NORTHWEST

Strategic Energy Management

COLLABORATIVE

Measurement and Verification Work Group, Effective Useful Life Subgroup

Effective Useful Life of Industrial SEM Programs: Northwest References and Resources

Introduction

Strategic energy management (SEM), as defined by the Consortium for Energy Efficiency (CEE), is a holistic approach to managing energy use and achieving continual improvement in energy performance at a company or facility. The purpose of SEM is for businesses to change their management practices to continuously improve energy performance and reduce energy waste (CEE 2014). Many businesses begin SEM by participating in utility or program administrator energy efficiency programs (EE programs) that foster this approach. In seeking to change management practices, EE program developers have used a variety of approaches in deploying SEM programs[1]. This variety is reflected in the inputs used to analyze SEM program effects.

The duration of energy efficiency savings attributable to the program that persist after program engagement ends is an important input for analyzing EE program's cost-effectiveness, as well as the potential for reducing the needs for additional energy resources. The duration of savings is called the program's effective useful life (EUL) and is defined as "the median length of time that an energy efficiency measure is functional" (Hoffman, et al. 2015). As SEM programs focus on management actions, not the installation of specific measures, a number of practical approaches have been taken to developing an input reflecting the EUL of an SEM program to enable analyzing that program.

The Northwest (NW) SEM Collaborative recognized SEM EUL as an area where limited cross-program research exists. Further research and understanding could benefit SEM professionals, including program administrators, implementers, evaluators, and others. A working group within the NW SEM Collaborative's Measurement and Verification (M&V) working group was established in 2018 to focus on this issue. This SEM EUL working group developed this reference guide for SEM professionals who develop or use industrial SEM EUL estimates in their current practice. This guide can also serve as a starting point for future research on methods for estimating SEM EULs.

The goal of this guide is to provide SEM professionals with relevant program references and resources for industrial SEM EUL. It focuses on program-level SEM EUL, not the EUL of specific actions to improve efficiency. It does so by summarizing NW program history for industrial SEM EULs and providing references and resources. Data from existing studies of industrial programs in the NW is included in Table 1. Evaluation and research reports providing EUL and measure persistence documentation are listed in Table 2. An annotated reference section is provided to assist SEM professionals in investigating the EUL for SEM programs, with both cited documents and relevant studies of interest to those assessing persistence.

[1] For example, some SEM programs focus only on operational improvements; others include a wider range of activities.

In addition to presenting the historic results of EULs from NW SEM programs, a methodology for estimating the SEM EUL by analyzing energy consumption is included in Appendix A. Where there is opportunity to obtain the needed usage and other data, this provides a way to estimate a program's EUL based on the observable program outcomes.

Finally, although this document is focuses on the industrial sector, several NW organizations have also deployed commercial SEM programs, and information pertaining to them is included in Appendix B.

EULs from NW Industrial SEM Programs

Many energy conservation programs in the NW have a long history of SEM programs. Table 1 provides information that organizations have provided about their current and historic industrial SEM programs. Information about commercial SEM programs is provided in Appendix B.

Table 1. Northwest SEM Industrial Program EUL Information

Program Administrator	Program Name	EUL (years)	Target Market Segments	Target Facility Size	Program Start Year	Program End Year (or ongoing)	Engagement Length (years)	Options for Multiyear Engagements	Basis for EUL	Website Reference
BC Hydro	SEM cohort	1 or 5	Industrial – All Segments	4-20 GWh/yr consumption	2016	Ongoing	2	Yes[1]	DSM persistence standard[2]	BC Hydro
BPA	High Performance Energy Management (HPEM)	1, 3 or 5[3]	Industrial and Municipal Water/ Wastewater	Cohort based: >= 4 GWh/yr average, 2 GWh/yr minimum per site	2009	2015	5 or 3	Required	Industrial SEM Impact Evaluation Report, February 2017	BPA Implementation Manual October 2014
BPA	Track and Tune (T&T)	3 or 5[4]	Industrial and Municipal Water/ Wastewater	Single site based: >= 4 GWh/yr	2009	2015	5 or 3	Required	Industrial SEM Impact Evaluation Report, February 2017	BPA Implementation Manual October 2014
BPA	Small-Industrial (SI) HPEM	1 or 2[5]	Industrial and Municipal Water/ Wastewater	Single site basis: 1 GWh/yr to 17.5 GWh/yr	2014	2016	2	Required	Internal analysis	BPA Implementation Manual October 2014
Energy Trust of Oregon	SEM	7[7]	Industrial – All Segments	$50k eligible energy spend[8]	2009	Ongoing	1	Yes	Industrial O&M Persistence Study	Energy Trust SEM Website

Program Administrator	Program Name	EUL (years)	Target Market Segments	Target Facility Size	Program Start Year	Program End Year (or ongoing)	Engagement Length (years)	Options for Multiyear Engagements	Basis for EUL	Website Reference
Idaho Power	SEM Wastewater Cohort	1	Wastewater	Industrial and Large commercial, wastewater, water, refrigeration	2014	Ongoing	2	Yes, up to 5	Conservative internal standard	Savings For Your Business
Idaho Power	SEM Water Cohort	1	Water	Industrial and Large commercial, wastewater, water, refrigeration	2016	Ongoing	2	Yes, up to 5	Conservative internal standard	Savings For Your Business
NEEA industrial Initiative	Industrial Initiative	4	Food Processing	Large	2009	2014	1	yes, up to 3	Evaluation report	NEEA Industrial Initiatives MPER #8, April 2014
Puget Sound Energy	Industrial SEM (I SEM)	3	Industrial	Greater than 3 GWh/yr/ site	2020 (2019 pilot)	Ongoing	3	Yes, up to 3	Conservative internal standard	PSE 2019 Annual Conservation Plan

Notes:

1. For BC Hydro, there is a multi-year option. After the initial two-year program is complete, customers have an optional Alumni program for years three and four. (Lighter touch offer vs. the original Cohort offer https://www.bchydro.com/powersmart/business/programs/energy-management/industrial-cohort.html.
2. The BC Hydro EUL is based on literature review of North American utility evaluations and public documents. At the end of Year 1, savings are claimed for 1 year. At the end of Year 2, participants are expected to submit a sustainment plan as part of the program requirements so that their savings can be claimed for 5 years.
3. For BPA Large Industrial HPEM, EUL is one-year during the engagement with an expected continuation by the end of the final year. Program Cycle: ML Yr1, Yr2, Yr3, Yr4, Yr5. Three year: 1, 1, 3. Five year: 1, 1, 1, 1, 6. Mixed industrial cohort delivery. Initial offering was a five-year commitment. Serving utilities were then offered the choice of three- or five-year engagements.

4. For BPA Track and Tune, it was mostly single-site delivery. Two refrigeration-focused cohorts. Initial offering was a five-year commitment. Serving utilities were then offered the choice of three- or five-year engagements.
5. For BPA Small Industrial HPEM, EUL is variable based on M&V method. Top down: two-year EUL. Bottom up: one-year EUL. Pilot offering. Used program and coaching support paired with online webinars and an EMIS system to enable remote and smaller participants participate in SEM.
6. For BPA SEM, there is a blend of cohort and single site delivery. Cohorts may be mixed industrial or targeted (refrigeration, wastewater, water treatment are the current targeted offerings). One-year EUL. Reenrollments are for another two-year period.
7. As a result of the 2020 Industrial O&M Persistence Study, Energy Trust has increased the measure life for both of Industrial SEM offerings to 7 years. Previously, all Industrial SEM engagements have a five-year measure life, with one exception. Participants who go through First Year SEM that do not proceed to Continuous are assigned a three-year measure life.
8. Because the Energy Trust SEM program includes gas and electric customers, a minimum energy spend requirement is used to qualify customers for the program.

Recent NW Research on EUL and Savings Persistence

Some research has been done on SEM EUL and savings persistence. These studies are encouraging in that they have consistently found that over 75% of O&M measures are still in place anywhere from six months to six years after implementation (see Table 2). A new persistence study by BPA is in planning stages.

Table 2. Summary of Recent Industrial SEM EUL Research

Program	Method(s)	Sample Size	Results	Reference
BPA	Customer surveys and site visits	Plan calls for 15 sites for SEM	**Forthcoming, 2021**	https://www.bpa.gov/EE/Utility/Evaluation/Documents/BPA_2020-21_Impact_Evaluation_Plan.pdf
Energy Trust of Oregon Production Efficiency	Database, documentation, and literature review	68 measures	Reviewed program document and data, and performed a literature review to assess the reasonableness of the three-year measure life used for O&M (and SEM) up until 2020.	DNV GL. *Persistence of Energy Trust O&M Energy-Efficiency Measures Study*. 2017. https://www.energytrust.org/wp-content/uploads/2018/07/Energy-Trust-OM-Measure-Persistence-Report-final-with-staff-response.pdf
Energy Trust of Oregon Production Efficiency	Interviews and site visits sampled from 2010 – 2013 SEM participants	80 measures	**89%** of activities (71 of 80) asked about during the interviews were still in place between two and six years after participants' SEM engagements	Cadmus. Energy Trust Production Efficiency Strategic Energy Management Evaluation Final Report. 2019. https://www.energytrust.org/wp-content/uploads/2019/03/Energy_Trust_SEM_Evaluation_Report.pdf
Energy Trust of Oregon Production Efficiency	Interviews	252 measures, 75 participants	This study supports a seven-year measure life for O&M and SEM (including both gas and electric savings).	DNV GL. Industrial O&M Persistence Study- Program Years 2010-17. April 28, 2020. https://semhub.com/assets/resources/DNVGL_2019_Persistence_Study_Report_FINAL-w-SR.pdf
PSE ISOP	Site visits	485 measures, 25 participants	**97%** of O&M action items were still in place between six and 30 months after implementation.	DNV GL. *Puget Sound Energy Industrial Systems Optimization Program Evaluation Report*. 2017. https://conduitnw.org/Handlers/conduit/FileHandler.ashx?rid=4118

References and Bibliography

This section provides SEM references organized in tables by type of document for both industrial and commercial studies. Table 3 lists persistence studies, Table 4 lists program evaluations, Table 5 lists program guidelines and documentation, and Table 6 lists summary documentation. A bibliography list is provided after the tables.

Table 3. Persistence Studies

Study Name	Description	Website Reference
BPA Persistence Study (title pending).	Persistence assessment of SEM to inform measure life, and if possible, the effect of capital measures on SEM savings	Pending, 2021.
DNV GL. *Persistence of Energy Trust O&M Energy-Efficiency Measures Study*. 2017.	Literature review and engineering assessment of persistence of O&M measures common in SEM programs; three-year measure life found to be reasonable.	https://www.energytrust.org/wp-content/uploads/2018/07/Energy-Trust-OM-Measure-Persistence-Report-final-with-staff-response.pdf
DNV GL. *Industrial O&M Persistence Study-Program Years 2010-17*. 2020.	Research study of persistence of Energy Trust's industrial O&M and SEM offerings; reports EUL with statistical range with seven years as the estimated median life.	https://www.energytrust.org/wp-content/uploads/2020/04/DNVGL_2019_Persistence_Study_Report_FINAL-w-SR.pdf

Table 4. Program Evaluations

Report Title	Description	Website Reference
Cadmus. *Energy Trust Production Efficiency Strategic Energy Management Evaluation Final Report*. 2019.	The evaluation of SEM savings included SEM participants from 2010 through 2013. Results were inconclusive because obtaining updated production and energy data was not possible. Because the sample of participants that provided updated production and energy data included only eight participants with electric savings and six with natural gas savings, these results could not be generalized to the population. However, SEM activities persisted among interviewed participants. Many participants continued to use their energy model (or another tool) to track energy used, most of the activities evaluators asked about remained in place or were continued, and many respondents had added projects to their list of potential opportunities since they participated in SEM.	https://www.energytrust.org/wp-content/uploads/2018/02/2012-Energy-Trust-PE-Impact-EvaluationSR.pdf
DNV GL. *Puget Sound Energy Industrial Systems Optimization Program Evaluation Report*. 2017.	Process and impact evaluation of ISOP, including savings, measure life assessment (four years) and risks to persistence.	https://www.energytrust.org/wp-content/uploads/2019/03/Energy_Trust_SEM_Evaluation_Report.pdf
DNV KEMA Energy and Sustainability. *NEEA Industrial Initiatives- Market Progress Evaluation Report #8.* 2014.	Evaluation of savings achieved, persistence, and market transformation of SEM in the food industry, including adoption of SEM elements.	https://neea.org/resources/neea-industrial-initiatives-market-progress-evaluation-report-8

Report Title	Description	Website Reference
Energy Trust of Oregon. *2014 Energy Trust Workshops on Strategic Energy Management Impact Evaluation: Report on Key Outcomes*.	Energy Trust held two workshops to discuss how best to evaluate SEM. The main outcome of those workshops was a set of evaluation guidelines.	https://www.energytrust.org/wp-content/uploads/2016/12/SEM_Evaluation_Workshop_Report.pdf
Evergreen Economics. *2018 Existing Buildings Process Evaluation*. 2019.	This process evaluation focused specifically on the five main program tracks (Standard, Custom, Lighting, Direct Install, and SEM) in Oregon and Southwest Washington for the 2017 and 2018 program years. Specific emphasis was placed on the Custom and SEM tracks of the program. This process evaluation included an analysis of the impact of SEM on capital project completion.	https://www.energytrust.org/wp-content/uploads/2019/04/ETO-Existing-Buildings-Process-Evaluation-FINAL-wSR.pdf
Opinion Dynamics. Energy Trust of Oregon 2017-2018 Production Efficiency Process Evaluation. 2020.	This report includes three SEM-specific analyses: (1) comparison of energy management practices across SEM participants, non-SEM participants, and nonparticipants; (2) an analysis of free-ridership rates before and after SEM participation, and between SEM participants and non-SEM participants; and (3) an analysis of the impact of SEM on capital project completion.	https://www.energytrust.org/wp-content/uploads/2020/08/ETO-2017-2018-Production-Efficiency-Process-Evaluation-w-SR.pdf
SBW Consulting, Inc. and Cadmus. *Bonneville Power Administration Industrial Strategic Energy Management Impact Evaluation Report*. 2017.	Performance between 2010 and 2014 of High Performance Energy Management (HPEM) and Track and Tune (T&T) facilities that had the longest history of participation in BPA's EM Program. The evaluation team estimated savings for these facilities and did not extrapolate to the program population. The evaluation estimates SEM energy savings and characterize year-to-year SEM savings trends for sampled facilities, verifies the EPT Team's estimated SEM savings and BPA's reported SEM savings, surveys participants about their adoption of SEM practices and assess whether differences in adoption can explain the	https://www.bpa.gov/EE/Utility/Evaluation/Evaluation/170222_BPA_Industrial_SEM_Impact_Evaluation_Report.pdf

Report Title	Description	Website Reference
	energy savings results, and develops recommendations on how to improve the MT&R guidelines and impact evaluation methods for this program.	

Table 5. Program Guidelines and Documentation

Document Name	Description	Website Reference
Bonneville Power Administration (BPA) *Implementation Manual*.	Provides the implementation guidelines for projects reported to BPA. Updated biannually.	https://www.bpa.gov/EE/Policy/IManual/Pages/default.aspx
BC Hydro. *Effective Measure Life and Persistence*. DSM Standard. BC Hydro Power Smart. 2019.	The document is designed to standardize the effective measure life for estimating the energy and non-energy impacts from demand-side management activities.	https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/regulatory-planning-documents/reference-documents/F20_F21_RRA_BCUC_1_178_01_LES_01.pdf
Consortium for Energy Efficiency. *Strategic Energy Management Minimum Elements*. 2014.	Provides a set of threshold criteria for energy management practices.	https://library.cee1.org/content/cee-strategic-energy-management-minimum-elements/
Efficiency Valuation Organization. 2016. International Performance Measurement and Verification Protocol.	Provides definitions of terms and methods for quantifying savings from energy efficiency measures.	https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp
Hoffman, Ian; Schiller, Steven, Todd, Annika, Billingsley, Megan, Goldman. *Energy Savings Lifetimes and Persistence: Practices, Issues and Data*. LBNL Electricity Markets and Policy Group Technical Brief. 2015.	Explains the concepts of savings persistence and energy saving lifetimes.	https://emp.lbl.gov/sites/all/files/savings-lifetime-persistence-brief.pdf
National Renewable Energy Laboratory. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 13: Assessing Persistence and Other Evaluation Issues and Cross-Cutting Protocols*. 2013.	Provides a general overview on energy efficiency savings persistence including methods and approaches to estimate it.	https://www.energy.gov/sites/prod/files/2013/05/f0/53827-13.pdf

Document Name	Description	Website Reference
Stewart, James. Chapter 24: Strategic Energy Management (SEM) Evaluation Protocol. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68316. 2017.	This document was developed for the U.S. Department of Energy Uniform Methods Project (UMP). The UMP provides model protocols for determining energy and demand savings that result from specific energy-efficiency measures implemented through state and utility programs. In most cases, the measure protocols are based on a particular option identified by the IPMVP; however, this work provides a more detailed approach to implementing that option.	http://www.nrel.gov/docs/fy17osti/68316.pdf
U.S. DOE 50001 Ready and U.S. DOE 50001 Ready Navigator	The U.S. DOE 50001 Ready program recognizes facilities and organizations that attest to the implementation of an ISO 50001-based energy management system. The 50001 Ready Navigator is a self-paced, no-cost way for organizations to build a culture of structured energy improvement that leads to deeper and sustained savings that does not require any external audits or certifications. 50001 Ready program partners with utilities and other organizations for implementation of 50001 Ready.	The 50001 Ready program is described at: https://betterbuildingssolutioncenter.energy.gov/iso-50001/50001Ready The 50001 Ready Navigator can be found at https://navigator.lbl.gov
U. S. Department of Energy. Superior Energy Performance 50001™ Program Measurement and Verification Protocol. 2019.	Provides rigorous methods for adjustment modeling for estimating energy performance improvements, including several model options and model validity requirements.	https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/SEP_50001_MV_Protocol_2019_0.pdf

Table 6. Summary Documentation

Document Name	Description	Website Reference
Consortium for Energy Efficiency. *SEM Program Case Studies Report 2014.* 2015.	Information about 2014 SEM program designs, delivery strategies and results.	https://library.cee1.org/content/sem-program-case-studies-2014
Consortium for Energy Efficiency. *2016 SEM Program Summary*. 2016.	2016 survey results from 14 North American SEM programs, including achievements, program design, incentives and engagement strategies.	https://library.cee1.org/system/files/library/12994/CEE_2016_Industrial_SEM_Program_Summary_Public.pdf
National Renewable Energy Laboratory. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 24: Strategic Energy Management Protocol.* 2017.	Treats the statistical determination of energy savings in SEM programs (amplifying Appendix 1 of this report). The methods presented in chapter 4, particularly 4.1.2.1, are designed to estimate SEM savings in multiple sub-periods, which can track savings over time, i.e. inform savings persistence.	https://www.nrel.gov/docs/fy17osti/68316.pdf
SBW Consulting and Opinion Dynamics. *NEEA SEM Meta-Analysis. In support of the Regional SEM Data Plan*. Presentation on January 13, 2020.	Library of NW SEM evaluation reports and SEM best practice reports, white papers, and program design manuals from across the country.	https://conduitnw.org/Pages/File.aspx?rid=4985 Library of Metadata about SEM programs in the NW region. https://conduitnw.org/Pages/File.aspx?rid=4985

Reference List

BC Hydro. 2019. *Effective Measure Life and Persistence*. DSM Standard. BC Hydro Power Smart. March. https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/regulatory-planning-documents/reference-documents/F20_F21_RRA_BCUC_1_178_01_LES_01.pdf

Bonneville Power Administration (BPA) 2014. *Energy Efficiency Implementation Manual*. October. https://www.bpa.gov/EE/Policy/IManual/Documents/FINAL_October_2014_Implementation_Manual_v2.pdf

Cadmus. *NEEA Commercial Real Estate Participant Cohorts Market Progress Report*. 2015. https://neea.org/resources/commercial-real-estate-participant-cohorts-market-progress-report

Cadmus. *Northwest Energy Efficiency Alliance Commercial Real Estate Market Partners Program Savings Persistence Analysis*. 2016. https://neea.org/img/uploads/cadmus-cre-sem-persistence-draftfinal-03-09-2016.pdf

Cadmus. *2012 Energy Trust of Oregon Production Efficiency Evaluation*. 2017. https://www.energytrust.org/wp-content/uploads/2018/02/2012-Energy-Trust-PE-Impact-EvaluationSR.pdf

Cadmus. *Energy Trust Production Efficiency Strategic Energy Management Evaluation Final Report*. 2019. https://www.energytrust.org/wp-content/uploads/2019/03/Energy_Trust_SEM_Evaluation_Report.pdf

Consortium for Energy Efficiency. *Strategic Energy Management Minimum Elements*. 2014. https://library.cee1.org/content/cee-strategic-energy-management-minimum-elements/

Consortium for Energy Efficiency. *SEM Program Case Studies Report 2014.* February 3, 2015. https://library.cee1.org/content/sem-program-case-studies-2014

Consortium for Energy Efficiency. *2016 SEM Program Summary*. November 21, 2016. https://library.cee1.org/system/files/library/12994/CEE_2016_Industrial_SEM_Program_Summary_Public.pdf

DNV GL. *Industrial O&M Persistence Study- Program Years 2010-17*. April 28, 2020. https://semhub.com/assets/resources/DNVGL_2019_Persistence_Study_Report_FINAL-w-SR.pdf

DNV GL.2017 *Persistence of Energy Trust O&M Energy-Efficiency Measures Study*. https://www.energytrust.org/wp-content/uploads/2018/07/Energy-Trust-OM-Measure-Persistence-Report-final-with-staff-response.pdf

DNV GL. 2017 *Puget Sound Energy Industrial Systems Optimization Program Evaluation Report*. 2017. https://library.cee1.org/content/sem-program-case-studies-2014

DNV GL 2016. *Impact Evaluation of Commercial Strategic Energy Management*. October 20, 2016. https://www.energytrust.org/wp-content/uploads/2017/03/FinalReport_EnergyTrust_CommSEM_ImpactEvaluation_wStaffResponse.pdf

DNV KEMA Energy and Sustainability. 2014. NEEA Industrial Initiatives- Market Progress Evaluation Report #8. https://neea.org/resources/neea-industrial-initiatives-market-progress-evaluation-report-8

Efficiency Valuation Organization 2016. International Performance Measurement and Verification Protocol. https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp

Hoffman, Ian; Schiller, Steven, Todd, Annika, Billingsley, Megan, Goldman. 2015. *Energy Savings Lifetimes and Persistence: Practices, Issues and Data*. LBNL Electricity Markets and Policy Group Technical Brief. May. https://emp.lbl.gov/sites/all/files/savings-lifetime-persistence-brief.pdf

International Performance Measurement and Verification Protocol: Concepts and Options for Determining Energy and Water Savings Volume I, EVO-10000-1.2012, Efficiency Valuation Organization.

Kociolek, Ericka, Phil Degens, Kim Crossman, Jeff Cropp, Jennifer Huckett, Heidi Ochsner, Jennifer Barnes. 2015. "Evaluating Strategic Energy Management: Guidelines from the Pacific Northwest." ACEEE Summer Study for Energy Efficiency in Industry. August.

National Renewable Energy Laboratory. 2013. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 13: Assessing Persistence and Other Evaluation Issues and Cross-Cutting Protocols*. https://www.energy.gov/sites/prod/files/2013/05/f0/53827-13.pdf

SBW Consulting and Opinion Dynamics. *NEEA SEM Meta-Analysis. In support of the Regional SEM Data Plan*. Presentation January 13, 2020. https://conduitnw.org/Pages/File.aspx?rid=4985. Library of Metadata about SEM programs in the NW region. https://conduitnw.org/Pages/File.aspx?rid=4985

SBW Consulting, Inc. and Cadmus. *Bonneville Power Administration Industrial Strategic Energy Management Impact Evaluation Report*.
2017. https://www.bpa.gov/EE/Utility/Evaluation/Evaluation/170222_BPA_Industrial_SEM_Impact_Evaluation_Report.pdf

SBW Consulting, Inc. *Evaluability Assessment for the BPA Commercial SEM Pilot Program*. 2017.
https://www.bpa.gov/EE/Utility/Evaluation/Evaluation/BPA_Commercial_SEM_Final.pdf

Stewart, James. 2017. Chapter 24: Strategic Energy Management (SEM) Evaluation Protocol. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68316.
http://www.nrel.gov/docs/fy17osti/68316.pdf

U. S. Department of Energy 2019. Superior Energy Performance 50001™ Program Measurement and Verification Protocol:2019. October 29, 2019.
https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/SEP_50001_MV_Protocol_2019_0.pdf

Vetromile, Julia, Jennifer Canseco, Michael Rudyk, Phil Degens, and Michael Noreika. 2018. "Persistence is not futile: Assessment of persistence of operations, maintenance and behavioral measures in commercial and industrial sectors.". ACEEE 2018 Summer Study on Energy Efficiency in Buildings, Aug.

Appendix A. Estimating SEM EUL Using Energy Consumption Analysis

This section describes an approach for estimating the EUL of SEM energy savings attributable to the program through energy consumption analysis that has been applied in the Pacific NW.

Energy Management EUL Concepts

Suppose a participant engages in an SEM program for one year. During this year, the participant makes management and organizational changes to improve energy efficiency. During the first year, the participant saves $s_1 > 0$ and in each subsequent year 'k', k=2, 3, …, the participant saves s_k.

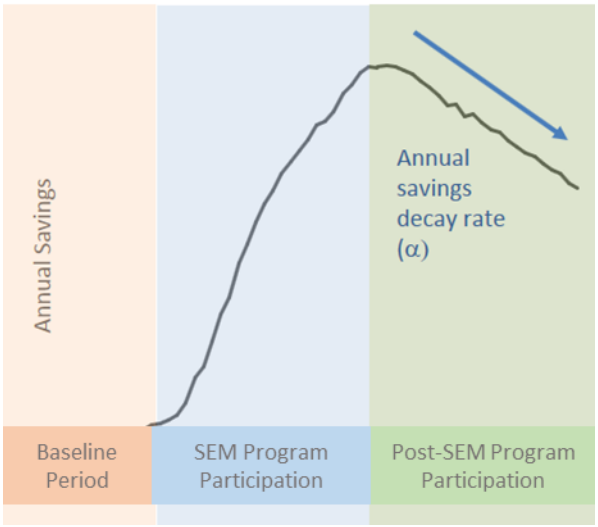
Since many of the individual measures were organizational, O&M, or behavior-based, it may not possible to associate a measure life with some or all of them or to calculate the program measure life as the weighted average of the life of individual measures. However, SEM EUL can be estimated by defining it as a function of first year and lifetime savings. Specifically, the SEM EUL can be expressed as the SEM lifetime savings in terms of first-year savings equivalents:

$$EUL = \frac{Lifetime\ Savings\ from\ Participation}{First\text{–}year\ Savings\ from\ Participation}$$

- For example, if the first-year SEM savings equal 2.5 GWh and the lifetime savings equal 10 GWh, the EUL would equal four years.

Calculating EUL in this way requires estimating first-year savings and lifetime savings. First-year savings can be obtained by using methods prescribed in the UMP SEM evaluation protocol or the Superior Energy Performance (SEP) M&V protocols (National Renewable Energy Laboratory 2013, U. S. Department of Energy 2019). Lifetime savings can be obtained by estimating the rate at which savings decay after SEM program participation ends and projecting savings **after treatment ends** as a function of the decay rate. Figure 1 illustrates the concept of savings decay.

Figure 1. Savings Decay



In this figure, annual savings decay after program participation ends, where the decay rate is equal to the slope of the blue line or $\delta = ds/dt$.

Suppose that savings in the first year equal 's' and after the program participation ends savings decay at an annual rate 'δ,' so that savings in the first year after the program ends equal 'δs' and savings in the second year after the program ends equal '$\delta^2 s$', and so on. Then lifetime savings would equal:

$$\text{Lifetime Savings} = s + s(1-\delta) + s(1-\delta)^2 + \ldots$$

$$= s/(1-(1-\delta))$$

$$= s/\delta$$

Measure life would equal $\frac{\frac{s}{\delta}}{s} = \frac{1}{\delta}\ldots$

For example, if savings decayed at 25% per year ($\delta = 0.25$), lifetime savings would equal the equivalent of four years of first year savings, and measure life would equal four years. (This example assumes that the savings decay rate is constant over time and that savings decay geometrically, but the decay could take other forms.)

The main point is that if a researcher can obtain an estimate of the first-year savings and the rate at which the first-year savings decay, the researcher can estimate the SEM EUL for a facility or a group of facilities.

Savings Persistence

If a participant facility participates in the SEM program for a second year and SEM savings persist at an annual rate of (1- δ), then some SEM savings in the second year will not be attributable to the second year of SEM participation. Specifically, savings attributable to the second year will equal:

$$s_2^* = s_2 - s_1 * (1-\delta)$$

where 's_t' denotes the total SEM savings in year t and 's_t*' denotes the first year (new) savings attributable to SEM participation in year 't.'

More generally, if savings persist at an annual rate of (1-δ), the first year (new) SEM savings attributable to SEM in program year 't' equal:

$$New\ savings\ in\ year\ t = s_t - \sum_{k=1}^{t} (1-\delta)^k s_{n,t-k}$$

Estimating Savings Decay and Persistence

The SEM savings decay rate or savings persistence rate can be estimated through regression analysis of facility energy consumption and savings data. For example, suppose that a researcher has annual SEM savings estimates for a facility for each year since the facility started participating in an SEM program.

Assume that the annual savings estimates were obtained from individual facility regressions as prescribed in the UMP SEM evaluation protocol or the SEP M&V protocols. (National Renewable Energy Laboratory 2013, U. S. Department of Energy 2019).

Then the facility's average annual savings decay rate can be obtained by estimating this individual participant regression:

$$s_t = \alpha + \delta\tau_{it}^{post} + \varepsilon_t \qquad \text{(Equation 1)}$$

where:

s_t = The annual percentage savings for the facility in year t, t=1, 2, …, T.

α = A constant representing the average annual percentage savings while the facility participated in the program.

τ_{it}^{post} = A time trend indicating years since program participation. τ equals 1 during the facility's first year after participation, 2 during the facility's second year after participation, etc.

δ = The average annual savings decay rate, i.e., the annual rate of change for savings since participation ended

ε_t = The error term for the facility in year 't,' capturing idiosyncratic effects on savings.

A researcher might not have enough years of data to precisely estimate a savings decay rate for an individual facility, or instead may wish to estimate the average savings decay rate across multiple facilities. In either case, the researcher could estimate a panel regression of annual savings for many facilities, as follows:

$$s_{it} = \alpha_i + \beta\tau_{it}^{prog} + \delta\tau_t^{post} + \mu_t + \varepsilon_{it} \quad \text{(Equation 2)}$$

where

s_{it} = The annual percentage SEM savings of facility i in year t.

α_i = A fixed effect for facility 'i,' which captures the facility's average annual savings over the sample period. The fixed effects account for differences between facilities in average annual savings (i.e., some facilities are big savers and others are small).

τ_{it}^{prog} = The average time trend of savings during program participation. This variable is equal to one during a facility's first year, two during a facility's second year, etc.

β = Average rate of change of annual savings during participation.

τ_{it}^{post} = A time trend for savings after program participation ends, equal to one during a facility's first year after participation, two during a facility's second year after participation, etc.

δ = The average annual savings decay rate, i.e., the annual rate of change for SEM savings since participation ended.

μ_t = A fixed effect for the calendar year, 't' that captures year-specific factors affecting the savings of all facilities. For example, in one of more years, mild weather may decrease electricity demand and energy savings from SEM facilities.

ε_t = Error term for facility "' in year 't,' capturing idiosyncratic effects on savings for the facility in the year.

Equation 1 and Equation 2 can be estimated using standard panel regression methods to obtain an estimate of δ, denoted $\hat{\delta}$. An advantage of this approach is that the regression analysis yields a standard error for $\hat{\delta}$ and therefore a measure of the uncertainty of the estimated savings decay.

The regression approach for estimating the decay rate does not assume that savings decay after program treatment ends, since there is no restriction on the sign of δ. If savings increase on average after participation, this coefficient will be positive. If a positive coefficient results, it would be interpreted to indicate that there is no savings decay over the range of the post-participation years observed in the analysis sample.[2]

It is important to note that estimating the SEM savings decay rate requires observing facilities after they stop participating in programs. Without making strong functional form assumptions, it is not possible to estimate a savings decay rate if all facilities in the analysis sample are still participating in the program. Specifically, it is not possible to differentiate between persistence savings from previous years of SEM treatment and savings caused by current treatments.

[2] A positive coefficient would imply an infinite measure life.

Appendix B. Commercial SEM Information

Table B-1. Northwest SEM Commercial Programs EUL Information

Program Administrator	Program Name	EUL (years)	Target Market Segments	Target Facility Size	Program Start Year	Program End Year (or ongoing)	Engagement Length (years)	Options for Multiyear Engagements	Basis for EUL	Website Reference
Energy Trust of Oregon	Commercial SEM	5	MUSH, office, retail, etc	Med-Large	2011	Ongoing	1	Yes	Internal analysis supported by subsequent evaluations	Multiple: Search "Energy Trust Commercial SEM Evaluation"
Idaho Power	SEM School Cohort	1	Schools	Schools	2018	Ongoing	1	Yes, up to 5	Conservative internal standard	Savings for your business
Puget Sound Energy	Commercial SEM	3	Schools, Commercial	1 GWh/yr or 100,000 therms per site	2002	Ongoing	3	Yes	Use of a fixed baseline, Evaluation, records of persistence of savings, review of actions taken by the energy champions	PSE 2019 Annual Conservation Plan

Table B-2. Commercial Program Persistence Analysis

Program	Sector	Method(s)	Sample Size	Results	Reference
NEEA CRE Market Partners Program	Commercial	Interviews	52 measures, 9 participants	**71%** of activities were still in place between one and six years after implementation.	Cadmus. *Northwest Energy Efficiency Alliance Commercial Real Estate Market Partners Program Savings Persistence Analysis*. 2016. https://neea.org/img/uploads/cadmus-cre-sem-persistence-draftfinal-03-09-2016.pdf

Table B-3. Commercial Evaluation Reports and Other References

Report Title	Description	Website Reference
Cadmus. *NEEA Commercial Real Estate Participant Cohorts Market Progress Report*. 2015.	The study assessed the presence of SEM adoption (56% of participants engaged with all five elements of SEM) and estimated energy savings and savings rates.	https://neea.org/resources/commercial-real-estate-participant-cohorts-market-progress-report
Cadmus. *Northwest Energy Efficiency Alliance Commercial Real Estate Market Partners Program Savings Persistence Analysis*. 2016.	Interviews of commercial SEM participants regarding the implemented activities found 71% persisted, many for five or six years.	https://neea.org/img/uploads/cadmus-cre-sem-persistence-draftfinal-03-09-2016.pdf
DNV GL. *Impact Evaluation of Commercial Strategic Energy Management*. 2016.	Evaluation of energy savings, assessment of modeling methods and recommendations	https://www.energytrust.org/wp-content/uploads/2017/03/FinalReport_EnergyTrust_CommSEM_ImpactEvaluation_wStaffResponse.pdf
SBW Consulting, Inc. *Evaluability Assessment for the BPA Commercial SEM Pilot Program*. 2017.	This memo documents findings from an investigation of BPA's Commercial SEM Program and to identify factors that are important to consider related to future evaluations of program savings. The memo describes how the program will be operated, the program's evaluability, and findings from the review of the savings estimation modeling conducted for three pilot buildings and	https://www.bpa.gov/EE/Utility/Evaluation/Evaluation/BPA_Commercial_SEM_Final.pdf

	provides recommendations on how this modeling may be improved.	

Contributing Authors

Sam Day, CLEAResult

Jennifer Huckett, Pacific Northwest National Laboratory

Heidi Javanbakht, California Energy Commission

Chellie Jensen, Idaho Power

Ross Lancaster, Strategic Energy Group

William Miller, Lawrence Berkeley National Laboratory

Tina Schnell, AESC, Inc

Jim Stewart, Cadmus

Julia Vetromile, David B. Goldstein and Associates, Inc.

Sara York, Cascade Energy