2012-2013 Commercial Data Center Program Impact and Process Evaluation Final Report

Contents:

- Navigant Impact and Process Evaluation Report
- PSE Evaluation Report Response

This document contains Navigant's Commercial HVAC Program Impact and Process Evaluation Final Report, and Puget Sound Energy's Evaluation Report Response (ERR). In accordance with WUTC conditions, all PSE energy efficiency programs are evaluated by an independent, third party evaluator.[1] Evaluations are planned, conducted and reported in a transparent manner, affording opportunities for Commission and stakeholder review through the Conservation Resource Advisory Group (CRAG) and reported to the UTC.[2] Evaluations are conducted using best-practice approaches and techniques.[3]

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

Please note that this is an evaluation of the program as it operated during the 2012-2013 program years, and does not necessarily reflect the program as currently implemented, or measures currently deployed by the program.

This and all PSE evaluations are posted to Conduit Northwest. To view an electronic copy and to leave comments, visit **https://conduitnw.org/Pages/Welcome.aspx**

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

NAVIGANT

COMMERCIAL ENERGY EFFICIENCY PROGRAM EVALUATION

Data Centers Program

Final Report

Prepared for:
Puget Sound Energy

PUGET SOUND ENERGY

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Executive Summary

This report describes the process and impact evaluation activities related to Puget Sound Energy's (PSE) Data Centers program for 2012-2013. Evaluation findings serve to inform Program managers of the performance of the program while also complying with the Washington Utilities and Transportation Commission (WUTC) filing requirements.

Process Evaluation

Key Process Evaluation Findings and Recommendations

Navigant has identified four program recommendations from this research with special relevance to PSE's data centers program as it transitions its management structure.

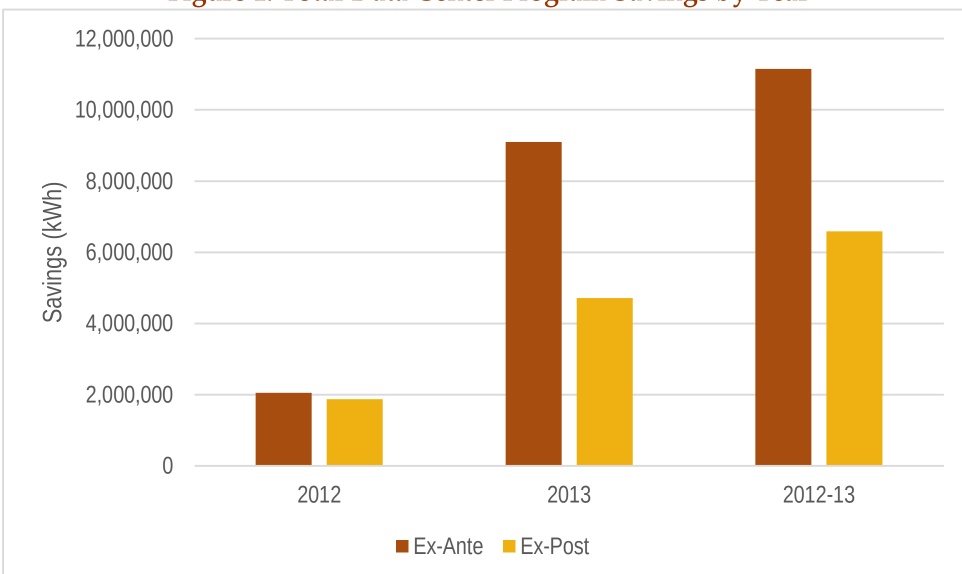
1. Navigant's findings from trade ally interviews supports PSE's decision to discontinue third party implementation of data center incentives, or establish boilerplate non-compete clause and nondisclosure agreements within its contracts to prevent conflicts of interest between the implementation contractor and program trade allies.
2. The concentration of savings opportunities in relatively few sites, and the rapidly evolving technologies that drive energy efficient design in data centers, will complicate PSE's ability to realize cost-effective savings as program management is absorbed into other programs. Navigant's findings support PSE's decision to discontinue a stand-alone data center program, the majority of savings opportunities will not be realized through conventional lighting and HVAC incentives. Energy incentives for UPS configurations, IT technologies and specialized HVAC systems could be structured algorithmically wherever engineering principles can be applied to establish robust estimates of energy savings. A salient example in this research pertains to high load-factor UPS configurations. Incentive structures for other technologies could be informed by ENERGY STAR certifications without the overhead of a standalone program. It is therefore worthy of consideration for PSE to absorb incentive management of data-center specific technologies into the custom incentive program.
3. PSE has an opportunity to improve customer and trade ally satisfaction, as well as reduce program costs, by offering online rebate calculators that improve the transparency of savings estimates for contractors as well as the end user. Improvements to PSE's website pertaining to specific data center energy efficiency opportunities could also increase program uptake.
4. Engineering firms represent the most direct and least utilized information channel in the data center services market. Partnerships with engineering firms in PSE's service territory could help ensure universal awareness of savings opportunities for data center retrofits, replacements and smaller projects.
5. Smaller data centers cannot generally raise enough capital for major capital improvements to otherwise operational facilities. Considering the relatively high costs and often rapid payback period, for data center upgrades, PSE might consider larger incentives and/or financing options for data center specific measures.

Impact Evaluation

Key Impact Evaluation Findings

Figure 1 shows the total Data Center *ex-post* gross program savings and realization rates for program years 2012, 2013, and 2012-2013 combined.

Figure 1. Total Data Center Program Savings by Year



Source: Navigant analysis of M&V data

Overall realization rates varied due to the impact of the largest projects. In particular, the largest project—which made up almost half of savings—had a realization rate of only 37%. If this project is excluded from realization rate calculations the overall realization rate increases from 59% to 81%.

The main drivers of realization rate differences are (a) the data and assumptions relied upon to calculate baseline and efficient usage, and (b) changes in operations affecting the new equipment. While the former can be improved with better verification after installation, the latter is not something that the program can necessarily anticipate. Additionally, one site showed inconsistencies between the ex-ante savings between the project files and the program database

There were nine Data Center program participants over the two year period being evaluated. Meeting PSE's desired confidence and precision target of 90/10 therefore required the evaluation to rely on the full census of program participants.

Key Impact Evaluation Recommendations

Based on the study of the PSE C&I Program impacts, and lessons learned in the evaluation process, Navigant's recommendations are presented in Figure 2:

Figure 2. Recommendations from Impact Evaluation

Program Data Requirements

- Require contractors to submit all calculation files and location data for installed equipment.

Program Data Tracking

- Confirm that database and project files contain the same ex-ante savings values.
- Keep electronic copies of all calculation spreadsheets in their native format (Excel, not PDF).

Savings Calcs & Documentation

- Confirm baseline conditions for ex-ante calcuations.
- Include post-installation verification data in ex-ante calculations.
- Apply extra scrutiny to very large projects.

1 Introduction

1.1 *Scope of the Evaluation*

PSE offers an array of energy efficiency (EE) services to its electric and natural gas customers in all market segments. The Company is committed to ensuring that all customers have access to these services by offering a mix of programs that address all major end uses. This report summarizes Navigant's evaluation of the Data Center Energy Efficiency Program for 2012 and 2013. This program is a part of the Commercial/Industrial Retrofit program, schedule E250.

The goal of this program is to encourage PSE C&I customers to use electricity more efficiently by installing cost-effective Energy-Efficient (EE) equipment, using energy-efficient operations at their facilities and adopting energy-efficient designs. Incentives are available for various custom upgrades, including lighting, server virtualization, hot/cold aisle isolation, airflow upgrades, cooling system upgrades and uninterruptable power supplies (UPSes).

Navigant assessed the program energy savings impacts and implementation processes during the 2012-2013 tariff years. Table 1 below shows the ex-ante performance of this program during 2012 and 2013.

Table 1. Summary of PSE's C&I Data Center Retrofit Programs Performance, 2012-2013[1]

Program Year	# of Projects	Total Grants ($)	*Ex-Ante* Savings (kWh)
2012	2	$533,479	2,052,723
2013	7	$1,088,202	9,098,080
Total	9	$1,621,681	11,150,803

Source: Navigant analysis of PSE tracking database.

Navigant's process evaluation began with the development of program logic models with program administrators for PSE's data center program. The results of this exercise informed Navigant's emphasis in trade ally interviews and best practice research. The findings were synthesized to offer actionable insights that might help PSE sustain the most cost effective savings opportunities as management of data center incentives is absorbed into other programs.

1.2 *Organization of This Report*

This report is divided into four sections:

- **Executive Summary:** Top line findings and key recommendations
- **Section 1: Introduction** (this section) frames the research undertaken by outlining the scope of the evaluation activities

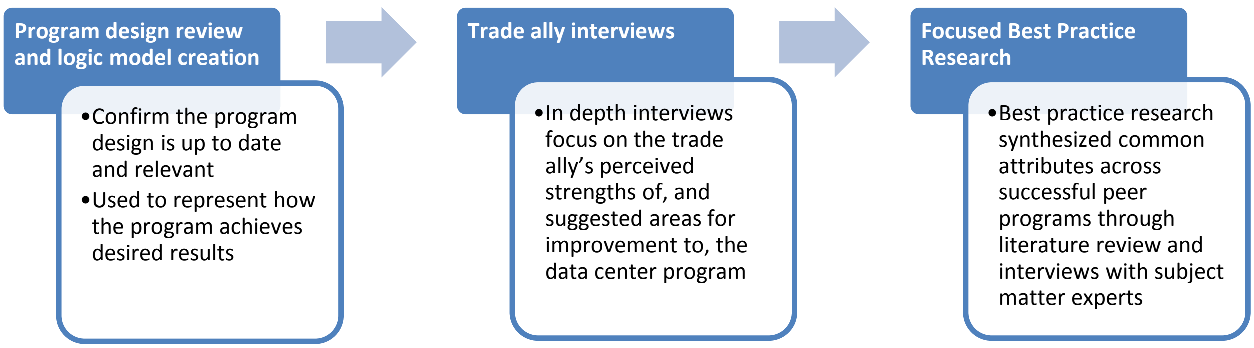
[1] Data provided by PSE in an Excel file: Clean commCSY.xlsx

- **Section 2: Process** evaluation covers the following activities: site contact interviews and logic model creation, trade ally interviews and best practices research. Methodologies and findings of the process activities are presented within each section.
- **Section 3: Impact** evaluation begins with a discussion of the methodology employed in the review of the tracking data and project files, then continues with a description of the sample design and finally presents the on-site measurement and verification data collection and analysis approach. Next the impact evaluation findings are presented at the annual, and project levels. This is followed by a discussion of the drivers of the realization rates, and the statistical validity of the findings. The section concludes with recommendations for PSE based on the impact evaluation findings.

2 Process Evaluation

This section discusses Navigant's process evaluation methodology, findings and recommendations regarding the effectiveness of PSE's data center program delivery. Process evaluation activities consisted of logic model creation, trade ally interviews and best practice research as shown in Figure 3 below.

Figure 3. Process Evaluation Activities



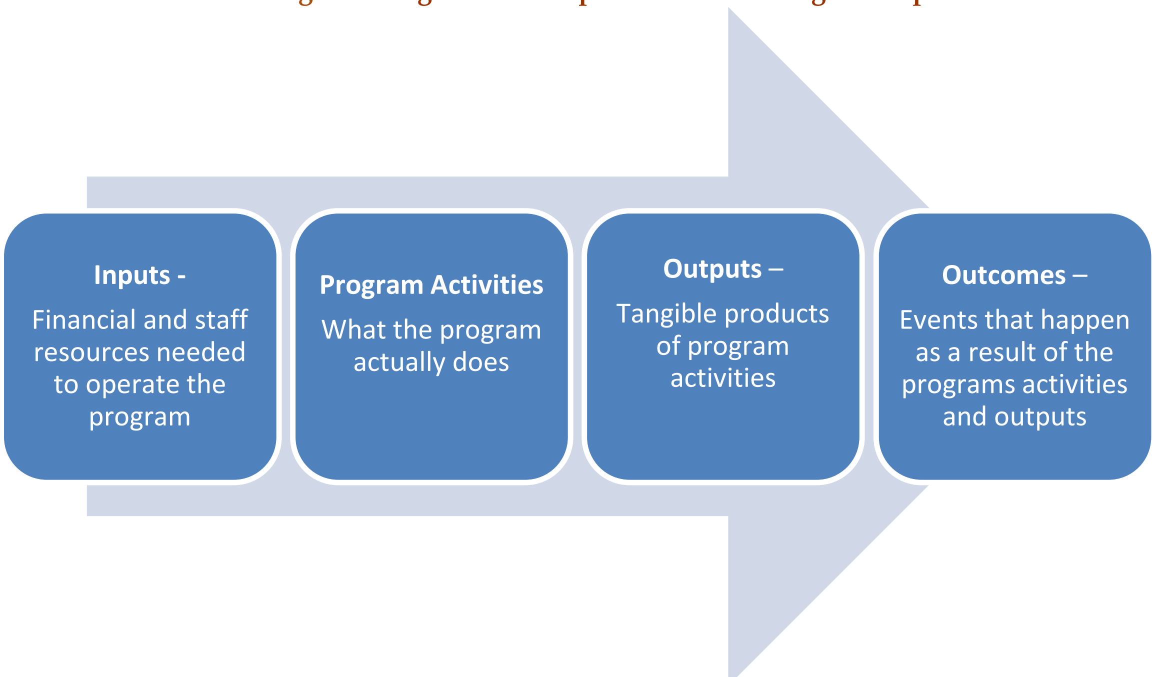
The following sections present findings from the process evaluation activities.

2.1 *Program Management In-Depth Interviews, Document Review and Logic Model Creation*

Logic models are a specialized application of flow diagrams that map causal links from program activities to desired outcomes. The intention is not to illustrate a chronology of events as one might expect in a process flow diagram, but to disaggregate program components to scrutinize their efficacy individually.

The nodes in a logic model represent events and arrows point from cause to effect. Nodes are typically arranged in four rows: *activities*, *outputs*, *short-term outcomes* and *long-term outcomes*, from top to bottom, with the causal logic flowing downward. In this framework, an *activity* is any program component requiring allocation of the agent's (PSE's) resources. An *output* is a measurable consequence of an activity, and an *outcome* is a realized program goal. In general, a node describes an *output* if it could be written into an enforceable contract; otherwise, it describes an *outcome.* A high level summary of the program aspects represented in logic model development are shown in Figure 4.

Figure 4. Logic Model Representation of Program Aspects



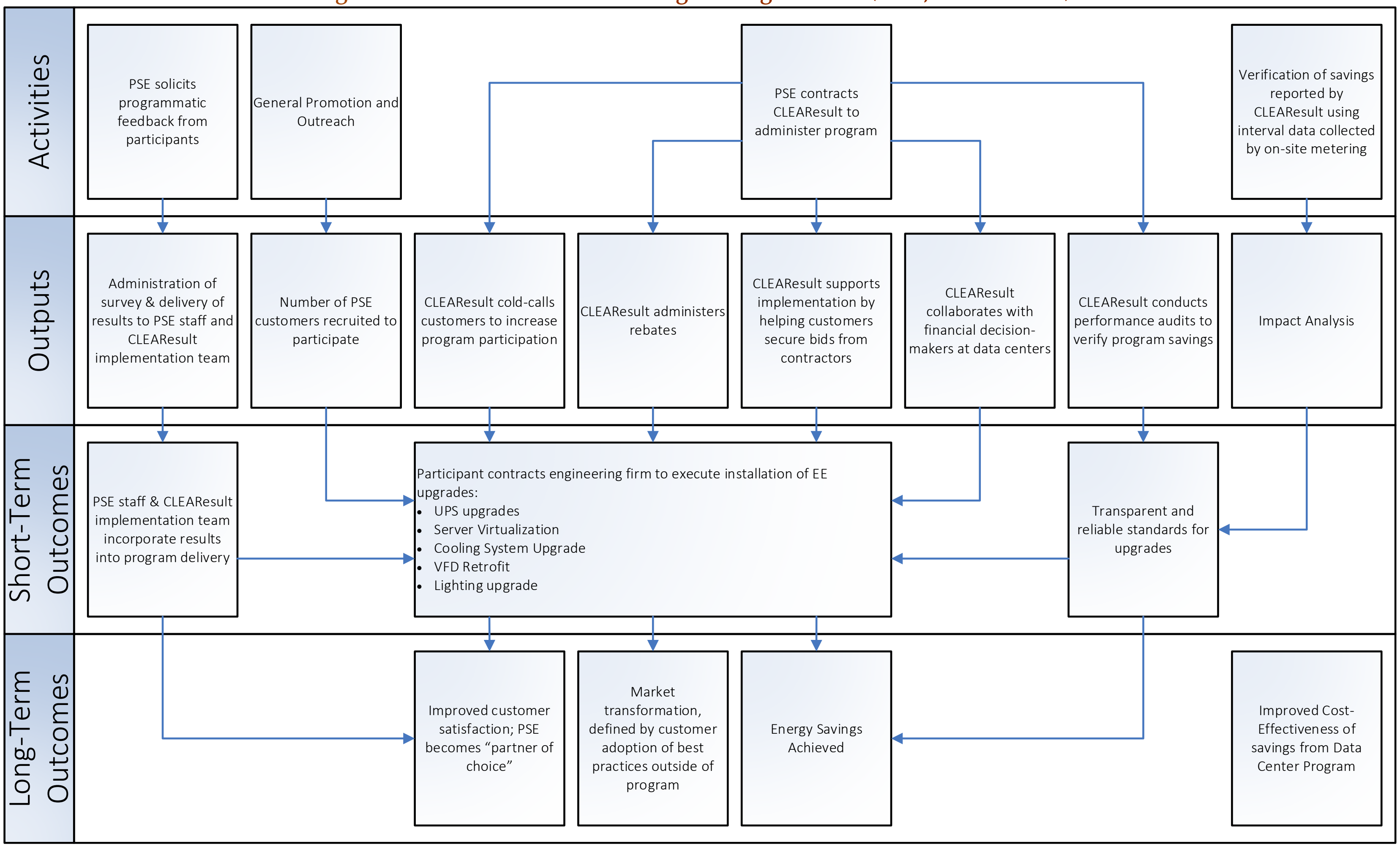
Navigant prepared a logic model to identify cost-effective interventions, the changes PSE should expect in targeted populations as a consequence, and the actors contributing to the desired outcome. Program documentation, marketing materials and application forms were reviewed to create the logic model. The draft was then reworked with program managers in a day-long meeting at PSE's Bothell facility to ensure it described the program structure faithfully.

Logic models are useful both for the evaluator to understand a program holistically; and also for program administrators to scrutinize the contributions of individual priorities within a complex program. The collaborative development of the Data Center Program logic model established three targets for qualitative research:

1. The association customers make between PSE and program incentives, as rebates are issued by a third-party implementer.
2. Missing coordination with engineering firms to prevent long-term investments in undesirable technologies.
3. Improvements in cost efficacy, a targeted long term outcome, are not connected to any activity, suggesting that changes in program priorities may be necessary to realize all of PSE's desired outcomes.

Figure 5 depicts the logic model developed in collaboration with PSE.

Figure 5. Data Center Incentive Program Logic Model (E250, C&I Retrofit)



2.2 *Trade Ally In-depth Interviews*

The following subsections summarize findings from our in-depth interviews with program participating trade allies.

Methodology

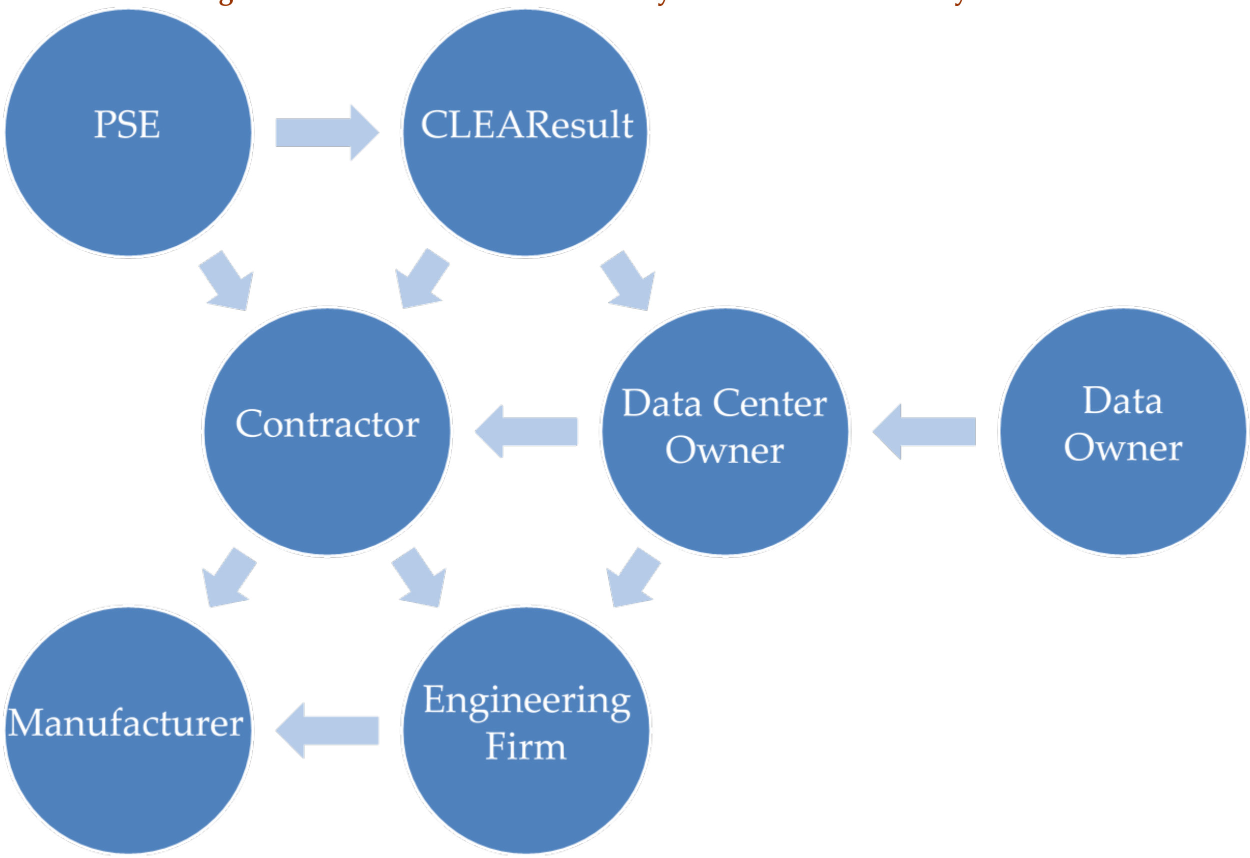
PSE provided Navigant with a list of five trade allies participating in the Data Center Program, but it was later determined that one had no experience with data centers in PSE's service territory. Following the interview guide approved by PSE program administrators, Navigant interviewed the remaining four trade allies and documented program experience and opportunities for improvement. Each was guaranteed anonymity to ensure candid and accurate responses. Verbatim quotes have been provided in the following sections to exemplify themes found through the interview process. These passages represent prevailing views among interview respondents only; it may not be accurate to draw population-wide conclusions considering the small sample size.

Industry Structure

Data center energy efficiency programs present a unique suite of challenges to program administrators. The savings potential is substantial, but opportunities for implementation are concentrated within relatively few sites. Additionally, the market changes driving energy efficiency opportunities are highly technical, and data center service providers are a specialized group who enjoy relatively little competition. Consequently, the most qualified subject matter expert for a given efficiency measure is not always easy to locate. For example, one trade ally pointed out that the manufacturer is typically the most knowledgeable authority on mainframe refresh options, but depending on the source of advancement in efficiency, the engineering firms might be more knowledgeable regarding efficiency opportunities.

Subject matter experts in the data center services industry are uncommon because the contract volume is relatively small. By contrast, the HVAC and lighting service industries support a competitive market of contractors and manufacturers. Where it might be shrewd for PSE to staff HVAC and lighting programs with subject matter experts, an analogous commitment in overhead would be more difficult to justify for a data center program. Figure 6 illustrates the structure of the data center services industry, with arrows denoting the flow of payments among parties.

Figure 6. Data Center Services Industry Structure and Monetary Flows



Three consequences arise from this sparse industrial structure:

1. **Structural communication barriers**. Figure 6 illustrates that the owner of *data* is not necessarily the owner of a data *center*. Information intensive businesses are in fact outsourcing data management increasingly as Cloud services grow in popularity. For example, Boeing is in the process of decommissioning its data centers and contracting the service to the Amazon Cloud. Of course, data stored in the Cloud is housed physically in a data center someplace; this market trend is reflective of the security and hardware scale economies.

   It is the prerogative of the data center owner to make hardware efficiency upgrades, but in many cases, they will be reluctant to interrupt service to their clients—the owners of the data, who could easily switch to a competing Cloud service—or even communicate with them about potential cost reductions from energy efficiency improvements. This barrier reflects a principal-agent problem: the hardware owner passes all operating costs on to the data owner, insulating themselves from the financial returns of efficiency improvements. The data owner, on the other hand, will more readily pay the marginally higher cost of inefficient equipment than the perceived risk of interruptions in data security. One trade ally explained that it can be prohibitively difficult assuaging the anxieties of a potential customer, and that some of the most valuable upgrade opportunities die for the simple lack of interest by end users to get over the learning curve about energy efficient efficiency measures.

2. **Potential conflict of interest by implementer**. The relatively small volume of data center upgrades and sparse structure of the service industry do not support a culture of informed end users. A data center owner typically relies on the service provider for the information they need to make the decision about contracting that same service provider. Data center contractors offer *credence services*— i.e. their customers cannot independently verify the value of an upgrade. Credence services are common in technical markets (a familiar example is automobile repair) and they can present a conflict of interest when service providers overstate their value to maintain business volumes. Navigant has determined in the course of these interviews such a problem is unlikely in PSE's service territory, as contractors enjoy an abundance of business opportunities.

   Credence service providers will also keep their estimates honest when their business model relies on a sound reputation. A contractor will be disinclined to overstate the savings potential of an energy efficiency upgrade if they believe it might compromise their credibility with consumers. In most markets, a service provider's reputation for honesty would be established by familiar means, such as consumer reports or word-of-mouth. But there are no institutionally kept reputations among data service providers, due to the relatively low volume of contracts and rapid changes in technology. As one trade ally put it, *"it's not like Yelp has a category for data center energy efficiency upgrades."*

   PSE's role in the marketplace for data center efficiency upgrades has established an incentive for contractors to maintain credibility. One contractor commented that her company invests substantial resources to develop accurate and conservative-leaning savings estimates of energy efficiency upgrades to ensure a continued relationship of trust with PSE.

   However, the introduction of a third-party implementer might have introduced a conflict of interest to the data center services market. CLEAResult's position in rebate administration has obliged at least one trade ally to disclose proprietary methodologies to estimate savings. Such methods are valuable intellectual property, and the trade ally worries that the arrangement has put her company at a competitive disadvantage.

3. **Timing & Information Channels**. Information technology upgrades yield the lion's share of savings in data centers. Server virtualization upgrades account for 31% of the savings opportunities and mainframe refresh upgrades account for 18%. Neither can be implemented without interruption of data services, so the success of an incentive program depends greatly on the timing of end-user engagement.

   Furthermore, data center owners might not be aware of rebate opportunities when they invest in system upgrades because they are not generally in contact with PSE program administrators— most of their information comes from engineering firms, which are not typically partnered with the utility or implementer. One trade ally remarked that the information on PSE's website was too cryptic to motivate data center owners, so even the ones taking initiative to educate themselves about rebates might begin a project without knowledge of incentives. Once an upgrade is in motion, it might be fifteen years before a data center owner considers upgrades again.

Figure 7 summarizes verbatim quotes from trade allies pertaining to industrial structure.

Figure 7. Trade Ally Quotations; Industry Structure

Structural Communication Barriers	Potential Conflict of Interest on part of Implementer	Timing & Information Channels
"The data-center owner doesn't necessarily own the data…their priority is not to bother their customers, so I have no way of reaching the real decision maker. Sometimes I lose traction and give up on the sale."	"I have some concerns about how a third party entity could actually implement this…CLEAResult has their own objectives, and we've had to expend additional time and effort to explain how these calculations work to them. It's a little awkward because we're giving them proprietary information, and they're a competitor. We don't know if they're using it to profit nationally and when they compete with us locally it's a real problem."	"There's really no information [on PSE's website] about incentives. They should go directly to known datacenters and make sure they're aware of the savings opportunities."
"One of our services is to estimate energy efficiency savings, and they are very reputable with PSE."		"Not a lot of thought goes into [energy efficiency] once the datacenter is up and running."
"Customers don't focus on their mechanical systems—their knowledge is all about the data. Part of our service is to educate the clients on this stuff."		"Customers generally learn about the program before they contact us, probably from an engineering firm...we don't offer any leads; I wouldn't know who to connect them with."

Typical Technologies

Trade allies report that the most common savings opportunities are upgrades to climate management systems. While some measures might be familiar to HVAC program administrators, their application to data centers requires specialized consideration. One trade ally offered the example that data centers HVAC systems rely heavily on recirculation to control dust and moisture. Other HVAC measures are unique to data centers. In order of frequency heard, these include:

1. **Hot aisle/cold aisle containment**. Contractors find that energy inefficient layouts are ubiquitous among data centers older than ten years. However, the major layout changes are especially disruptive to business operations, and therefore comprise a small percentage of the total energy savings opportunities.

2. **Variable frequency drives on fans and electrically commutated fan motors**

3. **Improved room temperature controls,** such as *iCOM* control upgrades

4. **CRAC** (Computer room air conditioning with typical refrigerant heat medium) **and CRAH** (computer room air-handling, which use water for a heat medium) **upgrades**. A common modification is to install the system directly adjacent to the hardware with the highest heat-load.

Opportunities to improve the efficiency of information technologies are less common, but offer substantial savings potential. The most common IT upgrades offered by trade allies are:

1. **UPS** (uninterruptable power supply) **upgrades to units with bypass capabilities**. Conventional UPS systems operate like a battery that continuously recharge from the grid. This technology was ubiquitous for many years because it insured load stability even when electric services were disrupted. UPS systems with bypass capabilities improve efficiency by preventing the energy loss associated with battery recharge. The novelty of the technology reflects advancements in the sensitivity of detection systems and their ability to transition seamlessly from grid to battery power.

2. **Energy efficient mainframe refresh technology**

3. **Server virtualization**

4. **PDU** (power distribution unit) **upgrades**. PDUs manage power to the service racks.

Trade allies described their technology selection process as a technical decision to meet the characteristics of the data center, and that the customer generally defers to their expertise. However, wherever multiple technologies are available to meet the needs of the customer, price is nearly always the most important criteria. One trade ally pointed out that for retrofits, the cost of an upgrade is really the only relevant criteria, as customers would be unwilling to peruse the contract in the first place for payback periods longer than two years. Sales training in lifecycle cost analysis could be beneficial to the program.

Figure 8. Trade Ally Quotations; Technologies and Sales Process

Effect of PSE Incentives

"Only 5-10% of our solicitations result in a sale, but all of them that I'm aware follow our suggestion to get the rebate."

"75% of the smaller data centers take our suggestion to make the upgrade, and they always take the rebate."

"Probably about half [of our solicitations result in a contract. The customer doesn't always] have the financial resources to go forward with the project, but if they do, they always take the incentive."

"Without the rebate, we'd never come close to a two-year payback period, which is usually the threshold for customer participation."

Technology

"Some of the newest technologies are indirect air handlers, servers with a lesser heat load, and servers that can operate at higher temperatures."

"The most common [opportunities] are hot aisle / cold aisle optimization, CRAC unit efficiency improvements and lighting control."

"Fans, VFDs and EC fans are growing in popularity…The EC fan is much quieter"

As the industry grows and changes so does the technology. Today, all the upgrades we make are standard in grass-roots data center projects…It's getting harder to find the low-hanging fruit."

Decision Making

"I look at the load size, floor space needs of the units and cost. We only do retrofits, and over the past few years energy efficient UPSs just come standard with the equipment. As these units get more efficient, I lose the opportunity to sell."

"It's driven by the model they have, how heavily loaded the equipment is and the room layout…We make our recommendations, but nine times out of ten, they're just looking at price."

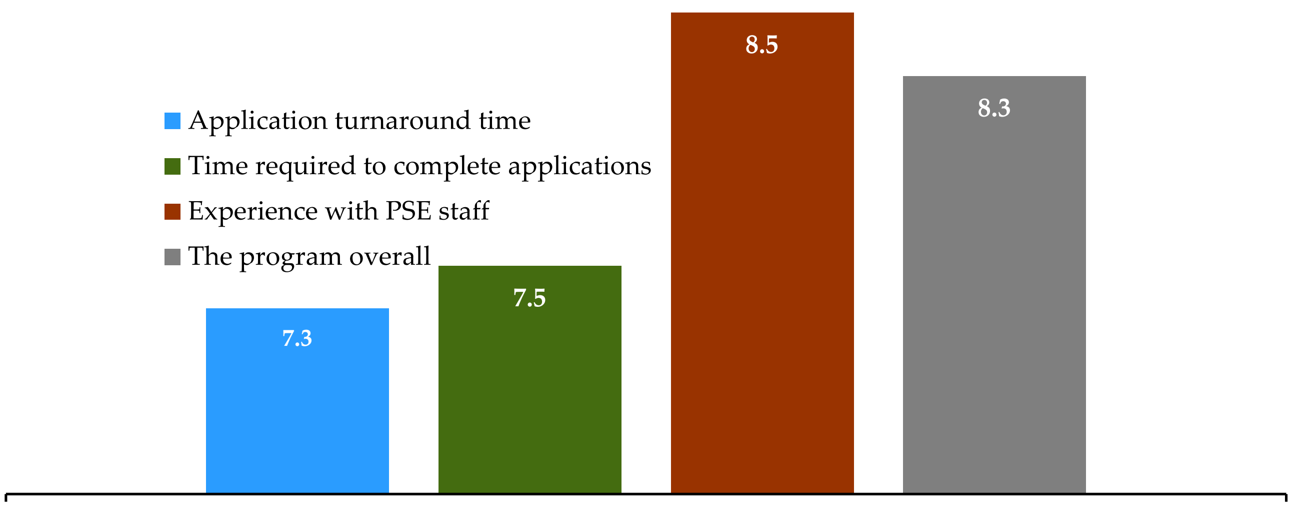
"It depends whether the equipment can be upgraded, and if it makes sense to upgrade it cost-wise."

Trade Ally Program Impressions & Suggestions for Improvement

Every interviewee offered positive feedback regarding working with PSE and the incentive program overall, although trade ally experience with CLEAResult was mixed. Every trade ally confirmed that they would enthusiastically recommend the program to other contractors or manufacturers**.** Figure 9 summarizes average trade ally ratings of different PSE success criteria on a scale from one to ten (one indicating very low satisfaction; ten indicating very high satisfaction):

Figure 9. Trade Ally Program Ratings by Category

Prompt: "I'd like you to rate a few of PSE's success criteria. On a scale from one to ten, with one indicating very dissatisfied and ten indicating very satisfied, how would you rate your program experience in the following categories"



Although it may not be accurate to extrapolate any insight from such a small sample size to the larger population, there were three suggestions for program improvements over the course of Navigant's interviews.

1. **Develop online tools to automate estimation of rebate size.** Many contractors process paperwork after normal business hours, and often times it is inconvenient to wait for program administrators estimate of rebate levels (although the general consensus was that PSE's response time to queries was not excessive).

2. **Contractually avoid conflicts of interest with implementer.** PSE has partnered with CLEAResult in its capacity as a program implementer, but the company also offers engineering services. PSE could help protect the proprietary methods of trade allies if CLEAResult were prohibited from competing within their service territories, and if PSE facilitated non-disclosure and intellectual property agreements between these parties. Such contractual protections would also encourage transparency among contractors.

3. **Alleviate burden on small data center owners.** Half of the trade allies interviewed, while sympathetic for PSE's obligations to gather data for verification, expressed concern that the cost of logging equipment was prohibitively expensive for small data centers. One trade ally invested in logging equipment, which she loans to clients who would otherwise not have pursued energy

upgrades. PSE might also improve participation among small data centers by helping to mitigate front-end costs of upgrades.

Figure 10. Trade Ally Quotations, Program Impressions and Suggestions

Program Impressions	Program Suggestions
"It's a wonderful way for customers to reduce their energy consumption. Some of these projects would never move forward without the incentives…[others] have corporate goals to reduce their carbon footprint, and the rebates help me show them there's value to be had as well.	"Validating the energy savings is a very long process, especially with more complex customers. So it wasn't always easy to figure out what the incentive was initially going to be and prove it to PSE. Even after you get approval from the utility, it's difficult to verify controls results… So much of the savings the customer was expecting gets eaten up during verification."
"I think it's a great program. It makes huge strides in helping customers want to—and be able to—implement energy savings features. Benefit to utility, benefit to customer, benefit to environment. If we didn't have this program, there wouldn't be very many companies shelling out the money."	"CLEAResult and [my company] both perform implementation and engineering tasks, both run the numbers…But CLEAResult gets to assign rebate levels, even for themselves. PSE's implementer should be excluded from competing as a contractor. It's a clear conflict of interest, and it's anticompetitive."
	"PSE should focus more on information technologies, as opposed to the HVAC side. Huge savings can be realized there, a lot of hardware is really old and it takes industry-specific knowledge to see the savings opportunities."
	"PSE could really improve participation with some kind of financing program, or at least paying the rebate up front…a lot of these customers just don't have enough capital sitting around.

Other Considerations

Navigant documented three additional noteworthy findings in the course of trade ally interviews.

1. **PSE visibility relative to CLEAResult.** A subject of special interest developed during the logic modeling exercise was the agent that end users associate with incentives. Three of the trade allies expressed confidence that PSE was more visible to their clients. However, the trade ally with the most direct contact with data centers stressed with certainty that PSE was not visible in the process.

2. **Concern with market saturation.** Multiple trade allies indicated that the most energy efficient technologies are standard in new data centers, and that advancements in energy efficient technologies are reaching a peak. The general consensus among those interviewed is that data center incentives will become ineffectual within a decade.

3. **Partnerships with engineering firms represent a critical information channel.** Three of the four trade allies interviewed by Navigant offered that the most underutilized information channel that

might inform data center owners about incentives are engineering firms. The fourth was the only trade ally not to have any working relationships with utilities (she was in fact confused that PSE knew how to contact her), and the only trade ally representing an engineering firm. The other three agreed that data centers become committed to new upgrades at the moment that they enter a contract with the engineering firm.

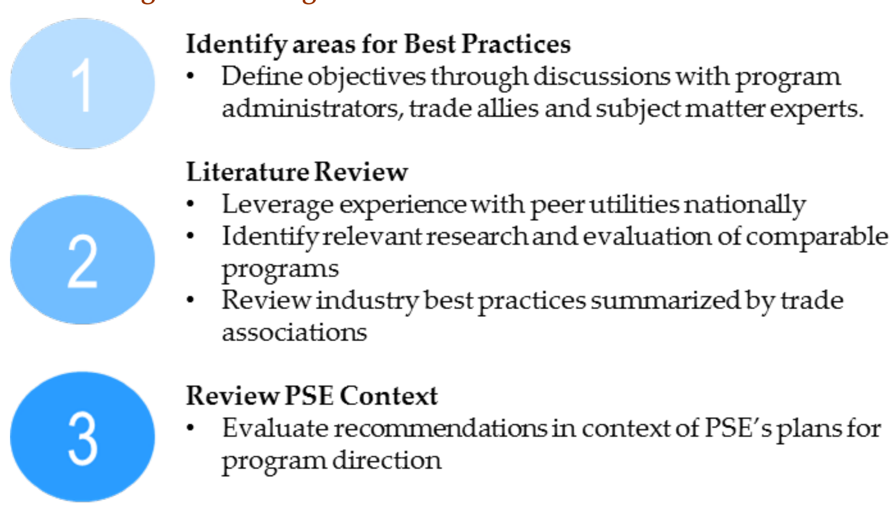
2.3 *Best Practices in Data Centers Energy Efficiency Programs*

Methodology

This section provides an overview of proven implementation strategies among peer utilities with outperforming data center programs. Navigant's research direction was informed by PSE's success criteria as discussed during logic model development, and themes were aligned by area of inquiry. The findings in this section were synthesized from literature reviews and interviews with subject matter experts.

The objective of this research is to offer actionable insights that might inform future iterations of PSE's data center incentives, and to flag savings opportunities that might otherwise be lost as data center incentives are absorbed into the Business Lighting Incentive Program and HVAC Incentive Programs. This summary is not intended to offer a program design template, but to synthesize trends in peer programs that have successfully implemented cost effective measures through data center incentives. Figure 11 summarizes Navigant's approach to this research.

Figure 11. Navigant Process to Focus Best Practice Research



Technology Categories

The most effective data center programs inform their rebate structures with the state of the technologies driving efficiency improvements. The most familiar saving measures—such as lighting fixture upgrades, HVAC system improvements and automated controls—are not the most cost effective ones. Less than 30% of a data center's energy use can be attributed to cooling systems, and the potential to achieve savings through HVAC upgrades is relatively small. And on average, only 2% of a data center's energy consumption is allocated to lighting[2]. EEDSM administrators cannot realize the majority of savings opportunities without some background in technologies unique to data centers. This section provides an overview of the most influential technologies driving data center efficiency, and some implementation approaches preferred by the most cost effective programs.

Information Technology (IT) Systems

The majority of a data center's energy needs are allocated to IT systems, and efficiency upgrades to IT equipment are some of the most cost effective. Sever virtualization technologies consolidate computational power so that inactive servers—which can use 50% or more of the of the power they use at full computational capacity—can be brought offline. A modern, 100 rack installation in California can save between $270,000 and $570,000 per year simply by investing in high efficiency power supplies, such as storage devices and network equipment[3]. AEP Ohio attributes 31% of its data center savings to server refresh technologies.

Program administrators sometimes have difficulty realizing IT savings opportunities because the decision maker that might invest in the most efficient technologies is often insulated from the costs of operation (as discussed in the trade ally interview section, this represents a principal-agent problem). PG&E approaches this disconnect by offering an internal budget incentive equal to 1-3 years energy savings for the purchase of equipment meeting the high efficiency performance level.

Uninterruptable Power Supply (UPS) Systems

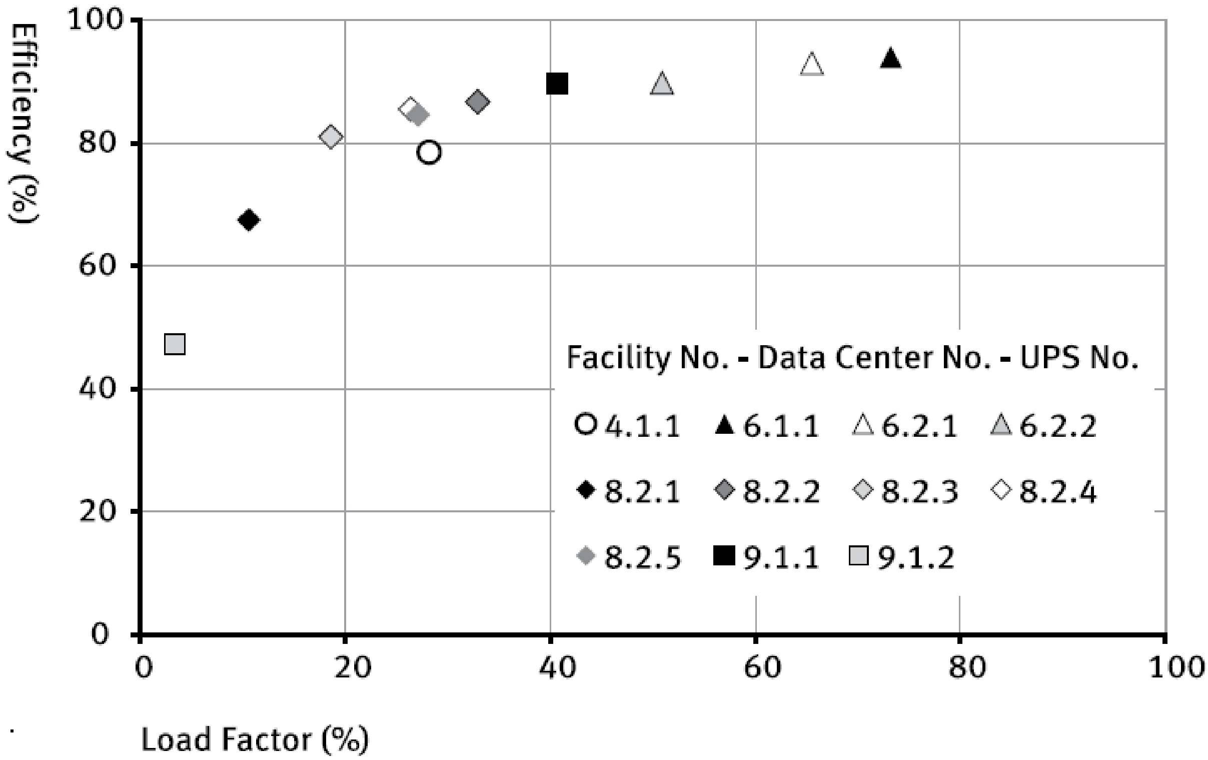
UPS systems guarantee a stable power supply to servers, and they are essential for to protect data and data center operations. UPS systems can back up grid electricity using generators, flywheels or fuel cells, but the most common technology remains lead battery banks[4]. Substantial energy is lost to the inherent inefficiencies of battery systems—PG&E estimates hundreds of megawatt hours are wasted every year in a typical data center UPS system—but waste is minimized for UPS batteries operating at high *load factors*, or the ratio of their actual power output to their maximum power output. Figure 12 plots the relationship between UPS operational load factor and efficiency.

[2] Loper, Joe, and Sara Parr. *Energy Efficiency in Data Centers: A New Policy Frontier. Washington, DC: Alliance to Save Energy.* 2007

[3] *Best Practices Guide for Energy-Efficient Data Center Design, United States Department of Energy, Energy Efficiency & Renewable Energy Information Center.* 2010. http://www1.eere.energy.gov/femp/pdfs/eedatacenterbestpractices.pdf

[4] Data Centers Best Practice Guide. Pacific Gas and Electric Company 2012.

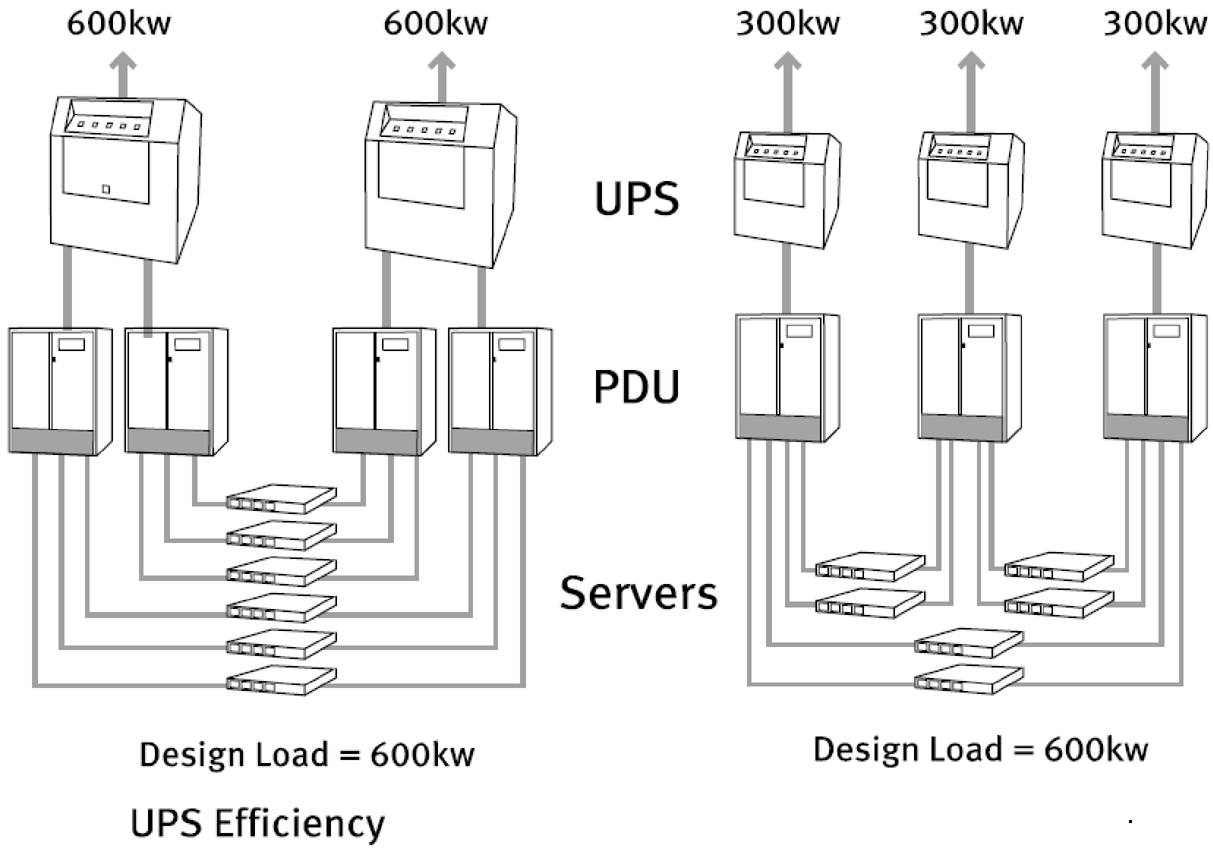
Figure 12. Example of efficiency gain from smaller UPS units running in parallel.



Source: Data Centers Best Practice Guide. Pacific Gas and Electric Company 2012.

Program administrators can incent efficient UPS systems by structuring rebates to encourage high operational load factors. Data centers generally size UPS battery banks to meet the server design load with one of the units out of service. UPS systems that run at higher load factors can be incented, then, with rebates that scale inversely with battery unit capacity. The principle is illustrated in Figure 13.

Figure 13. Example of efficiency gain from smaller UPS units running in parallel.



Source: Data Centers Best Practice Guide. Pacific Gas and Electric Company 2012.

Figure 13 exemplifies how two configurations serving the same the same design load and redundancy requirement can operate with different load factors. If the data center were consuming electricity at half its design load (300 kW), each unit in the left-hand configuration would be operating at a load factor of 25%. The same energy demand would result in a 33% load factor for each of the three batteries on the right-hand side of Figure 13. The increase of the load factor from 25% to 33% corresponds to an efficiency gain of approximately 5%, which would yield an annual savings of $38,000 per year for a typical 15,000 square foot data center in California.

Many of the savings opportunities for UPS systems, however, are driven by the technological state of the art. Some contemporary examples include low-power conditioning advancements, bypass capable systems and diesel generators with flywheel support. Rather than tracking the nuances of UPS research, outperforming data center programs are increasingly relying on ENERGY STAR certification of UPS systems to determine rebate structures.

Air Management Systems

Data center climate control systems are qualitatively unlike conventional HVAC in three respects.

1. Data center cooling loads are independent of ambient air temperatures, and orders of magnitude greater than the needs of spaces designed for occupancy.

2. Data center HVAC systems recirculate more air to protect hardware from dust and moisture.

3. HVAC units can and should be integrated into the overall layout of a data center to target hardware with the greatest cooling needs. Foot traffic is not generally a relevant consideration in data center floor plans.

Up to 30% of a data center's energy needs can be allocated to cooling systems, and the implementation of efficiency measures can reduce cooling costs by 60%[5]. Air economizers are an especially cost effective efficiency upgrade for data center HVAC systems. Air economizers optimize the ratio of recirculated air to outside air using measurements of ambient temperatures and humidity. Air economizers yield substantially better savings when paired with hot aisle/cold aisle configurations.

Outdoor economizing systems can be easily retrofitted to small data centers, but they should be integrated into the architectural planning of large data centers. Air handling systems usually rely on roof intakes or sidewall louvers, which add negligible incremental costs when included in the early design stages. Leading programs achieve cost effective savings simply by maintaining open communication channels with engineering firms in their service territories.

Sales Efforts and Communication Channels

Effective programs coordinate end-user outreach with the sales efforts of service providers to build program awareness before major renovations or upgrades begin. Accurate estimates of rebate levels and payback periods should be especially easy to find for data center owners taking initiative to pursue energy efficiency upgrade opportunities.

Conclusions

Navigant has identified four program recommendations from this research with special relevance to PSE's data center incentives as it transitions its management structure.

1. Navigant's findings from trade ally interviews supports PSE's decision to discontinue third party implementation of data center incentives, or establish boilerplate non-compete clause and nondisclosure agreements within its contracts to prohibit conflicts of interest. However, the concentration of savings opportunities and rapidly changing technology standards would make an in-house program difficult to justify. PSE would forego substantial energy savings opportunities without a mechanisms to incent energy efficient UPS configurations, IT technologies and specialized HVAC systems. It would be advantageous for PSE to automate rebate levels wherever engineering principles can be used to predict accurate savings, as is the case with high load factor UPS configurations. Rebates for energy efficient IT models might be manageable

[5] Lawrence Berkeley National Laboratory. *High Performance Data Centers: A Research Road Map.* 2003

through other existing prescriptive energy efficiency programs when ENERGY STAR certifications are available for relevant equipment. However, the technical nature of data center technologies is strongly suggestive that incentives should be issued through a custom incentive program.

2. It would be beneficial for PSE to automate rebate calculations as much as possible to empower both trade allies and interested end-users to explore savings opportunities instantaneously. Improvements to PSE's website pertaining to specific data center energy efficiency opportunities could increase program uptake.

3. Engineering firms represent the most direct and least utilized information channel in the data center services market. Partnerships with engineering firms in PSE's service territory could help ensure universal awareness of savings opportunities for data center retrofits, replacements and smaller projects.

4. Smaller data centers cannot generally raise enough capital for major capital improvements to otherwise operational facilities. Considering the relatively high costs and often rapid payback period, for data center upgrades, PSE might consider more lucrative incentives and/or financing options.

3 Impact Evaluation

This section presents the methodology, findings and statistical validity of the impact evaluation of PSE's Data Centers Program. Specifically, the impact evaluation aimed to characterize program-specific energy savings impacts for data center retrofit measures by:

- Quantifying the impacts of all projects on annual gross energy consumption
- Establishing post-implementation performance for installed projects
- Defining realization rates between *ex-ante* assumptions and *ex-post* findings
- Explaining discrepancies between the results of this study and the *ex-ante* savings estimates

Results are presented at the program level, as well as at the level of each project.

3.1 Impact Evaluation Methodology

Review of the C&I Program Tracking Database

Navigant completed a thorough review of PSE's Program Databases which store contextual project data along with *ex-ante* project savings estimates. In addition to verifying the consistency and quality of the information within these data files, the data was used to prioritize projects by their *ex-ante* savings in case it was not possible to include all sites in the impact sample. However Navigant included a full census of projects in the final sample.

Navigant reviewed the database of all the projects in the Data Centers program during the 2012-13 program years, and worked closely with PSE to determine which projects to include in the evaluation, resulting in a decision to include a full census of projects in the impact evaluation. Navigant then employed a detailed QC process to screen out projects from other programs, and to ensure that all measures within each project were included. A summary of the Data Center projects by measure category is presented in Table 2**.** The program included a total of 9 projects with the majority of savings coming from HVAC improvements.

Table 2. Data Centers Projects by Measure Category

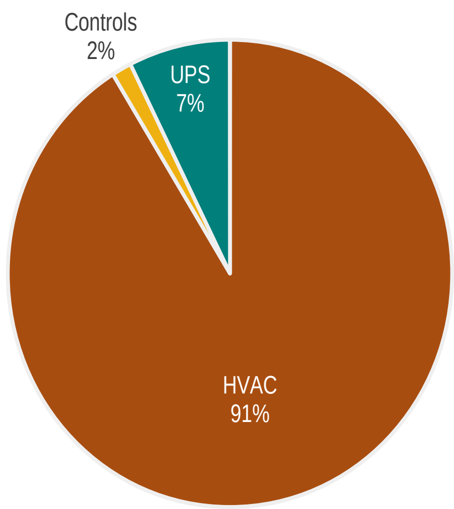
Measure Category	Number of Projects	Ex-Ante kWh Savings	Percent of Program Savings
HVAC	6	10,168,029	91.2%
Low Cost Measures (Controls)	1	160,150	1.4%
UPS	2	822,624	7.4%
Total	9	11,150,803	100%

Source: Navigant analysis of PSE tracking database.

Impact Evaluation Sample

After discussion with PSE, Navigant selected a census of sites for the impact analysis in the Data Centers program. Figure 14 shows the project type breakdown for the program, which is completely included in the sample.

Figure 14. Data Center Program Breakdown by Project Type



As shown in Figure 14 the majority of the savings are from HVAC measures. This is consistent with trade ally reporting that climate management systems are common. The population only contained one small site with hot or cold aisle containment, but also included many projects with changes to controls, fans, and CRACs and CRAHs. The most common HVAC improvement however were various types of free cooling, including economizers and cooling towers.

Sample Design

Due to the small size of the Data Center program, Navigant evaluated a full census of projects from the 2012-13 program years. Table 3 presents the breakdown of the program and sample by program year.

Table 3. On-Site Verification Sample Sizes

Program Year	Population (# of Projects	Total Ex Ante Savings (kWh)	Sample Size	Sample Ex Ante Savings (kWh)
2012	2	2,052,723	2	2,052,723
2013	7	9,098,080	7	9,098,080
Overall	9	11,150,803	9	11,150,803

Source: Navigant analysis of PSE tracking database.

Project File Reviews

Navigant completed a thorough review of the project file for each project selected. For each project file reviewed, Navigant characterized any data gaps, consistency issues, and the accuracy of the information used to estimate project-level savings. For example, checks were made for possible biases in the data, either because some customers were not included or because there was an absence of eligibility data for a particular group of customers.

Navigant compiled a detailed tracking database from the project files for the sampled sites, extracting all relevant data for each project and wrote a site specific measurement and verification plan (SSMVP) for the evaluation of each project. Navigant completed a detailed QC of the project file savings, identifying and fixing any errors in the data entry, and making notes of any line items for which the savings were calculated incorrectly. Comments on this process were included in the SSMVPs which also include site findings and results and are provided in a confidential appendix.

Finally, Navigant cross-checked the total savings calculated from the line-item data with the totals tracked in the project files and the tracking database and found differences for one of the sampled projects. This is discussed further in the results section of this report.

On-Site Measurement & Verification Analysis

Navigant collected on-site measurement and verification data from all sites selected in the sample, employing the IPMVP Protocols to guide the on-site data collection and evaluation strategies used. Table 4 provides an overview of these IPMVP Options:

Table 4. Overview of M&V Options

IPMVP M&V Option	Measure Performance Characteristics	Data Requirements
Option A: Engineering calculations using spot or short-term measurements, and/or historical data	Constant performance	• Verified installation • Nameplate or stipulated performance parameters • Spot measurements • Run-time hour measurements
Option B: Engineering calculations using metered data	Constant or variable performance	• Verified installation • Nameplate or stipulated performance parameters • End-use metered data
Option C: Analysis of utility meter (or sub-meter) data using techniques from simple comparison to multivariate regression analysis	Variable performance	• Verified installation • Utility metered or end-use metered data • Engineering estimate of savings input to SAE model
Option D: Calibrated energy simulation/modeling; calibrated with hourly or monthly utility billing data and/or end-use metering	Variable performance	• Verified installation • Spot measurements, run-time hour monitoring, and/or end-use metering to prepare inputs to models • Utility billing records, end-use metering, or other indices to calibrate models

Due to the variety of projects and available data within the sample Navigant used IPMVP Options A, B, and C to evaluate the projects included in this evaluation. Individual analyses are described in the site reports in confidential Appendix A.

The on-site data collection effort focused on the following key elements:

- Verification of equipment installation and operation
- Confirmation of the equipment type and details of installed equipment
- Confirmation of the presence and type of equipment controls
- Run-time data logging or trend data acquisition of equipment or a sample of equipment
- Confirmation of baseline conditions (as possible)
- Interview with building operators about equipment operation and schedule, although data centers are expected to operate continuously
- Confirmation of utility meter numbers if Navigant considered using IPMVP Option C for analysis

Verification Data Analysis

During the site visits Navigant verified operation and installation of the equipment and discussed baseline and current operations with facility staff. At each site Navigant obtained data showing its operation, either by installing data loggers or by obtaining trend or billing data showing operation at the site. At sites where it affected the installed measure, Navigant also obtained IT load data in order to normalize process related savings to load levels. For HVAC measures Navigant obtained weather data to normalize operation to weather in a typical meteorological year (TMY) using the most recent version of these data, known as TMY3.

Navigant then analyzed the data from the run-time data loggers and trend data to determine savings for each site. Since projects varied greatly in type and analysis methodology this is discussed separately for each site in the SSMVPs in confidential Appendix A.

Once the data was analyzed for each site Navigant applied a quality control process and checked the calculations and results. These results are shown in Section 3.2 as well as in detail in the SSMVPs in confidential Appendix A.

Realization Rate Calculations

Navigant calculated a project realization rate for each project, by taking the ratio of verified savings to the claimed savings from the project file, for all measures:

$$\begin{matrix} Project \\ Realization\ Rate \end{matrix} = \frac{Verified\ Ex\ Post\ Energy\ Savings}{Project\ File\ Ex\ Ante\ Energy\ Savings}$$

The program-level realization rate was calculated by taking the ratio of the total verified savings to the total tracking database savings, for all sites in the evaluation:

$$\begin{matrix} Program \\ Realization\ Rate \end{matrix} = \frac{\sum_{i=1}^{n} Project\ Verified\ Ex\ Post\ Energy\ Savings_i}{\sum_{i=1}^{n} Tracking\ Database\ Ex\ Ante\ Energy\ Savings_i}$$

3.2 *Impact Evaluation Findings*

Program-Level Savings

Table 5 shows the total *ex-post* gross program savings and realization rates for program years 2012-2013 for the Data Center Program.

Table 5. Total Program Savings by Program Year

Program Year	*Ex-Ante* Savings (kWh)	Realization Rate	*Ex-Post* Savings (kWh)
2012	2,052,723	91%	1,875,923
2013	9,098,080	52%	9,098,080
2012-13	11,150,803	59%	11,150,803

Source: Navigant analysis of M&V data

Overall realization rates were low, but this is in large part driven by a single large project as shown in Table 6. In general there is a large variation in realization rate by project, indicating ex-ante estimates could be improved. The large difference between the 2012 and 2013 results is due to the largest project in the program, which made up more than half of program savings in 2013 and had a 37% realization rate. Additional scrutiny of the ex-ante calculations and assumptions for this project could have reduced the discrepancy between ex-ante and ex-post savings values slightly but much of the difference is due to limited data available at the time of the ex ante calculations.

Verified Savings by Sampled Project

Table 6 shows the verified savings for each of the 9 projects in program years 2012 and 2013:

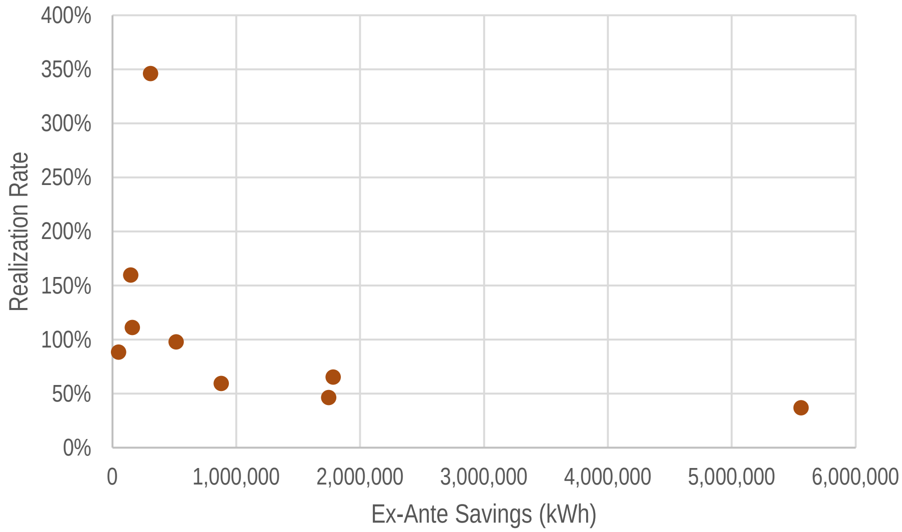
Table 6. Verified Savings by Project

Project Number	Project Type	*Ex-Ante* Savings (kWh)	*Ex-Post* Savings (kWh)	Realization Rate
899004	HVAC retrofit	5,560,415	2,057,301	37%
888563	HVAC retrofit	1,782,024	1,167,307	66%
856355	HVAC retrofit	1,745,511	812,494	47%
913151	HVAC retrofit	879,855	523,584	60%
913153	Efficient UPS	515,412	504,971	98%
825888	Efficient UPS	307,212	1,063,429	346%
913396	HVAC Controls	160,150	178,125	111%
899003	HVAC retrofit	149,110	238,317	160%
885250	HVAC retrofit	51,114	45,211	88%
Total	All	11,150,803	6,590,739	59%

Source: Navigant analysis of M&V data

Without the largest project, which made up almost half of program savings and had only a 37% realization rate, the overall realization rate for the program is 81%. Individual projects showed considerable variability in their realization rates as shown in Figure 15.

Figure 15. Realization Rate by Project Size



The variability in realization rates is due to a combination of factors, including issues with the ex-ante baseline or efficient estimates, discrepancies between the project file and database, and changes in operations at the facilities. These exceptional findings are summarized in Table 7 and details are provided in the confidential Appendix A:

Table 7. Exceptional Findings by Project

Project Number	*Ex-Ante* Baseline Incorrect	Efficient *Ex-Ante* Incorrect	File-Database Discrepancies	Operational Conditions Changed	Finding
899004	X	X			Ex ante fan usage counted only one of four operating fans in efficient case (12% reduction in ex ante savings) and ex ante claim for efficient chiller operation was too low since facility could not increase water temperature.
888563	X	X			Ex-ante used summer baseline and winter efficient case without weather normalization resulting in overestimation of savings.
856355			X		Ex-ante values in database and files do not agree. Values in the files are consistent with ex-post findings.
913151		X			Ex-ante savings based on only three days of efficient data in December which gives very low HVAC use.
825888				X	Under loaded UPS systems increase baseline use significantly since facility has not expanded as originally planned
899003		X			Ex-ante savings only included economization, but should have also included savings from more efficient HVAC units.

Source: Navigant analysis of M&V data

3.3 Factors Influencing Program Realization Rates

As noted in the exceptional findings described above, the main drivers of realization rates variations from unity were differences in ex-ante and ex-post baselines, incorrect estimates of usage after the project, and operational changes at the facilities. Additionally one file contained ex-ante savings values which did not match the program database, so that although the ex-post values were close to those in the project files they varied significantly from database values used to calculate realization rates.

Verified quantities of equipment were relatively consistent with what was reported for most projects, with the a few variations which are discussed in detail in the site write-ups in the confidential Appendix A. However operations varied at a number of sites compared to what was expected based on project file details. These operational differences, consisting of both unexpected changes and some which should have been allowed for in ex-ante calculations, accounted for most of the variations from ex-ante values as summarized in Table 8.

3.4 Validity and Reliability of M&V Findings

Since Navigant evaluated a census of projects for the 2012-13 program years, traditional confidence and precision terminology does not apply (i.e., we are 100% confident that the sample reflects the population, so the error margin is 0%). However this does not account for uncertainties in savings calculations for individual projects, which are not driven by sampling.

For example, the largest project, 899004, has significant uncertainty in its results. The ex-ante savings were determined using IPMVP Option A, which was the only viable method at the time. Navigant reviewed the data and found that analysis using IPMVP Option A resulted in 4.9 million kWh of savings, an 88% realization rate, whereas analysis by IPMVP Option C shows 2 million kWh, a 37% realization rate. Both methods have their weaknesses as discussed here.

IPMVP Option C:
Navigant received daily facility level billing data from the utility. Navigant performed the facility level billing analysis to calculate the ex post savings. There is a small change from the baseline to the efficient case IT load at the facility which is not significant. Navigant found that the drop in the facility usage due to the project was less than half what was expected in the ex-ante calculations. Savings were close to 2 million kWh, regardless of the regression type (linear, polynomial, or averaged values by temperature) and independent variable (average daily temperature or cooling degree hours).
Nevertheless the results from this method have uncertainties for several reasons:

1. Although the datacenter is not believed to have significant additional loads not associated with IT or it’s cooling and lighting it is difficult to verify this going back several years.
2. The portion of the IT load from the DC breakers, unlike the UPS, was not trended prior to around the time of the project and has been estimated for the calculations. While it is a relatively steady load this introduces additional uncertainty into the overall savings.
3. Although the ex-ante savings were around 22% of the bill, the billing analysis showed only 8% of the baseline bill in savings, increasing the uncertainties due to the smaller percent of variation in the bills.
4. Only daily, rather than hourly, billing data were available. This both reduced the number of data points and meant that calculations used average daily temperature, which has larger variations than would be seen with hourly data. Increased usage, primarily in the baseline data, at low outside air temperatures was particularly difficult to characterize with daily data.

IPMVP Option A:
Navigant applied IPMVP Option A using the same data gathered by the implementer at the time of the project because it was not possible to obtain more recent data that would be accurate for the time period of the project. Consequently the primary difference between the ex-ante and ex post savings in this case is the correction for fan load, which was undercounted in the ex-ante calculations.
The results from this method also have uncertainties associated with them:

1. The baseline trend data encompassed a single month in the fall but the efficient case covered only a single week in February, due to the timing of project installation. The short term, winter only data used for the efficient case is likely to underestimate chiller usage in warmer months.
2. Fan loads appear to have changed since the time of the project, although IT loads have remained mostly constant and there are no other changes to account for this. This could indicate variation in fan operation throughout the year but there is not enough data to determine if this is the case.

3. The humidifier annual hours were estimated from the fall-only baseline data and operating specifications because longer term data were not available. However the operation of these units was linked to weather so the annual hours may not be completely accurate.

At the time of the implementation IPMVP Option A was the only viable method to determine savings and post-installation trend data was limited by the project schedule so this was a reasonable methodology. Navigant chose IPMVP Option C because the facility did not provide trend data needed for IPMVP Option B. However billing data should easily show savings on the order of a 20% change (22% from the ex-ante calculations and 19% from Navigant's application of IPMVP Option A) in the bill and the data show that this is not being achieved. However, IPMVP Option C has its own pitfalls and the 8% savings relative to the baseline usage found using it has a sizable uncertainty as well so it is not possible to determine the exact savings for this project from the available data.

3.5 Impact Evaluation Recommendations

Based on the study of the PSE Data Center Program impacts, and lessons learned in the evaluation process, Navigant offers the following recommendations:

Program Data Requirements

» ***Require customers or contractors to submit all calculation files and location data for installed equipment.*** Most of the project files included details of installed equipment and savings calculations, but some were more vague about unit numbers and locations as well as algorithms, providing difficulties in verification.

Program Data Tracking

» ***Confirm that database and project files contain the same ex-ante savings values.*** Although most of the project files examined as part of this evaluation contained consistent savings values with the program database, one contained values that deviated significantly from those reported in the program database, resulting in a low realization rate.

» ***Keep electronic copies of all calculation spreadsheet data.*** Although many of the project files included detailed calculations files, some had only scanned copies of data showing installation locations, calculations, or raw data. This significantly increases the difficulty of verification and evaluation.

Energy Savings Calculations and Documentation

» ***Confirm baseline conditions for ex-ante calculations.*** Some of the variability in the evaluated realization rates could be mitigated by confirming baseline loading and conditions used for ex-ante calculations, particularly loading of fans and HVAC equipment.

» ***Include adequate post-installation verification data in ex-ante calculations.*** Some of the projects used post-installation data in determining the efficient case ex-ante usage, but other projects appeared to have obtained only very limited trend or other operational data post-installation, which limits the ex-ante savings accuracy and precision.

» ***Apply extra scrutiny to very large projects.*** The largest project in 2013 made up over 60% of that year's ex-ante savings but had a only a 37% realization rate. The low realization rate was driven both by unrealistically high savings for fan usage and by increased chiller use due to facility cooling requirements. While the latter might not have been easy to anticipate, review of ex-ante assumptions could have prevented the former overestimate of savings. For projects as large as this Navigant recommends that PSE apply extra scrutiny to savings assumptions and calculations, and possibly delay full incentive payments until longer term data can be collected for measures with weather or production variability, to reduce the discrepancies in ex-ante and ex-post savings values, particularly for the largest projects. The problem with the baseline in the largest project was apparent from reviewing facility bills and comparing them to the baseline load used in the calculations.

PUGET SOUND ENERGY

Evaluation Report Response

PUGET SOUND ENERGY

Evaluation Report Response

Program:	Data Center Energy Efficiency Program
Program Manager:	Julian Rodgers
Study Report Name:	2012-2013 Commercial HVAC Impact and Process Evaluation
Report Date:	March, 2016
Evaluation Analyst:	Michael Noreika
Date of ERR:	May, 2016

Evaluation Overview, Key Findings, Recommendations and Program Responses:

Overview:

This evaluation report documents the results of the impact and process evaluations of the PSE 2012-2013 Commercial Data Center Program. The program is designed to encourage the installation of selected cost-effective energy efficient measures in existing commercial data centers. The program provides financial incentives toward the installation of such measures.

The study's goals were to verify measure installations, quantify program level energy savings, collect feedback from trade allies, and present best practices from similar programs. Navigant developed the following as part of the process and impact evaluations of the 2012-2013 program years:

- Statistically representative savings analysis sample
- Program document and database review
- Logic model development
- Trade ally in-depth interviews

Key Findings:

Impact Evaluation –

- The analysis yielded the following electric gross savings realization rates:

Program Year	Ex Ante Savings (kWh)	Realization Rate	Ex Post Savings (kWh)
2012	2,052,723	91%	1,875,923
2013	9,098,080	52%	4,714,816
Total	11,150,803	59%	6,590,739

Overall realization rates were low, but this is significantly driven by a single large project in 2013. This project represented about 50% of the 2012-2013 ex ante savings, and the evaluation determined a 37% realization rate.

The main drivers of realization rates variations from unity were differences in ex-ante and ex-post baselines, incorrect estimates of usage after the project, and operational changes at the facilities. Additionally one file contained ex-ante savings values which did not match the program database, so that although the ex-post values were close to those in the project files they varied significantly from database values used to calculate realization rates.

Process Evaluation –

Navigant has identified four program recommendations from this research with special relevance to PSE's data centers program as it transitions its management structure.

1. Navigant's findings from trade ally interviews supports PSE's decision to discontinue third party implementation of data center incentives, or establish boilerplate non-compete clause and nondisclosure agreements within its contracts to prevent conflicts of interest between the implementation contractor and program trade allies.

2. The concentration of savings opportunities in relatively few sites, and the rapidly evolving technologies that drive energy efficient design in data centers, will complicate PSE's ability to realize cost-effective savings as program management is absorbed into other programs. Navigant's findings support PSE's decision to discontinue a stand-alone data center program, the majority of savings opportunities will not be realized through conventional lighting and HVAC incentives. Energy incentives for UPS configurations, IT technologies and specialized HVAC systems could be structured algorithmically wherever engineering principles can be applied to establish robust estimates of energy savings. A salient example in this research pertains to high load-factor UPS configurations. Incentive structures for other technologies could be informed by ENERGY STAR certifications without the overhead of a standalone program. It is therefore worthy of consideration for PSE to absorb incentive management of data-center specific technologies into the custom incentive program.

3. PSE has an opportunity to improve customer and trade ally satisfaction, as well as reduce program costs, by offering online rebate calculators that improve the transparency of savings estimates for contractors as well as the end user. Improvements to PSE's website pertaining to specific data center energy efficiency opportunities could also increase program uptake.

4. Engineering firms represent the most direct and least utilized information channel in the data center services market. Partnerships with engineering firms in PSE's service territory could help ensure universal awareness of savings opportunities for data center retrofits, replacements and smaller projects.

5. Smaller data centers cannot generally raise enough capital for major capital improvements to otherwise operational facilities. Considering the relatively high costs and often rapid payback period, for data center upgrades, PSE might consider larger incentives and/or financing options for data center specific measures.

PSE Response to Impact Evaluation Findings:

As noted in the findings of the Impact Evaluation, the overall realization is driven significantly by one very large project of the nine total projects in the program during 2012-2013. Although PSE staff acknowledges that the evaluation report contains a discussion of the validity and reliability of the findings, we would like to respectfully dispute the evaluation results due to the circumstances of that one project.

1. The low realization rate is not indicative of faults or shortcomings of the program delivery. At the time of the ex ante savings determination, PSE staff used an industry accepted methodology[4] to estimate energy savings from the implemented efficiency measures. The evaluation confirmed that the energy saving measures are in place, but the expected savings may be less than previously estimated due to changes in operation and other unforeseen circumstances.

2. During the ex ante savings determination, PSE staff used IPMVP Option A (Retrofit Isolation—Key Parameter Measurement). This method relies on engineering algorithms with inputs of key parameters that influence the energy usage of the equipment within the scope of the project. It was selected as the preferred M&V method because of the possibility of non-data center loads in the building changing during the course of the project. There are separate organizations within the facility that do not necessarily interact with each other but nonetheless share a common meter. Option A ensures that the analysis focuses on the affected systems. During the ex post savings determination, the evaluation consultant used IPMVP Option C (Whole Facility), which relies on an energy usage model calibrated to actual billing history and other independent variables (e.g., outside air temperature). PSE presented the following limitations of Option C during discussions with the evaluation consultant:

    a. The energy usage data from the IT equipment load showed unusual trends compared to outside air temperature. As the equipment is primarily for space cooling, the energy usage increased with warmer outside air temperatures. However, the data showed that the energy usage also increased with colder outside air temperatures. The data required to explain the unusual energy usage pattern, and the contribution of the data center to this energy usage, were not available from the project site.

    b. Between the time of the project completion in 2013 and the evaluation in 2015, staff at the project site changed. The comparability of the data that the original project site staff sent PSE for the ex ante calculations with the ex post data that the new project site staff sent the evaluation consultant was in doubt because of the discrepancy between the calculation results.

    c. The billing history includes a DC load that is managed by a group separate from the staff that manages the equipment that was within the scope of the project. This load was taken into account by both the original PSE analysis and the evaluator's analysis, however the data for the load was significantly different in each case. It was never determined which set of data was the accurate representation of the true DC load.

    As a result of the uncertainty of the energy usage data and unavailability of necessary explanatory data, PSE staff believes that Option C was not the best available method to determine energy savings for the very large project in the evaluation. PSE staff presented an analysis of the ex ante energy savings for the same project using Option A, and the calculated a realization rate of 88%, significantly higher than that calculated using Option C.

[4] PSE used Option A of the International Performance Measurement and Verification Protocol (IPMVP) http://evo-world.org/en/

Impact Evaluation Recommendations and Program Responses

The evaluation was looking back at the program as implemented in 2012 and 2013. Although data center projects are still eligible for incentives under the general Commercial and Industrial Retrofit program, it is important to note that PSE has discontinued the data center specific program in 2016, and will include data centers under the broader program. As the team plans and implements the 2016-2017 Commercial and Industrial Retrofit program we will address the evaluation report's recommendations. This section presents the specific recommendations made in the evaluation report, and program responses.

1. ***Require customers or contractors to submit all calculation files and location data for installed equipment.*** *Most of the project files included details of installed equipment and savings calculations, but some were more vague about unit numbers and locations as well as algorithms, providing difficulties in verification (p. 28).*

Program Response: Documenting all locations of retrofit equipment and lights is difficult for very large projects. PSE will consider ways to improve such documentation with evaluation in mind. Additionally, PSE will consider QR codes that tie to program records, but currently no plans are in place to do so.

2. ***Confirm that database and project files contain the same ex-ante savings values.*** *Although most of the project files examined as part of this evaluation contained consistent savings values with the program database, one contained values that deviated significantly from those reported in the program database, resulting in a low realization rate (p. 28).*

Program Response: Some projects are not required to have a QC review prior to the payment stage, so yes there could be instances of mismatched values. We do not think this is a systemic concern. However, PSE will consider changing the threshold for QC prior to the payment stage.

3. ***Keep electronic copies of all calculation spreadsheet data.*** *Although many of the project files included detailed calculations files, some had only scanned copies of data showing installation locations, calculations, or raw data. This significantly increases the difficulty of verification and evaluation (p. 28).*

Program Response: Beginning in 2015, PSE implemented a system to ensure electronic QC packages (including calculation spreadsheets) are archived appropriately.

Note: Regarding the following recommendations, the intent is to perform M&V activities in line with industry standards (IPMVP protocol) while remaining consistent relative to other PSE programs, mainly the custom grant program. In the future PSE may consider adding an internal review team that can proactively identify any M&V issues.

4. ***Confirm baseline conditions for ex-ante calculations.*** *Some of the variability in the evaluated realization rates could be mitigated by confirming baseline loading and conditions used for ex-ante calculations, particularly loading of fans and HVAC equipment (p. 28).*

Program Response: PSE program staff use the best available data to determine baseline conditions and ex ante savings. In order to ensure transparency of assumptions, PSE project staff will work closely with the quality control staff to ensure that all projects are held to the same standard quality control parameters. There are projects where the baseline shifts during implementation (i.e., IT load changes) and an attempt is made to ensure the ex-ante savings reflect actual conditions.

5. ***Include adequate post-installation verification data in ex-ante calculations.*** *Some of the projects used post-installation data in determining the efficient case ex-ante usage, but other projects appeared to have obtained only very limited trend or other operational data post-installation, which limits the ex-ante savings accuracy and precision (p. 28).*

Program Response: To remain consistent with the custom grant program, M&V efforts are to some extent proportional to the size of the project. As a rough guideline, lighting projects require additional M&V scrutiny if the claimed savings exceed 300,000 kWh. In the case of the data center program, this means that for smaller "steady state" type projects (UPS upgrades, for instance) spot readings of equipment are generally accepted as there is little fluctuation in loading over time. For larger projects or weather dependent measures, more extensive trend data is collected.

6. ***Apply extra scrutiny to very large projects.*** *The largest project in 2013 made up over 60% of that year's ex-ante savings but had a only a 37% realization rate. The low realization rate was driven both by unrealistically high savings for fan usage and by increased chiller use due to facility cooling requirements. While the latter might not have been easy to anticipate, review of ex-ante assumptions could have prevented the former overestimate of savings. For projects as large as this Navigant recommends that PSE apply extra scrutiny to savings assumptions and calculations, and possibly delay full incentive payments until longer term data can be collected for measures with weather or production variability, to reduce the discrepancies in ex-ante and ex-post savings values, particularly for the largest projects. The problem with the baseline in the largest project was apparent from reviewing facility bills and comparing them to the baseline load used in the calculations (p. 29).*

   Program Response: In the case of this project, extra scrutiny was applied and the savings originally claimed were in fact reduced by approximately 20% at PSE's direction. As PSE is contending an actual realization rate of 88%, as opposed to 37%, we would also contend that the scrutiny applied to larger projects was adequate.

Process Evaluation Recommendations

The process evaluation provided key findings and suggestions for program enhancements. However, the process evaluation was intentionally designed without statistical significance, thus the findings are informational, not actionable.