

MEASUREMENT AND VERIFICATION AND THE IPMVP

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With permission from the author, this section was adapted from a memo prepared by Pierre Langlois, Co-Chair of the Efficiency Valuation Organization (EVO), and uses extracts of the International Performance Measurement and Verification Protocol (IPMVP) 2007. The complete version of IPMVP 2007 can be downloaded for free at www.evo-world.org.

While a retrofit project may reduce energy consumption on a campus, a thorough measurement and verification (M&V) process is essential for two reasons. First, M&V assesses resource savings in regards to the performance guarantee. Second, M&V helps ensure that savings will persist over time. This section explains M&V in some detail and refers to important reference materials that provide internationally agreed upon protocols for ensuring a fair and dispute-minimized M&V process.

The results of energy efficiency retrofits cannot be directly measured, as they can only be defined by the absence of energy consumption resulting from an action that targeted such reduction. The adage that “what cannot be measured cannot be managed” cannot be truer than in the context of energy efficiency initiatives. There is thus an important need to “measure and verify” savings generated by a project. Without such M&V:

- One will not be able to value the results of an investment in energy efficiency (therefore not inviting recognition, duplication, continuous investments, etc); and
- Energy reduction gains achieved through the initiative/project will likely disappear in part or in totality over time.

The most widely used M&V procedure for Energy Performance Contracting (EPC) projects is called the International Performance Measurement and Verification Protocol (IPMVP) and is included and supported in CCI best practice terms and conditions. The protocols contained therein are written and periodically updated by the Efficiency Valuation Organization (EVO).

According to EVO, “M&V is the process of using measurement to reliably determine actual savings created within an individual facility by an energy management, energy conservation or energy efficiency project or program. As savings cannot be directly measured, the savings can be determined by comparing measured use before and after implementation of a project, making appropriate adjustments for changes in conditions.”

Facility owners or energy efficiency project investors can use M&V techniques to mitigate the various risks that can arise after project completion. Indeed, energy efficiency practitioners are using M&V for the following purposes:

- a) Improve engineering design and project costing: The preparation of a good M&V plan encourages comprehensive project design and costing by including all M&V activities and costs in an EPC project’s economics.¹ Good M&V also provides feedback for future project designs.
- b) Increase energy savings through proactive adjustments in facility operations and maintenance: Post-project implementation, a good M&V plan helps managers discover and manage maintenance and operating problems so they can run their facilities more effectively, improve savings, achieve greater persistence of savings over time, and lower variations in savings.

¹ See the end of this section for a brief discussion on M&V costs.

- c) 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 is the recommended basis for documenting performance in a transparent manner that can be subject to independent, third party verification.
- d) 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 project capital providers have in energy efficiency projects, enhancing the chances of projects receiving financing under the best terms possible.
- 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 a M&V plan for determining energy savings improves the accuracy and reliability of emissions-reduction reports. Thus documented, those reductions could possibly be sold in carbon markets, providing an opportunity to recover some portion of M&V and other project costs.
- g) Support evaluation and development of broader efficiency programs: Utility 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 predict/report on the performance of a broader program.
- h) Increase public and marketplace understanding of energy management as a public policy tool: Improving the credibility of energy management projects provides proof that such projects yield real reductions in energy use. One of the benefits of such proof is increased marketplace acceptance of and encourages investments in energy-efficiency and the emissions credits they may create.

MEASUREMENT AND VERIFICATION, BY WHOM?

As M&V is now well recognized as one of the fundamental tools for the success of energy efficiency projects and programs, a rising question in the community is who should develop and implement a M&V protocol for a specific project. As a matter of fact, any of the parties involved in a project can design and implement a M&V protocol. The design will be much more credible if it follows the recognized concepts in the best practice of this science, as provided in the IPMVP. In the specific case of a performance contracting project, the beneficiary of a project (the client), the project implementer Energy Service Company (ESCO), a combination of both of these parties, and/or a third party, are all good and acceptable options for creation and implementation of a solid M&V plan.

IPMVP: THE PRINCIPLES

M&V is a science that follows some fundamental principles:

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 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 all the significant measurable effects, while estimating all others.

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

CONSISTENT: The reporting of a project's energy effectiveness should be consistent among:

- 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 judgments which may not be made identically by all reporters. By identifying key areas of judgment, 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 in the M&V plan and M&V savings reports of all of the elements defined in chapters 5 and 6 of the IPMVP.

The balance of these principles enable a M&V expert to present a flexible framework of basic procedures for achieving M&V for energy efficiency projects.

IPMVP: THE DIFFERENT OPTIONS

Based on these principles the IPMVP provides four different acceptable approaches (called Options) for measuring and verifying savings. All four options use the following fundamental formula:

$$(\text{Baseline Energy} - \text{Reporting-Period Energy}) \pm \text{Routine Adjustments} \pm \text{Non-Routine Adjustments} = \text{Savings}$$

ESCOs will all have their own methodology for calculating baseline energy use in a particular year – see the ‘Performance Guarantee’ section for a high level discussion of the process. The reporting energy period represents the actual energy use in a facility as determined by the results of a given period’s measurement and verification report.

The four options for determining savings – A, B, C, and D – are described in Table I The choice among the options involves many considerations, one of which is the definition of the measurement boundary (e.g., an individual building or an entire campus.)² If the M&V plan calls for determining savings at the facility level, Option C or D may be favored. However, if only the performance of an individual FIM itself is of concern, a retrofit-isolation technique may be more suitable (Option A, B or D).

² For more detail on the “measurement boundary,” please see please see IPMVP Chapter 4.4 (page 14).

IPMVP OPTION	HOW SAVINGS ARE CALCULATED	TYPICAL APPLICATIONS
<p>A. RETROFIT ISOLATION: KEY PARAMETER MEASUREMENT</p> <p>Savings are determined by field measurement of the key performance parameter(s), which define the <i>energy use</i> of the <i>FIM</i>'s affected system(s) and/or the success of the project.</p> <p>Measurement frequency ranges from short-term to continuous, depending on the expected variations in the measured parameter, and the length of the <i>reporting period</i>.</p> <p>Parameters not selected for field measurement are <i>estimated</i>. <i>Estimates</i> can be based on historical data, manufacturer's specifications, or engineering judgment. Documentation of the source or justification of the <i>estimated</i> parameter is required. The plausible <i>savings error</i> arising from <i>estimation</i> rather than measurement is evaluated</p>	<p>Engineering calculation of <i>baseline and reporting period energy</i> from:</p> <ul style="list-style-type: none"> • short-term or continuous measurements of key operating parameter(s); and • <i>estimated</i> values. <p><i>Routine and non-routine adjustments</i> as required³.</p>	<p>A lighting retrofit where power draw is the key performance parameter that is measured periodically. Estimate operating hours of the lights based on building schedules and occupant behavior.</p>
<p>B. RETROFIT ISOLATION: ALL PARAMETER MEASUREMENT</p> <p>Savings are determined by field measurement of the <i>energy use</i> of the <i>FIM</i>-affected system.</p> <p>Measurement frequency ranges from short-term to continuous, depending on the expected variations in the savings and the length of the <i>reporting period</i>.</p>	<p>Short-term or continuous measurements of <i>Baseline and reporting-period energy</i>, and/ or engineering computations using measurements of proxies of energy use.</p> <p><i>Routine and non-routine adjustments</i> as required.</p>	<p>Application of a variable-speed drive and controls to a motor to adjust pump flow. Measure electric power with a kW meter installed on the electrical supply to the motor, which reads the power every minute. In the baseline period, this meter is in place for a week to verify constant loading. The meter is in place throughout the reporting period to track variations in power use.</p>

³ A routine adjustment is a baseline adjustment that would be done regularly, for example due to weather variations. A non-routine adjustment would occur once due to an isolated event such as the introduction of a new ventilation system.

IPMVP OPTION	HOW SAVINGS ARE CALCULATED	TYPICAL APPLICATIONS
<p>C. WHOLE FACILITY</p> <p>Savings are determined by measuring energy use at the whole <i>facility</i> or sub-<i>facility</i> level.</p> <p>Continuous measurements of the entire <i>facility's</i> energy use are taken throughout the <i>reporting period</i>.</p>	<p>Analysis of whole <i>facility</i> <i>baseline</i> and <i>reporting period</i> (utility) meter data.</p> <p><i>Routine adjustments</i> as required, using techniques such as simple comparison or regression analysis.</p> <p><i>Non-routine adjustments</i> as required.</p> <p>Consider using EPA's Portfolio Manager tool to calculate savings at the whole building level.</p>	<p>Multifaceted energy management program affecting many systems in a <i>facility</i>. Measure energy use with the gas and electric utility meters for a twelve-month <i>baseline period</i> and throughout the <i>reporting period</i>.</p>
<p>D. CALIBRATED SIMULATION</p> <p>Savings are determined through simulation of the energy use of the whole facility, or of a sub-facility.</p> <p>Simulation routines are demonstrated to adequately model actual energy performance measured in the facility.</p> <p>This Option usually requires considerable skill in calibrated simulation.</p>	<p>Energy use simulation, calibrated with hourly or monthly utility billing data. (Energy end use metering may be used to help refine input data.)</p>	<p>Multifaceted energy management program affecting many systems in a facility but where no meter existed in the baseline period.</p> <p>Energy use measurements, after installation of gas and electric meters, are used to calibrate a simulation.</p> <p>Baseline energy use, determined using the calibrated simulation, is compared to a simulation of reporting period energy use.</p>

THE COSTS OF M&V⁴

M&V costs will vary depending upon the IPMVP Options utilized in a project.

Given the wide variability among EPC projects, EVO is hesitant to provide option-by-option cost estimates as given in the table above. Instead, EVO reports that, based on a study by the U.S. Department of Energy of U.S. federal level EPC projects conducted under the auspices of the Federal Energy Management Program (FEMP), the average all-in cost of M&V services ranges between 3-5% of total costs⁵. IPMVP guides that typically M&V costs are less than 10% of total project costs⁶.

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:⁷

Option A = 1-5%

Option B = 3-10%

Option C = 1-3% (if meters are already installed)

Option D = 3-10%.

Factors which influence the appropriate level of M&V and thus the cost of M&V include:⁸

- Value of projected savings
- Complexity of efficiency equipment
- Total amount of equipment
- Number of interactive effects among resource consuming systems
- Level of uncertainty of savings
- Risk allocation for achieved savings between the school and the ESCO
- Other valuable uses of M&V data (e.g. optimizing O&M, selling carbon credits)
- Availability and capability of an energy management system.

⁴ The following language was not included in Pierre Langlois' original document. The information quoted is derived from previously existing reports, CCI's experience in working on EPCs, and interviews with EVO staff.

⁵ To access this USDOE report, please see: http://www.evo-world.org/index.php?option=com_content&task=blogcategory&id=470&Itemid=347

⁶ IPMVP Volume I, 2007, Chapter 8.5

⁷ 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.

⁸ Birr and Donahue.