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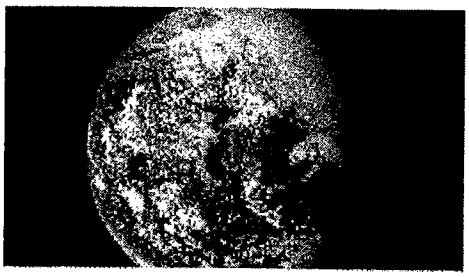

International Performance Measurement and Verification Protocol

Concepts and Options for Determining Energy and Water Savings Volume 1

Prepared by Efficiency Valuation Organization
www.evo-world.org

April 2007

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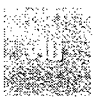
CHANGES IN THIS EDITION

The present edition makes numerous changes to the 2002 edition of Volume I, as part of EVO's continual effort to reflect best practice in its documents. These changes generally updated the document, restructuring and clarifying it, adding "Principles of M&V," defining several versions of the basic savings equation, re-writing examples and uncertainty text, and harmonizing this Volume with other IPMVP volumes. The changes are listed more fully below

1. Adds a Definition of M&V (Chapter 2)
2. Defines Principles underlying good M&V (Chapter 3)
3. Adds guidance on the contents of savings reports (Chapter 6)
4. Adds simple chart showing how savings are computed (Chapter 4.1)
5. Presents several versions of Chapter 4 Equation 1, to simplify adjustments to conditions of the post-retrofit (reporting) period and to encompass Option D.
6. Adds Volume III Part I's second method of computing savings in Option D (Chapter 4.10.3)
7. Allows a Volume III Part II Renewable Energy method of ECM On/Off Test (Chapter 4.5.3)
8. Updates references to other key documents such as ASHRAE Guideline 14, the U.S Federal Energy Management Program's M&V Guide Version 2.2, and the United States Green Buildings Council's Leadership in Energy Efficient Design program.
9. Clarifies the requirements for measurements and estimations in Option A, replacing the contract term "stipulation" with "estimation." Adds a table of Option A choices about what to estimate vs. measure for lighting examples. (Chapter 4.8.1).
10. Describes the M&V planning process as being in parallel with the retrofit planning process, rather than at a specific point in time (Chapter 4.3).
11. Simplifies examples in Appendix A and adds examples of more ECMs, including industrial projects. Shows application of currency rates to energy/demand savings. Provides expanded explanations of the reasons for the M&V design choices inherent in each example. Refers the reader to EVO's website for detailed calculation of two examples.
12. Adds explanations of the difference between "savings" and "cost avoidance," and elaborates on the various bases for adjustment (Chapter 4.6).
13. Clarifies the applicability of the document to water and demand saving projects (Chapter 4.2), industrial projects and new building construction.
14. Highlights in italics every defined term in the expanded definitions section.
15. Changes the term "baseyear" to "baseline period."
16. Adds a section on measurement period selection and length (Chapter 4.5).
17. Expands and improves the discussion of the use of uncertainty analysis in M&V Planning (Appendix B). Clarifies statements about statistically meaningful savings reports.
18. Defers to ASHRAE Guideline 14 for more detail on calibrating simulations.
19. Completely replaces the former Chapters 1 and 2, removing introductory remarks on financing of energy efficiency projects.
20. Directs on where to find information that may be needed by each kind of user of the document (Chapter 1.4).
21. Changes the term "Post-retrofit Period" to "Reporting period" to clarify that M&V reporting goes on as long as users wish to report, not for ever after retrofit.
22. Clarifies the distinction between routine adjustments and non-routine adjustments, throughout. Introduces the term "static factors" to describe energy influencing factors which are not regularly varying in a routine way (Chapter 8.2).
23. Adds to the M&V Plan specification an assignment of responsibilities for monitoring static factors to permit non-routine adjustments (Chapter 5).
24. Separately lists M&V Plan requirements that are Option-specific. Also rearranges requirements and removes the requirement to specify data that will be made available for an independent reviewer (Chapter 5).

25. The word "adherence" replaces any use of the word "compliance."
26. Adds a section on measurement boundary, to define the primary area of energy measurement. Requires analysis of which energy flows will be measured and how unmeasured 'interactive effects' (leakages) will be treated. Chapter 4.4
27. Replaces the term "whole building" with "whole facility"
28. Adds a logic diagram regarding Option selection, and a table of best Option selection criteria (Chapter 4.11).
29. Simplifies adherence to be consistent with the M&V Plan specification, and adds a requirement to note the specific IPMVP Version number that is being followed in any M&V Plan (Chapter 7).
30. Introduces a common section about retrofit isolation methods, Options A and B (Chapter 4.8).
31. Differentiates between procedures for dealing with missing or bad data in the baseline and reporting periods.
32. Integrates the former Appendix C on measurement into Chapter 8 and moves much of the former Chapter 5 measurement discussions into relevant parts of Chapter 4. The former measurement Appendix C disappears.
33. Introduces a version numbering system which follows international norms, allowing easy recognition of editions, revisions and errata.

The EVO website (www.evo-world.org) contains the latest updates to this document. It also contains a list of referenced web links which EVO endeavors to keep as current as possible, without issuing an errata sheet for each change.



CHAPTER 1. INTRODUCTION TO IPMVP

1.1 Purpose And Scope Of IPMVP

Efficiency Valuation Organization (EVO) publishes the International Performance Measurement and Verification Protocol (IPMVP) to increase investment in energy and water efficiency, demand management and renewable energy projects around the world.

The IPMVP promotes efficiency investments by the following activities.

- IPMVP documents common terms and methods to evaluate performance of efficiency projects for buyers, sellers and financiers. Some of these terms and methods may be used in project agreements, though IPMVP does not offer contractual language.
- IPMVP provides methods, with different levels of cost and accuracy, for determining savings[1] either for the whole facility or for individual energy conservation measures (ECM)[2];
- IPMVP specifies the contents of a Measurement and Verification Plan (M&V Plan). This M&V Plan adheres to widely accepted fundamental principles of M&V and should produce verifiable savings reports. An M&V Plan must be developed for each project by a qualified professional[3].
- IPMVP applies to a wide variety of facilities including existing and new buildings and industrial processes. Chapter 1.4, User's Guide, summarizes how different readers might use IPMVP.

IPMVP Volume I defines *M&V* in Chapter 2, presents the fundamental principles of *M&V* in Chapter 3, and describes a framework for a detailed *M&V Plan* in Chapter 4. The details of an *M&V Plan* and *savings* report are listed in Chapters 5 and 6, respectively. The requirements for specifying use of IPMVP or claiming adherence with IPMVP are shown in Chapter 7. Volume I also contains a summary of common M&V design issues, Chapter 8, and lists other *M&V* resources. Twelve example projects are described in Appendix A and basic uncertainty analysis methods are summarized in Appendix B.

IPMVP Volume II provides a comprehensive approach to evaluating building indoor-environmental-quality issues that are related to ECM design, implementation and maintenance. Volume II suggests measurements of indoor conditions to identify changes from conditions of the baseline period.

IPMVP Volume III provides greater detail on M&V methods associated with new buiding construction, and with renewable energy systems added to existing facilities.

IPMVP's three volumes are a living suite of documents, with the latest modifications to each edition available on EVO's website (www.evo-world.org).

1.2 Benefits Of Using IPMVP

IPMVP's history since 1995 and its international use brings the following benefits to programs that adhere to IPMVP's guidance.

- Substantiation of payments for performance. Where financial payments are based on demonstrated energy or water *savings*, adherenece to IPMVP ensures that *savings* follow good practice. An IPMVP-adherent *savings report* allows a customer, an energy user or a

[1] Words in italics have the special meanings defined in Chapter 8.
[2] Although there is some debate over the differences between two terms — energy conservation measure (ECM) and energy efficiency measure (EEM) — the common ECM term is defined to include both conservation and efficiency actions. See Chapter 8.
[3] www.evo-world.org contains the current list of Certified *M&V* Professionals (CMVPs), persons with appropriate experience and who have demonstrated their knowledge of IPMVP by passing an examination.

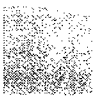
utility, to readily accept reported performance. *Energy service companies* (*ESCOs*) whose invoices are supported by IPMVP-adherent *savings reports*, usually receive prompt payments.

- Lower transaction costs in an *energy performance contract*. Specification of IPMVP as the basis for designing a project's *M&V* can simplify the negotiations for an *energy performance contract*.
- International credibility for energy *savings reports*, thereby increasing the value to a buyer of the associated energy *savings*.
- Enhanced building rating under the "Leadership in Energy Efficient Design" (LEED™) system of the United States Green Buildings Council, and others. These systems encourage sustainable design of new buildings and operation of existing buildings and encourage buildings to have an *M&V* program adhereing to IPMVP. For more information, see the USGBC's website at www.usgbc.org.
- Help national and industry organizations promote and achieve resource efficiency and environmental objectives. The IPMVP is widely adopted by national and regional government agencies and by industry organizations to help manage their programs and enhance the credibility of their reported results.

1.3 IPMVP's Relationship To Other *M&V* Guidelines

Chapter 9 lists other interesting resources for readers of IPMVP. Four particular documents are worth highlighting:

- ASHRAE, Guideline 14-2002 Measurement of Energy and Demand Savings (see Reference 3 in Chapter 10). This American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. document provides complementary detail for IPMVP. Guideline 14 had many of the same original authors as IPMVP. Though Guideline 14 provides technical detail following many of the same concepts of IPMVP, it does not use the same Option names as IPMVP. Guideline 14 is a useful resource for *M&V* professionals and is available for purchase through ASHRAE's bookstore at http://resourcecenter.ashrae.org/store/ashrae/.
- M&V Guidelines: Measurement and Verification for Federal Energy Projects, Version 2.2 - 2000 (see Reference 27 in Chapter 10). The U.S. Department of Energy's Federal Energy Management Program (FEMP) was established, in part, to reduce energy costs of operating U.S. government federal facilities. The FEMP M&V Guideline was first published in 1996 with many of the same authors as IPMVP. It provides detailed guidance on specific *M&V* methods for a variety of *ECMs*. The FEMP Guide is generally consistent with the IPMVP framework, except that it does not require site measurment of energy use for two specific *ECMs*. The Lawrence Berkeley National Laboratory website (http://ateam.lbl.gov/mv/) contains the FEMP M&V Guideline, and a number of other M&V resource documents, including one on the estimations used in Option A, and an M&V checklist.
- The Greenhouse Gas Protocol for Project Accounting (2005), jointly developed by the World Resources Institute and the World Business Council for Sustainable Development. The IPMVP Technical Committee was represented on the advisory committee for this document which defines means of reporting the greenhouse gas impact of carbon emission reduction and carbon sequestration projects. See www.ghgprotocol.org.
- The U.S. State Of California's Public Utilities Commission's California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals (April 2006). This document provides guidance for evaluating efficiency programs implemented by a utility. It shows the role IPMVP for individual site *M&V*. The Protocol can be found at the California Measurement Advisory Council (CALMAC) website http://www.calmac.org.



CHAPTER 2 DEFINITION AND PURPOSES OF *M&V*

"*Measurement and Verification*" (*M&V*) is the process of using measurement to reliably determine actual *saving*[4] created within an individual facility by an energy management program. *Savings* cannot be directly measured, since they represent the absence of *energy* use. Instead, *savings* are determined by comparing measured use before and after implementation of a project, making appropriate adjustments for changes in conditions.

M&V activities consist of some or all of the following:

- meter installation calibration and maintenance,
- data gathering and screening,
- development of a computation method and acceptable estimates,
- computations with measured data, and
- reporting, quality assurance, and third party verification of reports.

When there is little doubt about the outcome of a project, or no need to prove results to another party, *M&V* may not be necessary. However, it is still wise to verify that the installed equipment is able to produce the expected *savings*. Verification of the potential to achieve *savings* involves regular inspection and commissioning of equipment. However, such verification of the potential to generate *savings* should not be confused with *M&V*. Verification of the potential to generate *savings* does not adhere to IPMVP since no site *energy* measurement is required.

2.1 Purposes Of M&V

M&V techniques can be used by facility owners or *energy* efficiency project investors for the following purposes:

a) Increase *energy savings*

Accurate determination of *energy savings* gives facility owners and managers valuable feedback on their *energy conservation measures (ECMs)*. This feedback helps them adjust *ECM* design or operations to improve *savings*, achieve greater persistence of *savings* over time, and lower variations in *savings* (Kats et al. 1997 and 1999, Haberl et al. 1996).

b) Document financial transactions

For some projects, the energy efficiency savings are the basis for performance-based financial payments and/or a guarantee in a performance contract. A well-defined and implemented *M&V Plan* can be the basis for documenting performance in a transparent manner and subjected to independent verification.

c) Enhance financing for efficiency projects

A good *M&V Plan* increases the transparency and credibility of reports on the outcome of efficiency investments. It also increases the credibility of projections for the outcome of efficiency investments. This credibility can increase the confidence that investors and sponsors have in *energy* efficiency projects, enhancing their chances of being financed.

d) Improve engineering design and facility operations and maintenance

The preparation of a good *M&V Plan* encourages comprehensive project design by including all *M&V* costs in the project's economics. Good *M&V* also helps managers discover and reduce maintenance and operating problems, so they can run facilities more effectively. Good *M&V* also provides feedback for future project designs.

[4] Words in italics have the special meanings defined in Chapter 8.

e) Manage *energy* budgets

Even where *savings* are not planned, *M&V* techniques help managers evaluate and manage *energy* usage to account for variances from budgets. *M&V* techniques are used to adjust for changing facility-operating conditions in order to set proper budgets and account for budget variances.

f) Enhance the value of emission-reduction credits

Accounting for emission reductions provides additional value to efficiency projects. Use of an *M&V Plan* for determining energy *savings* improves emissions-reduction reports compared to reports with no *M&V Plan*.

g) Support evaluation of regional efficiency programs

Utilty or government programs for managing the usage of an *energy* supply system can use *M&V* techniques to evaluate the savings at selected *energy* user facilities. Using statistical techniques and other assumptions, the *savings* determined by *M&V* activities at selected individual facilities can help predict savings at unmeasured sites in order to report the performance of the entire program.

h) Increase public understanding of energy management as a public policy tool

By improving the credibility of energy management projects, *M&V* increases public acceptance of the related emission reduction. Such public acceptance encourages investment in energy-efficiency projects or the emission credits they may create. By enhancing *savings*, good *M&V* practice highlights the public benefits provided by good *energy* management, such as improved community health, reduced environmental degradation, and increased employment.

CHAPTER 3 PRINCIPLES OF *M&V*

The fundamental principles of good *M&V*[5] practice are described below, in alphabetical order.

Accurate *M&V* reports should be as accurate as the *M&V* budget will allow. *M&V* costs should normally be small relative to the monetary value of the *savings* being evaluated. *M&V* expenditures should also be consistent with the financial implications of over- or under-reporting of a project's performance. Accuracy tradeoffs should be accompanied by increased conservativeness in any estimates and judgements.

Complete The reporting of *energy savings* should consider all effects of a project. *M&V* activities should use measurements to quantify the significant effects, while estimating all others.

Conservative Where judgements are made about uncertain quantities, *M&V* procedures should be designed to under-estimate *savings*.

Consistent The reporting of a project's *energy* effectiveness should be consistent between:

- different types of *energy* efficiency projects;
- different *energy* management professionals for any one project;
- different periods of time for the same project; and
- *energy* efficiency projects and new *energy* supply projects.

'Consistent' does not mean 'identical,' since it is recognized that any empirically derived report involves judgements which may not be made identically by all reporters. By identifying key areas of judgement, IPMVP helps to avoid inconsistencies arising from lack of consideration of important dimensions.

Relevant The determination of *savings* should measure the performance parameters of concern, or least well known, while other less critical or predictable parameters may be estimated.

Transparent All *M&V* activities should be clearly and fully disclosed. Full disclosure should include presentation of all of the elements defined in Chapters 5 and 6 for the contents of an *M&V Plan* and a *savings* report, respectively.

The balance of this document presents a flexible framework of basic procedures and four Options for achieving *M&V* processes which follow these fundamental principles. Where the framework is silent or inconsistent for any specific application, these *M&V* principles should be used for guidance.

[5] Words in italics have the special meanings defined in Chapter 8.