Comparative Analysis of Meter Data-Driven Commercial Whole Building Energy Efficiency Programs
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Executive Summary

To accelerate shared learning and program development, the Consortium for Energy Efficiency (CEE) Commercial Whole Building Performance Committee collected detailed overviews of ten whole building programs and pilots (Program Overviews) that use utility meter data and energy analytics to engage customers or estimate energy savings. These Program Overviews highlight several emerging programs and pilots and present the first comparative analysis of meter data-driven whole building programs. By examining the designs and results of ten programs and pilots side-by-side, we can observe common lessons learned and shared challenges to inform new program development.

Six observations stand out from the analysis of the ten Program Overviews:

1. A cluster of whole building programs and pilots take a very similar approach regarding eligible measure types, use of meter data, incentive design, and other factors. We have termed this program type Building Performance Optimization.
2. Three customer success factors appear consistently across the overviews despite variations in program design and approach to customer engagement. These are consistent building schedules, noncontinuous (less than 24/7) operations, and centralized decision making over energy operations. Building types that often display these characteristics include owner-occupied office space, grocery stores, universities, libraries, municipal buildings, schools, and food service.
3. Given that most of the programs and pilots are new to the market, there is limited data regarding energy savings achieved. Savings expectations in the Program Overviews range from five to 20 percent of whole building energy consumption, with a cluster at 15 percent. Based on the more established programs in the group, these expectations may be high, though there are cases of customers achieving savings greater than 20 percent of whole building energy consumption.
4. The two pilots targeting SMBs use meter data to target customers.
5. The overviewed programs consistently used the same statistical criteria for whole building energy savings estimation and established similar thresholds for the associated metrics.
6. Data aggregation and handling was frequently cited as a challenge with meter data, particularly around flow of data from the meter to the efficiency program or EMIS system or provider.
CEE is developing a Commercial and Industrial (C&I) Energy Management framework to harness the capabilities of connected, interoperable devices and energy data to drive holistic energy savings and demand reductions in commercial and industrial facilities. The Program Overviews advance that work by capturing the landscape of meter data-driven whole building programs today and highlighting opportunities where these programs are clustering and the shared challenges they are facing. The CEE Commercial Whole Building Performance and Strategic Energy Management Committees will use the outcomes from this research to inform the development of the framework and the committees’ work and discussion and to advance the market for energy management technologies and services for C&I facilities of all sizes.

Specifically, the Program Overviews point to three priority areas for further potential energy program industry coordination:

**Identify successful energy management offerings for small and medium businesses (SMBs).** The Program Overviews detail two examples of energy management offerings targeting SMBs with no- or low-cost operational measures. This experience may offer significant value for CEE committee work in understanding the opportunity to use low cost energy data gathering, analysis, and controls technologies to bring effective, cost-effective energy management solutions to SMBs.

**Address challenges with meter data aggregation and handling.** The Program Overviews reveal that customer meter data can be challenging for integrated demand side management (IDSM) programs to access and deploy in energy management offerings. Most challenges revolve around data communication, aggregation, and handling rather than the limits of data analytics providers. CEE plans to engage the market players in this area to communicate IDSM programs’ shared challenges and needs.

**Develop norms or best practices for the statistical validity of whole building energy savings estimation.** The Program Overviews capture the statistical metrics and thresholds used by the ten programs and pilots, which may provide the basis for further Committee work to develop consistent norms for criteria for model fit, confidence, and savings uncertainty. For a thorough discussion of these criteria and their role in whole building program measurement and verification, see the CEE Introduction to Uncertainty Analysis (CEE member resource only).

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1 Lawrence Berkeley National Laboratory’s publication “Barriers and Opportunities to Broader Adoption of Integrated Demand Side Management” (February 2018) defines “Integrated demand-side management (IDSM) is a strategic approach to designing and delivering a portfolio of demand side management (DSM) programs to customers. IDSM can be defined as the integrated or coordinated delivery of three or more of energy efficiency (EE), demand response (DR), distributed generation (DG), storage, electric vehicle (EV) technologies, and time-based rate programs to residential and commercial electric utility customers.
1 Introduction

Advancements in technology, such as energy analytics tools, and the proven success of Strategic Energy Management (SEM) programs are enabling a shift in the energy efficiency program landscape from predominantly widget replacement programs to whole facility energy management. A growing number of IDSM program administrators are experimenting with new ways of using meter data to drive deeper, more cost-effective energy savings to a broad group of commercial customers. Many of these new programs and pilots use utility meter data to engage customers and estimate energy savings achieved at the whole building level. Designing and testing new program approaches, which builds individual organizations’ knowledge about successful methods and lessons learned, can be a lengthy process. Sharing challenges, successes, and lessons learned among the program community can accelerate development and replication of effective emerging program types, leading to deeper energy savings across the commercial sector and enabling further program and industry innovation.

To accelerate shared learning and program development, the Consortium for Energy Efficiency (CEE) Commercial Whole Building Performance Committee collected detailed overviews of ten whole building programs and pilots that use utility meter data and energy analytics to engage customers or estimate energy savings. The CEE Commercial Whole Building Program Overviews (Program Overviews) document maps the landscape of whole building programs and provides a resource for program designers interested in learning from the experiences of their peers. Additionally, the CEE Program Overviews support the broader efficiency community in

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2 “Whole building programs” for the purposes of this paper means programs that target energy savings from measures beyond just direct equipment replacement or address the energy consumption of the building as a whole, not through sub metering or individual system approaches.
identifying common challenges where working together would enable binational uptake of meter-driven integrated demand side management programs.

Between June 2017 and July 2018, CEE staff worked with ten CEE member organizations to develop overviews of programs and pilots, including:

- BC Hydro Continuous Optimization Program
- Commonwealth Edison (ComEd) Retrocommissioning Energy Advisor Program
- Duke Energy (Duke) Smart Saver® Performance Incentive Program
- Efficiency Maine Long-Term Care Building Tune-Up Pilot
- Efficiency Vermont PowerSaver Pilot
- Energy Trust of Oregon (Energy Trust) Pay for Performance Pilot
- Pacific Gas & Electric Company (PG&E) Commercial Whole Building Demonstration
- Puget Sound Energy (PSE) Commercial Strategic Energy Management Program
- Seattle City Light (City Light) Whole Building Pay for Performance Program
- Southern California Edison (SCE) Public Sector Performance-based High Opportunity Program

In addition to the program overviews given for each of these organizations, CEE staff looked across the set of overviews to frame the landscape of current meter-data driven programs and identify trends or lessons learned that point to energy program industry needs. Analysis discusses high-level analysis and key takeaways from the ten overviews, while Next Steps builds on this by explaining next steps for collective consideration and action based on the results from this project.

2 Analysis

CEE staff grouped the overviews into four categories based on variables such as eligible measure types, use of meter data, and expectations for participant engagement. The ten overviews are assigned to the following categories:

- **Building Performance Optimization**
  Improve building energy performance through capital, operations and maintenance, and behavior measures, as well as a pay-for-performance incentive approach
  Five overviews are in this category: Duke Energy, Energy Trust of Oregon, Pacific Gas and Electric, Seattle City Light, Southern California Edison

- **Customer Engagement**
  Uses energy information tools to engage customers with energy savings tips; includes operational and behavior change measures
  One overview is in this category: Efficiency Vermont

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Taking these ten overviews together, several observations stand out.

1. A cluster of whole building programs and pilots take a very similar approach regarding eligible measure types, use of meter data, incentive design, and other factors. We have termed this program type Building Performance Optimization.

2. Three customer success factors appear consistently across the overviews despite variations in program design and approach to customer engagement. These are consistent building schedules, non-continuous (less than 24/7) operations, and centralized decision making over energy operations. Building types that often display these characteristics include owner-occupied office space, grocery stores, universities, libraries, municipal buildings, schools, and food service.

3. Given that most of the overviewed programs and pilots are new to the market, there is limited data regarding energy savings achieved. Savings expectations in the Program Overviews ranges from five to 20 percent of whole building energy consumption, with a cluster at 15 percent. Based on the more established programs in the group, these expectations may be high, though there are cases of customers achieving savings greater than 20 percent of whole building energy consumption.

4. The two overviewed pilots targeting SMBs used meter data to target customers.

5. The programs overviewed consistently used the same statistical criteria for whole building energy savings estimation and established similar thresholds for the associated metrics.

6. Data aggregation and handling was frequently cited as a challenge with meter data, particularly around flow of data from the meter to the efficiency program or EMIS system or provider.

The remainder of this section takes a closer look at these six observations.

### 2.1 Pay-for-Performance and Building Performance Optimization

Meter data-driven programs are not new, but program designs that leverage meter data continue to emerge and evolve, including new models taking a broad pay-for-performance approach to
incentive design. The Program Overviews show that pay-for-performance incentive designs are common across different types of whole building programs, including monitoring-based commissioning, SEM, and building performance optimization programs. Table 1 highlights the presence of consistencies in the approaches using a pay-for-performance incentive structure, including similar measure types and meter data use cases.

Table 1. Comparison of Programs Using a Pay-for-Performance Incentive Approach

<table>
<thead>
<tr>
<th>Program category</th>
<th>ComEd</th>
<th>Duke Energy Trust</th>
<th>PG&amp;E</th>
<th>City Light</th>
<th>SCE</th>
<th>PSE SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pay-for-performance (PfP) incentive approach</td>
<td>Vendor PfP</td>
<td>PfP</td>
<td>PfP w/ persistence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Savings measures</td>
<td>Behavior</td>
<td>✓</td>
<td>❌</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Capital</td>
<td>❌</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>O&amp;M</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Minimum engagement</td>
<td>N/S</td>
<td>3-12 months</td>
<td>3 years</td>
<td>2 years</td>
<td>3-5 years</td>
<td>2 years</td>
</tr>
<tr>
<td>Use of raw data</td>
<td>Baseline development</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Savings estimation</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Performance visualization</td>
<td>❌</td>
<td>✓</td>
<td>❌</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Identifying measures</td>
<td>✓</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Customer targeting</td>
<td>✓</td>
<td>❌</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Criteria for savings uncertainty</td>
<td>Confidence R2</td>
<td>Yes</td>
<td>&gt;68%</td>
<td>&gt;80%</td>
<td>&gt;80%</td>
<td>&gt;80%</td>
</tr>
<tr>
<td></td>
<td>FSU</td>
<td>&lt;50%</td>
<td>&lt;50%</td>
<td>&lt;50%</td>
<td>&lt;50%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CV(RMSE)</td>
<td>&lt;20%</td>
<td>&lt;25%</td>
<td>&lt;25%</td>
<td>&lt;20%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Biggest data challenges</td>
<td>Security</td>
<td>Flow, isolating meters</td>
<td>Flow, data cleaning</td>
<td>Flow, rigor, and accuracy</td>
<td>Granularity and integration</td>
<td>Flow, rigor, and accuracy</td>
</tr>
</tbody>
</table>

3 For the purposes of the CEE Program Overviews, pay-for-performance was considered an incentive structure and not used as the key criterion for the categorization. Typically, the programs overviewed that were called “Pay for Performance” were categorized as Building Performance Optimization.
The group of whole building programs categorized in this report as Building Performance Optimization demonstrate further consistencies that may indicate the elements of an emerging, replicable program design. These elements are described below.

**Bundling of energy savings measures** In the past, many energy efficiency programs have kept capital measures separate from behavior or operations and maintenance (O&M) measures. Four of the five Building Performance Optimization (BPO) programs and pilots in 2017-2018 bundle capital, O&M, and behavior savings measures into one offering, however, and the fifth bundles O&M with capital measures. These pilots and programs claim savings from all implemented measures based on savings demonstrated via the meter data. Figure 1 shows the percentage of overviewed pilots and programs that include each type of measure.

**Figure 1. Percentage of Building Performance Optimization Programs Offering Behavior, Operations and Maintenance, and Capital Measures**

Minimum customer engagement of two or more years As seen in Table 1, the minimum customer engagement in the BPO overviews ranges from three months to five years. For one overview, Duke Energy, the engagement period is three months to one year because the program bases engagement on the anticipated measure life. When taking this into account and considering the remaining four overviews, it appears that these Building Performance Optimization programs have consistently identified a minimum customer engagement of at least two to three years as optimal.

**Consistent use of meter data** Using a customer’s utility meter data to support an energy efficiency program is not unique to Building Performance Optimization programs, as the CEE

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4 Lawrence Berkeley National Laboratory’s paper titled “Guide for Determining Energy Savings from Changes in Operations, Behavior, and Maintenance Procedures” (May 2017) defines “operational energy performance improvement actions involved the modification of equipment operating parameters (such as pressure, temperature, flow rate or speed) to reduce energy consumption without negatively affecting the production rate or the quality of service or product. Maintenance-related energy performance improvement actions adopting maintenance procedures or practices for equipment or systems which take energy performance into consideration. Behavioral energy improvement actions involve routine human behavioral adjustments, typically made by building occupants, manufacturing workers or equipment operators.”
Program Overviews demonstrate. Still, Figure 2, below, shows that the five BPO programs use meter data in a generally consistent fashion to develop baselines and estimate energy savings. Only one of them uses meter data for customer targeting, and one other uses meter data for measure identification; the remaining three BPO programs do not use meter data for either purpose. Sixty percent of BPO programs use meter data to provide customers with visualizations of their performance. Continuing to understand the types of data provided to the customers, and an understanding of the success programs are seeing from these reports, could coalesce energy programs and energy data analytics tool providers around a set of the most impactful data and reports customer need to achieve the greatest energy savings.

**Figure 2. Number of Building Performance Optimization Overviews Using Customer Meter Data by Use Case**

<table>
<thead>
<tr>
<th>Use Case</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Development</td>
<td>5</td>
</tr>
<tr>
<td>Saving Estimation</td>
<td>5</td>
</tr>
<tr>
<td>Performance Visualization</td>
<td>3</td>
</tr>
<tr>
<td>Customer Targeting</td>
<td>1</td>
</tr>
<tr>
<td>Measure Identification</td>
<td>1</td>
</tr>
</tbody>
</table>

**Using statistical metrics and similar criteria for savings uncertainty** All of the Building Performance Optimization overviews in this report use statistical metrics to understand and quantify savings uncertainty and model fit. Figure 3, below, highlights not only the consistency in the statistical metrics used, but the fact that many of the programs are also using the same criteria. More detailed descriptions of the statistical criteria discussed below can be found in the CEE Introduction to Uncertainty Analysis for Whole Building Programs\(^5\) or in ASHRAE Guideline 14-2014: Measurement of Energy, Demand, and Water Savings. The four statistical metrics most commonly used in the BPO programs include:

- **Coefficient of variation of the root mean squared error (CV(RMSE)),** a metric for understanding the accuracy of a model.

- **Confidence,** a measure of the reliability of the estimate of energy savings within a given range, typically expressed as a percentage. In terms of estimating energy savings from utility meter data, statistical confidence represents the percentage likelihood that a range of modeled energy savings contains the actual savings achieved.

- **Fractional Savings Uncertainty (FSU),** a measure of the size of the range containing the actual savings achieved, expressed as a percentage of the savings achieved. Savings confidence and FSU are mathematically related and are commonly expressed in the following

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\(^5\) The CEE Introduction to Uncertainty Analysis is a resource for CEE member programs that can be found on the CEE Forum at [http://forum.cee1.org/content/savings-estimation-subcommittee](http://forum.cee1.org/content/savings-estimation-subcommittee).
format (all number values are examples only): “We are 80 percent confident [savings confidence] that the building achieved savings of 100,000 kWh, plus or minus 30 percent [FSU].”

- **R Squared** ($R^2$), a measure of the extent a regression model explains variation between the dependent variables and its mean value.

Figure 3. **Building Performance Optimization Programs using Statistical Metrics by Criteria Requirements**

![Diagram showing statistical criteria thresholds with circles for USE CV(RMSE), USE CONFIDENCE, USE FSU, and USE OTHER METRICS.]

- **4 USE CV(RMSE)**
  - >20%
  - >25%

- **3 USE CONFIDENCE**
  - Other >80%
  - >68%

- **3 USE FSU**
  - <50%

- **2 USE R²**
  - <80%
  - <75%

- **2 USE OTHER METRICS**

Figure 3 shows the number of overviewed Building Performance Optimization programs and pilots using each common statistical metric and, for each metric, the different statistical criteria thresholds required by the programs or pilots using it. For example, four BPO overviews used CV(RMSE), of which three required statistical criteria of >25% and one required >20%.
2.2 Customer Success Factors

While all the overviews vary significantly in terms of their approach to customer engagement and the amount of energy savings achieved or expected, a few customer characteristics have been identified as indicative of success in whole building offerings and achieving energy savings. These are:

- **Consistent building schedules**: regular occupied/unoccupied hours or production shifts. Regular schedules are an enabling condition for cost-effective development of energy baseline models, a key element of many whole building programs. Buildings with consistent schedules offer two opportunities to achieve energy savings: 1) realignment of programming with actual schedules in cases where these are no longer well-matched and 2) establishing new schedules for operation of energy consuming systems that match with building operation needs where none previously existed.

- **Noncontinuous operations**: buildings with regular unoccupied hours or downtime. Noncontinuous operations are associated with greater opportunity for operational and maintenance savings opportunities, an important measure type for many whole building programs in the Overviews. Noncontinuous operations offer opportunities to achieve the energy savings associated with downtimes, for example through scheduling.

- **Centralized decision making over energy operations**: organizations in which a single individual has decision-making power over energy and operations for multiple similar sites can provide a point of leverage for whole building programs seeking scale, as changes can be made and replicated across sites quickly.

Based on the experience of these ten programs, building types with the first two characteristics include owner-occupied office space, grocery stores, universities, libraries, municipal buildings, schools, and food service. Table 2 shows these and other success factors highlighted by the programs and pilots in this report. These factors should not be seen as decisive—some facilities with consistent schedules and centralized decision making for energy may have poor results in whole building programs—nor should the absence of these factors disqualify potential program participants. Rather, they are a set of consistent observations from a small group of recent programs and pilots intended to inform future research and program design considerations.⁶

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### Table 2. Summary of Customer Success Characteristics Findings

<table>
<thead>
<tr>
<th>Program Category</th>
<th>Program Administrator</th>
<th>Characteristics of Customer Success</th>
<th>Less successful</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Performance Optimization</td>
<td>Duke Energy</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pacific Gas and Electric</td>
<td>Energy Trust of Oregon</td>
<td>Commitment to three-year contract; energy savings potential of 5% or more</td>
<td>Complicated/difficult to predict consumption in buildings</td>
</tr>
<tr>
<td>Seattle City Light</td>
<td>Large office buildings and possibly hotels</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Southern California Edison</td>
<td>Buildings 30 years or older, majority of space is conditioned</td>
<td>Master-metered campuses require additional building- or system-level submetering</td>
<td></td>
</tr>
<tr>
<td>Customer Engagement</td>
<td>Efficiency Vermont</td>
<td>SMBs are a complex market due to customer type variation</td>
<td>-</td>
</tr>
<tr>
<td>Monitoring-Based Commissioning</td>
<td>BC Hydro</td>
<td>University buildings</td>
<td>Shopping malls</td>
</tr>
<tr>
<td></td>
<td>Commonwealth Edison</td>
<td>Significant variability in energy needs between on and off hours; organizations with multiple locations, such as retail banks, big-box stores, retail in malls, and fast food locations; single decision-maker; utility account manager</td>
<td>24/7 operations; high process loads; for building types, industrial, three-shift operations</td>
</tr>
<tr>
<td>Efficiency Maine</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Strategic Energy Management</td>
<td>Puget Sound Energy</td>
<td>Executive-management focus on energy; centralized control of schedules—set points; stable occupancy and schedules; for building types, schools, municipal buildings, and owner-occupied buildings</td>
<td>Multiple tenants, high turnover; variable building schedule; high base load or process load; sites with inconsistent consumption, such as fire stations, museums, and athletic fields; for building types, managed office space, hospitals, fire stations, and industrial. Commercial office space is complicated because of non-routine adjustments with space use or occupancy changes.</td>
</tr>
</tbody>
</table>

Please note that details noted with a “-“ symbol indicate that there is insufficient program experience to date to determine any possible factors of success.

The success factors identified by these programs also rest on assumptions about key aspects of whole building energy savings measurement. Consistent building schedules are an indicator that a well-fitting energy baseline model can be developed using regression analysis techniques. Non-continuous operations were also cited partly because they can cause difficulty in model baseline development. If whole building baseline development practices shift away from regression analysis, these factors may be less significant.
In terms of target segments, three or more program administrators with monitoring-based commissioning, building performance optimization, and SEM programs highlighted retail, grocery, education, and municipal buildings as good candidates. These building types typically have the key customer success factors identified above. Additionally, three of the ten whole building programs cite office buildings as a target segment or good candidate, but the Puget Sound Energy SEM program found managed office buildings challenging because of high tenant turnover and non-routine events. More research is needed to understand if this variation is caused by differences in program design—that is, tenant turnover as a more significant issue for long-term, high-investment SEM approaches—or by local market factors or some other contributor.

Figure 4 shows the various participation criteria used by the overviewed programs and pilots, bundled by target segment, size, and other criteria. The figure demonstrates the breadth of participation criteria across the overviews, but also some areas of consistency:

- Four overviews identified size criteria using square footage, of which three used a minimum requirement of ≥50,000 ft².
- Two programs did not have any participation requirements; most of the remaining overviews established a combination of two metrics, usually size, target segment, or other requirements. Only one program used all three categories in their participation requirements.
- Two programs required that customers have a building automation system.
2.3 Energy Savings Achieved

Because most of the programs and pilots collected in this report are new in their markets, little conclusive data is available regarding energy savings achieved. Savings expectations from program designers and managers range from five to 20 percent of whole building energy
consumption, with a cluster at 15 percent whole building energy savings. Based on the more established programs in the group, these expectations may be high, though there are cases of customers achieving savings greater than 20 percent of whole building consumption. Table 3 breaks down energy savings achieved or expected by each program administrator and notes the program type and number of customers served.

Table 3. **Energy Savings and Customer Served of Overiewed Programs and Pilots**

<table>
<thead>
<tr>
<th>Program Type</th>
<th>Program Administrator</th>
<th>Expected Savings</th>
<th>Average Savings Achieved</th>
<th>Number of Customers Served</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Performance Optimization</td>
<td>Duke Energy</td>
<td>10-20% reduction in whole building energy consumption</td>
<td>31 projects</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Energy Trust of Oregon</td>
<td>5% energy savings over baseline</td>
<td>6 customers in Phase 2,</td>
<td>1 customer in Phase 1</td>
</tr>
<tr>
<td></td>
<td>Pacific Gas &amp; Electric Company</td>
<td>15% whole building consumption reduction across a portfolio of participating buildings</td>
<td>12 buildings</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Seattle City Light</td>
<td>15% over baseline in 2018</td>
<td>12-21% over baseline</td>
<td>15-20 buildings</td>
</tr>
<tr>
<td></td>
<td>Southern California Edison</td>
<td>10% reduction in whole building electricity consumption</td>
<td>1 university science building</td>
<td></td>
</tr>
<tr>
<td>Customer Engagement</td>
<td>Efficiency Vermont</td>
<td>20% of idle load</td>
<td>5,000 small and medium business customers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BC Hydro</td>
<td>7.2% of total consumption (electric and gas)</td>
<td>550 buildings, an estimated 30-35% of the addressable market</td>
<td></td>
</tr>
<tr>
<td>Monitoring-Based Commissioning</td>
<td>Commonwealth Edison</td>
<td>2.0 GWh in 2017 (preliminary evaluation estimate)</td>
<td>130 locations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Efficiency Maine</td>
<td>5-10% energy consumption reductions from operational savings</td>
<td>6 long-term care facilities</td>
<td></td>
</tr>
<tr>
<td>Strategic Energy Management</td>
<td>Puget Sound Energy</td>
<td>13% reduction in total energy consumption over 3 years; customers have the option to renew after 3 years, to achieve 15% reduction in years 4-6</td>
<td>14 million kWh and 500,000 therms annually</td>
<td>60 customer portfolios served annually</td>
</tr>
</tbody>
</table>

The two programs in this report with the longest-running programs, BC Hydro and Puget Sound Energy, have achieved robust, cost-effective energy savings over several years and hundreds of customer sites. The Seattle City Light BPO program has also achieved very strong savings results, though over a smaller sample. Together these three programs, each of which use a different
program design (monitoring-based commissioning, SEM, and BPO), demonstrate that meter data-driven whole building programs have the potential to achieve significant energy savings over a large number of customer facilities.

### 2.4 Use of Customer Meter Data

A key criterion for participating in the CEE Program Overviews project was using meter data to either engage customers or estimate savings, so it is unsurprising that all ten of the programs and pilots use meter data for savings estimation and all but one use it for baseline development. Beyond savings estimation and baseline development, the overviewed programs indicated that some are using meter data for performance visualization, measure identification, and customer targeting. Table 4 shows, by program type, how each organization’s program or pilot is using meter data.

#### Table 4. How Customer Meter Data is Used in Overviewed Programs and Pilots by Organization and Program Type

<table>
<thead>
<tr>
<th>Program Type</th>
<th>Program Administrator</th>
<th>Use of Customer Meter Data</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Savings estimation</td>
<td>Baseline development</td>
<td>Performance visualization</td>
<td>Measure identification</td>
</tr>
<tr>
<td>Building Performance Optimization</td>
<td>Duke Energy</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Energy Trust of Oregon</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Pacific Gas &amp; Electric Company</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Seattle City Light</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Southern California Edison</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td>Customer Engagement</td>
<td>Efficiency Vermont</td>
<td>✓</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Monitoring-Based Commissioning</td>
<td>BC Hydro</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Commonwealth Edison</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Efficiency Maine</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>SEM</td>
<td>Puget Sound Energy</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>X</td>
</tr>
</tbody>
</table>

Combining information from Table 3 and Table 4 shows that the two programs that specifically target small and medium business customers—ComEd and Efficiency Vermont—are also the only two using meter data for customer targeting and measure identification. Interval meter data
and analytics technologies may offer new opportunities to cost-effectively serve smaller business customers with energy management solutions. The CEE Commercial Whole Building Performance Committee plans to continue research into meter data-driven programs for small and medium businesses with the goal of identifying or developing program strategies that will enable more program administrators to utilize meter data and analytics to serve this customer segment.

2.5 Statistical Metrics and Criteria for Whole Building M&V

As previously discussed in 2.1 on Building Performance Optimization programs, there is some consistency in the statistical metrics and criteria employed by meter data-driven whole building programs to assess model fit and savings validity. Of the ten programs, seven use statistical metrics for whole building energy savings estimation or model fit. Six of these programs or pilots use one or more of the following metrics: CV(RMSE), FSU, R², or confidence. Figure 5 shows the use of the statistical metrics in the overviews and the threshold each program administrator requires, as well as how the threshold compares to those recommended in ASHRAE Guideline 14-2014.

Figure 5. Overviewed Programs’ and Pilots’ Use of Common Statistical Metrics, as Compared to ASHRAE Guideline 14-2014

**CV (RMSE)**

<table>
<thead>
<tr>
<th>3 Profiles</th>
<th>1 Profile</th>
<th>1 Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;20%</td>
<td>&gt;25%</td>
<td>&lt;35%</td>
</tr>
<tr>
<td>ASHRAE 14-2014</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**FSU**

<table>
<thead>
<tr>
<th>3 Profiles</th>
<th>1 Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;50%</td>
<td></td>
</tr>
<tr>
<td>ASHRAE 14-2014</td>
<td></td>
</tr>
</tbody>
</table>

**R²**

<table>
<thead>
<tr>
<th>2 Profiles</th>
<th>1 Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;70%</td>
<td>&gt;80%</td>
</tr>
<tr>
<td>ASHRAE 14-2014</td>
<td></td>
</tr>
</tbody>
</table>

**CONFIDENCE**

<table>
<thead>
<tr>
<th>1 Profile</th>
<th>3 Profiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;60%</td>
<td>&gt;80%</td>
</tr>
<tr>
<td>ASHRAE 14-2014</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5 plots the overviewed programs’ and pilots’ use of common statistical metrics, showing the number using CV(RMSE), FSU, R², and confidence. The image uses a scale of 0-100 percent to show what statistical threshold criteria are used by these programs and pilots and how these thresholds compare to ASHRAE Guideline 14-2014 recommendations.
As demonstrated in Figure 5, there appears to be growing consensus around the use of statistical methods and metrics, which has the potential to unleash increased program investment in whole building approaches and drive energy management adoption across a wide range of commercial and industrial businesses.

2.6 Challenges with Data Aggregation and Handling

Meter data has opened the door for new energy efficiency program approaches, but these data also present new challenges for program administrators. Eight of the ten program administrators indicated that their biggest data challenge is with data flow—getting data from the utility meter to the program, customer, or third party to support program or pilot participation. Participants highlighted the following challenges related to data flow:

- Aggregating meters and matching meters to customer accounts
- Transferring revenue and customer owned meter data to EMIS vendors
- Automating transfer of utility meter data
- Dealing with utility meter data that is not in a format that whole building energy management platforms or performance visualization tools can use
- Ensuring contractors can collect and provide all the relevant data
- Accessing customer’s energy data through internal processes, as advanced metering infrastructure (AMI) is built for billing, not for energy efficiency programs
- Maintaining a consistent, constant flow of data to customers and vendors

These organizations also cited challenges with data security, including providing customer data to a vendor, isolating meters, rigor and accuracy, granularity (campuses are master metered) and meter integration.

3 Next Steps

CEE is developing a consistent Commercial and Industrial (C&I) Energy Management framework to harness the capabilities of connected, interoperable devices and energy data to drive holistic energy savings and demand reductions in commercial and industrial facilities. The Overviews advance that work by capturing the landscape of meter data-driven whole building programs today, highlighting opportunities where these programs are clustering, and the shared challenges they are facing. The CEE Commercial Whole Building Performance and Strategic Energy Management Committees will use the outcomes from this research to inform the development of the platform and the committees’ work and discussion and to advance the market for energy management technologies and services for large, medium and small C&I facilities.

Specifically, the Program Overviews shed light on three priority areas for CEE Committees:
Identify successful energy management offerings for small and medium businesses (SMBs). The Program Overviews detail two examples of energy management offerings targeting SMBs with no- or low-cost operational measures. This experience may offer significant value for CEE committee work in understanding the opportunity to use low cost energy data gathering, analysis, and controls technologies to bring effective, cost-effective energy management solutions to SMBs.

Address challenges with meter data aggregation and handling. The Program Overviews reveal that customer meter data can be challenging for integrated demand side management (IDSM) programs to access and deploy in energy management offerings. Most challenges revolve around data communication, aggregation, and handling rather than the limits of data analytics providers. CEE plans to engage the market players in this area to communicate IDSM programs’ shared challenges and needs.

Develop norms or best practices for the statistical validity of whole building energy savings estimation. The Program Overviews capture the statistical metrics and thresholds used by the ten overviewed programs and pilots, which may provide the basis for further Committee work to develop consistent norms for criteria for model fit, confidence, and savings uncertainty. For a thorough discussion of these criteria and their role in whole building program measurement and verification, see the CEE Introduction to Uncertainty Analysis (CEE member resource only).

4 CEE Member Program Overviews

The remaining pages of this document are the individual overviews for the ten CEE members.

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7 Lawrence Berkeley National Laboratory’s publication “Barriers and Opportunities to Broader Adoption of Integrated Demand Side Management” (February 2018) defines “Integrated demand side management (IDSM) is a strategic approach to designing and delivering a portfolio of demand side management (DSM) programs to customers. IDSM can be defined as the integrated or coordinated delivery of three or more of energy efficiency (EE), demand response (DR), distributed generation (DG), storage, electric vehicle (EV) technologies, and time-based rate programs to residential and commercial electric utility customers.”
Program Overview

Continuous Optimization

Program Objectives and Success

The BC Hydro Continuous Optimization Program is intended to address a gap between existing BC Hydro programs for new construction and commercial building retrofits and to provide an avenue for commercial buildings to achieve operational savings. BC Hydro partners with FortisBC for a comprehensive electricity and natural gas energy conservation program.

Program Administrator Objectives

- Achieve cost-effective energy savings
- Research and innovation: in 2008 when this program was developed, it was very new to use utility meter data to provide energy management information for end users via third-party Energy Management Information Software vendors, and two key questions were:
  - Would energy management information based on whole building meter data be an effective tool to identify and motivate operational savings actions?
  - Would whole building meter data and analytics be sufficient to enable BC Hydro to quantify the energy savings achieved?

Customer and Market Objectives

- Provide a support framework, including energy information, energy services, and coaching, to enable large commercial buildings to address operational energy savings
- Engage facilities staff around energy performance and BC Hydro programs
- Build demand for energy management information systems (EMIS) by creating a market for technology providers within BC

Program Success Looks Like...

At launch, success looked like ten to 15 buildings participating in the program, with EMIS technology delivering participants information regarding their load profile and energy consumption in real time and consultants generating a better understanding of the value proposition of building recommissioning. Customer interest in the program was intense—customers asked to enroll entire portfolios of 50 to 60 buildings—requiring BC Hydro to phase in participation among customers with multiple buildings. For these customers, BC Hydro offered to implement EMIS immediately but...
staged the enrollment of the customers’ buildings over a period of up to two years, enabling service providers to keep up with demand.

Program Details

The Continuous Optimization program launched in 2008 and has worked with customers through two rounds of efficiency improvements. The program targets commercial buildings with a minimum of 50,000 square feet equipped with a building automation system. Round 1 of the program (2008–2016) included BC Hydro support for whole building EMIS to provide participants with energy information at the whole building level, including their consumption, cumulative sum of energy savings charts (CuSum), and load profile in real time. After the EMIS was set up, customer engagement followed these stages: investigation (12 months), implementation (18 months), and energy management coaching (12 months). As part of Round 1, BC Hydro assumed all (2008–2012) or 50 percent (2013–2016) of the financial risk for customers that were interested in trying EMIS and recommissioning in their buildings by providing incentives for an EMIS and retrocommissioning consultant. In return, participants agreed to implement all measures with a less than two-year simple payback to a maximum customer investment responsibility of $0.25/ft². This funding support was provided to the participant regardless of energy savings achieved—BC Hydro accepted the risk that energy savings achieved might not justify the cost of the EMIS and retrocommissioning consultant for a given building. That value proposition was very attractive to customers, as reflected by the degree of uptake and enthusiasm.

During Round 1, BC Hydro worked with 550 buildings through the program, an estimated 30 to 35 percent of the addressable market in the BC Hydro service territory. Participants had the option to renew annually for an additional four years after completion of the three stages, for a total of 7.5 years. During the annual renewal period, BC Hydro would pay for the cost of either continued EMIS or coaching services, though the customer could continue with both.

Round 2, which launched in 2017, is designed to restore the operational savings achieved by participants in Round 1 and to ensure their
persistence. Round 2 also marks the shift from whole building data and analytics to more granular data provided by the building automation system to facilitate an approach to Monitoring Based Commissioning, combining legacy recommissioning activities with installation of either fault detection and diagnostics or automated system optimization software. Program staff expect that the more granular building automation system (BAS) data and fault detection and diagnostic (FDD) analysis in Round 2 will identify specific operational changes or maintenance activities to achieve savings.

In Round 2, BC Hydro offers participants three recommissioning options:

- Refresh Your Building (100 percent of recommissioning costs up to $0.025/ft²): review of Round 1 measures only, conducted by either a consultant or BAS contractor
- Recommission Your Building (50 percent of recommissioning costs up to $0.05/ft²): building recommissioning by consultant, with comprehensive review of building systems
- Real Time Energy Management (RTEM) (50 percent of combined RTEM consultant + software up to $0.10/ft²): exploring the new generation of software tools, i.e. fault detection and diagnostics and automated system optimization

Regardless of which offer the participant chooses, the customer is responsible for implementing measures with a simple payback under two years, up to a maximum customer investment responsibility of $0.25/ft² (same as Round 1). Measures typically include both electricity and gas opportunities.

ROLE OF UTILITY METER DATA AND ANALYTICS

Round 1: Whole building meter data and EMIS were used to provide energy management information to participants (consumption, CuSum, load profile), to motivate and quantify energy savings actions. Meter data intervals from utility or customer owned meters were determined by the EMIS vendors, but were typically 15 minutes. The EMIS itself did not prove to be useful for program measurement and verification, as originally intended. It worked well where the model was valid, and no substantial baseline adjustments were identified. However, there was an insufficient number of projects at the time of evaluation to form a statistically valid sample. In addition, a consultant was needed to perform a separate analysis to confirm the results of the EMIS per a BC Hydro requirement, which resulted in a costly process. Ultimately, whole building data (ironically, the same data collected by the EMIS systems) were used to perform the evaluation, but using a different methodology.
Round 2: Participants have the option to choose “real time energy management,” which uses fault detection and diagnostics or automated system optimization software in addition to a recommissioning consultant, to identify measures to optimize the performance of existing building systems. Automated fault detection and diagnostics software are used in a monitoring role to identify and alert building staff to faults that may lead to energy savings.

ENERGY ANALYSIS TOOLS OR SERVICES USED
BC Hydro relied on several firms to provide EMIS technologies and services, using the following criteria to select vendors:

- Demonstrated methodology to model whole building energy demand and consumption
- Capability to visualize energy savings and building performance using a cumulative sum of energy savings chart
- Round 1—Anomaly detection using whole building interval data: the program did not achieve its objective with respect to using whole building meter data to detect anomalies. Anomaly detection requires finely-tuned models and granular inputs in order to provide meaningful feedback and avoid excessive false positives, which could not be achieved using whole building meter data.

MEASUREMENT AND VERIFICATION APPROACH
The program did not quantify energy savings using whole building consumption and baseline model data from the EMIS. Energy savings were quantified using engineering calculations, as in a custom offering. Recommissioning consultants performed the savings calculations, which were reviewed by BC Hydro staff. Achievement of savings was not a condition for payment to either program participants or consultants, so there was no motivation for consultants to overestimate savings achieved. To date, the program has had high realization rates.

Program Findings

ACHIEVED SAVINGS
BC Hydro found that Round 1 participants achieved on average a 7.2 percent reduction in energy consumption, combining electricity and natural gas. The program tracked participant savings by facility type

Program Findings

Average savings achieved 7.2% of total consumption (electric and gas)

Criteria for savings uncertainty and model fit Not applicable

Analytic tools used EMIS were provided by a set of qualified vendors

Energy data intervals used for modeling and analysis EMIS provider’s discretion, typically 15-minute, from utility- or customer-owned meter

Meter data challenges

- Flow—from the meter to the EMIS

M&V challenges Not applicable
and found that certain space types achieved greater results than others. University buildings showed the highest savings as a share of total consumption at 13.6 percent, whereas shopping malls showed the smallest share of savings, at 2.4 percent of total consumption. Additional information about the program results, including results by space type, are available on the BC Hydro website.

BUILDING CHARACTERISTICS AND BASELINE INTERACTIONS
Because the program does not use utility meter data to estimate energy savings achieved, model fitness was not a significant metric.

BIGGEST CHALLENGE WITH DATA COMMUNICATION OR INTEGRATION
Data flow to the EMIS vendors from BC Hydro revenue and customer-owned meters caused numerous problems. Of the four-person team working on this program, one person (an electrician) was dedicated part-time to addressing EMIS related issues, such as coordinating with BC Hydro meter shop and meter installation personnel, liaising with EMIS vendors regarding invoicing and site issues, and helping customers stay motivated when problems arose.

BIGGEST M&V CHALLENGE
BC Hydro faced relatively few challenges related to energy savings measurement because neither the participants nor the consulting engineers depended on savings performance for their incentives or payments.

ADDITIONAL LESSONS LEARNED
Whole building EMIS used in Round 1 was not able to deliver on two important aspects of its value proposition:

- EMIS was not sufficiently granular or tuned to building conditions and operations to provide accurate, relevant alarms or notifications to building staff about equipment faults or performance deviations to be investigated and corrected.
- Building performance information provided by the EMIS was not robust enough to be used for energy savings estimation by BC Hydro.

The shift to more granular system data and analytics tools in Round 2 reflects these issues with whole building meter data and analytics. Whole building EMIS did work very well to engage and motivate participants, who used the EMIS as a framework for building staff to monitor and maintain performance throughout the facility.
REMAINING QUESTIONS OR BARRIERS

Building facilities staff are a difficult and important audience to engage in energy efficiency. Round 2 includes specific requirements around facilities staff use of the fault detection and diagnostics tools to identify and respond to operational issues.

One of the anticipated problems with rolling out FDD software in Round 2 is that while the technology associated with detecting faults using “expert rules” is relatively straightforward, the process tends to expose a huge number of faults to a typically already under-resourced facilities management team. Since there is no point in installing software which will produce red flags if those flags are only going to be ignored, the facilities management team must be engaged up front, and have an opportunity to buy in to the new FDD software installation. To ensure this, the application process requires the signature of the Director of Facilities (or equivalent), identification of a “champion” from the facilities department, and a response flowchart from the facilities department indicating the proposed process from the time a fault is identified to when it is resolved.

The program also encourages use of the Monitoring-Based Commissioning (MBCx) Plan Template (found here) published by Lawrence Berkeley National Laboratory, and one of the program deliverables is a 12 Month Service Report which requires the customer to demonstrate the tool, preferably through the lens of their MBCx Plan.
PROGRAM OVERVIEW

Retrocommissioning—Energy Advisor

Program Objectives and Success

ComEd is continually looking for opportunities to leverage meter data, especially with the recent upgrades to smart meters for all customers. In Illinois, legislation created a process for program administrators, including ComEd, to solicit new designs for energy efficiency programs from third parties. The idea for this program came from a vendor through open solicitation.

PROGRAM ADMINISTRATOR OBJECTIVES

Achieve energy savings and complement other energy efficiency programs in ComEd’s portfolio. The majority of ComEd commercial incentives are for equipment replacement measures, and this program complements those offers by identifying and implementing operational improvements for existing equipment.

CUSTOMER AND MARKET OBJECTIVES

- Serve customers with little capital for equipment replacement measures
- Drive energy and cost savings for customers, positive customer experiences, and continued customer satisfaction

PROGRAM SUCCESS LOOKS LIKE...

Program performance metrics include number of customers served, amount of savings achieved, and customer satisfaction.

Program Details

ComEd launched the Retrocommissioning—Energy Advisor program in the spring of 2017. The vendor, Power TakeOff, is provided with data for all business customers, including 30-minute interval data and some firmographic size information, which is then used to screen buildings to identify good candidates to participate in the program. The vendor uses analytics to remotely identify which customers have the potential for significant savings opportunities from operation and maintenance or behavior measures. Additionally, the vendor uses publically available data to identify customers with a large portfolio of similar facilities that report to a single decision maker. Once candidates have been identified, the vendor performs the initial outreach
and customer acquisition. Via a phone call, the vendor coaches participants through a set of operational measures to achieve the identified savings. The customer’s actions are documented by the vendor, and their energy consumption is monitored for savings verification for three to nine months, depending on the measure. The vendor receives a fixed incentive amount per verified kWh saved. Customers do not receive any incentives directly from ComEd with this program, but receive the service and expertise at no charge, as well as savings on their energy bill.

In its first year the program focused only on facilities with demand under 100 kW, but in 2018 the program was expanded to include facilities with demand greater than 100 kW. However, at some point a facility is large enough that its savings potential justifies the cost of an engineer or commissioning consultant to perform a more detailed on-site study. ComEd has found that certain segments are good candidates for this type of program, particularly organizations with many similar locations, such as retail banks, big-box stores, mall retail, and fast food locations, even if the potential per-site energy savings is less than other facilities. Additionally, customers with multiple sites and a single decision maker, such as restaurant chains, are a good fit for the program. The vendor tool allows ComEd to look across a customer portfolio to identify the best candidate buildings and focus the customer’s attention where the opportunity is the greatest, which has improved engagement with decision makers.

As with other programs, ComEd is considering how to maintain relationships with program participants over time. Programs driven by meter data offer the potential to keep an eye on how customers are performing, monitor for backsliding, identify other offers or services for the account, and discover potential decay curves of measures.

ROLE OF UTILITY METER DATA AND ANALYTICS
ComEd provides the vendor with customer meter data and profile information. The vendor correlates the energy load profiles against the business type and weather conditions to identify customers with higher than expected consumption. Currently, ComEd is researching how weather conditions—heat versus cooling season—impact operational savings analysis and measure identification.
ENERGY ANALYSIS TOOLS OR SERVICES USED
Power TakeOff submitted a proposal through an open RFP for energy efficiency solutions. One key part of Power TakeOff’s proposal was that it included customer acquisition. ComEd staff emphasized that many providers offer analytics, but typically they do not undertake the customer acquisition or engagement piece, which can be the most challenging aspect.

MEASUREMENT AND VERIFICATION APPROACH
The measure verification period varies from two to six months, depending on measure type. The vendor performs the savings measurements, which are quantified using post-implementation meter interval use data, as opposed to direct measurements of system energy use. The savings numbers are then verified by the third-party evaluator. ComEd staff does not have a direct role in the measurement and verification process.

Program Findings

ACHIEVED SAVINGS
The preliminary evaluation estimate of savings achieved in 2017 was 2.0 GWh, exclusively from operations, maintenance, and behavior change measures.

BUILDING CHARACTERISTICS AND BASELINE INTERACTIONS
Industrial sites are not a good fit, as the process load typically represents a large fraction of total energy consumption. Cyclical changes based on time of day are needed for facilities with 24/7 operations, such as refrigerated warehouses. Additionally, operational savings are not easily obtained from customers with highly consistent operations, as many operational opportunities involve turning down certain equipment during nights and weekends or other off-hours.

BIGGEST CHALLENGE WITH DATA COMMUNICATION OR INTEGRATION
Data security was initially the biggest challenge, as the program design required ComEd to provide meter data for a large number of customers to a third party. The vendor needed to provide ComEd with a high level of confidence that they could protect customer data. Data flow has been mostly smooth but has involved ongoing work between IT staff at ComEd and the vendor.
BIGGEST M&V CHALLENGE
As described above, ComEd does not have a direct role in savings measurement or verification.

ADDITIONAL LESSONS LEARNED
Connecting the vendor with the ComEd national account management team not only helps with customer acquisition, but also shows a level of credibility, because many customers prefer to hear about energy efficiency opportunities through their account managers if possible. Working with the account manager can give the customer confidence that ComEd stands behind what is being offered by the vendor, as opposed to hearing a sales pitch directly from the vendor. The account managers are also frequently able to provide introductions to the appropriate energy management decision maker within the customer organization.

The combination of customer engagement and analytics has enabled the program and the vendor's approach to be successful. The vendor has been effective in acquiring program participants and convincing them to take action.

REMAINING QUESTIONS OR BARRIERS
1. The program model fits well for scale, but customer acquisition is an ongoing challenge.
2. What is the sweet spot on the upper bound of building size for this program? Where does it make more sense to invest more on deeper analysis to gain deeper savings?
3. How can this program be integrated with deeper offers such as SEM, so that each offering captures the intended customers, without creating competition within the ComEd program portfolio?
4. One challenge is sorting out which customers to serve with this offering and which to address with a higher-touch retrocommissioning program ComEd also offers. Program staff are cognizant of the potential of confusing customers by presenting parallel offers, but there is potential either to leave savings on the table with larger facilities through the remote analytical approach or to diminish cost-effectiveness by sending commissioning consultants to facilities that don’t justify their time.

Program Findings

Lessons learned
- Vendor lead customer engagement is more credible to customers when account managers are involved

Evaluation metrics used
TBD

Evaluation completed
Expected in 2018
PROGRAM OVERVIEW

Smart $aver® Performance Incentive

Program Objectives and Success

The program was created to support customers and projects with a higher degree of uncertainty than are covered under the Duke Energy custom programs, particularly in achieving savings from operational measures and emerging technologies. It also serves customers with uncertain operating or occupancy schedules.

PROGRAM ADMINISTRATOR OBJECTIVES

- Access new energy savings streams from innovative technologies
- Gain deeper savings through retrocommissioning, networked controls, and operational savings
- Reach a higher program realization rate due to meter-based M&V
- Achieve stronger, continuous engagement with customers instead of just issuing an on-time incentive payout
- Integrate Duke Energy products and services under one program platform to simplify engagement for customers
- Quantify the energy savings benefits of new networked lighting system controls and influence the market around the adoption of that technology

CUSTOMER AND MARKET OBJECTIVES

- Provide customers a simpler, all-in-one pathway to participate in Duke offerings and deeper savings opportunities
- Improve customer satisfaction with Duke programs
- Increase retrocommissioning activities in the Duke territory, including making the business case for these services more attractive to customers and easier for service providers to sell

PROGRAM SUCCESS LOOKS LIKE...
Customer satisfaction and constant customer engagement in a continuous energy savings process, as well as achievement of Duke energy savings goals.

Program Details

The Smart $aver Performance Incentive Program launched in January 2017 and is being offered to commercial and industrial customers in North and South Carolina and Indiana. Currently, there are no size or participation criteria for customers. Duke account executives and Business Energy Advisors
are in the process of building market awareness, and to date 31 projects at 226 sites are underway, with more in the pipeline. The program includes capital and operational measures. It is intended to support projects that are unable to participate in Duke’s prescriptive or custom programs because they involve innovative technologies or have uncertain building conditions.

The program provides incentives of $0.065 per kWh saved, and $150 per kW reduced, for measures with a simple payback greater than one year. It uses the following incentive schedule:

- **Initial incentive** This incentive is based on the portion of the savings that are expected to be achieved with a high degree of confidence, and is paid upon installation-implementation; for example, if the savings confidence level is 30 percent, the customer will receive 30 percent of the total estimated incentive amount.

- **Final M&V incentive** Customers receive the performance-based incentive after the completion of the M&V monitoring period; it is based on the actual savings achieved.

The monitoring period and duration of customer engagement is typically three to six months, or up to 12 months for projects with highly uncertain savings. The incentive cap is based on a percentage of the incremental measure cost: 75 percent in North and South Carolina, 50 percent in Indiana.

Participants receive monthly performance reports, developed using monthly utility meter data or customer sub-metered data, which include estimated savings achieved compared to target savings. These reports help the customers understand their progress and incentive earned, and support the identification of new savings opportunities. Duke is also piloting a new customer-facing benchmarking tool that compares a building against its peers, ENERGY STAR® data, and a weather-normalized comparison of the building over time.

**ROLE OF UTILITY METER DATA AND ANALYTICS**
Monthly utility meter data is used to estimate project savings and to develop monthly performance reports for customers.

**ENERGY ANALYSIS TOOLS OR SERVICES USED**
The monthly performance report was built specifically for Duke by a service provider and incorporates monthly meter data, weather data, and other dependent variable data to provide normalized energy.
performance information to participants. The ECAM tool is used for the development of building baseline model and savings estimation. The benchmarking tool being piloted was developed externally.

MEASUREMENT AND VERIFICATION APPROACH
The program estimates savings according to IPMVP Option C. Projects with estimated whole building savings of 15 percent or greater utilize normalized utility meter data for baseline development and savings measurement. Projects with estimated whole building savings less than 15 percent may rely on submeter data, in order to separate the savings from the statistical noise.

Program Findings

EXPECTED SAVINGS
Retrocommissioning projects are expected to achieve ten to 20 percent reductions in whole building energy consumption. Two projects completed to date have both slightly exceeded these expectations.

BUILDING CHARACTERISTICS AND BASELINE INTERACTIONS
Duke is still understanding how building characteristics and baselines interact, as the current project sample size is not large enough to develop conclusions. Initial projects had difficulties with model fitness that were addressed by utilizing daily metered data or by matching the actual monthly meter read dates with the weather data for that day to get a strong regression result.

BIGGEST CHALLENGE WITH DATA COMMUNICATION OR INTEGRATION
The program has experienced challenges with automating the transfer of utility data to a secure file transfer site accessed by the vendor and used for reporting savings to the customer. For example, duplicate files have been sent to the FTP site, and the automated system was unable to detect the error, requiring manual intervention.
BIGGEST M&V CHALLENGE
Initially, for projects that included capital measures, Duke Energy needed to manually adjust the models to account for the savings from these projects before determining the total savings achieved at the whole building level. Netting out capital project savings in this way significantly added to program cost. To address this issue, Duke stopped netting out capital project savings, measuring all savings types at the whole building level.

Non-routine adjustments also present a challenge to the program, as they require manual adjustments to the model and savings estimates. These situations posed challenges to the cost-effectiveness of operational measures and to the accuracy of savings attribution.

ADDITIONAL LESSONS LEARNED
Customers have been very receptive to the Performance program. They particularly like the fact that Duke is validating the savings expected and that there is an opportunity to receive incentives for installing innovative energy saving technologies or retrocomissioning their existing building, where there is a huge potential for savings but savings amounts can be uncertain.

The program has enabled Duke to support customers with multiple similar buildings sites cost-effectively by taking a statistical sample and extrapolating the savings. This provides the opportunity to cost-effectively address small buildings, where individual monitoring and data aggregation was previously a barrier.

REMAINING QUESTIONS OR BARRIERS
1. Incentive structure is a delayed payment to the customer that can be an impediment to participation; customers may have to wait 12 months to get their total incentive
2. Collaborating with energy service companies (ESCos); some ESCos have backed off from the offer due to assuming the risk from the delayed payment and the energy savings uncertainty, which has meant that they most likely are not promoting the program offering to customers

Program Findings

Meter data challenges
- Data flow—automation of data transfer

M&V challenge
Netting out capital savings and non-routine adjustments

Lessons learned
- Customers like that Duke is validating the expected savings
- Taking a statistical sample size and extrapolating savings is enabling cost-effectively addressing small buildings

Evaluation metrics used
TBD

Evaluation completed
No
PILOT OVERVIEW

Long-Term Care Building Tune-Up

Pilot Objectives and Success

Through this pilot, Efficiency Maine sought to develop a valid approach to quantify and claim savings from operational efforts in long-term care facilities using interval meter data.

PROGRAM ADMINISTRATOR OBJECTIVES

- Increase understanding within Efficiency Maine about the potential for operational upgrades and their persistence
- Provide a “recommissioning lite” program option for medium and small businesses that typically do not participate in recommissioning offers, but that have available operational savings

CUSTOMER AND MARKET OBJECTIVES

- Provide customers with access to operational savings opportunities

PILOT SUCCESS LOOKS LIKE...

- Building tune-up measures are identified as cost-effective, allowing Efficiency Maine the opportunity to dive a little deeper into sectors that this type of measure would be beneficial for
- Customers find value in operational measures and would pursue programs

Pilot Details

Efficiency Maine launched a building tune-up pilot for long-term care facilities in January 2017, with a plan to have all participants “tuned up” by early 2018. The pilot focuses on identifying and implementing operational savings opportunities, including optimization, scheduling, commissioning, and controls. Capital measures identified as part of the pilot are eligible to participate through other Efficiency Maine programs (any capital project savings are netted out from the pilot savings).

The pilot targets long-term care facilities with an energy management system or building operation system integrated with building HVAC. However, most long-term care facilities that Efficiency Maine contacted did not have these systems, so the pilot includes a mix of facilities with and without EMS-BAS. For facilities without EMS-BAS, Efficiency Maine staff and contractors
manually developed energy baselines and performed site visits to identify operational savings opportunities. The pilot provides customers with incentives to support implementation of the measures identified in the tune-up plan.

Efficiency Maine worked with six long-term care facilities, including nursing homes and assisted living for the elderly, to develop building tune-up plans.

**ROLE OF UTILITY METER DATA AND ANALYTICS**
15-minute interval data is used to:

- Develop facility baselines and show how the building is acting before any interventions or operational changes are made
- Advise customers about possible interventions
- Perform measurement and verification of the savings

**ENERGY ANALYSIS TOOLS OR SERVICES USED**
Analytics software platforms were used to develop model energy baselines and identify operational measure opportunities. The primary audience for the information output from the analytics was Efficiency Maine staff, but the data from the analytics platforms may be used to develop customer reports in the future.

Based on a previous pilot in which Efficiency Maine staff used site visits to validate the accuracy of remote audit reports, Efficiency Maine had determined it could trust the opportunities identified by two analytics providers used in this pilot, FirstFuel and Retrofiency. A third analytics provider, Gridium, was selected and used by the pilot implementation contractor at some participating facilities.

The analytics platforms will also be used for savings estimation in Phase 2 of the pilot, to be carried out three to six months after the building tune-ups are complete. The analytics will be used to estimate savings a second time, 12 months after the tune-ups are complete, to assess savings persistence. At the time of writing, Efficiency Maine did not have statistical criteria in place for model fitness or savings uncertainty. One outcome from the pilot may be to inform model fitness and savings uncertainty criteria for future offerings.

**MEASUREMENT AND VERIFICATION APPROACH**
Discussed in previous section
Pilot Findings

EXPECTED SAVINGS
Efficiency Maine staff expects pilot participants to achieve five to ten percent energy consumption reductions from operational savings. There is additional potential for capital savings, though the focus of the pilot is on the operational savings.

BUILDING CHARACTERISTICS AND BASELINE INTERACTIONS
The buildings that typically fit the model well were newer with energy management or controls systems. Older, poorly maintained buildings generally had poor model fit.

BIGGEST CHALLENGE WITH DATA COMMUNICATION OR INTEGRATION
Accessing the AMI data from the utility and transferring that data into a format that whole building platforms can digest is a primary challenge. There is a need for a common language and for compatibility between AMI data and other systems or platforms, including whole building EMIS, technology using the Internet of Things, and tools that target customers or sectors for energy efficiency programs.

BIGGEST M&V CHALLENGE
This has not been determined to date. The pilot will address measurement and verification issues in depth in the second half of 2018.

ADDITIONAL LESSONS LEARNED
- Having a time-based heat map of energy performance is extremely valuable for identifying energy waste and savings opportunities.
- The remote analytics platforms present a cost deterrent for businesses to perform energy management. Though less expensive than on-site audits, remote analytics platforms are still out of reach for many small businesses. One important role for efficiency programs may be to provide emphasis or consistent messaging for end users about the value that interval data can provide.
- Building operation and maintenance, and its correlation to model fitness, presents a job skills issue: building operation and maintenance staff in many facilities are not familiar with using building interval data and analytics as part of building management. There is a need for education and training opportunities for building operation and maintenance personnel in Maine to help them catch up with new technology.
REMAINING QUESTIONS OR BARRIERS
1. Will the pilot be able to accurately quantify and validate operational savings?
2. Will the pilot find persistence of O&M savings after 12 months?

Pilot Findings

Lessons learned
- Time-based energy performance heat maps can be important for identifying savings opportunities
- Although a cheaper option that audits, remote analytics platforms can be a cost deterrent
- Analytic based programs require workforce training

Evaluation metrics used
Not yet identified

Evaluation completed
No
PILOT OVERVIEW

**PowerSaver**

Pilot Objectives and Success

Efficiency Vermont developed the pilot to support behavior savings M&V for commercial customers and identify ways to serve small and medium businesses (SMBs).

**PROGRAM ADMINISTRATOR OBJECTIVES**
Identify methods that leverage smart meter data and analytics to package and deliver customized savings recommendations and efficiency services at a cost-effective scale suitable for this market.

**CUSTOMER AND MARKET OBJECTIVES**
The SMB market is recognized as diverse, busy, and a challenge to reach with one-size-fits-all efficiency solutions. The pilot has been an attempt to develop scalable, customizable solutions for this market that engage customers “where they are.”

**PILOT SUCCESS LOOKS LIKE...**
Demonstrating that measurable, cost-effective savings can be achieved with the SMB market through the piloted approach and that there is clear evidence that the measurement technique is reliable and its results replicable with a larger group.

Pilot Details

The PowerSaver pilot, launched in May 2017, provides customers with varying levels of exposure to resources for understanding their energy use and opportunities to change behavior to reduce idle load in commercial buildings. The pilot provides small and medium business customers (<100,000 kWh) in Vermont with free customized energy reports, including analytics and measure recommendations. The pilot does not provide customers with incentives beyond free access to customized reports, measure identification, and energy bill reductions. Efficiency Vermont estimates that idle load energy savings vary, ranging from one to 15 percent, based on the customer’s level of engagement with the energy information.
The participant population included a group of approximately 360 SMB customers that opted into the pilot, a group of approximately 300 customers selected to participate by their account managers, and a group of approximately 4,300 customers selected at random, for a total of 5,000. This group of 5,000 received a customized report created by Efficiency Vermont based on FirstFuel’s data analytics. The reports provided personalized energy savings recommendations and calls to action (“do it yourself,” “contact us,” and “go further by joining PowerSaver”).

ROLE OF UTILITY METER DATA AND ANALYTICS
Meter data is used to target participants, provide efficiency measure recommendations through automated remote audits, and automate savings measurement.

ENERGY ANALYSIS TOOLS OR SERVICES USED
For participant targeting, the pilot used in-house models based on the ASHRAE Inverse Modeling Toolkit, Open EE Meter, and Lawrence Berkeley National Laboratory Time-of-Week models.

Savings estimations for individual measures relied on FirstFuel’s analytics platform and AMI data. Efficiency Vermont used these data to develop 11x17 booklet-style printed reports, as these were not available from the analytics provider. Reports included “trust-building” data and visualizations that demonstrated recipients’ patterns of energy consumption, as well as custom energy conservation measures (ECMs) that suggested opportunities (for example, reducing always-on load, investing in LEDs, or upgrading refrigeration) based on business type and savings estimates based on utility data and business profile values gathered by the analytics platform.

MEASUREMENT AND VERIFICATION APPROACH
Weather-normalized pre-post savings were calculated on daily or 15-minute interval AMI data, depending on the selected weather model for that customer, minus any savings claimed for capital measures.

A randomized control trial with encouragement design (RED) was used with a matched control group, as shown below in Figure 6. This result will be compared to the savings calculated through the RED method.
Pilot Findings

Expected savings
20% of idle load

Criteria for savings uncertainty and model fit:
- **Confidence TBD**
- **$R^2$ TBD**
- **FSU** Based on expected idle savings
- **CV(RMSE)** Less than 0.35 for 10,000 of a total 35,000 accounts

Analytic tools used
- FirstFuel and custom, in-house models

Energy data intervals used for modeling and analysis
- 15-minute raw AMI data, with analysis and modeling using 1 hour and daily data

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**Pilot Findings**

**EXPECTED SAVINGS**
The pilot goal is to save 20 percent of high-engagement participants’ calculated idle load, which is their minimum energy use overnight or when major processes were idle. These savings translate to a smaller percent of their overall use. Note that FSU is calculated based on the anticipated savings percentage of the total load, using 20 percent of the calculated idle load. For less engaged customers, a lower level of savings is anticipated.

**Table 5. Projected Savings Based on Customer Engagement**

<table>
<thead>
<tr>
<th>Engagement Tiers</th>
<th>Engagement Details</th>
<th>Estimated Savings Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Receive report</td>
<td>1-2%</td>
</tr>
<tr>
<td>Medium</td>
<td>Receive report and some digital interactions</td>
<td>2-7%</td>
</tr>
<tr>
<td>High</td>
<td>Receive report, some digital interactions, and cohort</td>
<td>5-15%</td>
</tr>
</tbody>
</table>

**BUILDING CHARACTERISTICS AND BASELINE INTERACTIONS**
Participants were screened for model fitness; 35,000 accounts were tested. The best performing 10,000 accounts had a CV(RMSE) of less than 0.35 and were determined to be eligible to participate in the pilot. The remaining 25,000 accounts were deemed to be poor fits for the models used and were not eligible for participation in the pilot.
For each of the 10,000 accounts, Efficiency Vermont applied multiple weather models to identify the model with the best fit for each customer based on the CV(RMSE), which was then used to develop the existing conditions baseline.

BIGGEST CHALLENGE WITH DATA COMMUNICATION OR INTEGRATION

While data such as AMI, parcel, or business type is valuable, it is hard to find and match up to utility accounts. Program administrators are learning the constraints of what can and cannot be done based on available data:

- Are real estate parcel data available in your area?
- Do you have intelligence on your business customers, for example primary business type?
- How do your utility accounts, i.e. billing data, match up with your customers, for example franchises, multiple buildings, or tenants?
- Will it be challenging to feed this information into your algorithms?
- Will one customer receive multiple reports because of this configuration?

An upfront Exploratory Data Analysis (EDA) exercise and user-centered design thinking exercise is worth the time and money. In this pilot, utility data is rolled up to sites and accounts for bills, but this is not always good for engagement.

BIGGEST M&V CHALLENGE

Program staff struggled with how to compare high-fidelity data points in the pilot to the relatively low-fidelity participation data from the comparison untreated groups. For example, customers on the platform may indicate whether they have done a lighting retrofit, but the program does not have the same granular information about everyone else in the participant population to compare with this customer; how might the program tell that a mailed report or a customer’s use of an online platform induced the customer to do the retrofit? Efficiency Vermont does not currently have a consistent process for measuring program uplift, which involves not only linking program activity to utility accounts but also establishing some sort of baseline for program participation and criteria for identifying a comparison group.

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Pilot Findings

Meter data challenges
Profile matching—Correlating AMI to customer profiles

M&V challenges
It was difficult to compare performance between pilot participants and the comparison group, and therefore to measure and attribute savings to the pilot interventions

Lessons learned
SMFs are complex due to both the number of customers and the variation of business type

Evaluation metrics used
Pre-post weather normalized savings, program uplift, and engagement

Evaluation completed
To be completed after September 2017
ADDITIONAL LESSONS LEARNED

SMBs are a complex market, as not only are there many customers, but the type of customer varies among the population. For R&D purposes, it is important to balance traditional program performance goals with the ability to truly answer the research questions. For this pilot, Efficiency Vermont wanted to understand the value of different engagement methods as well as maximize savings. Efficiency Vermont kept more customers in the pilot to support the latter goal but may risk the ability to answer the former question by not removing “noisy” customers.

REMAINING QUESTIONS OR BARRIERS

1. Will participation rates be adequate for evaluation of the group?
2. How can program uplift be measured?
PILOT OVERVIEW

Pay for Performance

Pilot Objectives and Success

Energy Trust of Oregon (Energy Trust) developed the Pay for Performance pilot to expand the customer base for meter-based savings offerings, particularly to customers lacking the personnel resources for participation in the Strategic Energy Management (SEM) offering.

PROGRAM ADMINISTRATOR OBJECTIVES

- Profile the types of customers most interested in this model for attaining energy savings; learn what barriers exist to participation
- Test whether pay-for-performance is the most effective model to generate savings

CUSTOMER AND MARKET OBJECTIVES

Achieve deep energy savings through operational, maintenance, behavioral, and capital opportunities.

PILOT SUCCESS LOOKS LIKE...

Increased customer participation and recognized value from operational and comprehensive improvements that achieve an energy performance improvement of at least five percent. An additional success metric is the ability of the engineering firms to implement within their existing business models.

Pilot Details

The 2017 Pay for Performance (PfP) pilot looks to track savings over a three-year period to capture capital, operational, maintenance, and behavior measures. The pilot is targeting commercial buildings with a minimum of 50,000 square feet across selected building types (office, retail, medical office, and grocery) with a stable baseline and projected consistent ownership and operations. Most of these criteria are present to ensure that the building does not undergo major changes that are outside of the scope of the program during the pilot performance period.

To support the pilot, Energy Trust of Oregon is establishing a group of approved Pay for Performance Allies (PfP Allies). These firms are required to have experience with developing whole building regression models and a
minimum of three years’ experience performing energy analyses, and to hold commissioning accreditations from a list of qualified organizations.

The Allies enter into a contract directly with pilot participants and support the participants in developing and implementing a plan of energy savings measures. For a project’s acceptance into the pilot, the energy savings plan and model are reviewed by Energy Trust. For accepted projects, Allies maintain the participant’s energy models and provide savings analyses and projections directly to Energy Trust.

Energy Trust will pay incentives directly to the participant based on all kWh and therm savings verified annually. Incentive rates will be based on the ratio of capital versus operational-behavioral measures implemented. The incentives rates are as follows:

- If less than 50 percent of projected annual energy savings are from capital measures, incentives are $.05/kWh and $.60/therm per year, capped at 200 percent of estimated first year incentive total
- If 50 percent or more of projected annual energy savings are from capital measures, incentives are $.08/kWh and $1.00/therm, capped at 150 percent of estimated first year incentive total

The two incentive pathways account for the variations in the relative labor and capital costs for measures. Energy Trust gives the participant six months to install measures, then verifies measure completion post-installation. The participant and contractor are required to provide Energy Trust with project updates on a monthly basis in the first year and quarterly estimated energy savings in years two and three.

Although the engagement period with the participant is for three years and the participant is paid for energy savings in all three years, Energy Trust only claims savings achieved in year one.

Energy Trust launched the Pay for Performance pilot in 2015 with one customer. The second phase began in late 2017 and expects to have six participants.

ROLE OF UTILITY METER DATA AND ANALYTICS

P2P Allies will use monthly utility meter data to develop the whole building regression model for savings measurement and verification.
Energy Trust plans to offer Allies the use of a performance tracking tool with modeling capabilities that was developed for pay-for-performance and SEM offerings. This tool was released in early 2018.

ENERGY ANALYSIS TOOLS OR SERVICES USED
Energy Trust’s performance tracking tool will be offered to PIP Allies for the pilot to model energy savings. Use of the tracking tool will support the pilot in:

1. Providing alerts to program managers for any data or statistical criteria that are outside the range established by the M&V Guidelines and will need to be fixed
2. Following Energy Trust’s criteria for model fit

MEASUREMENT AND VERIFICATION APPROACH
Energy Trust has developed a set of M&V Guidelines that will be provided to the Allies to support their development of the regression models. In the past, with initiatives like SEM, models were developed according to the professional judgement of the Ally completing the work. Energy Trust hopes to improve consistency and work efficiency through a more standardized approach to modeling.

Pilot Findings

EXPECTED SAVINGS
Participants in the pilot are expected to achieve minimum energy savings of five percent (kWh or therm equivalent).

BUILDING CHARACTERISTICS AND BASELINE INTERACTIONS
Energy Trust is working to understand what characteristics make a building a good fit from a baseline modeling perspective, as the pilot is still underway.

BIGGEST CHALLENGE WITH DATA COMMUNICATION OR INTEGRATION
The biggest challenge is ensuring that the contractor is able to collect and provide all relevant data. Energy Trust is working to make sure that meters in non-project spaces are isolated from project spaces.
BIGGEST M&V CHALLENGE
Using existing conditions versus code as baseline may present challenges. The Pay for Performance pilot assumes existing conditions to be the measure baseline, but the Energy Trust custom program typically uses code as the baseline. Using existing conditions as a baseline could result in over-claiming of savings, and Energy Trust staff believe that some measures are likely to be more problematic in this area than others. To address this challenge, Energy Trust will evaluate all proposed measures for cost-effectiveness and may remove some measures from program savings calculations as a result.

ADDITIONAL LESSONS LEARNED
Scenario planning was essential. Energy Trust held a series of meetings over several months to examine various delivery designs and scenarios to ensure that the ultimate offer works for all parties—participants (both owners and building operators), allies, and Energy Trust staff.

REMAINING QUESTIONS OR BARRIERS
1. Will there be a disproportionate share of lighting measures that will cause a need to adjust the incentive mix?
2. How well will operation, maintenance, and behavior programs perform, and will they drive significant savings above the planned amount?
3. How does geographic region, building size, measure type, and savings percentage impact program participation and performance?
4. Evaluation list includes:
   a. Establish the savings adjustment factor (TBD for first-year savings review)
   b. Determine if lighting is appropriately addressed through the PfP model
   c. Assess the market interest for both the Capital and O&M-behavioral paths
   d. Assess PfP Ally contracting structures used
   e. Assess the appropriate measure life for PfP
   f. Determine if the 2017 PfP Pilot design successfully achieves deeper savings than were initially identified in the Energy Reduction Plan
   g. Understand any potential over- or underestimation of savings
   h. Determine if the PfP model serves customers that would not have participated with Energy Trust otherwise
   i. Determine market barriers to PfP participation for customers and contractors (Allies)
j. Determine if incentive rates are set appropriately
k. Capture total project life cycle costs
l. Examine the quality of energy models

Pilot Findings

Evaluation metrics used
Energy Trust plans to include the following metrics in the evaluation of the pilot: assessing the market interest for both capital and O&M-behavior paths, assessing appropriate measure life for PfP, capturing total project life cycle costs, examining the quality of energy models

Evaluation completed
No
DEMONSTRATION OVERVIEW

Commercial Whole Building

Pilot Objectives and Success

Pacific Gas and Electric Company (PG&E) initially developed the Commercial Whole Building Demonstration with the goal of testing a new meter data-driven whole building program approach that could be scaled to serve a large number of buildings. However, recent legislation requires investor-owned utilities in California to shift responsibility for design and implementation of a minimum of 60 percent of energy efficiency programs to third parties by 2020. As a result, the PG&E Whole Building Demonstration results will be used to inform a set of guidelines for third parties’ design and implementation of whole building programs.

PROGRAM ADMINISTRATOR OBJECTIVES

The objectives are to develop functional expertise and guidelines on designing and implementing programs that incorporate utility meter data to measure performance and assess results in near real time. The shift to third parties designing and implementing programs requires program administrators to have a thorough understanding of whole building approaches in order to check the work and assumptions being used.

CUSTOMER AND MARKET OBJECTIVES

- Achieve 15 percent improvement in whole building energy performance
- Increase customer awareness and engagement with their buildings’ energy use and how it impacts the bottom line—participation in this demonstration should be a stepping stone to Strategic Energy Management (SEM)

PILOT SUCCESS LOOKS LIKE...

PG&E’s goal with this demonstration was to develop a scalable whole building offering. Another goal was to contribute to the wider efficiency program industry’s understanding of meter-based whole building program approaches.
Pilot Details

The demonstration was based on utility meter data and analytics, which were used to select participants, provide participants with quarterly energy reports and a third-party performance dashboard, and measure and verify energy savings achieved. A third-party implementer assigned to each participant monitored their performance and supported measure development. Participants were required to complete a minimum of three qualifying measures, which could include a mix of behavioral, retrocommissioning, operational improvements, and capital measures. The goal was to achieve a 15 percent reduction in total electricity and 15 percent reduction in total gas consumption as a result of the completed measures. Savings were measured at the whole building level, using an existing conditions energy baseline that was developed using utility meter data.

When a project was scoped, the customer provided a plan for the measures they would implement. The demonstration qualified those measures and their costs and used those costs to calculate the incentive cap. The incentive paid to the customer was based on their measured performance but was capped at an amount based on the qualifying measure cost.

ROLE OF UTILITY METER DATA AND ANALYTICS
Utility meter data was the backbone of the demonstration. It was used in customer targeting, providing energy feedback to participants via a quarterly energy report and dashboard, and for savings measurement and incentive payments.

ENERGY ANALYSIS TOOLS OR SERVICES USED
The demonstration used two proprietary data analytic tools and three open source tools. To test the viability of the five tools, PG&E gave each analytics provider a fitness test using 2014 energy data and asked them to estimate 2015 consumption. PG&E’s approach in using five different analytic tools was to understand the capabilities of different tools available in the market.
An in-house data scientist developed a stacking ensemble machine learning technique to blend the counterfactual output of four of the five models into one final output. Machine learning takes the best pieces from the four models for each hour of the year and combines them into one. The stacked output should perform at least as well as the best performing model in terms of normalized RMSE (model fit).

The machine learning aspect may or may not be continued in the future, depending on the number of models to be utilized moving forward. The demonstration considered testing another machine learning technique, called “boosting,” to see if that produces a better outcome than stacking. Overall, though, the question is whether the cost of the time to perform the machine learning is worth the improvement in model fit it provides versus simply using tools that consistently provide good-fitting models. For example, the best-fitting model might have a normalized RMSE (NRMSE) of ten percent, which might be decreased to nine percent using machine learning. Is it worth the cost? The question comes back to: how good is good enough?

**MEASUREMENT AND VERIFICATION APPROACH**

The demonstration measured savings using International Performance Measurement and Verification Protocol (IPMVP) Option C and Option D. Customer incentives were estimated using Option C, but the demonstration used Option D for its internal savings measurement and verification because it allowed PG&E to estimate energy savings achieved above code for a given measure. Going forward, because of California Assembly Bill 802, savings eligibility will not be bound by code; this will enable future PG&E programs using an approach similar to the demonstration to use Option C as a means of measuring and claiming savings. Final rules for using Option C are expected from the utilities commission in late 2018.

All savings from eligible measures may be claimed within this demonstration, as they are not attributed to other PG&E programs.

**Pilot Findings**

**EXPECTED SAVINGS**

The demonstration was expected to achieve energy consumption reductions of 15 percent across a portfolio of participating buildings. Electricity and natural gas savings were both eligible to meet the 15 percent target. Please see the Appendix section at the end of this profile for graphs on initial findings.
BUILDING CHARACTERISTICS AND BASELINE INTERACTIONS

The demonstration targeted customers based on kW peak demand. It was open to various building types, such as office, grocery, library, and municipal buildings, that tend to be “well-behaved” in that their operations are fairly consistent. The goal was to test how well the regression models could work with different building types. In general, PG&E was looking for a steady-state building rather than a building where use is erratic.

Overall, it was more difficult than expected to know which buildings would fit the models well. A library in the demonstration was very consistent in terms of its load when open, but the model fitness was mediocre—greater than 20 percent NRMSE for all five tools, because of high variability in night loads in the baseline period and suspected poor quality, spiky data as described in the next section. However, the final stacked ensemble output lowered the NRMSE below 20 percent. Another site had an atypical event, which is expected to negatively impact model fitness, but the tools worked well, with some achieving better than a ten percent NRMSE.

The demonstration worked with a growing tech company in an office building in Silicon Valley. During the demonstration, there was a huge decrease in the building’s energy consumption, and PG&E found that the company had shut down a big section of their lab and shifted it to another location. This example highlighted the fact that analysis of interval data to check the regression model is a necessary step. It is also important to check the facts on the ground to identify non-routine events in order to understand interactive effects as well as key anecdotal information, such as whether the customer is growing or how their operation is changing. PG&E is still working to understand what makes a well-behaved building when it comes to regression analysis. One irony: while well-behaved buildings may make the best candidates for credible modeling, it is likely that poorly-behaved buildings have the most potential for improving energy use through efficiency projects. Once modeling issues are tackled to the satisfaction of key stakeholders, the industry can tackle those tougher potential projects.

Pilot Findings

Analytic tools used
Two proprietary data analytic tools and three open source tools

Energy data intervals used for modeling and analysis
15-minute kWh interval data is rolled up to hourly increments to match weather data feeds and daily intervals are used to track natural gas consumption

Meter data challenges
• Flow—Internal process to access data
• Consistent approach to cleaning data to address gaps and zero reads

M&V challenges
Consistent processes to identify and document non-routine events (NREs) and make NRE adjustments, as well as estimating gas savings under IPMVP Option C
BIGGEST CHALLENGE WITH DATA COMMUNICATION OR INTEGRATION

The biggest challenge was the internal processes to access customers’ energy data, as AMI is built for billing, not for energy efficiency programs. There were instances where meters went down and vendors did not get any of the gas data over an extended stretch during the performance period. Addressing that lack of functional expertise and access to data internally would be two priorities that would need to be addressed in order to scale meter data programs.

Another significant challenge was that the interval data provided by PG&E to their program vendors, implementers, and evaluation consultants did not cover the full time period being investigated. Some data were incomplete, containing empty intervals and duplicates. Additionally, there was a problem of anomalous spikes in usage, both zeros and non-zeros, which affected both baseline and performance period data. Data that could not be validated should have been clearly identified and tagged before it was released. Initial investigators suggest that most of these interval data issues are attributable to an API used to pull the data initially; this investigation was ongoing at the time this report was being completed.

BIGGEST M&V CHALLENGE

1. Non-routine adjustments have been a significant challenge for savings M&V. The demonstration used IPMVP Options C (whole building) and D (simulation), and the default was to use Option D to get into the savings results and update the building simulation inputs to net out the impacts of the non-routine adjustments. PG&E is researching the extent to which Option C may be used to assess and account for the impacts of non-routine adjustments.

2. Should savings be based on typical meteorological year (TMY) or actual weather during the performance period? This question will need to be answered based on the requirements in place within each jurisdiction. Within the State of California, energy efficiency savings goals are based on TMY.

3. Estimation of natural gas savings may be challenging under Option C, at least for mild or warmer climates. For half of the customer sites, NRMSE was beyond model fit thresholds the program would like. Study team members have often found excellent fits for gas models at other sites, so the reasons for issues here are under further investigation. The program may use Option D for gas savings, at least for sites with poor Option C model fits.
4. Data provided to vendors and implementers was not uniformly retained with project documentation to ensure that the same data can be provided to evaluators, who will be looking to reproduce the results from the vendors and implementers. Ultimately, it would be most helpful to evaluators if they were given sufficient confidence in the completeness, validity, and consistency of the data, minimizing the need for guessing about its quality.

ADDITIONAL LESSONS LEARNED

**Lessons learned about Option C models** The different open-source and proprietary Option C models that were investigated performed similarly when estimating electric savings. The various Option C models, using different algorithms and developed by different vendors, generally showed consistent estimates of electricity savings. The models showed statistically identical estimates for 80 percent of the site-model combinations; the estimates overlapped within the range of uncertainty for one of the public models, and the uncertainty band was narrow, with savings uncertainty typically under ten percent.

**Lessons learned comparing Option C and Option D models** There were greater differences between the Option C and Option D estimates. The reasons for these differences are still being researched, but they include lower accuracy (bias) with Option D simulations, inclusion of non-routine adjustments for Option D but not Option C, some differences in the meter data used as model inputs, and differences in project dates.

**REMAINING QUESTIONS OR BARRIERS** What analytical tools are acceptable for programs to use? Proprietary tools pose problems, because the program regulator cannot open them up and replicate what the tool does. This forces programs in California to use open source tools. Fortunately, the study has shown fairly consistent results between the better open source tools and the proprietary tools.
Appendix

The figures below demonstrate some of the initial demonstration findings, summarizing the electric, gas, and total savings at each site. Final electric savings were calculated from hourly models, while gas savings were calculated from daily models.

Figure 7. Percent Total Energy Savings with Confidence Intervals

Figure 8. Percent Electric Energy Savings with Confidence Intervals

Figure 9. Percent Gas Energy Savings with Confidence Intervals
PROGRAM OVERVIEW

Commercial Strategic Energy Management

Program Objectives and Success

Puget Sound Energy (PSE) developed this program in response to significant energy savings potential in large commercial and institutional customers, particularly for operational improvements. Puget Sound Energy’s Commercial Strategic Energy Management (SEM) program seeks to develop an internal resource within those large organizations to promote energy efficiency projects and develop management systems to drive and sustain operational efficiencies.

PROGRAM ADMINISTRATOR OBJECTIVES
- Generate long-term energy savings pipelines from large commercial customers
- Better understand the persistence of operations, maintenance, and behavior savings

CUSTOMER AND MARKET OBJECTIVES
Developing an internal resource to promote energy efficiency practices within the business structure of large portfolio PSE customers, as well as improving energy performance through operational and maintenance practice improvements.

PROGRAM SUCCESS LOOKS LIKE...
Achieving savings targets of 14 million kWh and 500,000 therms per year, and happy customer participants.

Program Details

The Commercial SEM program is designed to help customers manage energy across a large site or many different sites. It provides energy management training for participants, incentives for savings achieved, and a training allowance to support customers in improving their energy management skills. Participating customers also receive a startup incentive to complete:
• A resource management plan outlining the overall energy plan for an organization and detailing the policies that aid energy conservation efforts, including HVAC operating schedules, temperature set points, and lighting
• A facility action plan, a living document that lists energy savings opportunities at a given site, including operational and maintenance changes and capital upgrade opportunities

In return for the startup incentive and plans, the program requires that customers designate an active energy manager. This energy manager provides quarterly documentation to PSE about what is going on at each site and maintains the two plans. Puget Sound Energy also brings customer energy managers together to talk and share best practices.

Each customer SEM engagement is for a three-year period, with an option to renew. Currently, the program has several participants that have renewed four or five times and achieved their savings target for each period. Customer incentives and training allowances are calculated annually and based on savings achieved: $0.02/kWh and $0.15/therm achieved in a given year, up to a target based on a five percent total consumption reduction (three percent in the first year). Customers are incentivized to go beyond their target by increasing the incentive to $0.035/kWh and $0.25/therm for savings beyond the target.

Measure cost is difficult to quantify for operational savings, so the program assumes the salary of a full-time energy manager as the measure cost and caps the total incentive amount at 70 percent of an energy manager salary. This assumed measure cost is associated with a portfolio of customer facilities totaling 20 million kWh or an equivalent mix of kWh and therms of energy consumption. The cost can be prorated up or down based on the customer’s actual portfolio. For example, a customer with an energy portfolio of 20 million kWh and a full-time energy manager would have a savings goal of five percent for an average year in the program. This amounts to a one million kWh savings goal, for which the customer could be incentivized 1,000,000 kWh x $0.02 = $20,000 (prorated based on the size of the customer’s portfolio). When the customer meets this savings goal, they additionally receive a target incentive of $20,000. Thus, by meeting their savings goal in a given year, they effectively cover 50 percent of the assumed cost of an energy manager working full-time on the portfolio. This percentage
could reach an incentive of 65 to 70 percent of the energy manager salary with a savings goal of ten percent.

ROLE OF UTILITY METER DATA AND ANALYTICS
Interval meter data are used to enable participants to visualize and track their energy performance. For electrical use, data are shown in 15-minute intervals, while data for natural gas are shown in hour intervals. Electric and gas interval data are used to allow PSE staff to track progress and monitor energy use to engage customers to determine what is happening in the building. Interval data and analytics are also used to map documented energy savings actions against performance, to demonstrate that the observed energy savings are the result of program activities.

Daily energy consumption data are used to develop the model baseline and measure savings because 15-minute and hourly interval data are not of high enough quality and contain too much noise to be useful for those purposes. At sites for which the program does not have good occupancy data, daily data is “rolled up” to one-month increments to smooth out weekends and holidays.

ENERGY ANALYSIS TOOLS OR SERVICES USED
Puget Sound Energy developed a software tool, My Data Manager, that visualizes a customer’s energy performance data across their participating sites. My Data Manager includes invoice data and daily meter data from customer meters, as well as interval data when possible. Through this tool, customers are provided with graphs and comparisons of performance across different time periods or sites. The tool can also generate a CUSUM graph to visualize energy performance against baseline and energy savings achieved over time. For Puget Sound Energy, the tool allows program staff to normalize for heating and cooling degree days and estimate energy savings achieved.

MEASUREMENT AND VERIFICATION APPROACH
The Commercial SEM program uses the following minimum criteria for model fitness and savings uncertainty:

- Confidence: 80 percent or greater
- R squared: 75 percent or greater
- Model fitness: CV(RMSE): 20 percent or less
- Fractional savings uncertainty: Ideally, 50 percent or less

Fractional savings uncertainty tends to be high for SEM and other programs that claim only operational savings, as these savings are a smaller share of
total consumption. The result is that fractional uncertainty is greater. Ultimately, the program uses engineering judgment to determine model fitness when statistics show marginal criterion.

PSE develops a model baseline and will use that baseline until it is no longer accurate. If the building is very well-behaved (meaning that it shows a good model fit) and has a consistent energy manager, that baseline may be used indefinitely and the building baselines will only be recalculation as needed.

In cases where a baseline model that meets the criteria above cannot be developed, such as a site with very constant consumption, the actual baseline year consumption data is used as the comparison point in place of a model baseline. For these sites, the energy performance drivers are assumed to be constant year over year. Buildings that commonly fall into this group are municipal facilities like fire stations, museums, and baseball fields.

Each energy conservation measure is expected to impact savings or persist for three years. After this time, if a measure continues to provide savings, PSE can once again pay an incentive on the measure. For example, one customer matched the HVAC system to the building occupancy schedule. After three years, if the building is still showing savings from the HVAC schedule, PSE can again justify savings based on the action. This amounts to an incentive for the action so long as it continues beyond three years, and rewards customers who continue to have savings through energy conservation.

Customer energy managers provide PSE program staff with quarterly documentation, including capital projects completed, occupancy changes, changes to occupied hours, HVAC schedules, holiday schedules, and other information. Program participants are provided with a documentation template, but participants are allowed to report in other formats if they are already doing so for another administrator, such as the City of Seattle’s Energy Benchmarking Ordinance. The reporting requirement can be a struggle for some customers, as it requires time that some participants do not have available. Puget Sound Energy is considering ways to make the reporting aspect easier, while still enabling the program to account for the savings observed each year; to separate operational savings from capital measures; and to have

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**Program Findings**

**Expected savings**

13% reduction in total energy consumption over 3 years; customers have the option to renew after 3 years to achieve 15% reduction in years 4-6

**Average savings achieved**

14 million kWh and 500,000 therms annually

**Criteria for savings uncertainty and model fit:**

- **Confidence** >80%
- **R²** >75%
- **FSU** <50%
- **CV(RMSE)** <20%

**Analytic tools used**

My Data Manager, an in-house energy data visualization tool
confidence that the savings achieved derive from energy management activities and not from changes in occupancy or space use, such as a lab being moved to another building.

Program Findings

ACHIEVED SAVINGS
Historically, this program has achieved around 14 million kWhs and 500,000 therms of savings annually. The goal is to continue these savings numbers with the current level of customer participation and budget.

BUILDING CHARACTERISTICS AND BASELINE INTERACTIONS
Customer billing history provides a strong indication of whether or not a building has good model fitness. As the program scales up the number of sites served each year, it may be forced to rely more on rigid participation criteria around model fitness—currently the program requires a lot of engineer time. Schools and municipal buildings tend to be well-behaved buildings, in part because these space types are more constant in their consumption profiles, whereas fire stations, museums, and athletic fields generally are not. Commercial office space adds the complication of accounting for non-routine adjustments, such as changes in space use or occupancy.

BIGGEST CHALLENGE WITH DATA COMMUNICATION OR INTEGRATION
1. **Increasing the rigor and accuracy of savings estimation and analysis** The program is improving its accuracy by adding occupancy data to the models and incorporating daily meter data for 1,200 sites over 60 different customer portfolios.

2. **Providing consumption data to customers** Puget Sound Energy provides a data visualization tool for participants, but most already have their own energy information system. PSE has found that providing energy consumption interval data to customers with their own data analysis or visualization tools can be a challenge, as these tools often have different requirements for data formatting. The PSE tool works like a tunnel into the Puget Sound Energy data system, effectively automating the transfer of interval meter data. Data transfer has to be done manually for customers using a third-party energy information system, which often requires significant time.
BIGGEST M&V CHALLENGE
Evaluating operations, maintenance, and behavior change savings is tricky. An approach that seeks to match the impact of individual actions with meter savings does not work well when the savings are a small percentage of total energy use. Another tricky M&V issue is calculating measure life for this program. The small sample size and continued participation of customers makes it difficult to calculate persistence of savings.

ADDITIONAL LESSONS LEARNED
- **Software is not the silver bullet that program administrators are hoping for.** In the commercial SEM program, customers do not use the energy information platform as much as program staff would like, unless the user is an active energy manager.
- **The energy manager is critical to maintaining savings persistence.** Puget Sound Energy has found that a shift in focus within a business, or staff turnover of the energy manager position, can negatively impact the business’s energy management.
- **The personal touch is very important.** Program participants appreciate the sense of community among peer energy managers. In many cases, customer organizations only have one energy manager position, and these individuals do not have peers within their organization. Providing a network for them across program participants is valuable and appreciated.

REMAINING QUESTIONS OR BARRIERS
1. How can the rigor and accuracy of savings estimates be improved?
2. How can the program be more proactive with customers by monitoring their performance data and providing a notification if something unexpected is observed while simultaneously scaling the number of customer sites served?
3. How can the program provide a network for energy managers not only within the Puget Sound Energy territory but regionally or nationally?

Program Findings
**Evaluation metrics used**
Energy savings achieved, types of measures implemented, customer satisfaction

**Evaluation completed**
Yes
PROGRAM OVERVIEW

Deep Retrofit Pay for Performance

Program Objectives and Success

Seattle City Light (City Light) developed the Deep Retrofit Pay for Performance program to achieve deeper savings of 15 to 30 percent in large commercial buildings, as well as to lower transaction costs with large customers by implementing one program with multiple measures rather than multiple capital programs. The program aims to save time and cost by using the whole building approach (IPMVP Option C) to verify measure savings. This program complements the existing Seattle City Light energy efficiency program portfolio, as it provides customers the opportunity to achieve savings through capital measures as well as operations, maintenance, and behavior. By contrast, the Retrocommissioning program focuses on operations and maintenance measures. Further, City of Seattle considers many operational and maintenance measures to be code according to the recent tune-up ordinance. The Deep Retrofit Pay for Performance Program enables customers to achieve savings from multiple measure types with a greater emphasis on capital measures, enabling customers to capture savings from difficult-to-quantify interactive effects.

PROGRAM ADMINISTRATOR OBJECTIVES

- Achieving kWh savings
- Streamlining engagement for customers
- Supporting customer implementation of long-term capital improvement programs

CUSTOMER AND MARKET OBJECTIVES

- Achieving deeper savings in commercial buildings through continued program engagement of three to five years
- Improving customer experience by focusing holistically on results achieved, not validation of individual efficiency measures

PROGRAM SUCCESS LOOKS LIKE...

Increased customer engagement and energy savings of 15 percent (from capital improvements) or more. Metrics have not yet been established to evaluate the program, but City Light expects the primary focus to be on kWh savings achieved.

Organization Details

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Basic Program Details

Launch date July 2018

Type Resource acquisition

Approach Building performance optimization

Objectives

- Achieve deeper energy savings
- Streamline customer engagement
- Workforce development

Eligible measures

- Capital
- Operations and maintenance
- Behavior
Program Details

Prior to the launch of the Deep Retrofit Pay for Performance Program, City Light piloted the same approach with three commercial office buildings (please note that the “Program Findings” section responses are based on this pilot and not the Deep Retrofit Pay for Performance Program). The program launched in July 2018 after finalizing the incentive design and gaining legislative approval to extend authority to execute incentive agreements beyond its current two-year limit. The 2018 cohort targets commercial buildings greater than 50,000 square feet with at least one year of 15-minute interval data. Building energy consumption must be stable and suitable for regression modeling. Participants apply for the program by engaging a service provider and developing a three- to five-year capital investment plan to achieve a minimum of 15 percent energy reduction over baseline. City Light reviews the proposed plans and assesses savings estimates to make sure they are realistic. The program also develops an existing conditions baseline for the building if the customer has not provided one already.

There are currently 15 to 20 candidate buildings in the pipeline for this program. Because the participant pool is small, program staff is able to evaluate applicants individually; participant screening criteria are therefore inexact. The key criterion is access to 15-minute electric interval data through either the utility meter or a building management system, of which there are only several hundred among Seattle City Light customers.

The program relies on energy service providers such as Ameresco or McKinstry, which are retained by the program participants to develop and implement a set of capital measures, to achieve the energy savings target of 15 percent or more. The program does not prescribe particular target measures or systems. Measure identification and development are left up to the participant and their service provider. Behavioral, operational, and maintenance savings are eligible for incentive funding, but incentives were developed based on the expectation that the majority of energy savings will come from capital measures.

City Light’s incentive design for this program was developed with input from stakeholders and support from a third party, and provides

Basic Program Details

Customer characteristics
Commercial customers with buildings greater than 50,000 sq ft, interval consumption data, and a symmetrical profile in terms of occupancy and other routine adjustments to correlate energy consumption

Scale: 15-20 buildings

Duration of engagement
Three to five years

Incentive structure
Pay-for-performance, with two models or tracks: Persistence Model and Tiered Model
customers with two options after the completion of the 12-month implementation period to install measures:

1. Persistence model—$0.08/kWh of savings achieved annually for a term of three years; incentives are based on cumulative savings compared to the original baseline
2. Tiered model—Annual incentives starting at $0.18/kWh; the baseline resets each year and will increase in steps once cumulative kWh savings achieved is >15 percent of the original baseline (+$0.02/kWh per 5% reduction >15%)

Each of these incentive options includes assumptions about the proportion of capital measures versus O&M measures. Incentives are based on an average expected measure life of 12 years. Completed efficiency measures will be tracked by the utility to maintain the emphasis on capital improvements.

ROLE OF UTILITY METER DATA AND ANALYTICS
Fifteen-minute interval data is used to provide performance feedback to program participants and their service providers. Daily intervals are used for baseline model development and savings measurement. Using daily data has helped to sort out the noise observed in 15-minute data from regular temperature and occupancy changes.

ENERGY ANALYSIS TOOLS OR SERVICES USED
City Light is still determining how energy analytics tools and services are used in the program. Pilot participants choose their own analytics tools or service providers. City Light is examining the ECAM (Energy Charting & Metrics) Excel add-in tool as a potential option. City Light is also working with Lawrence Berkeley National Lab on tool criteria and “algorithms/tool components” that could be incorporated into a third-party tool for use by a program participant.

MEASUREMENT AND VERIFICATION APPROACH
Seattle City Light will use an approach primarily based on the 2012 IPMVP Option C (whole building) for savings measurement and verification. A normalized savings approach will be used, and the approach to estimate uncertainty leverages ASHRAE Guideline 14 and Bonneville Power Administration (BPA) M&V Protocols, given the expected changes to IPMVP 2018. City Light has engaged a third party to draft M&V Guidelines specific to its program. The current M&V plan calls for quarterly review of energy savings throughout the performance period. M&V will not be completed on a measure-by-measure basis but will require a summary report of measures.
completed, in progress, and planned. Documentation of measure costs, both capital and personnel, is required. City Light will maintain its own regression model for each participant, utilizing the same inputs as the participant-maintained model, to verify that participant-generated savings calculations fall within the program's acceptable range of savings for the building.

Program Findings (Based on Initial Pilot)

EXPECTED AND ACHIEVED SAVINGS
Customers in the 2018 program cohort are expected to achieve minimum energy savings of 15 percent over baseline from capital projects. Pilot participants achieved savings ranging from 12 to 21 percent compared to baselines; they did not have a specific energy savings target but were required to propose a rough plan of the measures to be implemented and expected savings.

BUILDING CHARACTERISTICS AND BASELINE INTERACTIONS
Buildings with steady consumption and a symmetrical profile in terms of occupancy and other routine adjustments generally show the best model fit. In the three-building pilot, weather and occupancy data were used for the energy model inputs. Occupancy was defined as the percentage of rentable floor area under the lease, which was updated monthly.

BIGGEST CHALLENGE WITH DATA COMMUNICATION OR INTEGRATION
Keeping the data flowing has been the biggest challenge. Due to the small number of participants in the pilot and program, City Light is able to spend time pulling energy use data for individual participating customers. As AMI meters are deployed in the service territory and customer participation increases, the current time-intensive process may be insufficient to meet scale. There is work being done internally to improve efficiency program access to customers’ interval data—the current system was designed for billing, not for program analysis of customer data.
BIGGEST M&V CHALLENGE
The use of regression analysis and whole building energy modeling was new to some of the service providers during the pilot, and additional time and support was needed to help these providers in the whole building analysis. As City Light transitions to a whole building approach across more programs, developing training for service providers is necessary to ensure they can manage whole building analyses and tools. Currently, City Light is working with the developer of the ECAM tool to improve the capabilities of its staff in whole building analysis.

ADDITIONAL LESSONS LEARNED
Different incentive structures were proposed and discussed with customers and service providers during the pilot, resulting in feedback that customers want. Seattle City Light proposed a deferred payment design with larger potential payments paid three years out and found that customers and providers did not like this structure, and while they were willing to wait for their incentives they very much liked the flexibility of pursuing measures without having to check with the utility.

REMAINING QUESTIONS OR BARRIERS
1. What other building types can this be applied to? The pilot showed that it applies well to large office buildings, and Seattle City Light expects it will work well with hotels.
2. What are the characteristics of a well-behaved building?
3. Which building types work well for this type of approach?
4. How does this scale for other, smaller types of buildings?
PROGRAM OVERVIEW

Public Sector Performance-Based Retrofit High Opportunity Program

Program Objectives and Success

Recent regulatory changes in California have enabled Southern California Edison to develop and test new program approaches, including the Public Sector Performance-Based Retrofit High Opportunity Program (HOP). Two key regulatory changes include: 1) California Assembly Bill 802 (AB 802), which directed utility program administrators to use whole building energy consumption data collected from the utility meter as the basis of energy savings measurement and verification across several program types, and 2) the California Public Utility Commission creation of a new High Opportunity Program or Project (HOPP) designation to enable program administrators to test new savings strategies in markets with high savings potential.

PROGRAM ADMINISTRATOR OBJECTIVES

- Test utility meter data-driven whole building program strategies and savings measurement approaches to better understand these types of projects and how they would fit into the broader savings portfolio, including understanding the following questions:
  - How should IPMVP Option C be applied in practice—what constitutes best-practice whole building M&V?
  - How should non-routine events be identified and addressed?
  - What is the appropriate duration of customer engagement?
- Achieve cost-effective energy savings, meeting a target of 11,517,453 kWh and 1621 kW
- Address market barriers unique to the public sector and encourage persistent energy savings through ongoing feedback and measured performance

CUSTOMER AND MARKET OBJECTIVES

- Streamline the application process by merging multiple program offerings—Retrofit, Behavior, Retrocommissioning, and Operational (BRO) and Weatherization and Add-On Equipment measures—into a unified program
- Support the University of California system, which has shown a strong interest in monitoring-based commissioning projects to reduce facility energy consumption and advance the UC system’s objectives to achieve carbon neutrality by implementing comprehensive, deep energy retrofits to individual buildings
PROGRAM SUCCESS LOOKS LIKE...
Meeting energy savings targets and learning from successful projects. If successful, the HOP will result in improved processes for customer engagement and savings measurement and verification and will inform future programs.

Program Details

The Public Sector Performance-Based Retrofit HOP utilizes whole building measurement and verification strategies to capture stranded energy savings within public sector facilities. Southern California Edison is focusing on public sector buildings because they tend to be susceptible to delayed improvements and indefinitely repaired equipment, making them ideal candidates for energy efficiency improvements. The program is intended to complement current customer energy savings goals by allowing participants to track savings and ensure long-term performance of energy efficiency investments while supporting customers’ economic goals and Climate Action Plans (CAPs).

The HOP targets buildings that have not previously been comprehensively retrofitted or commissioned and with some of the following characteristics:

- 30 years or older
- 40,000 square feet
- Have system-level control (for HVAC and other processes)
- Have the majority of the space conditioned
- Include lab space
- > 2,500 operating hours per year
- Are not designated for major redesign or reuse
- Include equipment currently operating beyond its useful life

The HOP offers comprehensive building optimizations in an effort to maximize savings generated at the meter through measures such as behavior, capital, operations and maintenance, and commissioning. Participating customers are required to complete at least one capital retrofit or measure with a payback greater than two years, and the portfolio of installed measures must reduce total facility electricity consumption by at least ten percent. SCE coordinates with Southern California Gas Company’s HOPPs program to track both electric and
gas savings and incentives, with SoCalGas providing incentives of $1 per therm at three months and $1.50 per therm at 12 months.

The SCE Public Sector HOP includes performance-based incentives capped at 80 percent of the project cost (sum of both electric and gas incentives). Incentive payments are made to the participants at intervals of three months, 12 months, and 24 months after project implementation, according to the schedule below:

- 3-Month Payment = $0.12 x Estimated Gross kWh Savings (at 3 Months) + $200 x Estimated Gross kW Peak Reduction (at 3 Month) x 40%
- 12-Month Payment = $0.12 x Estimated Gross kWh Savings (at 12 Months) + $200 x Estimated Gross kW Peak Reduction (at 12 Month) x 80% - 3-Month Payment
- 24-Month Payment = $0.12 x Estimated Gross kWh Savings (at 24 Months) + $200 x Estimated Gross kW Peak Reduction (at 24 Month) x 40% - 12-Month Payment – 3-Month Payment

Through key interventions, the program will interact with the public sector to reduce or eliminate market barriers and gaps, specifically:

- Providing technical support to assist resource-constrained customers to identify savings opportunities
- Metering or sub-metering, combined with performance monitoring, to drive greater energy efficiency by showing the direct ongoing economic impact of measures in existing buildings; limited visibility of individual building energy costs can be improved by providing meter-based feedback that helps determine whether energy savings goals are being achieved in a persistent fashion
- Educating maintenance staff to understand and track performance through data metered at the building level; participants will compile and document data to determine if savings persist

**ROLE OF UTILITY METER DATA AND ANALYTICS**

Potential participants are screened based on the presence of an interval meter. For buildings with interval meters, benchmarking tools are used to determine how efficient the building is compared to similar building types and use. For buildings without interval meters, participants and program staff must have confidence that the cost of building-level metering installation, in addition to the time spent collecting baseline data, will generate sufficient return on their metering investment.
The participant baseline is derived from either utility revenue meter data or non-revenue-grade sub-meters. Meter data is used to support the development of the baseline and for measurement and verification using other parameters that predict energy usage, such as temperature ranges that cover 80 percent of the heating and cooling values for the year.

ENERGY ANALYSIS TOOLS OR SERVICES USED
The Universal Translator tool was used in developing baseline models. Portfolio Manager and customer end use surveys (CEUS) are used for customer screening.

MEASUREMENT AND VERIFICATION APPROACH
Ongoing monitoring of program related savings will continue for two years for all measures, and annual energy savings are calculated using IPMVP Option C. Given that most public entities have internal maintenance programs, HOP implementers will measure savings directly and provide feedback to participants to help them manage their energy and ensure that savings persist. Participants that choose to rely upon their internal maintenance programs will be required to submit a full description of their program before approval. Any monitoring beyond year two will be determined through ex post evaluation, monitoring, and verification. Program participants are responsible for notifying SCE of any non-routine events by submitting a detailed narrative describing the changes that have occurred and the duration of the event. A revised baseline model will be developed to assess any major deviations from the post-installation usage pattern.

Program Findings

EXPECTED SAVINGS
The HOP seeks to achieve a minimum ten percent reduction in whole building electricity consumption for each building served (the first stage includes just one building). In total, SCE estimates that the program will achieve 11,517,453 kWh and reduce 1,621 kW over four years.
BUILDING CHARACTERISTICS AND BASELINE INTERACTIONS

Based on the experience of SCE’s Monitoring-Based Commissioning Program, the primary load driver in public sector buildings is heating and cooling. Intermittent high plug loads can be challenging to model, and therefore difficult for whole building program approaches. High fluctuation in building occupancy is also challenging from a modeling perspective. Buildings with relatively low plug load and consistent occupancy are generally a good fit for program approaches that rely on a baseline energy model.

BIGGEST CHALLENGE WITH DATA COMMUNICATION OR INTEGRATION

Public entities’ campuses are frequently master metered, without building-level metering, but in order to effectively manage energy usage building- or system-level data is critical. However, the cost of building- or system-level submetering can be prohibitive for program participation.

The HOP is also running into an issue with integration across energy information and controls systems. For example, the University of California Santa Barbara campus is using the Skyspark energy analytics platform, but the campus facilities need better controls capabilities to be able to use the full capabilities of the analytics.

BIGGEST M&V CHALLENGE

Sites that have multiple energy meters and energy flows require a much more robust M&V plan that is informed by detailed understanding of the building loads, schematics, and operation. Sites with single meter applications that do not take chilled or hot water from a central plant are preferable candidates.

ADDITIONAL LESSONS LEARNED

Requiring 12 months of energy consumption data, which was used to develop the model energy baseline, meant that customers who needed additional submetering could not be addressed because the data collection would add 12 months to the engagement. This has limited the number of sites that could be considered for enrollment in the program. Research studies from Lawrence Berkeley National Laboratory and other organizations have demonstrated that viable baseline models can be built using less than 12 months of data. Future program designs should consider these models for establishing baselines in situations where data is not available.
REMAINING QUESTIONS OR BARRIERS
1. How do projects and savings progress over time? How do savings mature or degrade over time?
2. Peak reduction is important, and peak hours are shifting in California. How that will be managed is an open question for this program.

Program Findings
Evaluation metrics used
Total resource cost, net to gross savings, realization rate for individual projects with bundled measures

Evaluation completed
No