National Measurement and Verification Protocols

J. Stephen Kromer, Lawrence Berkeley National Laboratory
Steven R. Schiller, Schiller Associates

The delivery of energy efficiency services in many sectors has moved from direct-finance to pay-for-performance. Many new programs involve third-party financing and periodic payment streams that are tied to some measure of verified energy savings. The growth of alternative-financed energy efficiency has created the need for standard measurement and verification (M&V) protocols to assess savings that can be used as contract instruments as well as performance indicators.

The US Department of Energy (DOE) identified the need for standard measurement and verification (M&V) protocols and initiated an effort to develop a national consensus document (drawing mainly from existing measurement techniques). DOE's goal was to create a set of protocols with input from a broad spectrum of industry, government, and university organizations that would be robust enough to provide surety, yet flexible enough to meet the needs of a variety of projects. One measure of the success of these energy savings protocols will be the degree to which financiers respond with lower finance rates and M&V method-specific rates.

The result of this effort of is DOE's efforts is the *North-American Energy Measurement and Verification Protocol* (NEMVP), one of three documents described in this paper. The others are the American Society of Heating, Refrigeration and Air Conditioning Engineers' (*ASHRAE) GPC 14-Guideline for Measuring Demand and Energy Savings* and the DOE's Federal Energy Management Program (FEMP) Measurement and Verification (M&V) Guidelines. The FEMP M&V Guideline is an application of the NEMVP prepared for use at federal facilities.

A key element of the NEMVP and FEMP documents is the definition of two M&V components: (1) verifying proper installation and the measure's potential to generate savings and (2) measuring (or estimating) actual savings. Different projects require different levels of effort for each of these two components and thus three generic M&V Options (A, B and C) have been defined in the NEMVP and are described in this paper.

INTRODUCTION

Prior to the days of performance contracts and demand-side management (DSM) programs the performance of energy efficiency measures (EEMs) was typically assessed using pre-installation savings estimates. Energy efficiency projects were authorized based on engineering calculations and the savings were calculated without the use of measured data. Contractors who installed the energy efficiency retrofits were responsible for the installation and initial operation of the equipment, not the long-term savings.

Now, with a decline in government appropriations for energy efficiency and reductions in utility DSM funding, the market has moved toward third-party financed projects and utility DSM bidding, pay for performance, programs. Energy savings performance contracting (ESPC) using third-party financing has grown and stands to increase even more when standard protocols for savings determination become available (Kats, Rosenfeld 1996).

Whereas previously an engineer might refer to a standard ASHRAE or American Refrigeration Institute (ARI) reference to benchmark the performance of energy consuming equipment, there were no standard methods to estimate how the operation of that equipment over time affected the energy consumed, and the energy bills. Protocols for the measurement of individual EEM's performance were limited to a few utility demand-side programs (Mazzucchi 1994) and state programs (Haberl et al 1996). While much of this work was of a high quality, the measurement approaches were specifically designed for the programs in which they would be used. Apart from general measurement guidelines (MacDonald 1989) and Chapter 37 in the ASHRAE handbook, by 1993 there were no nationally accepted standards for assessing savings from energy efficiency projects. There is general agreement and a great deal of literature regarding the engineering methods used to assess equipment **performance**, however there has often been disagreement about, and almost no guidance on, determining the correct *approach and level of measurement* to determine **savings** for specific types of projects.

The need for standard M&V was identified more or less coincidentally by three national organizations. Within the DOE, a group of policy advocates and the Federal Energy Management Program each determined that creating M&V protocols was a high priority. At the same time, ASHRAE had convened a committee (GPC 14) to provide Guidelines on how to approach energy savings measurements. Each of these efforts is covered in detail later in this paper.

SAVINGS CANNOT BE MEASURED

M&V is a tool for defining, controlling and allocating risks associated with energy project financing. The better the tool the more it can positively influence increasing levels of energy efficiency financing. However, there is still one small problem, *savings cannot be measured.*

ESPC relies on the concept that the M&V can be applied in an impartial way. Contractual language obligates both parties to agree on methods to estimate energy ''savings''. In fact, in some performance contracts, the energy ''savings'' are the commodity being purchased by the facility owner. However, again, can savings cannot really be measured.? The introduction to the current draft of ASHRAE's M&V Guideline GPC 14 reads:

There are no absolutes when assessing savings (the absence of energy use). Therefore any method is an estimate. The risks created by the error in the estimating method need to be understood before committing to a procedure.

The approach common to all M&V protocols consists of three major steps:

- Establish a baseline energy use representing conditions prior to implementing an energy efficiency measure (EEM)
- Make energy use measurements or calculations after the EEM is installed
- Adjust the baseline to accommodate changes in the operating conditions for the time period of interest.

For retrofit EEMs, savings are calculated by subtracting the post-installation energy consumption from the adjusted baseline consumption. In some cases, the baseline is adjusted based on changes in the weather, the operation of the building, or other independent factors. In every case, the use of the baseline as a proxy for what would have happened without the retrofit involves **assumptions**. Performance at any one moment **can** be **measured**, but savings must be calculated based on assumptions of what performance would have been.

The fact that savings cannot be measured directly does not imply that M&V doesn't work or isn't worth it. However, parties entering into contracts based on energy savings performance must understand thee implications of the M&V method(s) they select, and the impact of the selected M&V method(s) on the allocation of risk in the contract. Furthermore, recent experience with ESPC has shown that selecting the correct M&V approach is at least as important as the absolute accuracy of the actual measurements. (Heinemeir K., Akbari H., Kromer S. 1996).

The goal of the M&V documents described in this paper is to define a range of methods for determining savings under ESPC and DSM contracts and to formalize the primary assumptions and responsibilities inherent in each method.

PROCESS

The North American Measurement and Verification Protocol (NEMVP), ASHRAE GPC 14 (Measurement of Demand and Energy Savings) and the FEMP M&V Guidelines were created to meet the specific needs of their sponsors. In the case of the NEMVP, the goal was to create a vehicle that would lower barriers to investment in energy efficiency. ASHRAE saw a need to bring together much of the work that already existed within the Society and make it available in one place. FEMP needed contract language and methods that could be used in federal-sector performance contracts.

The following sub-sections provide background on each effort and the coordination between them.

NEMVP

In June 1994, Greg Kats and Art Rosenfeld at DOE convened a series of meetings with financiers from across the United States. Their goal was to establish a secondary market for third-party financed energy efficiency projects, much like the market for home loans. This new market would allow financiers to bundle and sell their energy efficiency portfolios, thereby freeing limited capital for further investment. Participants at these meetings identified the lack of an M&V standard as a barrier to expanding third party investment in energy efficiency.

DOE responded by bringing together industry, technical, and government organizations with an interest in determining savings in energy efficiency projects. The announcement of DOE's intention to convene a national advisory committee to direct the writing of a national protocol was made at the 1994 ACEEE Summer Study. Subsequent planning meetings were held in Washington, DC in September 1994 and in January 1995 with attendance open to all interested parties.

The NEMVP Development Plan was circulated in February 1995 and work began in earnest later that month.

The original participants on the National Energy Monitoring and Verification (M&V) Protocol Committee were:

- American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)
- National Association of Energy Service Companies (NAESCO)
- National Association of State Energy Officials (NASEO)
- National Association of Regulatory Utility Commissioners (NARUC)
- United States Department of Energy (USDOE)
- United States Environmental Protection Agency (USEPA)

In the past year the NEMVP committee has grown to where there are now:

- Policy Committee ~ 30 active members
- Technical Committee ~ 14 active members
- Financial Financial Advisory Committee ~ 15 members
- Corresponding Members -~ 250 members

NEMVP Participating Organizations in addition to those listed above, now include:

- Canadian Association of Energy Service Companies (CAESCO)
- Commission National Para El Ahorro De Energia (CONAE)
- Fideicomiso De Apoyo Al Programa De Ahorro De Energia Del Sector Electico (FIDE)

The first version of the NEMVP was published in February, 1996. The policy committee reconvened in April 1996 to create a plan for updating the document in 1996 and beyond.

FEMP Guidelines

The FEMP ESPC program is a mandated five-year pilot program designed to accelerate investment in cost-effective energy efficiency measures in existing federal buildings and thereby save taxpayer dollars. ESPC projects are expected to be the primary means of attaining the energy savings goals in the Energy Policy Act and Executive Order 12902. The methodology used to determine and verify energy savings or ''proof of performance'' are at the core of the ESPC transaction.

FEMP participated in writing the NEMVP document throughout the spring and summer of 1995. Using the NEMVP definitions of Options A/B/C as a framework, FEMP wrote an application that provides specific guidance in applying the M&V options in federal projects. Though the FEMP Guidelines were written for federal use, there is nothing specifically preventing their adoption for use in other sectors.

While FEMP does not emphasize which M&V oOption a federal agency should choose to accomplish a project, significant work was done to ensure that simple, effective methods were defined that minimize contract administration activities.. The intention is that a federal contracting officer references the M&V Guidelines and specifies one or more of the 24 M&V methods listed in the document. Then, the energy service company (ESCO) writes a site specific M&V plan based on the method(s) specified by the contracting officer.

ASHRAE GPC 14-Measurement of Demand and Energy Savings

ASHRAE GPC 14 was established in 1993 under the sponsorship of Technical Committee 9.6, Systems Energy Utilization. Since the first official meeting in the summer of 1994 the committee has continued to meet at each of ASHRAE's annual and winter meetings. In early 1996 the committee began a series of bi-weekly conference calls to accelerate the writing process.

As of this writing, GPC 14 has not finalized its scope. GPC 14 may concentrate on providing a set of technical references concerning measurement, or it may also provide guidance on which measurement method option is appropriate to a particular situation.

It is envisioned that the final ASHRAE document will provide technical references to support the types of measurements that are designated by the NEMVP and FEMP documents. However, because ASHRAE had strict rules regarding the consensus process, it is unclear to what degree the concepts or classifications in the NEMVP and FEMP Guidelines will be retained by GPC 14.

COORDINATION

While there is no formal coordination between the three documents, there has been a great deal of exchange of ideas among the participants in the efforts. Two of the authors of the FEMP document (who also happen to be the authors of this paper) were members of the NEMVP Policy and technical sub-committees, as was the chairman of GPC 14, George Reeves. Several of the participants in the NEMVP and FEMP activities, again including the authors of this paper, are also represented on GPC 14, thereby ensuring that ASHRAE will have the opportunity to benefit from the work done by NEMVP and FEMP. The entire GPC 14 committee has received copies of both NEMVP and the FEMP Guideline for their review and consideration.

The process of creating a generic application that will accompany the NEMVP was proposed started in May, 1996. The NEMVP technical sub-committee envisioned that this generic application would draw heavily from the FEMP guidelines.

Both the NEMVP, the framework for energy savings language, and the FEMP Guideline, a specific application of the NEMVP for federal projects, are designed to be living documents that will improve through use.

Latest Status

As of May 1996 both the NEMVP and the FEMP Guideline were available through DOE's Energy Efficiency and Renewable Energy Clearinghouse (EREC)[1] and on the World Wide Web at DOE's Efficiency and Renewable Energy Network (EREN)[2].

The NEMVP has been adopted for use by four states (California, Florida, Iowa and New York) and is being applied in the federal sector in Mexico.

ASHRAE GPC 14 is a work in progress. The most recent document is reviewed on a bi-weekly basis by all members of the committee and discussed via a DOE-sponsored conference call.

A DEFINITION OF MEASUREMENT AND VERIFICATION

The NEMVP and the FEMP Guideline are builtd around a common structure of three measurement options. The purpose of defining several M&V options is to allow a the user flexibility in determining the cost and method of assessing savings. Therefore, the M&V options, described briefly below, vary in accuracy and in cost of implementation.

The NEMVP and FEMP documents define two components in the measurement and verification of performance based projects:

- **Verifying the EEM's potential to perform and generate savings**, also stated as confirming that (a) the baseline conditions were accurately defined and (b) the proper equipment/systems were installed, they are performing to specification and they have the potential to generate the predicted savings; and

- **Measuring the EEM's performance (i.e., savings)** or, in other words, determining the actual energy savings achieved by the installed EEM.

The general approach to verifying baseline and post-installation conditions involves inspections, spot measurement tests, and/or commissioning activities. Commissioning is the process of documenting and verifying the performance of HVAC systems so that the systems operate in conformity with the design intent.

INTRODUCTION TO THE NEMVP M&V OPTIONS

The NEMVP and the FEMP Guideline are build around a common structure of three M&V options, Options A, B and C. TThese three M&V options are based on the two components to M&V, as defined above. The purpose of defining several M&V options is to allow the user flexibility in the cost and method of assessing savings. A particular option is chosen based on the expectations for risk and risk sharing between the buyer and seller and on site and EEMproject specific features.

The options differ in their approach to the level and duration of the verification measurements. For instance, Options A and B both focus at the system level, while Option C uses measurements taken at the whole-building, or whole-facility level. Option A uses short term measurements, while Options B and C use continuous or regular interval measurements during the term of the contract.

None of the options are necessarily more expensive or more accurate than the others. Each has advantages and disadvantages based on site specific factors and the needs and expectations of the ESPC customer.

The authors of this paper developed the concept of the three M&V options for NEMVP from the need to based on (a) different types of third-party financed projects require different levels of performance assurance, (b) for certain contracts, assuring the potential of the EEMs to perform, as defined above, is the critical factor, and (c) M&V can be defined

on a component or facility-wide level. In addition, the authors have found in practice, that a major step forward in performance contracting would be achieved in many cases if buyers could simply verify that they got what they were supposed to get and that it is working correctly.

Option A

Option A is a verification approach that is designed for projects in which the EEM's ''potential to perform'' needs to be verified, but the actual performance can be stipulated based on the results of spot measurements and engineering calculations. Option A involves procedures for verifying that:

- Baseline conditions have been properly defined;
- The equipment and/or systems that were contracted to be installed have been installed;
- The installed equipment components or systems meet the specifications of the contract in terms of quantity, quality, and rating;
- The installed equipment is operating and performing in accordance with the specifications in the contract and meeting all functional tests; and
- The installed equipment components or systems *continue, during the term of the contract*, to meet the specifications of the contract in terms of quantity, quality and rating, and operation and functional performance.

Option A, enables the contracting parties to confirm that the proper equipment components or systems were installed and that they have the potential to generate the predicted savings. Achieving this level of verification is all that is contractually required for these types of contracts. This option is recommended for projects where a significant portion of the associated uncertainty is in verifying the performance of the EEM (e.g., equipment quantities and ratings such as lamp wattages, chiller kW/ton, motor kW, or boiler efficiency). Verification of the potential to perform may be done with inspections and/or spot or short-term metering conducted right before and/or right after project installation. Annual (or some other shorter, regular interval) inspections may also be conducted to verify the EEMs' continued potential to perform and generate savings.

With Option A, actual achieved energy or cost savings are predicted using engineering or statistical methods that do not involve long term measurements. All end-use technologies can be verified using Option A. Within Option A, various methods and levels of accuracy in verifying performance are available. The level of accuracy ranges from an inventory method of ensuring nameplate data and quantity of installed equipment to short-term measurements for verifying equipment ratings, capacity and/or efficiency. Verification of baseline and post-installation equipment should occur at the same level of thoroughness. Either formally or informally, Aall equipment baselines should be verified for accuracy and for agreement with stated operating conditions. Actual field audits will almost always be required.

Option B

Option B is for projects in which (a) the potential to perform and generate savings needs to be verified; and (b) verification of actual performance during the term of the contract needs to be measured. Option B involves procedures for ***verifying the same items as Option A plus verifying actual achieved energy savings during the term of the contract***. Performance verification techniques involve engineering calculations with metering and monitoring. Because the post-installation baseline is subject to adjustment, the contract must specify what adjustments apply. Option B M&V involves:

- Confirming that the proper equipment/systems were installed and that they have the potential to generate the predicted savings, and
- Determining an energy (and cost) savings value using end-use measured data taken throughout the term of the contract.

All end-use technologies can be verified with Option B; however, the degree of difficulty and costs associated with verification increases exponentially as the complexity of the metering increases.
How accurate the energy savings value must be is defined by the federal agency or negotiated with the ESCO. The steps used in measuring or determining energy savings can be more difficult and costly than those used in Option A; however, the results will typically be more precise.

Methods used in this option will involve long term measurement of one or more variables. Long term measurement accounts for operating variations and will more closely approximate actual energy savings than the use of stipulations as defined for Option A. However, Llong term measurements do not necessarily increase the accuracy.

Measurement of all end-use operating systems may not be required if a statistically valid sampling method is used to select a sub-set of operating systems. Sampling guidelines for calculating sample sizes and sample selection are also discussed in the FEMP M&V Guidelines.

Option C

Option C is also for projects in which (a) the potential to perform needs to be verified and (b) actual performance during the term of the contract needs to be measured at a whole-building or facility level. Option C involves procedures for **verifying the same items as Option A plus verifying actual achieved energy savings during the term of the contract**.

Performance verification techniques include utility whole building meter analysis and/or computer simulation calibrated with utility billing data. Option C is the one M&V option that addresses aggregate, coincident demand, and energy savings from multiple resources at a single site. Option C also provides procedures for determining and verifying the impact of EEMs which are not directly measurable, or affect loads indirectly, such as increasing building insulation, or installing low-e windows.

All end-use technologies can be verified with Option C. This option is called for when there is a high degree of interaction between installed energy conservation systems and/or the measurement of individual component savings would be difficult. Accounting for changes other than those caused by the EEMs is the major challenge associated with Option C—particularly for long term contracts.

NEXT STEPS

As the NEMVP, FEMP and GPC 14 M&V efforts continue, additional M&V activities , such as developing methods for quantifying costs and benefits of incremental M&V efforts need to be determined. In addition, M&V methods defined in the documents will need to be tested and updated firmed up to ensure that they are repeatable. Efforts by the industry to provide , include case studies, application guides, and documentation of results and costs will also be needed to ensure success for performance based contracting.

Thus, as the performance contracting energy efficiency industry grows and implements more projectschanges, these measurement protocols will continue to evolve. The protocols and application guidelines that exist today will lead to a new generation of measurement protocols in the future. The Department of Energy, Federal Energy Management Program and ASHRAE have shown that separate organizations can work together to meet the needs of a changing industry.

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