Measurement and Verification Protocols –M&V Meets the Competitive and Environmental Marketplaces

J. Stephen Kromer, Enron Energy Services
Steven R. Schiller, Schiller Associates

ABSTRACT

This paper describes the status of measurement and verification (M&V) guidelines for determining savings from energy efficiency projects. Existing protocols such as the International Performance Measurement and Verification Protocol (IPMVP, 1997) and the Federal Energy Management Program M&V Guideline (FEMP, 2000) have been updated and expanded. In addition, new guidelines are available from the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE, 2000) and for emission reduction and state public benefits charge programs. These documents, particularly the IPMVP, have become industry standards and a required consideration for all performance contracting.

Also discussed are several important issues and M&V development requirements. These include differentiating Option A M&V methods from simple stipulation of energy savings; the use of uncertainty analysis in M&V, selecting M&V methods based on project value and risk; selecting an appropriate level of M&V rigor for specific projects and programs; and using M&V to determine the emissions reductions associated with energy efficiency projects and programs.

Several M&V trends are emerging related to these important issues. These trends include the increasing prevalence of simpler M&V approaches, resulting in the rise of deemed savings values in several public and private "performance contracting" programs. This trend is being driven by interest in reducing project costs while maintaining an appropriate level of confidence in the savings associated with common energy efficiency measures. Another trend is the use of new software tools to analyze facility energy data for a wide range of applications (such as commissioning, building fault detection and diagnosis, and energy commodity profiling). This trend can lead to lower M&V costs as the cost of data collection is spread across multiple uses. A third trend is the use of M&V to quantify benefits other than energy cost savings resulting from energy efficiency projects, particularly emission reductions. In order to include energy efficiency in emission credit programs, M&V systems are being developed to meet the myriad of technical, economic, social and political issues associated with documenting both energy and emission savings.

Introduction

The importance of performance measurement and verification for energy efficiency projects continues to grow as international financing authorities, administrators of U.S. public benefits charges (PBC), and governments continue to call for a method to contractually verify savings. California, Colorado, New York, Texas, and Wisconsin for example, are using well over $100 million of utility rate payer funds for performance-based programs in 2000 (Schiller, 2000). The Federal Energy Management Program intends to implement $6.6 billion

worth of performance programs by 2005 (FEMP, 2000a). States such as Colorado, Iowa, California and Texas (TECC, 1998) are using performance contracting as a mechanism for improving the efficiency of state facilities. Companies such as Enron Energy Services are using performance-based contracts for energy commodity sales and energy services. In addition, organizations such as the U.S. Environmental Protection Agency (EPA, 2000) and the World Bank (World Bank, 2000) are establishing programs that will credit air emission reductions associated with energy efficiency and renewables programs.

M&V is a critical element to ensure the appropriate use of public funds when they fund energy programs, whether as part of a rate payer funded PBC program or a program to reduce energy consumption in public facilities. M&V can be important for private companies when a mechanism for documenting savings is required for a facility owner to be convinced to proceed with a project. Also, with respect to emission trading programs, M&V has become the key technical issue for defining credible and tradable emission credits for efficiency and renewable energy programs and projects.

M&V has been an evolving art and science since the late 1970's, when it was performed on ad-hoc, case-by-case bases with no available standards. Since that time, numerous M&V guidelines have been promulgated, culminating in the International Performance Measurement and Verification Protocol (IPMVP). In the past five years, the existing suite of M&V guidelines and protocols has become standard references in the energy services/performance contracting industry. Indeed, referencing the IPMVP has essentially become a requirement associated with developing both individual energy efficiency performance contracting projects and performance contracting programs.

Publicly funded programs administered by utilities such as TXU Electric, Reliant Energy, Central and Southwest Utilities, New Century Energy, Pacific Gas and Electric Company, Southern California Edison, and Sempra all use the IPMVP as the basis for the measurement and verification requirements for their rate-payer funded performance contracting programs. Public agencies such as the New York State Energy Research and Development Agency, the states of Colorado, Iowa and Texas, the EPA, and FEMP have also used the IPMVP as the basis for developing their program's M&V requirements. Almost all performance-contracting firms now state that their work complies with the IPMVP, although the validity of that statement varies from firm to firm due to a lack of firm compliance requirements associated with the IPMVP. Thus, in a few short years the IPMVP has become the de-facto protocol for measurement and verification of performance contracts.

While the IPMVP has achieved an important goal for energy efficiency implementation—establishing a industry standard M&V protocol—there continues to be several outstanding needs within the M&V industry. These include (a) reducing the transaction costs associated with energy efficiency projects and (b) documenting emission reductions associated with energy efficiency projects. The former need has led to two—perhaps conflicting—trends:

1. Very simple or no M&V for so-called performance contracts. When the level of confidence has been very high with respect to achieving a pre-determined level of energy savings (as with simple lighting projects) or the buyer of the energy services is not driven by energy cost savings (as with a school that just needs a new boiler system) parties are agreeing to savings calculations that do not use measurements.

2. New software tools, guidelines, and techniques for reducing M&V costs and improving the reliability of savings determinations. Related to this is the use of data that may have been collected for M&V purposes being used for a wide variety of applications such as commissioning or building diagnostics, or vice versa.

These goals and trends are discussed later in this paper; first, an overview of current M&V protocols is provided.

M&V Protocols and Guidelines

There are three major M&V documents in use in the United States. These are the International Performance Measurement and Verification Protocol (IPMVP), ASHRAE 14-P, and the FEMP M&V Guideline.

IPMVP

The IPMVP remains the sole candidate for an international standard for describing the issues involved in assessing savings (Schiller, 1998). The IPMVP discusses procedures that, when implemented, allow building owners, energy service companies (ESCOs), and financiers of energy efficiency projects to quantify the performance and energy savings of energy conservation measure. The IPMVP provides an overview of current best practice techniques available for verifying savings from both traditionally and third-party financed energy and water efficiency projects.

Versions of the IPMVP have been translated into Bulgarian, Chinese, Czech, Japanese, Korean, Polish, Portuguese, Russian, Spanish, and Ukrainian (IPMVP, 2000). Sponsored by the U.S. Department of Energy, the IPMVP was first published in 1996 and a revision was released in 1998. A new version is scheduled for 2000 or 2001. At this point, it is intended that the IPMVP become more clearly a framework document of perhaps 30 to 50 pages (from the 200 pages it is now) on how to define and implement M&V activities. Published with the IPMVP would be technical appendices addressing issues such as indoor air quality, water conservation, energy efficiency (perhaps referencing ASHRAE Guideline 14P), and emissions reduction.

ASHRAE Guideline14P

After six years of development, ASHRAE's Guideline 14P, Measurement of Energy and Demand Savings, was issued for public comment for the first time on April 8, 2000 (ASHRAE, 2000). Members of ASHRAE's 14P committee are meeting this summer to begin the process of finalizing the document.

The guideline was prepared to meet the need for a standardized set of energy and demand savings calculation procedures (Reeves, 1999). The guideline provides methods, or approaches, for using measured pre-retrofit and post-retrofit data to determine savings. As such, IPMVP's Option A (an Option that, as discussed below, requires minimal measurement) is not specifically covered in ASHRAE's 14P Guideline. The approaches addressed are (and their equivalent IPMVP Options) are:

- Retrofit Isolation (Option B)
- Whole Building (Option C)
- Whole Building Calibrated Simulation (Option D)

One of the major advances of 14P is its formal addressing of the issue of quantifying the uncertainty of savings calculations. Calculations are provided on how to quantify uncertainty in whole building billing analyses and portions of the retrofit isolation and calibrated simulation approaches. While not fully addressing issues such as sampling and human error, the uncertainty analysis is a critical starting point for future work in calculating M&V uncertainty, the resulting risk of cost savings uncertainty, and allowable M&V expenditures to reduce that risk.

Another important element of 14P is that it provides both prescriptive and performance-based paths for compliance. Thus, this is the first M&V guideline with a clear definition of how compliance can be claimed. For most guidelines, including the IPMVP and the FEMP M&V Guideline, it can only be safely stated that one has used, not necessarily complied with, the document since there are so many options and methods specified.

With Guideline 14P there is a *prescriptive* compliance path for the whole building approach and *performance* compliance paths for the retrofit isolation, whole building and calibrated simulation approaches. For compliance there are the following requirements:

1. Prepare a measurement and verification plan.
2. Measure energy before and after retrofit while recording conditions.
3. Project pre/post energy use to common conditions (normalizing post-measure installation conditions).
4. Calculate uncertainty. While uncertainty calculations will be difficult to calculate for many M&V practitioners, the guideline, with its definitions, extensive instrumentation and data management chapter, examples, and overall descriptions of the state of the art for various approaches, will be a significant resource for all M&V practitioners.

FEMP M&V Guideline

Starting in the early 1990's, several M&V guidelines have been prepared for government and utility performance contracting programs. These include:

- 1992 New Jersey Standard Offer Protocol
- 1993 NAESCO M&V version 1.3
- 1994 PG&E PowerSaving Partners "Blue Book"
- 1995 EPA Conservation Verification Protocols
- 1996 Federal Energy Management Program (FEMP) M&V Guidelines
- 1998 Texas Performance Contracting Guidelines

More recently, ratepayer funded, standard performance contracting programs have resulted in M&V guidelines in California (1998 and 1999), New York (1998), and Texas (2000).

A heavily referenced document is the FEMP M&V Guideline (FEMP, 2000), which is used by the federal government for its performance contracting projects and has been used as a starting point for other state and utility programs. The FEMP Guideline provides procedures and guidelines for quantifying the savings resulting from the installation of cost

saving projects implemented with federal Energy Savings Performance Contracts (ESPCs), Basic Ordering Agreements, or Delivery Orders implemented under the SuperESPC program.

First published in 1996 this document was released for public comment in 1999 and a revised version was published in 2000. The 2000 version of the FEMP Guideline includes the following updates to the 1996 version:

- New information on how to select the appropriate M&V method for a particular project, minimum requirements for conducting M&V, and a "responsibility matrix" that can be used to define the risks associated with a performance project and which party is responsible for each risk
- New M&V methods for cogeneration, new construction, operations and maintenance, renewables, and water conservation projects.
- Editorial updates of the 1996 version, including revisions to bring the document into compliance with the 1998 version of the IPMVP.

Any future versions of the Guideline will probably reference ASHRAE's Guideline 14P and include more information on selecting M&V methods while providing examples of M&V plans and analyses.

Issue - Defining Option A

Earlier versions of the IPMVP (NEMVP, 1996) defined three categories of M&V; a fourth option, computer simulation, was added to the 1998 version. Options A and B both address savings verification at the end-use level. Option A was intended for situations in which *operation* of the retrofit over time was not a factor to be monitored, although verification of continued *performance* would be regularly evaluated. Option B addresses situations in which the savings calculation requires measurements of performance and operation continuously, or at regular intervals, throughout the term of a performance contract.

Experience has since shown that users of the protocol are confused about both the difference between Options A and B and the minimum amount of measurement that would constitute Option A. Many people are interpreting the allowance of stipulation in some elements of Option A to mean all savings could be stipulated, i.e. agreed to prior to project installation.

A basic tenet of the IPMVP is that its users be aware of the risks and trade-offs inherent in applying various savings verification strategies. Issues of cost and the site-specific needs of individual projects precluded a uniform M&V approach for all situations. The IPMVP's Options allow flexibility to design an M&V plan for a particular project and site. The role of the protocols is to provide framework definitions and guidance to users to allow parties to create plans that share risk according to their needs. Current versions of the FEMP M&V Guideline and IPMVP even include language that suggested that there are certain situations in which the parties may agree that savings calculations be based on totally stipulated data such as manufacturer's data and agreed-upon operating conditions. The reasoning for including a "no metering" method under Option A was that there are some situations (parking lot lighting retrofit) where such a calculation will be sufficient.

An unexpected consequence of including the "no metering" method under Option A is the widespread use of total stipulation as a default M&V strategy. Whereas Option A is intended to require periodic performance measurement in most cases, allowing for some

partial stipulations in the savings calculation, instead it is being applied using no measurements. A "race for the bottom" mentality, with ESCOs seeking lower cost and less risk, is resulting, in some markets, in Option A becoming synonymous with total stipulation.

Another area of confusion associated with Option A is the misunderstanding that stipulating some of the variables in a savings equation is equivalent to stipulating all variables. This interpretation misses the point that M&V is and should be about two parties identifying factors that create uncertainty and cost-effectively reducing that uncertainty (risk) through measurement of key variables and stipulation of non-key variables.

In early 2000, the technical committee of IPMVP reconvened with the goal of addressing several issues including better defining Option A. Consideration was given to defining an Option that would have made it clear when an M&V plan contained no metering. Option N, as it would have been called, would not have been considered a true M&V option (it would receive minimum credit under any M&V valuation methodology), but would be an alternative strategy to be used in some circumstances. This would have created a clear distinction from Option A, reducing confusion about partial stipulation. The drawback, however, was the potential for users to include "no metering" approaches as a valid IPMVP Option. For this reason, the concept of an Option N was dropped.

As of the writing of this paper, the IPMVP technical committee has decided that Option A will henceforth be defined as the "Partial Measurement" Option. Rather than define what variables will be measured and for what duration, the new Option A will allow users to claim adherence as long as (a) something is measured (performance factors or operation factors) and (b) the M&V plan addresses the uncertainty in the savings calculation and the subsequent risks to both parties.

This new definition for Option A is both broader and more flexible than before, but more clearly defines the minimum measurement standard. If there is no measurement in the M&V plan, it is not Option A. Furthermore, by having the parties to a performance contract identifying the key variables, it is intended that that will be measured as part of the Option A approach.

Regarding the difference between Options A and B, advanced practitioners understand that there is a continuum of approaches to verifying savings at the end-use level. M&V plans can measure pre and post, continuous or periodic, and address performance or operation. To define each potential combination would require many Options and become confusing. The IPMVP Technical Committee therefore decided that Option B now covers all of the M&V approaches that measure all of the relevant variables in the savings calculation – whether these measurements are taken continuously or for short periods of time during the performance period of a contract. To adhere to the IPMVP, users applying Option B will also need to address uncertainty in the savings calculation (see above for discussion of ASHRAE Guideline 14P's addressing of uncertainty).

Issue - M&V Rigor

When conducting M&V the essential question tends to be "how good is good enough?" Balancing the rigor (and thus cost) of M&V versus the level of uncertainty reduction requires knowledge about the impacts of various options, methods, and techniques on accuracy and M&V costs (Jump, 2000). On a program level (e.g., for rate payer funded

standard performance contracting programs), when establishing M&V requirements, it is not possible to know for each project in a program what the correct M&V method will be that balances cost effectiveness and rigor. Thus, most performance contracting programs' M&V Guidelines provide a range of options, as is the case with such diverse programs as California's standard performance contract programs and the Federal Energy Management Program.

To help address this issue and perhaps to provide a model for future programs, TXU Electric and Gas Company (TXU) has outlined three distinct M&V approaches for its standard offer program (SOP) (TXU, 2000). TXU's SOP is a recently developed utility ratepayer funded performance-contracting program and is the first utility administered program initiated as part of Texas' deregulation legislation and energy efficiency rules. The Texas Energy Efficiency Rules (Public Utilities Commission of Texas, 2000) emphasize low cost M&V for performance contracting programs. Other Texas utilities expect to use the TXU program as a model for their standard offer programs. These three M&V approaches may also be applied to other applications, such as verification of emissions reductions from energy efficiency projects.

TXU's three M&V approaches represent increasing levels of detail and rigor. The approaches are (1) deemed savings, (2) simple M&V, and (3) full M&V. Which method is chosen depends upon the availability of evaluation data from previous programs for particular equipment, the predictability of equipment operation, and the benefits of the method relative to the costs associated with the particular M&V method chosen.

Consideration of cost-effectiveness of measurement and verification was an essential element in outlining these three approaches. In developing these approaches, TXU's goal was to ensure that the relative value of the certainty of the energy savings (implying a high level of M&V) is balanced against the level of expected energy savings from a particular measure or piece of equipment. In practice, TXU, the Public Utilities Commission of Texas, Texas ESCOs, and other Texas based utilities hope to maximize the use of deemed savings values. In Texas, an independent evaluator will determine if the deemed savings provide sufficient levels of certainty with respect to the expenditure of ratepayer funds as incentives to project sponsors.

The three M&V approaches are discussed below:

Deemed Savings

Deemed savings refer to a savings verification approach that does not require short-term testing or long-term metering. Under this approach, energy savings for particular energy efficiency measures are stipulated in advance of installation based on evaluation data from past programs or other publicly-available industry data (such as from ASHRAE, the American Refrigeration Institute, etc.). To develop the deemed savings, TXU has made assumptions about typical operating characteristics, manufacturer's nameplate energy efficiency data, and types of equipment likely to be installed. This approach will be used for energy efficiency measures for which savings are relatively certain, including lighting efficiency and packaged HVAC equipment.

Simple M&V

A simple M&V approach may involve short-term testing or simple long-term metering, but relies chiefly on manufacturer's efficiency data and pre-set savings calculation formulas. A formula for calculating energy savings for a particular measure may be devised in advance for all measures of this type, but may require data collected through short-term metering to validate or calibrate the energy savings actually being achieved. For example, chiller energy savings will be estimated using a simple M&V approach, whereby the efficiency rating of the new chiller will be compared against a baseline unit's efficiency at the ASHRAE 90.1 1989 standard level. The ratio of these efficiencies will be applied to measured kWh data from the installed new chiller to obtain an estimate of energy savings.

Full M&V

A full M&V approach refers to any M&V activities that represent a higher level of detail than the simple M&V or deemed savings approaches. All full M&V methods were developed in accordance with industry standard practice, and may include one or more of the following approaches:

- Stipulated savings based on short term information
- Metered savings of equipment or systems
- Whole building billing analysis
- Calibrated computer simulation

Issue - Uncertainty Analysis, Value, Risk and the Need For Databases of M&V Data

M&V reports need to evolve away from simply providing an "answer" to the amount of savings towards reporting savings estimates with an associated uncertainty. As mentioned above, ASHRAE provides guidance on one way of assessing uncertainty. Modern computer tools developed for the financial and risk management industries allow users to report uncertainty on a wide range of models.

Since the early 1990s, the financial industry has been experimenting with techniques to measure risk in financial portfolios. Perhaps the most pervasive is Value At Risk, or VAR. The ideas behind measuring risk in financial instruments are very similar to the kinds of risks shared between parties in performance contracts. Such VAR calculations could become the basis for applying a confidence to savings estimates and subsequently providing risk-adjusted savings values.

The basis of VAR and risk-adjusted savings calculations is the idea that the relevant data in an energy savings calculation are not singular data points but distributions. The source of the distribution can be metered data from similar projects or buildings, or the results of models. Larger scale distributions (whole building end use intensities) have been developed for benchmarking entire buildings.

While several companies have developed databases of retrofit performance and building indices, there is no national repository for this information. Such a repository could benefit the entire energy efficiency industry by supporting what is known and allowing

ESCOs to focus future measurements where there is the greatest potential to reduce uncertainty.

An offshoot of VAR is the need for industry accepted standards for benchmarking and performing due diligence of savings estimates. A coordinated national database would allow all parties to build confidence in the energy efficiency industry.

Issue - M&V and Emission Reductions

Concern over the environmental impacts of energy use has contributed to policy initiatives for reducing emissions of greenhouse gases and air pollutants such as NOx and SOx. Energy efficiency projects are recognized as attractive opportunities to reduce greenhouse gas emissions under the Kyoto Protocol (Swisher 1998; Vine & Sathaye 1999) and to provide NOx and SOx emission-trading credits (EPA 2000). Measurement and verification guidelines for emissions reductions are necessary in order to include energy efficiency projects in emissions crediting programs. Guidelines are being developed by various parties that address a range of issues beyond the direct energy savings that result from a project. Three of these efforts originate at Lawrence Berkeley National Laboratory (LBNL), the World Bank, and the U.S. Environmental Protection Agency (EPA).

Researchers at LBNL, with support from the EPA and U.S. Department of Energy, have developed a framework for the measurement and verification of energy efficiency projects through joint implementation and the Clean Development Mechanism under the Kyoto protocol (Vine & Sathaye 1999). These "MERVC" guidelines address monitoring, evaluation, reporting, verification, and certification of energy efficiency projects. The MERVC guidelines provide an overview of M&V issues unique to greenhouse gas emissions reduction projects and provide broad guidelines that may be tailored to particular circumstances. Upcoming work at LBNL will result in a procedural handbook that provides guidance on specific measurement and evaluation methods to complement the general guidelines.

The World Bank is developing a separate set of guidelines to support the trading of carbon emissions reductions through the Prototype Carbon Fund (PCF). This fund, established in January 2000, provides the first market-based mechanism to promote the transfer of greenhouse gas emission reduction credits between countries as envisioned under the Kyoto Protocol. The World Bank anticipates investing approximately $150 million in 20 projects over the next three years. While the PCF will likely target renewable energy projects (World Bank 2000), energy efficiency projects are recognized as potential participants, and two energy efficiency projects have been chosen as pilots to better define M&V procedures. The PCF framework is similar to the MERVC guidelines, but is organized according to project "validation, monitoring, verification, and certification."

Parallel efforts to define M&V protocols are being developed to monitor emissions reductions of NOx and SOx by the EPA. The EPA has proposed regulations associated with state implementation plans under the Clean Air Act to reduce NOx emissions from state facilities in areas that fail to meet national air quality standards. The regulations are called the NOx SIP (State Implementation Plan) Call regulations. The EPA has enabled states to use energy efficiency and renewable energy projects to free up allowances that amount to approximately 5 to 15 percent of the state's total NOx emission allowances allocated by the

EPA for electricity generation. The EPA also allows utilities to use energy efficiency and renewable energy projects as a source of SO_2 emissions allowances. The EPA has established M&V guidelines in the past for its SOx programs and is currently drafting a document entitled *Measuring and Verifying Energy Efficiency and Renewable Energy in a Set-Aside Program* that explains how to adapt existing M&V protocols for use in the program. At this time the EPA is relying on the IPMVP as the framework for M&V and will allow states to develop their own guidelines (EPA, 2000).

Next Steps for Documenting Emissions Reductions from Energy Efficiency

As interest in using energy efficiency to reduce pollutant emissions grows, there will be an increasing need to better define related M&V methods. These M&V methods must address several important issues:

- **Cost-effectiveness.** The value of emission reductions may be very small. The PCF's target price of carbon ($20/ton) corresponds to approximately $4 per MWh saved (Swisher, Renner & Shepard 1999), which is far below incentive rates typically provided through utility-sponsored energy efficiency programs. To be cost-effective, the M&V process must be very inexpensive.
- **Determination of baselines.** The definition of the appropriate baseline under the "no-project" scenario can be very controversial. Baselines must exclude "free riders" that would have undertaken energy efficiency activities even if there had been no project. Under the World Bank's PCF, determination of baseline can include economic analysis to estimate private sector investment that would have occurred in the absence of the project and associated GHG emissions.
- **Monitoring domain.** Emission reductions are usually defined within a specific boundary, or domain. With energy efficiency, the domain can include both the site where the energy efficiency project is implemented as well a myriad of power plants that produce power for consumption at the site. Beyond this, consideration of issues such as free-ridership can result in the need for countrywide or regional domains. All of this indicates that emissions M&V can call for monitoring and analysis well beyond a project site's boundary.
- **Common Documentation and Reporting Criteria.** Since emission credits should be equivalent irrespective of their source or their location it is important that a common set of protocols, documentation requirements, and reporting formats be established. One example is the need to establish a consensus approach for discounting energy savings estimates (e.g., perhaps based on measurement methodologies, amount of uncertainty, etc.).
- **Multiple reporting**. Monitoring can take place and be reported at the project level or at an aggregate level for a program, organization, or government. Decisions will be required to limit double counting of savings at different levels.
- **Independent M&V certification**. Independent verification is generally recognized as necessary to ensure the credibility of monitoring results. Guidelines will need to establish the credentials and certifications of organizations that may be performing monitoring and verification activities. In addition, Accreditation organizations may be needed for certifying verification organizations.

Energy Efficiency/Emissions M&V Guidelines

Trading of emissions credits is becoming a preferred mechanism to improve air quality in the United States and to decrease greenhouse gas emissions internationally. M&V guidelines will be critical to establishing the credibility and ultimate success of emissions trading mechanisms. The challenge will be to create guidelines that are flexible enough to apply to a wide range of projects, but that can be simply tailored for individual projects and programs. The IPMVP is recognized as a starting point for verifying the energy savings that result from energy efficiency projects. Yet, much work remains to address the broader economic, social, and institutional issues related to emissions reduction projects. A framework of M&V based on deemed savings, simple M&V, and complex M&V will provide the proper balance between competing political, economic, and technical issues.

Conclusions

M&V is an evolving field in which significant progress has been made in establishing a common framework for M&V and raising the quality of the state of the art. In terms of future development there is an overarching needs for better guidance on defining the appropriate levels of M&V for given program and project objectives. Supporting this need will be efforts to better define the IPMVP's Options, quantify uncertainty, create databases of M&V results, and improve M&V methods in applications such as determining the emissions reductions associated with energy efficiency projects.

References

ASHRAE News Release, March 17, 2000, www.ashrae.org.

EPA, 2000, "Creating an Energy Efficiency and Renewable Energy Set-Aside in the NOx Budget Trading Program", Climate Protection Division, U.S. Environmental Protection Agency, EPA-430-K-00-004, April, 2000.

FEMP, 2000, Federal Energy Management Program Measurement and Verification Guideline, July, 2000, available at http://www.eren.doe.gov/femp/financing/measguide.html.

FEMP, 2000a Federal Energy Management Program Business Plan, available at http://www.eren.doe.gov/femp/aboutfemp/business_plan/fempbusinessplan.html.

IPMVP, 2000, International Performance Measurement and Verification Protocol website www.ipmvp.org, accessed March, 2000.

IPMVP, 1997, International Performance Measurement and Verification Protocol, U.S. Department of Energy, DOE/EE-0157, December, 1997, available at www.ipmvp.org

Jump, David A., Johnson, Devan A., and Farinaccio, Linda, "A Tool to Help Develop Cost-Effective M&V Plan," ACEEE Summer Study, 2000.

NEMVP, 1996. North American Measurement and Verification Protocol, U.S. Department of Energy, 1996.

Public Utilities Commission of Texas, Substantive Rules. Chapter 25. Electric, March, 2000.

Reeves, George, Guideline 14P Seminar, ASHRAE Annual Meeting Technical Program, June, 1999, Seattle, WA.

Schiller, Steven R. and Charles A Goldman, "Public Benefit Charge Funded Performance Contracting Programs - Survey and Guidelines", ACEEE Summer Study, 2000.

Schiller, Steven and J. Stephen Kromer, "Measurement and Verification Protocols – Facts and Fiction, News from the Field", ACEEE Summer Study, 1997.

Swisher, Joel. 1998. "Carbon Offset Accounting and Monitoring of Emission Reductions in Energy Efficiency Projects." Presented at the 1998 ACEEE Summer Study.

Swisher, Joel. R Renner and M. Shepard. "1999. Companies Act on Climate Change". E Source: Boulder, Colorado.

TECC 1998. "Texas Energy Performance Based Contracts", Texas Energy Coordination Council, September 4, 1998, http://tecc.ces.utexas.edu/index.html

TXU. 2000. Texas Electric Utility and Gas Company, TEEM Program website, www.txuefficiency.com, accessed June, 2000.

Vine, E and J. Sathaye. 1999. Guidelines for the Monitoring, Evaluation, Reporting, Verification, and Certification of Energy-Efficiency Projects for Climate Change Mitigation. LBNL-41543. Lawrence Berkeley National Laboratory: Berkeley, California.

World Bank. 2000. "World Bank Launches First-of-Its-Kind Market-Based Carbon Fund." News release (January 18). Available at www.prototypecarbonfund.org. Accessed March, 2000.