

MEASUREMENT AND VERIFICATION

International Performance Measurement & Verification Protocol (IPMVP)

The IPMVP publishes a widely recognized set of guidelines describing the common practice in measuring, computing, and reporting savings achieved by energy or water efficiency projects. Initially sponsored by the Department of Energy (DOE), IPMVP is now managed by Efficiency Valuation Organization (EVO) an independent non-profit corporation (<http://www.evo-world.org/>).

What is Measurement and Verification?

Measurement and Verification (M&V) describes the process of accurately measuring the amount of savings from an energy management program for a facility. In order to achieve these measured savings, energy use must be measured before and after the program was initiated, while taking into account adjustments for condition changes.

The following are typical items associated with M&V work:

- Meter calibration, installation, and maintenance
- Data collecting
- Development of reasonable calculation methods and associated estimates
- Calculations with measured data
- Final report with third party verification and quality control

There are many purposes to the M&V Plan, such as:

- Documentation of energy savings and transactions
- Enhanced credibility for energy efficient investments and chance for financing
- Increased facility effectiveness and reduced operating and maintenance issues
- Control energy usage budgets
- Improved environmental conditions

What are the basic M&V steps?

1. Define the Baseline (*)

The Baseline defines the energy usage before the energy management program is implemented. This data includes a physical inventory count with conditions, such as capacity, nameplate information, energy usage rates, and controls. Energy savings can only be determined if this information is known, so it can be compared with the energy usage after the program is initiated. It can be gathered from meter monitoring, site surveys, and spot measurements. It cannot be gathered after the installation of the retrofit.

(*) FEMP M&V Guidelines: M&V For Federal Energy Projects Ver. 3.0

In addition, the Baseline conditions may be used to monitor any changes that might occur during the performance plan’s operation. These changes might cause an adjustment in the baseline energy usage, and be used in the savings calculations. Factors such as weather conditions, operating and maintenance measures, equipment repairs, and differing energy rates may affect the baseline.

2. Develop an M&V Plan

A good M&V plan is the most important aspect of the energy management plan. It is part of the Final Proposal for the project, and contains the energy savings guarantee. It also can reduce uncertainties to reasonable levels, allow room for future adjustments, monitor equipment performance, improve operation and maintenance (O&M), and allocate risks to the appropriate parties.

The plan should consist of details for each energy cost reduction measure, including:

- Baseline measurements and data collected
- Assumptions and source documentation
- What will be done (and when)
- Who will conduct the work
- Agency witness for program requirements
- M&V work schedule
- Documentation of baseline and savings adjustments
- Risk assessment and savings uncertainties
- Discussion of engineering analysis and energy savings calculations
- Utility rate analysis and structures
- O&M savings details
- O&M reporting responsibilities definition

M&V Options A, B, C, and D

The *M&V Guidelines: Measurement and Verification for Federal Energy Projects* describe four generic methodologies for energy saving projects. They are labeled Options A, B, C, and D. The flexibility of these four options provides different approaches to calculate the energy savings based on the characteristics of the energy retrofit projects, as well as increased precision in energy savings and M&V costs. The following figure depicts the differences in each option.

M&V Option	Performance and Usage Factors	Savings Calculation
Option A Estimated and Short-Term Measured Factors	Combines short-term measurements taken of the system and estimated factors such as manufacturer or historical information.	Combines engineering calculations with system or component models

<p>Option B Periodically or Continuously Measured and Estimated Factors</p>	<p>Utilizes continuous or periodic measurements when the system is exposed to different factors and conditions. Short-term measurements can be used if condition variations are not present.</p>	<p>Combines engineering calculations with system or component models</p>
<p>Option C Utility Billing Data Analysis</p>	<p>Utilizes long-term building utility usage at the meter, facility, or the sub-meter level. Meter data can be used to account for energy use.</p>	<p>Utilizes regression analysis of utility data</p>
<p>Option D Calibrated Computer Simulation</p>	<p>Utilizes reasonable assumptions given historical information from the facility, specifications for existing and new equipment, reasonable estimates, short or long-term measurements of building systems, and whole building long-term utility data.</p>	<p>Utilizes calibrated whole-building and/or end-use utility data on a computer simulation model</p>

3. Commissioning (Cx)

Commissioning is a process of ensuring the building systems perform according to their unique design, as well as meeting the needs of the owner and occupants. Commissioning includes testing the systems in all forms of operation, and confirms these systems are functioning according to the original design intent. It can also identify any problems associated with them. It is different from M&V because it focuses more on system functionality, whereas M&V focuses solely on the energy savings perspective.

4. Post Verification Report

The results of the M&V work are provided in the *Post-Installation Report*, which is delivered by the contractor after the project has been installed and commissioned.

The *Post Verification Report* includes the following:

- Description of the project
- Performance measurements
- Documentation of such performance measures and activities conducted
- First year expected savings
- Information on any alterations from the original project scope and differing energy savings
- Construction period savings (if applicable)

The *Post-Installation Report* template can be found at:

<http://www1.eere.energy.gov/femp/financing/superespcs>

5. Continual Performance Verification

Annual reports are delivered by the contractor at the end of every year throughout the performance period in order to depict the savings occurred.

The Annual Reports include the following:

- Information on performance measurements and surveys
- Energy, O&M, and other cost savings achieved during the year
- Actual energy savings comparison to guaranteed savings
- Documentation of any analysis and computations, as well as adjustments to baseline
- O&M concerns that may require attention
- Summary of all O&M activities performed for the year

The *Annual Report* template can be found at:

<http://energy.gov/eere/femp/downloads/reviewing-post-installation-and-annual-reports-federal-espc-projects>

Useful Resources

International Performance Measurement & Verification Protocol (IPMVP) Energy Retrofit Options

<http://www.evo-world.org/>

SECO LoanSTAR Performance Contracting Guidelines

<http://www.seco.cpa.state.tx.us/perf-contract/>

(Following pages include excerpts from SECO Performance Contracting guidelines related to M&V)

M&V Guidelines: Measurement and Verification for Federal Energy Projects

<http://www1.eere.energy.gov/femp/>

ASHRAE, Guideline 14-2002 Measurement of Energy and Demand Savings

<http://www.ashrae.org/>

The above links are being provided as a convenience and for informational purposes only; although we make every effort to ensure these links are accurate, up to date and relevant.



Energy Savings Performance Contracting Guidelines for State Agencies

Part 6 Measurement and Verification of Savings

Measurement and Verification (M&V) of savings are central to determining the satisfactory performance of contracts subject to Government Code §2166.406. Normally, the ESCO provides the M&V. Additionally, the State Agency ESPC Guidelines require third party review of the M&V and the sample periodic utility savings reports as a part of the UAR review.

The choice of an M&V provider is an Agency decision and the circumstances and capabilities of the parties involved are widely varied. The M&V plan, its implementation, and the Periodic Utility Savings Reports may be provided by the Owner, the ESCO, a third party contractor or some combination of these as determined by contract agreement. The requirements set forth in this chapter apply regardless of the provider.

Table of Contents

Table of Contents..... 2
Introduction to Measurement and Verification 3
Standard Calculation Methodologies 3
Selection of Standard Calculation Methodologies..... 4
Qualifications and Responsibilities of the M&V Analyst and M&V Reviewer 5
M&V Plans: Purpose and Minimum Content 5
Measurement and Verification Plan Review..... 6
Periodic Utility Savings Report 6
Certifications 6
 Measurement and Verification Provider Certification.....7
 Periodic Utility Savings Report Certification.....10
 Conflict Of Interest Certification for Third Party Reviewer.....12

Introduction to Measurement and Verification

SECO requires the use of the International Performance Measurement and Verification Protocol (IPMVP) which was developed as a cooperative effort between industry and the U.S. Department of Energy.

Owner shall require a detailed scope of work and deliverables that clearly define the outputs and service levels expected from the Energy Savings Company (ESCO) for services provided after the installation of equipment.

The methodology for calculating savings varies by the type of modifications implemented in the building system. Modifications implemented under these Guidelines should be easily grouped into one of the categories listed in Figure 1. Each category modification has a specific principle associated with calculating savings that adheres to the current version of the International Performance Measurement and Verification Protocol in effect at the time of the development of the UAR. This IPMVP provides current best practice techniques available for verifying results of energy efficiency, water efficiency, and renewable energy projects in commercial and industrial facilities. The IPMVP is maintained with the sponsorship of the U.S. Department of Energy by a broad coalition of facility owners/operators, financiers, energy services companies, and other interested parties. The IPMVP outlines a number of methodologies for calculating savings that vary by the type of project installed.

Standard Calculation Methodologies

The standard calculation methodology used to calculate Utility Cost Reduction Measures (UCRM) consumption savings are as follows:

- **IPMVP Option A – Partially Measured Retrofit Isolation.** Savings are determined by calculating the energy use of the system(s) to which an UCRM was applied, separate from the energy use of the rest of the facility. Measured parameters may be continuously measured or periodically measured for short periods. Option A is most useful for constant load retrofits where the operating hours can be determined. The models will use data from a variety of sources including, but not limited to, field measurements, manufacturer's data, and/or reasonable engineering estimates.
- **IPMVP Option B – Retrofit Isolation.** Savings are determined by measurement of the energy use of the isolated system to which a UCRM was applied; separate from the energy use of the rest of the facility. Option B is most useful in retrofits which can be isolated from the rest of the system and have sufficient savings to justify the cost of monitoring. Monitoring can range from periodic spot measurements to continuous measurements.
- **IPMVP Option C – Whole Building.** Savings are determined by measuring energy use at the whole building or facility level. Short-term or continuous measurements are taken throughout the post-retrofit period. Option C is most useful where several retrofits are implemented and are difficult to isolate into separately measurable quantities.

Selection of Standard Calculation Methodologies

The table below lists several calculation methodologies that may be used to calculate savings in connection with a UCRM. The project category types correspond to the typical types of energy efficiency retrofit modifications.

Type 1: Simple Efficiency Improvement – Constant Operating Hours	For retrofits resulting in fixed demand reduction in equipment that is always operating, i.e., exit signs or operating at a known schedule.	Option A
Type 2: Simple Efficiency Improvement – Variable Operating Hours	For modifications resulting in fixed demand reductions from new equipment or equipment upgrades (i.e., lighting upgrades).	Option A
Type 3: Simple Operational Modification	For modifications resulting in reduced operating hours (i.e., on/off controls).	Option A or Option B
Type 4: Variable Operational Modification	For modifications resulting in reduced mechanical cooling when outdoor air economizers are being used and where savings are weather dependent.	Option B or Option C
Type 5: Variable Efficiency Improvement	For modifications that create savings from efficiency improvements in equipment that operate with variable output (i.e., air conditioning equipment and cooling towers).	Option B or Option C
Type 6: Modulating Efficiency Improvement	For modifications that create savings from installation of variable frequency drives that allow variable output for fixed consumption equipment.	Option B or Option C
Type 7: System Modifications	For modifications that affect the way entire subsystems are operated, performance improvements, and operational modifications are deployed (i.e., chiller or boiler plants, or compressed air systems).	Option B or Option C
Type 8: Whole Building	Where numerous modifications and operational changes are implemented, are difficult to isolate, or may not be significant enough to justify independent savings calculations. Also, the expected savings need to be large enough to be reasonably detected by monitoring the whole building consumption.	Option C

These methodologies can generally be applied to measure savings resulting from performance improvements, operational modifications, or equipment upgrades. Where specific site conditions make a listed methodology impractical, a case specific methodology conforming to IPMVP principles should be applied.

Qualifications and Responsibilities of the M&V Analyst and M&V Reviewer

The M&V Plan and the Periodic Utility Savings Reports produced using the data derived from it is how the agency determines how well the project is performing with respect to the guaranteed performance of contracts subject to Government Code §2166.406. The M&V Plan becomes part of the Contract and must be reviewed by an independent third party licensed engineer.

The analyst who develops or reviews the M&V Plan must meet the following criteria:

- Have a working knowledge of utility-using systems typical of those found in institutional and commercial buildings, have a working knowledge of energy and water efficient retrofits utilizing state-of-the-art technologies, and have a specific understanding of the subject building’s operation and maintenance procedures;
- Be experienced in conducting utility monitoring, identifying and measuring elements of utility consumption in institutional or commercial buildings, preparing comprehensive savings reports, have experience in on-site work to gather project data, and direct or perform all aspects of the data collection, data selection, data analysis, cost estimation, and provide final recommendations for the project.

It is the responsibility of the analyst to expedite the preparation of the report and to respond in a timely manner to any comments, questions, or necessary revisions resulting from the technical review.

M&V Plans: Purpose and Minimum Content

Any performance contract submitted must first and foremost provide substantial proof that the UCRM in fact will perform as stated in the project proposal and provide savings greater than or equal to those estimated. It is the overriding purpose of the M&V Plan to describe a method for achieving that proof.

M&V plans should contain, at a minimum, the following information:

- Name and qualifications of the M&V firm and individual technical analyst that will perform the M&V.
- A list of what will be measured.
- Time interval(s) to be used for the measurements.
- The total cost of the M&V Plan over the term of the Contract.
- Instruments that will be used for measurement and method of installation.
- How the instruments will be calibrated and the frequency of calibration.
- What baseline and post-retrofit analysis will be performed on the data that are collected.
- A sample calculation of the savings analysis including format (ASCII flat file recommended).
- A table that shows M&V approach to measure each UCRM or O&M measure.
- A Sample Periodic Utility Savings Report including examples of all required documents and showing all data elements, calculations and representative results.
- Certification of review by a licensed engineer.

Measurement and Verification Plan Review

The M&V Plan must be submitted along with the UAR, sample Periodic Utility Savings Report, and the proposed contract for an independent review by a licensed engineer.

Periodic Utility Savings Report

The Periodic Utility Savings Report will be reviewed by the Agency and /or third party reviewer based on the following criteria:

- Are the savings greater than or equal to those estimated or guaranteed in the UAR and the Contract? (If the estimated and guaranteed savings are not the same, both numbers must be shown throughout the documents.) Do they meet the requirements of Government Code §2166.406?
- Does the report contain the minimum required elements as listed in this document?
- Does the report present the data elements, calculations, and results as set forth in the M&V Plan?
- Do the parties (i.e., Owner, ESCO Contractor, or third party contractor) have any disputes or concerns regarding the report?

If it is determined that an independent third party review of the utility project savings report is needed, the contractually designated third party reviewer should respond to the review request within fifteen working days of its receipt. If the answers to the above questions are satisfactory to the contractually designated third party reviewer and the Owner, the report will be filed for future reference. If the answers are not satisfactory, closer review of the project will begin and the costs of that review along with the contractual remedies will be assigned to the party deemed responsible for the discrepancy, as determined by the third party reviewer and specified in the Contract.

Certifications

The following certifications address:

- 1) The preparation of the M&V Plan;
- 2) The Periodic Utility Savings Report, which is provided by the ESCO/Contractor;
- 3) The third party review of the Utility Savings Report; and,
- 4) Conflict of interest issues by third party providers.

Third party providers should either sign the certification for providing M&V services or the alternate certification for reviewing M&V reports.