Does SEM Achieve Verifiable Savings? A Summary of Evaluation Results

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ABSTRACT

The first strategic energy management (SEM) program was launched in 2005, creating an approach to facility energy efficiency similar to the Lean Six Sigma method to process efficiency. Since then, SEM programs have evolved and more program administrators are offering variants of SEM. In 2014, at least 12 SEM programs were offered in North America, excluding initiatives and certifications available through the U.S. Department of Energy and International Organization for Standardization 50001 (CEE, 2014a). Many SEM programs are relatively new, and only a handful have reported—much less verified—energy savings due to the challenges in quantifying savings. Some program administrators considering SEM are hesitant to implement programs without more evidence that savings are verifiable and sustainable.

This paper begins to address these barriers by outlining the variations in SEM program designs, identifying the challenges to quantifying energy savings, presenting evaluated savings for four SEM programs, proposing strategies for improving the likelihood that savings are quantifiable, and summarizing research in the pipeline.

Introduction

Strategic energy management (SEM) programs create an approach to managing energy similar to the Lean Six Sigma method[1] to process efficiency that makes sense to industrial facility operations managers. SEM is a holistic approach to reducing energy intensity over time, and includes efficient equipment upgrades, improvements in process efficiency, operations and maintenance best practices, and behavioral changes. There was not a standard definition for SEM until 2014, when the Consortium for Energy Efficiency (CEE) published their criteria for the minimum SEM activities of customer commitment (e.g., setting a goal, dedicating staff), planning and implementation (e.g., conducting an energy audit, implementing energy projects), and measuring and reporting energy performance. CEE based these criteria on common activities across existing SEM programs (CEE, 2014b).

Program Design Elements

Three program administrators in the Northwest have led the research and development of SEM programs, and all three have long-standing programs. The Northwest Energy Efficiency Alliance (NEEA) implemented the first SEM program in 2005. Energy Trust of Oregon and Bonneville Power Administration (BPA) followed, both implementing programs in 2009. Since the first program was implemented 10 years ago, SEM programs have evolved and more program administrators are offering variants of SEM. In 2014, there were at least 12 SEM programs being offered (CEE, 2014a), which differed widely in delivery strategies and incentive

[1] For more information about Lean Six Sigma, see http://www.leansixsigmainstitute.org/#!what-is-lss/c18pr

offerings. The most common design elements of SEM programs are summarized in Table 1 (Cadmus 2012; CEE 2014a).

Table 1. Common SEM Program Design Elements

Program Design Element	Common Strategies
Length of Engagement with Participant	Length of participation can be either: • A defined period of participation for 1 year up to 5 years • An undefined period of participation typically up to 5 years; customers receive support until they have the tools and processes in place to continue on their own
Incentive Structure	All programs provide technical support and coaching; some also provide financial support, in the form of one or more of the following: • Annual incentive based on savings (e.g., $0.02 per kWh savings) • Annual co-funding for the energy manager salary, can be based on savings goals or achieved savings • Bonus incentives when savings goals are met
Type of Customer Engagement	Programs provide one or both of the following types of engagements: • One-on-one interaction with an SEM advisor who provides coaching • Regular meetings and trainings attended with the energy managers from other participating facilities (cohort model)
SEM Activities	Programs typically provide SEM technical support and coaching that includes the following activities, though the emphasis on specific activities may vary between programs or between facilities in the same program: • Assign an energy manager • Assemble an energy team that meets regularly • Gain support from senior management • Conduct an audit, set a goal, and develop a plan to meet that goal • Implement energy projects • Track energy performance • Measure the reduction in energy intensity and progress toward goal • Report to senior management and employees on progress

Challenges in Quantifying Energy Savings from SEM Activities

The Northwest program administrators report SEM energy savings, which are verified by a third-party evaluator. Outside the Northwest, SEM programs are still relatively new, many are in the pilot phase, and few have reported savings due to the challenges and costs of quantifying savings.

The most common method to quantify energy savings for SEM participants is by conducting a regression analysis (IPMVP Option C) to calculate whole-facility savings. This is the most effective method since SEM involves behavioral activities, operations and maintenance activities, and efficient equipment upgrades. If participants received rebates for equipment or custom measures during the same time period as their participation in the SEM program, the savings associated with those measures are subtracted from the whole-facility savings to avoid double-counting those savings in both programs.

The independent variables in the regression model typically include facility production, weather, and other documented drivers of energy use. The model includes an indicator variable for the participation period and variables can also be included to account for the energy efficiency activities implemented during the baseline period or during the participation period if an engineering savings estimate was not available. Using a regression analysis to quantify SEM savings presents two main challenges:

- Savings must be large enough to be detected over the noise in the energy consumption data, and the uncertainty around the savings can be large.
- If a facility undergoes renovations, changes in product mix, changes to facility hours or shifts, or other significant changes during the baseline or program participation period that impacts energy consumption but were not due to the program, it can be difficult or impossible to control for those changes separately from changes attributable to the SEM program.

Despite these challenges, three program administrators in the Northwest were able to establish methods to identify and report savings.

Evaluated Energy Savings Results

In 2014, there were at least 12 SEM programs offered in North America excluding initiatives and certifications available through DOE and ISO 50001 (CEE, 2014a). Due to the fact that many programs are still quite new, verified energy savings were available for only four of the programs. The authors used the results from these programs as the basis for the analysis presented in this paper.

In reviewing the results, the authors noted that different programs' evaluators report verified savings in different units. The most comparable metric across programs is the electric savings as a percentage of consumption, as this is normalized for the number and size (in terms of energy use) of program participants. In addition, only one the BPA evaluation reported the confidence intervals around the results. We recommend all evaluations report savings as a percent of consumption and include the 80% confidence intervals with 20% precision around the results.

Table 2 presents the electric savings from industrial SEM programs that have undergone an impact evaluation and have publically available results, with savings converted to a percentage of consumption. Energy Trust achieved energy savings of 8% of baseline consumption (Navigant, 2013). NEEA's and BPA's programs achieved verifiable energy savings ranging from 1% to 5% of baseline consumption. BPA's and Energy Trust's results are representative of savings achieved during participants' first year implementing SEM. NEEA's savings results are across a different mix of facilities in each year, which may be at different stages of SEM implementation. Lastly, the evaluation results for NEEA's Industrial Initiative show that participants continue to achieve savings even after several years in the program (ERS, 2012 and DNV KEMA, 2014).

Energy Trust is showing higher savings than BPA and NEEA, and this is likely due to the differences in methodology for determining savings. Energy Trust quantifies energy savings by comparing energy consumption at the end of the engagement year to energy consumption before the engagement year (after controlling for weather and facility production). BPA and NEEA compare energy consumption from the *entire* engagement year to the energy consumption in the year before the engagement year. During the first year of engagement, facilities typically undergo a ramp up period where they begin to incorporate SEM practices and not many activities have been completed yet. BPA and NEEA do not need to exclude the ramp up period since they are engaging with customers for multiple years and activities implemented at the end of year 1 may not be fully captured in year 1 savings, but will be captured in year 2 savings. However, Energy Trust excludes the ramp up period since they only engage participants for one year.

Table 2. Evaluated Annual Electric Savings from SEM Programs

Program	Program Year(s) Evaluated	Number of Facilities	Evaluation Sample Size (Facilities)	Average Annual SEM Electric Savings as a Percentage of Baseline Consumption*	Source
NEEA's Industrial Initiative	2013	9	9	1.21%	DNV KEMA, 2014
	2011 - 2012	9	9	1%	DNV KEMA, 2014
	2010	13	11	2.9%	ERS, 2012; Correspondence with NEEA; Only includes food processing facilities
	2009	15	13	4.2%	
	2008	15	13	4.7%	
	2007	15	13	2.3%	
	2006	5	4	0.8%	
NEEA's Small to Medium Sized Industrial Facility SEM	2011 – 2013	10	10	1.2%	Energy 350, 2014
BPA's Energy Management Pilot	July 2010 – June 2011	HPEM: 15 T&T: 2	HPEM: 15 T&T: 2	2.7% ± 0.8%**	Cadmus, 2013
Energy Trust of Oregon's SEM	2009 – 2011	34	18	8%	Navigant, 2013; Correspondence with Energy Trust

* Savings are net of any projects that received incentives from other programs.
** At 80% confidence and 20% precision

Recommendations to Improve Likelihood of Detecting Savings

There are two main risks that have limited the implementation of SEM programs: 1) uncertainty about whether savings are verifiable, and 2) uncertainty about whether savings are sufficient for the program to be cost-effective. Based on our experience evaluating SEM programs, the following recommendations improve the likelihood of detecting savings and address both of these risks.

Evaluability Assessment. Program administrators who are new to implementing SEM programs should collaborate with an experienced SEM program implementer or evaluator early in the program design phase to understand and identify the specific data needs for quantifying energy savings. Beyond identifying the data to collect, an implementer or evaluator with experience quantifying SEM savings can provide insight as to the types of scenarios where savings may be difficult or impossible to determine and scenarios where the program administrator may need additional customer data or information.

For example, facility renovations may make it difficult or impossible to determine savings from SEM activities. If a facility was renovated within the last year, it may be difficult to establish the baseline if consumption is weather-dependent and the data after the renovation does not cover all seasons. If renovations occur during program participation, it is highly unlikely the model will be able to separate the impacts of the renovation from the impacts of the program SEM activities.

An example of when program administrators may propose collecting additional data is when a facility expects changes to the product mix. For some facilities, energy consumption can be explained by a single variable that represents the production of all products at the facility. However, if the product mix changes and one is more energy intensive than the other, then one single variable in the model will not adequately explain changes in energy consumption due to changes in overall production. In this case, collecting data for each individual product rather than total production would lead to a higher likelihood that the regression model can explain the change in consumption due to the product mix changes. This in turn improves the likelihood that the model can detect the savings due to the program SEM activities.

Anticipating the data needs will help ensure they are collected early on to improve the chance that energy savings can be detected.

Fractional Savings Uncertainty. Fractional savings uncertainty (FSU) analysis indicates whether the time series data—in particular, the frequency and series length—are sufficient to detect the expected (*ex ante*) savings at a particular significance level. A site's FSU is the ratio of the uncertainty about the savings to the total savings. It depends positively on the coefficient of variation of the regression root mean square error and the expected savings as a percentage of total consumption, and it depends negatively on the number of observations in the baseline and test periods. A lower FSU indicates that savings are more likely to be detected.

Program implementers could conduct an FSU analysis of new program participants to test whether the currently collected data are sufficient to detect savings. If the analysis shows that data are not sufficient, the implementer can work with the participant to improve the likelihood of detecting savings by collecting data more frequently, incorporating submetering on specific processes that drive energy consumption, or through other methods. Alternatively, the program administrator and customer could determine it is not worth the additional effort or expense to collect these data and terminate participation in the SEM program. This is a valuable process since it reduces the risk of investing in a site where it is unlikely that savings can be quantified. From the customer's perspective, if the program incentive is based on achieved energy savings that must be quantifiable, it is best to set their expectations around data needs early on.

BPA uses FSU analysis with new program participants. The evaluation of BPA's Energy Management Pilot shows the FSU analysis result compared to the energy savings result. The evaluation confirmed that facilities with statistically significant and positive energy savings tended to have a smaller FSU. Facilities with lower frequency data (e.g., monthly or bi-monthly) tended to have higher FSU than facilities with higher frequency data (e.g., daily or weekly). Also, the results showed it is possible to detect savings at sites with a high FSU if the savings are larger than expected (Cadmus, 2013).

Energy Management Information Systems. Higher frequency (daily or weekly) billing data and production data provide a higher likelihood that savings can be detected than monthly data. Collecting data more frequently could provide increased certainty in energy savings and decrease the confidence interval range. Energy management information systems (EMIS) could play a future role in SEM programs, being used to collect data more frequently and to provide more immediate feedback that improves measurement, tracking and reporting, and savings verification. Some EMIS have the functionality to automate a user-specified regression model that calculates and reports savings to the customers and program administrators. EMIS also offers additional benefits to customers that could help them achieve greater energy savings, such as the ability to manage energy by sending alerts when usage is outside a defined range.

Accept Some Uncertainty. As it is unlikely that an SEM program would cause an increase in energy intensity, following the above recommendations will minimize the number of facilities where the regression analysis results in no savings or an increase in energy use (after controlling for weather and production). However, even if the recommendations above are followed, there will likely still be a few facilities for which the regression model shows no savings, shows an increase in energy use, or is missing key inputs and the change in energy consumption cannot be explained. However, there is a high likelihood that overall program results will show savings. And, summarizing results at the program level should overcome any positive or negative bias in individual facility results.

Conclusions and Future Research

All of the evaluated SEM programs achieved energy savings ranging from 1% to 8% of baseline consumption. Additionally, the evaluation results for NEEA's Industrial Initiative show that participants continue to achieve savings during each year in the program. The Northwest programs have demonstrated that that savings are quantifiable, however there is still more to learn. Savings estimates are likely to improve as these programs grow and there are more facilities participating for more years.

These programs had success in quantifying energy savings by learning from NEEA's pioneering discoveries, by working with experts in econometric modeling, and by collaborating to share lessons learned. In particular, BPA worked with a program evaluator with econometric modeling expertise to conduct an evaluability assessment and document data needs prior to implementing their program. BPA also utilizes the FSU analysis when engaging with new participants.

The Northwest program administrators are now moving forward with research to investigate the following questions:

- Which program design is most cost-effective?
- Which program design leads to the longest persistence of savings? Does savings persistence depend on the customer's SEM maturity?
- How do savings change from year-to-year during a customer's participation in a SEM program?
- How do savings change from year-to-year after a customer's participation in a SEM program?
- Does continued practice of particular SEM activities lead to greater savings or longer savings persistence?

NEEA is beginning to support an SEM infrastructure to continue market transformation and begin to collect the necessary data to research these questions.[2]

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[2] For more information visit NEEA's website: http://neea.org/initiatives/industrial/commercial-and-industrial-sem-infrastructure

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