Energy Efficiency
Evaluation Measurement and Verification

Issues (and opportunities)

Regulatory Assistance Project Advocates Training

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Steve Schiller
steve@schiller.com
Context: Energy Efficiency Actions

There is a continuum of actions. Our goal is to greatly accelerate this continuum of actions. This presentation is about the role of EM&V in meeting this goal - it’s a resource, not a barrier.

RD&D
- Research
- Development
- Demonstration

Deployment
Implementation of projects and programs – outreach, education, subsidies, for example:
- Incenting early actors
- Incenting consumers, distributors, manufacturers
- Mass market and individual market strategies

Transformed Markets
Standard practice or Codes and standards
Objective for this presentation

- Provide a basic working knowledge of evaluation definitions, concepts and methods (just enough to be dangerous)—and dive deeper into the technical issues as time permits

- Address and provide input on key issues, many of which are interrelated and involve iterative discussion

- Recognize that EM&V is all about risk management – balancing costs and value of information/risk of not knowing the savings value – “how good is good enough”

- A question for stakeholders is: “there are a lot of issues, which are the key issues which you consider most important for providing input and guidance?”
EM&V Overview
Definitions: The Savings Hierarchy for Resource Acquisition Programs

Focus of this presentation is on EM&V for RA, but will cover some MT issues as well

**Bottom Up**

- Fundamental savings unit is the measure, equipment or strategy that reduces energy use while maintaining or improving service

- Projects are coordinated activities to install one or more measures at a facility

- Programs are collections of similar projects that are intended to motivate customers in a specific market (a describable group of customers) to implement more energy efficiency

- Portfolios are multiple program initiatives in specific market sectors
Definitions: Top Down Evaluation

Top Down Analysis

- Of course, the real goal is to reduce energy consumption within a sector or state or region, etc. ......and document it

- However, virtually all evaluations are done with bottom-up analysis
Definitions – EM&V

- **Evaluation** - The performance of studies and activities aimed at determining the effects of a program or portfolio.

- **Measurement and Verification** – Data collection, monitoring, and analysis associated with the calculation of gross energy and demand savings from individual sites or projects. M&V can be a subset of program evaluation.

- **EM&V** - The term “evaluation, measurement, and verification” is frequently seen in efficiency evaluation literature. EM&V is a catchall acronym for determining both program and project impacts.
Two Overarching Categories of Evaluation

- **Formative and Outcomes Evaluation**
  - **Formative**: Helping program design
  - **Outcomes**: Determining program results

- Often, the two categories are blended for maximum use of information and cost efficiency
# Six Types of Evaluations

<table>
<thead>
<tr>
<th>Evaluation Category</th>
<th>Phase at Which Implemented</th>
<th>Evaluation Type</th>
<th>Assessment Level</th>
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<tbody>
<tr>
<td>Formative</td>
<td>Pre-program Planning Phase</td>
<td>Market Assessment (includes characterization, baseline)</td>
<td>Market, Portfolio, Program</td>
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<td></td>
<td>Implementation Phase - ongoing</td>
<td>Potential or feasibility</td>
<td>Portfolio, Program, Project</td>
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<tr>
<td>Outcomes</td>
<td>Implementation Phase – ongoing and/or ex-post</td>
<td>Process</td>
<td>Portfolio, Program</td>
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<td>Impact</td>
<td>Program, Project, Measure</td>
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<td>Market Effects Evaluation</td>
<td>Market, Portfolio</td>
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<td>Cost Effectiveness</td>
<td>Portfolio, Program, Project</td>
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Why Evaluate?

- **Quantify Results**: Document and measure the energy savings of a program in order to determine how well it has met its goals; e.g., has there been a good use of investor or public money?

- **Understand why program effects occurred** and identify ways to improve current and future programs as well as select future programs.

  “Things that are measured tend to improve.”
Fundamental EM&V Issues

1. Savings cannot be directly measured, only indirectly determined by comparing energy use after a program is implemented to what would have been consumed had the program not been implemented (i.e., the baseline), thus:

   Evaluation attempts to measure “what did not happen” - its an estimate

2. EM&V is about risk management – documenting savings, using feedback to mitigate the risk of uncertainty

3. When conducting EM&V we have two major questions:
   - As compared to what?
   - How good is good enough?
Basics of Impact Evaluation (in 10 minutes)
Impact Evaluation Concepts

- Impact evaluations are used for determining directly achieved program benefits (e.g., energy and demand savings, co-benefits)

- Again - evaluation attempts to measure “what did not happen.”

\[
\text{Impact} = \text{Actual}_{\text{post}} - \text{Projected}_{\text{pre}} \pm \text{Adjustments}
\]
Isolating Effects of Efficiency vs. Other Factors that Affect Consumption

<table>
<thead>
<tr>
<th>Individual Buildings</th>
<th>Broader Issues</th>
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<tbody>
<tr>
<td>Changes in the building (e.g., renovation)</td>
<td>Weather</td>
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<tr>
<td>Changes in the household (e.g., new baby)</td>
<td>Economy</td>
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<tr>
<td>Changes in business activities (e.g., number of employees, evolving industrial processes and outputs, operating hours, etc.)</td>
<td>Energy prices</td>
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<tr>
<td>Changes in appliances/equipment apart from the program</td>
<td>Changing codes/standards and common practice</td>
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<td>Other Programs</td>
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Determining Savings

Comparison of energy use before and after a program is implemented
Determining/Using Savings on a “Macro Level”

Methods: Reconstitute Loads (shown below), Historic EE as Explanatory Variable, or Forecast with Changes in EE Trends

(Based on Frank Monforte, Itron, 2009)
EM&V for efficiency is based on what would have happened in absence of the project, thus a key question is “what is the baseline?”

- **Project-Specific Baseline**: defined by a specific technology or practice that would have been pursued, at the site of individual projects if the program had not been implemented – tends to be existing equipment for early replacement programs.

- **Performance Standard Baseline**: defined to avoid project-specific determinations, and thus most free ridership issues, and instead try to ensure the overall additionality of quantified energy and demand savings, and/or avoided emissions – tends to be codes, standards, or common practice.

- **Dynamic Baselines**: defined to change over life of measure, based on life of existing equipment or changing standards.
Impact Evaluation Results Reported

- **Estimates of Gross Savings:**
  Gross energy savings are the change in energy consumption and/or demand that results **directly from program-promoted actions taken by program participants regardless of the extent or nature of program influence on their actions.**

- **Estimates of Net Savings:**
  Net energy savings refer to the **portion of gross savings that is attributable to the program.** This involves separating out the impacts that are a result of other influences, such as consumer self-motivation. Given the range of influences on consumers’ energy consumption, attributing changes to one cause (i.e., a particular program) or another can be quite complex.

- **Estimates of Co-Benefits:**
  A co-benefit commonly documented and reported is avoided air emissions: the air pollution (e.g., greenhouse gases) that would have been emitted if more energy had been consumed in the absence of the energy efficiency activity.
Two Components to Impact Evaluation:
1. Verify potential to generate savings
2. Determine savings

Example: Lighting Retrofit
- Potential to Generate Savings:
  *Before*: 60 Watts/fixture
  *After*: 13 Watts/fixture
- Savings:
Savings determined based on operating hours and lifetime of lamps

Example: New Car
- Potential to Generate Savings:
  *Before*: 10 MPG
  *After*: 50 MPG
- Savings:
Savings determined based on how many miles driven and for how many years
Persistence – *often neglected*

First Year versus Lifecycle Savings

Persistence is how long energy savings are expected to last once an energy efficiency activity has taken place.

- **Changes during measure life:** changes are primarily due to retention and performance degradation, although in some instances changes in codes or standards or the impact of “market progression” can also reduce net savings.

- **Effective useful life (EUL):** term often used to describe persistence. EUL is an estimate of the median number of years that the measures installed under a program are still in place and operable.
Approaches for Determining Gross Energy Savings

- **Deemed savings** that are based on historical and verified data, are applied to conventional energy efficiency measures implemented in the program. A variant of this is the deemed calculated savings as used by the Northwest RTF.

- **Statistical analyses** of large volumes of metered energy usage data are conducted.

- One or more **measurement and verification (M&V)** options (A, B, C and/or D) from the IPMVP are used to determine the savings from a sample of projects. These savings are then applied to all of the projects in the program.
Gross Savings: Deemed Savings Approach

- Deemed savings are used to define savings values for projects with well-known and documented savings values.

- **Deemed Measures values**: For simple efficiency measures whose performance characteristics and use conditions are well known and consistent, a deemed savings approach may be appropriate.

- **Deemed Calculated Measures**: A slightly more complex approach to estimating savings is to use simplified, pre-defined calculations that employ a combination of deemed or “default” input assumptions with some site-specific inputs.

- The use of deemed values in a savings calculation is an agreement to accept a pre-determined value, irrespective of what actually “happens”.

- Deemed values and deemed calculation approaches are often documented in a “Technical Reference Manual”
When to Use Deemed Savings

- technologies alone do not save energy; it is how they are used that saves energy

Assessing a few key aspects of the project can drive decisions about whether to use stipulations and how to use them effectively in an evaluation plan:

- Availability of reliable information
- The project’s likelihood of success in achieving savings
- Uncertainty of the stipulated parameter and its contribution to overall project uncertainty
- The cost of measurement

Several “rules of thumb” are:

- The most certain, predictable parameters can be estimated and stipulated without significantly reducing the quality of the evaluation results.
- Stipulating parameters that represent a small degree of uncertainty in the predicted result and a small amount of savings will not produce significant uncertainty concerns.
- Parameters should be measured when savings and prediction uncertainty are both large.
- Even if savings are high, but uncertainty of predicted savings is low, full measurement may not be necessary for M&V purposes.
Gross Savings: Large-Scale Data Analysis Approach

- Large-scale data analysis applies a variety of statistical methods to measured facility energy consumption meter data (almost always whole-facility utility meter billing data) and independent variable data to estimate gross energy and demand impacts.

- Unlike the M&V whole-facility analysis option (IPMVP Option C) the meter analysis approach usually involves analysis of a census of project sites, versus a sample.

- Types:
  - Time series comparison
  - Use of comparison group
  - Comparison group/time-series

- Most large-scale data analyses involve the use of comparison groups.
Large-Scale Data Analysis

**Equations**

- **Time Series**

  \[
  \text{Savings} = Q_{\text{pre-installation}} - Q_{\text{post-installation}}
  \]

- **Comparison Group**

  \[
  \text{Savings} = Q_{\text{non-participants}} - Q_{\text{participants}}
  \]

- **Comparison Group – Time Series**

  \[
  \text{Savings} = (Q_{\text{pre-installation}} - Q_{\text{post-installation}})_{\text{participants}} - (Q_{\text{pre-installation}} - Q_{\text{post-installation}})_{\text{non-participants}}
  \]
Measurement and Verification Approach

The M&V approach involves determining gross energy and/or demand savings by:

1a. Determining the savings of each project in a program

Or

1b. Selecting a representative sample of projects

2. Determining the savings of each project in the sample, using one or more of the M&V Options defined in the IPMVP

3. Applying the sample projects’ savings to the entire population, i.e., the program
IPMVP Summary of Options

- The IPMVP has four M&V options: Options A, B, C, and D

- The options are **generic M&V approaches for determining energy savings from projects**

- Four options provide a **range of approaches to determining energy cost avoidance**, depending on the **characteristics of the energy efficiency projects being implemented**, and balancing accuracy in reporting with the cost of conducting M&V.
IPMVP: Retrofit Isolation and Whole Facility

- **The Retrofit Isolation Options:**
  Option A or B - Addresses only the retrofitted system - ignores interactive effects beyond the boundary (although these may be independently addressed)

- **The Whole Facility Options:**
  Option C or D - Addresses all effects in the facility
  - Retrofits AND other changes (intended and unintended)
  - Often uses the utility meter
Circling Back - “Typical” Combination for Determining a Portfolio’s Gross Savings

- Set of prescriptive programs use deemed savings values (e.g., residential CFLs and refrigerators)

- Set of prescriptive programs use deemed calculated approach with pre-defined equations, some deemed parameters, and ex-post site inspections for other parameters. (e.g., commercial ventilation fan measures)

- Another set of custom programs use M&V savings analyses (Options A, B, C and/or D) on a census of projects (e.g., industrial process measures)

- Residential weatherization/comprehensive retrofit program uses large scale billing data analyses
Net Energy Savings

- The primary, but not exclusive, considerations that account for the difference between net and gross savings are free riders and participant and non-participant spillover.

- Free riders are program participants who would have implemented the program measure or practice in the absence of the program. Free riders can be total, partial, or deferred.

- Spillover refers to reductions in energy consumption and/or demand caused by the presence of the energy efficiency program, beyond the program-related gross savings of the participants. There can be participant and/or non-participant spillover.
Assessing Free Riders – It Ain’t Easy

<table>
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<th>Free-Ridership Score</th>
<th>Already Ordered or Installed</th>
<th>Would Have Installed Without Program</th>
<th>Same Efficiency</th>
<th>Would have Installed All of the Measures</th>
<th>Planning to Install Soon</th>
<th>Already in Budget</th>
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Approaches for Determining Net Energy Savings, continued

Approaches:

- Self-reporting surveys
- Enhanced self-reporting surveys
- Statistical models that compare participants’ and non-participants’ energy and demand patterns
- Stipulated net-to-gross ratios
In practice...no technically correct answer

- What is a free rider and free driver is not usually perfectly clear cut

- Adoption is non-linear over time and so is free ridership

- Markets are dynamic and when interventions succeed change is accelerated
  - What is a true naturally occurring baseline 25 years after the first market interventions?
  - Today’s free riders are often yesterday’s market effects

- Measurement techniques are limited
  - No pure control groups
    - Though experimental designs can sometimes help
    - Variation in program type/intensity can be leveraged
  - The vagaries of self reports
  - The pain of market tracking
  - Data are “weak”
Evaluation Resources and National/Regional Efforts

Other Resources
Reference List

- See two page list in your “packet”
In the simplest form ‘TRMs’ are databases of deemed savings values with applicability conditions.

Examples of database contents are:

- kWh, kW, therm savings values
- Measure effective lifetimes
- Net to gross ratios
- Measure cost information
- Local/regional utility cost information for TRC calculations
- Work papers that document basis for values

Documents with varying level of detail that define how the evaluations (and M&V) are to be conducted with a particular jurisdiction. Contents might include:

- Which approaches to use
- Sample size requirements
- Evaluation timing
- Reporting requirements
Regional and National Efforts

- The Northwest Regional Technical Forum - an advisory committee established to develop standards to verify and evaluate conservation savings.  
  http://www.nwcouncil.org/rtf/about.htm

- Regional EM&V Forum (Northeast and Mid-Atlantic) - supports the development and use of common and/or consistent protocols to evaluate, measure, verify, and report the savings, costs, and emission impacts of energy efficiency. Covers 11 states.  
  http://www.neep.org/emv-forum

- EPA and DOE State Energy Efficiency Action Network – focuses on providing assistance states need to advance policies and practices that bring energy efficiency to scale.  
  www.epa.gov/cleanenergy/energy-programs/seeaction/index.html

- NAESB – Developing a business practice standard for measuring and verifying reductions in energy and demand from energy efficiency in the wholesale and retail markets.

- International Energy Agency – DSM task force to compare and develop international best practices for EM&V of energy, demand and emissions savings from efficiency

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<th>Executive Summary</th>
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<td>Chapter 2: Energy Efficiency Program Evaluation</td>
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<td>Chapter 3: Impact Evaluation Basics</td>
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<td>Part 3</td>
<td>Chapter 4: Calculating Gross Energy and Demand Savings</td>
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<td>Chapter 5: Calculating Net Energy and Demand Savings</td>
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<td>Chapter 6: Calculating Avoided Air Emissions</td>
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<td>Part 4</td>
<td>Chapter 7: Planning An Impact Evaluation</td>
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<td>Appendix B: Glossary</td>
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<td>Appendix C: Other Evaluation Types</td>
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<td>Appendix E: Resources and References</td>
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<td>Appendix F: Renewables and Combined Heat and Power Program Evaluation</td>
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<td>Appendix G: References</td>
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Policy and Implementation Issues
Technical Issues

Determining gross (and net) energy savings - well established bottom up processes
Policy and Implementation Issues

Balancing costs and value of information, attribution and additionality, scaling up EE and EM&V —

- That is our focus today

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From April 2010 LBNL Study: Review of Evaluation, Measurement and Verification Approaches Used to Estimate the Load Impacts and Effectiveness of Energy Efficiency Programs funded by the U.S. Department of Energy

- Six EM&V issue categories identified that are important to address in order to improve EM&V practices and methods in an evolving market and policy environment
  - Consistency in reported savings or load impacts (attribution)
  - Measurement methods used to estimate net savings
  - Quality control and accuracy
  - Allocation of evaluation resources
  - Independence of program evaluators
  - Integration of load impact results from energy efficiency programs into utility planning and forecasting
Issues For Developing EM&V Guidance

Objectives:
1. What are the evaluation objectives, metrics?
2. What cost effectiveness test will be used?
3. What are the evaluation principles that drive the effort?

Savings:
4. What are the baselines against which savings are judged (existing standards, codes and standards, dynamic baselines)?
5. Performance determined on basis of net or gross savings? What is included in net savings (free riders, spillover, etc.)
6. What is reporting “boundary”, are T&D considerations included, how ‘granular’ will be the results
7. How are savings applied – looking back/go ing forward
EM&V Issues, continued

Approaches

8. What impact evaluation approaches will be used and how will they be selected?

9. What are the schedules for implementing EM&V and reporting?

10. What are the data management strategies?

Budget, Scale and Quality

11. What are expectations for savings determination certainty (confidence and precision)?

12. How much money will be spent on evaluation? What is balance between or level of Impact, Market and Process evaluations?

Who

13. Who will conduct the evaluations, how is independent evaluation defined, what are the roles between utility and utility commission?

14. Who will be the arbitrator of evaluation disputes?
Expectations

From a very practical perspective, working on all these objectives simply sets the expectations for:

- What will be covered in the EM&V reports, when they will be delivered, and how detailed/accurate they will be?

- What will be the ‘scale’ of the EM&V effort (rigor and budget); how will budget be allocated between various activities?

- Who will do the evaluations and who will receive/review reports? What is process for ongoing engaging, oversight/dispute resolution.

- What will be done with the EM&V results?
Evaluation in Context: The Cycle of Program Planning and Implementation

1. Program Objectives
   - Policies
   - Operational
   - Load shape

2. Program Design & Selection; Evaluation Planning
   - End uses
   - Technologies
   - Marketing techniques
   - Customer issues
   - Utility issues
   - Benefit/cost
   - Logic modeling & evaluation planning

3. Program Implementation
   - Experiments
   - Pilot programs
   - Full-scale programs
   - Evaluation data collection

4. Program Monitoring & Evaluation
   - Process & impact evaluation
   - Feedback on objectives
   - Redesign of programs

Document Hierarchy

Advocates tend to have input on first and often second type of document

- **EM&V Guidance Plan or Protocol** – applies to all of portfolios/programs
  - Sets overall objectives, metrics, principles, high level indication of methods to be used, budget, schedule, certainty and QA/QC, and reporting expectations
  - May include a data management strategy
  - Defines what will be covered in the other two types of documents

- **Program Specific EM&V Plan** – applies to a specific program
  - Provides details of how metrics will be determined for each program including details sufficient to prepare a budget and staffing plan, e.g. sample sizes and which M&V methods will be used

- **Site Specific M&V Plan** – for custom projects
  - Provides detailed specification of M&V for each custom site that is actually analyzed (non-custom projects or mass market programs do not use M&V)
Objectives/Metrics and Principles
Objectives

- What are the overall goals of the efficiency programs?
  - define the metrics -
    - The “usual suspects”
      - Demand savings (how defined)
      - Energy savings
      - Cost-effectiveness (how defined)
    - First year or life-cycle?
    - Other co-benefits (examples)
      - Emissions avoidance
      - Jobs
    - “Milestones” (examples)
      - Homes served
      - People trained
    - Market transformation (examples)
      - EE product market penetration
      - Behavior associated with energy efficiency

- These metrics define what needs to be documented (measured, reported)
- Their value and risk in getting the metric’s value wrong defines the level of effort
Objectives, other considerations

- How will the information/metrics be used?
  - Judge compliance with savings and cost-effectiveness goals
  - IRP
  - Input for earnings calculations associated with decoupling mechanism and incentives
  - Input for project, program, portfolio improvement
  - Demand forecasting

- Are these leading to DEEP energy savings, are they pushing faster along the continuum?

- What level of transparency is required and for who?

- What are requirements for reporting of results to Commission, stakeholders and ratepayers

- How do results fit into any statewide or regional analyses?
Example EE Portfolio Objectives

- Maximize energy or peak savings within portfolio cost caps
- Maximize cost effectiveness of portfolios (or programs, or measures, or projects) without creating lost opportunities in the process
- Maximize leverage of portfolio dollars in creating private investment in energy efficient products to achieve savings
- Portfolios should defer specific resource planning needs - (peaking or base load power plants, transmission or distribution investments)
- Portfolios should minimize GHG gas emissions through efficiency up to the marginal cost per ton of the next available abatement technology for the premise (e.g., micro-gen)
- Maximize fraction of population participating in portfolios by sector (Equity – considerations include customer class, geographic distribution, etc.)
- Maximize customer satisfaction
Cost-Effectiveness – which test?

Depends on perspective to be considered

- Utility (Program Administrator) – UCT/PAC
- Total Resource (Societal) – TRC or SCT
- Program Participant – PCT
- Utility rate changes to all ratepayers (i.e., reflects impact of reduced kWh sales on rates, but not total bill impacts) - RIM

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<td>Direct Customer DSM Costs</td>
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<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Utility Program Administration</td>
<td>√</td>
<td>√</td>
<td>√</td>
<td></td>
<td>√</td>
</tr>
<tr>
<td>Lost Revenues</td>
<td></td>
<td></td>
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<td>√</td>
<td></td>
</tr>
</tbody>
</table>

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Example Evaluation Principles to Guide Development of Governance Structures

- Evaluators should be impartial in their work and not have their compensation tied to the magnitude of their impact evaluation results.

- Evaluators are expected to follow ethical guidelines (e.g., American Evaluation Association [http://www.eval.org/]).

- Transparent methods to estimate load impacts are reviewed in public forum to increase quality and reliability.

- Evaluation planning process identifies the types of evaluation information that is crucial to different stakeholders.

- Take advantage of work done elsewhere.

- Expert review of evaluation design in planning phase, not after completion; lean on evaluation experts.

- All key assumptions used by program planners are eventually verified in evaluations.

- Ensure procurement process used to select evaluation contractors is timely and flexible.

- Focus evaluation dollars and efforts on areas of largest/most important uncertainty.

- Over time, use impact evaluation used to refine input assumptions used in savings estimation and improve programs.
Savings Determination
Issues
What are the baselines against which savings are judged?

EM&V for efficiency is based on what would have happened in absence of the project, thus a key question is “what is the baseline?”

- Categories are Project-Specific Baselines, Performance Standard Baselines and the Dynamic Baselines.

- The issue is sometimes presented as: “is the baseline existing stuff or what would be required by common practice, best practice, or a code/standard?”

- Ideally one would look at projects in the categories of new construction, early replacement, and end of life replacement projects.

- Common approaches are:
  - New construction and end of life replacement: baseline is either common practice, best practice, or a code/standard
  - Early replacement: what is there now (existing stuff)
  - Sometimes, dynamic baselines will be used to change baselines over life of measure (say at end of useful life of early replaced equipment) – this is perhaps more accurate and more costly to determine
Net and Gross Savings

- Gross savings are the “bottom line” – and typically what is looked for in terms of energy “saved”

- Gross savings can be hard to determine, net savings tend to be VERY hard to determine

- Net savings tend to be about “attribution”. Attribution is important for:
  - “Giving credit where credit is due” – e.g., incentives
  - Feedback for program design and allocation of funds – e.g., if a program has high free ridership then perhaps its design should be adjusted or the program reduced/cancelled (and vice-versa for say spillover)

- Options tend to lead to reporting of both, but using gross and net for different purposes
  - Uncertainty of savings must be communicated
  - What is included in net savings (free riders, spillover) must be decided
Attribution and NTG

- Key Questions

- Will net or gross, or both savings be determined and reported?

- If net savings are reported, what will they be used for?

- If net savings are reported and used:
  - What is definition of net, what is included in NTG?
    - Free riders (would have implemented anyway)
    - Spillover (savings the program causes above and beyond direct results)
  - How will NTG be determined and how often? Surveys, control groups, stipulation?
  - How much effort will be put into determining net savings and how will reliability/certainty of results be reported
Reporting/Analysis Boundary

- Are results to be determined and reported on at measure, project, program and/or portfolio level
  - Information at measure/project level is typically used for project/program improvement and attribution - for example, with customer or contractor incentives
  - One key question is whether cost-effectiveness is to be judged at measure, project, program or portfolio level

- Are results to be reported:
  - Per measure, project/site, program and/or portfolio?
  - Per hour, day, season, year, lifetime?
  - For typical or actual conditions?

- Another boundary question is whether T&D losses are to be credited – can be in 5-20% range
Ex-Ante vs Ex-Post Deemed Savings: Looking Forward, Going Back

- Estimates of costs and savings from EE measures are typically made both prior to program implementation (i.e., *ex ante*) and post-program implementation (i.e., *ex post*).

- *Ex post* estimates of cost and savings are generally considered a more accurate representation of actual cost and savings.

- Question: Should stipulated savings claims, based on values in an approved TRM, be adjusted retroactively or only applied on a going forward basis?

- For example:
  - If the use of TRM values developed in 2009 indicate that the savings from measures installed in a utility program in 2010 are 100 MWh
  - However, an ex-post evaluation indicates that the values in the TRM were overly optimistic and the actual savings are 90 MWh.
  - If all the measures were installed, does the Commission credit the utility with 100 MWh of savings or only 90 MWh?
Ex-Ante vs. Ex-Post Deemed Savings – Typical Approach

- Cost and savings estimates in the Technical reference Manual (TRM) should be based on the best available information at the time these estimates and/or calculations are made and they determined in a rigorous transparent manner.

- Therefore, if *ex post* cost and savings estimates for efficiency measures and programs vary from *ex ante* estimates of cost and savings, *ex post* estimates should be the preferred values for adopted for use in future program savings claims.

- However, as a rule, deemed or deemed calculated savings claimed for prior measures or programs should not be adjusted retroactively for investments made in the prior year. Effective useful life values however may be adjusted.

- Savings from custom projects or programs, where savings are determined ex-post using agreed to protocols, should use these *ex post* values as the credited savings.
Evaluation Approaches

Selection of Approaches, Schedules and Data Management
What impact evaluation approaches will be used and how will they be selected?

- Most likely all of the approaches will be used:
  - Deemed Savings (from where?)
  - M&V
  - Large Scale Data Analyses

- The most useful thing in a guidance document related to this subject is a “selection guide” indicating what approaches will be used under what circumstances

- This “selection guide” flows from EE measure characteristics, experience, common practice and the answers to the other issues presented here – most importantly – budget, scale and reliability/certainty expectations, and the granularity required of results (by measure, facility, program, etc.)
What are the schedules for implementing EM&V and reporting?

- **Real time (new paradigm)**. The evaluator is in on the project from the beginning. The evaluation and the implementation team work together. Great advantages:
  - The evaluator is no longer just the “auditor”
  - Great for collecting the right data at the right time
  - Course corrections in real time

- **Retrospective assessments (old paradigm)**. The evaluator comes in on the tail end of the project. Looks back. Often looks for things that were not done right. Often data needed were never collected.

The feedback loop is what makes evaluation useful.
When and over what time frame the evaluation effort will take place is determined by:

**Period of Analyses**
- What will be the time period of analyses, i.e. how many years?
- Will persistence of savings be determined, and if so, how?

**Regulatory Requirements**
- The timing for policy decisions and evaluation planning.
- Whether only an end of program report is needed or whether interim or even monthly reports are desired

**Program/Evaluation Needs**
- The desire to have early feedback for program implementers.
- Program lifecycle stage (evaluating a first time program or a long-established program)
- Evaluation data collection time lags
- Timing needs for using the evaluation results to update specific measure energy and demand savings and measure life estimates
Typical Evaluation Steps

- Set high-level guidance for EM&V
- Develop reporting requirements and schedule
- Establish EM&V priorities for the current cycle
- Develop one or more project specifications
- Assemble internal team and/or retain one or more independent contractors
- EM&V team develops detailed research plan outlining how to meet the specified study requirements
- Regulators and stakeholders review final product
- Final sign-off of evaluation results (who, when, how!)
Data Reporting and Management

- A great deal of data is generated in the evaluation and project/program management process.

- A data management and tracking system is virtually a necessity – it can be a huge undertaking and a huge benefit for implementers, evaluators and regulators, as well as for regular reporting to other stakeholders.

- Some items that are typically specified are:
  - Data required
  - Format of data to be provided by tracking systems; compatibility
  - Access to data and summaries
  - Data confidentiality protection protocols
  - Data quality assurance and control
Budget, Scale and Quality
How Good is Good Enough? As Compared to What?

Incremental certainty

Value of information

Cost of incremental EM&V

Balance point of diminishing returns

value of improved certainty ≥ cost of improved EM&V

value of improved certainty < cost of improved EM&V
Uncertainty

Uncertainty is a measure of the “goodness” of an estimate

- Uncertainty is affected by:
  - Systematic errors – e.g. measurement error
  - Random errors – error by chance such as in sampling error

- Efficiency EM&V has uncertainty because of lack of direct measurement

Dealing With Efficiency EM&V Uncertainty

- Random Error: Define it quantitatively / control it – for example defining confidence and precision of a sample and increasing sample sizes

- Systematic errors: Define it qualitatively / control it – for example – meter calibration and quality control procedures
Accuracy: Precision and Bias Reporting – it's more than sampling error

- Right methods, high budget
- Wrong methods, high budget
- Wrong methods, low budget
- Right methods, low budget

Precision

Imprecise

Biased/Inaccurate

Unbiased/Accurate
Evaluation “Scale” and Budget

Issues to consider when setting the scale:

- How large is the program?
- Is it a new program with uncertain savings or an established program with understood savings?
- Is the program likely to be expanded or contracted?
- How certain an estimate of energy and demand savings are required?
- Do savings need to be attributed to certain programs, how important is net to gross?
- How long is the program cycle?
- What is the time period for reporting savings (annual, monthly, etc.)?
- What are the reporting requirements and who must review and approve results?
- What sample sizes are required to achieve the desired precision/confidence?
- Are avoided emissions and other co-benefits to be analyzed?
What to Do About Budget, Scale, and Quality

What is typically done: The budget is set, everything flows from that budget based on experience and best practices

What is good to do:

- Provide answers to the issues and questions raised in this presentation

- Conduct an iterative process of costing out approaches and risk analysis till the right balance is reached

Practical Reality – most of the first and some of the latter within context of overall budget
# What Jurisdictions Spend on EM&V

Review of Evaluation, Measurement and Verification Approaches Used to Estimate the Load Impacts and Effectiveness of Energy Efficiency Programs, LBNL Report, April 2010, Mike Messenger, Ranjit Bharvirkar, Bill Golemboski, Charles A. Goldman, Steven R. Schiller

## Table 1. Ratepayer-funded energy efficiency budgets and EM&V expenditures for selected states

<table>
<thead>
<tr>
<th>State</th>
<th>2008 Total EE Budget (million $)</th>
<th>2008 Total EE Budget per Capita ($)</th>
<th>2008 EM&amp;V Budget (million $)</th>
<th>2009 Total EE Budget (million $)</th>
<th>2009 Total EE Budget per Capita ($)</th>
<th>2009 EM&amp;V Budget (million $)</th>
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<tbody>
<tr>
<td>CA</td>
<td>1014.2</td>
<td>28</td>
<td>80.2</td>
<td>1376.7</td>
<td>37</td>
<td>79.3</td>
</tr>
<tr>
<td>CT</td>
<td>113.6</td>
<td>32</td>
<td>1.7</td>
<td>107.4</td>
<td>31</td>
<td>1.4</td>
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<tr>
<td>FL</td>
<td>124.3</td>
<td>7</td>
<td>?</td>
<td>138.9</td>
<td>7</td>
<td>0.1</td>
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<tr>
<td>IA</td>
<td>58.9</td>
<td>20</td>
<td>3</td>
<td>90.5</td>
<td>30</td>
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</tr>
<tr>
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<td>41.0</td>
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<td>1.3</td>
<td>67.4</td>
<td>5</td>
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<td>5.1</td>
<td>208.5</td>
<td>32</td>
<td>7.8</td>
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<tr>
<td>ME</td>
<td>16.8</td>
<td>13</td>
<td>0.2</td>
<td>20.8</td>
<td>16</td>
<td>0.2</td>
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<tr>
<td>MN</td>
<td>136.5</td>
<td>26</td>
<td>1</td>
<td>73.7</td>
<td>14</td>
<td>1.3</td>
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<tr>
<td>NEEA*</td>
<td>97.5</td>
<td>NA</td>
<td>1</td>
<td>105.2</td>
<td>NA</td>
<td>1.8</td>
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<tr>
<td>NY</td>
<td>287.9</td>
<td>15</td>
<td>7.7</td>
<td>421.2</td>
<td>22</td>
<td>7.6</td>
</tr>
<tr>
<td>OR</td>
<td>76.8</td>
<td>20</td>
<td>1.6</td>
<td>105.4</td>
<td>28</td>
<td>2.2*</td>
</tr>
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<td>PA</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>8.7</td>
<td>1</td>
<td>0.1</td>
</tr>
<tr>
<td>TX</td>
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<td>4</td>
<td>0.1</td>
<td>101.8</td>
<td>4</td>
<td>0.2</td>
</tr>
<tr>
<td>WI</td>
<td>140</td>
<td>25</td>
<td>2.4</td>
<td>162.4</td>
<td>29</td>
<td>4.8</td>
</tr>
</tbody>
</table>

Source: Consortium for Energy Efficiency (2008), Consortium for Energy Efficiency (2009) and U.S. Census Bureau.\(^{11}\)
What Jurisdictions Spend on EM&V – percents and allocations

The allocation of the total EM&V budget among process, load impact, and market research studies varies significantly among the jurisdictions. Impact studies accounted for 75% or more of total EM&V funding in six states and between 50-60% of total EM&V funding in 4 states and 30% in one state.

Table 8. EM&V 2008 funding levels and allocation among activities

<table>
<thead>
<tr>
<th>State</th>
<th>EM&amp;V Funding (million $)</th>
<th>EM&amp;V Funding as % of Total EE Funding</th>
<th>Allocation of EM&amp;V Budget (% Impact / % Process / % Market Research)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>25 to 45*</td>
<td>&gt; 5%*</td>
<td>75 / 15 / 10</td>
</tr>
<tr>
<td>CT</td>
<td>2.0</td>
<td>3%</td>
<td>NA</td>
</tr>
<tr>
<td>FL</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>IA</td>
<td>8</td>
<td>&gt; 5%*</td>
<td>50 / 30 / 20</td>
</tr>
<tr>
<td>ID</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>IL</td>
<td>2.6</td>
<td>2-3%</td>
<td>75 / 15 / 10</td>
</tr>
<tr>
<td>MA</td>
<td>6.3</td>
<td>3-5%*</td>
<td>75 / 15 / 10</td>
</tr>
<tr>
<td>ME</td>
<td>0.5</td>
<td>2-3%</td>
<td>30 / 50 / 20</td>
</tr>
<tr>
<td>MN</td>
<td>0.7</td>
<td>3-5%</td>
<td>NA</td>
</tr>
<tr>
<td>NEEA</td>
<td>NA</td>
<td>3-5%</td>
<td>60 / 30 / 10</td>
</tr>
<tr>
<td>NY</td>
<td>8</td>
<td>3-5%</td>
<td>80 / 10 / 10</td>
</tr>
<tr>
<td>OR</td>
<td>2*</td>
<td>2-3%*</td>
<td>50 / 30 / 20</td>
</tr>
<tr>
<td>PA</td>
<td>NA</td>
<td>&lt;1%</td>
<td>50 / 30 / 20</td>
</tr>
<tr>
<td>TX</td>
<td>0.8</td>
<td>&lt;1%</td>
<td>75 / 15 / 10</td>
</tr>
<tr>
<td>WI(^{21})</td>
<td>3 to 4</td>
<td>3-5%</td>
<td>100 / 0 / 0</td>
</tr>
</tbody>
</table>

* Range depicts answers provided by different respondents from California; funding also includes evaluations activities for codes and standards.
NA = not available
Who Does the Evaluation?
Who Does What?

**Major Task Categories**
- Utility, Statewide or regional market studies
- Planning and Management
- Process Evaluations
- Databases
- Primary Data Collection and Impact Analyses
- Audit - Data Collection and Impact Analyses (optional)
- Reporting
- Best Practices and Communication

**Decisions based on:**
- Realities and perceptions of conflict of interest
- Resources and capability to manage and timely implement
- Resources to conduct (major issue in industry is lack of human EM&V capacity)
Typical Roles

Impact

- Administrator (utility) conducts EM&V with internal staff
- Administrator (utility) conducts EM&V with third-party consultants
- Commission (or Commission surrogate) conducts EM&V with third-party consultants
- Administrator (utility) conducts EM&V and Commission (or Commission surrogate) conducts review/audit

Process

- Almost always done by administrator (utility) – with internal staff or more often third-party consultants

Market

- Almost always done by administrator (utility) – with internal staff or more often third-party consultants -- but can be initiated by others particularly if looking at statewide or regional market analyses (good to combine resources)

Planning

EE potential studies – can be done for utility IRP, can be done regionally, etc.
Oversight

- Each jurisdiction is different and has different needs and requirements

- Often an oversight or advisory committee participates, consisting of:
  - Regulators
  - Utility representatives
  - Regional partners
  - Academic institutions
  - Other stakeholders

- Roles can include:
  - Defining overall objectives, metrics and scale of evaluation
  - Reviewing (approving?) program level EM&V and market evaluation plans
  - Reviewing (approving) evaluation
Example of Roles and ‘Who Does What’

- See Maryland PSC Order in your “packet”
Closing Comments on Evaluation Issues

From Albert Einstein:

“Everything should be as simple as it is, but not simpler”

“Everything that can be counted does not necessarily count; everything that counts cannot necessarily be counted”
Diving Deeper Into Impact, Process and Market Evaluations
IPMVP and Verification
The International Performance Measurement and Verification Protocol

Today, IPMVP is the leading international energy efficiency M&V protocol:

- Still primarily operated as a volunteer organization - with document drafting and peer review technical committees
- IPMVP has been translated into 10 languages and is used in more than 40 countries
- Since going online, there have been more than 20,000 downloads of the IPMVP

More information can be found at www.evo-world.org

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Option A – Retrofit Isolation: Key Parameter Measurement

Typical Application: Lighting retrofit where power draw is the key performance parameter that is measured periodically.

- Estimate operating hours of the lights based on building schedules and occupant behavior.
Option B - Retrofit Isolation: All Parameter Measurement

Typical Application: Variable-speed drive and controls installed on a motor to adjust pump flow

- Measure electric power with a kW meter installed on the electrical supply to the motor, which reads the power every minute.

- In the baseline period this meter is in place for a week to verify constant loading. The meter is in place throughout the reporting period to track variations in power use.
Option C – Whole Facility Energy Bill Analysis

Typical Application: Multifaceted energy management program affecting many systems in a facility.

- Measure energy use with the gas and electric utility meters for a twelve month baseline period and throughout the reporting period.
Option D – Whole Facility
Calibrated Simulation

Typical Applications: Multifaceted energy management program affecting many systems in a facility but where no meter existed in the baseline period - new construction

- Energy use measurements, after installation of gas and electric meters, are used to calibrate a simulation.

- Baseline energy use, determined using the calibrated simulation, is compared to either:
  - a simulation of reporting period energy use, or
  - actual meter data.
Regardless of the Option followed, similar steps are taken to determine savings:

- Step 1: Develop a **Project Specific M&V Plan**
- Step 2: **Gather the baseline data** (energy, demand and operating conditions)
- Step 3: **Verify the proper equipment/systems were installed and are performing to specification** - *potential to perform*
- Step 4: **Gather post-retrofit measured data** and compute energy and demand savings (and cost avoidance) as defined in the M&V Plan - *actual performance*
Verification

Recall that there are two parts to EM&V: (1) determining potential for savings and (2) determining actual savings.

- Not all of the evaluation approaches require field inspections, but it is recommended that there be some physical assessment of at least a sample of the individual projects.

- This is to ensure that the measures installed are to specification and thus the projects included in a program have the potential to generate savings.

- This potential to generate savings can be verified through observation, inspections, and spot or short-term metering conducted immediately before and after installation.

- Sometimes, all you need is verification and the use of a deemed savings value.
Determining Avoided Emissions
Determining Avoided Emissions

The basic approaches:

- Applying emission factors (e.g., pounds of CO₂ per MWh) to net energy savings

- Using emissions scenario analyses, e.g., using computer models to estimate the difference in emissions from power plants with and without the reduced electricity consumption associated with an efficiency program.
Avoided Emission Approaches

**Emission Factor Approach**

- Multiplying the program’s net energy savings by emission factors (e.g., pounds of SO₂ per MWh) that represent the characteristics of displaced emission sources to compute hourly, monthly, or annual avoided emission values (e.g., tons of NOₓ or CO₂).

  \[
  \text{Avoided emissions} = (\text{net energy savings}) \times (\text{emission factor})
  \]

**Scenario Analysis Approach**

- Calculating a base case of sources’ (e.g., power plants connected to the grid) emissions without the efficiency program and comparing that with the emissions of the sources operating with the reduced energy consumption associated with the efficiency program. This is done with computer simulation, dispatch models, models.

  \[
  \text{Avoided emissions} = (\text{base case emissions}) – (\text{reporting period emissions})
  \]
Evaluation Issues Specific to GHG Emission Mitigation

- Defining additionality
  - Policy versus technical decision
  - A free rider can be total, deferred or even partial
  - Not necessarily defined the same for energy and carbon programs

- Policy context
  - Capped system (set asides) versus uncapped systems (offsets) – real reductions a concern in capped systems
  - Programs versus projects
Market Level Evaluations

Baseline Studies
Potential Studies
Market Effects Evaluation
MT: Market Transformation Basics

- There are several definitions for market transformation, but what common definition is: *Long-lasting sustainable changes in the structure or functioning of a market achieved by reducing barriers to the adoption of energy efficiency measures to the point where further publicly-funded intervention is no longer appropriate.*

- Often involve working “upstream” with manufacturers, retailers, etc. – working to increase market penetration

- Can appear in conjunction with other strategies

- “Done” when the less efficient alternative is either unavailable, unprofitable, or ‘illegal’ (codes and standards).
Market Transformation Concepts

- The goal of market transformation programs is to move a product or technology market along the “S” curve of market adoption either at an accelerated pace and/or to a higher level of adoption along the curve.

- In other words, market transformation programs seek to make products more accessible, through improved availability and lower pricing and/or better financing, so that more customers will buy and install them. They can also be used to “jump start” new technologies and/or accelerate the adoption of products.
Market Baseline, Potential, and Market Effects Studies

- Market baseline studies look at the broader market for EE products and services within which a program operates and establishes existing levels of efficiency – done before program

- Potential Studies – savings potential – done before programs and/or at regular intervals
  - Technical potential
  - Economic potential
  - Market potential

- Market Effects - looking at the broader market effects of EE programs (e.g., sometimes rebate programs may increase product availability and drive product prices down, resulting in...)

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Market Indicator Examples

- Market audience awareness and knowledge of products/services/practices and benefits/values
- Market share/penetration
- Repeat purchase/persistence
- Product Availability
  - Can be purchased through existing market/distribution channels
  - Shelf space or other metric of inventory % increases
  - Units produced
- New market actors emerge/existing market actors begin to supply
- Market actors/partners promoting the product/service/technology, as evidenced by marketing communications, programs, and/or dollars spent
- Price of products
- More stringent standards/codes

(Source: Northwest Energy Efficiency Alliance)
Market Evaluation Issues

- Can be useful both for program tracking and targeting.

- Not always possible to measure at the level of resolution required to determine whether markets have changed specifically due to the presence of a program.

- Important to clarify the purpose of the research and establish tracking mechanisms in situations where long-term effects are expected to be tracked over time and where the effects are expected to be identifiable later if such tracking is initiated.

- Possible Approach: Focus on market studies that will serve to inform program design and/or those that are of interest to the Collaborative. May be most useful for program additions and innovative strategies. Leverage efforts of other organizations in building saturation research and other ongoing activities.
Process Evaluations
Process Evaluation

- Assesses the process a program undergoes during implementation
- Documents program goals and objectives from a variety of perspectives
- Describes program strengths and weaknesses so that success is highlighted and improvements can be made
Purpose of Process Evaluation

To recommend ways to improve a program’s efficiency and effectiveness (both implementation and cost-effectiveness)

Frequency:

- For a new program
- Whenever there are major changes in the program
- Or after 2-3 years

Process evaluations are particularly valuable when:

- The program is new or has many changes
- Benefits are being achieved more slowly than expected
- There is limited program participation or stakeholders are slow to begin participating
- The program has a slow startup
- Participants are reporting problems
- The program appears not to be cost-effective
Elements of a Process Evaluation

- **Program Design**
  - The program mission
  - Assessment of program logic
  - Use of new practices or best practices

- **Program Administration**
  - Program oversight
  - Program staffing
  - Management and staff training
  - Program information and reporting

- **Program Implementation**
  - Quality control
  - Operational practice — how program is implemented
  - Program targeting, marketing, and outreach efforts
  - Program timing

- **Participant Response**
  - Participant interaction and satisfaction
  - Market and government allies interaction and satisfaction