Introduction

This document provides a set of model protocols for determining energy and demand savings that result from specific energy-efficiency measures or programs. The methods described here are approaches that are—or are among—the most commonly used in the energy-efficiency industry for certain measures or programs. As such, they draw from the existing body of research and best practices for energy-efficiency evaluation, measurement, and verification (EM&V).

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 commonly deployed energy-efficiency measures.

1 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 policy makers can adopt these methods with the assurance that: (1) they are consistent with commonly accepted practices, and (2) they have been vetted by technical experts in the field of energy 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 investments across programs, portfolios, and jurisdictions.

These protocols do not provide stipulated values for energy savings; however, the wide-spread use of these protocols would provide a common analytic foundation for determining "deemed" values while still allowing for the use of inputs appropriate for a project's particular circumstances. Nor do these protocols prescribe how baseline conditions should be defined for the calculation of impact for specific measures or programs (such as codes and standards or actual market conditions). Baseline conditions tend to vary with the type of measure or program, implementation method and whether the measures are for new construction, early-replacement, or replacement on burnout. Finally, these protocols do not prescribe specific criteria for either statistical confidence or the accuracy of savings estimates. Such thresholds are assumed to be set by the audiences, 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.

2 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," thus amplifying its critical role in electric 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 (EERS) 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 10% or more of forecast load by 2020, while in six jurisdictions, savings of over 20% are expected.[1]

With greater reliance on energy efficiency as a means of meeting future energy resource requirements, there is a growing demand for publicly available information on energy-efficiency programs, how their savings are measured, and how the achieved savings are reported. By the sharing and vetting of information among experienced practitioners and those new to the energy-efficiency field, this knowledge can reinforce the reliability of the savings. To this end, these protocols offer measure-specific evaluation methods and techniques for determining energy savings based on generally accepted practices in the energy-efficiency industry.

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.

3 The Audiences and Objectives

In response to the interest of the State and Local Energy Efficiency Action Network (SEE Action)[2] EM&V Working Group and others, DOE commissioned this effort to provide a voluntary set of standard protocols for determining savings resulting from particular energy-efficiency measures and programs.

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[1] See *Energy Efficiency Resource Standards: A Progress Report on State Experience*, American Council for an Energy Efficiency Economy (ACEEE), Report Number U112, June 2011.

[2] U.S. DOE: www.seeaction.energy.gov

While 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 evaluators working under the direction of regulators and/or program administrators in at least these four ways:

1. Providing a reliable basis for evaluating the effectiveness and viability of energy efficiency, thus offering regulators a basis and the means for both assessing the prudency of rate-payer-funded investments in energy efficiency and determining compliance with savings targets.
2. Offering utility resource planners and program administrators greater certainty about the performance of program performance and reduce planning and regulatory compliance risks.
3. Supplying independent EM&V contractors with a standard set of tools and techniques that would enhance the credibility of their findings.
4. Providing a resource for educating EM&V practitioners and a basis for the calculation of deemed 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 perceived risks of investing in energy efficiency and stimulate greater participation.

4 Definitions

Savings resulting from energy efficiency may be defined differently by various 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). 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:[3]

- ***Projected Savings*** are values reported by a program implementer or administrator before the efficiency activities are completed.[4]
- ***Claimed (Gross) Savings*** are values reported by a program implementer or administrator after the efficiency activities have been completed. [5]

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[3] Source: For more complete and detailed descriptions see the State and Local Energy Efficiency Action Network. 2012. *Energy-Efficiency Program Impact Evaluation Guide*. Prepared by Steven R. Schiller, Schiller Consulting, Inc. www.seeaction.energy.gov

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.

- ***Evaluated (Gross) Savings*** are 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, and may include evaluators retained by the program administrator or a regulator, for example.
- ***Net Savings*** are changes in energy use that are 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, induced market effects, and changes in the level of energy service (e.g., rebound).

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 elements of net-to-gross (NTG) adjustments and the methods for measuring them will be described in a separate cross-cutting section dedicated to the topic in the second phase of this project. 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.

5 Project Process

The UMP project is a two-phase undertaking. This report, which presents the results of the first phase, contains protocols for these seven measures, which are primarily applicable to the residential and commercial facilities:

- Refrigerator recycling
- Commercial lighting
- Commercial lighting controls
- Residential lighting
- Residential furnaces and boilers
- Residential and small commercial unitary and split system air conditioning equipment
- Whole-building retrofit

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 across all jurisdictions; and (3) have a significant remaining savings potential.

In the second phase, this list will be expanded, so the final set of measures covered is expected to represent a significant share of the available technical and economic energy-efficiency potential in most jurisdictions.

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 a sufficient level of 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 cross-cutting topics, which are organized in the following five sections, are referenced in measure-specific protocols, where applicable:

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

5.1 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 Oakridge National Laboratories (ORNL, 1991[6]), the Electric Power Research Institute (EPRI, 1991[7]), U.S. Environmental Protection Agency (EPA, 1995[8]), DOE, 1996[9] and DOE, 2008.[10]

Several of these protocols were developed to address specific policy objectives, such as the verification of utility program savings, the determination of savings from special performance contracts, and environmental compliance. In addition, 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*. It provides both an introduction to and a summary of the practices, planning, and associated issues of documenting energy savings, demand savings, avoided emissions, and other non-energy benefits resulting from end-use energy-efficiency programs.[11]

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[6] Oak Ridge National Laboratory, Handbook of Evaluation of Utility DSM Programs, ORNL/CON-336, December 1991.

[7] Electric Power Research Institute. Impact Evaluation of Demand-Side Management Programs, Vol. 1: A Guide to Current Practice, EPRI CU-7179, Palo Alto, CA, February, 1991a.

[8] Conservation Verification Protocols, Version 2, EPA-430/B-95-012, June 1995.

[9] The North American Energy M&V Protocols, U.S. Department of Energy, DOE-GO 10096-248, February 1996.

[10] Federal Energy Management Program (FEMP) M&V Guidelines: Measurement and Verification for Federal Energy Projects Version 3.0, U.S. Department of Energy Federal Energy Management Program, April 2008.

[11] An initial examination of issues raised by pursuing a broadly applicable approach to EM&V can be found in National energy efficiency Evaluation, Measurement and Verification (EM&V) Standard:

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 also conform to the International Performance Measurement and Verification Protocol (IPMVP).[12] The UMP protocols expand upon 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.

6 Considering Resource Constraints

The UMP protocols are designed to represent approaches for providing accurate and reliable estimates of energy-efficiency savings that draw upon best practices without undue cost burdens. However, the UMP protocols do not offer recommendations regarding the levels of rigor and the specific criteria for accuracy of the savings estimates. Those issues are largely matters of policy, ease and costs 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. 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 in conducting EM&V for similar programs.

7 About EM&V Resource Requirements

Historically, the costs of determining energy savings are embedded in the larger range of EM&V activities undertaken as part of large-scale programs for which public information is readily available. The range of those total evaluation costs can be obtained by reviewing those sources. For example,

- DOE's FEMP 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

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Scoping Study of Issues and Implementation Requirements at http://www1.eere.energy.gov/seeaction/pdfs/emvstandard_scopingstudy.pdf

[12] International Performance Measurement and Verification Protocols, Concepts and Options for Determining Water and Energy Savings, Vol. 1, Prepared for the Energy Valuation Organization (EVO), January 2012.

costs.[13] The FEMP Guidelines report M&V expenses averaging 3.3% of costs for the typical performance-contracting project.[14]

- A report sponsored by NAESCO and the U.S. EPA suggests that each IPMVP Option will cost the client the following percentages of total project costs: from 1% to 5% for verification involving key parameters (IPMVP Option A), and from 3% to 10% for verification involving all parameters (IPMVP Option B).[15]
- 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 3% of portfolio costs in Indiana to 4% of portfolio costs in California.[16]

As a general rule, the EM&V effort—and expenditures—should be scaled to both the program being evaluated and the accuracy necessary to inform the decision for 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.

7.1 Options for Small Utilities

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).[17] In these circumstances, program administrators may consider using deemed savings values from either:

- Technical reference manuals (TRMs) created by regional or state entities, or
- Values resulting from 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 has been verified.)

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[13] FEMP M&V Guidelines, op. cit., p. 5-2.

[14] FEMP M&V Guidelines, op. cit., p. 5-9

[15] David Birr and Patricia Donahue, "*Meeting the Challenge – How Energy Performance contracting Can Help Schools Provide Comfortable, Healthy, and Productive Learning Environments*" (The National Association of Energy Services Companies and the US Environmental Protection Agency), pp. 32-33.

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

[17] According to the Small Business Administration, small utilities are currently defined as electric load serving entities with annual sales of less than 4 million MWh. Additional information on the costs and benefits of different measurement and verification approaches for small utilities can be found in the *Analysis of Proposed Department of Energy Evaluation, Measurement and Verification Protocols*, sponsored by the National Rural Electric Cooperative Association (NERCA) available at: http://www.nreca.coop/issues/ElectricIndustryIssues/Documents/EMVReportAugust2012.pdf

Deemed savings may be adjusted to allow for climate or other factors (regional or economic/demographic) that differ from utility to utility. Given the differences in how TRMs determine savings for identical measures, program administrators choosing this path should use deemed savings values that are 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.)

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

8 Project Management and Oversight

This project was funded by DOE and managed by the National Renewable Energy Laboratory (NREL). 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 so as to ensure technical excellence. To facilitate the final appeal and acceptance of the work products, the following steps were taken.

8.1 Project Oversight by Variety of Stakeholders

NREL formed a project steering committee to provide general direction and guidance for the project. The steering committee consisted of regulators, utility managers, energy planners and policy makers, and representatives of industry associations.

8.2 Authorship by Experts

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

8.3 A Review by Technical Advisory Groups

Two four-member technical advisory groups—one focusing on the validity of the protocols and other on applicability—reviewed the drafts of the technical experts. These advisory groups consisted of experts from major consulting firms engaging in EM&V throughout North America.

8.4 A 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.