Success Factors for Utility-Sponsored Strategic Energy Management Initiatives

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ABSTRACT

Strategic Energy Management (SEM) is an emerging program concept with significant potential for new and sustained energy savings in commercial and industrial environments. The goal of SEM is to achieve energy savings through low-cost efficiency improvements, usually through operation, maintenance and behavioral changes. A common question asked by organizations considering SEM is: "What are the key program success factors?" This paper examines that question by identifying and quantifying the success factors associated with end-customers' energy savings as a consequence of their involvement in the sponsored SEM program.

The antecedents to successful energy savings considered in this study include degree of engagement by executive sponsor, energy champion/energy team and employees, together with involvement with data analysis, number of energy-saving projects implemented, and size of the organization's energy team. The sample for this study is drawn from 124 industrial participants in programs sponsored by Energy Trust of Oregon, Bonneville Power Administration and AEP Ohio and delivered by CLEAResult from 2009 to 2014. Our study found that the most important SEM program success factor is energy-saving project implementation, followed by (in decreasing order of impact) measuring, targeting and reporting (MT&R)/data engagement, energy champion/team engagement, and general employee engagement. Degree of executive sponsor engagement and size of the energy team did not have a statistically significant effect on program savings. The range of energy savings attributable to SEM programs ranged from zero to 19.9%. The average first year annualized SEM program savings was 4.8% of total energy use, and the median was 3.6%.

Introduction

CLEAResult's SEM delivery includes the standard SEM program elements as defined by the Consortium for Energy Efficiency (CEE 2014). The standard SEM program approach is to bring eight to fourteen industrial customers into a peer support network (cohort) and then work with them (via an energy coach) using a structured approach to help adopt a continuous improvement process for energy management. The process includes a series of group workshops and one-on-one activities with each end-customer designed to achieve the following objectives:

- Establish organizational commitment, which includes setting a savings goal, ensuring an executive is committed to sponsoring the initiative, and assigning appropriate accountability and resources within each end-customer's organization.
- Collect and analyze data to allow construction of a predictive energy model, covering a pre-SEM baseline period to provide the organization with feedback on progress during the program and to measure the accumulated energy savings attributable to the program.

- Establish a long-term continuous energy improvement process to identify, track, prioritize and implement opportunities. These may include capital projects in addition to operational and maintenance (O&M) improvements. This long-term process typically consists of employee engagement (suggestions, recognition, etc.), energy scans (Kaizen events) and a multi-year energy audit or assessment plan, among other elements.
- Create a strategic plan and a process to sustain the effort. The strategic plan reviews progress, revises energy reduction goals and identifies new activities to achieve established goals.

Initial questions from SEM participants and program sponsors are often focused on key SEM program success factors. Specifically, with limited organizational resources, where does it make sense to focus time and effort to maximize energy savings from a SEM engagement? To answer that question, this study explored a SEM implementation database accumulated through our program delivery experience between 2009 and 2014 involving 124 industrial companies in programs sponsored by Energy Trust of Oregon, Bonneville Power Administration and AEP Ohio. All programs were delivered using similar scheduled events, materials and tools. Furthermore, the measure of program success used in this study is participants' percent of electricity saved in the first year due to their SEM engagement.

SEM Programs

This study includes results from three SEM program sponsors:

- **Energy Trust of Oregon –** Since 2009, Energy Trust's SEM offerings have helped industrial facilities change their culture and business practices in order to gain significant energy savings. The main focus is to shift how each organization's facilities department and management team views energy use. Through these programs CLEAResult has assisted over 98 facilities in SEM engagements.
- **Bonneville Power Administration –** CLEAResult has implemented BPA's Energy Smart Industrial High Performance Energy Management (HPEM) program since 2010. To date, CLEAResult has delivered or is in the process of delivering the HPEM program to over 45 SEM participants. HPEM is a comprehensive SEM cohort-based program that includes an intensive first year SEM curriculum as well as follow-up MT&R statistical analysis tracking and SEM maintenance activities for up to five years.
- **AEP Ohio –** AEP Ohio started a Continuous Energy Improvement (CEI) program in 2013. This program applies continuous improvement principles and practices to energy for customers. CEI is a multi-year program that offers a comprehensive SEM delivery to large industrial companies across multiple cohorts throughout Ohio.

Sample Description

Data were compiled from 162 sites representing 124 companies across 24 industries in Ohio, Oregon and Washington that participated in sponsored SEM programs. Thirty-four sites either did not complete the SEM program or did not have energy savings data available at the time of analysis and were excluded from the sample, providing 128 sites for analysis. The sample included 69 sites from Energy Trust of Oregon programs, 22 sites from Bonneville Power Administration and 37 sites from AEP Ohio. All of the companies focused primarily on electricity savings and secondarily on natural gas savings. For consistency across sponsors, natural gas models were excluded from the study and all of the regression models used to estimate program savings were for electricity only. Median annual energy consumption on a per site basis at the start of the SEM program was about 14 million kWh. Company industry distribution is shown in Figure 1.

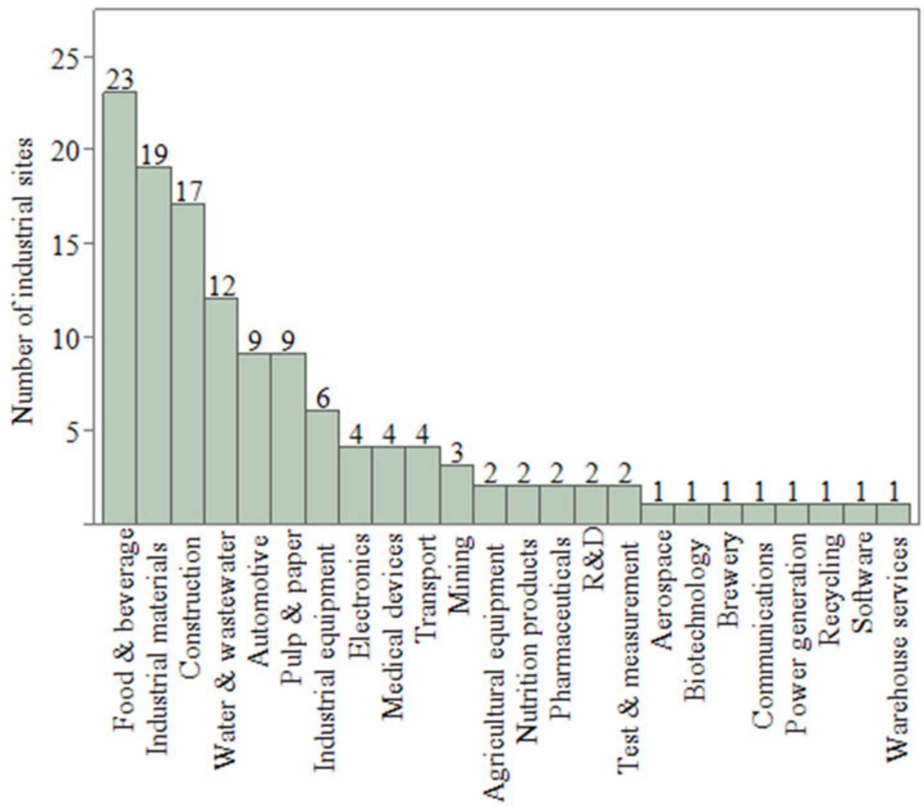

Figure 1. Distribution of companies by industry

Model Development

The energy savings attributed to the SEM programs included in this study were estimated from statistical models. The model's envelope (or system boundary) generally encompassed the entire industrial site, which ranged from a single building to a large campus of many buildings. Each model was based on historical and current metered energy use provided by the utility plus any on-site energy generation data from the industrial firm itself. Typically, two years of total energy use prior to the SEM program is used to calibrate each site's baseline model. The model's energy estimates commonly use production, weather and other relevant variables specific to the site. Program energy savings were calculated by subtracting actual energy consumption from the pre-SEM value predicted by the model. All savings reported in this study are first year SEM savings, excluding savings attributed to site capital projects. If a program included multiple years of engagement, only the first year of savings was included. The number of months from which savings was annualized varied across program sponsors.

The models used to estimate each participant's program savings were constructed using the same basic design process and criteria. Each was developed using the well-established method of ordinary least-squares linear regression. This technique's application to energy modeling is described in *ASHRAE Guideline 14-2002,* Annex D: Regression Techniques. As summarized in that publication:

> *Linear regression is the process of finding a "best fit" straight-line equation between a dependent variable [energy] and one or more independent variables [predictors]. It assumes that variations (residuals) from the straight line are random and normally distributed. Then the best fit is one that minimizes the sum of the squares of the residuals.*

The sample size of each model varied depending upon model frequency (sub-daily, daily, weekly or monthly). Monthly models had the smallest sample size, typically 24 months. Weekly or daily models typically included 104 weeks or 730 days of baseline data. The largest single category in our sample was monthly (44%), followed by weekly (34%) and daily (21%) models. Sub-daily models constituted the remainder.

Model development usually employed stepwise regression as a starting point, followed by successive manual changes to the model's specification to identify a model with good predictive performance and a reasonable number of predictors given the available sample size. The distribution of each variable in the model was examined for suitability in regression modeling. A time series plot of each variable was analyzed. Outliers were investigated on a univariate basis (through examination of standardized Z-scores) and on a multivariate basis through analysis of Cook's distances and leverage plots (partial regression plots) to identify any excessively influential cases. The strength of association between variables was evaluated using bivariate correlations as well as partial correlations and associated scatter plots.

The performance of each model was assessed through a variety of statistical measures including overall fit (R^2), coefficient of variance, autocorrelation of the regression residuals, X-Y plot of actual versus predicted values and a time series plot of actual versus predicted values superimposed. The residuals (prediction errors) were examined for normality (via an omnibus normality test) and to identify outlier predictions. The residuals were also examined graphically for statistical homoscedasticity (equal variance) across the range of predicted energy values. Furthermore, the cumulative sum of the residuals (CUSUM) was plotted as a time series to evaluate the model's predictive consistency.

Method

This study uses a series of ANOVA analyses to explore the relationship between program-related energy savings and SEM success factor levels. ANOVA (analysis of variance) is a statistical technique that identifies differences between group means. In the context of this study, the groups are the various levels of each SEM success factor (i.e., low, medium and high). Program-related energy savings were estimated with the regression models described above. Levels were assessed by the SEM energy coach most familiar with the program participant. Specific definitions of levels (Table 1) were used to promote uniformity of assessment across energy coaches.

Table 1. Levels of SEM program success factors

Program success factor	Low	Medium	High
O&M projects implementation	Long list on Opportunity Register	Prioritized projects	Proactive in completing projects
MT&R/Data engagement	Proactive with getting model data	Enthusiastic about getting model working accurately	Proactive with updating model
Size of energy team	1 or 2 members	3 to 5 members	6 or more members
Energy champion/ team engagement	Held effective team meetings regularly	Enthusiastic about saving energy	Reached out to all departments
Executive sponsor engagement	Aware of program and supportive	Active in supporting team and overall engagement	Proactive in engaging employees and rest of executive team
Employee engagement	Employee awareness of initiative	Effective communications boards	Employees joined in to save energy

Six ANOVA tests were performed. All six tests share a common dependent variable (DV): electrical energy savings. An assumption of ANOVA testing is normality of the DV. The distribution of the DV was examined and statistically transformed so that it would conform to the normal (bell-shaped) distribution as closely as possible. Another underlying assumption of the ANOVA technique is equality of variance across groups (homogeneity of variance). We used Levene's test to check each of the six SEM success factors for homogeneity of variance. We also examined the distribution of the transformed energy values for the presence of outliers.

Each ANOVA test produces an *F*-test statistic that indicates if the group means differ in a statistically significant manner. If the group means were found to differ (i.e., kWh savings was different at differing levels of engagement), then follow-up tests were performed to identify which specific groups differed from one another. We wished to compare all possible pairings of groups (e.g., Low versus High, Medium versus High, etc.) for their effect on energy savings. Multiple comparisons of this kind risk inflating the likelihood of Type I errors (erroneously concluding that there is an effect when there is not). Consequently, we used the Tukey-Kramer HSD *t*-test to control for Type I error inflation. The HSD (honestly significant difference) test adjusts the *p*-values to account for the fact that multiple comparisons are being made. We chose to use the conventional maximum alpha level of 0.05 as our threshold for statistical significance.

Results

This section begins with a description of the overall energy savings attributed to the SEM programs. It then explores the effect on savings associated with different levels of specific SEM program success factors. The section concludes with a rank-order comparison of the success factors' relative impact on energy savings.

Overall Electricity Savings

Annualized energy savings attributed to sponsored SEM programs ranged from none (0%) to a high of 19.9%. Average energy savings was 4.8% (standard deviation = 4.1%) and the median savings was 3.6%. Figure 2 shows the distribution of energy savings in terms of program participants' percentage of total annual electricity use. The shape of the distribution of savings percentages shown in Figure 2 is highly skewed and does not follow the bell-shaped normal distribution. This observation was confirmed by the Shapiro-Wilk test for normality which yielded a *p*-value of < 0.0001, rejecting the test's null hypothesis that the data are normally distributed. To better satisfy ANOVA's normality assumption, the dependent variable (kWh savings) was transformed by taking its square root. The transformed distribution is shown in Figure 3.

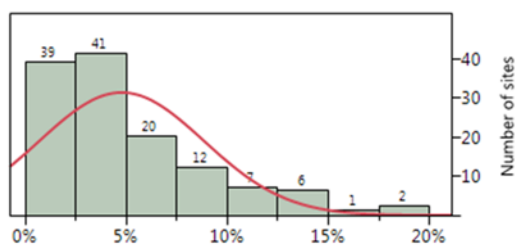

Figure 2. Annualized energy savings

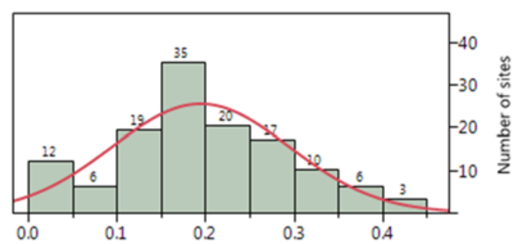

Figure 3. Square root of annualized energy savings

The normality test was rerun to judge the success of the transformation. The results of the Shapiro-Wilk test yielded a *p*-value > 0.05, leading to the acceptance of the test's null hypothesis that the transformed data are normally distributed. The transformed energy values were then checked for the presence of outliers. An outlier is indicated if a Z-score is outside the range of ± 3.0 standardized units. We computed standardized values (Z-scores) for each energy savings figure. The Z-scores ranged from -1.95 to +2.51. Each ANOVA test was preceded by Levene's test. Levene's test checks to make sure that the ANOVA assumption of equal variance across groups (e.g., low, medium and high engagement levels) is satisfied. The data passed this test in each case.

The statistical tests that follow (ANOVA *F*-statistics, *t*-statistics and all *p*-values) were conducted on the transformed data. All energy savings figures are in actual kWh.

Effect of O&M Projects

Degree of O&M project engagement was categorized into one of three groups or levels: low, medium or high engagement per the criteria shown in Table 1. Table 2 reports the average energy savings for each level of O&M projects. The ANOVA test showed that savings differed depending upon projects implementation level: $F_{2, 125} = 22.14$, $p < 0.0001$. The savings difference between high and low levels was 5.20 percentage points and was statistically significant ($p = < 0.0001$). The savings difference between medium and low levels was 2.98% and was statistically significant ($p < 0.0001$). The savings difference between high and medium levels was 2.23% and was statistically significant ($p = 0.0127$). Table 3 summarizes the foregoing differences.

Table 2. Savings by level of projects implementation

Implementation level	Number of companies	Mean savings
Low	22	1.58%
Medium	63	4.55%
High	43	6.78%

Table 3. Differences from projects implementation

Difference in implementation	Energy savings difference	*t*-test *p*-value
High versus Low	5.20%	< 0.0001
Medium versus Low	2.98%	< 0.0001
High versus Medium	2.23%	0.0127

Effect of MT&R/Data Engagement

Table 4 reports the average energy savings for each of the MT&R/data engagement levels. The ANOVA test showed that savings differed depending upon engagement level: $F_{2, 125} = 6.73$, $p = 0.0017$. The savings difference between high and low engagement levels was 3.64 percentage points and was statistically significant. The savings difference between medium and low engagement levels was 2.86% and was statistically significant. The 0.78% savings difference between high and medium engagement levels was not statistically significant. Table 5 summarizes the foregoing results.

Table 4. Savings by level of MT&R/data engagement

Engagement level	Number of companies	Mean savings
Low	12	1.74%
Medium	40	4.60%
High	76	5.38%

Table 5. Differences from MT&R/data engagement

Difference in engagement level	Energy savings difference	*t*-test *p*-value
High versus Low	3.64%	0.0011
Medium versus Low	2.86%	0.0072
High versus Medium	0.78%	0.7978

Effect of Size of Energy Team

Table 6 reports the average energy savings for each of energy team size category. The ANOVA test showed that program savings did not differ depending upon size of the energy team: $F_{2, 125} = 0.27$, $p = 0.7658$. That is, the savings differences shown in Table 6 were not statistically significant. When a non-significant ANOVA result is obtained, follow-up pairwise comparisons of the means are not performed.

Table 6. Savings by size of energy team

Team size	Number of companies	Mean savings
Low	32	5.20%
Medium	67	5.13%
High	23	4.29%

Effect of Energy Champion/Team Engagement

Table 7 reports the average energy savings for each of the energy champion/team engagement levels. The ANOVA test showed that program savings differed depending upon engagement level: $F_{2, 125} = 7.32$, $p = 0.0010$. The savings difference between high and low engagement levels was 3.52 percentage points and was statistically significant. The savings difference between medium and low engagement levels was 2.26% and was statistically significant. The 1.25% savings difference between high and medium engagement levels was not statistically significant. Table 8 summarizes the foregoing differences.

Table 7. Savings by level of energy champion/team engagement

Engagement level	Number of companies	Mean savings
Low	18	2.14%
Medium	38	4.40%
High	72	5.66%

Table 8. Differences from energy champion/team engagement

Difference in engagement level	Energy savings difference	*t*-test *p*-value
High versus Low	3.52%	0.0006
Medium versus Low	2.26%	0.0288
High versus Medium	1.25%	0.3888

Effect of Executive Sponsor Engagement

Table 9 reports the average energy savings for each of the executive sponsor engagement levels. The ANOVA test showed that program savings did not differ depending upon the level of executive sponsor engagement: $F_{2,\,125} = 2.13$, $p = 0.1236$. That is, the differences in mean energy savings shown in Table 9 were not statistically significant and consequently follow-up pairwise comparisons of the means are not performed.

Table 9. Savings by level of executive sponsor engagement

Engagement level	Number of companies	Mean savings
Low	48	3.93%
Medium	37	5.45%
High	43	5.64%

Effect of Employee Engagement

Table 10 reports the average energy savings for each of the employee engagement levels. The ANOVA test showed that savings differed depending upon engagement level: $F_{2,\,125} = 5.30$, $p = 0.0062$. The savings difference between high and low engagement levels was 2.66 percentage points and was statistically significant. The savings difference between medium and low engagement levels was 1.90% and was not statistically significant. The 0.76% savings difference between high and medium engagement levels was not statistically significant. Table 11 summarizes the foregoing differences.

Table 10. Savings by level of employee engagement

Engagement level	Number of companies	Mean savings
Low	44	3.30%
Medium	43	5.20%
High	41	5.96%

Table 11. Differences from employee engagement

Difference in engagement level	Energy savings difference	*t*-test *p*-value
High versus Low	2.66%	0.0065
Medium versus Low	1.90%	0.0522
High versus Medium	0.76%	0.7145

SEM Success Factors Comparison

We also examined the relative effect of the significant SEM success factors on program savings by rank ordering their improvement ratios. We define the improvement ratio of each success factor as ratio of the average program savings associated with a high achievement level on the factor divided by the average program savings associated with a low level of achievement on the factor. In this way we see how much savings there is to be gained by striving for a high attainment level on each factor. The results are shown in Table 12 and illustrated in Figure 4. For projects implementation, average SEM program savings was 1.58% for companies with a low degree of projects implementation versus 6.78% savings for companies with a high degree of projects implementation. This difference of 5.20 percentage points represents more than four times the energy savings. Likewise, the effect on energy savings with respect to high versus low engagement by the MT&R/data engagement is a tripling of savings. The improvement ratios for executive sponsor engagement and energy team size are not shown because the differences in energy savings between high and low levels for those factors was not statistically significant.

Table 12. SEM success factors comparison

SEM success factor	Success factor level		Improvement ratio
	High	Low	
Projects implementation	6.78%	1.58%	4.29
MT&R/Data engagement	5.38%	1.74%	3.09
Energy champion/team	5.66%	2.14%	2.64
Employee engagement	5.96%	3.30%	1.81

Percent figures are average annualized SEM program energy savings.

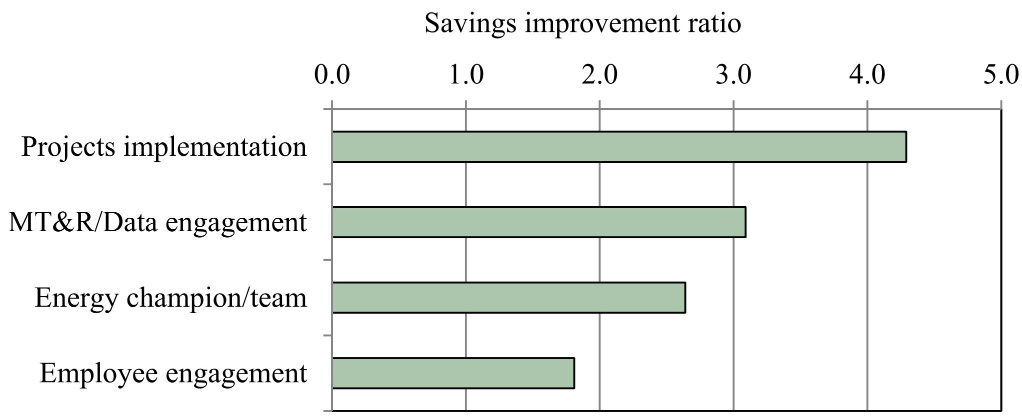

Figure 4. Relative savings improvement from high versus low attainment on SEM program success factors

Discussion

This study shows that several factors are associated with the degree of energy savings achieved through participation in sponsored SEM programs. The ability of these factors to affect energy savings differs considerably. Four of the six factors had a large and statistically significant effect on energy savings, while two factors demonstrated non-significant effects.

As expected, the strongest factor associated with energy savings was project implementation. A higher number of completed O&M projects can be expected to lead to higher savings. This finding supports the idea that the most important element to focus on in the first year of an SEM program is energy saving projects. Although more projects typically result in greater savings, the savings potential of the project is also important. A single high-savings project can be more useful than many low-savings projects.

The second strongest success factor was engagement in energy savings measurement (MT&R data). Mid-level or greater engagement on this factor was a strong indicator that the company will see first year energy savings. A low-level of engagement on this factor was associated with low program savings. A high level of engagement in energy measurement is characterized by updating the MT&R savings estimation model with fresh data on a routine basis, communicating savings to staff, exploring any unexpected results and taking corrective action. Availability of the timely quantitative feedback afforded by an up-to-date MT&R savings estimation model may give teams the information they need to adjust their activities to maximize energy savings.

The third strongest factor was the engagement of the energy champion and energy team. The champion and their team must be engaged and actively involved to drive projects to completion. Often the organization's energy champion is primarily or even solely responsible for completing energy-saving projects. Alternatively, the energy team may divide and allocate responsibilities or employ staff outside of the energy team (e.g., facilities, engineering, management or production staff) to complete projects. In any case, completing O&M projects requires a high level of team engagement, which may explain why the projects implementation factor and energy champion/team engagement factor both demonstrate a high impact on savings.

We found that the level of employee engagement is also indicative of program savings. Sites with low engagement typically do not make an effort to engage employees outside of the energy team in saving energy. Sites with mid-level engagement reach out to some employees outside of the energy team. This level of engagement typically includes announcements at shift meetings, communication via newsletters and emails, or informal communication to managers and employees. At this level of engagement, some energy teams also choose to post signage about energy savings, consumption and/or tips for reducing usage. High employee engagement is characterized by working to engage employees throughout the facility and having an engagement event such as an energy fair, training or similar event.

Our study failed to find a statistically significant difference in program savings as a result of differing levels of sponsor engagement. Companies with low or mid-level engagement appear to achieve roughly similar levels of energy savings as companies that have more extensive sponsor engagement. Nevertheless, our experience suggests that companies with no executive-level involvement do not typically achieve high savings. Engagement behaviors include attending the program kick-off meeting, making program announcements to staff, attending workshops and directly participating in establishing the energy program. The last factor, size of the energy team, also did not have a statistically significant effect on energy savings. Larger energy teams were not associated with higher energy savings. Larger companies do not necessarily have larger teams, nor do they need to, to succeed. This finding suggests that the energy team should be appropriately sized for each company's structure and culture to be successful in SEM.

Conclusions

One of the most important contributions of this study is to separate what influences savings from what does not. Standard practice in SEM program delivery is to push for strong executive sponsorship, large energy teams and deep employee engagement to build support for project completion. In contrast, the results of this study suggest an optimal profile of success factors: a high degree of project implementation, and a moderate or high level of commitment to the use of MT&R energy savings models, energy champion and energy team engagement, and general employee engagement with the SEM program. At least some degree of executive sponsor engagement is needed if only to authorize the program, but neither their engagement nor size of the energy team is predictive of program success.

Although our study did not assess savings after the initial year of program engagement, anecdotal evidence suggests that programs that continue to save energy reach higher levels of executive, employee and energy measurement engagement in later years. Since these elements are much harder to achieve and do not result in higher savings in the first year of engagement, it would be prudent to place more effort on energy team and project engagement in the first year as this will lay the groundwork for additional support and savings to follow.

Acknowledgments

CLEAResult appreciates the importance of the partnerships and individuals who have contributed to the energy programs and SEM offerings from Energy Trust of Oregon, Bonneville Power Administration and AEP Ohio.

Limitations

A limitation of this study is the lack of geographical diversity of the companies in the sample. This concentration was the result of using a convenience sample rather than a nation-wide or internationally-based random sample. This limitation constrains the ability to generalize the study's results across geographies. A second limitation is the use of subjective assessments of the various engagement levels by individuals aware of each firm's energy savings. Because the same individuals judged the levels of all of the success factors, it is possible for the judgments to track one another. A third limitation is that each SEM program was delivered by the same company; this may also constrain the generalizability of the results. Finally, as SEM is still an emerging program, savings used were measured in close proximity to the implementation of the program. Long-term, sustained savings is unknown. A follow-up study focused on long-term effects could offer additional insights into the antecedents of successful SEM programs.

Disclaimer

In no event will CLEAResult (formerly Triple Point Energy, Inc.) be liable for (i) failing to achieve energy savings by using any success factors included herein, or (ii) for any damages to customer or customer's site, including but not limited to any incidental or consequential damages of any kind, in connection with this study or the deployment of any identified energy saving ideas.

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