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# Model Energy Efficiency Program Impact Evaluation Guide

A RESOURCE OF THE NATIONAL ACTION PLAN FOR ENERGY EFFICIENCY

NOVEMBER 2007

This *Model Energy Efficiency Program Impact Evaluation Guide* is provided to assist gas and electric utilities, utility regulators, and others in the implementation of the recommendations of the National Action Plan for Energy Efficiency (Action Plan) and the pursuit of its longer-term goals.

This Guide describes a structure and several model approaches for calculating energy, demand, and emissions savings resulting from facility (non-transportation) energy efficiency programs that are implemented by cities, states, utilities, companies, and similar entities. By using best practices and consistent procedures, evaluations can support the adoption, continuation, and expansion of efficiency programs.

The primary audience for this Guide is energy efficiency program designers and evaluators looking for guidance on the evaluation process and key issues relating to documenting energy and demand savings, documenting avoided emissions, and comparing demand- and supply-side resources. Introductory portions and Appendix C are also intended for policy-makers seeking information about the basic principles of efficiency evaluation.

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The *Model Energy Efficiency Program Impact Evaluation Guide* is a product of the National Action Plan for Energy Efficiency Leadership Group and does not reflect the views, policies, or otherwise of the federal government. The role of the U.S. Department of Energy and U.S. Environmental Protection Agency is limited to facilitation of the Action Plan.

If this document is referenced, it should be cited as:

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In addition to direction and comment by the Leadership Group, this Guide was prepared with highly valuable input from the Advisory and Technical Groups. Steven R. Schiller of Schiller Consulting, Inc., served as project manager and primary author to the Guide, under contract to the U.S. Environmental Protection Agency (EPA).

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# List of Abbreviations and Acronyms

## A

| | |
|---|---|
| **Action Plan** | National Action Plan for Energy Efficiency |
| **ASHRAE** | American Society of Heating, Refrigerating, and Air Conditioning Engineers |

## B

| | |
|---|---|
| **BAU** | business as usual |
| **BM** | build margin (for electricity generating units) |

## C

| | |
|---|---|
| **CDD** | cooling degree day |
| **CFL** | compact fluorescent lamp |
| **CHP** | combined heat and power |

## D

| | |
|---|---|
| **DEER** | California Database for Energy Efficiency Resources |
| **DOE** | U.S. Department of Energy |
| **DSM** | demand-side management |

## E

| | |
|---|---|
| **ECM** | energy conservation measure |
| **EE** | energy efficiency |
| **EEM** | energy efficiency measure |
| **EM&V** | evaluation, measurement, and verification |
| **EPA** | U.S. Environmental Protection Agency |
| **ER** | emission rate |
| **EUL** | effective useful life |

## F

| | |
|---|---|
| **FEMP** | Federal Energy Management Program |

## G

| | |
|---|---|
| **GHG** | greenhouse gas |

## H

| | |
|---|---|
| **HDD** | heating degree day |
| **HHV** | high heating value |
| **HVAC** | heating, ventilation, and air conditioning |

## I

| | |
|---|---|
| **IPMVP** | International Performance Measurement and Verification Protocol |
| **ISO** | independent system operator or International Organization for Standardization |

## K

| | |
|---|---|
| **kW** | kilowatt |
| **kWh** | kilowatt hour |

## L

| | |
|---|---|
| **lb** | pound |

## M

| | |
|---|---|
| **M&V** | measurement and verification |
| **MW** | megawatt |
| **MWh** | megawatt hour |

# List of Abbreviations and Acronyms

## N

| | |
|---|---|
| **NEB** | non-energy benefits |
| **NTGR** | net-to-gross ratio |

## O

| | |
|---|---|
| **OM** | operating margin (for electricity generating units) |

## Q

| | |
|---|---|
| **QAG** | quality assurance guideline |

## T

| | |
|---|---|
| **TBE** | theory-based evaluation |
| **T&D** | transmission and distribution |

# Executive Summary

***This Model Energy Efficiency Program Impact Evaluation Guide provides guidance on model approaches for calculating energy, demand, and emissions savings resulting from energy efficiency programs. The Guide is provided to assist in the implementation of the National Action Plan for Energy Efficiency's five key policy recommendations for creating a sustainable, aggressive national commitment to energy efficiency.***

## Importance of Energy Efficiency Evaluation

Improving energy efficiency in our homes, businesses, schools, governments, and industries—which consume more than 70 percent of the natural gas and electricity used in the country—is one of the most constructive, cost-effective ways to address the challenges of high energy prices, energy security and independence, air pollution, and global climate change. Despite these benefits and the success of energy efficiency programs in some regions of the country, energy efficiency remains critically under utilized in the nation's energy portfolio. It is time to take advantage of more than two decades of experience with successful energy efficiency programs, broaden and expand these efforts, and capture the savings that energy efficiency offers. Program evaluation that is based on credible and transparent model methods needs to be a key component of the solution.

Evaluation involves real time and/or retrospective assessments of the performance and implementation of a program. There are two key objectives of evaluations:

1. To document and measure the effects of a program and determine whether it met its goals with respect to being a reliable energy resource.

2. To help understand why those effects occurred and identify ways to improve current programs and select future programs.

Another objective can be to document compliance with regulatory requirements. Many energy efficiency evaluations are oriented toward developing retrospective estimates of energy savings attributable to a program, in a manner that is defensible in regulatory proceedings that are conducted to ensure that public funds are properly and effectively spent. However, the role of evaluation can go well beyond simply documenting savings to actually improving programs and providing a basis for future savings estimates. If applied concurrently with program implementation, evaluations can provide information in real time to allow for as-needed course corrections. In summary, evaluation fosters more effective programs and justifies increased levels of energy efficiency investment. Perhaps the imperative for conducting evaluation is best described by John Kenneth Galbraith and William Edwards Deming: *"Things that are measured tend to improve."*

There are three different types of evaluations:

1. **Impact evaluations** determine the impacts (e.g., energy and demand savings) and co-benefits (e.g., avoided emissions, health benefits, job creation, energy security, transmission/distribution benefits, and water savings) that directly result from a program. Impact evaluations also support cost-effectiveness analyses aimed at identifying relative program costs and benefits.

2. **Process evaluations** assess program delivery, from design to implementation, in order to identify bottlenecks, efficiencies, what worked, what did not work,

constraints, and potential improvements. Timeliness in identifying opportunities for improvement is essential to making corrections along the way.

3. **Market effects evaluations** estimate a program's influence on encouraging future energy efficiency projects because of changes in the energy marketplace. These evaluations are primarily, but not exclusively, used for programs with market transformation elements and objectives.

## The Role of This Guide

This Guide has been developed to assist parties in implementing the five key policy recommendations of the National Action Plan for Energy Efficiency. (See page 1-2 for a full list of options to consider under each Action Plan recommendation.) The Action Plan was released in July 2006 as a call to action to bring diverse stakeholders together at the national, regional, state, or utility level in order to foster the discussions, decision-making, and commitments necessary to take investment in energy efficiency to a new level.

This Guide supports the Action Plan recommendation to "make a strong, long-term commitment to implement cost-effective energy efficiency as a resource." A key option to consider under this recommendation is developing robust evaluation, measurement, and verification procedures. The model approaches described herein offer a set of options and an information resource for entities seeking to support the adoption, continuation, and expansion of energy efficiency programs.

The specific types of evaluations conducted are determined by the program goals and the objectives of those responsible for implementing and overseeing the programs. This Guide focuses on *impact evaluations* for programs designed to directly reduce energy consumption, demand, and air emissions. These programs are typically called *resource acquisition* programs, although other types of programs, such as market transformation programs, may also be assessed using impact evaluations. The efficiency programs considered here are those designed for facility or stationary (e.g., home, commercial building, factory) improvements, as opposed to transportation sector improvements.

The objective of this Guide is to provide a framework that jurisdictions and organizations can use to define their "institution-specific" or "program/portfolio-specific" evaluation requirements. To this end, the Guide defines a standard evaluation planning and implementation process, describes several standard approaches that can be used for calculating savings, defines terms, provides advice on key evaluation issues, and lists efficiency evaluation resources. While each jurisdiction, or entity, will need to define its own policy requirements, this Guide provides a structure for applying consistent approaches and definitions. This can facilitate the implementation of "cross-border" programs to establish energy efficiency as a priority resource or as a greenhouse gas mitigation option.

The audience for this Guide is energy efficiency program designers and evaluators looking for guidance, resources, and references on the evaluation process and key issues relating to (a) documenting energy and demand savings and (b) documenting avoided emissions. Introductory portions of this Guide are also intended for policy-makers seeking information about the basic principles of impact evaluation. Readers looking only for basics may want to read only this executive summary and the first few chapters, and perhaps refer to the appendices for overviews of other evaluation types, definitions, and references. Some readers who are new to evaluation assignments may read the entire document, while others may benefit from focusing on the evaluation planning chapter (Chapter 7) and using the rest of the document as a reference.

# Overview of the Program Impact Evaluation Process

The basic steps in the impact evaluation process are:

- Setting the evaluation objectives in the context of the program policy objectives.
- Selecting an evaluation approach and preparing a program evaluation plan that takes into account the critical evaluation issues.
- Implementing the evaluation and determining program impacts, such as energy and demand savings and avoided emissions.
- Reporting the evaluation results and, as appropriate, working with program administrators to implement recommendations for current or future program improvements.

This Guide is about program, versus project, evaluation. In this context, a project is a single activity at one location (for example, an energy-efficient lighting retrofit in an office building). A program is a group of projects with similar characteristics that are installed in similar applications, such as a utility program to install energy-efficient lighting in commercial buildings, a company's program to install energy management system in all of its stores, or a state program to improve the efficiency of its public buildings. Programs are typically evaluated using a sample (versus a census) of projects, with the results systematically applied to the entire program "population" of projects. Sampling is one of the issues discussed in the Guide.

The three impact evaluation results that are typically reported are:

- **Estimates of gross savings.** Gross energy (or demand) savings are the change in energy consumption or demand that results directly from program-promoted actions (e.g., installing energy efficient lighting) taken by program participants regardless of the extent or nature of program influence on their actions.
- **Estimates of net savings.** Net energy or demand 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 or greenhouse gases that would have been emitted if more energy had been consumed in the absence of the energy efficiency program. These emissions can be from combustion of fuels at an electrical power plant or from combustion of heating fuels, such as natural gas and fuel oil, at a project site. Other co-benefits can be positive or negative; examples are comfort and productivity improvements, job creation, and increased maintenance costs due to unfamiliarity with new energy efficient equipment.

It is important to note that energy and demand savings, and avoided emissions, cannot be directly measured. Instead, savings are determined by comparing energy use and demand after a program is implemented (the reporting period) with what would have occurred had the program not been implemented (the baseline). The baseline and reporting period energy use and demand are compared using a common set of conditions (e.g., weather, operating hours, building occupancy). These are then adjusted so that only program effects are considered when determining savings. Avoided emissions and other co-benefits can then be calculated using the energy savings values and other relevant information.

Note that each of the above bullets defines an "estimate." This is because the nature of efficiency evaluation involves measuring energy consumption. The difference between (a) actual energy consumption and (b) what energy consumption would have occurred during the same period had the efficiency measures not been installed, is an *estimate* of energy (and demand) savings. The energy that would have been consumed

during that same time *was not*, and so must be estimated rather than measured.

As indicated, a key objective of program evaluation is to produce an estimate of energy and demand savings (and, as desired, associated co-benefits). However, the value of the estimates as a basis for decision-making can be called into question if their sources and level of accuracy are not analyzed and described. Therefore, evaluation results, like any estimate, should be reported as "expected values" with an associated level of uncertainty. Minimizing uncertainty and balancing evaluation costs with the value of the evaluation information are at the heart of the evaluation process.

Implementing the impact evaluation process for determining energy and demand savings, and avoided emissions, involves:

1. Determining gross program savings using one of the following approaches:

   a. One or more measurement and verification (M&V) methods, from the IPMVP,[1] are used to determine the savings from a sample of projects. These savings are then applied to all of the projects in the program.

   b. Deemed savings, based on historical and verified data, are applied to conventional energy efficiency measures implemented in the program.

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

In some cases these approaches are combined, particularly the deemed savings and M&V approaches.

2. Converting gross program savings to net energy savings using a range of possible considerations. The primary, but not exclusive, considerations that account for the difference between net and gross savings are free riders (i.e., those who would have implemented the same or similar efficiency projects without the program now or in the near future) and participant and non-participant spillover. Non-participant spillover is defined as savings from efficiency projects implemented by those who did not directly participate in a program, but which nonetheless occurred due to the influence of the program. Participant spillover is defined as additional energy efficiency actions taken by program participants as a result of program influence, but actions that go beyond those directly subsidized or required by the program. Net savings are determined using one of the following approaches:

   a. Self-reporting surveys in which information is reported by participants and non-participants without independent verification or review.

   b. Enhanced self-reporting surveys in which self-reporting surveys are combined with interviews and documentation review and analysis.

   c. Statistical models that compare participants' and non-participants' energy and demand patterns, their knowledge about efficiency options, and/or the trade-offs they are willing to make between efficiency options and the costs of purchasing and installing them.

   d. Stipulated net-to-gross ratios (ratios that are multiplied by the gross savings to obtain an estimate of net savings) that are based on historic studies of similar programs.

3. Calculating avoided emissions by either (a) applying emission factors (e.g., pounds of $CO_2$ per MWh) to net energy savings or (b) using emissions scenario analyses (e.g., using computer models to estimate the difference in emissions from grid-connected power plants with and without the reduced electricity consumption associated with an efficiency program). Within these two categories, a variety of approaches can be used to calculate emission factors or prepare scenarios analyses ranging from using a simple annual average emission factor to preparing detailed hourly calculations of displaced energy sources and their emissions. However, the question of whether emissions are actually avoided depends on whether the energy savings are truly additional to what would have occurred without

the program's influences, whether all significant emissions sources associated with a program were taken into account, and the scheme under which any affected emission sources may be regulated.

## Evaluation Characteristics and Evaluation Planning

While this document is intended as a policy-neutral guide to program evaluation, the Action Plan recommends that regulators and senior officials adopt the following practices as part of the evaluation process:

- The evaluation process should be integral to what is typically a cyclic planning-implementation-evaluation process. Therefore evaluation planning should be part of the program planning process so that the evaluation effort can support program implementation, including the alignment of implementation and evaluation budgets and schedules, and can provide evaluation results in a timely manner to support existing and future programs.
- Evaluation budgets and resources should be adequate to support, over the entire evaluation time period, the evaluation goals and the level of quality (certainty) expected in the evaluation results.
- Evaluations should use the planning and implementation structure described in this Guide, as well as the definitions provided for evaluation terms.
- Energy and demand savings calculations should follow one or more of the approaches defined in this Guide for net and gross savings.
- Evaluations should be complete, transparent, relevant, consistent, and balanced in risk management between certainty of results and costs to achieve the results. They should also follow the guiding principles defined by the American Evaluation Association, which are listed in this Guide (see Section 3.8).

With the above characteristics in mind, individual entities can define their own policy-specific program evaluation requirements. These requirements are determined by the program objectives, regulatory mandates (if any), expectations for quality of the evaluation results, intended uses of the evaluation results, and other factors that can vary across jurisdictions and programs. In this Guide, seven key evaluation planning issues are defined and discussed to help define policy-specific program evaluation requirements. These are:

1. Defining evaluation goals and scale, including deciding which program benefits to evaluate.
2. Setting a time frame for evaluation and reporting expectations.
3. Setting a spatial boundary[2] for evaluation (i.e. what energy uses, emission sources, etc., the analyses will include).
4. Defining a program baseline, baseline adjustments, and data collection requirements.
5. Establishing a budget in the context of expectations for the quality of reported results.
6. Selecting impact evaluation approaches for calculating gross and net savings, and avoided emissions.
7. Selecting the individual or organization that will conduct the evaluation.

These issues above are listed in what can be considered a sequential process, however many are interrelated and the overall planning process is iterative. After each of these issues is addressed individually, the results can be compiled into a formal evaluation plan.

In conclusion, this guide can be used at the onset of program planning to initiate a parallel evaluation planning effort. Doing so will help evaluators take an integral role in the program's success and help those who are implementing the program understand the parameters under which they will be evaluated and what information they are expected to provide, and receive from, the evaluation.

# Notes

1. Measurement and verification is the process of using measurements to reliably determine actual savings created within an individual facility. IPMVP is the International Performance Measurement and Verification Protocol (available at <http://www.evo-world.org>). The IPMVP is a measurement and verification protocol for projects, whereas this Guide focuses on programs, which are collections of similar projects.

2. Spatial boundary refers to "how big a circle is going to be drawn around" the energy efficiency measures being evaluated. Is the analysis only going to be on the affected equipment, the whole facility, or perhaps even the entire generation, transmission, and distribution system?

# 1: Introduction

Improving the energy efficiency of homes, businesses, schools, governments, and industries—which together consume more than 70 percent of the natural gas and electricity used in the United States—is one of the most cost-effective ways to address the challenges of high energy prices, energy security and independence, air pollution, and global climate change. Mining this efficiency could help us meet on the order of 50 percent or more of the expected growth in U.S. consumption of electricity and natural gas in the coming decades, yielding many billions of dollars in saved energy bills and avoiding significant emissions of greenhouse gases and other air pollutants (see the Action Plan's report, available at <http://www.epa.gov/cleanenergy/actionplan/report.htm>).

Recognizing this large opportunity, more than 60 leading organizations representing diverse stakeholders from across the country joined together to develop the National Action Plan for Energy Efficiency. The Action Plan identifies many of the key barriers contributing to underinvestment in energy efficiency; outlines five key policy recommendations for achieving all cost-effective energy efficiency, focusing largely on state-level energy efficiency policies and programs; and provides a number of options to consider in pursing these recommendations (Figure 1-1). As of November 2007, nearly 120 organizations have endorsed the Action Plan recommendations or made public commitments to implement them in their areas. Effective energy efficiency program evaluation is a critical step toward achieving the Action Plan objectives.

## 1.1 About the Guide

This Guide describes a structure and several model approaches for calculating energy, demand, and emissions savings from energy efficiency programs. By adhering to best practices and standard procedures, stakeholders can use program evaluation as an effective tool to support the adoption, continuation, and expansion of energy efficiency programs.

### Guide Objective

After reading this Guide, the reader will be able to define the basic objectives, structure, and evaluation approaches that can be used to conduct program-specific impact evaluation. Depending on experience level, the reader may be able to prepare a complete program impact evaluation plan. Appendix E provides a list of references that can also assist with this process.

The Action Plan's Leadership Group (see Appendix A for a list of group members) identified the area of energy efficiency program evaluation, measurement, and verification as one where additional guidance is needed to help parties pursue the recommendations and meet their commitments to energy efficiency. Specifically, this Guide supports the Action Plan recommendation to "Make a strong, long-term commitment to implement cost-effective energy efficiency as a resource." A key option to consider under this recommendation is developing robust measurement and verification procedures that support the adoption, continuation, and expansion of energy efficiency programs.

Further, two recent surveys of the energy efficiency industry indicated a need for guidance documents that foster best practices for evaluation and promote consistent evaluations of energy efficiency programs (NEEP, 2006; Schiller Consulting, 2007). This Guide fills the identified gaps by providing:

- A model impact evaluation process that individual jurisdictions (states, utilities, etc.) can use to establish their own evaluation requirements.
- Policy-neutral[1] descriptions and guidance for conducting impact evaluation of resource acquisition programs.

## Figure 1-1. National Action Plan for Energy Efficiency Recommendations & Options

**Recognize energy efficiency as a high-priority energy resource.**

*Options to consider:*

- Establishing policies to establish energy efficiency as a priority resource.
- Integrating energy efficiency into utility, state, and regional resource planning activities.
- Quantifying and establishing the value of energy efficiency, considering energy savings, capacity savings, and environmental benefits, as appropriate.

**Make a strong, long-term commitment to implement cost-effective energy efficiency as a resource.**

*Options to consider:*

- Establishing appropriate cost-effectiveness tests for a portfolio of programs to reflect the long-term benefits of energy efficiency.
- Establishing the potential for long-term, cost-effective energy efficiency savings by customer class through proven programs, innovative initiatives, and cutting-edge technologies.
- Establishing funding requirements for delivering long-term, cost-effective energy efficiency.
- Developing long-term energy saving goals as part of energy planning processes.
- Developing robust measurement and verification procedures.
- Designating which organization(s) is responsible for administering the energy efficiency programs.
- Providing for frequent updates to energy resource plans to accommodate new information and technology.

**Broadly communicate the benefits of and opportunities for energy efficiency.**

*Options to consider:*

- Establishing and educating stakeholders on the business case for energy efficiency at the state, utility, and other appropriate level, addressing relevant customer, utility, and societal perspectives.
- Communicating the role of energy efficiency in lowering customer energy bills and system costs and risks over time.
- Communicating the role of building codes, appliance standards, and tax and other incentives.

**Provide sufficient, timely, and stable program funding to deliver energy efficiency where cost-effective.**

*Options to consider:*

- Deciding on and committing to a consistent way for program administrators to recover energy efficiency costs in a timely manner.
- Establishing funding mechanisms for energy efficiency from among the available options, such as revenue requirement or resource procurement funding, system benefits charges, rate-basing, shared-savings, and incentive mechanisms.
- Establishing funding for multi-year periods.

**Modify policies to align utility incentives with the delivery of cost-effective energy efficiency and modify ratemaking practices to promote energy efficiency investments.**

*Options to consider:*

- Addressing the typical utility throughput incentive and removing other regulatory and management disincentives to energy efficiency.
- Providing utility incentives for the successful management of energy efficiency programs.
- Including the impact on adoption of energy efficiency as one of the goals of retail rate design, recognizing that it must be balanced with other objectives.
- Eliminating rate designs that discourage energy efficiency by not increasing costs as customers consume more electricity or natural gas.
- Adopting rate designs that encourage energy efficiency by considering the unique characteristics of each customer class and including partnering tariffs with other mechanisms that encourage energy efficiency, such as benefit-sharing programs and on-bill financing.

- A list of other reference documents and resources on energy efficiency evaluation.
- Information on calculating avoided emissions from energy efficiency programs.

Jurisdictions and organizations can use this Guide as both a primer on efficiency impact evaluation and a framework to define their own institution-specific, program-specific, or portfolio-specific evaluation requirements. While each jurisdiction or entity will need to define its own policy requirements, this Guide provides a structure, evaluation approaches, and definitions that can be applied to a variety of policy requirements. If applied consistently, the approaches described in this Guide could ease the implementation of "cross-border" greenhouse gas programs that rely on efficiency as a mitigation option.

## 1.2 Subjects Covered in This Guide

This Guide focuses on evaluating the impact—i.e., the energy, demand, and emissions savings—of energy efficiency programs implemented in facilities (it does not cover transportation-related efficiency programs). Therefore, the Guide helps determine the fuel oil, natural gas, and electricity savings from programs that encourage lighting, space conditioning, process approaches, and similar energy efficiency strategies in residential, commercial, and industrial facilities. Also addressed are the avoided emissions associated with these energy savings.

The Guide is intended to assist in the evaluation of programs for which energy and demand savings are the primary objectives (i.e., commonly referred to as "resource acquisition" programs), although other types of programs may be assessed using impact evaluations. Appendix C briefly discusses evaluation approaches for market transformation, codes and standards, and education programs, with emphasis on process, market, and cost-effectiveness evaluations.

This Guide lays out a basic evaluation structure, highlighting issues that need to be addressed in order to prepare a jurisdiction-specific evaluation plan or protocol for a single program or portfolio of programs.[2] These issues include:

1. Defining evaluation goals and scale. (This includes deciding which program benefits to evaluate.)
2. Setting a time frame for evaluation and reporting expectations.
3. Setting a spatial boundary for evaluation.
4. Defining a program baseline, baseline adjustments, and data collection requirements.
5. Establishing a budget in the context of expectations for the quality of reported results.
6. Selecting impact evaluation approaches for gross and net savings calculations, and avoided emissions calculations.
7. Selecting who (or which type of organization) will conduct the evaluation.

### Planning Issues

**While reading this Guide's first six chapters, the reader should keep in mind the seven "evaluation planning" issues listed in Section 1.2. Chapter 7 addresses these issues in more detail and describes how material from previous chapters can be used to prepare an evaluation plan.**

It is also important to indicate what the Guide does *not* cover:

- It is not sufficiently detailed to be the only resource for planning or conducting evaluations of specific programs. Rather, it provides high-level guidance, identifies issues, and direct users to resources for defining policy- and program-specific requirements and details. For example, it does not describe specific data collection and analysis options, although Appendix E does list documents where this information can be found for various program types and technologies.

- It is not intended for use in assessing the savings and benefits from a *future* energy efficiency program, but rather to inform on what has been, is being, or is projected to be accomplished with an existing program.

## 1.3 How to Use This Guide

In practical terms, evaluation planners can use this Guide to:

- Define the questions and hypotheses that the evaluation effort is intended to answer.
- Identify appropriate evaluation approaches and methods that minimize uncertainty while meeting budget constraints.
- Set realistic expectations among the evaluation process stakeholders regarding the nature and practical value of results to be delivered, as well as the expected quality of quantitative estimates of program impacts.
- Set appropriate schedules and budgets that reflect the level of certainty expected in the results.

In addition, introductory portions of this Guide are also intended for policy-makers seeking information about the basic principles of impact evaluation.

The intended audience is:

- Program and evaluation managers looking for basic guidance—or a roadmap—on process and key issues relating to:
  - Documenting energy and/or demand savings.
  - Documenting avoided emissions.
  - Comparing demand- and supply-side resources.
- Program designers looking to understand how their programs will be evaluated.
- Policy-makers and regulators looking for a basic understanding of evaluation objectives, processes, and issues.
- Members of the energy efficiency community looking for:
  - Common terminology definitions.
  - A central reference that provides guidance, but also lists publicly available best practices resources.
  - An understanding of the mechanisms for determining the potential value of energy efficiency as an emissions avoidance strategy.

### Using This Guide

**Policy-makers and those looking for the "basics":** Read the Executive Summary and first few chapters; and perhaps refer to the appendices for overviews of other evaluation types, definitions, and references.

**Experienced evaluation planners:** Go straight to the planning chapter (Chapter 7) and use the rest of the document as a reference.

**Readers new to evaluation and/or energy efficiency:** Read the entire document.

Table 1-1 to the right also summarizes the contents and intended readers for each part of the Guide.

## 1.4 Source Documents

The information in this document is a summary of definitions, approaches, and best practices developed over the last 30 years of energy efficiency program implementation and evaluation. This experience and expertise is documented in numerous guides, protocols, papers, and reports. The key documents that were used in the development of the Guide are:

- 2007 International Performance Measurement and Verification Protocol (IPMVP).
- 2006 California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals.
- 2000 FEMP M&V Guidelines.

## Table 1-1. Model Energy Efficiency Program Impact Evaluation Guide Overview

| Document Element | Titles | Contents and Intended Audience |
|---|---|---|
| **Part 1** | *Executive Summary* | Summarizes importance and types of evaluations, the impact evaluation process, key issues, and evaluation planning.<br><br>**Intended for all readers.** |
| **Part 2** | *Chapter 1: Scope and Uses of this Guide*<br><br>*Chapter 2: Introduction to Energy efficiency and Program Evaluation*<br><br>*Chapter 3: Impact Evaluation Basics* | Provides basics of energy efficiency evaluation.<br><br>**Chapters 2 and 3 are intended for readers who want overview of evaluation and the key aspects of impact evaluation.** |
| **Part 3** | *Chapter 4: Calculating Gross Energy and Demand Savings*<br><br>*Chapter 5: Calculating Net Energy and Demand Savings*<br><br>*Chapter 6: Calculating Avoided Air Emissions* | Provides details on the process and approaches for quantifying energy savings and avoided emissions from energy efficiency programs.<br><br>**Intended for readers whose programs are to be evaluated, evaluators, and managers and regulators of evaluation activities.** |
| **Part 4** | *Chapter 7: Planning an Impact Evaluation* | This chapter "brings it all together" and describes how the basics and details described in earlier Chapters can be utilized to plan an evaluation effort.<br><br>**Also intended for readers whose programs are to be evaluated, evaluators, and managers and regulators of evaluations. *Some readers with background in evaluation may want to go directly to this chapter.*** |
| **Part 5** | *Appendix A: Leadership Group List*<br><br>*Appendix B: Glossary*<br><br>*Appendix C: Other Evaluation Types*<br><br>*Appendix D: Uncertainty, Rigor and Sampling*<br><br>*Appendix E: Resources*<br><br>*Appendix F: Renewables and Combined Heat and Power Project Evaluation* | These Appendices provide resources and further background on evaluation issues.<br><br>**Intended for readers interested in specialty subjects or reference materials.**<br><br>**Appendix B, the glossary, and Appendix C may be of interest to policy makers. Appendix C summarizes the various types of efficiency programs and the types of ways in which programs can be evaluated, in addition to impact evaluation.** |

- 2004 California Public Utilities Commission (CPUC) Evaluation Framework.
- 2002 ASHRAE Guideline 14 Measurement of Energy and Demand Savings.

More information on these documents and other evaluation resources is contained in Appendix E.

## 1.5 Structure of the Guide

This Guide primarily covers *impact evaluations* (determining the energy, demand, and emissions savings that directly result from a program) and is organized into five parts:

- The Executive Summary, which briefly describes the evaluation process outlined in this Guide.
- Chapters 1 through 3, which introduce this Guide and energy efficiency as well as program impact evaluation concepts and basics.
- Chapters 4 through 6, the core of the Guide, which describe approaches for determining gross and net energy (and demand) savings and avoided emissions from energy efficiency programs.
- Chapter 7, which discusses the evaluation planning process and key evaluation planning issues as well as presenting some evaluation plan outlines that entities can use to prepare their own evaluation requirements.
- Appendices on terminology, references and resources, other types of program evaluations (process and market), evaluation statistics, and evaluation of combined heat and power and renewable energy programs.

## 1.6 Development of the Guide

This Guide is a product of the Year Two Work Plan for the National Action Plan for Energy Efficiency. The Action Plan's Leadership Group formed an Advisory Group and a Technical Group to help develop the Guide. Steven R. Schiller of Schiller Consulting, Inc., was contracted to serve as project manager and primary author. Commissioner Dian Grueneich (California Public Utilities Commission) and Dian Munns (Executive Director of Retail Energy Services, Edison Electric Institute) co-chaired the Guide's Advisory Group.

Additional Advisory Group members include:

- Chris James, (formerly with the Connecticut Department of Environmental Protection).
- Rick Leuthauser, MidAmerican Energy Company.
- Jan Schori, Sacramento Municipal Utility District.
- Peter Smith, (formerly with New York State Energy Research and Development Agency).

The Technical Group members are:

- Steve Schiller, Schiller Consulting: project manager and primary author.
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- Nick Hall, TecMarket Works.
- M. Sami Khawaja, Quantec: Appendix D author.
- David Sumi, PA Consulting.
- Laura Vimmerstedt, National Renewable Energy Laboratory.
- Edward Vine, Lawrence Berkeley National Laboratory.

## 1.7 Notes

1. The Guide is "policy neutral" in that it can be applied to energy efficiency and emission avoidance programs irrespective of the programs' policy objectives or constraints.
2. Since the Guide is a policy-neutral document, following it will not necessarily ensure that a program evaluation plan will be in compliance with regulatory or similar mandates. The entity-specific program plan must address any jurisdictional policy requirements.

# 2: Energy Efficiency Program Evaluation

***Chapter 2 provides a brief overview of the importance of energy efficiency evaluation and describes the context in which it is conducted. The chapter also makes the distinction between evaluations for individual energy efficiency projects and multifaceted efficiency programs. Because this Guide focuses on program evaluation, additional background on program categories and related evaluation approaches is provided.***

## 2.1 Importance of Evaluation

Evaluation is the process of determining and documenting the results, benefits, and lessons learned from an energy efficiency program. Evaluation results can be used in planning future programs and determining the value and potential of a portfolio of energy efficiency programs in an integrated resource planning process. It can also be used in retrospectively determining the performance (and resulting payments, incentives, or penalties) of contractors and administrators responsible for implementing efficiency programs.

Evaluation has two key objectives:

1. To document and measure the effects of a program and determine whether it met its goals with respect to being a reliable energy resource.
2. To help understand why those effects occurred and identify ways to improve current programs and select future programs.

Most energy efficiency evaluations are oriented toward estimating retrospective or real-time energy savings (versus predicted estimates) attributable to a program in a manner that is defensible in regulatory proceedings. However, evaluation should be viewed as one part of a continuous, and usually cyclic, process of program planning, implementation, and evaluation. Thus, the results of impact evaluation studies do not stand alone, but are used as inputs into planning and improving future programs.[1] Furthermore, rigorous evaluations help ensure cost-effective programs and help sustain program savings and cost-effectiveness.

There are several technical and policy barriers to the full use of cost-effective energy efficiency, and to the incorporation of efficiency programs into energy resource portfolios. One of these barriers is proving that energy efficiency "can be counted on." Consistent, complete, accurate, and transparent evaluation mechanisms for documenting energy savings and avoided emissions address this barrier. Indeed, having effective evaluation policies, processes, and trained personnel in place to document the energy and environmental benefits of energy efficiency programs is critical to the success of energy efficiency and climate mitigation programs that must prove their value and worthiness for continued investment.

### Some Applications of Energy Efficiency Evaluation

- Utility-administered energy efficiency programs.
- Government efficiency programs, either for their own facilities or for private-sector incentive programs.
- Independent system operator (ISO) programs to reduce demand, e.g., a forward capacity market.
- Air-pollution and greenhouse gas mitigation programs that utilize efficiency.
- Private company programs.
- Energy service company contracts.

## Why Conduct Evaluations?

The reasons to do an evaluation can be summarized in two words: improvement and accountability. Evaluations provide information that can help improve programs and they demonstrate internal and external accountability for the use of resources.

Program evaluations provide timely information to improve program implementation, as well as the design of future programs and individual energy efficiency projects. They can answer the following questions:

- Are the program and the projects that make up the program achieving their goals? If so, how and why?
- How well has the program/project worked?
- What changes are needed to improve the program/project?
- What is the program's impact on actual projects and future projects?
- Should the program/project be replicated, adjusted, or cancelled?

An evaluation also indicates whether the "resource" can be relied upon. Knowing whether the efficiency program will reliably generate savings (e.g., MWh) is critical to the ability of existing and future programs to serve as an important part of an energy resource portfolio.

An evaluation also provides an understanding of:

- Program approaches that are most and least effective, and how to improve future programs.
- Where to focus for greater savings.
- Actual values that can be used in future estimates of benefits (e.g., estimates of energy savings per square foot of office space).

## 2.2 Defining Program Versus Project Evaluation

A program is a group of projects with similar technology characteristics that are installed in similar applications, such as a utility program to install energy-efficient lighting in commercial buildings, a company's program to install energy management system in all of its stores, or a state program to improve the efficiency of its public buildings. A portfolio is either: (a) a collection of similar programs addressing the same market (e.g., a portfolio of residential programs), technology (e.g., motor efficiency programs), or mechanisms (loan programs) or (b) the set of all programs conducted by a particular entity (which could include programs that cover multiple markets, technologies, etc.). This Guide covers program evaluation, though the basic concepts can be applied to a portfolio if the impacts of interactions between programs and savings estimates are considered. In this context, a project is a single activity at one location, such as an energy-efficient lighting retrofit in an office building. Programs are often evaluated using a sample (versus a census) of projects, with the results applied to the entire program "population" of projects.

## 2.3 Efficiency Program Categories

Energy efficiency programs are planned and coordinated actions designed for a specific purpose. These actions are usually made up of projects carried out at individual facilities, for example as part of a utility efficiency incentive program. There are many types of energy efficiency programs but no standard way of differentiating them—this Guide differentiates programs by their primary objectives:

- **Resource acquisition**—primary objective is to *directly* achieve energy and/or demand savings, and possibly avoid emissions, through specific actions.
- **Market transformation**—primary objective is to change the way in which energy efficiency markets operate (how manufacturers, distributors, retailers, consumers, and others sell and buy energy-related products and services), which tends to result in

energy and demand savings in a more *indirect* manner. To a large extent, all programs can be considered market transformation in that they involve changing how energy efficiency activities take place in the marketplace.

- **Codes and standards**—primary objective is to define and enforce mandated levels of efficiency in buildings and products.
- **Education and training**—primary objective is to inform consumers and providers about energy efficiency and encourage them to act on that information.
- **Multiple objective**—objectives can include some or all of the above listed objectives.

This Guide focuses on documenting the impacts of resource acquisition programs, including directly achieved energy and demand savings, and related emissions reductions. Appendix C briefly discusses evaluation of the other program categories listed above. It should be noted that while a program may have one primary objective there are often secondary objectives that are integral to program's overall success. This is frequently the case when resource acquisition and market transformation objectives are involved. With respect to evaluation, it is more important to focus on the performance goals to be assessed than on categorizing individual program types.

Energy efficiency is part of the general category of activities known as demand-side management (DSM). DSM programs are designed to encourage consumers to modify their level and pattern of energy usage. Another category of DSM is demand response (DR), defined by DOE as "changes in electric usage by end-use customers from their normal patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized" (DOE, 2006). DR programs employ rate design, customer incentives, and technology to enable customers to change their demand in response to system conditions and/or prices. Effective DR programs can improve system reliability and reduce capital costs associated with transmission and generation capacity investment by lowering overall peak demand. Because DR programs can include energy efficiency elements, the Action Plan defines DR as a form of efficiency. However, DR programs: (a) tend to have relatively short-term

## NYSERDA Portfolio Evaluation Approach

The resources available for New York Energy $mart[SM] Program evaluations at NYSERDA are more limited than what most energy organizations confront when establishing their evaluation approaches. In the traditional approach, single programs are evaluated, using any or several of the primary types of evaluation—impact, process, market characterization/assessment, etc.—by either a single contracted evaluator, a single evaluator using a team of subcontractors, or a consulting firm. This can be effective when funds are sufficient, programs are evaluated one at a time, and those programs are essentially independent from one another.

In NYSERDA's case, there was concern that the traditional approach might be less useful given that its many programs are intended to work in tandem to meet the needs of multiple customers.

NYSERDA was also concerned that the traditional approach would not be sufficient, given available resources, to determine whether public policy goals set for the New York Energy $mart Program were being met.

To meet its unique needs, NYSERDA selected an evaluation approach that departs from the traditional method of focusing on a single program. NYSERDA hires teams of contractors that specialize in one facet of evaluation—impact, process, markets, etc.—and then each team analyzes a suite of programs. At the end of an evaluation cycle, NYSERDA combines and integrates the results from each of the program evaluations and "rolls them up" to the portfolio level to provide an estimate of the overall effects of the portfolio, i.e., the whole of New York Energy $mart, and its progress toward achieving the public policy goals.

effects on energy consumption, (b) may shift use from a time of high energy costs to a lower-cost time, but not reduce overall electricity use, and (c) may reduce energy use at high-cost times by paying for a reduction in the level of service provided.

Energy efficiency evaluation has a fairly long history, while DR evaluation is relatively new and appropriate methodologies are still under development.[2] While this Guide does not specifically address DR programs, the basic evaluation approaches and planning process explained here can be applied to DR with the understanding that the emphasis for DR program evaluation is demand savings. Demand savings definitions and evaluation techniques are highlighted in Section 3.2. Chapter 7 includes a sidebar on the ISO-New England DR program measurement and verification Guide; Appendix E includes some DR references as well.

## 2.4 Program Evaluation Categories

Evaluation involves retrospectively assessing the performance and implementation of a program. The following bullets describe three basic types of evaluations, all considered "ex post" because they analyze what has already occurred. The Guide focuses primarily on impact evaluations that quantify direct energy and capacity saving benefits. The other two evaluation types are summarized in more detail in Appendix C.

1. **Impact evaluations** determine the impacts (usually energy and demand savings) and co-benefits (such as avoided emissions health benefits, job creation, and water savings) that directly result from a program. All categories of energy efficiency programs can be assessed using impact evaluations, but they are most closely associated with resource acquisition programs.

2. **Process evaluations** assess how efficiently a program was or is being implemented, with respect its stated objectives and potential improvements for future programs. All energy efficiency program categories can be assessed using process evaluations.

### Program Planning and Evaluation

Evaluation is a retrospective process for determining how a program performed over a specific period of time (month, season, year, etc.). The Latin term *ex-post* (meaning after the fact) is used to describe the typical evaluation process. This is in contrast to *a priori* (before the activity – postulated or prospective) analyses. Note though, that evaluations that produce results while the program is operating can be very useful. When possible, evaluations should be done within a program cycle so that feedback is frequent and systematic and benefits the existing program(s) and informs the design of future programs and their evaluation.

For planning a future program, historical evaluation results can help with program design. However, for estimating how a program will perform, *potential studies* and/or *feasibility studies* are the typical analyses performed. Both of these types of studies look at what levels of savings are possible from technical, economic and market acceptance perspectives. Potential studies are typically conducted on a market sector basis (e.g. residential, commercial, industrial sectors) and feasibility studies tend to be focused on specific customers that may be involved in a particular program.

3. **Market effects evaluations** estimate a program's influence on encouraging future energy efficiency projects because of changes in the marketplace. Again, all categories of programs can be assessed using market effects evaluations, but they are primarily associated with market transformation programs that indirectly achieve impacts and resource acquisition programs that are intended to have long-term effects on the marketplace. For example, if the goal of the evaluation is to assess cost-effectiveness for stakeholders or regulators, excluding the measurement of market effects in a resource acquisition program could result in under- or overestimating the overall benefits of a program as well as its cost-effectiveness.