NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Chapter 1:

Introduction

The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures

Created as part of subcontract with period of performance September 2011 – December 2014

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The Cadmus Group, Inc., Portland, Oregon

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Subcontract Report
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February 2015

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Acronyms

DOE	U.S. Department of Energy
EM&V	evaluation, measurement, and verification
FEMP	Federal Energy Management Program
IPMVP	International Performance Measurement and Verification Protocol
M&V	measurement and verification
NTG	net-to-gross
TRM	technical reference manual
UMP	Uniform Methods Project

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1 Description

This chapter provides a set of model protocols for determining energy and demand savings that result from specific energy efficiency measures implemented through state and utility efficiency programs. The methods described here are approaches that are—or are among—the most commonly used and accepted in the energy efficiency industry for certain measures or programs.[1,2] As such, they draw from the existing body of research and best practices for energy efficiency program evaluation, measurement, and verification (EM&V).[3]

These protocols were developed as part of the Uniform Methods Project (UMP), funded by the U.S. Department of Energy (DOE). The principal objective for the project was to establish easy-to-follow protocols based on commonly accepted methods for a core set of widely deployed energy efficiency measures.

[1] The protocol for data centers is the only exception to this statement. Programs for data centers are relatively new. As such, the evaluation industry has yet to arrive at a preferred measurement and verification (M&V) approach for these measures. With the data centers protocol, the UMP attempts to describe a preferred approach.

[2] The UMP protocols are meant to be used primarily for evaluating the impacts of rate payer-funded programs, but they might be also be used to measure savings from individual projects such as those developed by energy services companies under performance contracting schemes. A project consists of one or more participating facilities or sites within a program.

[3] Measurement and verification (M&V) is distinct from evaluation in that it focuses on determining savings for individual measures and projects, while evaluation aims to quantify the impacts of a program.

2 About the Protocols

The methods described here represent generally accepted standard practices within the EM&V profession; however, they are not necessarily the *only* manner in which savings can be reliably determined. Still, program administrators and policymakers can adopt these methods with the assurance that: (1) they are consistent with accepted practices; and (2) they have been vetted by technical experts in the field of energy efficiency program evaluation. If widely adopted, these protocols will help establish a common basis for assessing and comparing the performance and effectiveness of energy efficiency policies and investment decisions across programs, portfolios, and jurisdictions.

These protocols do not provide stipulated values for energy savings; however, their widespread use would provide a common analytic foundation for determining "deemed" values and allow for the use of inputs appropriate for a project's particular circumstances. These protocols are designed to provide estimates of savings at a high level of rigor, but they do not prescribe specific criteria for either statistical confidence or precision of savings estimates. Such thresholds are assumed to be set by the stakeholders, as determined by their unique objectives and priorities. Instead, the protocols provide a structure for deciding on and applying such criteria consistently and for reporting the uncertainty associated with the indicated savings estimates.

3 Rationale

Investment in energy efficiency has increased steadily in the United States in recent years. In many jurisdictions, energy efficiency now accounts for a significant share of utilities' integrated resource portfolios. In several jurisdictions, energy efficiency has been recognized as the "fuel of first choice," which amplifies its critical role in electricity resource reliability and adequacy.

This trend of increasing investment in energy efficiency will likely continue as utilities strive to meet the energy efficiency resource standards that have been adopted through legislative or regulatory mandates in 26 jurisdictions—and are being considered in several more. In at least half of these jurisdictions, the standards are designed to achieve aggressive savings of at least 10% of forecast load by 2020; in six jurisdictions, savings of more than 20% are expected (ACEEE 2011).

With greater reliance on energy efficiency as a means of meeting future energy resource requirements, there is a growing demand for publicly available information about energy efficiency programs, how their savings are determined, and how the achieved savings are reported. When experienced practitioners share and vet this information with each other and with those new to the energy efficiency field, this knowledge can reinforce the reliability of the savings. To this end, these protocols offer evaluation methods and techniques for determining energy savings based on generally accepted practices in the energy efficiency industry for certain common measures and programs.

To help reduce the uncertainty associated with determining energy efficiency savings, this material offers guidance for implementing the techniques and interpreting results. It can also provide a basis for comparing the impacts of energy efficiency portfolios and policy initiatives across the country.

DOE envisions the following specific goals for this project:

- Offer guidelines that help strengthen the credibility of energy efficiency program savings calculations.
- Provide clear, accessible, step-by-step protocols to determine savings for the most common energy efficiency measures.
- Support consistency and transparency in how savings are calculated.
- Reduce the development and management costs of EM&V for energy efficiency programs offered by public utility commissions, utilities, and program administrators.
- Allow for comparison of savings across similar efficiency programs and measures in different jurisdictions.
- Increase the acceptance of reported energy savings by financial and regulatory communities.

4 The Audiences and Objectives

DOE commissioned this effort to provide a voluntary set of standard protocols for determining savings resulting from particular energy efficiency measures implemented through state and utility efficiency programs.

Although these protocols are applicable to a wide range of situations, their initial audience is expected to be stakeholders in states where energy efficiency is relatively new (or is newly expanded) *and* the issues of documenting savings have gained importance. From this general perspective, these protocols primarily serve stakeholders by:

- Providing a reliable basis for evaluating the effectiveness and viability of energy efficiency, thus offering regulators a basis and the means for assessing the prudency of rate payer-funded investments in energy efficiency and determining compliance with savings targets.
- Offering utility resource planners and program administrators greater certainty about program performance and reducing planning and regulatory compliance risks.
- Supplying independent EM&V contractors with a standard set of tools and techniques that will enhance the credibility of their findings.
- Providing a resource for educating EM&V practitioners and a basis for calculating deemed and algorithm-based savings in technical reference manuals (TRMs) that are being developed or updated in various jurisdictions.

By making the methods for calculation and verification of savings more transparent and uniform, these protocols will increase the reliability of energy efficiency results reported by program administrators and implementation contractors. This will help mitigate the risks of investing in energy efficiency and stimulate greater participation. To achieve the objective of transparency, EM&V contractors should identify where alternative approaches to UMP are used.

5 Definitions

Various market participants in the energy efficiency industry (such as end-use energy consumers, project designers, contractors, program implementers and administrators, and utility resource planners, as well as independent, third-party evaluators) may define savings resulting from energy efficiency differently. The UMP uses standard industry definitions to differentiate the four ways savings are reported at the design, implementation, and evaluation stages of a program's life cycle (SEE Action 2012):

- **Projected savings.** Values reported by a program implementer or administrator before the efficiency activities are completed.[4]
- **Gross savings.** Changes in energy consumption that result directly from program-related actions taken by participants in an energy efficiency program, regardless of why they participated.
- **Claimed (gross) savings.** Values reported by a program implementer or administrator after the implementation activities have been completed.[5]
- **Evaluated (gross) savings** Values reported by an independent, third-party evaluator after the efficiency activities and impact evaluation have been completed. The designations of "independent" and "third-party" are determined by those entities involved in the use of the evaluations and thus may include evaluators retained by the program administrator or a regulator, for example.
- **Net savings.** Changes in energy use attributable to a particular energy efficiency program. These changes may implicitly or explicitly include the effects of factors such as freeridership, participant and nonparticipant spillover, and induced market effects.

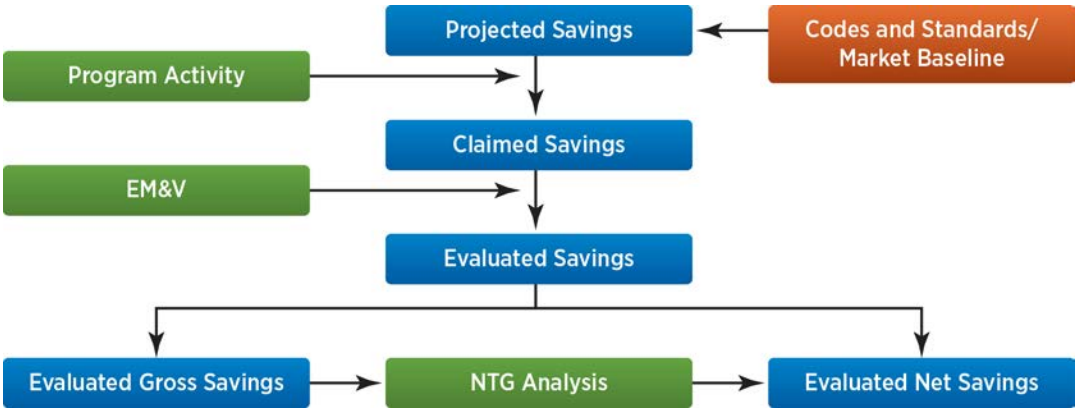

Figure 1. Savings definitions

[4] In certain cases the projected savings may be based on deemed values approved by regulators.
[5] In certain cases these savings may have been adjusted by a predetermined net-to-gross (NTG) ratio.

The UMP protocols provided here focus primarily on estimating evaluated gross first-year savings, except where estimates of net savings may be derived as part of the same method. The chapter *Estimating Net Savings: Common Practices* (Violette and Rathbun 2014) includes a more comprehensive discussion about the elements of NTG adjustments and the methods for measuring. The definition of *net savings* (for example, whether it includes participant and/or nonparticipant spillover) and the manner in which NTG is applied also vary across jurisdictions as a matter of policy. Therefore, UMP does not offer specific recommendations on how NTG is applied.

Assumptions about baseline conditions form the basis for calculating savings and should be defined for technology-based energy efficiency programs, depending on whether the efficiency actions involve early replacement or retrofit of functional equipment still within its expected useful life, replacement of functional equipment beyond its rated useful life, unplanned replacement of failed equipment, or new construction and replacement on burnout. While "as-found" (existing) conditions usually represent an appropriate basis for establishing baselines for early replacement actions, either common practice or the requirements of applicable efficiency codes and standards are usually appropriate for the other categories of efficiency actions.[6]

[6] As a rule, the more efficient of the applicable common practice or code/standard requirement should be used if either might be applicable. Information on establishing baselines is discussed in Section 7.1 of SEE Action (2014). Because the manner in which baseline conditions are defined has a direct bearing on how net savings are defined and calculated, methods for establishing baseline will be discussed in greater detail in the second phase of the project.

6 Project Process

The UMP has created protocols for 15 energy efficiency measures, which are primarily applicable to residential and commercial facilities:

- Residential lighting
- Residential furnaces and boilers
- Residential behavior
- Refrigerator recycling
- Whole-building retrofit
- Commercial lighting
- Commercial lighting controls
- Commercial unitary and split-system air-conditioning equipment
- Commercial new construction
- Chillers
- Compressed air systems
- Data centers
- Heating, ventilation, and air-conditioning controls
- Retro-commissioning
- Variable frequency drives.

These measures were selected because they: (1) represent a diverse set of end uses in the residential and commercial sectors; (2) are present in most energy efficiency portfolios in nearly all jurisdictions; and (3) have a significant remaining savings potential.

6.1 Protocol Organization

The material in measure-specific protocols is organized in a similar structure to provide consistency. Each protocol provides the following information:

- **Measure description.** A brief description of the measure or measures covered by the protocol
- **Application conditions of protocol.** Details on what types of delivery channels or program structure are or are not covered by the protocol
- **Savings calculations.** The prevailing algorithm(s) needed to estimate energy savings with explanation of parameters included
- **M&V plan.** The recommended approach, including the International Performance Measurement and Verification Protocol (IPMVP) option, for determining values for the parameters required in the savings calculation

- **Sample design.** Overview of considerations on how to segment the population to provide a representative sample for evaluation; in some protocols, this is discussed in conjunction with the M&V Plan
- **Other evaluation issues.** Any additional information deemed pertinent by the author and/or reviewers, including brief discussions of persistence or NTG considerations; often this information is supplemented by the crosscutting protocols.

Because each measure is unique, some protocols have additional sections to provide more details about specific areas of interest or consideration.

For each energy efficiency measure, the protocol explains the underlying technology, the end uses affected by the measure, the method for calculating the measure's savings, and the data requirements. Also, each protocol attempts to provide sufficient detail without being overly prescriptive, allowing flexibility and room for professional judgment.

The measure-specific protocols are supported and complemented by separate chapters that discuss technical issues and topics common to all measures. These crosscutting topics, which are organized into the following six sections, are referenced in measure-specific protocols, where applicable:

1. Sample design
2. Survey design
3. Metering
4. Calculation of peak impacts
5. Other evaluation topics (including rebound and persistence of savings)
6. Net savings, methods, and practices.

These supplemental, crosscutting discussions help extend the measure-specific method for determining savings and evaluating whole programs.

6.2 Relationship to Other Protocols

The protocols provided here are based on long-standing EM&V practices, and their methods conform to well-established engineering and statistical principles. They draw from and build on a number of previous attempts to develop comprehensive, systematic approaches to estimating the impacts of energy efficiency. Those efforts were conducted by various entities, including Oak Ridge National Laboratory (ORNL 1991), the Electric Power Research Institute (EPRI 1991), the U.S. Environmental Protection Agency (EPA 1995), and DOE (1996, 2008).

Several of these protocols were developed to address specific policy objectives, such as (1) verify utility program savings; (2) determine savings from special performance contracts; and (3) achieve environmental compliance. A number of protocols have been developed to address specific EM&V requirements in certain jurisdictions (such as California and the Pacific Northwest).

A valuable companion document to this set of protocols is the *SEE Action Energy Efficiency Program Impact Evaluation Guide* (SEE Action 2014). It provides an introduction to and a summary of the practices, planning, and associated issues of documenting energy savings, demand savings, avoided emissions, and other nonenergy benefits resulting from end-use energy efficiency programs (DOE n.d.).

Designed to be consistent with the *SEE Action Energy Efficiency Program Impact Evaluation Guide*, the UMP protocols are more detailed and specific for particular measures and projects. (The preparation of these protocols was closely coordinated with that guide.)

The EM&V methods described here draw on the IPMVP (DOE 2002). The UMP protocols expand on the IPMVP options by adding detail and describing specific procedures for application to program- and portfolio-level evaluations. To this end, each protocol clearly identifies the IPMVP option with which it is associated. For many technologies, evaluation tools and methods continue to improve, and the industry will continue to benefit from advancements to evaluation methods so that system performance can be estimated more accurately in the future. As such, the evaluation methods will no doubt continue to evolve in response to these changes.

7 About Evaluation, Measurement, and Verification Budgets

Historically, the costs of determining energy savings are embedded in the larger context of evaluation activities undertaken as part of large-scale programs. The range of those total evaluation costs can be obtained by reviewing those sources. For example:

- DOE's Federal Energy Management Program M&V Guidelines for federal-level performance contracting projects estimate the average, all-in cost of M&V as ranging from 3% to 5% of total project costs (DOE 2008, p. 5.2). The FEMP Guidelines report M&V expenses averaging 3.3% of costs for the typical performance-contracting project (DOE 2008, p. 5.9).
- A report sponsored by the National Association of Energy Service Companies and the U.S. Environmental Protection Agency suggests that each IPMVP option may cost 1% to 5% more for verification involving key parameters (IPMVP Option A), and 3% to 10% more for verification involving all parameters (IPMVP Option B) (Birr and Donahue 2001, pp. 32–33).
- In several jurisdictions, the evaluation costs for large demand-side management portfolios are available from regulatory filings. Our review revealed portfolio-level EM&V expenditures ranging from 2% of portfolio costs in Indiana to 4% of portfolio costs in California.[7]

As a rule, the EM&V effort—and expenditures—should be scaled to the program being evaluated and the accuracy necessary to inform the decision about which evaluation results matter. The value of the information provided by the EM&V activity is determined by the resource benefits of the program and the particular policy and research questions the EM&V activity aims to address.

These budget figures should be considered as only rough guidance, because they are mostly self-reported, and the definitions of cost categories may vary significantly across states and program administrators. This is particularly true considering how internal verification processes may differ from independent, third-party evaluations (SEE Action 2014, Section 7.5.2).

Evaluation resource requirements also depend on how often they are conducted. The frequency with which evaluations are performed depends on a number of considerations, including, but not limited to, the type and complexity of the measure and its expected contribution to portfolio savings, the uncertainty about the savings, the life cycle stage of the program in question, and regulatory requirements. In light of these considerations, UMP has no specific recommendation about how often programs should be evaluated.

[7] Similar estimates are also available for Illinois (3%), Indiana (5%) Michigan (5%) and Pennsylvania (2%–5%), Arkansas (2%–6%).

8 Considering Resource Constraints

The UMP protocols are designed to represent approaches for providing accurate and reliable estimates of energy efficiency savings that draw on best practices without undue cost burdens. However, the UMP protocols do not offer recommendations about the levels of rigor and the specific criteria for accuracy of the savings estimates. Those issues are largely matters of policy, ease and cost of data acquisition, and availability of resources.

To provide maximum flexibility, each protocol contains recommendations for alternative, lower cost means of deploying the protocol, such as relying on secondary sources of data for certain parameters and identifying guidelines for selecting appropriate sources of such data. Practitioners should document when they have used these alternative means. The costs of deploying the UMP protocols will vary, depending on the features of the energy efficiency program being evaluated, the participant characteristics, and the desired levels of rigor and accuracy. Thus, cost estimates for implementing the protocols are not provided. Instead, the utilities and program administrators adopting the protocols should consider benchmarking their programs and gauging their EM&V budgets against those of other entities with experience conducting EM&V for similar programs.

8.1 Options for Small Program Administrators

UMP recognizes that even the lower cost options provided in the UMP protocols may be impractical where resources are constrained or programs are small (such as those offered by small utilities) (GDS Associates, Inc. 2012).[8] In these circumstances, program administrators may consider using deemed savings values from:

- TRMs created by regional or state entities
- Evaluations of similar programs performed by other regional utilities. (These can serve as the basis for determining energy efficiency savings, provided that the installation and proper operation of the energy efficiency measure or device have been verified.)

Deemed savings may be adjusted to allow for climate or other factors (regional or economic/ demographic) that vary from one jurisdiction to another. Given the differences in how TRMs determine savings for identical measures, program administrators choosing this path should use deemed savings values based on calculations and stipulated values derived using the UMP protocols when possible. Those using this approach should update their deemed savings values periodically to incorporate changes in appliance and building codes and the results of new EM&V studies (such as the primary protocols developed under the UMP or other secondary sources).

Alternatively, where possible, program administrators may consider other cost-saving measures, such as pooling EM&V resources and jointly conducting evaluations of similar programs through local associations. (This has been done successfully in small utilities in California, Michigan, and the Pacific Northwest.)

[8] According to the Small Business Administration, small utilities are currently defined as electricity load serving entities with annual sales of less than 4 million megawatt-hours.

Small utilities may also consider either coordinating with larger regional utilities or adopting the results of evaluations of similar programs implemented by larger utilities.

9 Project Management and Oversight

This project was funded by DOE and managed by the National Renewable Energy Laboratory. The Cadmus Group, Inc., was engaged to manage the protocol development and provide technical oversight. The project was designed to be inclusive of a broad set of stakeholders to ensure technical excellence. To facilitate the final appeal and acceptance of the work products, the following steps were taken.

9.1 Project Oversight by Variety of Stakeholders

The National Renewable Energy Laboratory formed a project steering committee to provide general direction and guidance. The steering committee consisted of regulators, utility managers, energy planners and policymakers, and representatives of industry associations.

9.2 Authorship by Experts

Nationally recognized experts on specific energy efficiency measures and technologies drafted each protocol.

9.3 Review by Technical Advisory Group

A technical advisory group reviewed draft protocols. Each member provided comments on one or more protocols. This advisory group included experts from major consulting firms engaging in EM&V throughout North America.

9.4 Review by Stakeholders

The protocols were subject to a review process that enabled stakeholders to provide feedback about the draft protocols before they were released in their final form.

The material covered in the measure-specific and crosscutting protocols may be updated in future phases of the project if new information from future research warrants.

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