SEM – Break Down Barriers and the Savings Persist

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ABSTRACT

There are substantial energy savings to be captured in industrial facilities, including savings attributed to behavior changes from Strategic Energy Management (SEM) programs. While SEM programs have been evaluated, there has been little research to assess how long recommended activities persist after engagement and what other benefits utilities and customers gain from participating. This paper integrates findings from a process evaluation that included 53 interviews with program and utility staff members, regional stakeholders, and industrial facility managers, with findings from persistence analyses of 108 measures. These findings explore the mechanisms by which SEM provides benefits to customers and utilities and provide context with field data and analysis on the lifetimes of SEM-initiated activities to investigate persistence and effective useful life of measures.

The SEM program discussed in this paper includes in-depth engagement with industrial facility staff to develop energy management plans and implement measures. While the time commitment required of this engagement can be daunting, participants ultimately find the effort to be valuable. The persistence of measures confirmed that the efforts most valued by participants result in "sticky" changes that remained in place at organizations. In fact, persistence analyses suggested that on average, measures are in place for 8.5 years. The insights we gained through this study and share in this paper will help the industry better understand which activities have lasting impacts on the behaviors of industrial facilities, and the recommendations provide a road map for utilities to better interact with and support their industrial customers.

Introduction

According to semhub, an online resource from the Northwest Energy Efficiency Alliance (NEEA), "Strategic Energy Management (SEM) is a system of organizational practices, policies, and processes that create persistent energy savings by integrating energy management into business practices". As of 2021, there were at least 24 active SEM programs run by utilities or third-parties in North America (Therkelsen et al. 2021), with the estimates on energy savings potential ranging from 6 to 10 percent in the first year of the program, with some savings persisting beyond the first year. There are other benefits for SEM, including increased awareness of energy efficiency and better collaboration with industrial customers. Though there have been many evaluations of SEM programs and their savings across the industry, less attention has been given to persistence, or how long SEM activities remain in place after their initial engagement.

This paper combines two evaluations of the same SEM program to learn quantitatively about measure persistence and qualitatively about other program features. The evaluation objectives were to determine how long SEM-initiated measures are operational after participants leave the program, and to explore barriers and benefits of SEM that may drive success.

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BPA SEM Background

The Bonneville Power Administration’s (BPA's) Energy Management (EM) Program was one of the nation’s first large-scale deployments of a strategic energy management (SEM) program in the industrial sector, having engaged 74 projects as of June 2018. BPA is a nonprofit federal power marketing administration within the US Department of Energy that delivers power to communities across the Northwest. BPA began offering its EM Program to industrial facilities in 2010 as part of a portfolio of energy efficiency programs that BPA, along with its public power utility partners, offers in the Pacific Northwest.[1] Through the EM Program, BPA provides long-term energy management consulting services to educate and train industrial energy users to (1) develop and execute a long-term energy-planning strategy and (2) permanently integrate energy management into their business planning.

An in-depth evaluation of BPA’s EM Program was completed in 2017 and found that SEM savings persisted during the participation period (SBW 2017). However, that evaluation did not address the issue of persistence after the program engagement ended, or the factors that led some programs to be more successful than others.[2] In California, the California Public Utilities Commission (CPUC) estimates a five-year EUL for SEM is five years, but BPA program staff suspected that the program impacts would last longer. In order to claim what was actually happening, they had to initiate a quantitative study of persistence.

Understanding the program delivery mechanisms is key to identifying successful engagements. In this report, we define success as participants retaining their energy management training and contributing to a culture of change in their facilities. We measured this through the persistence of measures, which can lead to more lasting change. In this section, we provide an overview of the delivery of the SEM Program before diving into findings.

Each SEM engagement is a two-year commitment, with savings reported at the completion of each year. There are two key elements of BPA’s SEM Program: 1) energy management plans and 2) support from program implementation staff. Cohort workshops guide participants through the process of identifying and prioritizing energy management opportunities, which they document in their energy management plans.[3] As a component of engaging in SEM, BPA assists facilities in establishing baseline energy usage models and helps participants track energy savings resulting from the energy management activities they undertake. The offering includes a software package called Energy Sensei to help participants track energy savings, although participants can opt for other energy management software packages if they choose.[4]

The cohort approach identifies representatives from industrial facilities and brings them together to participate in workshops. In some cases, cohorts consist of similar types of facilities (e.g., wastewater treatment plants) or facilities with similar types of equipment (e.g., large refrigeration systems), allowing the program implementation team to bring in experts on specific processes or equipment types. In other cases, cohorts may include a more diverse mix of industrial facilities. The cohort approach requires facility representatives to meet regularly to

[1] While BPA does offer SEM to some commercial customers, this paper focuses on industrial SEM only.
[2] In this research, persistence refers to the lifetime of a specific measure listed in the SEM plan, defined as how long the measure continues to be in operation.
[3] Energy management activities may include changes to the way equipment is operated to reduce energy use (operational changes), behavioral changes, and capital improvements.
[4] The Energy Sensei software also includes project management tools to support energy management activities.

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exchange ideas. Often, these meetings are scheduled in a convenient location for all attendees, but during the height of the COVID-19 pandemic, they were moved online for safety.

In addition to energy management plans and cohorts, program implementation staff members also support the utilities and end users engaged in SEM. Program implementation staff work as a single point of contact for industrial facilities to address a wide range of energy efficiency offerings, including rebates for capital improvements as well as SEM. Program implementation staff work with industrial end users to identify and support their participation in the program elements with the greatest potential to benefit their facilities.

Notably, for BPA, SEM is one of multiple components that make up the broader energy efficiency portfolio for industrial end-use customers. Therefore, program implementation staff are also trained to support participating industrial end users in leveraging other program elements in addition to SEM, including:

- Custom project incentives for capital improvements;
- Co-funding for an end-user employee or contractor to manage energy efficiency improvements in the end-user facility; and
- Program staff to support the development of and completion of efficiency projects.

Methods

This paper combines findings from a process evaluation and a persistence evaluation, both completed in September 2022. The goal of the process evaluation was to assess and document how the SEM Program was functioning and how it was being received by utilities and industrial end users, and to identify any areas for improvement (Evergreen 2022). The persistence evaluation utilized a survival analysis approach to estimate the effective useful life (EUL) of SEM measures, which revealed how long the measure or engagement could be expected to persist (Evergreen Economics 2021). We detail the methods for each of these studies in the next sections of this paper.

Process Evaluation

Specific evaluation objectives focused on how industrial facilities were engaging with SEM and adopting SEM practices, the value proposition for industrial facilities and for utilities, results from industrial facilities' participation, opportunities to increase effectiveness of the offering's delivery, and opportunities to expand the offering to more recipients.

To address this evaluation's research activities, we interviewed program staff and regional stakeholders, participating and non-participating utilities, and end users between April and June of 2022 to ensure a wide coverage of perspectives for this evaluation (Table 1).[5] We conducted the interviews via video conference, and each lasted approximately one hour.

Interviewed utility staff members were often heads of departments, other key personnel in the energy efficiency and management departments, or key account managers for industrial customers. Utility interviewees provided an array of experiences to draw from for this evaluation; they represented utilities with various levels of participation and industrial energy savings, and they varied in their own years of experience and familiarity with the SEM offering.

[5] Regional stakeholders included SEM program managers from Energy Trust of Oregon, BC Hydro, NEEA, Idaho Power, and PacifiCorp.

Industrial facility respondents were primarily site-level managers who acted as champions for energy management activities in their facilities. To capture a diversity of perspectives on the offering, we stratified interview respondents by their tenure with SEM. Table 1 lists the number of interviews completed with each group.

Table 1. Utility and industrial facility interviewed groups

Group	Subgroup	Number of respondents
Participating utilities	High industrial energy savings	7
	Low industrial energy savings	4
Non-participating utilities	High industrial energy savings	1
	Low industrial energy savings	2
Industrial facilities	New participants (currently in their first engagement)	11
	Ongoing participants (completed their initial engagement but remain involved)	9
	Past participants (no longer actively involved with the offering)	6
Regional Stakeholders		5

Persistence Data Collection

To evaluate the persistence of SEM changes, we randomly sampled 15 EM participants that were active in the program between 2015 and 2017 from a sample frame of 44 distinct sites (Evergreen 2021). An average of 11 SEM measures were listed for each site, with a range of 2 to 38 measures per site, for a total of 108 measures in the sample. To use our time and budget effectively, we sub-sampled SEM measures with the intent of focusing on the most influential measures in terms of energy savings due to the high cost and time commitment required to address every measure. It was important to have variety in the sample so that we could look for patterns in persistence across measure types and industries. Typical SEM measures included:

- Non-incentivized capital measures that were rolled into an SEM engagement (e.g., small motors, variable speed drives, lighting improvements);
- Changes in process (e.g., adding a measurement step to reduce process time, changing boiler setpoints, increasing batch size); and
- Changes in behavior: (e.g., training staff to operate equipment more efficiently, scheduling staff to do routine leak maintenance).

For each sampled site, we conducted a detailed review of reports and tracking data. For measures with sufficient detail, we determined the least intrusive, but reliable, method to determine:

- The status of each measure/if the measure was no longer operational.
- When the measure was started and when the measure was stopped, estimated to the nearest quarter year.
- The reason the measure was no longer in operation such as a change in management, change in production, shifting to another similar measure, or a direct result of the COVID-19 pandemic.
- If a measure was modified, did the savings qualitatively increase or decrease?

For measures without sufficient detail, we enlisted the help of program implementation staff. The program staff reviewed the sample and provided the following additional information:

- Detailed descriptions and implementation dates where needed for clarity.
- Flagged measures that they assumed would not be verifiable.
- Comments on verification plans to improve data collection

With the assistance of the program implementation staff and utility staff, we then contacted sampled customers between July and October of 2021 and collected the needed data regarding the status of each measure and the dates when any measure was uninstalled or abandoned. For onsite data collection, we followed the strictest health and safety guidelines set by the program participant, the state in which the end user resided, and guidelines set by the evaluator. In some unique cases, site visits were not possible due to the COVID-19 pandemic. For projects where site visits were not possible, we developed a more robust data collection survey that could be administered via telephone and e-mail with the appropriate program participant and vendor staff. This included a greater reliance on file review findings; customer staff providing specifications, control system trend data, screen prints, or photos or videos and sending them to the evaluation team.

Persistence Analysis

Across SEM programs in other regions, effective useful life (EUL) for SEM measures varies widely. Many estimated EULs are not based on primary data and face issues of standardization. Therefore, to estimate the survival model necessary for developing an estimate of the EUL of BPA's SEM measures, we gathered the following characteristics for each SEM-initiated measure from the sample of former program participants (n=108 measures):

- Installation (or begin) date of SEM-initiated measures;
- Whether the SEM-initiated measure ended or is still in place; and
- If the measure ended, the approximate date and reason the measure ended.

With this information, we created "time-to-event" variables to conduct survival analysis. In this case, the "event" is the date the measure ended, either due to an elective removal or physical measure removal. The survival analysis method is used to analyze data when the outcome of interest is the time until an event occurs; this method is a better choice than standard methods of statistical modeling such as linear or logistic regression, which do not account for both the status of an event and the timing of when the event occurred, nor do standard regression methods adequately account for the censoring characteristic of time-to-event data.[6] The statistical term for a situation in which the outcome of an observational unit is only partially known is *censoring*.

For example, the status is a binary variable that equals 1 if the event has occurred (i.e., the SEM-initiated measure is no longer in place and/or it has ended), else 0. Time is the length of time in years between initiation of the measure and the event. If event=1, the time is the difference between the date the measure was installed (or begun) and the date the measures ended. If event=0, the time is the difference between the date the measure was installed (or begun) and the date the status of the measure was checked.

Once we determined the status and time of each event, we conducted survival analysis to estimate the EUL of each SEM activity group. When censoring is present in the data, estimates of the true time-to-event will be underestimated unless statistical methods specifically designed for time-to-event data are used. Survival analysis methods utilize the information on all observations—those that have experienced the event and those with censored data—to provide unbiased estimates of the future time-to-event for each censored observation.

The general survival function below defines the probability of survival; this is the likelihood that "the event" has not occurred at a given time, *t*. Alternatively, the hazard function characterizes the probability "the event" will occur at a given time, *t*.[7]

Survival function:

$$S(t) = Pr\{T \geq t\} = 1 - F(t) = \int_t^{\infty} f(t)dt,$$

Hazard function:

$$\lambda(t) = \lim_{dt \to 0} \frac{Pr\{t \leq T < t + dt | T \geq t\}}{dt}$$

Where:

S = Survival, aka. the likelihood that "the event" has not occurred
λ = Hazard, aka. the probability "the event" will occur
t = Current time-interval t
T = Time that the event occurred (i.e., measure removal or failure);
dt = The width of the time interval (e.g., day, month, year)

The survival and hazard functions are related, and if one is known, the other can be computed. Figure 1 shows an example of a survival function and corresponding hazard function. The survival function (upper figure) shows the proportion of a population expected to survive over a 50-year time period. The hazard function (lower figure) shows the proportion of the

[6] In statistics, the term *censoring* refers to the circumstance in which the value or outcome of an observation is only partially known. For time-to-event data, the activity end date is censored for all activities that are still in place at the end of the "period of observation." For our purposes, the "period of observation" would be the years between the date an activity began through the respective utility program and the date in which we could verify whether the activity ended or is still in place.
[7] The numerator of the hazard function is the conditional probability that the event has occurred given that it has not occurred before.

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population of measures expected to cease operating (i.e., experience the event) each year. In this example, the hazard rate grows through age 10 and then begins to decline. The survival function and hazard function are inversely related.

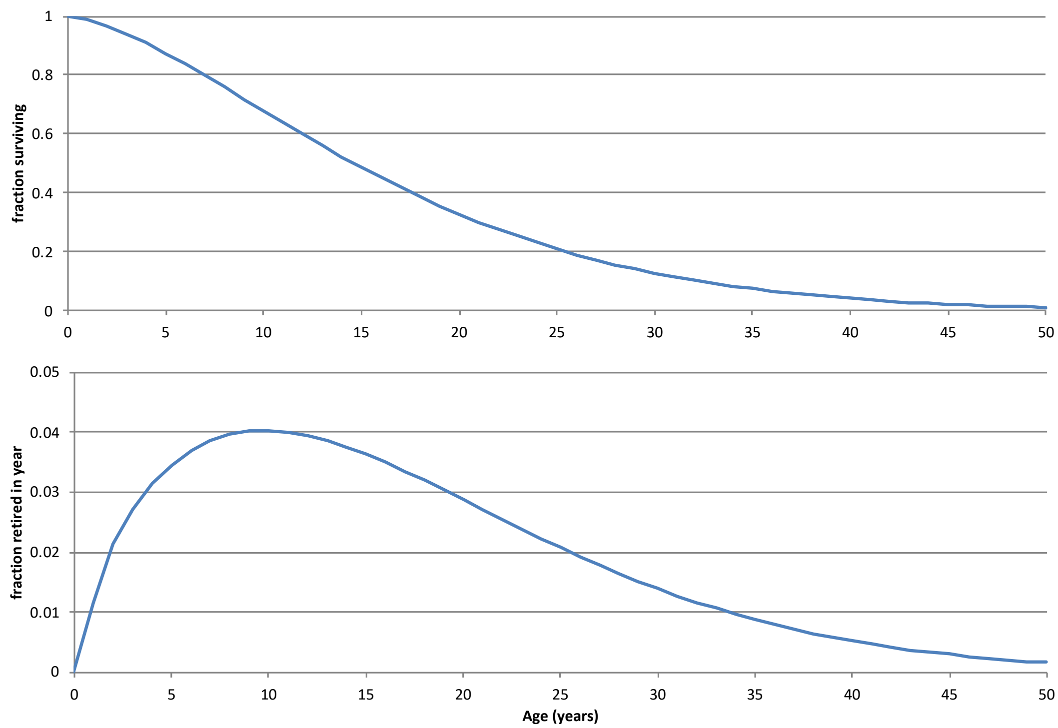

Figure 1. Example of a survival function (upper) and hazard function (lower). *Source*: Evergreen Economics.

For the analysis, we used the Kaplan-Meier estimator, which is the most common non-parametric approach for estimating survival functions (Stalpers and Kaplan, 2018). This estimator does not require assumptions regarding the shape of the underlying survival distribution; however, estimated useful lives (EULs) may be biased toward longer life expectancies when a large proportion of observations are censored.[8] Using the Kaplan-Meier estimator, we developed an overall estimate of the EUL for SEM measures and EULs for each measure type. We used the log-rank test to determine if there were statistically significant differences in survival times between measure types.[9] Differences identified through the log-rank test would be valuable for the SEM Program to know in order to assign appropriate EULs to different measures, industries, or industrial practices for the most accurate estimates.

In addition to estimating EULs, we estimated the remaining useful life (RUL) of SEM measures based on the age (i.e., time since implementation) of the measure. Figure 2 shows how a survival function is used to estimate RUL based on computing median residual life (MRL) of a

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[8] For the study of SEM persistence, censoring (or more precisely, "right censoring") simply means that the event of interest (removal/failure of the SEM activity) has not yet occurred. In other words, the SEM activity is still in place and operating.

[9] The log-rank test is a statistical test for comparing the distribution of time-to-event distributions between two or more independent groups.

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measure. In this example, the measure has been operational for 14 years. Computing the MRL requires four steps:

1. Determine the survival probability at a given age. Example: Survival (age=14) ≈ 0.8
2. Divide the survival probability from Step 1 in half. Example: 0.8/2.0 ≈ 0.4
3. Determine the age that corresponds with the survival probability calculated in Step 2. Example: approximately 26 years
4. Subtract the current age of the measure from the age determined in Step 3. Example: 26–14 ≈ 12 years

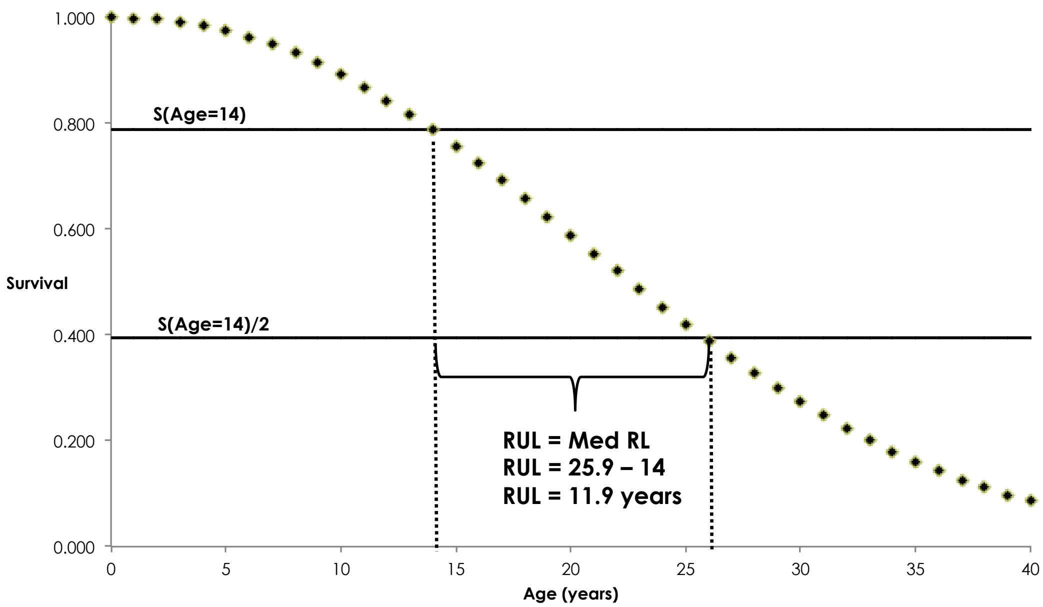

Figure 2: Computing median residual life based on a survival curve. *Source*: *Early Replacement Measures Study, Phase II Research Report,* A report to the Regional Evaluation, Measurement and Verification Forum facilitated by Northeast Energy Efficiency Partnerships, prepared by Evergreen Economics, Michaels Energy, and Phil Willems.

Findings

The SEM offering leads participants to operational energy savings, creates organizational awareness of energy savings, and is effectively managed.

Interviewed utilities and industrial facility representatives reported that the SEM offering results in operational energy savings.[10] Industrial facility representatives further described increased awareness of energy use in their facilities as a primary benefit of participation as well as non-energy benefits such as opportunities to gain recognition and build relationships across their organizations. Utilities reported that the SEM offering allows them to understand their customers' businesses better and to communicate with them more frequently. Additionally, industrial end users and utility staff were complimentary of the program's delivery of the SEM

[10] While these operational energy savings could feasibly be isolated from savings related to equipment purchases, the focus of this paper was on how long each SEM activity/measure was in place rather than the savings associated with SEM.

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offering, often highlighting the valuable role of the implementation staff to provide both strong technical advice on industrial processes and support for cohorts and energy management plans, as well as ongoing encouragement.

SEM also leads to additional energy savings achievements via capital projects, "spillover" of savings into participants' other facilities, and a focus on other environmental benefits.

Through building an increased awareness and organizational commitment to energy savings, both utility staff and facility representatives reported many "spillover" benefits after participating in SEM. Industrial facility representatives reported an increase in the number of capital projects due to increased awareness of energy savings opportunities and as a direct outcome from SEM activities. They also reported applying concepts they learned through SEM at other existing facilities, in new facilities, and even in their own homes. Facility representatives also noted that their energy management activities contributed to their organizations' sustainability goals, such as reductions in both solid waste and in greenhouse gas emissions.

The time commitment for SEM can be daunting, but once participants have committed their organization to making use of the offering, they find the effort associated with cohort meetings and energy management plans to be valuable.

Interviewed utility and program staff reported that the time commitment required to participate in SEM was a barrier for some facilities. Industrial facility representatives also reported that the time commitment had been an initial concern when they learned about SEM. However, they also reported that cohort meetings are an extremely valuable element of the SEM offering, and taking the time to create energy management plans has inherent value. Once they had experienced the benefits of SEM, participants reported that the effort required was justified.

Our research did not include any participants following a "SEM light" model. SEM light refers to programs or measures that include the underlying mechanism of SEM and that seek to create a culture of organizational awareness and responsibility of energy management, but without enrolling participating facilities in the full menu of program activities. SEM light can be a more approachable way for busy facility operators to benefit from the program. Findings from the process evaluation interviews suggest that some participants may not have experienced the same level of value or savings without the up-front time and effort invested in the program. We heard this from facility representatives from both small and large facilities.

Staff capacity and turnover are key barriers to SEM efforts, which exacerbates the natural tension between SEM and other business priorities.

Industrial facility representatives reported that staff capacity and turnover were both significant barriers to participating in SEM or fully addressing energy management opportunities. Staff turnover can lead to a loss of organizational focus on energy savings. Another issue for utilities is staff capacity constraints; they often do not have the resources to recruit and educate customers on SEM. Additionally, staff turnover at utilities can lead to a loss of knowledge, which can be a barrier to recruitment.

Interviews with facility representatives also indicated, however, that SEM could help mitigate the difficulty that staff turnover in utilities can cause. Having experts in SEM at BPA dedicated to supporting facilities and utility staff in recruitment into and engagement with SEM would allow staff transitions at utilities and facilities to go smoother while minimizing the impact to existing SEM engagements.

The EUL for BPA's SEM measures was estimated to be 8.5 years. There were no significant differences by measure type, industry group, or equipment type.

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Using the Kaplan-Meier estimator, we developed an overall estimate of the EUL for SEM measures for participants that were active in the program between 2015 and 2017, as well as EULs for each measure type, industry group, and equipment type. We used the log-rank test to determine if there were statistically significant differences in survival times between measure types, equipment types, and industry groups (n=108).

Table 2 shows the estimated EUL for all SEM measures (8.5 years) and the estimated EULs for the three different measure types. We also estimated EULs using parametric survival analysis. We found that the exponential model best fit the underlying data.[11] A characteristic of the exponential model is a constant failure rate, which implies that, regardless of the length of time in which an SEM measure has been in place, we would expect it to remain in place (its RUL is equal to the EUL). While such an assumption may not be reasonable for capital equipment that wears out over time at an increasing or decreasing rate, for SEM measures, which focus on optimizing processes and behaviors, it may be reasonable to assume that once in place, the SEM measure stays in place until the process is no longer needed or a superior process is implemented.[12] Regardless, the RUL of the SEM process is a function of exogenous forces.

The estimated EULs for the individual measure types are not statistically significantly different based on the log-rank test, which is a test of the probability of failure between the three measure types at any time point.

Table 3 shows the estimated EUL by industry impacted by the SEM measure. The results of the log-rank test indicate that the EULs for the three industries do not differ. Table 4 shows the estimated EUL by type of equipment impacted by the SEM measure. The EUL for Refrigeration Support Services (6.3 years) appears to be substantially less than the EULs for production processes and "all other" support services (9.1 years); however, the estimated EULs for each of the three equipment types fall within the confidence intervals of the equipment types. In addition, the results of the log-rank test indicate that the EULs for the three equipment types do not differ.

Table 2. Table of estimated effective useful life (EUL) by measure type

Segment	EUL	RUL*	95% confidence interval lower & upper bounds		n
All measures	8.5	8.5	3.7	13.3	108
Operations	8.6	8.6	4.1	13.0	84
Physical repairs	7.6	7.6	1.3	14.0	13
Routine maintenance	8.7	8.7	2.2	15.3	11

[11] We determined that the exponential model best fit the underlying data using the Akaike information criterion (AIC) to test five alternative distributions: Weibull, exponential, lognormal, loglogistic, and gamma. The AIC is a statistical measure of the "information loss" associated with using a particular distribution. The AIC criterion is to choose the distribution with the minimum AIC value—representing the least amount of information loss—which was the Weibull distribution.

[12] While behavioral measures often face high attrition, we found that behaviors within industrial processes are typically highly structured and systematic, leading to lower attrition rates. Of the 108 measures evaluated, 13 were no longer in place at the time of the evaluation.

Segment	EUL	RUL*	95% confidence interval lower & upper bounds	n
Log-rank test of no difference between survival rates: ** Chi-square = 1.74, Significance = 0.42				

* RULs were estimated assuming the underlying population is distributed exponentially with a constant failure rate, suggesting that, regardless of the time in which an SEM measure is in place, one would expect its RUL to be equal to its EUL. *Source*: Evergreen Economics.

Table 3. Table of estimated effective useful life (EUL) by industry

Segment	EUL	RUL*	95% confidence interval lower & upper bounds		n
All industries	8.5	8.5	3.7	13.3	108
Manufacturing	10.7	10.7	2.1	19.3	28
Wastewater	7.5	7.5	3.9	11.0	24
Refrigeration storage	7.8	7.8	4.9	10.6	56
Log-rank test of no difference between survival rates: ** Chi-square = 3.1, Significance = 0.21					

* RULs were estimated assuming the underlying population is distributed exponentially with a constant failure rate, suggesting that, regardless of the time in which an SEM measure is in place, one would expect its RUL to be equal to its EUL. *Source*: Evergreen Economics.

Table 4. Table of estimated effective useful life (EUL) by equipment

Segment	EUL	RUL*	95% confidence interval lower & upper bounds		n
All equipment	8.5	8.5	3.7	13.3	108
Production processes	9.1	9.1	4.8	13.3	51
Support services – refrigeration	6.3	6.3	3.3	9.3	24
Support services – all others	9.1	9.1	2.2	16.0	33
Log-rank test of no difference between survival rates: ** Chi-square = 3.6, Significance = 0.16					

* RULs were estimated assuming the underlying population is distributed exponentially with a constant failure rate, suggesting that, regardless of the time in which an SEM measure is in place, one would expect its RUL to be equal to its EUL. *Source*: Evergreen Economics.

In all cases, the estimated EUL from this research was longer than assumptions found for other programs. In California, the California Public Utilities Commission (CPUC) estimates a five-year EUL for SEM programs (CPUC 2018). The assumptions for EUL have cost-effectiveness implications, as longer measure life assumptions can drive down cost-effectiveness ratios and help SEM better fit into program portfolios.

Notably, our research in SEM persistence did not include savings persistence. While we found that on average, measures persisted longer than expected, we cannot comment on whether the savings persist at the same levels. A study of another SEM program in the Northwest found that savings of 4 percent were achieved for most of the years in which the program was active (Vetromile and Phoutrides 2015), while others have found that savings may increase in the second and third years of engagement, leveling off to reach about 9 percent in their fifth year (Thompson et al. 2013). Due to the variability of SEM implementation and engagement, evaluation and quantification of impacts, benefits, and persistence are challenging to standardize.

Of the 108 SEM measures evaluated, only 13 were found to be no longer in place and operating. These measures were removed within 1.7 years of engagement.

Figure 3 shows the smoothed survival curves for all SEM measures and for the three SEM measure types. The survival curves were constructed using a parametric survival model, which was necessary due to the small number of measures for which we have complete information. That is, of the 108 SEM measures we evaluated, only 13 were found to be no longer in place and operating. On average, measures were removed within 1.7 years, as shown in Table 5 below.

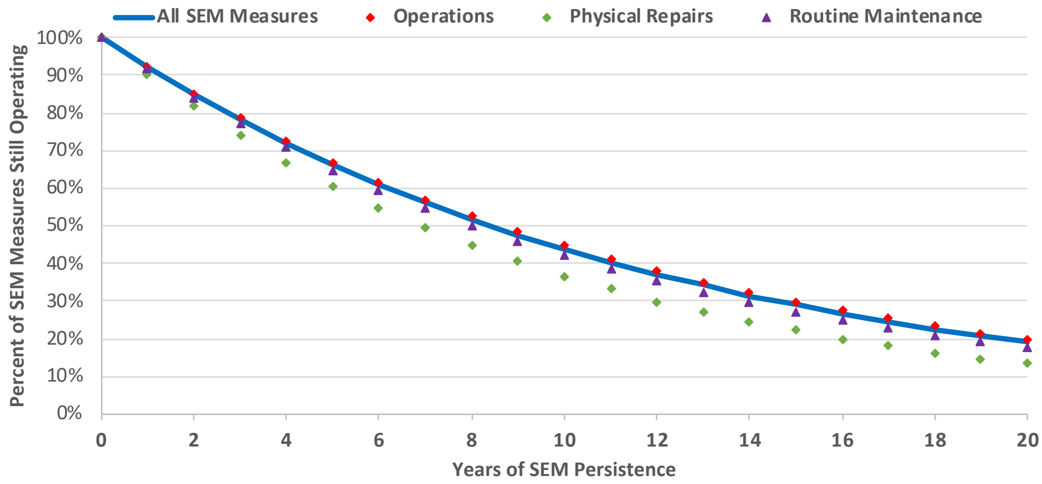

Figure 3: Smoothed survival curves for SEM measures. *Source:* Evergreen Economics

Table 5. Average age of SEM measures that were removed (n=13)

Category	Sub-category	Average age
SEM measure type	Operations	1.7
	Physical repairs	1.8
	Routine maintenance	1.0
Industry group	Manufacturing	1.7
	Wastewater	1.0
	Refrigeration storage	2.0
Equipment	Production processes	1.3
	Support services – refrigeration	1.0
	Support services – all others	2.1
Overall		1.7

Source: Evergreen Economics.

For the 13 SEM measures that were no longer in place, we know the year of installation and/or initiation and the year in which they were removed and/or discontinued. For these 13 measures, we have complete time-to-event information.

For the other 95 SEM measures, we only know the year in which the measure was installed and/or initiated and that it is still in place and operational. Since no event has occurred—i.e., the SEM measure has not been removed and/or discontinued—we do not have complete time-to-event information for these measures. The statistical term for a situation in which the outcome of an observational unit is only partially known is *censoring*.[13] As a non-parametric approach, the Kaplan-Meier method does not predict the time-to-event of censored observations. Instead, to estimate the time-to-event for censored observations, we utilized a parametric survival model, which allowed us to develop the survival curves shown in Figure 3.

The survival curves for the Operations and Routine Maintenance measure types are effectively indistinguishable from the survival curve for All SEM Measures, while the survival curve for Physical Repairs is slightly steeper. We expect that half of SEM measures would still be in place after 8.5 years (i.e., the EUL) and that about 20 percent of SEM measures would be in place after 20 years.

Conclusions

BPA's SEM Program relies heavily on its program implementers and staff to customize each participating facility's experience and maximize the benefits from the program. The tailored approach with industry experts and relevant programming leads to a deeper engagement that provides benefits to both utilities and facilities.

The benefits of SEM are likely understated. Facility representatives and utility staff agreed that the time and effort spent learning about organizational awareness and energy savings provided value far beyond the expected operational savings from implementing SEM at their facilities. Participants reported an increased uptake in other capital measures, spillover of energy management practices into participants' other facilities, and a greater focus on other environmental benefits. Furthermore, both utilities and industrial facilities reported a strengthened relationship with each other, and often cited this as the greatest driver of their satisfaction and engagement with the SEM Program.

This research also found evidence that SEM is effective in changing behavior and creating lasting change beyond the initial engagement period. The research identified common barriers such as staff time and competing company goals, but also found that the implicit effort and time required to participate in SEM was a key factor in creating the culture of energy savings at participating facilities. The persistence analyses supported this—facilities that removed measures after ending their engagement with SEM did so early (on average, 1.7 years after ending their engagement). If a participating facility did not remove their measures early and remained in the program, we found that they stay engaged even after the program engagement period ended—for an average of 8.5 years.

While some utilities and jurisdictions may consider "SEM light" offerings, we encourage care when deciding which elements of SEM to cut. Even as smaller facility representatives that we interviewed reported a lack of staff capacity as a barrier, they also reported that the time spent creating the energy management plan, conducting the facility walk throughs, attending the cohort

[13] For time-to-event data, the activity end date is censored for all measures that are still in place at the end of the "period of observation." For our purposes, the "period of observation" would be the years between the date of an activity begun through the respective utility program and the date in which we would verify whether the activity has ended or is still in place.

workshops, and educating and engaging with their workforce on energy efficiency was key to their success in the program. The additional time invested in the start of the program was crucial for the facilities' long term and positive engagement with the program, and removing those elements to make it easier for facility operators to participate may also reduce the value.

Finally, for jurisdictions across the U.S. that already have or are considering adding SEM to their portfolio of offerings, we found evidence that estimated EUL beyond program engagement is significant. In addition to a longer estimated EUL, when considering cost effectiveness, shifting from first year savings to lifetime savings may provide a more balanced approach to SEM engagements, due to the persistence of the measures we found in this research. Notably, our research found that the measures persist, but we did not explore whether the savings also persist. Further research on whether savings persist within this SEM Program and others would be a valuable next step to adding context to our findings of measure life and persistence.

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