



Evaluation, Measurement & Verification (EM&V) Best Practices & Recommendations for Industrial Strategic Energy Management Programs

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About NEEP

NEEP was founded more than 20 years ago as a non-profit to accelerate energy efficiency in the Northeast and Mid-Atlantic states. Today, it is one of six Regional Energy Efficiency Organizations (REEOs) funded, in part by the U.S. Department of Energy to support state efficiency policies and programs. Our long-term shared goal is to assist the region to reduce carbon emissions 80% by 2050. For more about our 2017 strategies and projects, see this [2-page overview](#) or these [project briefs](#). You can also watch this brief [video](#) regarding our history.

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Executive Summary

Strategic Energy Management (SEM) is a relatively new energy efficiency strategy that has demonstrated the ability to capture comprehensive savings from large industrial and commercial facilities. SEM program designs focus on achieving energy savings from continuous improvement of operational control of equipment, processes and systems as a practice to help customers and program administrators realize the savings potential. The purpose of this report is to provide energy efficiency program planners, evaluators, and regulators with information on the issues related to evaluation of savings and cost-effectiveness based on some of the current experience associated with evaluation and implementation of Strategic Energy Management, including consideration of associated non-energy benefits.

SEM program designs and requirements vary. The U.S. Department of Energy (US DOE) describes a continuum from foundational SEM programs to ISO 50001, in which programs can be certified to meet an international standard, to Superior Energy Performance programs, which receive a higher tier of certification through specific energy savings achievements and ISO50001 certification. SEM programs generally share a set of minimum elements that have been identified by the Consortium for Energy Efficiency and which address commitment, planning and implementation, and measurement and reporting aspects of the programs.

As of 2016, SEM programs provided by energy efficiency programs have served 707 industrial sites overall. In 2015, 10 programs provided services to 287 facilities. Most of the growth in customers served since 2014 is attributable to the Energy Trust of Oregon and AEP Ohio programs. Most companies claim energy savings from SEM programs; some claim demand impacts as well. A majority of the programs included operational, maintenance or behavioral measures in their energy savings. While some include savings from capital measures as part of SEM program total savings, some claim capital investment savings as results of separate programs; some SEM programs serve as a pipeline to other utility capital investment programs.

Measurement and verification (M&V) is conducted to estimate performance, for example energy consumption, and may be applied to individual measures or facilities; the results may have a variety of uses, including early program feedback, the basis for performance contract payments, and as inputs to evaluations. Impact evaluation focuses on estimating savings for a program. The evaluation, measurement and verification (EM&V) approaches used to estimate gross energy savings from SEM programs typically include use of whole building or whole facility regression models. Several existing protocols help inform savings estimation: 1) IPMVP Option C¹ 2) SEP M&V² and 3) ISO 50001. In addition, the Uniform Methods Protocol is forthcoming. This report summarizes the key elements of the UMP protocol.

¹ The Efficiency Valuation Organization (EVO) publishes the International Performance Measurement and Verification Protocol (IPMVP) to increase investment in energy and water efficiency, demand management and renewable energy projects around the world. The IPMVP allows building owners, energy service companies, and financiers of energy efficiency projects to quantify the energy savings performance of energy conservation measures (ECMs) and at a facility level. It provides an overview of current best practice techniques available for verifying savings from both traditionally funded and third-party-financed energy and water efficiency projects. The IPMVP was recently revised, and is now in three volumes, available at <http://www.evo-world.org/>.

² See Superior Energy Performance Measurement and Verification Protocol for Industry, November 19, 2012. Available at: https://www.energy.gov/sites/prod/files/2014/07/f17/sep_mv_protocol.pdf



A review of the literature on SEM programs illustrates that results of evaluations of SEM programs demonstrate that they deliver reliable savings, commonly ranging from two to 15 percent of electricity consumption. The SEP programs range from zero to 20 percent electricity savings and four to 26 percent natural gas consumption³. Programs are often delivered to – and evaluated for – cohorts of facilities. Savings continue to evolve over the program performance period of multiple years. However, various challenges associated with EM&V exist. The discussion of challenges in this report is informed by literature and insights provided by evaluators, implementers and other stakeholders. Key challenges include the treatment of impacts when operations/maintenance/behavior and capital investment actions are disaggregated, approaches to savings persistence, reporting of program results, consideration of non-energy impacts, including benefits which deliver important value and approaches to program cost-effectiveness analysis. Key takeaways and recommendations are summarized below.

Protocol Use and Development

Existing approaches to measuring savings are reasonably reliable and documented in several protocols. Regression analysis at the whole-building level is recommended for either the measurement of total impacts or as the starting point for disaggregating capital investment program impacts from operations, management and behavioral (OMB) impacts.

As program experience increases, protocols can evolve to reflect best practice in addressing evaluation approaches to elements of SEM programs for which guidance is not currently available, including interactive effects between OMB and capital investment programs, treatment of baselines and persistence when disaggregating OMB from capital investment savings, assessing impacts from the implementation of multiyear program, and potentially, guidance on quantifying significant non-energy benefits.

Evaluation Approaches

Most of the experience is focused on modeling savings at single sites. To date, most of the programs discussed in the literature have served relatively small numbers of customers. These features contribute to challenges associated with standardizing evaluation across programs. With more program experience, the measurement approaches can be refined to improve accuracy and the ability to measure diverse program applications.

Overall costs of SEM, including evaluation costs, can be high, in part due to the individuality of facilities in an SEM program. Various tactics that can help reduce evaluation costs include: more detailed and consistent record-keeping by participants, which can improve accuracy of engineering estimates and inform non-routine adjustments; use of facilities' energy management information system (EMIS) data to inform program performance; scaling up program participation and use of relatively simple model specifications to focus on accuracy of results at the program level; establishing homogenous cohorts to increase consistency in the facilities being treated and evaluated.

³ See <https://www.energy.gov/sites/prod/files/2015/09/f26/SEP%20program%20planning%20guide.pdf>.



Evaluation Results

SEM program impacts in the range of two to 15 percent of electric consumption are commonly observed, however negative savings are found in some facilities; it is important to include these in estimates of total program impacts to avoid bias in the program results. For multiyear programs, it is important to assess impacts over the performance period, as impacts have been observed to change over time.

Also, more information is needed about the consequences of long-term SEM engagement, in order to understand the full measure life of SEM programs. Guidance is needed on estimation and reporting of measure life of SEM at the program level when capital investment and OMB activities are elements of the program.

Results are reported in various ways, but would benefit from use of consistent and transparent reporting conventions across utilities and programs. Useful information includes disaggregated and total impacts, information about the reliability of savings estimates, realization rates, as well as reporting the savings as percent of consumption metric. Clarity is also needed on whether the SEM program is OMB only or OMB combined with capital investment.

SEM programs deliver gross program impacts; the prevailing indication is that customers would not have taken the efficiency actions on their own in the absence of the highly individualized service they receive from the SEM engagement. However, net savings (savings attributable to a program) have been estimated for some Superior Energy Performance (SEP)-certified facilities. SEM programs that expand to serve a large volume of customers with less personalized, more automated education should also examine net impacts.

Addressing aspects of SEM not generally included in evaluation studies of SEM programs can help demonstrate or document the value of SEM; these include: demand impacts; gas program impacts; and non-energy benefits.

M&V 2.0

Looking ahead, SEM programs should consider exploring the application of “M&V2.0” approaches as more information about best practice becomes available, especially since SEM programs already use some aspects of these approaches in the program implementation. M&V2.0 generally refers to the use of regression models of interval sub-metering data to estimate whole-building energy savings; it is suitable for utilities with advanced metering infrastructure or with utility customers with smart energy management systems (systems that deliver feedback to the customer). The benefits of this approach are that it could speed up feedback on continuous improvement and potentially reduce evaluation costs. For some utilities, the analysis could be carried out for all efficiency projects, avoiding problems associated with sampling in program evaluation. However, it is important to note that multiyear assessment of SEM programs impacts would still be necessary in order to assess persistence of impacts. A number of challenges associated with the current whole-building regression-based SEM program evaluation approach also exist for M&V2.0, such as treatment of baselines, need to apply non-routine adjustments, and explanatory variables beyond weather, for example associated with production.⁴

⁴ SBW Consulting, Inc., January 19, 2017, Evaluation Strategies for the Site-Specific Savings Portfolio. Available at: www.bps.gov/goto/evaluiton.



Non-energy Impacts

SEM programs have a variety of non-energy impacts (benefits) of value to society, utilities, or participating customers. Estimation of non-energy impacts is not commonly included as part of SEM program evaluation.

Evaluators should explore use of production efficiency as a variable in regression models used for SEM program evaluation. This has been done for some SEM programs, those that both measure and communicate the economic benefit of the SEM program to stakeholders.

Customers' activity logs and other tracking of non-energy impacts should be incorporated in formal data collection efforts and templates to enable evaluators to document and/or estimate these for various purposes, including marketing the program and as inputs to cost-effectiveness analysis.

Evaluation methods used to estimate non-energy impacts from other commercial and industrial energy efficiency programs, such as self-report surveys combined with engineering information, should be explored for transferability to SEM programs.

As part of national protocol development in support of SEM, consideration should be given to developing a web-based tool and database focused on the industrial sector that includes the following elements: method for assessing non-energy impacts of energy efficiency projects; a non-energy impact database that allows users to search by project type; case studies with details; and a questionnaire to assist utilities with identification and assessment of non-energy impacts.

Cost-Effectiveness

The Total Resource Cost Test widely prevails as the tool used to assess cost-effectiveness of SEM programs, and templates and tools are available to assist utilities in categorizing and applying the TRC test for SEM programs. Utilities should apply the TRC test symmetrically, quantifying both costs and benefits of any element in the test, to reduce or avoid bias in the test.

Going forward, utilities may want to consult the [National Standard Practice Manual](#) for Assessing Cost-Effectiveness prepared by the National Efficiency Screening Project. This provides updated guidance on cost-effectiveness testing and includes a recommendation that tests be designed to align with state policies and that the state policies should guide the range of impacts included in cost-effectiveness testing.

When cost-effectiveness is a concern, utilities commonly focus their attention on how to reduce costs or design alternate strategies for presenting the savings before they turn to comprehensive evaluation of non-energy benefits.



Introduction

The industrial sector represents 20 percent of the energy used in the Northeast/Mid-Atlantic region. NEEP's 2016 Market Assessment Report⁵ found that energy management practices amongst most industrial companies and facilities tend to be unsophisticated, irregular, and focused mainly on ad hoc capital improvements. The report includes several exciting pathways for the industrial sector to become more energy efficient, but highlights Strategic Energy Management (SEM) as an emerging opportunity for the region. SEM is an energy efficiency strategy that has demonstrated the ability to capture comprehensive savings from large industrial and commercial facilities. It is relatively new in energy efficiency program portfolios, yet the approach holds great promise. There are many opportunities to learn from some of the current experience.

Purpose

The purpose of this report is to provide energy efficiency program planners, evaluators and regulators with clear information on the issues related to evaluation of savings and cost-effectiveness associated with implementation of SEM. Lack of programmatic and regulatory experience with Strategic Energy Management, specifically the measurement of related costs and savings, has been a barrier to adoption in the Northeast and Mid-Atlantic region.

This report offers guidance that addresses key questions related to energy efficiency program evaluation of SEM offerings, including an exploration of issues related to cost-effectiveness of program implementation. It also explores the non-energy benefits (reduced operating and maintenance expenses, water savings, improved worker satisfaction, health and productivity) that Strategic Energy Management provides, and offers recommendations on how they may be accounted for.

This effort has leveraged existing results and best practices from the Uniform Method Protocol's draft Strategic Energy Management Protocol and program cost-effectiveness screening methods informed by a variety of sources, ranging from the U.S. Department of Energy (US DOE) Superior Energy Performance (SEP) program and international efforts to program experience concentrated in Vermont and the Northwest (Bonneville Power Administration (BPA), Energy Trust of Oregon) as well as the draft version of a National Standard Practice Manual developed by the National Efficiency Screening Project.

History and Definition of Strategic Energy Management

Energy saving potential in industrial facilities and large commercial buildings can be significant and cost-effective with short payback times. Moreover, the positive effects of energy efficiency in these sectors can go far beyond energy savings to include reduced maintenance and operational costs, improved productivity, and other benefits. Strategic Energy Management programs that focus on achieving energy savings from improved operational control of equipment, processes and systems have emerged within the last decade as a practice to help customers and program administrators realize the savings potential.

However, for various reasons, including lack of priority, corporate concern about risks to investment or productivity, or the organizational structure of a company or enterprise, realizing the potential savings is often

⁵ Northeast Energy Efficiency Partnerships, Inc. 2016. "Northeast and Mid-Atlantic Industrial Sector Report: Market Assessment and Recommended Strategies to Accelerate Energy Efficiency." Available at: <http://www.neep.org/sites/default/files/resources/Northeast-MidAtlantic%20Industrial%20Market%20Assessment%20FINAL.pdf>



constrained, delayed or prevented. While SEM can overcome many barriers to saving energy, “because of the work and costs involved, they require a customer of a certain sophistication and size to ensure the program is successful and cost effective.”⁶

ISO 50001 helped set the stage for development of Strategic Energy Management initiatives. The International Organization for Standardization (ISO) is the world's largest developer and publisher of international standards. In 2008, recognizing energy management among the priorities for development of international standards, it created a project committee to carry out the development of ISO 50001. This standard provides organizations with an internationally-recognized framework for implementing an energy management system (EnMS). The standard addresses the following:

- Commitment and engagement by top management to continually improve energy performance;
- Measurement, documentation, and reporting of past and present energy use and consumption;
- Variables affecting energy performance that can be monitored and influenced by the organization
- Identification of significant energy uses and opportunities for energy performance improvement including operational control and capital actions;
- Design and procurement practices for energy-using equipment, systems, and processes.

Commitment by top management and an EnMS are keys to ISO 50001 success. When top management approves the pursuit of SEM, appoints a responsible officer and receives reports, SEM is raised to a level of organizational importance similar to supply chain management or production efficiency. An EnMS helps an organization internalize the policies, procedures, and tools to systematically track, analyze, and improve energy efficiency in an all-encompassing way. This method considers maintenance practices, operational controls, and the design and procurement of renovated, modified, and new equipment, systems, processes, and facilities. While the standard does not prescribe minimum performance criteria, energy reductions or targets, it does seek to integrate energy management into normal business processes throughout an organization, and it requires an organization and facility to demonstrate continual energy performance improvement. The U.S. Department of Energy contributed actively to the development of ISO 50001 and helps support its broad implementation domestically through various initiatives⁷.

At a high level, Strategic Energy Management (SEM) targets large and medium commercial and industrial energy efficiency and it is designed to overcome barriers to energy savings through holistic, continuous improvement in energy performance over the long term⁸. As noted by the Consortium for Energy Efficiency (CEE):

“SEM emphasizes equipping and enabling plant management and staff to impact energy consumption through behavioral and operational change. While SEM does not emphasize a technical or project centric approach, SEM principles and objectives may support capital project implementation.”⁹

⁶ Optimal Consultant Team, 2016. “Increasing Energy Productivity through Strategic Energy Management.” Memo to MA EEAC Council. March 10. P. 7. www.ma-eeac.org.

⁷ See <https://energy.gov/eere/amo/doe-promotion-iso-50001> for information on DOE promotion of ISO 50001.

⁸ Enabling self-management rather than externally imposed requirements on industrial customers and an interest in preserving domestic manufacturing jobs and competitiveness are two impulses that motivated federal contributions to the development of ISO 50001 and related SEM initiatives.



Core Elements of SEM

Typically SEM programs incorporate some, if not all, of the elements shown in the table below. Moreover, many SEM programs provide training on energy management practices and financial incentives to participating facilities or organizations. “The “minimum elements” highlight three essential components of SEM: (1) customer commitment, (2) planning and implementation, and (3) a system for measuring and reporting energy performance. SEM’s uniqueness as a program design, and its manifold benefits for program administrators and industrial businesses, is in the interactions among these elements.”¹⁰

Table 1.1 Minimum Elements of SEM Programs

Minimum Elements of SEM Programs	
COMMITMENT PHASE	
1	Set and communicate continuous improvement objective and long-range energy performance goals
2	Ensure SEM initiatives are sufficiently resourced and a responsible individual is designated
PLANNING AND IMPLEMENTATION PHASE	
3	Assess current energy management practices using a performance scorecard
4	Develop a map of energy use and cost
5	Establish clear, measurable metrics and goals
6	Register or record actions to be undertaken to achieve the energy performance goals
7	Engage employees
8	Implement planned actions
MEASURING AND REPORTING PHASE	
9	Periodically reassess energy performance
10	Collect and store performance data, making it available over time
11	Analyze energy use data determining relevant variables affecting use compared to a baseline
12	Reporting

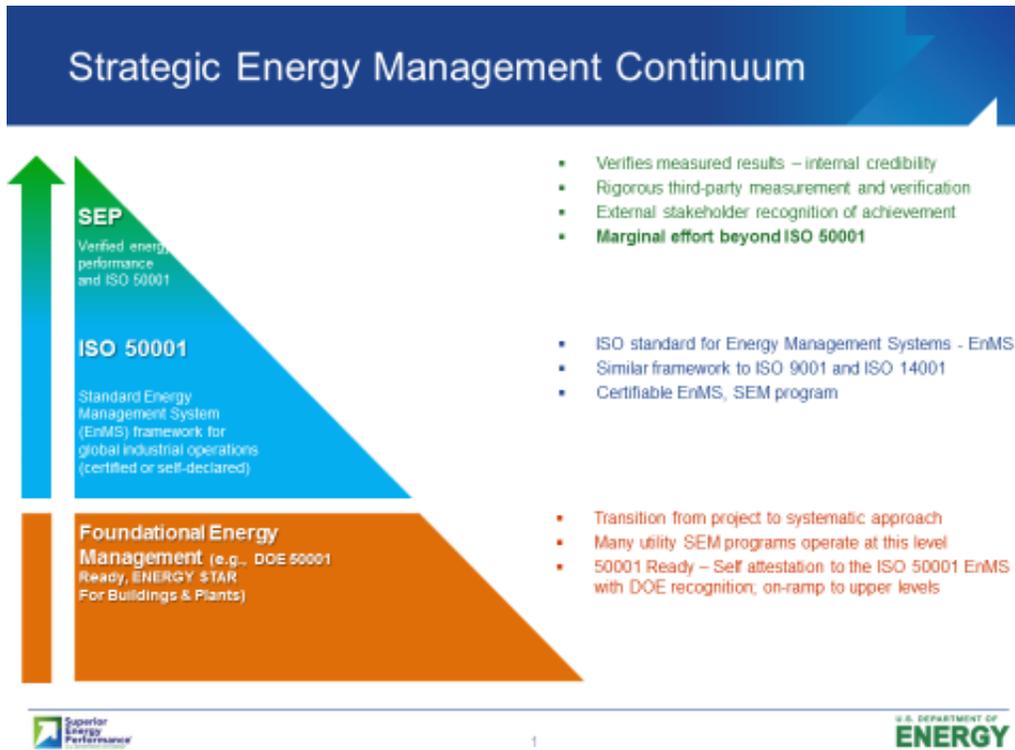
⁹ Consortium for Energy Efficiency. 2014. “CEE Industrial Strategic Energy Management Initiative” http://library.cee1.org/sites/default/files/library/11282/Industrial_SEM_Initiative.pdf Ecova. 2014 “2015 Energy and Sustainability Predictions.” http://www.ecova.com/media/1078586/ecova_report_2015_energy_and_sustainability_predictions.pdf

¹⁰ Burgess, Jess et al. 2015. “The Second Generation of Strategic Energy Management Programs.” ACEEE Summer Study on Energy Efficiency in Industry.

Developments in SEM Programs

SEM programs are offered both at the utility or state and national level. SEM programs of all types continue to evolve as customer feedback and a greater understanding of elements of SEM programs are gathered.

Figure 1.1 U.S. DOE Classification of Strategic Energy Management Program Types



At the utility or state level, SEM programs began as pilot efforts in the northwest US and Canada in 2009. Since 2011, when CEE identified seven program administrators offering SEM, it has grown steadily. In 2014 CEE counted 21 program administrators with SEM offerings for industrial end users, and more than 420 industrial facilities that have participated in SEM programs. Consensus agreement on the minimum elements was facilitated by CEE in January 2014, in order to encourage alignment among program administrators around effective approaches to achieve measurable, persistent, and cost-effective energy saving through the implementation of SEM in industrial facilities. Since publication of the SEM minimum elements, programs have been increasingly formalizing the concept of an EnMS which in many instances is based upon, or at least guided by, ISO 50001.

U.S. DOE’s Advanced Manufacturing Office AMO has classified three levels of Strategic Energy Management (SEM) as illustrated in Figure 1.1¹¹. The first level is referred to as Foundational Energy Management. This level is the most basic and includes only the very core aspects of SEM. The next step is becoming certified to meet [ISO 50001](#) energy management standards and the third tier of certification is [Superior Energy Performance](#) (SEP). In addition to the three tiers of SEM, DOE provides multiple resources for industrial facilities.

¹¹ U.S. Department of Energy. AMO Energy Resources Center website; <https://ecenter.ee.doe.gov/layouts/ecenter/ppc.eguide/home.aspx#>



Nationally, the US DOE operates and is developing ISO 50001-based SEM recognition programs. Developed in 2007, the Superior Energy Performance (SEP) program recognizes organizations that achieve ISO 50001 certification and third-party verification of energy performance improvement as defined by the SEP Measurement and Verification Protocol. Analysis of energy and cost savings from SEP participants shows that the implementation of an ISO 50001 EnMS results in, on average, a greater than three times improvement in energy performance (energy consumption normalized to production or some other relevant variable) as compared to before EnMS implementation.¹²

In support of the SEP program, the Institute for Energy Management Professionals¹³ offers certifications to individuals in the areas of EnMS development and implementation, energy performance verification, and auditing.

In order to facilitate greater uptake of ISO 50001-based EnMS in the industrial and commercial sectors, the US DOE is developing the 50001 Ready Program. This new program will recognize facilities that submit to the US DOE an attestation signed by a senior executive stating they have followed the guidance of the US DOE's 50001 Ready Navigator to implement an ISO 50001-based EnMS as well as an energy performance improvement value for the year. The US DOE has also developed a regression-based energy savings calculation tool, EnPi Lite in support of the 50001 Ready Program¹⁴. Both the 50001 Ready Navigator and EnPi Lite are meant to be open source and available for utilities and states to rebrand and use as part of their programs if desired.

EM&V Protocols for SEM

The purpose of this section is to provide an overview of protocols available or soon-to-be available, and address how SEM should be measured and evaluated. It identifies key steps involved in development of SEM savings estimation and evaluation per the guidance. The Uniform Methods Protocols (UMP) developed by the US DOE outlines best practices for energy impact estimation as part of measurement and verification (M&V) or as evaluation, measurement and verification (EM&V). Currently, a Strategic Energy Management Evaluation UMP is in a public review draft stage. The SEM UMP document draws broadly upon today's most common SEM EM&V protocols. Key elements of the draft protocol are summarized in this section. Beyond the SEM UMP document, domestic and international SEM EM&V protocols and guidance documents continue to evolve and be developed.

M&V vs EM&V

For any discussion of "EM&V", it is helpful to establish common understanding of the terms and distinctions and connotations associated with evaluation, measurement and verification (EM&V). There are many ways that measurement, "a procedure for assigning a number to an observed object or event"¹⁵ can take place, but regardless of method, it describes the process of quantification. In the energy efficiency industry, measurement and verification (M&V) refers to "data collection monitoring and analysis associated with the calculation of gross

¹² Therkelsen, Peter et al. 2015. "Development of an Enhanced Payback Function for the Superior Energy Performance Program." 2015 ACEEE Summer Study on Energy Efficiency in Industry <https://eta.lbl.gov/sites/all/files/publications/lbnl-190883-3.pdf>

¹³ See <https://ienmp.org> for more information about the Institute for Energy Management Professionals.

¹⁴ See http://www.neep.org/sites/default/files/SEM%20Workshop_Glatt_Wrobel.pdf.

¹⁵ Model Energy Efficiency Program Impact Evaluation Guide, November 2007, Appendix B-3.



energy and demand savings from individual sites or projects. M&V can be a subset of program impact evaluation.”¹⁶ It can also be a part of the activities associated with program delivery and implementation. This is particularly true in SEM programs, since, by design, the initial phases of SEM projects include data collection and modeling to calculate gross energy consumption, and criteria for screening an SEM project include estimating energy savings and determining whether data are sufficient to develop an energy consumption model.

By contrast, the definition of evaluation in the energy efficiency industry is broader in scope. It is defined as “the performance of studies and activities aimed at determining the effects of a program; any of a wide range of assessment activities associated with understanding or documenting program performance, assessing program or program-related markets and market operations; any of a wide range of evaluative efforts including assessing program-induced changes in energy efficiency markets, levels of demand or energy savings, and program cost-effectiveness,”¹⁷¹⁸. That said, it can sometimes be difficult to draw a bright line between M&V and EM&V. At a high level, evaluations involve independent review and typically focus on estimating program level rather than individual participants; they may employ the same tools that are used for M&V. Program evaluation asks: “What happened – compared to baseline conditions - and why?”

A key distinguishing feature of evaluation is a “look back” after the program has performed for some period of time. As such, it can take the form of third-party review of previously conducted data collection and modeling (M&V) or generation of a new model. Evaluation as an activity can extend beyond calculations to include examination of documents and input assumptions, tracking systems, and processes¹⁹. In addition, evaluation may assess a broader range of impacts than the gross energy and demand impacts that are the focus of M&V.

Net savings (program-induced impacts, accounting for market or customer spillover effects as well as freeriding customers’ behavior) and non-energy impacts (various indirect results of programs) are two examples of topics that are included among evaluation activities in some cases and are discussed briefly in this report.

M&V Protocols for SEM Programs

Prior to development of Uniform Methods Protocols for SEM, SEM programs have been able to draw from other existing protocols to inform estimation of gross energy savings. The most pertinent of these are: 1) IPMVP Option C²⁰ and 2) SEP M&V²¹.

¹⁶ Ibid.

¹⁷ Model Energy Efficiency Program Impact Evaluation Guide, November 2007, Appendix B-2

¹⁸ In addition to quantifying program impacts, EM&V can include process evaluation, which involves critical examination of program design and delivery for the purpose of improvement.

¹⁹The Cadmus Group, October 26, 2015, “Process Evaluation of California’s Continuous Energy Improvement Pilot Program,” CALMAC Study ID SCE0394.01 as an example of a process evaluation conducted to gain insight into possible program improvements or refinements.

²⁰ The Efficiency Valuation Organization (EVO) publishes the International Performance Measurement and Verification Protocol (IPMVP which provides an overview of current best practice techniques available for verifying savings from both traditionally funded and third-party-financed energy and water efficiency projects. It is in three volumes, available at <http://www.evo-world.org/>.



The IPMVP Protocol

International Performance Measurement and Verification Protocol (IPMVP) was developed to increase investment in energy and water efficiency, demand management and renewable energy projects around the world. It allows building owners, energy service companies, and financiers of energy efficiency projects to quantify the energy savings performance of energy conservation measures at the measure level and at a facility level. It provides an overview of current best practice techniques available for verifying savings from both traditionally funded and third-party-financed energy and water efficiency projects. IPMVP Option C recommends regression analysis with energy consumption data at the whole or sub-facility level as a method for estimating whole building impacts from large commercial and industrial efficiency programs.

The SEP M&V Protocol

The Superior Energy Performance Measurement and Verification Protocol for Industry (2012) defines procedures for determining compliance with the energy performance requirements of the US DOE SEP Program. While similar to IPMVP Option C at a high level, the SEP M&V Protocol is more specific in its requirements, and it is more prescriptive than guidance developed for SEM programs. The SEP M&V Protocol prescribes the following for verifying that a facility has met the requirement for SEP certification:

- Conducting top-down analysis of facility energy use, as opposed to end-use specific analyses;
- Defining facility boundaries that remain constant between baseline and reporting periods;
- Defining at least 12 consecutive months of baseline and reporting periods;
- Accounting for all types of energy consumed within the facility boundaries unless the energy accounts for five percent or less of total primary energy consumption, in which case it may be ignored;
- Using only data that can be verified and obtained from precise control or measurement systems;
- Using statistical models to determine baseline or normalized energy use;
- Estimating the SEP Energy Performance Indicator, which indicates the percent energy performance improvement; and
- Conducting a bottom-up analysis to assess plausibility of the top-down energy savings and performance improvement.

An updated version of the SEP M&V Protocol (2017) is near publication and builds upon international advancements in M&V for facilities with an ISO 50001 EnMS. The International Standards Organization has published ISO 50015:2014 – Measurement and verification of energy performance of organizations – General principles and ISO 50047:2016 – Determination of energy savings in organizations. Together ISO 50015 and ISO 50047 establish clear guidance on the process of measuring and verifying energy performance improvement through the determination of energy savings. These two guidance standards cannot be used for certification of energy performance improvement, as they do not include detailed requirements. The updated SEP M&V protocol provides the requirements to ensure credibility in third party verified energy performance improvement values.

²¹Superior Energy Performance Measurement and Verification Protocol for Industry, November 19, 2012. Available at: https://www.energy.gov/sites/prod/files/2014/07/f17/sep_mv_protocol.pdf



The Uniform Methods Protocols and SEM

In an effort to strengthen the credibility of energy savings determinations by improving EM&V, increasing the consistency and transparency of how energy savings are determined, the US DOE has been publishing Uniform Methods Protocols²² addressing key efficiency technologies, end uses, or practices. These protocols provide:

- A clear, accessible reference for recommended EM&V practices;
- A description of the measure and application conditions;
- An algorithm for estimating savings in the context of the technology, end use or practice under consideration;
- An example of a typical program offering and alternative delivery strategies; and
- Considerations for the measurement and verification process, including an International Performance Measurement and Verification Protocol (IPMVP) option.

The protocols are voluntary and are intended to serve a varied audience of stakeholders. For energy efficiency program administrators and regulators, protocols make it easier and less costly to quickly establish good EM&V practices, and to help manage regulatory uncertainties. For resource planners, protocols help assess validity of energy savings estimates. For investors, protocols can reduce financial risk to underwriters. Finally, all stakeholders benefit from a system that simplifies the comparison of savings resulting from similar programs in different jurisdictions and supports the development of best practices for energy efficiency programs.

The UMP Protocol for SEM is one of the most recent topics for which Uniform Methods Protocols have been drafted, and as noted above it is awaiting publication. It has applicability to both initial quantification of energy savings from an SEM program and to program evaluation. At this early stage in the life of SEM as an energy efficiency strategy, program administrators and evaluators are acquiring experience quantifying savings as part of program planning or implementation as well as evaluating results of the programs; as experience with evaluating SEM grows, the UMP is expected to also evolve.

The SEM UMP Draft Protocol is similar to Option C and to SEP in that it recommends regression analysis at the whole building or facility level as a strategy for estimating impacts. However, this protocol places more specific focus on the nature of SEM as a program design. As such, at a high level, it can be characterized as more flexible than the SEP protocol, in recognition that SEM programs are a relatively new offering and that delivering energy efficiency to industrial customers can involve unique situations that present challenges for standardization.

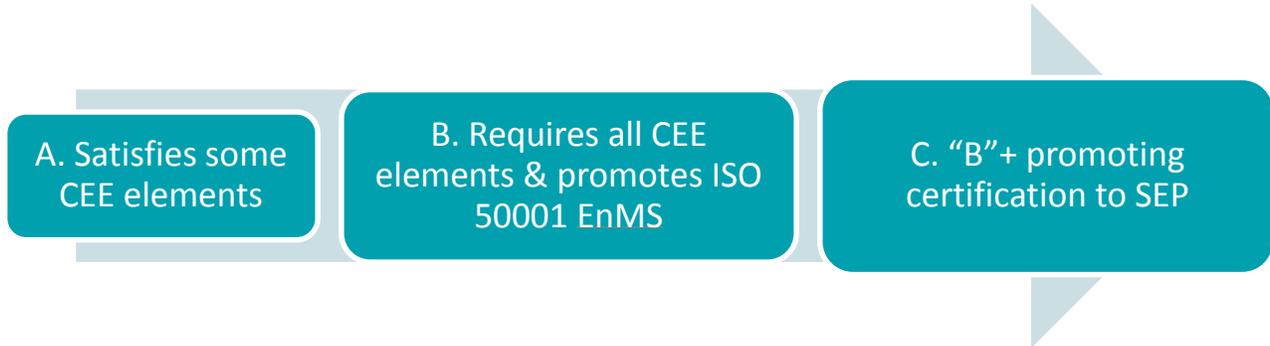
Elements of SEM Programs

SEM program elements may be characterized as a hybrid of many program features: custom commercial and industrial (C&I) capital investments in efficiency measures, operations and maintenance (O&M) practices & behavioral strategies, and likely also some common prescriptive C&I measures. Program design and delivery for SEM programs include an educational component and some focus on continuous improvement as part of the strategy. In fact, the UMP draft protocol notes that it is applicable to the continuum of types of SEM programs,

²² For more description of the Uniform Methods Project and links to existing protocols, see <https://energy.gov/eere/about-us/about-ump>.

illustrated in Figure 1.1 and also below in Figure 2.1, as ranging from A) programs that satisfy some but not necessarily all of the Consortium of Energy Efficiency (CEE) minimum elements for SEM programs, and B) programs that meet or exceed the CEE elements and promotes ISO 50001 Energy Management Standards²³, to C) programs that are intended to promote certification to SEP.

Figure 2.1. The Uniform Methods Protocols Apply to a Range of Types of SEM Programs



The minimum elements of SEM program implementation (shown in Table 1.1) include several steps (specifically steps four, six, and 9-11) that are important for evaluation, measurement and verification, in that they contribute to quantification of savings estimates. Step four is development of a map of energy use and cost; step six is to record actions to be undertaking to achieve energy savings goals; and steps 9-11 address data collection, analysis, periodic reassessment and reporting.

Overview of the UMP Strategy for Estimating SEM Project Impacts

Like the IPMVP Option C²⁴ and the SEP M&V Protocol, the Uniform Methods Protocol (UMP) recommends collection of 12 months of facility energy use data and regression analysis to construct a valid baseline. Option C of the IPMVP (2012) refers to analysis of metered energy use at the whole facility or sub-facility level. Perhaps a

²³ As noted in <http://www.iso.org/iso/home/standards/management-standards/iso50001.htm>, ISO 50001, is intended to make it easier for organizations to integrate energy management into their overall efforts to improve quality and environmental management. Certification to ISO 50001 is possible but not obligatory.

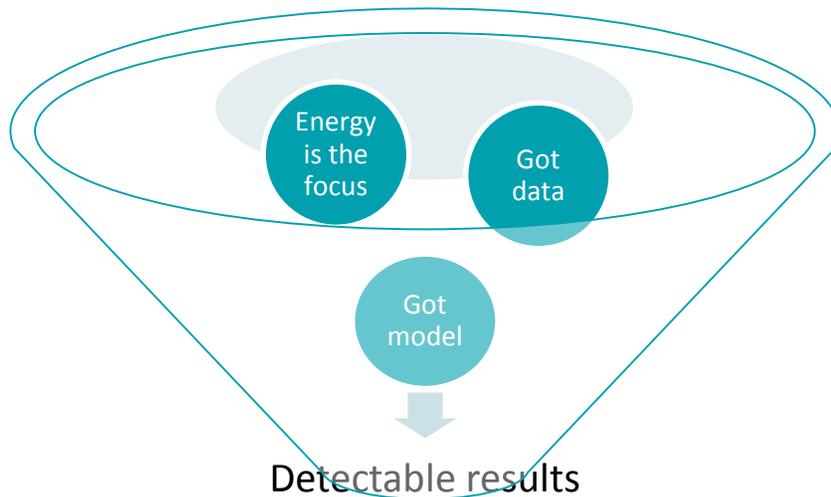
²⁴ The Efficiency Valuation Organization (EVO) publishes the International Performance Measurement and Verification Protocol (IPMVP) to increase investment in energy and water efficiency, demand management and renewable energy projects around the world. IPMVP is an industry standard for M&V applied at the individual facility level. The IPMVP allows building owners, energy service companies, and financiers of energy efficiency projects to quantify the energy savings performance of energy conservation measures (ECMs). It provides an overview of current best practice techniques available for verifying savings from both traditionally funded and third-party-financed energy and water efficiency projects. IPMVP provides four Options for determining savings (A, B, C and D). The choice among the Options involves many considerations. The IPMVP was recently revised, and is now in three volumes, available at <http://www.evo-world.org/>, where Volume I - Concepts and Options for Determining Energy and Water Savings (2009); Volume II - Indoor Environmental Quality Issues (2002); Volume III – Applications (Concepts and Options for Determining Energy Savings in New Construction (2006) and Concepts and Practices for Determining Energy Savings in Renewable Energy Technologies Applications (2003)).

noteworthy distinction is that the Uniform Methods Protocol is focused on a slightly higher level of aggregation; it focuses on best practices for estimating savings of individual commercial or industrial facilities *and* it also describes methods for conducting analyses to estimate average savings per facility for a panel of facilities. Two key aspects of SEM evaluation are: 1) it typically employs regression modeling as the primary method of estimating impacts; and 2) that the facility is the core unit of analysis. As such, facility may be one building with one meter, or multiple buildings with multiple meters, or even a subset of buildings that comprise a discrete part of an industrial site that can be clearly delineated. This recognizes that an evaluation of an SEM program can examine either specific projects - one by one, or it can examine a program, in which case it would report results across a panel of facilities.

In a nutshell, the strategy for estimating savings from SEM projects is to estimate adjusted baseline energy consumption without SEM at the facility level and compare that to facility level energy consumption over an appropriate defined period of time when the SEM program was implemented. It is important to note that while the UMP recommends whole facility or whole building modeling, it acknowledges that some programs require disaggregation of program impacts. For this, the UMP notes that it assumes SEM impacts are as follows, and that additional analysis and calculations are required for disaggregation of the categories of impacts:

Facility (or building) impacts = Capital (or retrofit) investment impacts + OMB (Operations, Maintenance, and Behavioral) impacts – Interactive Effects

To successfully detect SEM project impacts per the UMP, several conditions must be present.



Specifically,

1. The objective of the evaluation must be estimation of changes in energy use or energy use intensity (i.e. energy use is appropriately normalized, for example by production output or square feet). The savings may be reported for a single fuel or across multiple fuels. The UMP method does not examine time-differentiated impacts such as from demand response programs.
2. Sufficient data must be available.
3. A valid model to explain facility energy consumption must be achievable.
4. Savings from the SEM activities must be detectable in the model (sufficiently large signal relative to noise).

Steps in the Evaluation Process

At a high level, there are four steps identified by UMP as part of the evaluation process:

- Planning the evaluation.
 - a. Collaboration among stakeholders: The UMP stresses the benefits of having program administrators, implementers and evaluators working together from the beginning of the program to agree on evaluation goals, types and level of granularity of the data needed and available, and the evaluation approach. Not only does this ensure that the necessary conditions can be met in order to obtain results, but it manages expectations and delineates roles and responsibilities.
 - b. Establishing boundaries for units of measurement: It is important to be clear on what the units of measurement are. When using subsets of sites, it is important to avoid complications from interactive effects between the subset and other buildings outside of the subset.
 - c. Accounting for energy sources: It is important to understand whether the facility substitutes between fuels, if the evaluation includes multiple fuels. It is also important to establish whether energy consumption is measured as delivered or primary energy. Energy consumption = on-site generation + delivery – exports – inventory changes.
- Assessing the probability of detecting savings: “statistical power” should be assessed. This refers to the ability based on the model and available data to determine that an effect or hypothesized result is distinguishable from random behavior.
- Data collection
 - a. Identifying all relevant measureable and descriptive variables: These include energy consumption, weather, explanatory variables associated with the facility and production process, operating conditions and schedules, as well as tracking of the SEM-related activities, such as behavioral, maintenance or operational changes, capital investments, and retrofits, and consideration of the maturity of the program implementation. Granular data on expenses and labor may be needed to track costs and benefits and to disaggregate cost-effectiveness of the behavioral SEM activities from capital investment savings.
 - b. Interviewing facility staff: Evaluators use this to help develop a valid model and to verify installations and SEM-related activities, scheduling adjustments, expectations, and to obtain valuable process-related insights as well as understanding of non-routine factors.
 - c. Defining sufficient analysis periods: Both the baseline metering and the performance period metering should be sufficient to capture seasonal variations and any other important sources of variation.
- Regression modeling
 - a. Specifying the model: This typically involves determining what independent variables will be included, selecting the dependent variable (energy consumption per output or area, for example), and what the functional form of the model will be. This step typically involves some exploratory statistics and alternative formulations.
 - b. Developing the adjusted baseline: The adjusted baseline is the energy consumption observed prior to SEM implementation, but ‘normalized’, i.e. modified to account for

the conditions such as weather, occupancy, production output, for example, during the SEM implementation period. When adjusting the baseline, it is important to control for all the relevant variables that characterize facility conditions during the delivery period; it is also important to minimize measurement error associated with the independent variables, and to make any ad-hoc adjustments to the baseline for impacts that cannot be modeled statistically. These ad hoc adjustments are also referred to as non-routine adjustments.

- c. Fitting the model and estimating savings: After estimating the model, appropriate tests of key model assumptions are appropriate to assess the goodness of fit of the model. Does the model explain energy use at all ranges of output or weather at which the model is intended to be applied? Are the estimates unbiased and statistically significant? The evaluator should first estimate the adjusted baseline and then estimate savings as the difference between the baseline and metered energy used; the UMP notes several regression approaches that are available.
 - Final results and reporting: Documentation of methods and results is vital to support the transparency of M&V or evaluation impacts.
 - Disaggregating impacts: While the UMP focuses on whole-facility impacts, evaluations often require estimates for OMB (operations, maintenance and behavioral) impacts separate from and capital and retrofit project impacts. This is not a trivial effort. In addition to netting out retrofit project impacts, it is important to consider the possible existence of interaction effects between the categories of savings, and to consider the error associated with the retrofit impact and the facility level savings estimate when developing and reporting results²⁵.
 - Reporting impacts: Evaluators should report point estimates of SEM savings for the reporting period and standard errors or confidence intervals. The savings should be reported in units of energy and in a percentage of the adjusted baseline. Important aspects of the savings estimation – methods, assumptions, adjustments – should be part of the documentation.

Importance of SEM Project Data Collection and Model Specification

The discussion in the UMP which addresses these topics acknowledges that successful estimation of SEM program impacts can rest heavily on quantity and quality of quantitative and qualitative data as well as on the ability to specify and fit a model (or models) leveraging the available data. There is a large body of technical literature, both academic and from the energy evaluation industry that covers model, specification, decisions regarding data, and diagnostic tests and parameters that advise analysts about the quality of the model specification and fit. Those topics are outside of the scope of this more high level report.²⁶

²⁵ It is common for SEM programs to report SEM savings at a disaggregated level. This can involve calculating overall facility level impacts (top-down) econometrically and subtracting field-validated “bottom up” measure-specific savings, or by modeling energy consumption in multiple scenarios, one with only capital investment projects included and one baseline with no energy efficiency, as well as modeling overall facility-level consumption, and then examining the differences.

²⁶ Proceedings from the International Energy Program Evaluation Conference (www.iepec.org) are a valuable source for further exploration of experience with use of regression analysis in energy program impact analysis. Another helpful reference is Chapter 8: Whole Building Retrofit with Consumption Data Analysis Evaluation Protocol in The Uniform Methods Project Methods for Determining Energy Savings for Specific Measures (<https://energy.gov/sites/prod/files/2013/11/f5/53827-8.pdf>.)



Examples of the kinds of details and decisions that are needed to inform the process include:

- What are the boundaries of the program? Are the boundaries correctly aligned with the modeling?
- What on-site energy sources are impacted?
- How much data and what kind: Are appropriate qualitative & quantitative inputs collected?
- Does the baseline change over the course of the program? How?
- Is the regression model valid? How well does it perform?

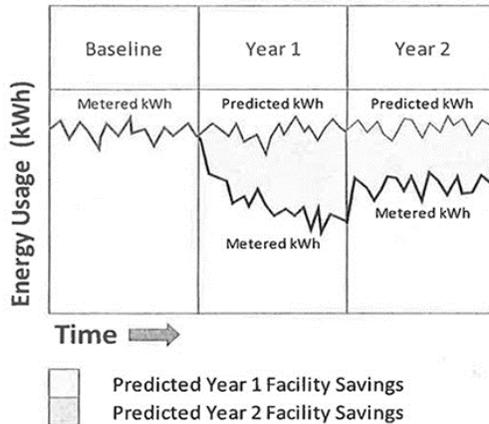
Modeling Approaches for Facility-Level Impacts and Non-routine Adjustments

- **Forecast or backcast:** Regression model describes energy consumption as a function of relevant variables. It forecasts post-performance baseline or backcasts the pre-performance baseline, depending on data available for the facility.
- **Pre-Post:** Regression model of average energy consumption/time unit with dummy variable(s) identifying SEM performance period(s) and coefficient(s) to estimate savings for the facility; can capture impacts from different phases of implementation.
- **Panel Regression:** Regression strategy for multiple facilities. (Assume either fixed or random effects).

Figure 2.2 Illustration of forecasted baseline comparison with metered conditions

SEM Evaluation Methods

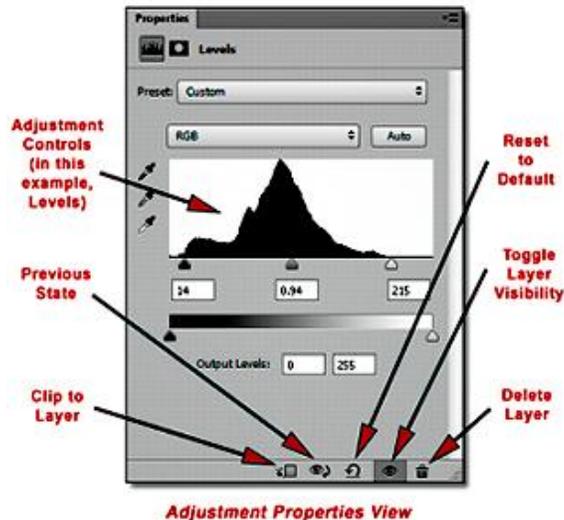
Three model types typically used in SEM evaluation



1. Forecast
(or CUSUM) Model
2. Simple
Pre-Post Model
3. Fully Specified
Pre-Post Model

Non-routine adjustments are ad hoc “tweaks” to model results to eliminate model bias when special circumstances defy modeling. By way of illustration, the figure below, which shows a small blip in the graph with the label “adjustment controls” is an example of a place where a non-routine adjustment may be necessary to improve the ability of a model to describe observed behavior. In a facility, breakdown and repair of some large equipment is one situation in which a model may require a non-routine adjustment, for example.

Figure 2.3 Example of Loadshape Curve with Non-routine event





Net Impact Estimation: Free Ridership, Spillover, and Net Savings

The SEM UMP, which is primarily concerned with estimation of gross savings using a regression-adjusted baseline, recommends that evaluators consult UMP Chapter 23 (Estimating Net Savings: Common practices)²⁷ for guidance on development of free ridership, spillover or aggregate net savings impacts. This document is an excellent informational resource that describes the key concepts pertaining to net savings. It provides summary discussion of the gamut of analytical methods currently available for estimation of free ridership and spillover and in some cases overall net impacts, and it identifies key decision criteria that policymakers or evaluators can use to match what analytical method to apply to what type of energy efficiency program.

NEEP's Regional EM&V Forum developed a complementary, more condensed, source of guidance on applications of net savings to efficiency programs. Neither source addresses SEM programs explicitly. The literature on SEM program evaluations does not include any formal reports on net savings evaluation. However, several takeaways from the guidance documents provide considerations that may be applicable to various SEM programs.

SEM programs in which facilities are evaluated individually bear similarities to custom programs that usually have few participants and in which each project will be markedly different from another, so commonly applied net savings approaches relying on billing analysis with exogenous comparison groups with billing analyses have not been practical or feasible for SEM. More information about individual customers' intentions would be needed in order to understand whether free ridership or spillover were influencing the program impacts. The net savings guidance documents suggest that when net savings estimates are needed for custom C&I style programs, the best approach is to view each project individually, relying on a case study methodology or interviews. Should additional confirmation be required, the free ridership and spillover findings should be acquired using a Delphi approach or some other structured expert judgment to understand what, if any actions would have taken place above and beyond the program.²⁸

Anecdotal evidence from conversations with SEM program managers, testimonials from facility managers, and evaluators, as well as an understanding of the comprehensive nature of most program designs suggests that free ridership is at or close to zero, particularly for the components of the program that involve training to influence behavior and operational changes. And because the intent of the program is continuous improvement, spillover of behavior change beyond the program, conceptually, is unlikely to be positive. Based on cumulative experience with SEM, observations noted by ETO are that the program has been especially successful for customers with the combination of time, willingness to invest, ability, and executive buy-in that allows them to take the actions required to realize savings; this set of criteria is not necessarily restricted to large industrial segment. The large customer investment required means SEM has a very small number of free-riders because no ETO customers would do this on their own.²⁹ However, net savings have been estimated for some Superior Energy Performance (SEP)-certified facilities.³⁰

²⁷ Violette, Dan and Pam Rathbun. September 2014. "Estimating Net Savings: Common Practices Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures." Available at <http://www.nrel.gov/docs/fy14osti/62678.pdf>

²⁸ See <http://bit.ly/NetSavingsFrmwrk0517>

²⁹ Phil Degens, September 16, 2016, personal communication.

³⁰ See https://eetd.lbl.gov/sites/all/files/aceee_sep_paper.pdf.



If the SEM programs evolve to embrace small C&I customers and training and tracking of participation that is more impersonal, some examination of net savings may be both more feasible and necessary. With large numbers of customers receiving access to similar and somewhat anonymous training, use of random control trial methods or customer and non-participant surveys, and guidance pertaining to the top-down macro-consumption models are potentially applicable.

Evaluation Experience: Findings, Practice, Challenges and Promise

This section reviews program results and evaluation practices drawn from studies and information available about existing experience with SEM program evaluations and illustrates the range of impacts, challenges associated with evaluations, and evolving nature of existing ongoing programs.

Program Impacts: Verifiable Savings Achieved from SEM

To date, a relatively small number of program administrators provide evaluation reports on quantified savings. The publicly-reported savings have undergone vetting and corroboration (verification) or additional assessment independent analysis (evaluation). The summary of programs provided in the Appendix indicates that most companies claim energy savings from SEM programs; some claim demand impacts as well. A majority of the programs included operational, maintenance or behavioral measures in their energy savings. While some include savings from capital measures as part of SEM program total savings, some claim capital investment savings as results of separate programs; one function some SEM programs serve is to be a pipeline to other utility capital investment programs. A majority of programs had submetering and also had some form of energy management information system (EMIS) available, which can assist with development of impact estimates for specific measures disaggregated from whole building modeling results.

A review of literature on evaluations and savings from SEM programs confirms that these programs are still relatively rare and new. For example, BC Hydro launched its SEM program in 2007, Energy Trust of Oregon (ETO) and Bonneville Power Authority (BPA) in 2009, and Focus on Energy WI and Efficiency Vermont in 2014. The most comprehensive overview of SEM programs is available from the Consortium of Energy Efficiency (CEE).³¹ As of 2016, SEM programs have served 707 industrial sites overall. In 2015, 10 programs provided services to 287 facilities. Most of the growth in customers served since 2014 is attributable to the Energy Trust of Oregon and AEP Ohio programs. Keeping in mind that each program administrator uses different program development processes and schedules, the Consortium for Energy Efficiency (CEE) summarized the status of SEM program development. Some key observations from CEE that characterize the diversity of programs are noted below:

- Five programs had 2015 SEM program budgets of \$0.5 million or less; five had budgets of \$1.5 million or more.
- Five programs reported savings of 32.3 GWh from operations, maintenance and behavioral actions (OMB) only. Three programs reported savings of 46.1 GWh from OMB and capital projects combined.
- Two programs reported gas savings of 434,294 therms (one from a dual fuel program, one gas only).

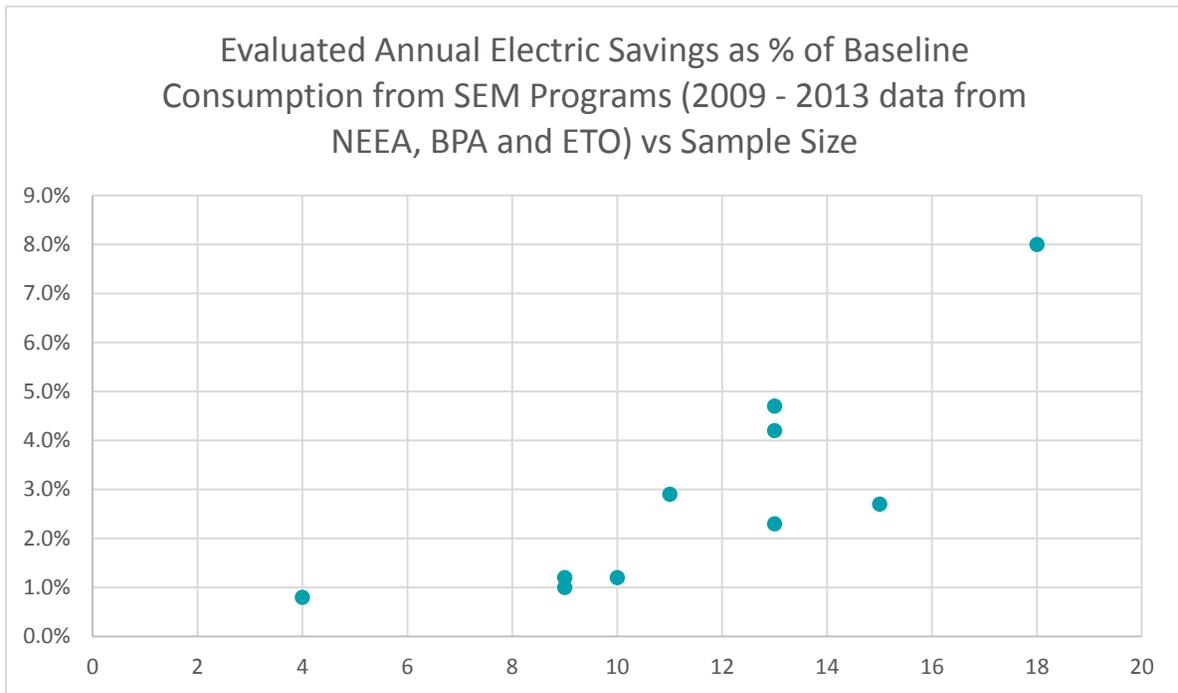
³¹Consortium for Energy Efficiency. November 21, 2016. "CEE 2016 Strategic Energy Management Program Summary." Available at: [at https://library.cee1.org/content/cee-2016-industrial-strategic-energy-management-program-summary-0](https://library.cee1.org/content/cee-2016-industrial-strategic-energy-management-program-summary-0)

- Programs vary widely in design. Four of 10 programs that claim OMB savings do not provide performance-based incentive, three offer no incentives for SEM, and one only incents capital projects.

Northwest Experience

Figure 2.2 and Table 2 below capture information from a study in 2014 that summarized and analyzed verified savings from four Northwest programs – Northwest Energy Efficiency Alliance (NEEA), BPA, and ETO – that have undergone an impact evaluation and have publically available results.

Figure 2.2 Evaluated Average Annual Electric Savings from SEM Programs ³²



³² Based on information presented in Ochsner, Heidi et al. 2015. “Does SEM Achieve Verifiable Savings? A Summary of Evaluation Results.” Washington, D.C. ACEEE Summer Study on Energy Efficiency in Industry.

Table 2.1 Program-specific Evaluated Electric Savings from SEM Programs³³

Program	Program Year(s) Evaluated	Number of Facilities	Evaluation Sample Size (Facilities)	Average Annual SEM Electric Savings as Percentage of Baseline Consumption (net of projects that received incentives from other programs)	Source
NEEA's Industrial Initiative	2013	9	9	1.21%	DNV KEMA, 2014
	2011-2012	9	9	1%	
	2010	13	11	2.9%	ERS 2012; Correspondence with NEEA; Only includes food processing
	2009	15	13	4.2%	
	2008	15	13	4.7%	
	2007	15	13	2.3%	
	2006	5	4	0.8%	
NEEA's Small to Medium Sized Industrial Facility Management Pilot	2011 – 2013	10	10	1.2%	Energy 350, 2014
BPA's Energy Management Pilot	July 2010 – June 2011	HPEM:15 T&T:2	HPEM:15 T&T:2	2.7% +8% at 80% confidence and 20% precision	Cadmus, 2013
Energy Trust of Oregon's SEM	2009 - 2011	34	18	8%	Navigant 2013; Correspondence with Energy Trust

There are many possible reasons for the variation in results from the Northwest programs. Some of the results (2.7 percent and eight percent) are representative of first year implementation from BPA and ETO, respectively. The savings from NEEA's programs (results ranging from .8 percent to 4.7 percent) include different mixes of facilities in each year of analysis and different stages of SEM implementation. Moreover, results are based on studies from five different evaluation contractors. Verified savings were reported in different units. Confidence and precision results were not reported for all studies, and different methodologies were used to determine savings, which limits the ability to dive more deeply into results. Energy Trust's approach quantifies energy savings by comparing energy consumption at the end of the engagement year to energy consumption before the engagement year (after controlling for weather and facility production). BPA and NEEA compare energy consumption from the entire engagement year to the energy consumption in the year before the engagement

³³ Ibid.



year. During the first year of engagement, facilities typically undergo a ramp up period where they begin to incorporate SEM practices and not many activities have been completed yet. BPA and NEEA do not need to exclude the ramp up period since they are engaging with customers for multiple years and activities implemented at the end of year one will be captured in year two savings. However, Energy Trust excludes the ramp up period since they only engage participants for one year.

The most recent Impact evaluation by BPA found SEM saved 2.3% of consumption. The evaluation used a forecast approach and statistical analysis of individual facility consumption to estimate savings. Data collection included documentation of non-routine adjustments, collection of high-frequency consumption data, and use of workbooks to track and report consumption increases. The evaluation tracked examined savings annually and in aggregate over a four-year period for 9-12 facilities. Results showed significant variation between facilities and from year-to-year for individual facilities; however facility savings increased each year overall. The SEM savings were positive 78 percent of the time due to consumption increases in some facilities. Various topics were recommended for future research to improve the evaluations; these included: track SEM elements annually; assess post-participation persistence and capital project savings persistence; assess cost-effectiveness and other fuel savings; explore sampling for the program evaluation; explore whether participation in SEM program increases capital projects; explore the relationship between SEM activities and savings; and examine the practice of re-baselining every two years.³⁴

AEP Ohio Experience

From 2013 – 2015, AEP Ohio launched six cohorts of SEM participants throughout the state, consisting of 70 participating customers. Results from 37 large manufacturing participants with 16-24 months in the program were validated by an independent evaluator. Savings as a percent of load, shown in Table 2.2, from 2.4 to 8.6 percent, are similar in range to those of the Northwest results.

Table 2.2 AEP Ohio CEI Results from 2013 – February 2015³⁵

Cohort	Months in program	Participants	Total MWh Savings through February 2015	Average Savings as % of Load
1	24	14	41,800	8.6
2	20	7	17,000	7.5
3	17	7	6,600	4.2
4	16	9	12,400	2.4

³⁴ Bonneville Power Authority, February 23, 2017, Industrial Energy Management Impact Evaluation Powerpoint. Available at: www.bpa.gov/goto/evaluation.

³⁵ Results are from Burgess, Jess et al. 2015. “The Second Generation of Strategic Energy Management Programs.” Washington, D.C. ACEEE Summer Study on Energy Efficiency in Industry.



AEP Ohio’s Continuous Energy Improvement (CEI) Program is a version of SEM designed to specifically depart from the traditional capital project approach to energy efficiency and to focus on low cost/no cost operational and maintenance savings that are typically not captured by conventional programs. These measures can include, but are not limited to, compressed air leak programs, optimization of shutdown procedures, shutting off idling equipment, HVAC optimization.

The CEI program uses a regression energy model for predicting energy use, and thereby determining energy savings attributed to the program. Energy savings calculations require interval meter data and relatively granular production data. The interval meter data is used with independent variables to determining the weekly energy intensity for each site. The variables used in the model are determined by understanding the customer’ process, and applying rigorous analysis and testing of how variables correlate with energy usage. The initial energy models were assessed by an independent evaluator and determined to be valid method for measuring energy savings.

Vermont Pilot Experience

Efficiency Vermont’s Continuous Energy Improvement (CEI) Pilot includes four components: capital upgrades, employee engagements, process improvements and maintenance which are pursued in a coordinated and deliberate way to allow businesses to achieve comprehensive energy savings.³⁶ Evaluation of the CEI pilot in Vermont estimated results by participant and overall from eight organizations, seven industrial and one healthcare which received capital upgrades, process improvements, O&M guidance and employee engagement training. The evaluation activities included process evaluation, impact estimation by year, and cost-effectiveness analysis. The impact methodology included construction of the baseline regression model of energy use by facility. The program achieved a 91 percent realization rate in 2015. Realization rate is a ratio of measured (ex post) to initial (ex ante) savings estimates. Facility and program savings were estimated as follows:

Facility savings = Adjusted baseline energy – metered energy

CEI savings = facility savings – capital project savings (these may involve use of submetering)

Table 2.3 Evaluated Efficiency Vermont CEI Program Electric Savings for 2015³⁷

Savings Categories	2015 Savings as Percent of Electricity Consumption	Evaluated Savings MWh/year
Evaluated Capital Project Savings	2.5	868.6
Evaluated CEI Savings*	2.9	1,009.2
Total Evaluated Facility Savings	5.4	1877.8

**Evaluated CEI Savings by facility ranged from -1% to 14% as percent of facility consumption*

³⁶ See <https://www.encyciencyvermont.com/Media/Default/docs/white-papers/encyciency-vermont-continuous-energy-improvement-brings-encyciency-next-level-white-paper.pdf>.

³⁷ Cadmus. July 26, 2016. “Continuous Energy Improvement Pilot Evaluation Vermont Public Service Department.” <http://publicservice.vermont.gov/sites/dps/files/VT%202015%20CEI%20Behavior%20Pilot%20Evaluation%20Summary.pdf>



Impact Evaluation Challenges

Even with the imminent publication of the UMP protocol for SEM, there is plenty of room for discussion on the challenges and promise of evaluating the energy impacts of these programs.

Reliability of Impact Estimates from Whole Building Regression Modeling

The whole-facility evaluation approach recommended in the UMP has the benefit of being comprehensive, able to assess the “tangled” impacts from operation maintenance and behavioral (OM&B) and capital equipment change-outs which occur simultaneously – maybe interactively. However, whole-building modeling with billing analysis is not universally supported for more routine C&I program evaluations, never mind more complex industrial facilities. For example, while billing analysis has been used to evaluate lighting impacts from small C&I lighting programs, in recent years in MA and NY those methods are not employed due to the inability to achieve model results with satisfactory fitness criteria including confidence and precision around the estimates.

Common questions include: Are the models valid? Do they yield reliable savings estimates? As summarized by one evaluator on the topic of complex facilities using whole-building modeling, “reasonable experts can disagree on the best model; it is not clear there is a single truth.” Individual site models can be very sensitive to the variables and functional form of the model. When trying to estimate savings under 10 percent, the range of most savings observed in SEM program evaluations, frequently there is a “signal to noise” problem, in which the impact being examined is too small to be estimated reliably relative to the variability in the input data; this is why the UMP recommends assessing a facility’s suitability for modeling as an initial step in the EM&V process.

One modeling-related challenge is that the construct of the regression model used in program planning for SEMs and the evaluation model constructs can differ. At or near the beginning of projects, the stakeholders, typically program implementers, construct program models. These may be used for considering treatment options, for example, making go/no go decisions regarding implementation or for planning specific energy efficiency measures. Program models are constructed without complete information. The model developed for the evaluation does not necessarily match the program planning model, given that evaluation “has the luxury of hindsight and multiple years of data and history”³⁸ These differences can invite questions but are sometimes interpreted as criticisms of one model construct or the other. On a positive note, Bonneville Power evaluations have been able to fully use data collected from the program implementation process. No additional customer contact was required. Staff expertise was a key contributor to the success of the process, and in particular, to informing non-routine modeling adjustments needed to estimate savings. The current approach involves a 3-4 year delay between program implementation and evaluation.

Evaluations may be conducted by examining/modeling individual facilities one by one for the entire population, or by conducting an analysis at the program level based on a sample from the population. A consideration for SEM programs as for other program evaluations, is that it is necessary to characterize results that are representative of the entire population of the program participants. Procedures are needed to establish how outlier facilities are handled, to assure that the sample of buildings being evaluated is an unbiased representation of the population.

³⁸ Lauren Gage, September 16, 2016, personal communication.



Suitability for regression modeling is not an element of the Minimum Criteria for SEM; thus, some facilities participating in these programs but not suitable for whole building modeling may require another strategy for estimating savings, such as the combination of self-report information and engineering based estimates employed by Building Operator Certification programs to estimate O&M impacts, for example.

One common strategy in program evaluation is to estimate a realization rate based on a representative sample of program participants. The realization rate which can be applied to all participants in a program allows results to be estimated given not all SEM projects may be modeled or evaluated in a given year. Realization rates require extra steps to go beyond measurement of individual facility savings and assess how well the savings are estimated in the initial project planning stage as compared to the savings estimated from program performance. For programs with relatively small participation, such as the pilots and early years of SEM programs, it is important to recognize that realization rate can have large variance and may not be a reliable planning tool.

Looking ahead, technological advances in the energy industry hold some promise for increasing the applicability of whole building measurement for evaluation. The use of AMI, or smart meters, will increase the granularity and volume of data available, which can improve modeling results in some cases. (The Northwest experience with modeling for SEM evaluations has found that “weekly is better than monthly, but not seeing lots of benefit of hourly modeling inputs due to autocorrelation in the current models”). Pay-for-performance program designs dovetail with the technology advances of big data and auto analytical software, but at present for SEM “it can’t meet the goals” in the Northwest. Smart technologies and energy management systems are also emerging data sources that could supplement whole building metering and help inform future evaluation modelling efforts.

Accurate Baseline Characterization

Another evaluation consideration to note for SEM programs relates to the baseline characterization. The baseline assumed for measures that are installed as replacement on burnout or renovations (i.e. code) differs from the pre-installation usage baseline that is used to describe equipment retrofit and behavior program baselines. When using a whole-building model to establish the facility’s baseline for SEM program savings that include O&M as well as capital savings, adjustments to a model or to disaggregated savings would be required to accurately characterize each component’s impacts. In the case where a decline in SEM savings over time is noted, it may be due to slacking off in efficient behaviors and O&M practices, or it may be due to degradation in the performance of various pieces of equipment that existed in the facility prior to the program. This is another example in which accurate characterization of the baseline is important.

Error Associated With Disaggregation of Impacts

Most of the evaluation studies that are available involve reporting disaggregated as well as total facility impacts. This is true of the evaluations of the SEM programs in the Northwest, which are the largest source of recent experience. Planners and regulators frequently want to know impacts from capital investments separate from behavior for many reasons. Key questions or risks with SEM programs that evaluators address often focus on the OM&B component of savings: Are the energy savings credible? Are they large enough to be cost-effective? However, this can invite questions about model validity and interactive effects. In the Northwest, “people are feeling comfortable with whole building evaluation” and “have confidence in results at the program level”. Disaggregation – distributing savings between capital and behavior measures - still leaves room for improvement, and see pros and cons to whole-facility and disaggregated approaches. Problems associated with

disaggregation include that it became cost-prohibitive to model capital investment impacts when they comprised a small portion of the portfolio, and disaggregation also led to negative behavior savings in some cases. However, “putting the capital project into the overall facility model” as in the whole-building evaluation approach “loses persistence” and “re-baselining can lead to loss of savings.” ETO currently has 20 SEM projects per year. Planning models are developed by the implementers and evaluators review the models, typically comparing the simplest model to what was estimated by the implementer. They extrapolate program impacts after the first year savings and claim savings for three years currently, using conservative estimates. One of the challenges is with the quality of program data available for evaluation. “It is important for people to be explicit in entries in the opportunity register [log of activities undertaken] to enable bottom up estimates of engineering-based O&M savings [estimates of impacts associated with specific O&M actions recorded in a log]”, or to identify other capital projects going on at the same time in the post-installation period so they can be backed out of SEM savings, for example.³⁹

Reporting Evaluation Results

Attempts to compare SEM results across programs revealed various challenges that make it difficult to interpret findings based on how evaluation results are reported. The definition of SEMs is not as uniform as the name implies; program designs vary which can drive differences in evaluation approaches, and in turn, in reporting of results. In the Pacific Northwest, OMB is a larger focus of SEM programs. In the Northeast (with the exception of the Continuous Energy Improvement pilot program in Vermont) there is some experience with the Strategic Energy Management Plan (SEMP) program which focuses on capital investment projects.

Some SEM programs work with individual participating facilities over multiple years; some work with cohorts of facilities. In these cases SEM evaluations have to confront questions about whether it is appropriate to report savings at the facility, cohort, or program level, although most report results at both facility and program level. Given a multiyear context, there is no consistent practice regarding whether behavioral impacts over multiple years be reported year by year, added, averaged, or reported at the end point. The occurrence of small negative impacts in the first performance year for some facilities prompted discussion about these issues in the Northwest. Vermont’s pilot program results revealed a lack of cost-effectiveness in first year but yielded cost-effective results overall based on three years of results. Evaluating multiple years for multiple facilities introduces significant complexity. Reporting program level savings that describe performance overall is generally considered the most reliable strategy, but valuable insights are gained from understanding the details.

Studies of BPA’s and NEEA’s versions of SEM programs offer insights regarding multi-year engagement and multi-year impacts. BPA drilled down into the multiyear performance of 24 of the sites in two 2011 cohorts in its Energy Smart Industrial (ESI) Program, revealing the variability in energy performance over three years, both in capital- and behavior-based savings. The sites “varied in their rate of adoption, relative emphasis on capital or behavior-based energy savings. Some sites made incremental improvements each year, while other sites struggled to maintain their performance.”⁴⁰ However, on average, they demonstrated that energy management

³⁹ Phil Degens, September 16, 2016, personal communication.

⁴⁰ Eskil, Jennifer et al. 2015. “Promoting Reliability of SEM Savings Through Multi Year Engagements.” Washington, D.C. ACEEE Summer Study on Energy Efficiency in Industry.



maturity increases energy savings and reliability. BPA tracks persistence of energy savings by measuring and reporting energy savings annually throughout the multiyear engagement, as illustrated by Table 2.4 below.

Table 2.4 Bonneville Power Authority SEM Program Gross Energy Savings by Cohort for Multiple Years

Cohort Description				Gross Energy Savings Relative to Pre-HPeM Baseline			
Cohort	Started	# Sites	Total Load	Year 1	2	3	4
1	6/11	13	250M KWh	3.9%	7.2%	8.4%	10.2%
2	11/11	11	600M KWh	0.8%	1.1%	3.1%	NA

Evolving Programs in Response to Evaluation

Process evaluations and utility experience are helpful to identify changes to program design and delivery that could improve cost-effectiveness and evaluation efficiencies. ETO, for example, has been reviewing both program delivery and evaluation with an eye to how to scale up the program with these issues in mind. ETO’s program is moving toward continuous SEM and a focus on a few, simple model inputs such as production and weather variables instead of a more intense one year engagement, due to the fact that “people do not maintain the first year model.” The opportunity register will likely become a “Plan B” source of information to address challenges to evaluation or models. The program is also in the process of expanding into the commercial sector and small industrial sector based on conclusions of some “mini-evaluations” indicated that small and large industrial customers have similar motivating factors”. This increase in scale is inspiring consideration of “more automated and consolidated reports” and simplification of the modeling approach.

Efficiency Vermont is another organization that is in the process of modifying its program design to take advantage of scale and increasing uniformity among customers as a way of reducing program costs, among other reasons. Its first cohort was a diverse assortment of industrial facilities. For the second cohort, EVT targeted large industrial customers with ammonia refrigeration efficiency potential, and this strategy provided greater opportunities for company-to-company sharing. The second year of this cohort two engagement will focus on broader company-wide engagement energy management activities like the energy management assessment and employee engagement while continuing to implement technical opportunities for savings identified in the first year. The third cohort will focus on large industrial and institutional customers with chilled water efficiency opportunities. This strategy of common technology-defined cohorts delivered more rapid and larger savings than the first cohort.

Yet another cohort-based strategy called CEI-Lite is being introduced in 2017 and is intended to reach out to small and medium sized commercial customers and employ online education and training to stimulate behavior-related savings. This strategy has been characterized as a hybrid between formal SEM and residential behavioral programs utilizing energy reminders providing energy-in-context, and it leverages the availability of advanced metering infrastructure (AMI) data to target customers with high base loads.

Another type of change under consideration by Efficiency Vermont this year is to aggregate savings from behavioral and O&M sources into one bucket, instead of the existing evaluation strategy of separately examining and reporting capital investment, O&M, and behavioral program impacts. The rationale for this



approach is that there is a blurry line between O&M and behavior improvements. This change may also impact the cost-effectiveness of the behavior element of the CEI program. Making set-point changes to equipment controls is an example of where this line is blurry in the delivery of the SEM program.

Persistence of Savings with Multi-Year Engagement

One topic of concern, particularly for programs designed to influence behavior, is how long do impacts last. The evaluation literature already includes a few studies that examined addressed the question of whether SEM program impacts persist over time, even during the period of continued engagement with the program implementers. The evaluation results for NEEA’s Industrial Initiative⁴¹ noted that that participants continue to achieve savings even after several years in the program. A study of persistence of savings from companies with up to six years of engagement with SEM programs in the Northwest found that savings of four percent of energy consumption were achieved for “most of the years in which the program was active”⁴². Savings for each facility were estimated using modeled baseline period energy consumption for a given facility without program activity compared to modeled consumption during the program. Total program savings included the sum of capital investment and retrofit (measure-specific) as well as other behavior and O&M SEM activities. Savings for the capital investment activities were three percent, while all other SEM savings were approximately one percent of baseline during two consecutive years in which the program was active.

A study that reviewed of persistence of savings from SEM programs from several companies across the country posits that the ability to deliver savings over multiple year engagements is enhanced in programs from “mature” SEM-type program administrators (organizations with 3-8 years of experience in implementing SEM plans). Case studies documented the following results from mature programs⁴³:

Table 2.5 Results from Three Mature SEM Programs

Company	Pacific Gas & Electric CEI effort (9 customers)	Pennsylvania Power & Light – Act 129 programs + 5%	Energy Trust of Oregon, Industrial and Commercial CEI
Period	April 2010 – 2014	July 2010 – 2014	February 2009 – 2014
Results	8.4% total savings (average)	5-10%	5% savings average over 2 cohorts without capital investment projects

Savings persistence has been qualitatively linked with other features of program engagement, and level of maturity of the program participant, as summarized below:

⁴¹ See DNV KEMA and Research Into Action. April 29, 2014. Industrial Initiatives Market Progress Report #8, prepared for Northwest Energy Efficiency Alliance. Available at: <https://neea.org/docs/default-source/reports/neea-industrial-initiatives--market-progress-evaluation-report-8.pdf?sfvrsn=10>

⁴² Vetromile, Julia and Steve Phourtrides, 2015. “What Gives SEM Staying Power?” Washington, D.C. ACEEE Summer Study on Energy Efficiency in Industry.

⁴³ Results are summarized from Kevin Collins and Ed Birch, 2015. “Strategic Energy Management Maturity and Its Impact on Savings and Savings Persistence.” Washington, D.C. ACEEE Summer Study on Energy Efficiency in Industry.

Table 2.6 Savings Persistence Associated with Stages of SEM Program Maturity⁴⁴

Attributes	Level 1. Develop EMS	Level 2. Practice Energy Management	Level 3. Energy Management Maturity
Description	Develop the foundation to manage energy consumption	Systematically improves ability to manage energy consumption	Resilient EMS embedded in business
Program Involvement	High	Variable	Light
SEM Curriculum	Sequenced	Targeted	None
Energy Savings Measures	Focus on near-term wins and simple measures	Increased level of complexity and implementation ownership	Larger number of process-oriented measures requiring organizational buy-in
Savings Persistence	Fragile	Durable	Resilient

NEEA undertook an econometric study of CEI program participants from 16 food-processor facilities to investigate whether analysis of a relatively long and consistent time series of energy usage and production data could reveal patterns or predict resources required to ensure persistence of savings. It estimated each facility’s baseline electric usage for the reporting period and estimated cumulative savings by plant and year for six years. Among the findings were that half of the plants showed higher than baseline (i.e. negative savings) in the first reporting year. Overall, however, savings increasing dramatically to 3.5 percent in the second and third years and leveling off reaching nine percent by year five, which is consistent with a mature effort and also with other studies. An aggregate econometric analysis, (top-down model) was also conducted to better understand the relationships between industrial production, expected savings from capital projects, from O&M projects as well as other variables such as weather. This effort was partially successful; it showed production has a strong impact on electricity usage and that energy intensity is significantly reduced with investment in the SEM capital projects. However the model on its own “does not demonstrate how efficiencies would have changed over time or whether capital projects would have been undertaken without the CEI program. It also does not discern patterns of increasing or decreasing savings or provide evidence to support or continue projecting savings”⁴⁵. The ability to draw conclusions was limited by correlation between the independent variables (multicollinearity), but the study yielded useful qualitative insights regarding the impact of various facility level interventions over time, as well as best practices for long-term SEM engagement.

Non-Energy Impacts

While the focus of energy program evaluation is on energy impacts, other impacts of the programs also have value to the program administrators, customers, and society. A conundrum for many energy efficiency programs

⁴⁴ Ibid.

⁴⁵ Thompson, Mark et al. “Top-Down Analysis of Electric Savings in Food Processor Facilities: Taking a Step Back to Inform Forward-Reaching Industrial Strategies,” ACEEE Summer Study on Energy Efficiency in Industry, 2013.



that is particularly true for SEM is that attributes other than energy consumption and energy costs are more important and drive investment decision-making for many if not most customers. Moreover, goals are set and reported at corporate rather than facility levels. To illustrate this, Sappi North America pulp and paper mills' 2015 Sustainability Report includes the following key performance indicators, which include energy, environmental and other metrics that could potentially be influenced by SEM program activities:

- ***Total energy by percent fuel type (reported at the mill level and in total)***
- ***Energy intensity in GJ/admt² air-dried metric ton of saleable product***
- ***Annual consumption of alternate fuels in TJ and by percent of renewable energy***
- ***Emissions, including tons of CO₂/admt² by mill and total; kg/ admt² of SO₂; and kg/ admt² of NO_x***
- ***Water intake/water discharge in m³ /admt²***
- ***Solid waste to landfill (kg/admt²) and beneficial use of solid waste (tonne/yr)***
- ***Average hours of training per year per employee by employee category***

Due to the comprehensive nature of the program design, SEM is especially-able to deliver a broad spectrum of non-energy benefits. As noted by the Sappi example, industrial facilities track performance indicators that could potentially be used to develop estimates of non-energy benefits associated with efficiency program impacts.

A variety of sources, including industry newsletters and a recent international study⁴⁶ reviewing many existing studies notes that the “multiple benefits”, also referred to as non-energy benefits for businesses from energy efficiency measures in industry include:

Other fuel impacts. SEM customers frequently consume multiple fuels. For some SEM programs savings of fuels beyond the fuel or fuels provided by the program administrator funding the SEM program may be considered an indirect impact. Bonneville Power Authority, for example, considers customers' gas savings as an indirect participant benefits because BPA is an electric power supplier.

Water and other resource impacts. Some efficiency measures or OMB practices also reduce water consumption, wastewater costs, and waste streams.

Occupational health and safety and improved work conditions. The following testimonial from Nissin, a brake system manufacturer, provides an example of health benefits that, in turn, also lead to improved product quality: “Better lighting has helped to reduce operator fatigue, which translates into an overall increase in the quality of the parts Nissin is delivering to its customers – proof that putting the brakes on energy waste is good for business.”⁴⁷

Productivity, enhanced competitiveness, process and product quality and related operations and cost savings from decreased liability, reduced environmental compliance costs. In one example cited by Nissin Brake, lower energy costs stabilized overall costs allowing them to “deal with production volume changes”. In another, Crown Battery is a manufacturing facility that values energy efficiency's ability to help it “stay ahead of the pack” by

⁴⁶ International Energy Agency. 2014. “Capturing the Multiple Benefits of Energy Efficiency.” www.iea.org

⁴⁷ Alliance for Industrial Efficiency, “Energy Efficiency is Good for Business,” alliance4industrialefficiency.org.



reducing operating expenses and bolstering its brand. “Not only are we saving money, but it helps increase our sales”⁴⁸.

Emissions reductions. It is worth noting that the industrial sector is the economy’s largest energy user; thus significant carbon dioxide emission reductions could be achieved by increasing energy efficiency for many industrial customers. Many companies include environmental goals in their missions. Nissin, for example, has a company goal of cutting greenhouse gas emissions by 10 percent over 10 years.

Asset value/equipment life. Improved operations and maintenance practices can extend the life of manufacturing and facility equipment as well as increasing its energy efficiency.

Economic development. Good energy efficiency programs can help states retain businesses and industry.

Although the costs of participation in SEM are high, the non-energy benefits are among the values influencing customers’ decisions about whether to participate in the program. Non-energy benefits are among the elements that address policy goals of some energy programs that go beyond efficiency, such as carbon reduction and economic development, and as such, they frequently influence customers’ decisions to invest in energy efficiency. The types of benefits and their value will differ significantly among different types of projects. To the extent that jurisdictions take into consideration customer costs of participation in energy efficiency programs, they should also take into account the benefits of customers’ participation. Quantifying some of the non-energy impacts poses challenges, however.

Anecdotal and Qualitative Evidence of the Value of Non-energy Benefits

Research findings support that there is value to non-energy benefits in utility SEM programs, and the value takes various forms.⁴⁹ Non-energy benefits, such as lowered maintenance costs or market appeal, can also play a key role in influencing the decision to participate in utility SEM programs. Some of these provide continued support of work teams for successful implementation by developing new skills and outlets for positive employee engagement. Preventive and predictive maintenance efforts initiated through SEM programs provide both savings and further the objectives of key stakeholders in energy programs. These proactive approaches cost less than emergency repairs in the long run by avoiding equipment failure and resulting down time. Reduced maintenance costs are one of the most-cited unexpected benefits of SEM by program participants.

Non-energy benefits of SEM extend into soft areas of the enterprise such as culture. SEM facilitates interdepartmental cooperation and a greater understanding of how independent functions within an organization interact through the medium of energy. By serving as a novel channel for collaboration SEM efforts have been reported by participants to improve communication and spur innovative solutions to business issues beyond the scope of the energy program.

One role of non-energy impacts is to consider them in early the implementation stage of SEM, as part of the prioritization of the energy efficiency measures to be addressed by the customer. “In addition to economic considerations, issues such as process and equipment reliability, product quality, complexity of implementation,

⁴⁸ Ibid.

⁴⁹ Lancaster, Ross et al. 2015. “When Does Energy Management become Strategic?” Washington, D.C. American Council for an Energy-Efficiency Economy.



and problem systems should be included in the prioritization exercise - non-energy benefits such as maintenance savings and occupant satisfaction should be factored in to the greatest extent possible.”⁵⁰

The largest non-energy impact noted in the AEP Ohio’s CEI program, a version of SEM, was the dramatically improved relationship between the utility and its largest customers. “AEP Ohio was transformed from a faceless provider of a commodity to the role of trusted energy advisor and viewed as a company that was genuinely interested in helping customers control costs in their businesses.”⁵¹

“Projects identified in a SEM program should identify measures and activities beyond behavior and no/low-cost process improvements. These projects feed other programs, including prescriptive measures, more complicated custom measures, retro-commissioning, and especially planning energy efficiency into future needed facility changes.”⁵²

ETO tracks non-energy benefits anecdotally. For example, ETO tracks gas savings, since they advise on opportunities to save gas but do not provide capital measures. ETO looks at and models SEM projects in terms of production efficiency, rather than as energy reduction, and communicates that value to its customers.

Research conducted in Europe⁵³ indicates that if “if NEBs (non-energy benefits) are included, the true value of the energy efficiency projects might be up to 2.5 times higher than if looking at the energy efficiency improvements alone. Access to information on NEBs and their size might thus lead to higher acceptance and implementation of energy efficiency projects.”⁵⁴

While the existence of NEBs is not new, one of the barriers to incorporating these features into decision-making is that they are not systematically assessed or documented. Increased efforts by all stakeholders to collect case-by-case information on multiple benefits in industry will raise awareness of their potential value and support improved methodologies for quantifying them. Some Danish energy researchers posit that “visualization of NEBs increases the probability that company decision-makers will implement energy efficiency projects”⁵⁵. To that end, they are developing a web-based tool and database focused on the industrial sector that includes the following elements:

- Method for assessing NEBs of energy efficiency projects;
- NEI database that shows users to search by project type;
- Case studies with details; and
- Questionnaire for identification and assessment of NEBs.

⁵⁰ D’Antonio, Mark et al. 2015. “Strategic Energy Planning: A Roadmap to Carbon Reduction in Large Industrials.” Washington, D.C. American Council for an Energy-Efficient Economy.

⁵¹ Burgess, Jess et al. 2015. “The Second Generation of Strategic Energy Management Programs.” Washington, D.C. American Council for an Energy-Efficient Economy.

⁵² Michaels Energy Rant enews, September 19, 2016

⁵³ See Appendix to Gudbjerg et al 2014 article for list of examples of international NEB literature largely focused on the large commercial and industrial sector.

⁵⁴ Gudbjerg, Erik et al. 2014. “Spreading the word – an online non-energy benefit tool.” ECEEE Industrial Summer Study Proceedings.

⁵⁵ Ibid.



This effort classifies NEBs into four main categories: influencing productivity, sales and company image, internal company environment, and external environment/society. It uses an index which rates the “size” of the NEB relative to the energy savings. The size of the NEB may be calculated based on documentation and measurement, or based on subjective ratings by the customer, or by some combination. The goal of this system is to stimulate interest and participation in future energy efficiency, not as part of a cost-effectiveness proceeding. The NEB further assesses relative size of NEI values relative to energy efficiency savings. The goal of this effort is to capture highest priority NEBs experienced by customers rather than comprehensive inventory of all NEIs.

Methodologies to Account for Non-energy Impacts

Ideally all impacts should be estimated in monetary terms so that they can be directly included in cost-effectiveness analysis. Several challenges remain in quantifying industrial benefits, including: establishing causality, inter-linkages among benefits; understanding direct and indirect benefits; and changes in the value of benefits over time. The overarching challenge is to assign monetary value so they can be used to assess the value of projects or their results. However, approximating hard-to-quantify impacts is preferable to assuming that they have no value or do not exist. The following approaches are available:

- Jurisdiction-specific studies. Some impacts, such as O&M or other fuel impacts are reported in technical reference manuals, for example. Some utilities have conducted evaluation studies to quantify cross-program non-energy impacts for commercial-industrial programs.
- Studies from other jurisdictions. The results of these may be transferable.
- Proxies. Also referred to as adders, these are quantitative values that can be used as a substitute for a value that is not monetized, if monetized impacts are not available or if the evaluation expense of monetizing qualitative information is inappropriate.

More discussion of these approaches, and examples of sector-level impact values (commercial-industrial adders, for example) can be found in the Appendix to EM&V Forum guidance on cost-effectiveness.⁵⁶

No studies have estimated industrial program non-energy impacts specific to SEM. The table below summarizes results from estimation of non-energy impacts from a comprehensive and in-depth evaluation across the range of commercial and industrial retrofit programs (a mix of early replacement and replace on failure) for Massachusetts program administrators to use in their 2013-2015 plan and in future annual plans. These estimates were developed based on a large scale interview effort with sufficient sample to provide statistically significant NEI estimates across prescriptive and custom measure groups. The sample was drawn from customers who had participated in 2010 programs and had responded to a prior free-ridership and spillover survey. NEI data on dollar values of NEIs was obtained for a wide variety of impacts (O&M costs; other labor costs; transport costs; water usage; waste disposal costs; sales; revenues; permitting, legal and other fees; product quality or defects).

⁵⁶ Cost-Effectiveness Screening Principles and Guidelines, NEEP, 2014.



Summary of Average Annual Gross Non-energy Impact (NEI) Estimates, Massachusetts C&I Retrofit Programs⁵⁷

Electric Measures	n	Avg annual NEI/measure (\$) =NEI/kWh*avg ann kWh	NEI/kWh	90% CI Low (\$)	90% CI High (\$)	Stat Sig
Prescriptive Measures						
HVAC	27	7,687	0.097	0.054	0.139	Y
Lighting	163	1,636	0.027	0.018	0.037	Y
Motors & Drives	50	541	0.004	(0.001)	0.009	Y
Refrigeration	30	5	0.001	(0.000)	0.008	N
Other	32	28	0.004	(0.000)	0.008	N
Total	302	1,439	0.027	0.019	0.036	Y
Custom Measures						
CHP/Cogen	6	(12,949)	(0.015)	(0.025)	(0.005)	Y
HVAC	20	5,584	0.024	0.000	0.045	Y
Lighting	89	5,686	0.059	0.032	0.087	Y
Motors & Drives	42	1,433	0.015	(0.001)	0.031	N
Refrigeration	90	1,611	.047	.024	.071	Y
Other	29	15,937	.056	.004	.109	Y
Total	276	4,454	.037	.023	.051	Y
Gas Measures	n	Avg annual NEI/measure (\$) =NEI/therm* avg annual therms	NEI/therm	90% CI Low (\$)	90% CI High (\$)	Stat Sig
Prescriptive						
Building Envelope	2	1,551	3.612	2.642	4.589	Y
HVAC	50	755	1.346	0.543	2.150	Y
Water Heater	47	129	0.260	(0.001)	0.522	N
Total	99	439	0.834	0.363	1.305	Y
Custom						

⁵⁷ TetraTech. June 29, 2012. "Massachusetts Program Administrators Final Report – Commercial and Industrial Non-Energy Impacts Study." P 1-4.



Building Envelope	46	922	0.477	0.126	0.829	Y
HVAC	41	2,798	0.229	0.152	0.306	Y
Water Heater	23	803	0.182	(0.495)	0.860	N
Other	2	1,905	0.525	(5.658)	6.708	N
Total	112	1,940	0.247	0.149	0.346	Y

In this study electric HVAC, lighting and other measures showed the highest non-energy impacts; negative NEIs for CHP/cogeneration are because the equipment required increased preventative maintenance and increased administrative costs. All of the NEI benefits in this study were largely influenced by O&M cost changes, some from reduced repair costs associated with new equipment. The researchers also examined NEIs per kWh saved by sector. “Within the manufacturing sector, the most prevalent NEIs resulted from internal labor as electricians spent less time maintaining lighting because there were fewer repairs to high-end equipment. Respondents reported production gains as plants experienced less downtime and an overall increase in worker activity”.⁵⁸ While this study demonstrates the presence and quantification of some of the types of NEIs relevant to SEI, it also notes some challenges and limitations inherent in the study. This study was done in association with a previous examination of free ridership and spillover study. Per the design of SEI programs, SEI customers are not necessarily representative of typical C&I customers. For example, the study notes that their assumptions used to depreciate and amortize the cost differentials between new and old equipment may not reflect customers’ actual decisions; also they may vary with the age of the measures being replaced. Self-reports introduce possible bias into this study because many respondents had previously been interviewed. Furthermore, self-reports are less accurate than company tracking and accounting. Results could be influenced by the mix of measures and the focus on annual NEIs. If these results were to be used in other jurisdictions, adjustments to regionally-specific labor costs may be advised.

Cost-Effectiveness of SEM

For adoption of SEM programs to increase, achieving cost-effectiveness is paramount. The high costs of delivery, participation and evaluation relative to savings has been identified as a potential barrier. It can influence how the program is delivered and evaluated. In the Northwest, SEM programs are cost-effective, but as noted by one evaluator, “it is a big effort”.

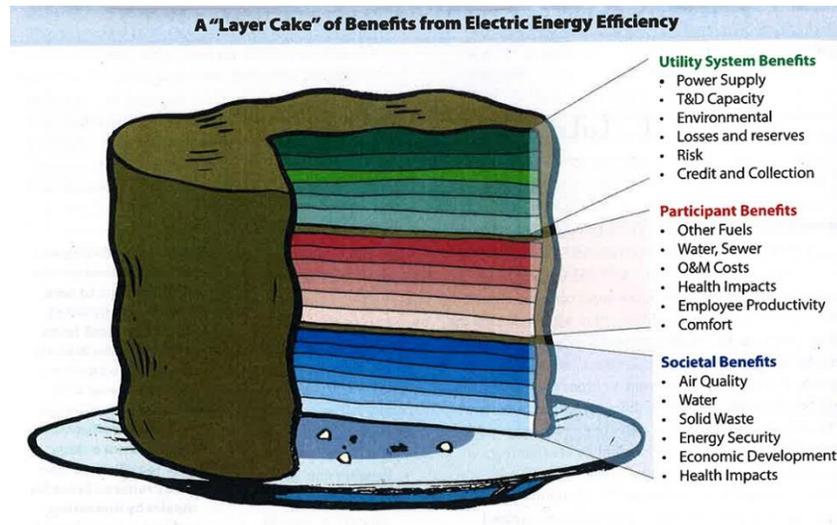
How is cost-effectiveness approached?

States where most SEM programs are currently offered rely on the Total Resource Cost (TRC) test for cost-effectiveness. In theory, this test includes utility and participant costs and benefits. The TRC test, which includes consideration of participant as well as utility costs and benefits is highly appropriate for SEM programs, given

⁵⁸ Stevens, Noel et al. 2013. “Innovative Tools for Estimating Robust Non-Energy Impacts that Enhance Cost-Effectiveness Testing and Marketing of Energy Efficient Programs.” IEPEC

that non-energy benefits are among the key selling features of SEM for customers, and that the program requires significant customer investments (training time, as well as possible copayments). Use of the Societal Test would allow jurisdictions to even more fully value of energy efficiency programs, with the categories of benefits shown in the figure below.

Figure 4.1 Categories of Benefits from Energy Efficiency Included in Societal Cost-Effectiveness Test⁵⁹



In practice, the TRC test is often applied asymmetrically, for various reasons. Many benefits which are may be hard to track or monetize are not included. Also, as noted earlier in this report, when SEM program evaluations disaggregate categories of savings from capital investment, O&M, and behavioral savings, it can be hard to disaggregate the savings correctly and it can be hard to appropriate the costs between these categories. If programs are cost-effective without comprehensive inclusion of benefits, the problem of asymmetry is not apparent. When programs are not cost-effective, program administrators may focus attention on how to reduce costs or alternate strategies for presenting the savings before they turn to quantification of non-energy benefits.

Vermont’s experience with SEM is an illustration of challenges associated with cost-effectiveness in the delivery of this type of program. Vermont began an SEM pilot referred to as Continuous Energy Improvement (CEI) in 2014 with one cohort targeting Vermont’s large industrial and institutional customers and has been continuing as a pilot since then, as Vermont regulators have not yet approved CEI as a formal resource acquisition program. An evaluation of one year of the first cohort, the CEI program was deemed not cost-effective using a one-year measure life for behavioral savings. However, the first cohort’s performance was deemed cost-effective at a measure life of three years. Therefore, Vermont’s regulators kept the program under the pilot framework for further evaluation. A second cohort was formed and a third is under development. Efficiency Vermont has instituted a number of programmatic modifications since the first cohort, all of which are intended to improve the performance and cost-effectiveness of the program. One change is the transition from an initial focus on broad efforts in employee-engagement (the “softer” side of energy management) to a more narrow technical focus for cohort recruitment. Vermont sees the benefit of engaging the cohorts in seeing real energy savings materialize before introducing more abstract and resource intensive concepts to companies in the cohort.

⁵⁹ Lazar, Jim and Ken Colburn. September 2013. “Recognizing the Full Value of Energy Efficiency.” Available at raponline.org.



Cost-effectiveness was evaluated using the Societal Cost Test, the test used for energy efficiency in Vermont. Non-electric benefits included environmental externalities and use of a 10 percent adder to reflect other non-energy benefits. While the evaluation report does not provide detail on program administration costs, and does not identify whether participant costs were included, Greg Baker, Engineering Manager at Vermont Energy Investment Corporation, noted that it appears Vermont may include “more costs in its cost-effectiveness analysis than some other utilities. More research and discussion with the evaluation community is needed”⁶⁰.

Cost-effectiveness varied depending on the measure life – defined as the time period examined. The program evaluation determined that the program was cost-effective at a measure life of three or five years, as shown below.

Table 4.1. Cost-Effectiveness Results from Vermont CEI Pilot Program over Time⁶¹

Parameter	One-Year Measure Life	Two-Year Measure Life	Three-Year Measure Life	Five-Year Measure Life
Benefits	\$158,223	\$306,255	\$449,194	\$698,866
Costs	\$350,042	\$350,042	\$99,151	\$348,824
B/C Ratio	0.45	0.87	1.28	2.00

Various strategies are employed to reduce program costs. For example, bringing SEM to scale – by delivering the program to cohorts rather than as a purely individualized endeavor – and ETO’s plan to expand the program to commercial facilities and to simplify the evaluation and modeling – help manage program administrator costs. At the individual project level, evaluators face decisions about how much to invest in bottom up (engineering/metering studies) versus top down (econometrics) approaches based on the mix of measures in the program. The evaluation costs have been a significant consideration and one of the drivers of BPA’s choice of evaluation strategy, which is to net out capital measure savings from the whole building model rather than do heavier capital model evaluations. BPA does not quantify non-energy benefits.

Thanks to the activity logs and close interaction with participants, information about participant costs can be quantified. Both ETO and BPA include these in their cost-effectiveness screening.

BPA does not include non-energy benefits in its cost-effectiveness screening. However, on the participant benefits side, data on the value of O&M benefits and productivity benefits and any changes in fuel consumption for fuels outside of the program administrator’s regulation may be available. BPA which only provides incentives for electric efficiency, does track gas savings, for example. Other hard-to-monetize benefits have not been examined or included in the cost-effectiveness screening.

⁶⁰ Greg Baker, Vermont Energy Investment Corporation, personal communication, 2/8/2017

⁶¹ The Cadmus Group. July 26, 2016. “Continuous Energy Improvement Pilot Evaluation for Vermont Public Service Department 2014-2015.” <http://publicservice.vermont.gov/sites/dps/files/VT%202015%20CEI%20Behavior%20Pilot%20Evaluation%20Summary.pdf>



How should cost-effectiveness be approached?

Guidance from NEEP’s Regional EM&V Forum (2014) on cost-effectiveness screening identifies several key principles that should be applied to cost-effectiveness to ensure that the tests deliver appropriate, unbiased results that are understood by all stakeholders. These include:

Symmetry: Energy efficiency screening practices should ensure that tests are applied symmetrically, where both relevant costs and relevant benefits are included in the screening analysis. For example, a state that chooses to include participant costs in its screening test should also include participant benefits, including low-income and other participant non-energy benefits.

Hard-to-Quantify Benefits: Energy efficiency screening practices should not exclude relevant benefits on the grounds that they are difficult to quantify and monetize. Several methods are available to approximate the magnitude of relevant benefits, as described below.

Transparency: Energy efficiency program administrators should use a standard template to explicitly identify their state’s energy policy goals and to document their assumptions and methodologies.”⁶²

What resources are available?

For general guidance on cost-effectiveness screening, the California Standard Practice Manual (2002)⁶³ has been the prevailing source, and it discusses the commonly used cost-effectiveness tests: Utility Test, Total Resource Cost Test, and Societal Test. Recently additional guidance has emerged to assist jurisdictions with cost-effectiveness screening. A National Standard Practice Manual for Energy Efficiency Assessment is currently under development, in draft, and public release is expected in 2017; it builds on the Regional EM&V Forum’s 2012 Cost-effectiveness Guidance.

A [simple spreadsheet](#) is available from the Regulatory Assistance Project which categorizes all energy efficiency benefits according to the various cost tests.

A publicly available cost-effectiveness [screening tool](#) and [planning guide](#) have been developed by Lawrence Berkeley Lab and Synapse Energy Economics for the Superior Energy Program. While the tool is designed for SEP, it has relevance to SEM programs. The tool is intended to assist program administrators or other stakeholders interested in exploring whether developing offerings for SEP in a project or program is likely to achieve positive net benefits, based on various cost-effectiveness tests. The screening tool evaluates the cost-effectiveness of an SEP program using the Program Administrator Cost (PAC) test, the Total Resource Cost (TRC) test, the Societal Cost (SC) test and the Participant Cost (PC) test. This tool was designed to be comprehensive to cover the range of efficiency plan requirements throughout the country. Not all of the tests or program elements are relevant to all program administrators.

⁶² Regional EM&V Forum, “Cost-Effectiveness Principles and Guidelines”, November 2014, <http://neep.org/cost-effectiveness-screening-guidelines>.

⁶³ The California Standard Practice Manual (2001) is available at: http://www.calmac.org/events/spm_9_20_02.pdf



The table below reviews the components in commonly applied cost-effectiveness tests. Note that non-energy impacts are components of the TRC and societal tests.

Table 4.2 Components of Cost-Effectiveness Tests

Component	Utility Cost Test	TRC Test	Societal Test
Costs			
Utility System Costs	X	X	X
Participant Costs		X	X
Benefits			
Other Fuels		X	X
Water		X	X
Participants		X	X
Public Interest or Societal (Public health & safety, environmental, economic development, etc.)			X

Using this tool, program administrators can estimate the net benefits of a new SEP program offering to one or more facilities participating in a single year. The key assumptions (defaults) for the Screening Tool are based on data from SEP program experience to date and other sources. Outputs are presented in a way that is directly useful for a state regulatory filing for a new energy efficiency program pursuing SEP projects. A methodology has been devised to quantify the costs and benefits associated with SEP participation, and this methodology has been applied to nine SEP certified demonstration facilities.⁶⁴

Summary and Recommendations

Key observations are summarized and recommendations regarding protocol use and development, evaluation and cost-effectiveness for SEM programs are provided below.

Protocol Use and Development

Evaluation of SEM programs is nascent and evolving. Existing approaches to measuring savings are reasonably reliable and documented in several protocols. Regression analysis at the whole building level, as recommended by existing (IPMVP) and forthcoming protocols can be a cost-effective and reliable means for assessing the impacts of SEM program impacts. These modeling approaches are recommended for either the measurement of

⁶⁴ See https://eetd.lbl.gov/sites/all/files/aceee_sep_paper.pdf



total impacts or as the starting point for disaggregating capital investment program impacts from operations, management and behavioral (OMB) impacts.

As program experience increases, protocols can evolve to reflect best practice in addressing evaluation approaches to elements of SEM programs for which guidance is not currently available, including interactive effects between OMB and capital investment programs, treatment of baselines and persistence when disaggregating OMB from capital investment savings, assessing impacts from the implementation of multiyear program, and potentially, guidance on quantifying significant non-energy benefits.

Evaluation Approaches

Most of the experience is focused on modeling savings at single sites and is applied to relatively small program sizes. The existing approaches to measuring savings are reasonably reliable, even those focused on savings at a single site. The combination of limited experience with the programs (relatively short history, small number of participants), differences in program designs and complexity of facilities all contribute to challenges associated with standardizing evaluation across programs.

With more program experience, the measurement approaches can be refined to improve accuracy and the ability to measure diverse program applications.

Overall costs of SEM program delivery can be high; evaluation costs can be high because, for example, of the diversity of facilities in a program or when submetering is required to disaggregate the OMB and capital investment impacts.

Various tactics can help reduce evaluation costs. These include: more detailed and consistent record-keeping by participants which can improve accuracy of engineering estimates and inform non-routine adjustments; use of facilities' energy management information system (EMIS) data to inform program performance; scaling up program participation and use of relatively simple model specifications to focus on accuracy of results at the program level; establishing homogenous cohorts in term of types of customers or major energy systems to increase consistency in the facilities being treated and evaluated.

Evaluation Results

SEM program energy savings impacts in the range of two to 15 percent of electric consumption are commonly observed, however in a program negative savings have been found in some facilities. In multiyear programs, results are assessed annually and cumulatively across the performance periods. Some results indicate that a pattern of increase followed by leveling off of OMB savings during the course of multiple years of program implementation.

While some studies have examined the patterns of savings over multiple years of program implementation, more information is needed about the consequences of long-term SEM engagement.

Results are frequently reported by facility and cohort as well as at the program level. OMB and capital investment impacts are often reported separately and combined. Use of consistent and transparent reporting conventions, including disaggregated and total impacts, information about the reliability of savings estimates, realization rates, as well as reporting the savings as percent of consumption metric will contribute to increased understanding and more meaningful comparison of results, as experience with these programs grows.



Little information exists about certain impacts from SEM programs. These include: electricity peak demand impacts; gas program impacts; explicit statement of whether energy impacts are gross or net; and non-energy benefits. As programs grow, addressing and reporting these aspects in evaluation studies can improve the documentation of the value of SEM.

Evaluation results typically do not become available until one or more years after the program, because of the requirement of sufficient post-program data for modeling purposes. Looking ahead, SEM programs should consider and explore the use of M&V2.0 software in concert with metering data as an evaluation approach, as more information about best practices with these resources becomes available. The application of M&V2.0 software for evaluation purposes is still in pilot program research and development stage. The benefits of this approach could speed up feedback particularly on OMB activities, reinforcing continuous improvement and potentially reducing evaluation costs. However, it is important to note that multiyear assessment of SEM programs impacts would still be necessary in order to assess persistence of impacts.

Non-energy Impacts

Non-energy impacts can be positive (benefits) or negative. Anecdotal evidence shows that SEM programs have a variety of non-energy benefits that are of value to society, valued by utilities or valued by participating customers and may drive or influence a customer's decision to participate in the program. Some benefits are quantifiable, such as reductions in operations and maintenance costs or labor and some are softer such as improved employee satisfaction. Estimation of non-energy impacts is not commonly included as part of SEM program evaluation.

Evaluators should model production-related energy usage distinct from non-production energy usage to measure and communicate the economic (production) benefits of the SEM program to stakeholders. Furthermore, focusing programs on reductions in energy intensity (energy per unit of production) rather than energy reductions would more accurately support facilities' business objectives.

Customers' activity logs and other tracking of non-energy impacts should be incorporated in formal data collection efforts to enable evaluators to document and/or estimate these for various purposes, including marketing the program and as inputs to cost-effectiveness analysis.

Evaluation methods used to estimate non-energy impacts from other commercial and industrial energy efficiency programs, such as self-report surveys combined with engineering information, should be explored for transferability to SEM programs. Similarly, results from some evaluations of other commercial and industrial programs should be explored to determine if they are applicable to SEM programs.

As part of national protocol development in support of SEM, consideration should be giving to developing a web-based tool and database focused on the industrial sector that includes the following elements: method for assessing non-energy impacts of energy efficiency projects; a non-energy impact database that allows users to search by project type; case studies with details; questionnaire to assist utilities with identification and assessment of non-energy impacts.

Cost-Effectiveness

The Total Resource Cost Test widely prevails as the tool used to assess cost-effectiveness of SEM programs. Templates and tools are available to assist utilities in categorizing and applying the TRC test for SEM programs.



Utilities that use the TRC should apply the TRC test symmetrically, assuring that for any element represented in the test, both costs and benefits are represented quantitatively. This is important to reduce or avoid bias in the results of a cost-effectiveness test.

If programs are cost-effective without comprehensive inclusion of benefits, the problem of asymmetry is not apparent. When programs are not cost-effective, program administrators may focus attention on how to reduce costs or alternate strategies for presenting the savings before they turn to quantification of non-energy benefits.

When participant costs are included in cost-effectiveness screening, as is called for in the TRC, it is important to also include estimates of participant benefits. For important impacts/benefits that are hard to measure but non-zero, it is appropriate to include an estimate derived using another approach, for example an adder based on expert judgment.

Utilities should exercise care in the disaggregation of program costs when accounting for SEM program OMB savings separately from capital investment savings. Just as there can be interactions between the energy savings from these types of programs, it can be difficult to separate costs associated with delivering these measures, especially since SEM can serve as a pipeline to retrofit measures.

Going forward, utilities may want to consult the forthcoming National Standard Practice Manual which provides guidance on cost-effectiveness testing and includes a recommendation that tests be designed to align with state policies and that the state policies should guide the range of impacts included in cost-effectiveness testing.⁶⁵

⁶⁵ See <https://nationalefficiencyscreening.org/> for more information.



References

Agnew, K.; Goldberg, M. (April 2013.) Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol. The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. NREL.

Amundson, T., et al. (2013). “Elements of Defensible Regression-Based Energy Models for Monitoring and Reporting Energy Savings in Industrial Energy Efficiency Operation and Maintenance Projects.” Paper presented at the 2013 ACEEE Summer Study on Energy Efficiency Industry.

ASHRAE. (2014.) *ASHRAE Guideline 14-2014—Measurement of Energy and Demand Savings*. Atlanta, Ga.: American Society of Heating, Refrigerating and Air-Conditioning Engineers.

Bonneville Power Administration. (2012.) *Regression for M&V: Reference Guide*. Prepared for BPA by Research into Action, Inc. et al. Available at:
https://www.bpa.gov/EE/Policy/Manual/Documents/July%20documents/3_BPA_MV_Regression_Reference_Guide_May2012_FINAL.pdf

Jess Burgess, Consortium for Energy Efficiency (CEE) Michelle Cross, AEP Ohio Greg Baker, Efficiency Vermont and Puja Vohra, National Grid, “The Second Generation of Strategic Energy Management Programs” In Proceedings of the ACEEE 2015 Summer Study on Energy Efficiency in Industry.

Jess Burgess, Consortium for Energy Efficiency (CEE) Michelle Cross, AEP Ohio Greg Baker, Efficiency Vermont Puja Vohra, National Grid Consortium for Energy Efficiency, 2014, “CEE Strategic Energy Management Minimum Elements”.<http://library.cee1.org/content/cee-strategic-energy-management-minimum-elements/>

Cadmus Group. (February 2013.) *Energy Smart Industrial—Energy Management Pilot Impact Evaluation*. Prepared for Bonneville Power Administration. Available online: http://www.bpa.gov/EE/Utility/research-archive/Documents/BPA_Energy_Management_Impact_Evaluation_Final_Report_with_Cover.pdf

Consortium for Energy Efficiency. (2014a.) *CEE Strategic Energy Management Minimum Elements*. Available at: <https://library.cee1.org/content/cee-strategic-energy-management-minimum-elements/>

Consortium for Energy Efficiency. (2014b.) *CEE Industrial Strategic Energy Management Initiative*. Available at: http://library.cee1.org/sites/default/files/library/11282/Industrial_SEM_Initiative.pdf

Consortium for Energy Efficiency. (2015.) *SEM Program Case Studies Report*. Available at: <http://library.cee1.org/content/sem-program-case-studies-2014>

Consortium for Energy Efficiency. 2014. “CEE Industrial Strategic Energy Management Initiative” http://library.cee1.org/sites/default/files/library/11282/Industrial_SEM_Initiative.pdf Ecova. 2014 “2015 Energy and Sustainability Predictions.” http://www.ecova.com/media/1078586/ecova_report_2015_energy_and_sustainability_predictions.pdf

Consortium for Energy Efficiency, 2015, “CEE Strategic Energy Management Program Case Studies Report”.<http://library.cee1.org/content/sem-program-case-studies-2014>

DNV KEMA Energy and Sustainability; Research Into Action, Inc. (April 2014.) *NEEA Industrial Initiatives—Market Progress Evaluation Report #8*. Prepared for the Northwest Energy Efficiency Alliance. Available online:



<http://neea.org/docs/default-source/reports/neea-industrial-initiatives-market-progress-evaluation-report-8.pdf?sfvrsn=10>

Energy 350. (April 2014.) *Small to Medium Industrial SEM Energy Savings Validation*. Prepared for the Northwest Energy Efficiency Alliance. Available online: <http://neea.org/docs/default-source/reports/small-to-medium-industrial-sem-energy-savings-validation.pdf?sfvrsn=12>

Energy Information Administration. (2008.) Commercial Building Energy Consumption Survey, Table E1A, Major Fuel Consumption (Btu) by End Use for All Buildings (2003). Available at <http://www.eia.gov/consumption/commercial/data/2003/pdf/e1a-e11a.pdf>

Efficiency Valuation Organization. (2012). *International Performance Measurement and Verification Protocol – Concepts and Options for Determining Energy and Water Savings Volume 1*. Washington, D.C.: Efficiency Valuation Organization.

Jones, T., et al. July 2011. “The Evolution of Continuous Energy Improvement Programs in the Northwest: An Example of Regional Collaboration.” In Proceedings of the ACEEE 2011 Summer Study on Energy Efficiency in Industry, Niagara Falls, NY.

Khawaja, M. S.; Rushton, J.; Josh Keeling J. (April 2013.) *Chapter 11: Sample Design Cross-Cutting Protocols*. The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. NREL.

Kolwey, 2013, “SWEEP Report: Utility Strategic Energy Management Programs”.

http://swenergy.org/data/sites/1/media/documents/publications/documents/Utility_SEM_programs_03-2013.pdf

Kolwey, N. 2013. Utility Strategic Energy Management Programs. Boulder: Southwest Energy Efficiency Project. http://swenergy.org/publications/documents/Utility_SEM_programs_03-2013.pdf

Leritz, N., C. Gilliss, and R. Hart. 2014. " Strategic Energy Management – It’s time to grow up! A maturity model for SEM implementation." In Proceedings of the ACEEE 2014 Summer Study on Energy Efficiency in Buildings, 7:1–12. Washington, DC: ACEEE.

MetaResource Group. 2014. “SEM Evaluation Workshop Report”. Portland, OR. Energy Trust of Oregon http://assets.energytrust.org/api/assets/reports/SEM_Evaluation_Workshop_Report.pdf

Navigant Consulting, Inc. *Impact Evaluation of Energy Trust of Oregon’s 2009–2011 Production Efficiency Program*. December 2013. Prepared for the Energy Trust of Oregon. Available online: http://assets.energytrust.org/api/assets/reports/PE_Impact_Eval_2009-11.pdf

Northwest Industrial Strategic Energy Management Collaborative. (2013a). *Tools and Methods for Addressing Auto-correlation in Energy Modeling*. Available online: <https://conduitnw.org/Pages/File.aspx?rid=1763>

Northwest Industrial Strategic Energy Management Collaborative. (2013b.) *Tools and Methods for Addressing Multicollinearity in Energy Modeling*. Available online: <https://conduitnw.org/pages/file.aspx?rid=1762>

Ross Lancaster, Jamil Panni, Diane Levin, Ecova Glenda Towns, Southern California Gas Company. 2015. “When Does Energy Management Become Strategic?”. ACEEE Summer Study on Energy Efficiency in Industry. <http://aceee.org/files/proceedings/2015/data/papers/1-194.pdf>



Stern, F. (April 2013.) *Chapter 10. Peak Demand and Time Differentiated Energy Savings Cross Cutting Protocols.* The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. NREL.

Superior Energy Performance: IIP Policy Efficiency Database. <http://iepd.iipnetwork.org/policy/superior-energy-performance>

Therkelsen, P., R.Sabouni, A. McKane, and P. Scheihing. July 2013. "Assessing the Costs and Benefits of the Superior Energy Performance Program." In Proceedings of ACEEE Summer Study on Energy Efficiency in Industry, Niagara Falls, NY.

U.S. Department of Energy. *Superior Energy Performance Measurement and Verification Protocol for Industry.* 2012. Available at: <http://energy.gov/eere/amo/downloads/superior-energy-performance-measurement-and-verification-protocol-industry>

Violette D. M.; Rathburn, P. (September 2014.) *Chapter 23: Estimating Net Savings: Common Practices.* The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. NREL.

Appendix 1: SEM Program Summary Information⁶⁶

Program (Year Launched)	Types of Savings Claimed ⁶⁷	C/E Tests	Impacts Reported to Regulators	Persistence	Monitoring/Reporting Practices
Ameren Illinois (2015)		TRC	<ul style="list-style-type: none"> kWh savings Customer sat 	N/A	SEM participant reporting
BC Hydro (2012)	OMB Capital inv.	TRC	<ul style="list-style-type: none"> kWh savings Program cost 	5 years with a plan Else 2 years	Data collection and analysis by IEM; Review by BC Hydro engineering
Bonneville Power Authority (2009)	OMB Capital inv	TRC	<ul style="list-style-type: none"> kWh savings & stat. sig. Persistence Program cost 	Varies – 2-10 years	Custom models w some automation of analysis; ESI program develops the model
Commonwealth Edison and Nicor Gas (2014)	OMB Capital inv**	TRC	<ul style="list-style-type: none"> kWh savings & stat. sig kW savings (not reqd) Persistence Program cost 	2-3 years	Utilities provide 2 years of pre-SEM performance data; contractor builds baseline model and maintains model; participants update model
Efficiency Nova Scotia (2014)	OMB Capital inv**		<ul style="list-style-type: none"> kWh savings & stat sig kW savings Program cost 		Customers supply data; utility creates model and updates; customer tracks activities
Efficiency Vermont (2015)	OMB Capital inv	Societal Test	<ul style="list-style-type: none"> kWh savings & stat sig kW savings Persistence Program cost Customer sat 		EVT consultants perform impact reporting
Energy Trust of Oregon (2009 Core; 2016 CEI)	OMB Capital inv**	TRC & UCT	<ul style="list-style-type: none"> kWh savings Persistence Program cost Customer sat 	3 years for core; 5 years for CEI	Customer collects data; Coach creates model and oversees customer updates

⁶⁶ The information in this Appendix has been excerpted from <https://library.cee1.org/content/cee-2016-industrial-strategic-energy-management-program-summary-0>.

⁶⁷ ** denotes that the impacts are claimed by a separate program; OMB refers to savings from Operations, Maintenance and Behavioral actions; Capital inv (investment) refers to installation of incented energy efficiency measures.

Focus on Energy (2014 pilot; 2015 program)	OMB	TRC	<ul style="list-style-type: none"> • kWh savings & stat sig • kW savings • Program cost • Customer sat 		Participants to provide quarterly top down-bottom up analysis
Hydro Quebec (2015)	OMB Capital inv**	TRC UCT PCT RIM		10 years, w 5 year SEM commitment	
Idaho Power (2011, 2013 & 2016)	OMB Capital inv Capital inv** attributed to	TRC ICT PCT	<ul style="list-style-type: none"> • kWh savings & stat sig • Persistence • Program cost • Customer sat 	1 year	Customer collects data; Contractor creates and maintains baseline
Pacificorp (2013)	OMB Capital inv**	TRC UCT PCT RIM	<ul style="list-style-type: none"> • kWh savings & stat sig Persistence • Program cost 	3 years	Utility conducts monitoring during the engagement
Southern California Edison – SoCalGas (2010)	OMB Capital inv**		<ul style="list-style-type: none"> • Program is used as pipeline to other programs – not reported to regulators 	n/a	Top down approach using energy intensity and bottom up approach documenting impacts of measures; Contractor monitors and reports.
Xcel (2007 & 2015)	Capital inv Operational savings that are not behavioral are claimed	TRC UCT PCT RIM	<ul style="list-style-type: none"> • kWh savings & stat sig • kW savings • Persistence • Program cost • Other costs by type 	7 years for operational savings	Contractor or auditor performs post-monitoring; expense born by program, not customer.