# 2014 Energy Trust Workshops on Strategic Energy Management Impact Evaluation: Report on Key Outcomes

## Background

Over the past six years, Energy Trust of Oregon (Energy Trust) has piloted and offered numerous Strategic Energy Management (SEM)[1] programs to both industrial and commercial customers. SEM is now a standard offering for Energy Trust's Production Efficiency and Existing Buildings programs.

Energy Trust has been evaluating the energy savings impact of its SEM programs on an ongoing basis. Energy Trust has contracted for a number of process evaluations, many of which included engineering reviews of the projected energy savings. The engineering reviews have not identified significant issues in how Energy Trust has calculated SEM savings to date.

The impact evaluation for the Energy Trust's 2009-2011 Production Efficiency (PE) program for industrial customers included some of the SEM projects conducted during these three years. Evaluators successfully completed the impact evaluation, and estimated a realization rate of 105% for SEM projects over these three years. However, in the process of conducting the evaluation, a number of challenges arose. The most fundamental was that because Energy Trust staff and evaluators had no agreed upon SEM impact evaluation guidelines for industrial sites, they found they lacked clarity and consensus on the best way to proceed.

These challenges, as well as Energy Trust's lengthy and continuing presence in the SEM market, support the idea of refining and standardizing impact evaluation guidelines for SEM offerings, particularly for industrial SEM. To support guideline development, Energy Trust Evaluation staff held two half-day workshops attended by experts with a broad range of experience in SEM, including program design, implementation, and evaluation. These experts brainstormed and discussed key SEM impact evaluation issues, shared their knowledge on best approaches, and laid out next steps and needs related to guideline development. Almost all the discussion focused on industrial SEM; very little was noted about commercial SEM, for which MT&R methods are different and not focused on production.

This report covers:

- Workshop Goals
- Workshop Format and Attendees
- Definitions of SEM and MT&R
- Typical Program Implementation and Evaluation Timeline
- Common Issues with MT&R
- Basic SEM Impact Evaluation Methods
- Next Steps for SEM Evaluation Research and Guideline Development

[1] Energy Trust uses the definition of SEM from the Consortium for Energy Efficiency (CEE) SEM Minimum Elements: http://library.cee1.org/sites/default/files/library/11283/SEM_Minimum_Elements.pdf

## Workshop Goals

Energy Trust Evaluation staff held two four-hour workshops in August 2014 to discuss and develop SEM evaluation methods and guidelines, with 24 and 18 attendees respectively. (See Appendix A for an attendee list.) Energy Trust invited people with differing perspectives and experience with SEM to bring balance and depth to the discussion.

Two consulting teams with extensive experience in SEM impact evaluation led each workshop: The Cadmus Group (Cadmus) and TRC/Navigant. These teams presented their view of common SEM impact evaluation issues and challenges, and methods for addressing them. The teams then led workshop attendees in a discussion to reach consensus on the most important issues, current best practices and approaches, research needs, and proposed next steps. The discussion was captured and organized into this report by MetaResource Group.

Energy Trust's desired outcome from these workshops was to gather background information and guidelines for SEM impact evaluation to provide to program implementers and evaluators. Energy Trust wants the evaluation methods to be relevant to the way SEM is currently being implemented. In addition, Energy Trust hoped these workshops would inform the development of a "research roadmap" outlining many of the remaining evaluation questions and issues for further research.

In particular, Energy Trust wanted to determine the best approaches to evaluating SEM savings across a whole facility or a process over time, given varying levels of documentation and energy monitoring, and often given changing production processes, volumes, and product types. Energy Trust also sought to determine what factors influence the persistence of SEM practices, and how best to isolate the SEM savings from non-SEM related impacts (e.g. capital projects or production changes). These methods may also influence SEM program design and the calculation of initial SEM savings.

## Workshop Format and Attendees

Cadmus led the first four-hour workshop on August 12, 2014. They prepared a PowerPoint presentation with 70 slides and moderated the discussion (see Appendix B for slides). There were 24 attendees including the five Cadmus team members. Staff from Navigant and TRC led the second workshop on August 26, 2014. They prepared a presentation with 54 slides and moderated the discussion (see Appendix C for slides). There were 18 attendees including the three Navigant and TRC team members. As an additional resource, Appendix D contains further SEM and evaluation resources and references. Jennifer Stout of MetaResource Group attended both workshops, documented the discussions, and prepared this report.

## Definitions of SEM and MT&R

Energy Trust uses the following definition of Strategic Energy Management (SEM) from the Consortium for Energy Efficiency (CEE). While Energy Trust did not formally communicate this definition to workshop participants before or during the workshops, it is likely that participants are aware of it.

> *Strategic Energy Management can be defined simply as taking a holistic approach to managing energy use in order to continuously improve energy performance, by achieving persistent energy and cost savings over the long term. It focuses on business practice change from senior management through shop floor staff,*

*affecting organizational culture to reduce energy waste and improve energy intensity. SEM emphasizes equipping and enabling plant management and staff to influence 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.*[2]

Program designers, implementers, and evaluators alike who attended the workshops agreed that Monitoring, Targeting & Reporting (MT&R) with its use of regression analysis is at the core of sound evaluation of energy savings from SEM, and the use of MT&R makes evaluating SEM different from other resource acquisition offerings. Below is a basic definition of MT&R from Bonneville Power Administration.

*[Monitoring, Targeting, & Reporting (MT&R)] refers to the measurement systems, statistical tools, and business practices associated with measuring energy intensity, establishing targets for improvement, and reporting results and impacts. The MT&R methodology in conjunction with a process to track specific activities is used to verify, quantify, and validate energy savings… [MT&R is used] to establish the baseline energy models at a whole facility or subsystem level and ultimately quantify energy savings associated with the implementation of multiple energy efficiency measures over a defined performance period…The primary energy driver is typically production… In the process of variable selection, the model developer will face competing objectives of capturing the full subset of statistically significant regressor variables, while aiming to provide the customer with a model that is simple and easy to maintain.*[3]

Current MT&R practices for SEM use regression models to help implementers and evaluators with one of the most basic SEM evaluation challenges: unlike equipment upgrades, SEM involves actions affecting *multiple energy end uses*. Also, savings are typically small (~5% of annual facility baseline energy consumption) and are most often measured at the whole-facility level. Workshop attendees agreed that MT&R models have many uses: for customers as a tool to track progress, for program implementers to estimate savings, and for evaluators to verify savings.

## Typical Program Implementation and Evaluation Timeline

For reference, we provide the figure below to illustrate the timeline for a typical Energy Trust SEM program implementation and evaluation. As shown, the baseline period is typically the two years before the program "intervention" (implementation). The program intervention typically lasts between 12 and 15 months.

The implementation contractors, with input from the customer and Energy Trust, develop the "implementation MT&R model," also known as the "baseline model"[4] using data on energy use and variables, such as production, from the baseline period. The twelve- to fifteen-month program intervention then begins.

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[2] http://library.cee1.org/sites/default/files/library/11283/SEM_Minimum_Elements.pdf

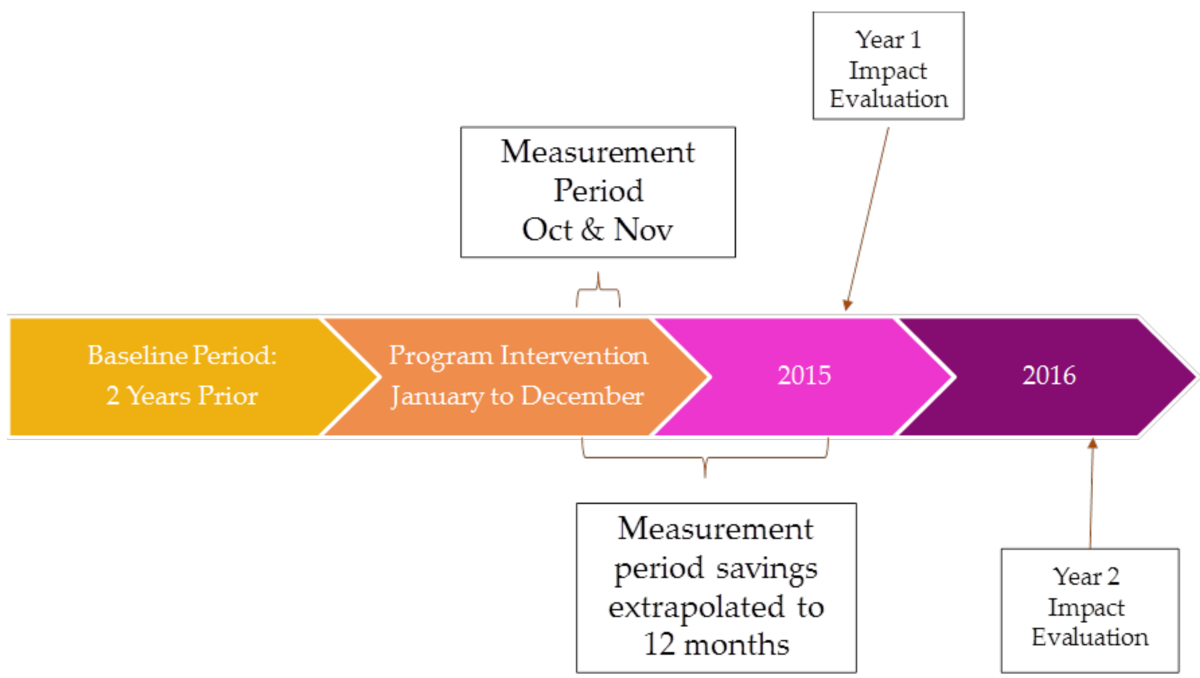
[3] MT&R Reference Guide, Version 4. Bonneville Power Administration. http://www.bpa.gov/EE/Policy/IManual/Documents/July%20documents/MTR_Reference_Guide_Rev4_0.pdf

[44] Readers should note that this timeline discussion assumes implementers use MT&R (regression) models, rather than "Key Performance Indicators" (KPIs). The section below titled "MT&R and KPIs Compared" describes why implementers might use one instead of the other and what the advantages and disadvantages are for each.

During the last two to three months of that intervention period – typically the point at which the customer has implemented some changes and is tracking their activities – implementation contractors collect new data on the customer's usage (see "Measurement Period" in the figure). The implementation contractors enter these new data into the implementation M&TR model, and use the model to project this new usage out one year as an estimate of energy savings from the program.

After the first year of the program intervention, evaluators conduct an impact evaluation ("Year 1 Impact Evaluation" in the figure below) to determine if they can verify the savings projections of the implementation contractors. The evaluators collect further data and enter it into the implementation MT&R model. Some people call this model with the new data entered into it the "evaluation model." Actually, however, if the implementation model remains valid for the customer's plant, it is neither an implementation nor an evaluation model – it is one single evolving "MT&R model," created during the implementation phase and then updated with new data by the evaluators.

There are cases, however, in which the evaluators cannot use the implementation MT&R model. A customer may make so many significant changes to their plant – things like changing or adding products or production processes – that the original implementation MT&R model is no longer "valid." In these cases, evaluators must create a new model. This report section "When Are MT&R Models No Longer Valid?" discusses the issue of models no longer being valid.



## Common Issues with MT&Rs

Below we describe some particular issues that emerged during the workshops related to MT&Rs.

### *Data Granularity and MT&Rs*

A key to effective use of MT&R is the availability of data at adequate and consistent levels of granularity. However, these data are seldom available at the optimal levels ideally preferred by evaluators; evaluators have to be flexible, skilled, and creative in working with what they can obtain. As one workshop attendee noted, "You evaluate the data you have, not the data you want."

Challenges with utility data include:

- *Gas data:* Most gas companies only record consumption data on a monthly basis and do not provide interval data.
- *Cost of interval data:* While electric data are usually available at 15-minute intervals, it still can be expensive to obtain, especially if there are many meters at a facility.
- *Data lag:* There is a lag with non-AMI meters[5] between the reading of the meter, the customer receiving the bill, and the customer finally entering the data into the MT&R model.
- *Data access:* Some utilities archive historic billing data, making it difficult to obtain. In some cases, utilities delete old data altogether.

Challenges with production data include:

- *Data collection:* Identifying production data that are:
    - actually driving energy consumption (for example, pounds of product);
    - easily collected by the customer;
    - historically available to develop a baseline MT&R model;
    - sufficiently granular to provide meaningful correlation to energy use; and,
    - meaningful to both evaluators and customers (for example, number of shipments may be easy for a customer to understand, but shipments do not correlate to energy consumption).
- *Data alignment:* Aligning different time periods for energy billing, production, and weather data.
- *Complex processes:* It can be difficult to manage data collection when a plant produces multiple products, uses production processes of varying lengths, or uses batch processing.
- *A time lag between when the production process actually uses energy, and when the customer records the production data:* For example, a customer may use energy when firing a batch of bricks in a kiln, but not record that batch as a "unit of production" until it is shipped out.
- *Post-engagement MT&R model maintenance:* Customers may not maintain the MT&R model in the post-engagement period consistently and with the same granularity of data. Evaluators may be able to repopulate the model if the data are available, but sometimes must create a new model.

### *MT&R and KPIs Compared*

[5] Advanced Metering Infrastructure means that data is sent continuously and electronically to the utility.

Substantial workshop discussion concerned advantages, disadvantages, and possible applications of Key Performance Indicators (KPIs) as compared to MT&R models. Typically, quantitative KPIs for SEM are simple aggregate indicators of energy intensity such as energy use per unit of output, pounds of output, gallons produced, gallons processed or another relevant production variable. In the case of commercial customers, a workshop attendee mentioned energy use per square foot as a KPI to consider.

Workshop attendees commented that evaluators and others must be judicious in where and how they apply KPIs. They must understand, and communicate clearly to customers, what a KPI can and cannot tell them depending on the circumstances. Below is a summary table from Navigant and TRC's presentation comparing MT&R and KPIs.

| **MT&R** | **KPIs** |
|---|---|
| Complex | Simple |
| Includes multiple factors | Only one dependence |
| High effort to maintain | Minimal effort to maintain |
| Dummy variable for pre-post | Separate analysis pre-post |
| More likely to accurately predict facility energy use with high $R^2$ | Less likely to accurately predict facility energy use |
| Both fail with major changes at a site which affects the models | |

A KPI that represents energy as a function of production does not accurately account for baseload energy use and it is not weather-normalized. However, this KPI can be an adequate way to estimate energy savings if: (1) a large proportion (say 75 percent) of facility energy use is production; (2) weather is not relevant, and; (3) there are no structural or macroeconomic changes during the baseline, implementation, or evaluation periods. One workshop attendee suggested cold storage as a good candidate for KPIs; another suggested a lumber mill with no enclosed walls, and therefore little to no conditioned space. However, most facilities have some portion of non-production load.

KPIs might be applied effectively to portions of the facility, such as a sub-metered production line. Attendees speculated that in some cases, including weather and operating hours in an MT&R model might not yield a more accurate savings estimate. One attendee suggested that KPIs might be a "lite" version of energy monitoring for smaller customers or serve as an "off ramp" for customers not interested in using or maintaining the more complicated models. Another useful application of KPIs could be on a portfolio basis, where the evaluator is rolling up multiple actions and/or sites.

However, attendees focused on the fact that KPIs do not allow inclusion of multiple variables that may be driving energy use. With KPIs, the same regression line may result, but it may have more scatter. You will not know whether you have the right answer. Another confounding factor for KPIs may be a change in material inputs (although this is also a problem for MT&R models). For example, it is a problem if the type of wood being dried at a mill changes from a type with a 20-hour drying time to one with a 40 hour drying time, and your KPI is energy per board feet.

Another cautionary note was around the simplicity of KPIs. Indeed, KPIs are simpler to derive, more readily understood by customers, and require less effort to track over time than MT&R. However, the very simplicity of an energy/production KPI can be risky. While such KPIs can be a useful directional indicator that the executive suite pays attention to, such KPIs will not reflect what is actually happening in the plant; customers should not use them for diagnosis. In contrast, an MT&R approach, while it is more complex and requires more training and understanding, shows the customer data they can respond to, and creates "a solid fact-based narrative," as noted by one attendee. This same attendee remarked that, "ultimately, to be successful at SEM, the customers need to gain a more sophisticated understanding of energy use. The MT&R gives them that and KPIs do not."

### *When Are MT&R Models No Longer Valid?*

In industrial plants, changes to processes, production lines, products, and entire facility buildings are common. If evaluators do not incorporate these changes into the MT&R model, the model's accuracy in estimating SEM savings will be compromised to varying degrees, or even be rendered invalid, requiring creation of a new model. This understanding is key to improving program design and implementation.

An MT&R model is considered no longer valid when it cannot be used to accurately predict energy use because circumstances at the facility being analyzed have changed so substantially that even if these changes could be incorporated into the model, it would no longer apply to either the baseline period or the post-participation period.

Major causes for the MT&R to become invalid could include:

- Major additions at the sites such as production lines and/or entire buildings
- New process equipment
- Changes in schedule/production
- A new product quality management protocol that impacts production methods and/or levels
- Major economic changes leading to changes in production hours

### *What Can Evaluators Do When Models Are No Longer Valid?*

Options include:

- Integrate the changes into the existing MT&R model.
- Create a new MT&R model. The new model can "shift" to the implementation post-period as evaluation pre-period. That is, consider an updated timeframe for both the baseline and program period in the MT&R model.
- Use a KPI instead of an MT&R model.
- Create an engineering model involving a "bottom up" measure-level analysis to calculate energy savings, rather than a regression analysis. Evaluators would use this approach when there are a few measures that are "big hitters." An engineering model also can be a useful "sanity check" on the regression results from the MT&R model, or even the main source of savings information if the MT&R model is no longer valid.
- Interview the customer to find out what happened, what changes they made, whether the energy efficiency practices carried over, and incorporate these factors into the analysis. This would obviously create a more qualitative analysis.

Attendees acknowledged that changes to the baseline in the implementation MT&R do occur and need to be carefully documented. However, there is also a need to create some standards or common understanding of what needs to be adjusted in the baseline, and at what point, or what amount of error in the model, constitutes an invalid model. These will be even more important considerations for Energy Trust as it considers implementing continuous SEM.

Another workshop attendee did point out, however, that as dire as it sounds to abandon the MT&R model, the MT&R model and the evaluators' model do not have to be the same. Evaluators can and should use the implementation MT&R model as a "springboard," deciding if it is still valid. But if it is not, it can potentially be used as the basis for a new model.

This same attendee pointed out that when an implementation model becomes invalid, the implications are greater for program designers and implementers than for evaluators. If the changes are sufficiently substantial at a plant to invalidate the implementation model, the energy savings activities that are part of design and implementation may no longer be valid. Implementers may have to do further intervention, or even redesign the program if these issues come up repeatedly for multiple customers.

## Basic SEM Impact Evaluation Methods

The following section covers the basics of SEM impact evaluation methods, and common challenges, presented and discussed by the workshop leaders and attendees. The final section describes unresolved issues, and suggestions made in the workshops for next steps and further research to resolve them.

Methodologically sound regression analysis underlies the evaluation of savings from SEM in industrial facilities.[6] Effective regression analysis depends on including the right explanatory variables and not omitting any key variables, as the latter will result in a biased estimate.

***Step 1: Review regression model***

As a first step, the evaluators carefully assess whether the implementation (baseline) MT&R model accounted for all the variables driving energy use. They analyze the model using baseline data only, and try to replicate the results described in the implementers' MT&R report. If the replication is successful, the evaluators then predict what energy use would be in the post-period if SEM had not been implemented. Then they repopulate the implementation MT&R with updated data gathered from participants and look at the actual post-period energy use to determine the energy savings.

***Step 2: Gather additional information as needed to update the model***

If the evaluators cannot replicate the baseline MT&R model, they look for confounding factors that may necessitate changing or updating the model, and gather additional data using the approaches described below. The data gathered also helps explain why savings occurred.

- Review the "opportunity register." Energy Trust's opportunity register for each participating site lists:
    - Operations and maintenance-based actions that directly save energy, and can be formally documented through institutionalized channels such as Standard Operating Procedures.

[6] International Performance Measurement and Verification Protocol (IPMVP), Option C

    - Indirect actions that may enable energy savings such as, an employee awareness/action campaign. (These actions may be entered in the opportunity register; they are qualitative, explanatory factors for energy savings.)

- Interview the energy champion, energy team, or other site staff members about:
    - Actions they are doing (either from the opportunity register or in addition to it).
    - Any changes made to plants, processes, and product lines that may be affecting the validity of the baseline MT&R model.
    - Changes to management support of SEM and how the energy champion and Energy Team have evolved over time (e.g. roles, responsibilities, focus).

- If there are a few dominant measures in terms of savings, conduct a bottom-up, measure-level analysis as a broad check of the magnitude of savings.

It is possible that the model will no longer be valid after this effort at updating. In this case, the evaluators may have to take one or more of the approaches described in the section above, "What Can Evaluators Do When Models Are No Longer Valid?"

***Step 3: Evaluate and subtract out capital project savings***

Evaluating and subtracting out savings from any capital projects that receive Energy Trust (utility) incentives ensures that SEM savings are isolated and savings are not double counted. Three possible approaches are described below, ordered by robustness:

- Good: Use the realization rate for the program or that specific end use to adjust incentivized capital measure savings; back that savings out of the change in consumption.
- Better: Enter the estimated capital measure savings into the MT&R model to adjust for the capital measure savings.
- Best: Visit the site, find out what the customer has done (including capital projects), measure the capital project savings as accurately as possible, calculate a realization rate, and subtract these savings out on annual basis. (This approach is similar to IPMVP, Option C.)

## *Future of Impact Evaluation: Sampling*

Populations of customers doing SEM have historically been small (50 or fewer per year) and heterogeneous in terms of the types and sizes of facilities (most are industrial). This often makes a census necessary. In addition, because of the heterogeneity of industrial sites, it typically is not possible to find a control group, a difficulty that can reduce the certainty of results.

However, the increasing focus on SEM is leading to higher rates of participation and larger study populations. Populations of program participants will remain heterogeneous, but will have homogeneous subpopulations. This growth will make using a census for evaluation more expensive, but it will help move SEM evaluation towards statistically robust sampling, and more accurate and stable estimates of savings.

Larger populations, say 30 sites or more, will also support the development of simplified models, especially for smaller customers. These models would be non-site-specific and minimally acceptable;

implementers could automatically generate the model for all participants, both in the baseline and in the post-period. In the model, energy consumption might be a function of production, and evaluators would test both heating degree-days (HDD) and cooling degree-days (CDD) at reference temperatures of 40 to 70 degrees to determine if they are good explanatory variables. One would also want to test whether dummy variables for season or month are the same or better as explanatory variables, since the temperatures might just be acting as a proxy for the seasonal production variables.

## Next Steps for SEM Evaluation Research and Guideline Development

As part of the second workshop, attendees discussed next steps for SEM evaluation. All agreed that the findings and next steps from these workshops, including the PowerPoint presentations, should be documented and distributed.

**SEM Evaluation Guidelines**

- Develop SEM evaluation guidelines for Energy Trust implementers and evaluators.
  - Incorporate SEM evaluation guidelines into future RFPs, either for evaluation or for implementation of SEM.
  - Develop a standard set of interview questions for impact evaluations.
  - Operationalize the outcomes of these workshops through subsequent impact evaluations.
- Find out when The Cadmus Group expects to publish their Uniform Methods Project (UMP) for SEM.[7]

**SEM Persistence**

- In general, the persistence of SEM savings over time are not well understood by program implementers and evaluators. Research should be conducted to answer the following:
  - How often should savings be reevaluated?
  - How much savings are achieved over time?
  - How should savings be adjusted for a three-year measure life when evaluators only measure savings in year 2 or 3?
  - Are the savings reliable at the facility and on the aggregate program basis?
  - Are the SEM savings estimated in the current Production Efficiency program impact evaluation persisting?
  - Does the savings rate change over time, i.e., is there a savings trajectory?

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[77] Cadmus Group has helped the US Department of Energy with some of the UMP work described here http://energy.gov/eere/about-us/initiatives-and-projects/uniform-methods-project-determining-energy-efficiency-progr-0

**MT&Rs**

- Develop guidelines for determining when an MT&R model is intact, when it is compromised, and when it is no longer valid. A related need is for standards for reusing and updating original MT&R models so the models reflect current conditions.
    - Develop a process to determine if a model is no longer valid, and steps that should be taken to either (1) update the model to make it valid, or (2) do a "bottom up" evaluation approach that looks at savings of actions documented in the participant's opportunity register.

**KPIs**

- Research how well KPIs perform for evaluators, for which sites and circumstances KPIs work better, and how KPIs work best as a tool for SEM for the customer.
- Develop methods to use KPIs to estimate savings in facilities where no MT&R is maintained.
- Research whether production data is the most important KPI, or if there are other KPIs more directly correlated to energy consumption. (A frequent evaluation constraint is customers' production data.)

**Data**

- Energy Trust is updating an analysis on SEM's influence on customers' capital measure adoption. This report will be useful to the industry.
- Develop a study to determine the costs and benefits of obtaining metered interval data for analysis rather than just using monthly data. Questions to consider include:
    - Especially for gas data, does analysis based on metered interval data make a difference in evaluation outcomes and customer motivation?
    - Are monthly data sufficient for estimating savings from the evaluation standpoint?
    - Do interval data motivate customers to engage and follow-through on measures?
    - If MT&R models have more granular data, do customers actually use their models to troubleshoot (in near-real time) issues such backsliding on savings? Does this troubleshooting result in customer intervention and promotion of persistence?
- When the population of customers doing SEM is sufficiently large, research if a sample based approach is feasible for estimating program level savings.
- Pre-populate models with utility data and automate the MT&R process where possible (instead of asking the customer for utility data). This approach also sets up a process for having weather variables from a nearby weather station included.

# Appendix A
# List of Workshop Attendees

| Name | Organization | Title | Role in SEM | August 12 Workshop | August 26 Workshop |
|---|---|---|---|---|---|
| Kim Crossman | Energy Trust | Sector Lead, Industry and Agriculture | Program Design & Implementation | ✓ | ✓ |
| Philipp Degens | Energy Trust | Evaluation Manager | Evaluation | ✓ | ✓ |
| Dan Rubado | Energy Trust | Evaluation Project Manager | Evaluation | ✓ | |
| Erika Kociolek | Energy Trust | Evaluation Project Manager | Evaluation | ✓ | ✓ |
| Athena Petty | Energy Trust | Project Manager – Industrial | Implementation | ✓ | ✓ |
| Sarah Castor | Energy Trust | Evaluation Sr. Project Manager | Evaluation | ✓ | ✓ |
| JP Batmale | Energy Trust | Sr. Program Manager – Industrial | Program Design & Implementation | ✓ | ✓ |
| Brad London | Energy Trust | Program Assistant – Commercial | Program Design & Implementation | ✓ | ✓ |
| Kathleen Balkhayat | Energy Trust | Project Manager – Commercial | Program Design & Implementation | ✓ | ✓ |
| Jim Stewart | Cadmus Group | Senior Associate | Evaluation | ✓ | |
| Heidi Ochsner | Cadmus Group | Senior Associate | Evaluation | ✓ | |
| Jennifer Huckett | Cadmus Group | Associate | Evaluation | ✓ | |
| Hossein Haeri | Cadmus Group | Senior Vice President | Evaluation | ✓ | |
| Mesut Avci | Cadmus Group | Associate | Evaluation | ✓ | |
| Jennifer Barnes | TRC Energy Services | Associate Vice President | Evaluation | | ✓ |
| Roger Hill | Navigant | Managing Consultant | Evaluation | | ✓ |
| Deborah Swarts | Navigant | Managing Consultant | Implementation | | ✓ |
| Josh Weissert | Energy 350 | Engineer | Implementation | ✓ | ✓ |
| Lisa Green | Energy 350 | Senior Engineer | Implementation | ✓ | ✓ |
| Richard Hart | EnerNOC | Principal Project Manager | Implementation | ✓ | ✓ |
| Chad Gilles | EnerNOC | Senior Associate | Implementation | ✓ | |
| Jim Volkman | Strategic Energy Group | Principal | Implementation | ✓ | |
| Mark Hamilton | Triple Point Energy | Principal | Implementation | ✓ | ✓ |
| Ross Lancaster | Ecova | Senior Manager | Implementation | ✓ | ✓ |
| Christopher Frye | NEEA | Senior Manager | Evaluation | ✓ | ✓ |
| Todd Amundson | Bonneville Power Admin | Engineer | Program Design & Implementation | ✓ | |
| Ron Ross | Portland General Electric | Senior Engineer | Implementation | ✓ | |
| Rob Morton | Cascade Energy | President | Implementation | | ✓ |
| **TOTAL ATTENDEES** | | | | 24 | 18 |

**Appendix B**
**Cadmus Group PowerPoint Slides**




CADMUS

# SEM Evaluation Workshop

8/12/14

CADMUS

# Schedule

- Introductions and Agenda 9 – 9:15 am
- Presentation 9:15 – 11 am
- 10-Minute Break @ 11 am
- Presentation 11:10 – 12 pm
- Lunch @ 12 pm & Break Until 12:15 pm
- Presentation 12:15-12:30 pm
- Discussion 12:30 – 1 pm

# INTRODUCTIONS

# Cadmus Team

- Hossein Haeri
- Jim Stewart
- Heidi Ochsner
- Jennifer Huckett
- Mesut Avci

# SEM Evaluation Experience

- NEEA Industrial Initiative
- NEEA Commercial Real Estate SEM Cohorts
- BPA Energy Management Pilot
- Energy Trust Production Efficiency (current)
- CA CEI Pilot
- BC Hydro Continuous Optimization Program
- BC Hydro Workplace Conservation Initiative
- PPL Electric CEI Program
- DOE/EPA Better Plants Program

# AGENDA

# Agenda

- SEM evaluation perspectives, 9:15-9:30 am
- Energy savings estimation methods, 9:30-10:15 am
- Persistence, 10:15 -10:30 am
- Sampling methods, 10:30-11 am, 11:10-11:25 am
- Level of SEM adoption, 11:25-11:45 am
- Other impacts 11:45 – 12 pm
- Non-energy benefits, 12:15 – 12:30 pm
- Discussion, 12:30 – 1 pm

CADMUS

# SEM EVALUATION PERSPECTIVES AND CHALLENGES

CADMUS

# SEM Evaluation in Perspective

- SEM encourages O&M practices and behavioral changes
  - Establishing the baseline/Persistence of savings
- SEM affects multiple energy end-uses
  - Whole-building/site energy-use data and billing analysis
- Savings are small percentage of site energy use
  - Dependent on level of SEM adoption
  - Large analysis sample or data on main drivers of energy use required

# Level of SEM Adoption

- Applicability
  - Measures and tracks market diffusion of SEM
  - Measures and tracks an organization’s progress in the SEM program
  - Could help explain why some facilities have higher savings than others
  - Identifying popular and effective measures
  - Informing deemed savings
  - Informing potential savings
  - Provides insight into persistence of energy savings at an organization

# SEM Evaluation Challenges

- Randomized field experiments are difficult
  - Small numbers of large commercial and industrial customers
  - Heterogeneity in customer energy use and industry type
  - Program design (opt-in) and utility control over recruitment/participation

# SEM Evaluation Challenges

- Quasi-experimental methods often used but…
  - Strong assumptions required to achieve unbiased savings estimates
  - Savings estimates sensitive to regression specification and estimation
  - Can be difficult to separately estimate capital and O&M measure savings
- Persistence of savings during and after treatment not well understood
  - Necessary to re-evaluate over time

# ENERGY SAVINGS ESTIMATION


# Measure Types

- O&M
- Behavioral
- Capital measures (new or replacement equipment)

CADMUS

# Savings Estimation Steps

1. Review documentation and collect data
2. Verify individual measure savings
3. Facility energy use regression
4. O&M savings estimation
5. Reporting

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# ENERGY SAVINGS ESTIMATION

## STEP 1: REVIEW DOCUMENTATION AND COLLECT DATA

CADMUS

# Review Documentation

- List of projects implemented and timing
- Regression model specification and supporting documentation
- Capital measure savings calculations and supporting documentation
- Other relevant information
  - Renovations or expansions
  - Changes to processes
  - Changes to product lines during baseline or test period
  - Changes to the energy team

# Collect Data

- Develop data collection plan in collaboration with implementation contractor
- Facility variables
  - Energy use
  - Outputs (intermediate or final)
  - Capital measure savings
  - Production process or personnel changes
- Weather

CADMUS




# ENERGY SAVINGS ESTIMATION

## STEP 2: VERIFY INDIVIDUAL MEASURE SAVINGS

CADMUS

# Verify Capital Measure Savings

- Three methods
  - File review
  - On-site data collection to verify installation and operating characteristics for a sample of measures
  - Data logging or obtain EMS trend data, where available, and as necessary and relevant

# File Review

- Organize information, identify gaps
- Understand the systems & measures
- Review initial calculation methods
- Identify key parameters for calculations
- Prepare evaluated savings calculations
- Contact sites
- Obtain details to prepare for on-site visit (safety equipment, training, initial information on measures)

# On-Site Data Collection

- Communicate on-site support and access
- Verify equipment is installed and operating properly
- Determine whether to obtain EMS trend data or install data loggers
- Acquire contextual information to support savings calculations (nameplate information, operating hours, operating temperature, production data, etc.)

# Data Logging / EMS Data

- Data can be analyzed to calculate energy savings for individual measures or processes
- Data can also be included in the regression analysis to help explain facility-level energy consumption
- More granular information (often one to five minute intervals) which provides much more contextual data than monthly billing data

# Gas Interval Metering

- Gas data rarely sub-metered
- Often provided only on monthly basis, which makes it difficult to use for energy efficiency analysis
- Working with Cadmus, one Northwest utility added “pigtails” to their gas meters at ten sites
- We connected pulse adaptors, which gave us one-minute interval data on gas flow rates

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# ENERGY SAVINGS ESTIMATION

## STEP 3: FACILITY ENERGY USE REGRESSION

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# Facility Regression Estimation

- Begin with the implementation team’s model
- Establish the validity of the baseline
- Estimate other model specifications, if necessary
  - Update the model with more recent billing data
- Conduct other analyses depending on study objectives and budget
  - Persistence of savings
  - Estimate savings for large O&M projects using regression
  - Other?

# Facility Regression Specification

- Site energy-use regression analysis
- Metered site energy use per unit of time $e_t$

$$e_t = g(\mathbf{y}_t, \mathbf{w}_t, \mathbf{k}_t, I_t)$$

where

$\mathbf{y}_t$ = vector of final outputs (e.g., lbs of carrots, gallons of treated wastewater)

$\mathbf{w}_t$ = vector of weather variables (e.g., HDD, CDD, etc.)

$\mathbf{k}_t$ = vector of capital measure variables (indicator variables or engineering savings estimates)

$I_t$ = indicator variable(s) for SEM activity

# Facility Level Modeling Challenges

- Validity of models depends on controlling for major sources of energy use
- No unobserved changes in energy use correlated with SEM activity
- Requires accurate measurements of model variables and correctly characterizing relationships between energy use and other variables
- Savings estimates may be sensitive to model specification and estimation
  - Omitted variable bias

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# Common Modeling Challenge #1

- *Unavailability of data can constrain energy use modeling and ability to detect savings*
- Common data limitations
  - Low frequency (monthly and bi-monthly) energy-use data.
    - Solutions: Install higher frequency meters, perform statistical power analysis to estimate probability of detecting savings
  - Production data reported at a lower frequency than energy use.
    - Solution: Match energy use and production frequencies.
  - Unavailability of engineering savings estimates for capital measures.
    - Solution: Capture impacts with indicator variables
  - Ambiguity about initiation of SEM activities
    - Solution: Assume activity starts later rather than earlier

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# Common Modeling Challenge #2

- *Installation of incentivized capital project(s) during baseline period*
- Solutions
  - A. Explicitly control for capital project in energy use regression
    - Include engineering savings estimates or indicator variable (if savings estimate not available) as regressor
  - B. Limit analysis sample to period after capital projects
  - C. Adjust energy use in periods after capital projects to account for project savings

# Common Modeling Challenge #3

- *Installation of incentivized capital project(s) in post-SEM training period*
- Solutions:
  - A. Subtract evaluated capital measure savings from total site savings after regression analysis
  - B. Incorporate capital measure savings as an explanatory variable in regression analysis
    - Requires accurately distributing capital measure savings across relevant time periods

# Common Modeling Challenge #4

- *Experienced a major change in the baseline period (operations/processes/physical characteristics of the plant)*
- Solutions:
  - Case 1: Energy impacts of change can be measured
    A. Explicitly control for change in energy use regression
  - Case 2: Energy impacts of change cannot be measured
    B. Confine attention to baseline period after change occurred

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# Common Modeling Challenge #5

- *Experienced a major change in post-SEM period (operations/processes/physical characteristics of the plant)*
- Solutions:
  – Case 1: Energy impacts of change can be measured
    A. Explicitly control for change in energy use regression
  – Case 2: Energy impacts of change cannot be measured
    B. Confine attention to post-SEM period before change occurred

# Common Modeling Challenge #6

- *Installation of incentivized capital project(s) or experience major change (operations /processes/physical characteristics of the plant) at the same time as SEM training*
- *Solutions:*
  - Case 1: Confounding energy impacts can be measured
    - A. Estimate facility savings and subtract capital project or process change savings
  - Case 2: Confounding energy impacts cannot be measured
    - B. No solution

# Facility Energy Use – Assessing Model Validity

- Models must yield accurate estimates of baseline energy use
- Verifying validity of baseline involves checking:
  - Model explanatory power ($R^2$)
  - Within-sample predictions
  - Out-of-sample predictions
  - Signs and statistical significance of explanatory variables
  - Robustness checks – results sensitive to omission or inclusion of variables?

# ENERGY SAVINGS ESTIMATION

## STEP 4: O&M SAVINGS ESTIMATION

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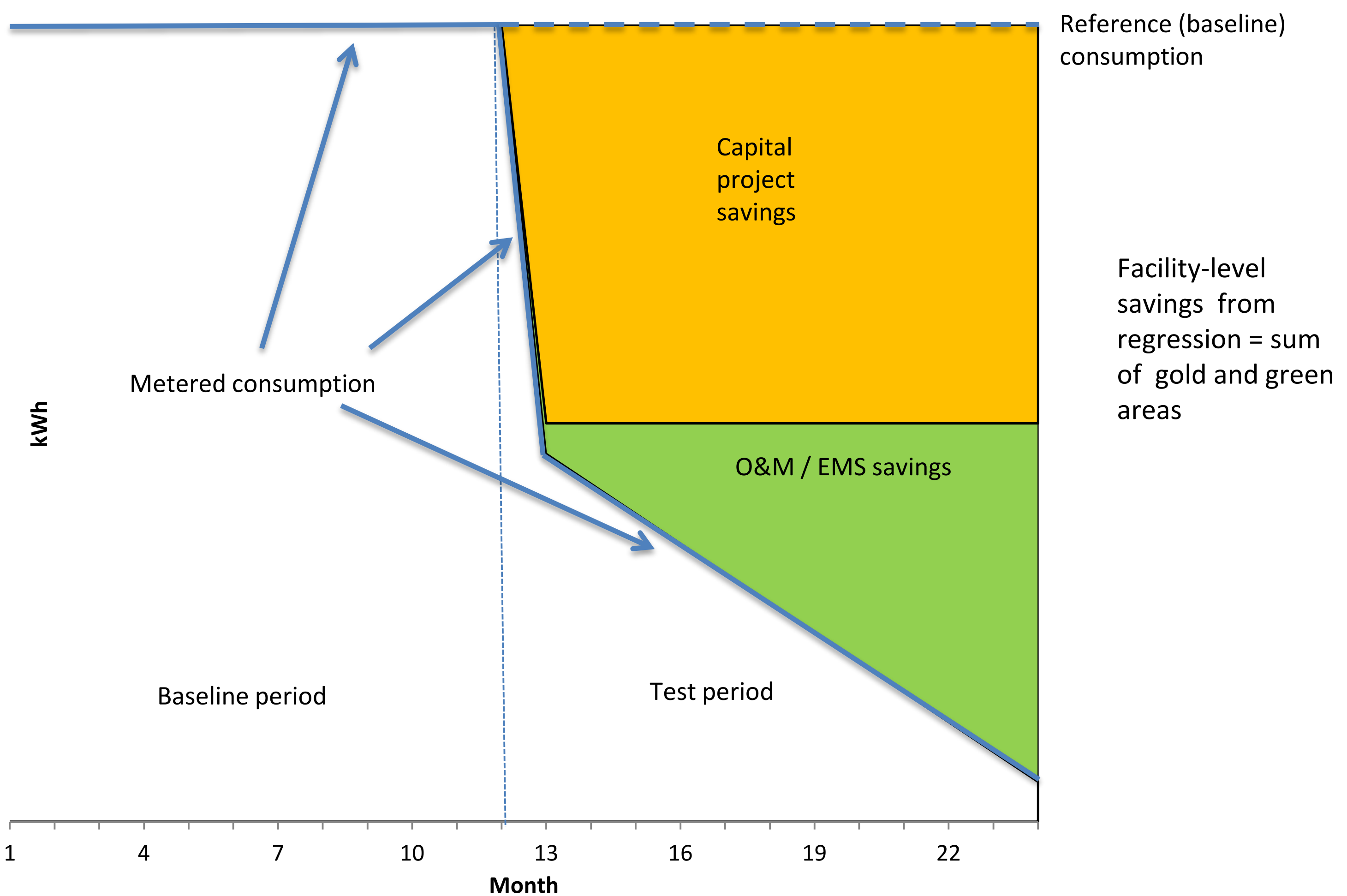
# O&M Savings Estimation

- O&M savings are estimated conditional on capital measure savings
- Two approaches for controlling for capital measure savings
  - Subtract capital measure savings from facility savings
  - Control for capital measure savings directly in regression model
- Accurate estimation of O&M savings depends on obtaining unbiased estimates of capital measure savings

# Illustration of Savings Estimation



# ENERGY SAVINGS ESTIMATION

## STEP 5: REPORTING

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# Reporting - Standard Metrics

For electric and gas results

| | Reported Savings | Verified Savings | LB 80% CI | UB 80% CI | Verified Savings as a Percent of Consumption | Realization Rate |
|---|---|---|---|---|---|---|
| **Capital Measure Savings** | | | | | | |
| **O&M Savings** | | | | | | |
| **Total Savings** | | | | | | |

# PERSISTENCE

# Persistence

- Researching savings persistence:
  - Annually, while participants still engaged in the program (in-treatment savings)
  - After graduating from the program (post-treatment savings)
  - Do savings decay after treatment ends? How fast?
  - Behavioral/O&M measures vs. capital measures
  - Relationship with SEM adoption level
- How to measure persistence?

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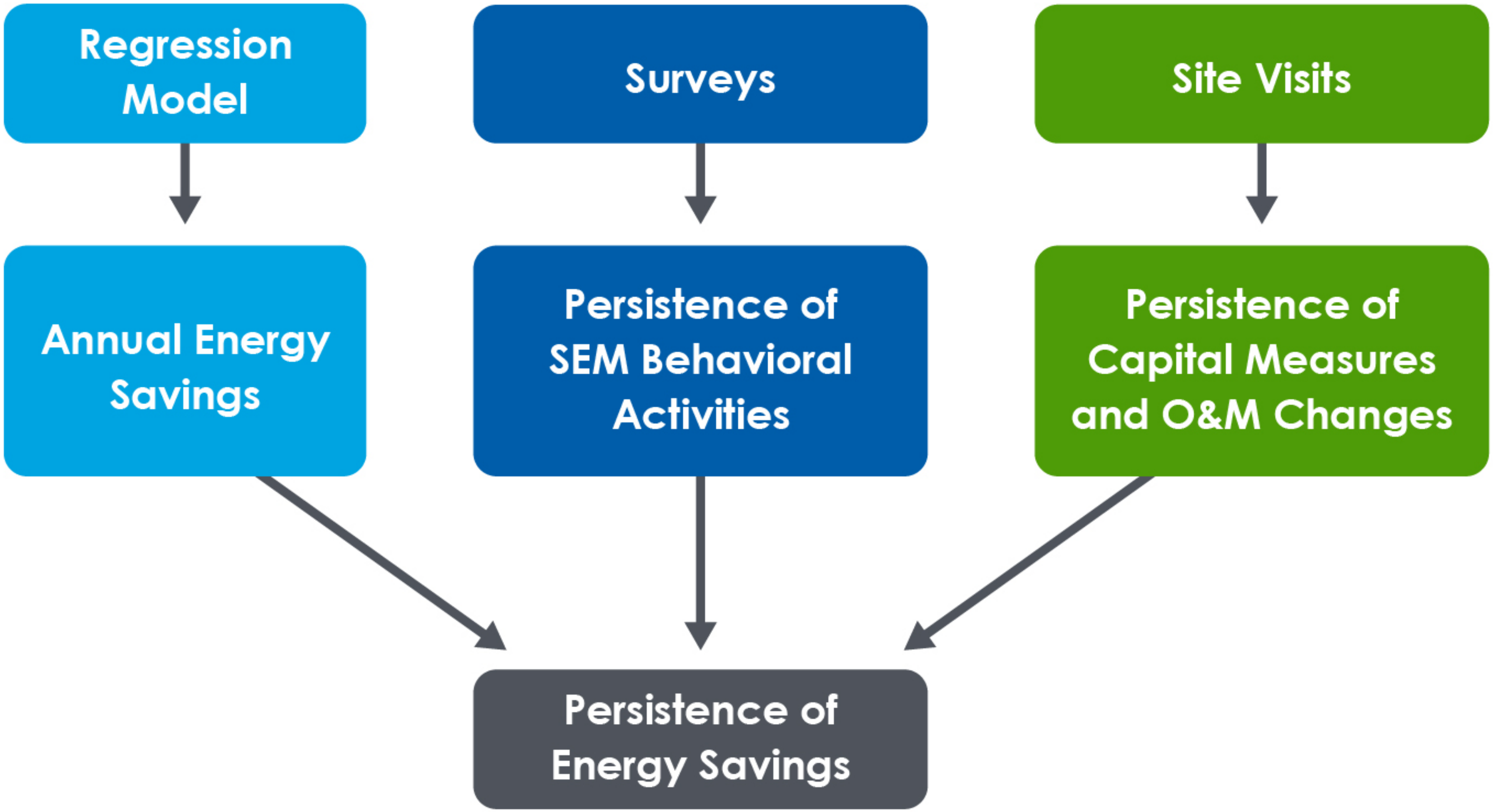
# Measuring Persistence



# SAMPLING

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# Sampling Challenges

- **Historically**
  - SEM implemented in a relatively small number of projects and sites
  - Census is feasible and cost effective
  - Savings estimates not dependent on sampled projects – all included in analysis!

# Sampling Challenges, cont'd.

- **Future**
  - Increasing focus on SEM will lead to higher rates of participation & larger study populations
  - Census will become cost-prohibitive!
  - Populations expected to remain heterogeneous, but with homogeneous subpopulations
  - With large populations, sampling can lead accurate and stable estimates of savings

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# Sampling Challenges, cont'd.

- **Current**
  - – Number of projects greater than in previous years
  - – Still pretty small but growing fast
  - – Considerable heterogeneity, homogeneous subpopulations?
  - – Sampling & analysis

# Sampling

- Steps to developing a sampling plan
    1. Understand the objectives of data collection
    2. Summarize the population & develop the sampling frame
    3. Determine the levels of analysis and confidence / precision requirements
    4. Define the sample design
    5. Calculate sample sizes
    6. Optimize sample sizes, cost, and scheduling
    7. Select units into sample

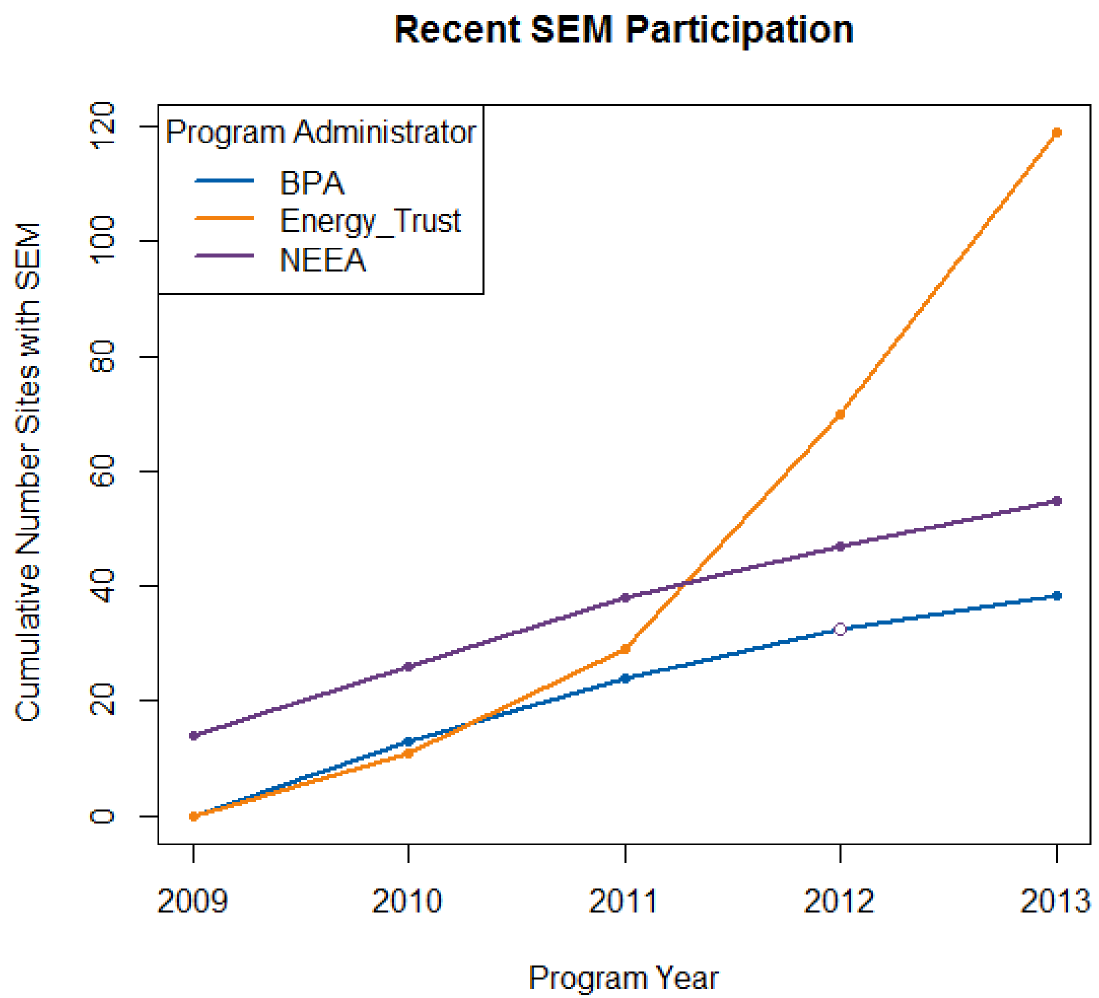
# 1. Understand the Objectives

- For which part of the analysis is the sampling being planned?
  - Measure level savings estimation (site visits)
    - Measure verification or metering?
  - Facility level saving estimation (regression analysis)
  - Both
    - Regression and site visits on all sampled sites?
    - Nested design with regression for all sampled sites but site visits for a subset of these?
- Sampling differs depending on objectives and planned analyses
- Planning may require a few iterations to balance objectives and resulting sample sizes with time & effort

# 2. Summarize the Population

- Summarize in terms of
  - Total number of projects and sites
  - Duration of participation
  - Distribution of savings
  - Variation of reported savings
  - Expected variation in evaluated savings
- Summarize within subpopulations (strata) & compare

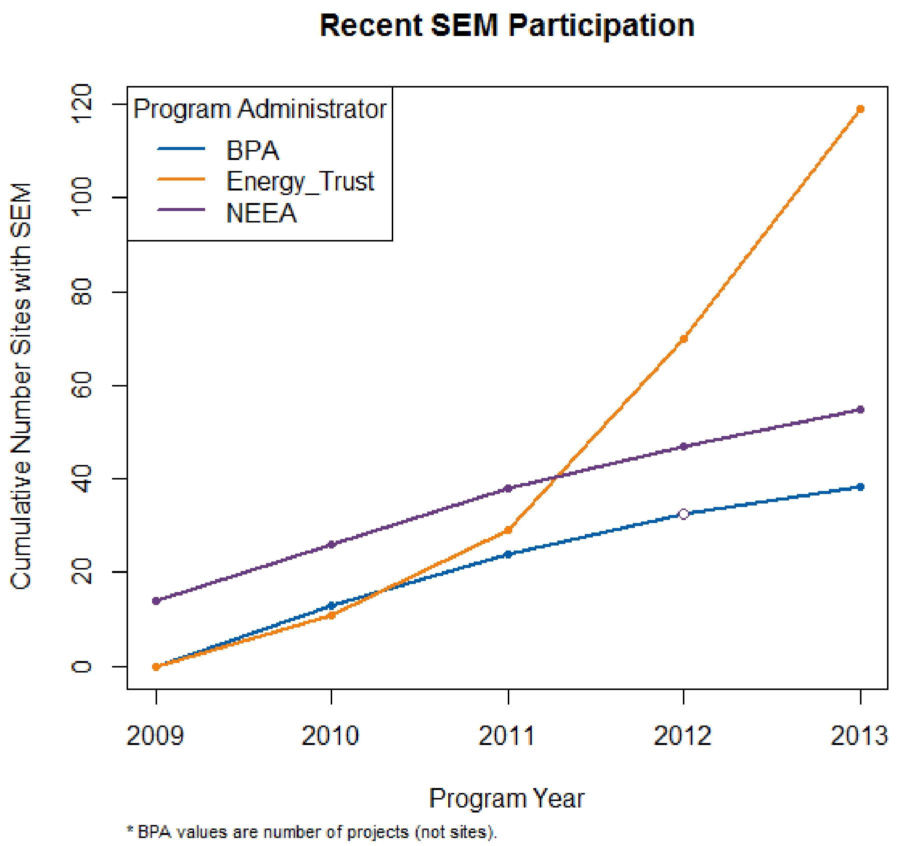
# Population Over Time




* BPA values are number of projects (not sites).

# Special Considerations

- Program Activity
- Consider
  - Current program year
  - Previous program years
- Total number of projects increasing quickly!



# 3. Levels of Analysis & CP Requirements

- Confidence / precision (CP) requirements
- Consider whether and how to incorporate sampling uncertainty into final results
  - Regression uncertainty + sampling uncertainty?
  - Sampling uncertainty in measure level savings + regression uncertainty in facility level savings?
  - Effects on sample design and sample size calculations

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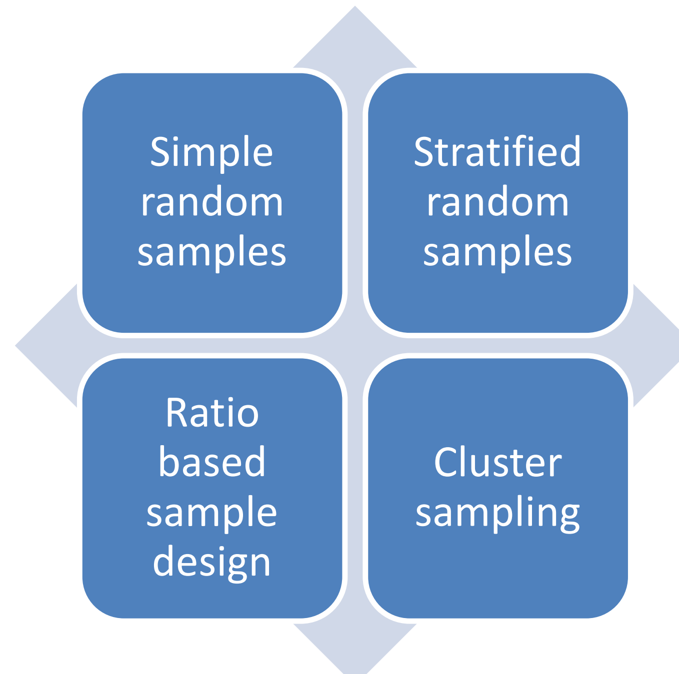
# 4. Define the Sample Design

- Heterogeneous populations (common in SEM)
  - Stratified random sampling
    - By savings
    - By data frequency
    - Certainty strata
  - Probability of selection
    - Proportional to savings?
    - Proportional to probability of detecting savings?



# Sensitivity of Results to Sampling

- Selecting a representative sample is a challenge when
  - Populations are small
  - Population units are very unique
- Standard sample design and sample size calculation
  - Assume sufficiently large populations and representative samples
  - Methods  based on target confidence / precision and expected variation may not be the best approach
  - Must consider accuracy
- Example based on a simulation study


# Simulation Study

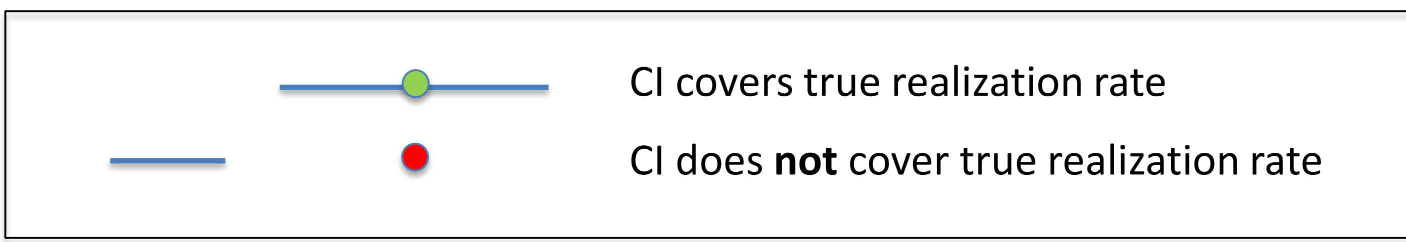
- Application
  - Sample design for previous and current years’ projects
  - Building level regression and site level measure verification for selected projects
- Concerns
  - Sampling will give inaccurate results
  - Population size is small
    - $N_{previous}$ = 15 projects and $N_{current}$ = 12 projects
  - Variation is high (but not astronomical)
    - Error Ratio = 0.54

# Simulation Study, cont'd.

- Evaluate the impact of sampling
  - Use results from previous evaluation - census of projects
  - Simulate random sampling and results
- Stratified sample design
  - Two strata (high / low savings)
  - Certainty stratum
    - Include projects contributing to top 65% of savings → $N_{census} = 6$
  - Sample stratum
    - Smaller projects included in sample stratum → $N_{sample} = 9$
  - Confidence / precision
    - 90/10 → $n_{total} = N_{census} + n_{sample} = 6 + 7 = 13$
    - 90/15 → $n_{total} = N_{census} + n_{sample} = 6 + 5 = 11$

# Simulation Study, cont'd.

- In each simulation
  - Select all census stratum projects
  - Randomly sample projects from sample stratum
  - Calculate realization rate, total verified savings, precision, and confidence interval
- Assess performance
  - Compare true realization rate to confidence interval




  - Coverage rate = percent of time CI covers true RR

# 100 simulations

| True RR = 94% | Sample Realization Rate | Relative Precision | Confidence Interval | | Contains true RR result? |
|---|---|---|---|---|---|
| | | | LB | UB | |
| Simulation 1 | 91% | 13% | 78% | 104% | YES |
| Simulation 2 | 83% | 14% | 70% | 97% | YES |
| Simulation 3 | 100% | 1% | 99% | 101% | NO |
| Simulation 4 | 90% | 12% | 78% | 102% | YES |
| Simulation 5 | 108% | 3% | 105% | 111% | NO |
| Simulation 6 | 86% | 13% | 73% | 99% | YES |
| . | | . | | | |
| . | | . | | | |
| . | | . | | | |

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# Results – 100 simulations

| Simulation Conditions | $n_{total}$ | Average RR | Average Relative Precision | Coverage Rate | Notes |
|---|---|---|---|---|---|
| Census | 15 | 94% | 0% | 100% | *No sampling error* |
| Target 90/10 | 13 | 94% | 8% | 73% | *CI contains true RR < 75% of samples* |
| Target 90/15 | 11 | 94% | 12% | 48% | *CI contains true RR < 50% of samples* |
| Target 90/20 | 9 | 92% | 18% | 39% | *CI contains true RR < 40% of samples* |
| Target 80/15 | 9 | 92% | 18% | 39% | *CI contains true RR < 40% of samples* |
| Target 80/20 | 7 | - | - | - | *Only 1 project left after certainty stratum selected – cannot compute SE* |

# Future Sampling Research

- Investigate and evaluate sample designs
- Determine optimal stratification, sample sizes
- Identify constraints
  - Program/population changes: more SEM at smaller sites
  - Data availability: high frequency data more likely for some sites
- Requirements
  - Data on census of projects and sites
  - Peer review of sampling research
  - External validity of program savings estimation
  - Collaboration!

# LEVEL OF SEM ADOPTION

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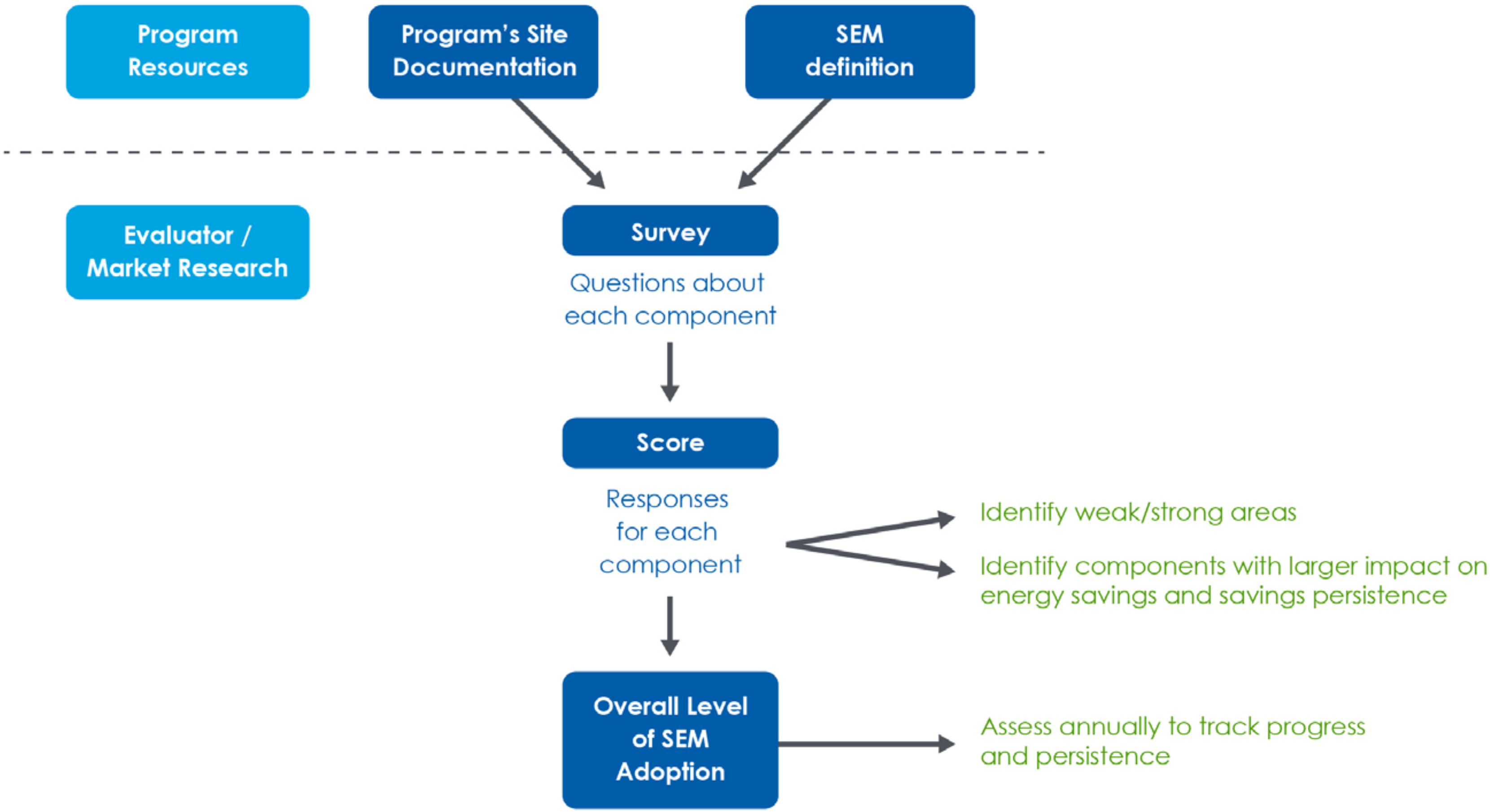
# Measuring SEM Adoption



# OTHER EVALUATION ISSUES

# Other Evaluation Issues

- Increased participation in other programs?
- How to ensure all savings are counted?
- Which program claims the savings?
- Is there concern about free-ridership appearing to increase in other programs? If so, how to address?

# NON-ENERGY BENEFITS

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# Non-energy Benefits

- Water savings
- Waste stream reduction
- Improved safety
- Increased throughput
- Improved product quality
- Longer equipment lifespan
- Emission reductions

# DISCUSSION / QUESTIONS

# Appendix C
# TRC and Navigant PowerPoint Slides

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# SEM Evaluation Workshop

*Facilitated by TRC Energy Services and Navigant Consulting*

Energy Trust of Oregon

August 26, 2014

# Table of Contents

# Workshop Agenda

| | |
|---|---|
| *9:00 - 9:15* | *Introductions, Goals & Context, etc.* |
| *9:15 - 9:45* | *KPI vs MT&R* |
| *9:45 - 10:00* | *Break* |
| *10:00-10:15* | *MT&R Issues for Evaluation* |
| *10:15-10:30* | *Measure Life & Savings Trajectory* |
| *10:30-12:00* | *SEM Scenarios* |
| *12:00-12:15* | *Break/Get Lunch* |
| *12:15-1:00* | *Discussion and Wrap Up* |



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# Introductions & Objectives

## *Introductions*

## *Workshop Objectives*

- Common Evaluation Methods and Guidelines
  - Define Issues
  - Discuss SEM Program Concerns
  - Discussion of Solutions
  - Guidelines
    - Evaluation should leverage/complement implementation
    - Relevant to the program strategy





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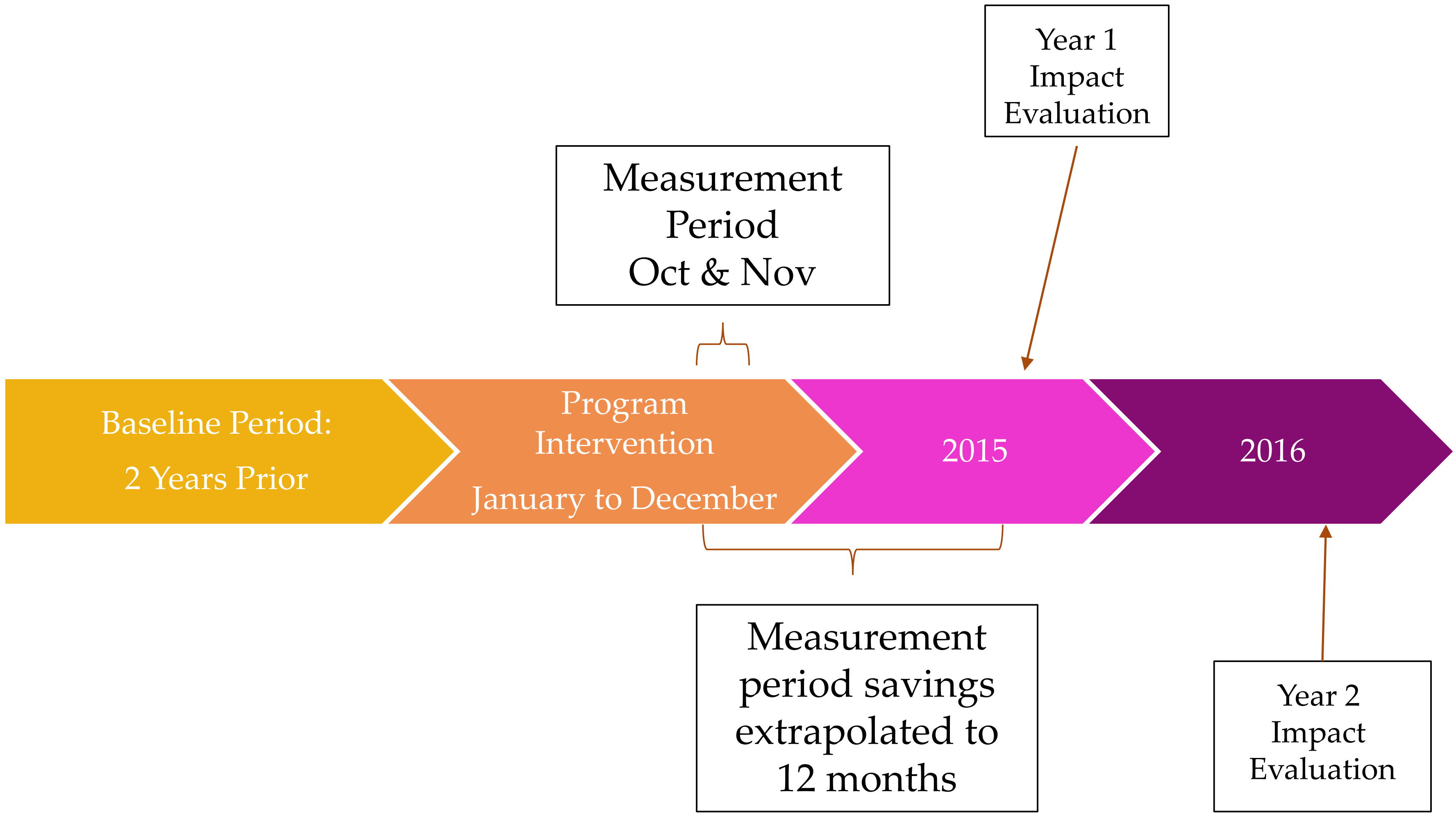
# SEM Program Timeline



# Recap: SEM Evaluation Challenges

## *Availability and granularity of data*

- Interval meter or demand rate/meter
- Usage data at least as granular as production data

## *Alignment of data*

- Billing month may not correspond with production month or weather month

## *Projects/savings alignment to IPMVP Option C*

- Facility-wide systems
- Savings greater than 10%
- Inability to isolate savings or parameters

## *Site maintenance of MT&R or other tracking tool*

# Recap: Population and Sampling Challenges

## *Population*

- Small; much fewer than 50 participants annually
- Mostly diverse industrial; few sites are comparable

## *Sampling*

- Size reduced by homogeneity
  - Industrial sites are highly diverse
- Greater proportion needed for small populations
- Lack of control groups reduces certainty of results
- Single versus multi-year evaluations
  - Longer term data where programs still in place
  - Increased population

# Common Evaluation Methods

## *Metering and Monitoring:*

- Site verification or indirect measure isolation (IPMVP A)
- Direct measure isolation (IPMVP B)
- **Regression/billing analysis (IPMVP Option C)**
- *Building simulation (IPMVP D)*

## *Alternate or Supplemental Approaches:*

- Interviews with energy team or others
- Employee surveys
- Expert judgment and literature reviews
- Standard operating procedures (SOP) or policy review

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# Terminology

## *KPI: Key Performance Indicators*

Typically production as a function of facility energy use

May be used for other benchmarking at site

## *MT&R: Monitoring, Tracking, and Reporting*

SEM specific benchmark

Model variables:

- detailed production, energy use, weather, operating hours, etc.

# Method Applicability - KPI

- *Single variable correlation without statistical framework*
- *Pre- and post-participation modeled separately*
- *Does not accurately account for baseload energy use (non-production energy)*
- *Not weather correlated*
- *KPIs for each of several production lines if sub-metered*
- *KPI can be an adequate model if:*
  - Large proportion (say 75%) of facility energy use is production
  - Weather is not relevant
  - No structural or macro-economic changes



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# Method Applicability - MT&R

*Multi-variable regression factors to energy use:*

- Weather
- Occupancy
- Different types of production
- Dummy variable for pre- and post-participation

*More complex and high effort to maintain*

*All variables need to be tracked to sustain model*

*Time intervals for all datasets must match*

*Necessary for facilities with complex energy dependence*

# Conversion from KPI to MT&R

## *If the KPI is robust, we can use it:*

- High correlation
- No facility changes or other influencing factors

## *Additional data needs, for instance:*

- Weather
- Occupancy
- Production hours and details

## *Required data*

- Granularity: daily or weekly
- Data alignment




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# More MT&R vs. KPI

*Both use regressions: IPMVP Option C*

*Both can be appropriate, but for different situations*

*Complexity of MT&R can be justified by improvement in model correlation and forecasting*

| MT&R | KPI |
|---|---|
| Complex | Simple |
| Includes multiple factors | Only one dependence |
| High effort to maintain | Minimal effort to maintain |
| Dummy variable for pre-post | Separate analysis pre-post |
| Both fail with major changes at site which affect model | |

*Regressions have limits*

# Discussion – MT&R vs KPI

*Evaluator implications*

*Customer perspectives*

*Sampling*

- Number of sites participating
- Types of sites participating
- Granularity of data at sites

*Out-of-model analysis*

- Capital projects
- Other

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# Off Ramping When MT&R Breaks

*Assume they maintain MT&R or have adequate data to calculate*

*Causes:*

- Major additions
- New process equipment
- Change in schedule/production/utilization
- Major economic change

*Options:*

- Find a simple KPI model
- Begin a new baseline period for future MT&R
- Engineering model

# Abandoning MT&R for KPI

*High residuals in MT&R model*

- Means model is no longer predictive
- Caused by changes at site or over specification in initial model

*Customer pushback against tracking*

- Not tracking data or just not maintaining MT&R

*Changes at site require new MT&R*

*Discuss effects on implementation and evaluation*

# Data Concerns

*Granularity*

- Hourly data are good, but can be difficult to obtain or work with over long periods of time
- Weekly or daily can be easier to work with but hourly adjusts for operations
- Longer term participation can compensate for less granularity

*Alignment of data*

*False correlations due to degrees of freedom*

*Overfitting caused by too many variables without enough data points*

# Engineering Evaluation

| Measure | Comments | Evaluation method |
|---|---|---|
| Employee engagement | | Surveys, eventually C |
| Shutting off equipment | May have records | A or B or Surveys |
| Steam trap repairs | | A |
| Convert to notched belts | | A |
| More frequent maintenance | Depends on equipment type | A or B or Surveys |
| Setpoint adjustments | | A or B |
| Benchmarking | Compare facilities | Surveys or C |
| Compressed air pressure | Quantifiable if facility has detailed compressed air monitoring | A or B |
| Appropriate uses (CA) | | A or B |
| Compressed air leaks | | A or B |
| Unoccupied setbacks | | A, B, or C |
| Other | | Varied |

# Effects on Site Evaluation

## *Ideal Evaluation*

- Interval energy data
- Daily or better production data
  - By line or product
- Measure isolation or sub-meter data
- Operational hours
  - Production
  - Occupancy
  - Intervals
- On-site weather data or local station
- Other

# Evaluation  Challenges

| Challenges | Approaches |
|---|---|
| Only monthly data | Expect poor confidence in results |
| Billing and production data cycles not aligned. | Collapse more granular data or align proportionally |
| Inadequate production data | Revert to simple KPI model |
| Poor model - regression correlations | Create new model and baseline |
| No operational records | Find proxy data |
| Major structural changes | Get records of changes (net results after regression) |
| Energy champion disappears | Develop new relationships |
| Capital changes | Get records of capital changes (net results after regression) |

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# Measure Life – Site Level

*Energy Trust uses 3 years*

*Justifying measure life beyond typical 1 year for operational measures*

*Ideal circumstances*

- Sustained MT&R
- Good tracking of capital improvements
- Good records of procedures
- Automation of measures

# Measure Life – Program Level

*Need a large, representative population sample to evaluate measure life*

- Challenges due to small populations and diversity of the participants
- Conduct a census if the population is small
- Pull a sample if the population is large enough
  - Random sample
  - Stratified sample
  - Requires persistence and confidence requirements

# Savings Trajectory

- *Long term (multi-year) participant data required*
  - May be difficult to obtain at some sites
- *Evaluation requires long-term buy-in from participants*
- *Better determined by later evaluation than by program verification*
- *Sampling strata-years or facility type?*
- *Compare initial KP&I to long term data adjusting for capital projects and facility changes*

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# Scenarios

1. *Facility completes SEM training and continues the monitoring, tracking and reporting (MT&R) initiated during the training and SEM practices actively maintained*
2. *Facility does not actively maintain MT&R, energy tracked using alternative method (Energy Expert, monthly bills, metered data), energy actively managed and SEM practices actively maintained*
3. *Energy use monitored, tracked, and managed using KPI(s) (i.e. kWh per pound, therms per unit) and SEM practices maintained*
4. *Energy not actively tracked but SEM practices actively maintained*
5. *Energy not actively tracked and SEM practices not actively maintained*

# CORE Example: Data Variation

## *Site One*

Monthly energy

Raw material used per month

Monthly production hours

## *Site Two*

15 minute energy

Weekly production by product

## *Site Three*

Calendar monthly processed weight

15 minute energy

# Scenario Discussion Framework

## *Implementation challenges*

Frequency of occurrence

Participant circumstances

## *Evaluation challenges*

Sampling approach

Data availability/granularity

Measure types (O&M, behavioral, capital)

Evaluation options

Threats to validity of results

## *Complicating factors*

Changes (production, site, etc.)

# Potential SEM Engagement Scenarios

1. ***Facility completes SEM training and continues the monitoring, tracking and reporting (MT&R) initiated during the training and SEM practices actively maintained***
2. *Facility does not actively maintain MT&R, energy tracked using alternative method (Energy Expert, monthly bills, metered data), energy actively managed and SEM practices actively maintained*
3. *Energy use monitored, tracked, and managed using KPI(s) (i.e. kWh per pound, therms per unit) and SEM practices maintained*
4. *Energy not actively tracked but SEM practices actively maintained*
5. *Energy not actively tracked and SEM practices not actively maintained*

# Maintains MT&R and Practices

## *Does the MT&R continue to be valid?*

- Yes: Ideally confirm MT&R results
- No: Compare MT&R to simple KPI model
  - Try to obtain at least daily data if possible
  - Re-model
  - Adjust all for additional measures outside of program, or that received separate rebates
- Capital measures
  - Ideally conduct M&V through SEM evaluation (site visit)
  - Find out if this is already being done in maintained model
- Challenges
  - How common is this situation?
  - Will evaluation of individual measures be too much effort or cost?

# Potential SEM Engagement Scenarios

1. *Facility completes SEM training and continues the monitoring, tracking and reporting (MT&R) initiated during the training and SEM practices actively maintained*
2. ***Facility does not actively maintain MT&R, energy tracked using alternative method (Energy Expert, monthly bills, metered data), energy actively managed and SEM practices actively maintained***
3. *Energy use monitored, tracked, and managed using KPI(s) (i.e. kWh per pound, therms per unit) and SEM practices maintained*
4. *Energy not actively tracked but SEM practices actively maintained*
5. *Energy not actively tracked and SEM practices not actively maintained*





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# Maintains Practices and Alternate Method

## *What are the alternate models/methods?*

- Compare MT&R to simple KPI model and model used
- Adjust all for additional measures outside of program, or that received separate rebates

## *Capital measures*

- Ideally conduct M&V through direct evaluation (site visit)
- Find out if this is already being done in maintained model

## *Try to obtain at least daily data if possible*

## *Challenges*

- What are common models?
- How common is this situation?
- Evaluation approach in this situation

# Potential SEM Scenarios

1. *Facility completes SEM training and continues the monitoring, tracking and reporting (MT&R) initiated during the training and SEM practices actively maintained*
2. *Facility does not actively maintain MT&R, energy tracked using alternative method (Energy Expert, monthly bills, metered data), energy actively managed and SEM practices actively maintained*
3. ***Energy use monitored, tracked, and managed using KPI(s) (i.e. kWh per pound, therms per unit) and SEM practices maintained***
4. *Energy not actively tracked but SEM practices actively maintained*
5. *Energy not actively tracked and SEM practices not actively maintained*

# Maintains Practices/Track with KPI

*Determine reason for not using MT&R*

*Assess the validity of customer approach*

- Confirm if production is large driver of energy use
- Use their KPI model
- Obtain tracking data for alternative method
- If possible compare to MT&R to extent possible if data are available.
- Obtain energy vs production data and compare

*Adjusting for other projects*

*Challenges*

- Evaluation approach in this situation

# Potential SEM Scenarios

1. *Facility completes SEM training and continues the monitoring, tracking and reporting (MT&R) initiated during the training and SEM practices actively maintained*
2. *Facility does not actively maintain MT&R, energy tracked using alternative method (Energy Expert, monthly bills, metered data), energy actively managed and SEM practices actively maintained*
3. *Energy use monitored, tracked, and managed using KPI(s) (i.e. kWh per pound, therms per unit) and SEM practices maintained*
4. ***Energy not actively tracked but SEM practices actively maintained***
5. *Energy not actively tracked and SEM practices not actively maintained*

# Energy Not Tracked / Practices Maintained

- *Do they not track data or do they just not put into a model?*
- *Obtain energy and production data and ideally repopulate MT&R*
- *Determine if other projects have been incentivized and need model adjustment*
- *Determine reason for not tracking energy*
- *Challenges*
  - Lack of data
  - Customer reluctance

# Potential SEM Scenarios

1. *Facility completes SEM training and continues the  monitoring, tracking and reporting (MT&R) initiated during the training and SEM practices actively maintained*
2. *Facility does not actively maintain MT&R, energy tracked using alternative method (Energy Expert, monthly bills, metered data), energy actively managed and SEM practices actively maintained*
3. *Energy use monitored, tracked, and managed using KPI(s) (i.e. kWh per pound, therms per unit) and SEM practices maintained*
4. *Energy not actively tracked but SEM practices actively maintained*
5. ***Energy not actively tracked and SEM practices not actively maintained***

# No Energy Tracking or Practice Maintenance

- *Useful baseline situation if site cooperates*
  - Very challenging to obtain data as site may be reluctant to spend time with evaluators
- *Need data on KPI and/or MT&R variables during post-SEM period*
- *Inadequate sites to provide statistically significant results at present*
  - Small participant population in general
- *Surveys may be an option to evaluate savings*

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# Disruptive Factors – MT&R Fails

*Try to determine why it failed*

- False correlation in initial model
- Facility changes (operational hours, production levels, headcount, physical facility)
- Additional capital projects not accounted for
- Poor data (production levels not correct, etc.)
- Energy team turnover
- Developing and implementing new energy saving actions outside of model

*Need new model – KPI or MT&R?*

*Effects on evaluation*

# Disruptive Factors

## *Lack of Data*

- Customer does not maintain granular production data
- Data lack adequate granularity to align variables
- Consider engineering analysis of measures if practical (requires appropriate measures and data)
- Rudimentary KPI model on available data may be only option
  - May work for some facilities
  - May need to estimate alignment between energy and production months





TRC Results you can rely on

NAVIGANT ENERGY

# Additional Energy Efficiency Measures

*Prescriptive capital measures – deemed or semi-deemed*

*Custom capital measures – calculated*

*Documented O&M practices*

- Typical measures
- Some measures may have previous studies of savings

*O&M on a piece of equipment*

- Sometimes savings can be calculated

*Behavioral O&M measures*

- Interviews?

# Savings Persistence

*Challenges*

- Projects may be implemented over time
- Production requirements may affect savings

*MT&R should account for ramp-up and persistence*

*Look to industry guidance for engineering approach*

- Example:
  - Annual compressed air leak studies with on-going PM
  - One-time effort will have a measure life of 1 year
  - Leak program might persist longer

# Savings Trends

## *Industry trends*

- Movement towards new practices
- Changes in economics

## *Site trends*

- Measures implemented over time
- Measures sustained over time
- Employee engagement

## *Challenges*

- Actions have multiple effects
- Difficult to measure savings or system effects
- Difficult to quantify effects

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# Wrap Up

» Areas of Agreement

» Outstanding Issues

» Next Steps for Addressing Outstanding Issues

# *Key* CONTACTS

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# Appendix D
# References and Resources

Consortium for Energy Efficiency (CEE) SEM Minimum Elements:
http://library.cee1.org/sites/default/files/library/11283/SEM_Minimum_Elements.pdf

Bonneville Power Administration Monitoring, Targeting & Reporting Reference Guide – Revision 4.0:

Energy Trust Evaluations
Strategic Energy Management Introductory Pilot Evaluation:
http://energytrust.org/library/reports/SEMi_Report_140604.pdf

Commercial Strategic Energy Management Pilot, Report 1:
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Industrial Energy Improvement, Cohort 2, Year 1 Report:
http://energytrust.org/library/reports/IEI_Cohort_Report.pdf

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http://energytrust.org/IEI-Year-1-Report.pdf

2009-2011 Production Efficiency Impact Evaluation:
http://energytrust.org/library/reports/PE_Impact_Eval_2009-11.pdf

Kaizen Blitz Pilot, Report 2:
http://energytrust.org/library/reports/Kaizen_Blitz_Year_2_Report.pdf

Kaizen Blitz Pilot, Report 1:
http://energytrust.org/library/reports/101026_KaizenBlitzPilot.pdf

Cadmus Group has helped the US Department of Energy with some of the Uniform Methods Project (UMP) work described here: http://energy.gov/eere/about-us/initiatives-and-projects/uniform-methods-project-determining-energy-efficiency-progr-0