas of risk and opportunities for refinement.
- **M&V Planning:** Review of database files for each sampled project to identify key parameters. Creation of measure-specific M&V plans for air conditioner and domestic hot water measures to assess the current operation and savings achieved.
- **Data Collection:** Collected data through email correspondence with each site participant to confirm project database information and key input parameters.
- **Analysis:** Determine evaluated savings using the data collected through participants to update key parameters to the savings calculations. DNV calculated savings using the reviewed measure case algorithms. The measure assumptions were replaced with key parameters when available.

8.2.1 Sample Design

This sub-section presents an overview and summary of the sample design used to evaluate the PY2021-2022 Commercial Midstream program. DNV used random sampling by measure to select an efficient representative sample of projects for evaluation. The sample was designed to provide a reliable estimate of program performance. Table 8-2 summarizes the planned sample design for this program.

Table 8-2. Preliminary Commercial Midstream sample design parameters

PSE Program	Sub Domain	Anticipated Population Size	Expected Total Savings (kBtu)	Assumed Error Ratio	Sampling Rounds	Planned Sample	Expected Relative Precision
Commercial Midstream HVAC & Water Heat	Gas	618	117,566,666	0.6	1	10	36%
	Electric	188	3,052,953	0.6	1	5	80%

Sampling occurred at the premise level. For each sampled premise, we selected all projects completed between January 1, 2021, and December 31, 2022, under the selected premise number. The key design elements for the sample were:

- Stratification based on size of savings reported by site (Premise ID)
- Fuel saved (electric vs gas)

Table 8-3 shows the actual sample frame and primary sample counts by fuel.

Table 8-3. Final Commercial Midstream sample design by stratum

Compliance Program	Sampling Phase	Project Fuel	Premises in Sample Frame	Savings (kBtu) in Sample Frame	Primary Sample	Probability of Inclusion
Commercial Midstream HVAC & Water Heating	Phase II	Gas	643	125,334,704	10	0.016
		Electric	234	4,998,244	5	0.021
Total			**877**	**130,332,948**	**15**	**N/A**

8.2.2 Program Measure Review

PSE provided DNV with measure case documentation for each of the sampled measures. The measure case documentation is updated annually, changes between the versions are due to updated references. The appropriate measure case is selected based on the product sale date for the project, which is included in the database and will be tracked for all measures after 2023.

8.2.2.1 Ductless Heat Pump

This measure claims savings for the installation of DHPs that exceed the efficiency values of a code minimum baseline DHP. The code minimum baseline DHP is currently defined through IECC 2015.

PSE Methodology

This measure is PSE-deemed and calculated based on a method recommended by the DOE's UMP. The total electric savings for this measure are claimed based on the difference between the code minimum heating and cooling efficiencies of a DHP set by IECC 2015 and the heating and cooling efficiencies of the installed DHP.

The following equations detail the savings algorithm and inputs used by PSE to determine the electric savings for this measure:

$$kWh\ Savings = Heat\ Pump\ Quantity \times (kWh_{Heat} + kWh_{Cool})$$

$$kWh_{Heat} = Ton_{Heat} \times \left(\frac{12}{HSPF_{Baseline}} - \frac{12}{HSPF_{Measure}}\right) \times EFLH_{Heat}$$

$$kWh_{Cool} = Ton_{Cool} \times \left(\frac{12}{SEER_{Baseline}} - \frac{12}{SEER_{Measure}}\right) \times EFLH_{Cool}$$

Based on our review of measure case and savings algorithm documentation, DNV agreed that this was a reasonable method to determine savings. DNV confirmed changes made to the measure case assumptions between the annually updated measure case documentation and concluded that PSE is making the appropriate effort to update their measure case assumptions.

Evaluation Approach

DNV collected project details through phone calls and emails based on the site contact's preference. Site contacts were asked to confirm installation of the equipment at the listed address, verify the installed quantity, provide the model number(s) of the installed equipment, and confirm the facility type of the installation site. The heating and cooling efficiencies were verified with the model number of the installed DHP through Air-Conditioning, Heating, and Refrigeration Institute (AHRI) data. When applicable, the actual installed building type was used to refine the assumed EFLH used in the savings calculation.

8.2.2.2 Condensing Hot Water Heaters

This measure claims gas savings for the installation of condensing hot water heaters that exceed the efficiency values of a code minimum baseline water heater. The code minimum water heater is currently defined through IECC 2018.

PSE Methodology

This measure is PSE-deemed and uses a savings formula that matches standard water heater calculation used in Technical Resource Manuals (TRM) around the country. With this approach, PSE calculates deemed savings based on the actual rated efficiency of the unit on the application. The gas savings for this measure are claimed based on the difference between the code minimum heating efficiency of a condensing hot water heater and the heating efficiency of the installed condensing hot water unit.

The following equations detail the savings algorithm and inputs used by PSE to determine the gas savings for this measure:

$$Savings = \frac{Gallons}{Day} \times \frac{Op\ Days}{Year} \times \frac{8.33\ lb}{gal} \times (Temp_{hot\ water} - Temp_{main}) \times \left(\frac{1}{Eff_{Baseline}} - \frac{1}{Eff_{Installed}}\right) \times \frac{1\ therm}{100{,}000\ Btu}$$

Based on our review of measure case and savings algorithm documentation, DNV concluded that PSE's algorithms and assumptions used to calculate project savings are reasonable. DNV confirmed changes made to the measure case assumptions between the annually updated measure case documentation and concluded that PSE is making the appropriate effort to update their measure case assumptions.

Evaluation Approach

This program was evaluated at a low rigor (rigor level of 1). Therefore, DNV completed a verification-only approach. We collected project details through phone calls and/or emails based on the sampled site contact's preference. The verification portion of this evaluation approach aimed to confirm the following measure identifiers:

- Installation of the equipment at the listed address
- Installed quantity
- Model number(s) of the installed equipment
- Facility type of the installation site

The installed heating efficiency was verified with the model number of the installed condensing hot water heater through AHRI data. The baseline heating efficiency was determined using code minimum for the installed equipment type. Based on the product sales date, input into PSE's program delivery operating system and, when possible, confirmed by the site contact, DNV selected the appropriate PSE iteration of the tool to determine the applicable baseline efficiency.

8.2.3 Final Evaluated Sample

Table 8-4 shows the final sample achieved for this impact evaluation alongside the planned sample. The difference between the planned sampled and completed sample is due to challenges recruiting participants for evaluation. Several sites refused to participate in the evaluation, and we could not collect quality contact information for several others, which contributed to the number of unresponsive sites. PSE's program implementation staff were able to provide additional contact information for several of the sampled sites and we quickly replaced unresponsive sites with backup sample points to meet our target. The final sample, while smaller than originally planned, is representative of the program.

Table 8-4. Commercial Midstream evaluated site count summary

Compliance Program	Sampling Frame Q1 2021-Q4 2022	Planned Sample 2023 (Phase II)	Completed Sample 2023 (Phase II)
Commercial Midstream	877	15	11
Total	**877**	**15**	**11**

8.2.4 Program Realization Rates

The project-specific results for the final evaluated sample were extrapolated back to the sampling frame to determine the evaluated savings for the population and the program realization rate. The calculated realization rates should be applied to the final 2022-2023 biennium tracked savings to estimate the evaluated savings for the program over the biennium. Table 8-5 provides the electric evaluation results from the evaluation sample of 4 projects with electric savings that have been expanded to the sample frame of 643 projects with electric savings.

Table 8-5. Commercial Midstream electric impact evaluation results

Project Count with Electric Savings	Realization Rate	Relative Precision at 90% Confidence Interval
Sample Frame = 643 Evaluated = 4	97%	7%

Table 8-6 provides the gas evaluation results from the evaluation sample of 7 projects with gas savings that have been expanded to the sample frame of 234 projects with gas savings.

Table 8-6. Commercial Midstream gas impact evaluation results

Project Count with Gas Savings	Realization Rate	Relative Precision at 90% Confidence Interval
Sample Frame = 234 Evaluated = 7	91%	7%

8.2.5 Sources of Variance

The primary driver of variance in electric savings is due to a change in the installed equipment specifications for one site. During the site interview, the sampled participant stated that the installed equipment model number was different than originally scoped, and less efficient. Updating the corresponding AHRI specifications for the installed equipment resulted in a decrease in electric savings.

The primary driver of gas savings variance is differences between the baseline efficiency used to estimate tracked savings and the baseline efficiency outlined by the 2022 measure case documentation. DNV found that the vendor used 2020 or 2021 measure documentation regardless of the product sales date. Many of the selected condensing hot water heater measures had product sales dates in 2022, so the 2022 measure case documentation should have been used to determine project savings. Between 2021 and 2022, PSE increased the baseline efficiency to 84% from 82% based on IECC 2018, which resulted in reduced gas savings.

8.3 Process Evaluation

8.3.1 Program Manager Interview

DNV conducted an in-depth interview with the managers of the Commercial Midstream program. The interview covered program delivery and changes and program challenges and barriers.

8.3.1.1 Program Delivery and Changes

The program is delivered through Energy Solutions, PSE's third-party implementer. Energy Solutions uses their trade ally manager to actively work with distributors to implement the program. The largest distributors in PSE service territory are enrolled in the program, and the enrolled distributors are estimated to make up 90% of the market. Each year, the program staff discuss strategies for adding distributors and how to support and appeal to distributors that may not be enrolled in the program.

While Energy Solutions is the primary implementer of the HVAC and Water Heating program, there is some interaction between PSE and the distributors, through gathering data, problem solving, and complaint resolution. Currently, PSE only pays Energy Solutions for distributor engagement, but they see contractor engagement as an important tactic and are exploring including contractor engagement as part of the program moving forward.

DNV asked the program manager about any changes in 2022. The program manager explained that in 2022, they stopped requiring meter matches for small equipment and began using an assumption that the end user is in PSE service territory based on zip code. Additionally, they stopped requiring serial numbers on the small equipment. Both of these changes increased distributor satisfaction.

8.3.1.2 Program Challenges and Barriers

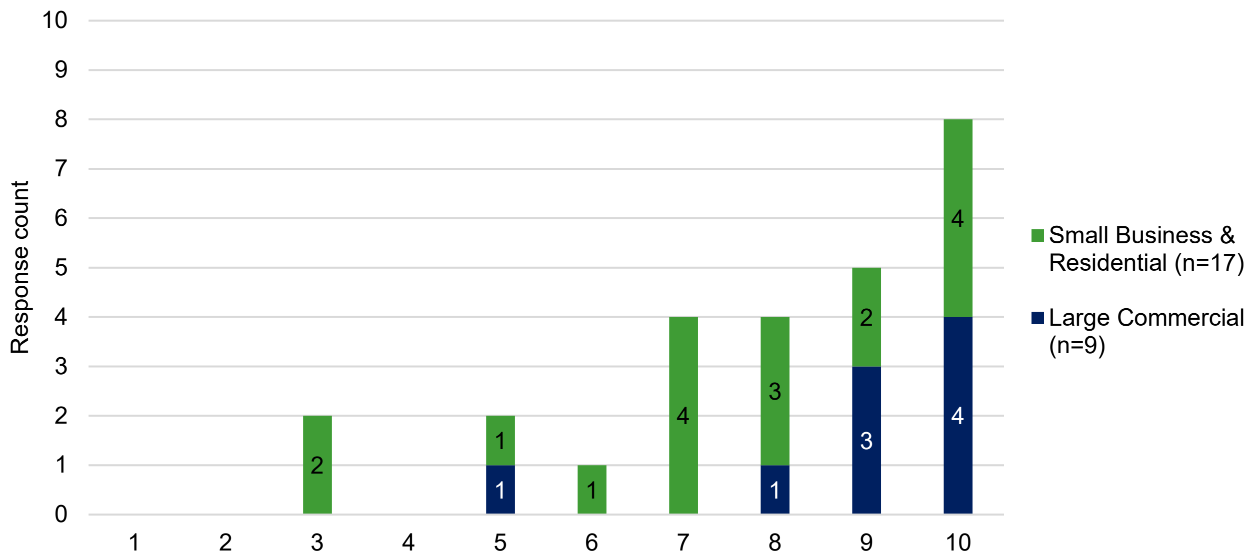
One challenge that was mentioned in our interview with the program manager is the administrative burden of providing and verifying installation addresses. This process is especially difficult for new construction buildings that may not have an address or for cases in which the meter address is different than the building address. This causes delays in payment and frustration both for the program staff and for distributors. The switch to using an assumption based on zip code, as noted above, will help alleviate these frustrations.

Another challenge is invoicing and forecast delivery delays from the implementer. The vendor struggles with providing invoices and forecasts accurately and on time, causing some months to show zero savings and spending due to issues not being resolved until past month-end. Program staff have attempted to mitigate this issue with penalty charges, but it continues to be an issue.

8.3.2 Participant Survey

In 2022, PSE conducted a survey to assess distributor and contractor satisfaction with the program. The survey was conducted for both Small Businesses and Residential and Large Commercial. Distributors were asked to rate their satisfaction with the program on a scale of 1 to 10, where "1" is "Unacceptable" and "10" is "Outstanding." Figure 8-1 shows the responses by program type.

Figure 8-1. Distributor satisfaction by program type



The average overall program rating was 7.47, with the majority of respondents rated their satisfaction as 8 or higher, indicating high satisfaction. One of the low responses of 3 was a distributor that Energy Solutions and PSE worked with after the survey responses were provided to resolve a large claims issue. The frustration before the resolution likely influenced this response.

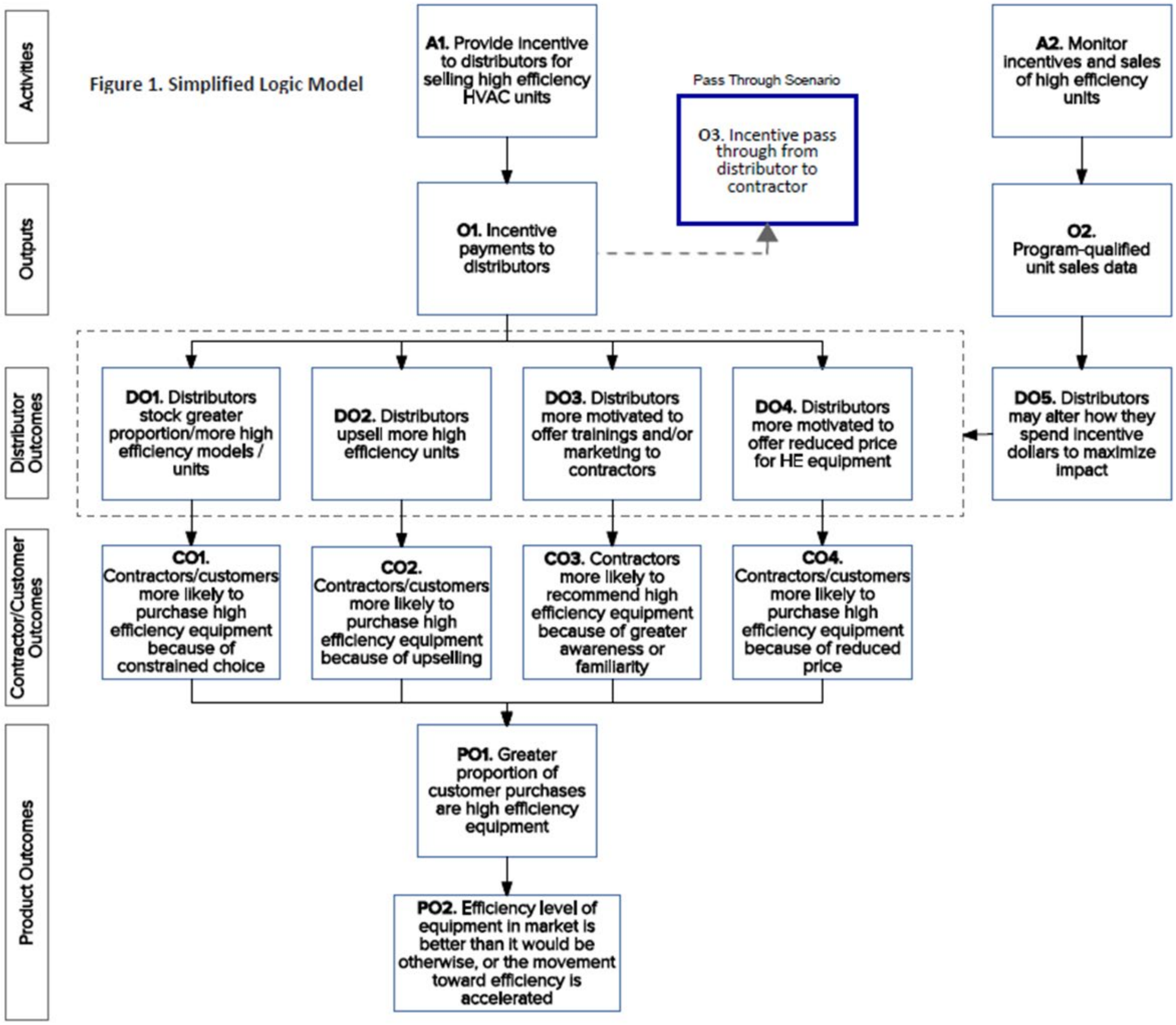
As part of the 2022 survey, contractors were asked about their satisfaction with the program and were asked to provide feedback on how the program could be improved. The primary pain point identified in the contractor survey was year-to-year changes in the program, which meant some units where the contractors stocked more than what they needed at the time were not eligible by the time they sold the equipment. One way to improve stocking and participation on the small commercial/residential side is to ensure messaging of program changes are promoted to contractors through different methods, not just through the distributor to ensure they have adequate time to plan stocking purchases and submit claims from previous year purchases to the program.

8.3.3 Program Theory Logic Model

Logic models are effective tools to assist in program planning, implementation, management, evaluation, and reporting. They help define a program's intended impact and goals, the sequence of intended effects, which activities are to produce which effect, and where to focus outcome and process evaluations.

The program used a recently developed PTLM, which illustrates how Energy Solutions implements the program. Figure 8-2 shows the PTLM.

Figure 8-2. Commercial Midstream HVAC and Water Heating PTLM



While the PTLM effectively shows the pathways in which the Midstream Commercial HVAC and Water Heating offering is designed to have influence through Energy Solutions, there is an opportunity to include internal PSE processes throughout program delivery.

8.3.4 Key Performance Indicators

The KPIs currently being tracked by the program manager are energy savings, forecast and invoice delivery dates, and data quality. Previously, the program manager tracked customer satisfaction as a KPI but that has since been removed. KPIs have been assigned to forecast and invoice delivery timing, with success criteria being the 10th of the month and 15th of the month, respectively. There is a $2,000 penalty for every month in which these are delivered late or with data quality errors, and the vendor is allowed two late submissions/upload errors per year.

8.4 Findings, Recommendations, and Considerations

This section documents DNV's findings, recommendations, and considerations for the Commercial Midstream program.

8.4.1 Impact Key Findings and Recommendations

- **Key Finding** – Based on our review of measure case and savings algorithm documentation, DNV concluded that PSE's algorithms and assumptions used to calculate project savings are reasonable. DNV confirmed changes made to the measure case assumptions between the annually updated measure case documentation and concluded that PSE is making the appropriate effort to update their measure case assumptions.
- **Key Finding** – DNV found that multiple premises did not use the appropriate measure case documentation to determine project savings. Several condensing hot water heater measures were using the outlined baseline efficiency from 2020-2021, rather than using the updated baseline efficiency that was detailed in the 2022 measure case documentation. DNV updated the measure case use based on product sale data in the database.
    - **Recommendation** – Communicate the reasoning behind changes to the measure case documentation. Remind implementers to use the measure case document that corresponds to the product sale data which should be input and confirmed by PSE.

8.4.2 Impact Findings and Considerations

- **Finding** – DNV used the tracked product sales date to determine the appropriate evaluation methodology, since PSE's tools are provided annually. However, there was uncertainty that the product sales date was accurate for specific program pathways.
    - **Consideration** – Since the product sales date is a driver of the measure savings, it should be tracked in PSE's program delivery operating system and verified for all projects submitted through this program, regardless of the pathway they are incentivized through.

8.4.3 Process Key Findings and Recommendations

- **Key Finding** – This is a successful program with significant energy savings and participants who are satisfied with the program overall.
- **Key Finding** – Contractors are not being informed of year-to-year program changes to qualifying products.
    - **Consideration** – Develop a communication plan surrounding program changes. Ensure contractors are being alerted of program changes from a variety of sources. Changes should be communicated to distributors and contractors concurrently. Additionally, PSE should consider developing training opportunities for contractors and developing training for the engagement team on program changes and how to address common contractor questions.
- **Key Finding** – There is an ongoing administrative burden of providing and verifying physical addresses to approve payment.
    - **Consideration –** Consider revising the address verification process. Distributors cite timely payments and simple customer eligibility requirements as key drivers in their participation in midstream programs. Similar to simplifying/eliminating the meter verification, this will help to streamline payment processing and alleviate the administrative burden on PSE.

8.4.4 Process Findings and Considerations

- **Finding** – The PTLM is not updated regularly or utilized by program staff.
    - **Consideration –** PSE should review program logic models annually. Consider adding elements of the internal PSE process to better understand bottlenecks, barriers, and successes.

9 E 258 – LARGE POWER USER

This section summarizes the impact and process evaluation approach, results, and recommendations of PSE's 2019-2022 LPU program.

9.1 Program Overview

The LPU program (previously known as the High Voltage Program) has existed for more than 20 years in the PSE portfolio. It is a self-directed program available to roughly 30 large PSE non-residential customers in specific rate classes. These customers only receive incentives through the LPU program and cannot receive funding from other energy efficiency programs. Through the program, customers identify custom energy efficiency projects at their facilities and apply for financial incentives from a funding pool. The program achieves electric savings only.

The program is implemented in 4-year cycles. During the first 2 years (the non-competitive phase), customers may apply for incentives up to their funding allocation, which is based on electric usage and rate schedule. In the second 2 years (the competitive phase), PSE may open unreserved funds to competitive bidding by all eligible customers, which may access funds beyond their original allocation. The previous program cycle (2019-2022) concluded recently, with 2023 beginning a new cycle. PSE manages the program in-house through a program manager in addition to PSE account representatives and energy management engineers. While the program is intended as self-directed, PSE may help customers identify projects or complete energy savings analysis if needed.

Proposals are evaluated by PSE engineering staff for technical soundness, cost-effectiveness, and compliance with energy code and tariff requirements. PSE engineers conduct pre- and post-inspections as part of the standard review process. Projects are mostly funded as custom grants provided upon project completion and verification. The incentive amount for the recently completed four-year cycle was up to $0.50 per annual kWh savings, subject to PSE cost effectiveness standards.[3] Deemed rebates can be provided if PSE-provided deemed rebates exist for the measure in another non-residential program.

9.1.1 Program Savings

Table 9-1 shows the energy savings tracked by the program during the 2019-2022 cycle. Lighting was the primary contributor to program savings, accounting for 42% of the total savings.

Table 9-1. Tracked PY2019-22 program savings by measure, LPU

Measure Category	Project Count	Tracked Electricity Savings (kWh)	Percent of Total LPU Tracked Savings
Commissioning	3	7.027,276	17%
Energy Recovery System	2	714,117	2%
Fan – VFD	3	414,942	1%
Generic Measure	5	4,527,645	11%
HVAC	3	3,700,780	9%
HVAC – Control	7	2,695,648	7%
Insulation	2	216,608	1%
Lighting	36	17,134,880	42%
Motor	2	2,630,057	6%
Process	2	876,943	2%
Pumps – Vacuums and VFDs	4	1,032,805	3%
Study – Engineering – Custom	7	-	N/A
Unitary Equipment	2	145,810	N/A
Total	**78**	**41,117,511**	**100%**

[3] The LPU program incentives increased to $0.75 per annual kWh for the 2023-2026 program cycle.

9.2 Impact Evaluation

This section documents DNV's independent estimate of the program realization rate and review of the calculation methods used by the program. Each element of our evaluation process is discussed below along with relevant findings. The section concludes with our estimate of the program realization rates followed by the primary drivers of variance between PSE's tracked savings estimates and DNV's evaluated savings estimates. DNV completed the following steps for the impact evaluation of the LPU program:

- **Sample Selection:** Selection of a representative sample of completed projects for evaluation.
- **Project File Review:** Review of sampled project files and tracking data provided by PSE to identify reported calculation methods and key parameters, ensure sufficient information exists to evaluate the project, and verify reported inputs and supporting information through invoices, applications, and other provided documentation.
- **M&V Planning:** Creation of project-specific M&V plans. The project-specific M&V plans identified the key project-specific input parameters, stipulated values to research and their verification method, and detailed interview questions to evaluate the project based on the project file review.
- **Data Collection:** Interviews with sampled participants via telephone or videoconference to review each project, baseline assumptions, and current operating parameters.
- **Project Analysis:** Estimated evaluated savings using the data collected to update key input parameters or conduct a consumption analysis.

9.2.1 Sample Design

This sub-section presents an overview and summary of the sample design used to evaluate the 2019-2022 LPU program savings. DNV used stratified random sampling to select an efficient representative sample of projects for evaluation. The sample was designed to provide a reliable estimate of program performance. Table 9-2 summarizes the planned sample design for this program.

Table 9-2. Preliminary LPU sample design parameters

PSE Program	Sub Domain	Anticipated Population Size	Expected Total Savings (kBtu)	Assumed Error Ratio	Sampling Rounds	Planned Sample	Expected Relative Precision
LPU, 449 and Non-449	Non-Lighting	30	45,973,896	1	2	10	42%
	Lighting	27	57,411,859	0.4	2	10	14%

Sampling occurred at the project level. The sample was selected from LPU projects completed between January 1, 2019, and December 31, 2022. The key design elements for the sample were:

- Stratification by size of savings reported at the project level and use of a certainty stratum to increase the magnitude of savings evaluated and the accuracy of the estimated savings realization rate.
- Lighting/non-lighting measure distinction to ensure the selection of 50% lighting projects and 50% non-lighting projects.

The sample design resulted in the selection of 20 unique projects for evaluation. Table 9-3 shows the sample design and primary sample counts by stratum.

Table 9-3. Final LPU sample design by stratum

Compliance Program	Sampling Phase	Measure Category	Project Size	Projects in Sample Frame	Savings (kBtu) in Sample Frame	Primary Sample	Probability of Inclusion
LPU 449 and non-449	Phase I	Non-Lighting	Small	6	4,236,374	1	0.176
			Medium	4	9,572,688	2	0.500
			Large	2	10,188,645	1	0.500
			Certainty	1	17,193,345	1	1.000
		Lighting	Small	7	3,160,617	1	0.143
			Medium	3	4,051,897	1	0.375
			Large	5	15,707,661	2	0.400
			Certainty	1	10,560,719	1	1.000
	Phase II	Non-Lighting	Small	11	8,472,748	2	0.176
			Medium	2	4,786,344	1	0.500
			Large	2	10,188,644	1	0.500
			Certainty	1	17,193,345	1	1.000
		Lighting	Small	14	6,321,233	2	0.143
			Medium	5	8,103,793	2	0.375
			Large	0	0	0	0.400
			Certainty	1	10,560,718	1	1.000
			Manual	3	3,188,255	3	1.000
Total				**68**	**143,487,026**	**23**	**N/A**

9.2.2 Project File Review

Project file reviews are structured site-specific reviews of PSE's LPU program application files and calculations that systematically examine and record the evaluation team's conclusions on ex ante savings development practices. DNV reviewed each sampled project's files for sufficient documentation, program savings methodology, and accurate savings reporting. This review included:

- Assessing completeness of documentation and comparison to tracking data
- Verifying the existence of signed application or participation agreement
- Identifying the building type
- Determining if the sampled entity was operating normally, operating under modified conditions, or closed based on a web-based search
- Verifying of the existence of engineering calculations with outputs that match the reported savings
- Identifying key building or system operation parameters contributing to the reported savings
- Verifying building electric meter numbers and assessing building annual electric consumption to determine the percentage of savings resulting from the project

9.2.3 M&V Planning

DNV developed one M&V plan for lighting measures and a site-specific M&V plan for each sampled non-lighting project using our M&V Plan template. The lighting-specific M&V plan identified the key input parameters for PSE's lighting calculator and was tailored to each sampled lighting site as needed to guide the data collection effort. The M&V plans for non-lighting projects detailed the evaluation approach, identified key input parameters in the applicant's analysis and DNV's evaluation approach, and determined the data that would need to be requested of the site contact during the data collection effort. The study did not collect information on all drivers of end-use energy consumption.

9.2.4 Data Collection

All data collection occurred remotely via telephone or videoconference. No independent data logging or metering was completed for this evaluation. Data collection followed the M&V plan developed for each project. At a minimum, DNV verified installation and active operation, confirmed the business type, reviewed operating hours of installed equipment, asked about pre-retrofit conditions, and verified the scope of the installed project. For non-lighting sampled projects, we requested trend data (if available) selected based on the key input parameters to increase the accuracy of the estimated savings and verify the applicant's estimates or assumptions. During our interview, we determined whether any changes in project operation were due to the impacts of the COVID-19 pandemic, and if so, whether the operation changes were considered temporary or permanent.

DNV also requested and received utility meter data from the utility detailing the facility's recent consumption. This data was used to validate the percent of savings based on annual facility consumption and if applicable, this facility meter data was used to conduct a consumption analysis to determine project savings.

9.2.5 Project Analysis

DNV used the information gathered during data collection to update the key calculation input assumptions. DNV evaluated each sampled lighting project using the Business Lighting 2022 – STANDARD V2-1 calculator. Key inputs for the evaluated savings calculations, such as fixture quantities, wattages, annual hours of use, and controls strategies were determined from the most valid data source including participant interviews, site EMS data, and program project files. The sampled projects used a previous version of the PSE Business Lighting standard calculator or a simplified standard PSE lighting template to calculate project savings. Lighting projects submitted through the LPU program are not required to use a specific savings calculator. DNV compared the 2022 Business Lighting calculator to the standard PSE lighting template, and found that the savings were not significantly different, except for a small impact due to rounding and the removal of HVAC interactivity savings for heated/cooled spaces.

For non-lighting projects evaluated in this program, DNV used the same calculation tool or methodology 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 EMS data, schedules, setpoints, program project files, and utility meter data. Typically, adjustments were made to the evaluation analysis to model the conditions observed by the evaluation. When DNV found that the evaluation period facility operating parameters (setpoints, schedule and control logics, etc.) were different from their respective program modeled values, the evaluation determined if such parameters were part of the implemented improvement or not. If they were part of the implemented measure improvements, the evaluation energy model implemented those changes to the post-project model only, and those evaluation findings became the basis of having a different modeled evaluation savings compared to program modeled savings. However, if the parameters and setpoints were not part of the implemented measure, the evaluation ensured that such parameters, setpoints, and control logics should act as energy-neutral while determining the evaluation savings. In other words, these parameters are kept identical both in the pre- and post-project models. This is achieved by utilizing identical values of such parameters in both the baseline and post-project energy analysis.

9.2.6 Final Evaluated Sample

Table 9-4 shows the final sample achieved for this impact evaluation alongside the planned sample. The difference between the planned sampled and completed sample is due to one sampled site's refusal to participate in the evaluation and one site's staff turnover; the remaining staff were unfamiliar with the particulars of the sampled project. For each site that was unresponsive after a few attempts, we requested recruitment assistance from PSE's program implementation staff by asking them to connect us to the participant or provide alternate contact information for the site, which was successful and helped us nearly meet our target. The final sample is representative of the program.

Table 9-4. LPU evaluated site count summary

PSE Program	Measure Category	Sampling Frame Q1 2019-Q4 2022	Planned Sample 2022 (Phase I)	Completed Sample 2022 (Phase I)	Planned Sample 2023 (Phase II)	Completed Sample 2023 (Phase II)
LPU 449 and non-449	Non-Lighting	29	5	5	5	3
	Lighting	39	5	5	5	6
Total		**68**	**10**	**10**	**10**	**9**

9.2.7 Program Realization Rates

The project-specific results for the final evaluated sample were extrapolated back to the sampling frame to determine the evaluated savings for the population and the program realization rate. The calculated realization rates should be applied to the final 2019-2022 tracked savings to estimate the evaluated savings for the program over the four program years. Table 9-5Table 9-5 provides the evaluation results from the evaluation sample of 19 projects that have been expanded to the sample frame of 68 projects.

Table 9-5. LPU electric impact evaluation results

Project Count with Electric Savings	Sub Domain	Tracked Electric Savings (MWh) of Evaluated Sites	Realization Rate	Relative Precision at 90% Confidence Interval
Sample Frame = 68 Evaluated = 19	Non-Lighting	7,944	48%	42%
	Lighting	9,443	94%	8%
Total		**17,387**	**71%**	**17%**

9.2.8 Sources of Variance

The primary driver of savings variance were projects in where we found that the measures were not implemented — either measures were removed after implementation or measures were not implemented as originally scoped. This was the case for three of the evaluated projects.

- For a commissioning measure, we found that the described measures were not implemented/operating based on evaluation period performance trends. The original analysis identified significant savings that increased gradually from 2020 through 2022 in the building HVAC operation. DNV determined that the decreased fan power was due to unoccupied building operation over the evaluation period and not due to measure implementation. Though the reduced fan power verified the building HVAC energy savings, it was not a result of the originally scoped measures and could not be attributed to the program.
- For a process measure, we updated the applicant's calculation with performance data provided for the evaluation period and found that the installed annual energy use was higher than the baseline annual energy use (i.e., the project had no verified measure savings). The project implementer determined that the equipment installed had been removed for maintenance and not reinstalled.
- For a lighting measure, the applicant scope identified 399 metal halide fixtures to be replaced; however, we confirmed with the implementer that only 250 fixtures were replaced due to misplaced parts or other reasons at the time of evaluation.

Additionally, for two evaluated HVAC control projects, we found that the control measures were not operating as claimed by the applicant either due to the capability of the installed equipment or the preference of the facility. Another driver of savings variance comes from one evaluated project that had a calculation error in the analysis file which resulted in an overestimation of baseline equipment power draw.

9.3 Process Evaluation

This section summarizes the key findings for the LPU process evaluation. It includes results from participant surveys and in-depth interviews with customers eligible to participate in the 2019-2022 program cycle.

9.3.1 "Nonparticipant" Interviews

PSE program management said it was difficult to attract a significant portion of eligible customers to participate in the LPU program. Indeed, 14 of the 30 eligible customers spent 0% of their funding allocation during the 2019-2022 cycle, and 16 of 30 spent less than 50% of their funding allocation. As such, DNV focused its process evaluation activities on interviewing and gaining a better understanding of "nonparticipating" customers. This section summarizes results from those interviews. DNV sought to collect feedback on the following topics:

- Program awareness
- Barriers to participation
- Program satisfaction
- Suggestions for improvement

9.3.1.1 Sample frame

PSE provided DNV with a list of 30 customers eligible to participate in the LPU program in early 2023. DNV removed from the sample frame 14 customers that spent at least 50% of their funding allocation during the 2019-2022 cycle. Among the remaining 16 "nonparticipating" customers, DNV completed interviews with representatives from six of these customers in March 2023. On average, these respondents spent 3% of their funding allocation.

9.3.1.2 Program Awareness

Familiarity with the LPU program varied among the "nonparticipant" respondents. Four had long-standing engagements as the primary staff person (or one of a few) responsible for their organizations' participation, and two were relatively new to the role with limited familiarity and interaction with program staff.

In general, respondents thought that PSE communicated sufficiently about the program. Among those able to give a response to the adequacy of PSE communication with respect to the LPU program, the average numerical rating was a 4.3 (on a five-point scale in which "5" meant "very adequate").

However, PSE program staff acknowledged that they are not always adequately informed when key customer staff that interface with the LPU program leave, which can lead to a lack of sufficient knowledge transfer and stagnation in program engagement. During its outreach to the listed contacts for "nonparticipating" customers for this evaluation, DNV discovered and notified PSE of changes to key staff for multiple eligible customers. In these cases, the "new" staff generally lacked knowledge of the LPU program.

9.3.1.3 Barriers to Participation

Unsurprisingly, the "nonparticipating" customers rated their own organizations poorly in terms of how actively they had been in pursuing LPU program funds allocated to their organization, giving an average rating of 2.4 on a five-point scale (in which "5" indicated "very actively").

The majority of customer-cited barriers to participating more actively generally centered around difficulty identifying cost-effective projects that qualify for the LPU program. These could be broken down into three categories:

- Three respondents indicated that the “low-hanging fruit” within their facilities had already been picked. This is at least partly a result of many of these organization being involved in the LPU program for well over a decade. PSE program managers also mentioned this dynamic as a continuing (and perhaps increasing) barrier to participation.
- Three respondents indicated that staff members lacked the necessary time or a project “champion” to pursue energy efficiency projects among competing priorities. PSE program managers also mentioned this dynamic as a continuing barrier to participation.
- Two respondents indicated confusion about what types of projects are eligible and would qualify for LPU program incentives. For example, one of these respondents (falsely) said that new construction projects were not eligible for program funds.

Another barrier to increased program engagement (cited by two of six respondents) was a lack of buy-in from key decision-makers within their organization on potential projects.

9.3.1.4 Suggestions for Improvement

“Nonparticipants” suggested a variety of ways to improve the delivery of the LPU program. Suggestions with more than one respondent included:

- Provide “case studies” for eligible customers to both provide project ideas and to help convince key decision-makers to more aggressively pursue funding allocation (two respondents).
- Help customers gain a better understanding of what types of projects qualify for program incentives (two respondents).
- Provide more regular reminders of the program to eligible customers, including a tally of remaining funding allocation in customers’ monthly bills (two respondents).
- Loosen eligibility criteria for funding grants, including electrification projects (two respondents).

9.3.2 Participant Surveys

During the course of the impact evaluation, DNV completed brief surveys (including information relevant to the process evaluation) with 10 unique customers participating in the LPU program. These were knowledgeable respondents, as all said they were involved in their organization’s decision to participate in the program. This section summarizes findings collected through those surveys in two topics: program influence and program satisfaction. On average, these respondents spent 124% of their 2019-2022 funding allocation.

9.3.2.1 Program Influence

We asked the participants: “The program provides incentives to help offset the cost of going from standard to high performance equipment. How important was the PSE incentive in your decision to make these upgrades?” Respondents rated the importance of PSE incentives using a five-point scale in which “1” is “not at all important” and “5” is “very important.” The average importance of PSE incentives was 4.1, with 7 of 10 participants giving at least a 4 (“somewhat important”). One participant gave a particularly representative response when asked about program influence:

> “Incentives are critical. Energy costs are much lower in this territory than we see in other states, so it helps keep this state/facility motivated to complete energy efficiency projects. Incentives drive the project.”

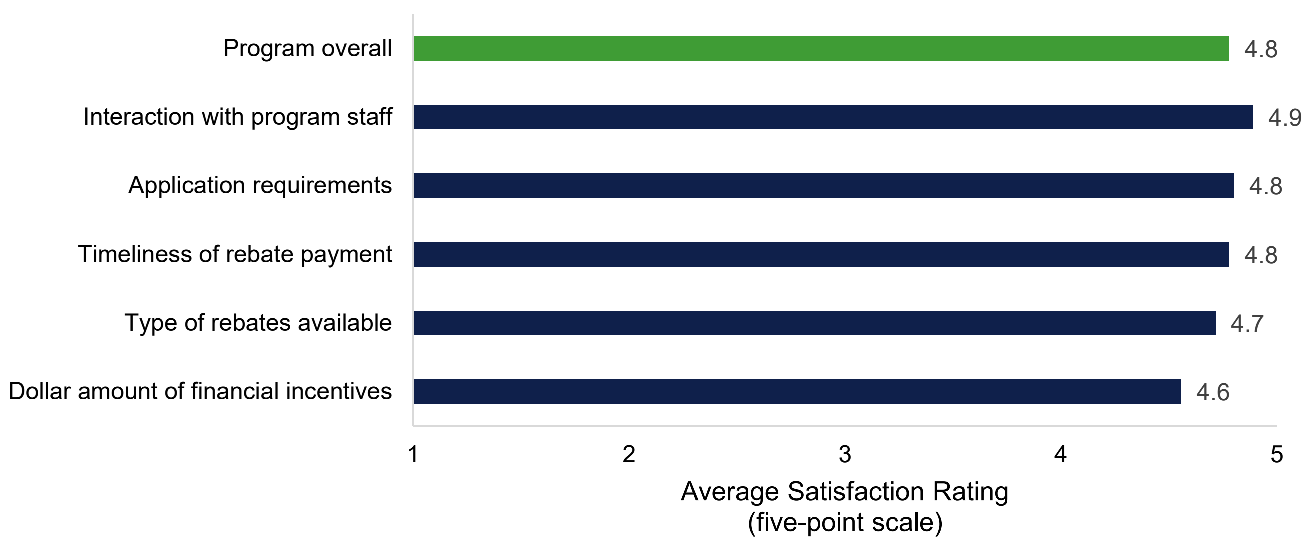
Next, we asked the participants: “If the incentives had not been available, would you have selected any different equipment, or would the timing, or size, of the project be any different?” Seven of nine respondents said the project(s) they completed would have been different absent the BLi Program. Notably, for three respondents, the project(s) would not have been completed at all without LPU Program incentives.

Among other types of program impacts, most common was that the project timing would have been impacted without the program (three respondents), followed by the size or scale of the project would have been reduced without the program (two respondents). Additionally, one respondent said they would have installed different equipment in the absence of program incentives.

9.3.2.2 Participant Satisfaction

Participants are generally very satisfied with the LPU Program, giving an average rating of at least 4.6 to all (using a five-point scale in which “5” meant “very satisfied” and “1” meant “very dissatisfied”). Figure 9-1 shows the average satisfaction ratings for all program aspects. The only aspects that received any less-than-satisfied responses were the rebate amounts and the timeliness of rebate payment (one respondent each giving them a three), and all but one respondent were “satisfied” with every program aspect.

Figure 9-1. Participant satisfaction with LPU program



9.3.3 Previous Evaluation Review

DNV did not find any recommendations from previous evaluations. However, we did find two considerations that are applicable to the current program cycle, both originating in the 2018-19 LPU Compliance Program Evaluation Report. PSE has some made progress in addressing these considerations.

The first recommendation centered around increasing monitoring of the largest projects. The previous evaluation team thought this would help identify changes to building conditions or project measures that could negatively impact savings and minimize negative shocks for the program at the evaluation stage. During the evaluation of the 2019-2022 program cycle, DNV found this consideration to be still valid, with more work to be done. This is discussed in more detail in section 9.4.1. As a result, DNV believes that this consideration is in progress.

The second consideration was to align evaluation cycles with program cycles. The previous evaluation spanned two different LPU program cycles (2015-2018 and 2019-2022), which presented challenges in assessing program performance against participation and savings goals. For this evaluation, DNV developed a sampling strategy to ensure later-stage projects were not missed, and that projects throughout the entire four-year cycle were included. As a result, DNV considers this recommendation completed.

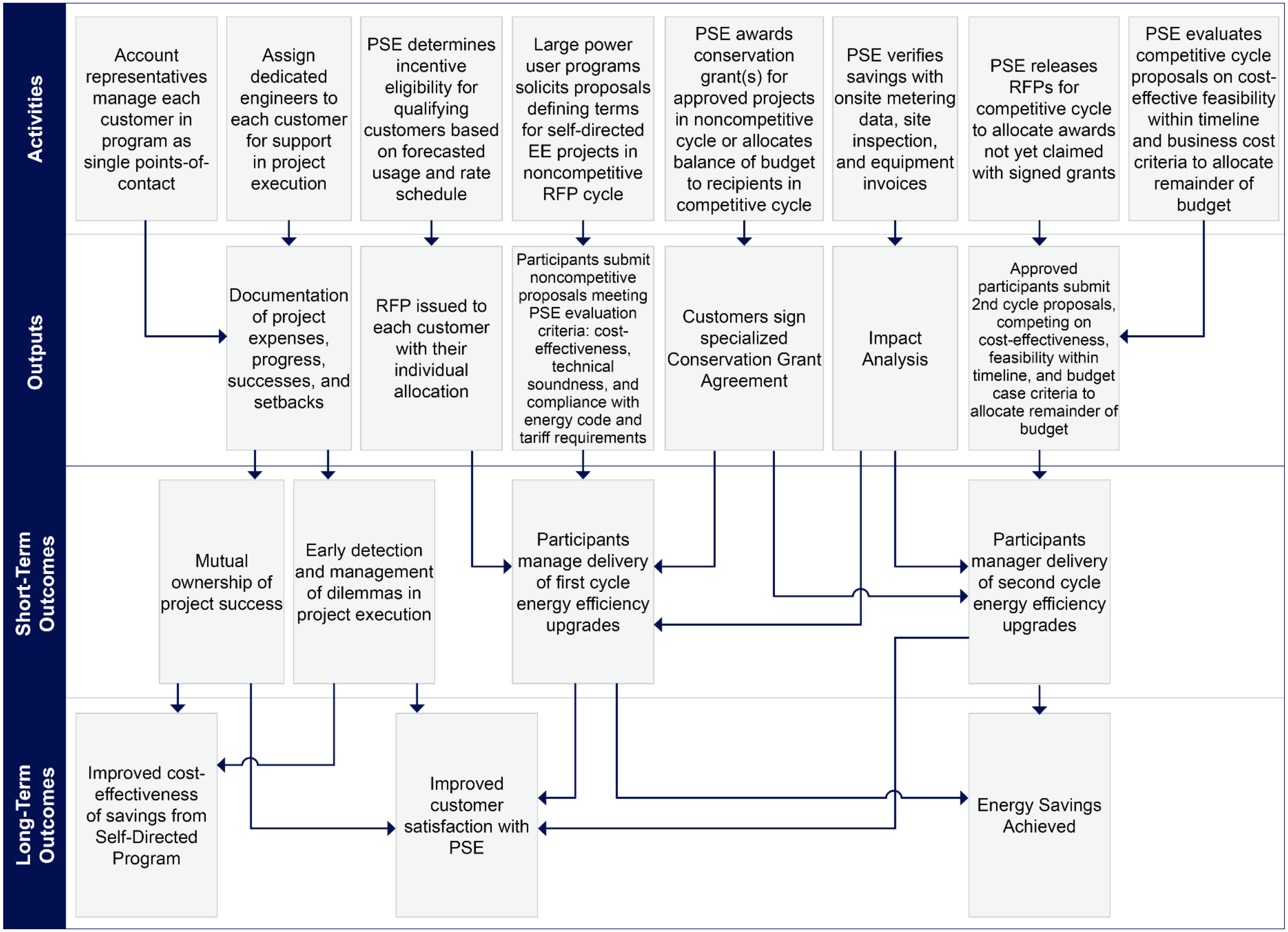
9.3.4 Program Theory Logic Model

Logic models are effective tools to assist in program planning, implementation, management, evaluation, and reporting. They help define a program's intended impact and goals, the sequence of intended effects, which activities are to produce which effect, and where to focus outcome and process evaluations.

DNV also reviewed the PTLM currently used by the LPU management team and confirmed that it effectively captures program processes and aligns with program priorities (Figure 9-2). We suggest a couple of additions to further increase its effectiveness, including:

- Given the lack of engagement with the LPU Program among some eligible customers, add activities meant to increase customer awareness and prioritization of the program.
- Add an outcome for increased participation that follows from the activities in the bullet above.

Figure 9-2. LPU program theory logic model



9.3.5 Key Performance Indicators

LPU program managers track three metrics as KPIs, considering “greater than previous program cycle” as success criteria for each. However, all three decreased in the 2019-2022 program cycle compared to the previous (2015-2018) cycle. These included:

- Electric savings (MWh; down 43% from cycle to cycle)
- Program expenditure (percent of total funding allocation spent; down 28%)
- Participation (percent of eligible customers receiving at least one grant; down 22%)

It is worth noting that the COVID-19 pandemic and associated impacts (including increased staff turnover, increased “remote work”, and supply chain issues) likely negatively affected program savings and participation in the recently completed four-year cycle. However, the extent of this effect is unknown.

9.4 Findings, Recommendations, and Considerations

This section documents DNV’s findings, recommendations, and considerations associated with the LPU program.

9.4.1 Impact Key Findings and Recommendations

- **Key Finding** – Evaluated lighting projects submitted under the LPU program achieved high realization rates. We were able to verify savings inputs and determined that the calculation methodology was reasonable.
- **Key Finding** – DNV identified four instances where the measures were not implemented, had been removed at the time of evaluation, or were not implemented as scoped at the time of the project application, which significantly impacted the project savings.
    - **Recommendation** – Increase verification measures and/or change post-inspection protocols if the project is expected to save over a certain threshold.
- **Key Finding** – In evaluating an ongoing, multi-year commissioning project, DNV identified that the measures were not implemented/operating based on evaluation period performance trends. Though savings were present in the comparison of pre- and post-installation periods, we identified that the savings were due to a change in facility operation, not the described measures. Since the scoped measures were not implemented, this project could not claim savings attributable to the program.
    - **Recommendation** – Change ongoing commissioning verification protocols.
- **Key Finding** – An error in a savings calculation formula resulted in a large variance for one site. For this site, the applicant calculated total motor power draw using total current rather than average current which overestimated the baseline energy use by 67%.
    - **Recommendation** – Projects going through QA/QC review should verify that the power draw of the equipment is being calculated correctly.

9.4.2 Impact Findings and Considerations

- **Finding** – Variances with a significant impact on program savings were concentrated on specific accounts enrolled in the program.
    - **Consideration** – Connect with the account representative if patterns are identified in not realizing measure savings and identify any account-specific concerns or factors that should be accounted for in the project analysis. Also, increase verification measures and/or change post-inspection protocols if the project is expected to save over a certain threshold.

9.4.3 Process Key Findings and Recommendations

- **Key Finding** – In the recently completed four-year LPU program cycle (2019-2022), total energy savings, the percentage of total funding allocation spent, and participation rate by eligible customers all decreased from the previous 4-year cycle (2015-2018). While the COVID-19 pandemic and associated effects likely played some role in those outcomes, most of the "nonparticipating" customers that DNV spoke with cited a difficulty identifying cost-effective, qualifying projects as a barrier, which will make growing and even maintaining program participation and savings difficult.
    - **Recommendation** – Given these challenges, work to identify program design and/or delivery changes in the current 4-year cycle specifically intended to increase participation and savings. Based on evaluation work to date, items to consider include:
        - Work to align the LPU Program with other (even non-energy efficiency) programs to widen customers' options for reducing energy usage and emissions and provide a more holistic approach (e.g., possibly including electrification).
        - Develop and provide "case studies" to help key staff within eligible customer organizations to better obtain decision-maker support.

9.4.4 Process Findings and Considerations

- **Finding** – In general, both "participating" and "nonparticipating" eligible customers were satisfied with PSE's communication with respect to the LPU program. However, PSE is not always adequately informed when eligible customers experience key staff turnover, which can lead to a lack of knowledge transfer and stagnation in customer engagement and participation. Further, lack of buy-in from key decision-makers was cited as a barrier to increased participation.
    - **Consideration** – Proactively provide customers with more frequent communication throughout the four-year program cycle to ensure the LPU program does not get "lost in the shuffle" of competing priorities.
    - **Consideration** – Increase the number and widen the types of staff within eligible customers' organizations that regularly engage with the LPU program to include decision-makers and increase the likelihood of a project "champion" emerging.
- **Finding –** The PTLM currently used by PSE for the LPU program effectively captures program processes and aligns with program priorities. However, the PTLM could use some additions, including the following:
    - **Consideration –** Given the lack of engagement with the LPU program among some eligible customers, add activities meant to increase customer awareness and prioritization of the program.
    - **Consideration –** Add an outcome within the PTLM of "increased participation" that follows from the activities in the bullet above.

10 APPENDICES

10.1 Appendix A: Sample Design

This appendix provides a summary of the sampling approach DNV used for this evaluation.

10.1.1 Background

Conventional methods are documented in standard texts such as Cochran's *Sampling Techniques*.[4] MBSS is grounded in theory of model-assisted survey sampling developed by C.E. Sarndal and others.[5,6] MBSS methodology has been applied in load research for more than 30 years and in energy efficiency evaluation for more than 20 years. This fusion of theory and practice has led to important advances in both model-based theory and interval load data collection practice, including the use of the error ratio for preliminary sample design, the model-based methodology for efficient stratified ratio estimation, and effective methods for domains estimation.

MBSS and conventional methodologies are currently taught in the Association of Edison Illuminating Companies' *Advanced Methods in Load Research* seminar. MBSS methodology is also documented in *The California Evaluation Framework*.[7] MBSS has been used successfully for decades in countless load research and program evaluation studies. It has also been examined in public utility hearings and in at least two Electric Power Research Institute, Inc. (EPRI) studies.

10.1.2 The Role of the Statistical Model

MBSS uses a statistical model to guide the planning and the sample design. The parameters of the model, especially the error ratio, are used to represent prior information about the population to be sampled. The model describes the nature of the variation in the relationship between any target *y variable* of the study, in our case the normalized daily consumption of the customer, and one or more *x variable*s that can be developed from known billing data and other supporting information. The *x variable* is usually a measure of the size of the customer, e.g., annual use, and assumes good information is available in the billing to support the analysis. The model is used to help choose the sample size *n*, to assess the expected statistical precision of any sample design, and to help formulate a sample design that is efficiently stratified for ratio estimation using case weights.

The model is used as a *guide* to the sample design, but the results of the study itself are *not* strongly dependent on the accuracy of the model.[8] Once the sample design is selected, the subsequent analysis of the data is based only on the sample design and not on the model used to develop the sample design. The resulting estimates will be essentially unbiased in repeated sampling and the confidence intervals will also be valid, provided that the sample design has been followed to select the sample customers. The results will be consistent with traditional sampling theory as found in texts such as Cochran's *Sampling Techniques* and consistent with standard load and market research practice.

10.1.3 Stratified Ratio Estimation

We assume that the data collected and analyzed in the study is for a given population of *N* accounts in a given customer class. In this study, annual energy savings will be the unit of measure. We let *y* denote the annual savings determined through evaluation, and we let *x* denote the annual savings estimated by the program administrator.

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4 *Sampling Techniques*, by W. G. Cochran, 3rd. Ed., Wiley, 1977.

5 *Model Assisted Survey Sampling*, by Carl Erik Sarndal, Bengt Swensson and Jan Wretman, Springer-Verlag, 1992.

6 Wright, R. L. (1983), "Finite population sampling with multivariate auxiliary information," *Journal of the American Statistical Association*, **78**, 879-884.

7 The report can be downloaded from the webaccount http://www.calmac.org/calmac-filings.asp

8 Other methods, called model-dependent sampling, are much more dependent on the accuracy of the model. Such methods are not commonly used in load research applications since they would be more difficult to defend than MBSS and conventional methods.

We define the population ratio (realization rate) *B* by the equation:

$$B = \frac{\sum_{i=1}^{N} y_i}{\sum_{i=1}^{N} x_i}.$$

Here the summations are over the entire *N* units (e.g., customers) in the target population. We note that the population mean, or total of *y*, is equal to *B* times the population mean or total of *x*. The latter is assumed to be known from the billing or tracking data.

We assume that a sample of *n* customers is selected following a stratified sample design. For each sample customer, we define the case weight *w* to be equal to the number of customers in the target population within the stratum containing the given customer divided by the number of customers in the sample within the given stratum. The case weight is used to avoid any bias that might otherwise arise from the different sampling fractions used from one stratum to another.

Using the case weight, we define the combined ratio estimator of *B* by the equation:[9]

$$b = \frac{\sum_{i=1}^{n} w_i y_i}{\sum_{i=1}^{n} w_i x_i}$$

Then, if desired, the population mean or total of *y* can be estimated as *b* times the population mean or total of *x,* known from the tracking or billing data.

Using the case weights, we calculate the relative precision at the 90% level of confidence in three steps:

1. Calculate the sample residual $e_i = y_i - bx_i$ for each unit in the sample.
2. Calculate[10] $se(b) = \frac{\sqrt{\sum_{i=1}^{n} w_i (w_i - 1)\ e_i^2}}{\sum_{i=1}^{n} w_i x_i}$.
3. Calculate $rp = \frac{1.645\ se(b)}{b}$.

A 90% confidence interval for *B* is calculated using the equation: $b \pm rp\ b$. A confidence interval for the mean or total can be calculated in a similar way.

We can also use the sample data to estimate a measure of population variability called the error ratio, denoted *er*. The error ratio is the key determinant of the expected relative precision, along with the sample size *n*. We estimate the error ratio from the sample using the following equation:

$$\hat{er} = \frac{\sqrt{\left(\sum_{i=1}^{n} w_i\ e_i^2 / x_i^{\gamma}\right)\left(\sum_{i=1}^{n} w_i\ x_i^{\gamma}\right)}}{\sum_{i=1}^{n} w_i\ y_i}$$

The parameter γ (gamma) is defined in the next section. In practice, it is usually taken to be 0.8. We will not attempt to interpret the preceding equation here, but we will define both the error ratio and gamma in the following section.

10.1.4 The Ratio Model

The ratio model is used to choose the appropriate sample size, n, to assess the expected statistical precision of any stratified sample design, and to develop an efficiently stratified sample design. The ratio model describes the relationship

[9] This equation gives the same result as the conventional stratum-weighted equation: $b = \frac{\sum_{h=1}^{L} N_h \bar{y}_h}{\sum_{h=1}^{L} N_h \bar{x}_h}$.

[10] The conventional equation is $se(b) = \frac{1}{\sum_{h=1}^{L} N_h \bar{x}_h} \sqrt{\sum_{h=1}^{L} N_h^2 \left(1 - \frac{n_h}{N_h}\right) \frac{s_h^2(e)}{n_h}}$ where $s_h^2(e) = \frac{1}{n_h - 1} \sum_{i=1}^{n_h} (e_i - \bar{e})^2$. Our equation assumes that $\frac{1}{n_h - 1} \sum_{i=1}^{n_h} (e_i - \bar{e})^2$is approximately equal to $\frac{1}{n_h} \sum_{i=1}^{n_h} (e_i)^2$in each stratum.

between y and x for the set of all units in the population. The model consists of two equations called the primary and secondary equations respectively:[11]

$$y_i = \beta \ x_i + \varepsilon_i$$
$$\sigma_i = sd(\varepsilon_i) = \sigma_0 \ x_i^{\gamma}$$

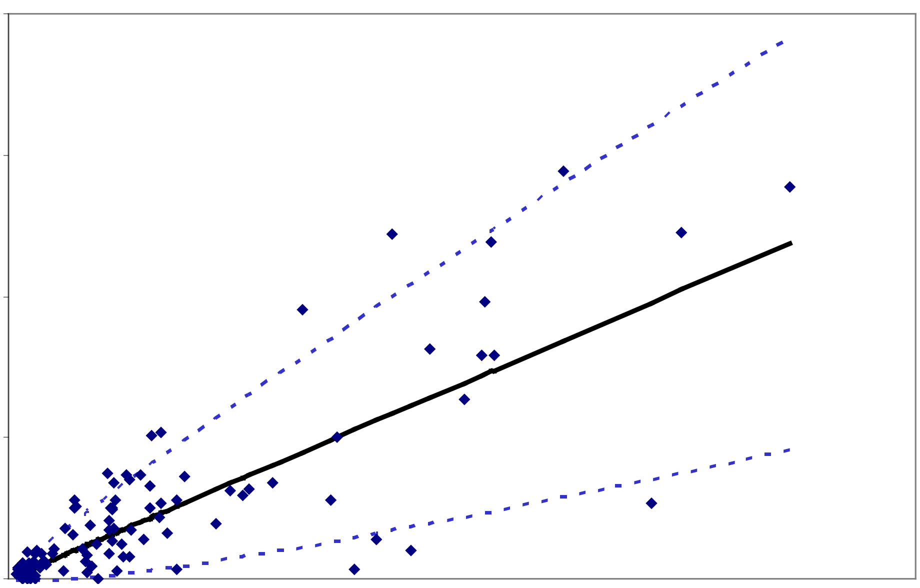
Here *i* denotes any customer, account, or HVAC units in the target population. $x_i > 0$ is usually known throughout the population. The primary equation describes the relationship between the *y variable* of interest, e.g., normalized daily use, and the *x variable* used in the ratio estimate, i.e., actual daily use. Since we assume that $E(\varepsilon_i) = 0$, the primary equation can also be written as $\mu_i = E(y_i) = \beta \ x_i$. Here μ_i denotes the expected value of *y* for unit *i.* The primary equation says that under the model, the expected value of y_i is equal to a fixed constant β times the known x_i.

The quantity, $\varepsilon_i = y_i - \mu_i$, is called the residual. The *N* residuals are considered to be *N* independent random variables. The standard deviation of ε_i is denoted as σ_i. We refer to σ_i as the residual standard deviation of each customer *i*. The secondary equation is used to estimate the residual standard deviation and to guide the development of an efficient sample design.

To summarize, under the ratio model, the target variable y_i is a random variable with expected value μ_i and standard deviation σ_i. The expected value μ_i is determined by the primary equation of the model. The standard deviation σ_i is determined by the secondary equation of the model. There are three parameters in the model: β (beta), σ_0 (sigma-naught), and γ (gamma).

Figure 10-1 shows an example. The points of the scatterplot represent the values of (x, y) for each site in the population. The solid line represents the equation$y = \beta \ x$, i.e., the expected value of y given x. This is a line through the origin with slope given by the parameter β. The two dashed lines represent the equation $y = \beta \ x \pm \sigma$, i.e., the one-standard deviation interval around the expected value. Here $\sigma = \sigma_0 \ x^{\gamma}$ so the dashed lines are determined by the two parameters σ_0 and γ.[12]

Figure 10-1. Example of a ratio model of a stratified sample



[11] The x-variable in the primary equation is sometimes different than the x-variable in the secondary equation. In the SAS modules, we refer to the later as the stratification variable. For simplicity, we will not make this distinction in the theoretical discussion given here.

[12] The role of gamma can be seen by rewriting this equation as $log(\sigma) = \alpha + \gamma \ log(x)$ where $\alpha = log(\sigma_0)$. This shows that for each site in the population the log of sigma is a constant plus gamma times the log of the value of x for the site. Gamma is the slope in the relationship between the log of x and the log of sigma.

Now we are finally positioned to define the error ratio. The error ratio is defined by the equation:

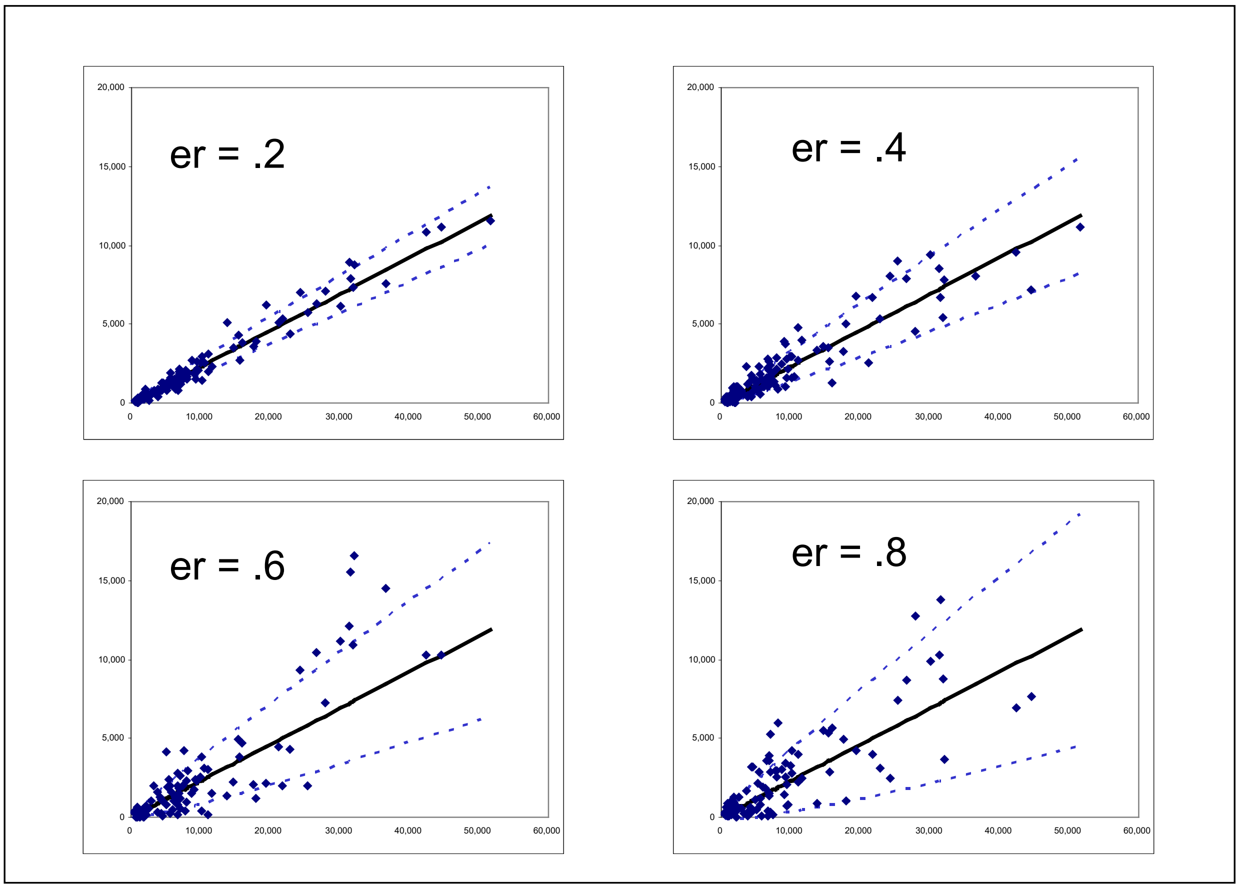
$$er = \frac{\sum_{i=1}^{N} \sigma_i}{\sum_{i=1}^{N} \mu_i}$$

The error ratio can be regarded as an alternative parameter to σ_0 since under the preceding ratio model,σ_0 can be calculated from the error ratio using the equation:

$$\sigma_0 = er \; \frac{\sum_{i=1}^{N} \mu_i}{\sum_{i=1}^{N} x_i^{\gamma}}$$

The error ratio is the key measure of variability when stratified ratio estimation is to be used to analyze the data. Figure 10-2 shows examples. If the error ratio is close to zero, there is a strong relationship between x and y. If the error ratio is larger, the relationship is weaker.

Figure 10-2. Examples of different error ratios



10.1.5 Choosing the Sample Size

We assume that the ratio model provides a reasonably accurate description of the relationship between *y* and *x* in the target population. We also assume that the sample design will be efficiently stratified as discussed previously and that the analysis will use stratified ratio estimation.

Under these assumptions and the added assumption that the population size *N* is large, then the expected relative precision is given by the equation: $rp = z\frac{er}{\sqrt{n}}$**.** Where z is the standard normal deviate or 1.645 for 90% confidence and 1.96 for 95% confidence, "er" is the error ratio and "rp" is the required relative precision. If the population is relatively small, the finite population correction factor can be added, giving:

$$rp = z\ \sqrt{1-\frac{n}{N}}\frac{er}{\sqrt{n}}$$

In Cochran, the relative precision "rp" is referred to as the desired relative precision "*D."* If D, is specified, then the preceding equations can be solved to determine the required *n.* If the population size *N* is large, we have:

$$n = \left(\frac{z\ er}{D}\right)^2$$

Please note, the error ratio (er) and the z-value have a modest impact on the sample size whereas the desired relative precision has a significant impact. For example, halving the desired relative precision from ±10% to ±5% effectively quadruples the sample size.

If the population is small, the sample size can be calculated in two steps. First, calculate $n_0 = \left(\frac{1.645\ er}{D}\right)^2$. Then calculate $n = \frac{n_0}{1+n_0/N}$. These equations and some reasonable assumptions are generally enough to develop a preliminary plan.

10.1.6 Stratification

DNV will regularly utilize stratification in the sample design. Under the ratio model, an efficiently stratified sample design for ratio estimation can be developed in the following steps:[13]

1. Use the sampling frame and the assumed model to calculate σ_i for each customer in the population.
2. Choose the desired number of strata,14.
3. Sort the sampling frame by increasing σ_i.
4. Choose stratum cut points to divide the sum of the σ_i approximately equally between the strata.
5. Allocate an equal number of sample customers to each stratum.
6. Make added adjustments if the sample size exceeds the population size in any stratum.

Under the ratio model, σ_i is determined by the x variable together with the value of γ. Methods are available for estimating γ from a sample. Indeed, we have estimated γ in numerous load research studies. We have found that the estimated values are clustered around 0.8. We have also found that the key results are not sensitive to γ. Therefore, in interval load data collection applications, we recommend the use of $\gamma = 0.8$ both in constructing strata as discussed in this section and in estimating the value of the error ratio from a given sample.

[13] This methodology is the model-based version of the Dalenius-Hodges method of constructing strata combined with optimal allocation of the sample using the within-strata population standard deviation of the e_i. However, Dalenius-Hodges stratification is approximately optimal for stratified mean per unit estimation whereas model-based stratification is approximately optimal for stratified ratio estimation. Moreover, with conventional methods it is common to calculate the required sample size from the within-stratum population standard deviation of x_i. This practice can yield very misleading results and cannot be recommended.

[14] With MBSS methodology we can systematically assess the gain from increased stratification. These studies indicate that five annual-use strata are usually sufficient in most load research applications. Some applications may call for added stratification by seasonal use, customer load factor, etc.

10.1.7 Evaluating the Precision of any Design

For any sample design, we define the inclusion probability of each site in the population, denoted π_i, to be the probability that the site is included in the sample. For a stratified sample design, the inclusion probability is the sampling fraction in each stratum, i.e., n_h/N_h.

Under the ratio model and any sample design, the expected relative precision of the stratified ratio estimator is:

$$rp = z\sqrt{\sum_{i=1}^{N}\left(\pi_i^{-1} - 1\right)\ \sigma_i^2}\Bigg/\sum_{i=1}^{N}\ \mu_i$$

Here $z = 1.645$ for the 90% level of confidence. This key result has the following mathematical implications:

1. For any given sample size n, a sample design is said to be efficient if the sample design minimizes the expected relative precision. For any efficient sample design, $\pi_i = \frac{n}{\sum_{i=1}^{N} \sigma_i}\ \sigma_i$ provided that the right-hand side is less than one.
2. If the right-hand side is greater than one, the site should be included with certainty.
3. If the sample design is efficient and the population is large, then the expected relative precision is $rp = \frac{z\ er}{\sqrt{n}}$.
4. The model-based sample design is practically efficient as long as the number of strata is large enough.

The preceding equation can also be used to calculate the expected statistical precision of any sample design in any domain of interest.

10.2 Appendix B: Project-level Evaluation Results

Table 10-1 shows the unweighted results for each evaluated project, along with a short description for the primary reason behind any variance between the tracked savings and the evaluated savings.

Table 10-1. Project-level evaluation results of each sampled project for the BLi Program

Project ID	Tracked Electric Savings (kWh)	Tracked Gas Savings (Therms)	Tracked Total Savings (kBtu)	Evaluated Electric RR	Evaluated Gas RR	Evaluated Total RR	Variance Reason
P_1028287	119,366	0	407,294	76%	-	76%	Other
P_1123471	106,270	0	362,608	100%	-	100%	-
P_1129733	344,589	0	1,175,786	87%	-	87%	Calculation Methodology
P_1134376	465,084	0	1,586,932	95%	-	95%	Calculation Methodology
P_1134856	347,733	0	1,186,514	82%	-	82%	Calculation Methodology
P_1135126	498,363	0	1,700,485	82%	-	82%	Calculation Methodology
P_1135223	328,745	0	1,121,725	88%	-	88%	Calculation Methodology
P_1161465	143,419	0	489,366	135%	-	135%	Facility Changes
P_1174621	195,468	0	666,965	99%	-	99%	Calculation Methodology
P_1197108	50,028	0	170,703	100%	-	100%	-
P_1145913	7,920	0	27,024	117%	-	117%	Calculation Methodology
P_1145949	9,900	0	33,780	117%	-	117%	Calculation Methodology
P_1135348	416,242	0	1,420,277	105%	-	105%	Other
P_1186482	11,562	0	39,451	100%	-	100%	-
P_1191993	272,480	0	929,740	86%	-	86%	Calculation Methodology
P_1203377	387,698	0	1,322,880	100%	-	100%	-
P_1205565	95,313	0	325,221	101%	-	101%	Calculation Methodology
P_1205823	81,640	0	278,567	114%	-	114%	Installed Quantity
P_1215000	28,126	0	95,970	82%	-	82%	Installed Quantity
P_1234356	107,708	0	367,515	100%	-	100%	-
P_1238958	9,395	0	32,057	100%	-	100%	-
P_1256505	234,511	0	800,185	93%	-	93%	Calculation Methodology
P_1260827	121,252	0	413,729	53%	-	53%	Facility Changes
Total	**4,382,812**	**0**	**14,954,775**	**94%**	**-**	**94%**	**-**

Table 10-2. Project-level evaluation results of each sampled project for the C&I Retrofit Program

Project ID	Tracked Electric Savings (kWh)	Tracked Gas Savings (Therms)	Tracked Total Savings (kBtu)	Evaluated Electric RR	Evaluated Gas RR	Evaluated Total RR	Variance Reason
P_1044116	1,150,000	8,079	4,731,844	102%	152%	76%	Calculation Methodology
P_1103678	109,109	53,104	5,682,568	101%	117%	100%	Facility Changes
P_1103823	0	1,853	185,296	-	135%	87%	Baseline Adjustment
P_1114475	214,445	0	731,717	60%	-	95%	Calculation Methodology
P_1125564	702,716	0	2,397,767	38%	-	82%	Tracking Calculation Error
P_1129707	0	840	83,998	-	47%	82%	Baseline Adjustment
P_1136455	419,296	26,460	4,076,634	101%	93%	88%	Calculation Methodology
P_1145102	254,971	0	869,997	35%	-	135%	Calculation Methodology
P_1177491	0	7,064	706,383	-	34%	99%	Baseline Adjustment
P_700693	2,805,033	0	9,571,165	174%	-	100%	Facility Changes
P_796418	0	51,374	5,137,277	-	25%	117%	Facility Changes
P_919376	0	29,192	2,919,130	-	40%	117%	Calculation Methodology
P_1103943	0	9,856	985,576	-	97%	111%	Calculation Methodology
P_1124264	308,460	0	1,052,509	13%	-	116%	Calculation Methodology
P_1130080	0	141,390	14,138,662	-	108%	135%	Facility Changes
P_1131585	0	794	79,398	-	107%	60%	Facility Changes
P_1136390	850,129	53,648	8,265,432	101%	93%	38%	Installed Quantity
P_1136978	1,055,106	66,724	10,272,412	100%	92%	47%	Installed Quantity
P_1178188	239,622	0	817,624	87%	-	96%	Facility Changes
P_1205870	11,487	0	39,195	100%	-	35%	-
P_1231820	1,464,734	0	4,997,880	100%	-	34%	-
P_1232816	1,332,612	31,150	7,661,986	100%	100%	174%	-
P_1260901	1,145,988	15,904	5,500,635	100%	100%	25%	-
P_980623	0	319,083	31,907,537	-	91%	40%	Facility Changes
Total	**12,063,708**	**816,515**	**122,812,624**	**88%**	**90%**	**89%**	**-**

Table 10-3. Project-level evaluation results of each sampled project for the IEM Program

Project ID	Tracked Electric Savings (kWh)	Tracked Gas Savings (Therms)	Tracked Total Savings (kBtu)	Evaluated Electric RR	Evaluated Gas RR	Evaluated Total RR	Variance Reason
P_1106385	677,278	0	2,310,967	81%	-	81%	Calculation Methodology
P_1152471	1,170,592	0	3,994,224	218%	-	218%	Calculation Methodology
P_1082379	307,902	0	1,050,605	95%	-	95%	Calculation Methodology
P_1086843	176,742	0	603,069	95%	-	95%	Calculation Methodology
P_1137808	26,163	0	89,272	75%	-	75%	Calculation Methodology
P_1140265	139,911	21,903	2,667,644	96%	100%	99%	Calculation Methodology
P_1158905	110,594	2,413	618,657	44%	75%	56%	Calculation Methodology
Total	**2,609,182**	**24,316**	**11,334,437**	**121%**	**98%**	**114%**	**-**

Table 10-4. Project-level evaluation results of each sampled project for the Commercial HVAC Program

Project ID	Tracked Electric Savings (kWh)	Tracked Gas Savings (Therms)	Tracked Total Savings (kBtu)	Evaluated Electric RR	Evaluated Gas RR	Evaluated Total RR	Variance Reason
P_1164941	3,178	0	10,844	100%	-	100%	-
P_1205196	255	30	3,870	101%	103%	103%	Calculation Methodology
P_1147396	2,384	0	8,133	73%	-	73%	Tracking Calculation Error
P_1202835	39,150	0	133,585	100%	-	100%	-
P_1178035	64,041	11,229	1,341,388	115%	9%	26%	Calculation Methodology
P_1202848	206,190	0	703,549	100%	-	100%	-
P_1140972	36,135	2,886	411,891	47%	22%	30%	Installed Quantity
P_1202855	122,670	0	418,567	100%	-	100%	-
Total	**474,002**	**14,145**	**3,031,828**	**98%**	**12%**	**58%**	**-**

Table 10-5. Project-level evaluation results of each sampled project for the Commercial Midstream Program

Project ID	Tracked Electric Savings (kWh)	Tracked Gas Savings (Therms)	Tracked Total Savings (kBtu)	Evaluated Electric RR	Evaluated Gas RR	Evaluated Total RR	Variance Reason
7000064507	0	1,137	113,697	-	92%	92%	Other
7000085134	756	0	2,580	77%	-	77%	Other
7000350186	0	1,967	196,695	-	84%	84%	Baseline Adjustment
7000459865	0	1,780	177,996	-	100%	100%	-
7000636118	0	1,039	103,898	-	85%	85%	Baseline Adjustment
7000765196	0	2,078	207,795	-	85%	85%	Baseline Adjustment
7000966573	1,336	0	4,559	100%	-	100%	-
7001065700	1,272	0	4,340	100%	-	100%	-
7001069563	0	562	56,199	-	82%	82%	Baseline Adjustment
7001566437	0	1,872	187,196	-	100%	100%	-
7001711866	1,808	0	6,169	100%	-	100%	-
Total	**5,172**	**10,435**	**1,061,123**	**97%**	**91%**	**91%**	**-**

Table 10-6. Project-level evaluation results of each sampled project for the LPU Program

Project ID	Tracked Electric Savings (kWh)	Tracked Gas Savings (Therms)	Tracked Total Savings (kBtu)	Evaluated Electric RR	Evaluated Gas RR	Evaluated Total RR	Variance Reason
P_1025705	68,916	0	235,151	100%	-	100%	Calculation Methodology
P_1093487	953,263	0	3,252,668	0%	-	0%	Other
P_1121353	685,091	0	2,337,628	19%	-	19%	Tracking Calculation Error
P_1132033	341,275	0	1,164,479	63%	-	63%	Installed Quantity
P_1054112	84,093	0	286,937	49%	-	49%	Baseline Adjustment
P_1059045	2,336,672	0	7,973,056	100%	-	100%	Calculation Methodology
P_1079075	4,527,276	0	15,447,707	9%	-	9%	Other
P_1087960	909,533	0	3,103,455	100%	-	100%	N/A
P_1151095	720,343	0	2,457,912	99%	-	99%	Calculation Methodology
P_1184116	726,924	0	2,480,368	99%	-	99%	Calculation Methodology
P_1159250	204,478	0	697,708	96%	-	96%	Other
P_1189651	3,853,410	0	13,148,381	104%	-	104%	Savings Interactivity
P_1197078	67,481	0	230,255	99%	-	99%	Calculation Methodology

Project ID	Tracked Electric Savings (kWh)	Tracked Gas Savings (Therms)	Tracked Total Savings (kBtu)	Evaluated Electric RR	Evaluated Gas RR	Evaluated Total RR	Variance Reason
P_1215326	295,625	0	1,008,714	120%	-	120%	Calculation Methodology
P_1246924	177,063	0	604,164	100%	-	100%	N/A
P_1261329	102,107	0	348,404	100%	-	100%	N/A
P_1270330	767,143	0	2,617,601	100%	-	100%	N/A
P_1272040	65,174	0	222,383	100%	-	100%	N/A
P_984695	501,405	0	1,710,865	63%	-	63%	Facility Changes
Total	**17,387,272**	**-**	**59,327,835**	**71%**	**-**	**71%**	**-**

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