June 10, 2015

From: Philippus Willems, Ryan Kroll

To: Dan Rubado, Evaluation Project Manager, Energy Trust of Oregon

Re: Review of Commercial SEM Savings Methods

The purpose of this memo is to present the results of the PWP/Michaels Energy team's review of methods used to calculate and report savings from the Commercial SEM program and develop recommendation to help standardize that process.

Background

The evaluation team completed interviews with Energy Trust program staff as well as with both of the program delivery contractors (PDCs) currently delivering Commercial Strategic Energy Management (SEM) – Strategic Energy Group (SEG) and CLEAResult (formerly Triple Point Energy). From discussions with both groups, we obtained feedback regarding current methods, potential changes, and the impact of recommendations made in the second SEM evaluation report, which was published in December 2014 and can be found at:
http://assets.energytrust.org/api/assets/reports/141202_SEMReport.pdf

There is a solid basis for using regression to estimate savings using billing data, and the technique is called out in International Performance measurement and Verification Protocol (IPMVP) as Option C: Whole Building Analysis. However, IPMVP notes that for Option C "billing analysis is appropriate when:

- Savings are above noise—that is, the estimated energy savings are greater than at least 10% to 20% of the monthly utility bill being analyzed.
- There is a high degree of interaction between multiple measures at a single site.
- The energy conservation measure (ECM) improves or replaces the building energy management or control system.
- The ECM involves improvements to the building shell or other measures that primarily affect the building load (e.g., thermal insulation, low-e windows).
- The measurement of individual component savings is not relevant.
- Other approaches are too expensive."

While SEM meets several of the above criteria, expected savings from SEM fall far below the 10-20% threshold noted, which suggests that caveats in applying regression analysis must be scrupulously adhered to, with any deviations thoroughly documented. That fact underlies several of our recommendations for standardizing the application of this approach to Commercial SEM. In addition, it is important for the analysis technique to be applied as transparently as possible, so that participants, Energy Trust staff, and program evaluators can readily see how savings were calculated and what assumptions were made.

For this research, we examined the following aspects of the savings estimation and reporting process:

- Selection of the baseline period

- Specification of the model
- Selection of measurement period and extrapolation of results
- Linking of results to specific SEM actions
- Reporting of savings to participants and to Energy Trust

Findings are presented below. It should be noted that recommended approaches include some that are current practice in some cases; however, the goal of the recommendations is to standardize impact assessment methods so that best practices are used, with any deviations thoroughly explained and documented.

Baseline period

Recommendations:

1. The baseline period should cover at least 12 months immediately before participation
2. If a different baseline period is selected, the reasons should be thoroughly documented

Discussion:

The baseline period is meant to capture the relationship between weather and usage under standard operating procedures before a customer becomes involved in SEM. Ideally, this would cover about 24 months of billing data that reflect a time period when there were relatively few external factors affecting usage, such as equipment retrofits or significant changes in building use or occupancy. Unfortunately, the more months of data are included, the more likely the influence of external factors. Even if more than 12 months of data are available, they should not be used unless there are at least 24 months, to ensure that no time period is overrepresented.

We recommend that the baseline period for the savings analysis cover either the 12 or 24 months immediately preceding participation, with participation defined as the time when initial actions to assess and address savings opportunities are undertaken. In other words, merely signing the paperwork to enroll in the program would not mean that practice would be expected to change and savings observed, so if a participant enrolls in October and attends a kickoff event in November, both October and November could reasonably be considered part of the baseline period. This should mean a greater likelihood that the "participation" billing data will actually reflect program savings.

There have been instances where a PDC chose to use a period other than the 12 months immediately preceding participation because another 12 month period appeared to provide a clearer relationship between weather and energy usage. However, we believe that any exclusion of a period of time within what would normally be the baseline period requires a detailed explanation. If several months of data are not reflective of true "baseline" usage, that should be called out and explained. If a regression using the 12 months prior to participation yields inferior results to those for an alternate baseline period, both sets of results should be presented; e.g., the 12 months prior to participation could not be made to yield better than an R^2 of 0.65 and t = 1.9, while an alternate baseline ending 6 months earlier yielded a regression with an R^2 of 0.9 and t = 2.15. Simply stating that the alternate baseline provides a "better" fit is not sufficient.

In addition, if there are reasons why the 12 months immediately prior to participation are not representative of typical operations, those reasons (i.e., the anomalies in operations) must be discussed in detail to show why the post-participation period would not also be affected.

It should be noted that while a high R^2 is desirable as an indication that the model strongly reflects the operation of the building, the selection of the baseline period based on the R^2 value can result in periods being selected that are consistent, but may not be representative of the operation immediately prior to the SEM actions.

In some cases, deviation from the consistent operation may be an indicator of changes to variables not included in the analysis that need to be incorporated to increase accuracy. For example, a building at 50% occupancy may have very predictable energy usage based on heating degree days and cooling degree days only. However, if the occupancy level increases or decreases, the energy consumption predicted by the original analysis will no longer be correct and will not be the correct basis of comparison for going forward.

Specification of the model

Recommendations:

1. Use the minimum number of variables needed to obtain a good fit, including variables that reflect the influence of heating and cooling, as well as other relevant variables (e.g., occupancy, schedule) that vary over the baseline period.
2. Use analytical tools such as stepwise regression or Lasso to ensure that the most powerful explanatory variables are entered first and error is minimized.
3. Variables should be defined so that the causal relationship between the independent (weather and other) variables and energy usage is clear to the participant and can be used to calculate savings in the future
4. Pooled models and standardized building type models are not recommended at this time.
5. Interval data should be used only for customers with the resources to interpret and update models developed with such data.

Discussion:

There are a number of documents[1] that specify good practice in the use of regression models to estimate energy savings, and we do not make specific recommendations that differ from the general guidelines those documents offer.

In general, the model selection procedure should be simple to apply and produce consistent, repeatable results. Selecting the "best" model can be done depending on the goodness of fit as measured by the R^2, coefficient of variation of the normalized annual consumption (i.e., CV(NAC)) or coefficient of variation of the root mean squared error (i.e., CV(RMSE)). We do not specifically recommend any one of these measures, but do encourage PDCs to use several of these criteria when evaluating alternative models.

[1] See, for example, Annex D to "ASHRAE Guideline 14-2002, Measuring Energy and Demand Savings"

More importantly, the final model should "make sense" to customers; that is, the variables should be defined so that the causal relationship between the independent (weather and other) variables and energy usage is clear. Similarly, while the use of interval data can help provide a more refined model, it is important that the final specification employs data that customers have access to so that they can continue to update the savings Cumulative Sum (CUSUM) results after the engagement ends. The independent variables should be readily available to individual customers and their sources (e.g., US Weather Service data from PDX) identified in the write-ups provided to customers and Energy Trust with the model results.

The use of pooled models or standardized building type models does have some potential advantage for simplifying the analysis in some cases. However, both of these approaches removed the ability to easily identify causality between SEM actions and capital projects and the resulting savings on the usage for the specific building, which is a fundamental goal of SEM programs. Therefore, neither of these approaches is recommended at this time.

In some cases, the use of interval data can show the effects of SEM activities more quickly and reliably than the use of monthly billed data. By increasing the number of data points, this approach can increase the number of unique variables that can be incorporated in the model, which can significantly increase model accuracy. However, the use of interval data can greatly increase the time required for analysis and can increase the work required to collect the data to include each variable, which would make customers less likely to perform the consistent updating of all model variables. Additionally, not all variables may be available on as granular of a level, and estimation may be required, which would add uncertainty to the analysis. Therefore, the use of interval data is not recommended except for customers who thoroughly understand the analysis, have access to the required data, and are willing and able to update the model regularly.

Selection of measurement period and extrapolation of results

Recommendations:

1. Eliminate the current practice of extrapolating partial-year results to an annual savings estimate and replace it with a calculation of cumulative, measured savings at the end of the first 12 months of participation.
2. If Energy Trust decides it wants to claim annual savings, use a rule of thumb, such as the result of a linear extrapolation of monthly savings, divided by 2 (e.g., 4 months of savings would be multiplied by 1.5).

Discussion:

One of the most challenging aspects of calculating savings by PDCs has been the extrapolation of savings for a few months to an annual estimate. In most cases, there are three or at most four months of post-participation usage data available to reflect SEM actions taken by program participants; moreover, those months typically fall during the summer (cooling) period, and may not be typical of overall operation over the course of a year. PDC analysts do their best to adjust the limited savings data to reflect non-cooling months by extrapolating using typical meteorological year (TMY) data and professional

judgment, but there is clearly no way to accurately predict heating season usage based on cooling usage data.

We recommend that the current approach for the annualizing of savings, described in the evaluation report referenced above, be discontinued. Instead, we would recommend that the measurement period used to determine the claimed savings for the program be the 12 month period following the initiation of SEM activities. The claimed first-year savings are then savings calculated using the CUSUM analysis for the first full year after SEM activities are initiated. Similarly, billing data for the next 12 months would be used to calculate second year savings from additional SEM actions taken after the initial engagement ends. This approach eliminates any extrapolation of savings and the uncertainty associated with current annual savings estimates. Because many participants have as few as three months of post-SEM bill history and rarely have more than six months of data at the time savings are currently estimated, extrapolation of these data is inherently inaccurate, as discussed above.

We recognize that deferring calculation of annual savings poses challenges from a programmatic standpoint. Specifically, this approach will provide a one-year disconnect between the costs associated with SEM and the resulting savings. If the savings must be claimed in the same year as costs for program cost-effectiveness or other factors, then we recommend a rule of thumb approach like that described in recommendation 2, above. This would still free PDC analysts from the time consuming task of annualizing savings and may allow more time to be spent on other activities.

Linking of results to specific SEM actions

Recommendations:

1. To enhance the value of the savings analysis to participants, link reductions in billed usage to SEM activity through enhanced communication with the participant.
2. Work with participants to develop proactive project strategies and timelines
3. Incorporate both operational and behavioral activities in the variance log or other record of actions

The most challenging aspect of linking energy savings to SEM actions has been the lack of consistent tracking of SEM activities completed at participant sites. For many participants, activity tracking is not occurring until the CUSUM analysis identifies savings, which causes the participant and the PDC to go back through maintenance records or discuss what has happened at the facility to try to append the actions to the result. This retroactive tracking of actions is even more difficult when the participant has multiple buildings or multiple maintenance or other staff involved in the SEM process. Each person will often act independent of the other staff and have a different threshold or idea of what activities should or should not be entered into the variance log or otherwise tracked.

To reduce this, several strategies are recommended. First, we suggest that the participant should be contacted frequently, especially early in the SEM participation period, to provide guidance on how SEM-related operational changes should be documented.

Second, we would recommend that during those frequent check-ins there should be more discussion of identified needs or upcoming potential activities. By discussing these activities prior to completion, the

PDC can cement in the participant's minds which activities are SEM related and need to be recorded to help create an appropriate feedback loop linking activities to savings.

Finally, customers should be encouraged to report not just adjustment and changes to building operations (e.g., schedules, setpoints), but also education/information campaigns that seek to influence occupant behavior. Meetings of energy management teams that are formed or active during most SEM engagements are often used to discuss or promote such activities, and the minutes of team meetings could serve as a useful source of input on non-operational changes that could be linked to the savings analysis.

Reporting of savings to participants and to Energy Trust

Recommendations:

1. Improve reporting to participants to include alternate ways of presenting savings that are more recognizable to the participant.
2. Differentiate the reporting of savings from non-SEM capital projects between participants and Energy Trust to minimize participant confusion, and provide participants with a detailed explanation when SEM savings are reduced by these capital projects.

The most significant challenge in reporting savings to participants has been the difficulty for customers to understand and quickly interpret the CUSUM graphs. Specifically, PDCs said that some customers find it hard to interpret that the expected savings for SEM activities are represented by changes in slope in the CUSUM graph.

Customers generally seem to find it easier to understand savings when these are presented in charts comparing actual usage to modeled baseline usage, and we recommended that such alternate graphs be included in the customer reports. We note, however, that this graph does not present cumulative savings, so the CUSUM graph should not be eliminated. However, it should clearly present the cumulative savings as the area under the curve and not require interpretation based on the differences in slopes.

The reporting process is also complicated by participants who have completed capital projects during the SEM baseline or analysis periods. Especially for custom calculated projects, there can be a significant disconnect between the savings claimed for the projects and the savings seen on the bills. If claimed savings for capital projects are greater than those observed in the billing data, the SEM savings analysis can lead to negative savings attributed to the SEM program.

While claimed savings from capital projects clearly need to be netted out of the SEM savings analysis to ensure consistency for reporting for Energy Trust, providing the total combined savings for both projects is important to provide the positive feedback loop that SEM seeks to provide. In addition, the analysis could present the realization rate associated with that specific type of capital project and explain how that would affect the "residual" SEM savings. Presenting negative SEM savings out of context may give the customer an incorrect assessment of the impacts of their actions, and could lead them to take incorrect actions as a result. For calculating program incentives, the SEM savings as reduced by savings associated with capital projects will still need to be presented; however, both in the savings report to the participant and in subsequent discussions, the PDCs can make sure that they discuss the interactions between the savings claims for the two programs.

MEMO

Date: October 5, 2015

To: Energy Trust of Oregon Board of Directors

From: Kathleen Belkhayat, Commercial Sector Project Manager

Subject: Staff Response to the Review of Commercial Strategic Energy Management Savings Methods

The purpose of this memo is to document next steps for savings recommendations made by PWP/Michaels Energy team in their review of methods used to calculate and report savings from the Commercial Strategic Energy Management program. For each of the areas covered, Energy Trust will take the following actions.

- Baseline period and model specification: Recommendations will be taken and documented for program delivery contractors in a Commercial SEM modeling guidelines document.
- Savings measurement period: Energy Trust will move from projecting annual savings, based on a few months of measured savings, to directly measuring savings for each complete year, without doing any projections.
- Identifying and documenting SEM actions: Energy Trust will work with the SEM program delivery contractors to continue to find ways to encourage documentation of SEM activities and make documentation easier for participants.
- Reporting savings to participants: Energy Trust will work with the SEM program delivery contractors and SEM curriculum developers to streamline tools and provide any additional tools to make savings more well-defined for the participant and easier to present to their stakeholders.