Title

The Role of Measurement and Verification (M&V) in Managing Risks in Energy Efficiency Investments

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The Role of Measurement and Verification (M&V) in Managing Risks in Energy Efficiency Investments

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1.0 Introduction

Energy and water efficiency projects meet a range of objectives, including upgrading equipment, improving performance, helping to achieve environmental compliance, or simply saving energy and money. All projects have one thing in common, an initial financial investment. The type of investment may be an internal allocation of funds (in-house project) or it may be a complex contractual agreement with an ESCO and/or third-party financial institution. A lack of resources to implement costly capital intensive infrastructure improvement projects such as replacement of old chiller, installation of variable speed drives, upgrading the lighting system, etc. has led to an increase in third-party financed projects.

All types of financial investments have a common goal - making money or a "return" on investment. Investment performance is measured by various financial yardsticks such as simple payback, return on investment, or internal rate of return. The expected rate of return is governed by the risk associated with the investment. Typically, the higher the project risk, the greater the return demanded. Risk takes a variety of forms in efficiency projects. Most risks can be identified and managed. The premiums for many risks associated with investing in energy or water efficiency project can be measured using tools common to the finance industry, such as internal rate of return or customer credit-worthiness.

Measurement and verification (M&V), sometimes also referred to as monitoring and verification, is a process, which is used to determine energy and demand savings. The primary application of measurement and verification is in those energy efficiency projects where the return on the capital investment is tied to the projected energy savings that will be achieved. Measurement and verification of energy savings becomes a central part of a contract if the contract payments or performance guarantee in a project is dictated by the magnitude of the energy savings that will result from the implementation of a set of energy efficiency measures e.g. the installation of an energy management control system, installation of a variable frequency drive, etc. M&V is primarily focused on risks that affect the measurement or determination of savings from energy or water efficiency programs. These risks are defined in the terms of the contracts between the participants.

2.0 Basic Concepts

Energy or demand savings are determined by comparing measured energy use or demand before and after implementation of an energy savings program (IPMVP 2001a).

Energy Savings = (Baseline Energy Use) – (Post-Retrofit Energy Use) +/- (Adjustments)

While the above equation is relatively simple in concept, the "Adjustments" term can be extremely complex and difficult to apply in practice. Adjustments term in the above equation brings energy use in the two time periods – before and after the implementation of energy efficiency measures – to the same set of conditions. Adjustments may be positive or negative and can be applied either to the baseline energy use or post-retrofit energy use. Adjustments are commonly made to re-state baseyear energy use under post- retrofit conditions. Such adjustment process yields energy savings estimates, which are often described as "avoided energy use" because the actual energy reduction can never be measured. The level of such savings are dependent on performance of the measures and on post-retrofit period operating conditions. Conditions commonly affecting energy use are weather, occupancy, building changes, plant throughput, and equipment operations. Adjustments, as a matter of rule, are derived from identifiable physical facts. The adjustments are made either routinely such as for weather changes, or as necessary such as when a second shift is added, occupants are added to the space, a new wing is added to the building, or with increased usage of electrical equipment in the building.

When planning the M&V process, it is helpful to consider the nature of the facility's energy use pattern, as well as impact from the energy efficiency measures sometimes also referred as Facility Improvement Measures (FIMs). Consideration of the amount of variation in energy use patterns, which is influence by both the load and operating hours, and the delta change that needs to be verified will help to establish the amount of effort needed to determine savings. The following three examples show the range of scenarios that may arise:

1. Lighting project where lamps and ballasts in an office building are changed, but the operating hours of the lights do not change. This energy efficiency measure reduces load without changing its operating hours.
2. Automatic controls shut down air handling equipment or lighting during unoccupied periods. This energy efficiency measure reduces operating hours while load is unchanged.
3. Installation of a more efficient chiller together with a new control strategy for resetting of chilled water temperature, thereby reducing chiller load and operating periods. This energy efficiency measure reduces both load and operating hours.

Since both equipment/system load and its operating hours can be constant or variable, different M&V strategy is required for different conditions. Generally, conditions of variable load or variable operating hours require more rigorous measurement and computation procedures and subsequently are more resource and time intensive.

It is important to estimate costs and effort associated with completing metering and data analysis activities. Time and budget requirements are often underestimated leading to incomplete data collection. It is better to complete a less accurate and less expensive M&V plan for savings determination than to have an incomplete or poorly done, yet theoretically more accurate determination that requires substantially more resources, experience and/or budget than available.

Table 2 below describes the four M&V options and their typical applications and has been excerpted from IPMVP (IPMVP, 2001a).

Table 2: M&V Options

IPMVP Options	Description	Typical Applications
A. Partially Measured Retrofit Isolation	Savings are determined by partial field measurement of the energy use of the system(s) to which an ECM was applied, separate from the energy use of the rest of the facility. Measurements may be either short-term or continuous. Some but not all parameters may be stipulated.	Lighting retrofit where power draw is measured periodically. Operating hours of the lights are assumed to be one half hour per day longer than facility occupancy hours.
B. Retrofit Isolation	Savings are determined by field measurement of the energy use of the systems to which the ECM was applied, separate from the energy use of the rest of the facility. Short-term or continuous measurements are taken throughout the post-retrofit period.	Application of controls to vary the load on a constant speed pump using a variable speed drive. Electricity use is measured by a kWh meter installed on the electrical supply to the pump motor.
C. Whole Facility	Savings are determined by measuring energy use at the whole facility level. Short-term or continuous measurements are taken throughout the post-retro-fit period.	Multifaceted energy management program affecting many systems in a building. Energy use is measured by the gas and electric utility meters for a twelve month baseyear period and throughout the post-retrofit period.
D. Calibrated Simulation	Savings are determined through simulation of the energy use of components or the whole facility. Simulation routines must be demonstrated to adequately model actual energy performance measured in the facility. This option usually requires considerable skill in calibrated simulation.	Multifaceted energy management program affecting many systems in a building but where no baseyear data are available. Baseyear energy use is determined by simulation using a model calibrated by the post-retrofit period data.

2.1 M&V Planning

Figure 1 below provides a M&V planning framework (FEMP, 2003b) and lists key decision points from the inception of the project to the development of the M&V plan.

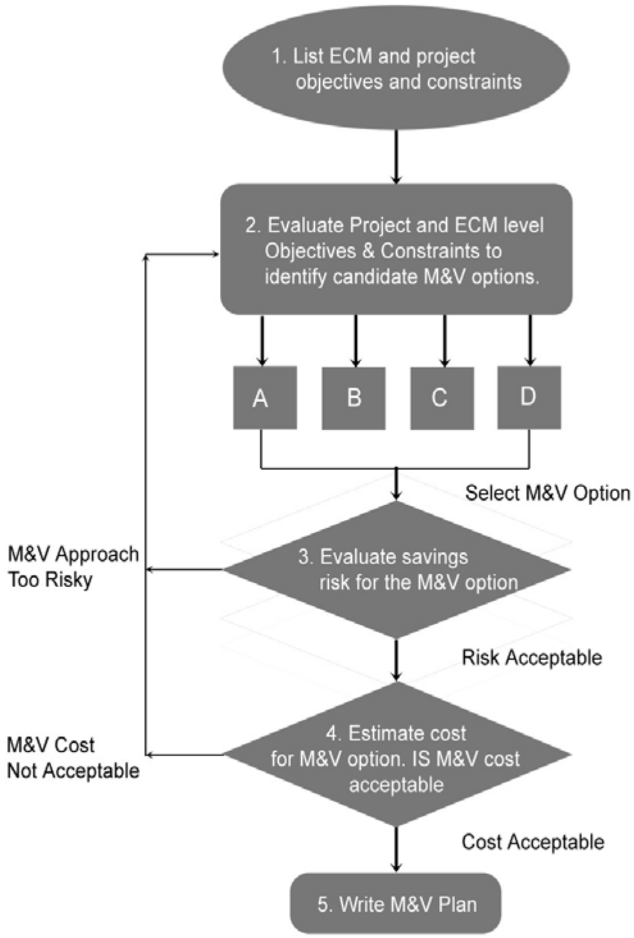

Figure 1: M&V Planning Flowchart

The M&V Planning Flowchart assumes that a detailed energy survey has been performed and a credible energy baseline energy use has been established by following industry best practices for conducting energy audits (ASHRAE 2004).

Step 1 entails developing objectives for the project's M&V program.

Examples of typical objectives are a) Ability to track energy savings through utility metering; b) Ability to Verify Energy Performance Continuously; c) Track Post-Retrofit Consumption and Adjust Baseline for Changes; d) Maximize Infrastructure by using Least-Cost M&V Option.

Examples of typical constraints are a) Historical utility data not available; b) Lack of dedicated utility meters; c) High degree of interaction between FIMs; d) Scope of FIMs affects a small percentage of total utility bill.

Step 2 entails evaluating project and ECM level objectives and constraints to identify the most appropriate M&V Option. Check to determine if a single M&V Option can be used and is desirable for the entire project or if a more custom M&V approach is required for the proposed set of measures.

Step 3 entails evaluating the savings risk associated with the selected M&V Option/s. To perform this exercise, a custom list of risk elements should be developed based on project and EEM specifics[1]*. See discussion under Section 4: M&V as a Risk Management Tool.*

Examples of risk elements include operating hours, Environmental/process loads, degradation of savings, weather, building occupancy, major changes to the facility, savings risk associated with the performance of O&M, repair & replacement, etc.

Step 4 entails estimating the cost of using the M&V Option/s in relation to savings risks. Do the M&V requirements and the savings risk justify the M&V expenses? If not, return to Step 2.

Step 5: If all the M&V requirements are met and the savings risk justifies the M&V expenses, proceed with the development of the M&V plan for the project.

2.2 The All-Important M&V Plan

The preparation of an M&V Plan is central to proper savings determination and the basis for verification. A good M&V plan, at a minimum, should include the following information (IPMVP, 2001a):

- Description of the Energy Conservation Measure and its intended result.
- Identification of the boundaries of the ECM for savings determination.
- Documentation of the facility's baseline conditions and resultant baseline energy data.
- Identification of any planned changes to conditions of the baseline
- Identification of the post-retrofit period.
- Establishment of the set of conditions to which all energy measurements will be adjusted.
- Specification of which Option will be used to determine savings
- Specification of the exact data analysis procedures, algorithms and assumptions.
- Specification of quality assurance procedures.
- Specification of how results will be reported and documented.
- Specification of the data that will be available for another party to verify reported savings, if needed.
- Definition of the budget and resource requirements for the savings determination, both initial setup costs and ongoing costs throughout the post-retro-fit period.

Savings are a function of both performance and usage factors. Selecting which factors to measure (or not) depends on how the risks should be allocated between parties. If we consider

[1] Since the development of the M&V Planning Tool, new thinking within FEMP favors identifying and allocating different risk factors (that can result in a shortfall of energy savings) to the customer or contractor in Step 1 and Step 2 itself. That way, the M&V plan can be developed to mitigate those risks for which the contractor/ESCO is responsible.

the energy use as the product of performance of the equipment/system and its usage, savings result from a reduction in one or both factors. Figure 3 illustrates this concept graphically:

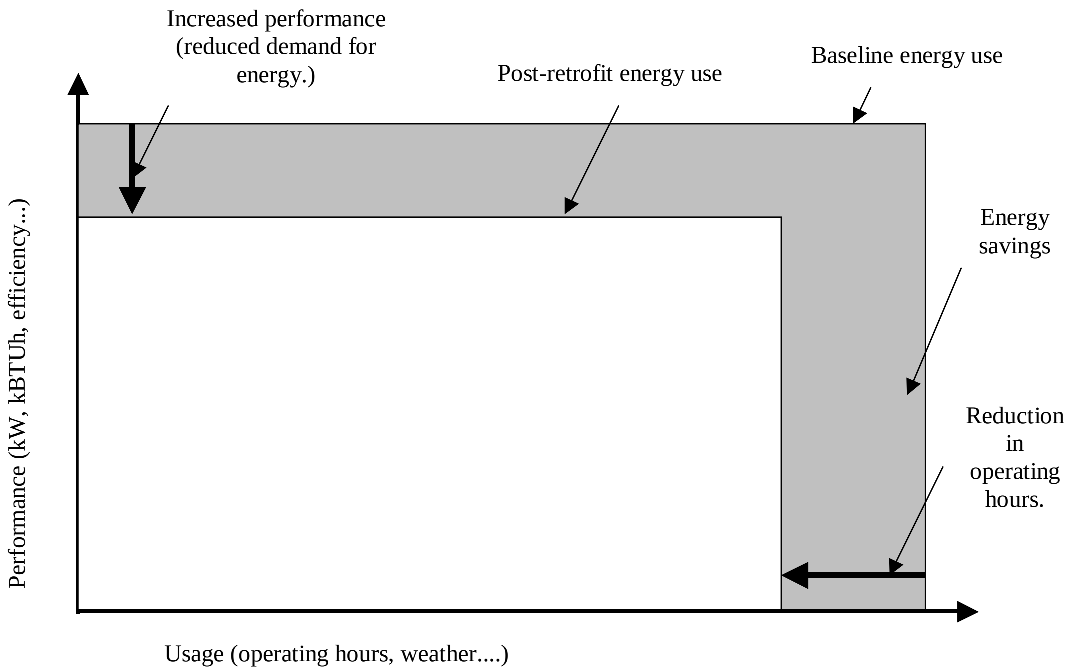

Fig. 3: Baseline and Post-Retrofit Energy Use

The larger rectangle represents the baseline energy use. Increases in performance (reductions in demand) and/or reductions in operating hours reduce the energy use of the affected system. The energy savings are the difference in area between the two rectangles, shown here in grey.

3.0 M&V Protocols, Guides, and Tools

Guidance on developing a good measurement and verification plan that meets the requirements of energy efficiency projects is available at many levels. At the top level, there are protocols and guidelines that offer high-level guidance by defining the various M&V Options, contents of a good M&V plan, a set of standard terms that are used across the industry, and a framework, which can be filled in with details. The three most important documents in this category are:

1. *International Performance Measurement and Verification Protocol (IPMVP 2001a, IPMVP 2001b):*

- Is a savings verification tool whose principles are applicable to commercial and industrial energy conservation measures. It can also be used for determining water savings and improving indoor environmental quality (IEQ) in buildings.
- Standardizes M&V terminology and the four M&V Options (A, B, C, and D) that are widely used for verifying results of energy efficiency, water efficiency, and renewable energy projects both at the "whole facility" level or at the individual technology level.

- Is a risk management tool that helps allocate risks between buyers and sellers of energy services by selecting an M&V approach that measures performance of variables that affect energy savings.
- Outlines M&V procedures that i) can be applied to similar projects throughout all geographic regions, and ii) are internationally accepted, impartial and reliable.
- Presents procedures, with varying levels of accuracy and cost, for measuring and/or verifying: i) baseline and project installation conditions, and ii) long-term energy savings.
- Provides a comprehensive approach (when both Volume I and II are used) to ensuring that building indoor environmental quality issues are addressed in all phases of ECM design, implementation and maintenance.
- Creates a living document that includes a set of methodologies and procedures that enable the document to evolve over time.

2. *Federal Energy Management Program's Measurement and Verification Guide (FEMP v2.2, 2000)*[2]*:*

- Serves as a reference document for specifying M&V methods and procedures in delivery orders, requests for proposals (RFPs), and performance contracts.
- Is a resource for those developing project-specific M&V plans for federal performance contracting projects.
- Is a discussion of performance contracting responsibility issues and how they affect risk allocation.
- Provides M&V guidelines including procedural outlines, content checklists, and option summary tables.
- Provides Measure-specific guidelines for developing an appropriate M&V Option for common measures.
- Lists new M&V strategies and methods for cogeneration, new construction, operations and maintenance, renewable energy systems, and water conservation projects.

3. *American Society of Heating, Refrigerating, and Air-Conditioning, Engineers Guideline 14 (ASHRAE 2002):*

- Provides guidance on minimum acceptable level of performance for determining energy and demand savings, using measurements.
- Provides additional details on methods equivalent to IPMVP Options B, C and D (ASHRAE uses slightly different terminology for some of these options).
- Covers the topic of physical measurements and determination of savings uncertainty in much greater detail as compared to the other two documents.
- Is an excellent reference manual for M&V techniques and engineering calculations for determining energy savings.

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[2] FEMP Option A Detailed Guide is a supplement to FEMP's M&V Guide. The document details the proper use of Option A, especially the use of stipulations in savings determination methods, in federal performance contracts, and includes specific recommended practices for the most common ECMs.

- Does not, in the opinion of the authors, provide the flexibility that may be required to develop a M&V plan that is tailored to managing the savings shortfall risks in a cost-effective fashion.

Table 1 helps illustrate the approach of the three documents on key issues that affect the development of the M&V plan:

Table 1: Comparison of IPMVP, FEMP M&V Guide, and ASHRAE Guideline 14

Topic	IPMVP	FEMP M&V Guide	ASHRAE Guideline 14
Stipulation[3] (see Section 3.1 for a detailed discussion on this topic)	Allows for limited stipulation under Option A.	Allows for limited stipulation under Option A. Certain M&V methods allow the use of entirely stipulated (i.e. unmeasured) values.	Does not allow the use of stipulation at all.
Purpose	Provides framework, language to allow parties to develop M&V plans for their projects/programs	Provides framework, language to allow parties to develop M&V plans for a specific program – FEMP's Super Energy Savings Performance Contracts.	Reliably measure the energy and demand savings in building energy management projects.
Issues pioneered by the documents	Standardized M&V terminology, provides industry accepted definitions of Options A, B, C, and D, and creates a framework for savings determination with broad applicability.	FEMP Option A Detailed Guide (supplement to FEMP M&V Guide) discusses how Option A methods and stipulations can be used to tailor the M&V plan to the responsibilities assumed by the two parties and how to make the M&V method work with, not against, the savings guarantee.	Brings in engineering rigor with prescriptive metering requirements and uncertainty calculation techniques without being encumbered by the arguments for cost-effectiveness of the M&V approach.
Contractual issues	Discusses contracts and risks in general terms and how they can affect the development of M&V strategies.	Emphasizes contractual and risk allocation issues because it was developed to provide guidance on M&V requirements for a very specific contract. The development of M&V plan, to a large extent, is developed keeping in mind the risk allocation between and the responsibilities of the customer and the contractor.	Does not address contractual clauses and risk and responsibility allocation in providing guidance on the development of the M&V plan.

[3] Although stipulation is dealt differently in the three documents, in practice, it is almost impossible to develop a M&V plan for savings determination that does not use stipulation to some extent.

Adherence/ Compliance	Defines adherence in terms of creating an M&V plan that is acceptable to both parties within the terms of the contract in force.		Defines compliance as a target for measurement accuracy of savings calculations. Provides guidance on 4 compliance paths and associated target accuracy.

3.1 Treatment of Stipulation

Allowing use of stipulations for certain parameters in the determination of energy savings means that the contractor and the customer agree to use a set value for a parameter throughout the term of the contract, regardless of the actual behavior of that parameter.

IPMVP and FEMP M&V guide have always had an Option A to provide a low-cost M&V method where the primary activity is to verify that an ECM has the *potential to perform*. The intent of Option A is to use a combination of spot measurements, stipulated values based on historical data or reasonable assumptions, and periodic (annual) inspections to verify that an ECM was installed and is working properly. Option A was never intended to be used as the 'stipulate the savings' method. However, the provision that allows savings from some measures (especially lighting) to be completely stipulated based on assumptions, industry standards, and estimated values has often been misinterpreted to suggest that Option A allows the savings to be stipulated.

In an effort to clarify the intent of Option A, the latest version of the IPMVP significantly changed the definition of Option A and modifies the definition of the word 'stipulate.' Emphasis is placed on spot or short-term measurements (periodic) by changing the name of the method to *partially-measured retrofit isolation*. To meet the intent of this Option A definition, *at least one parameter must be measured*, preferably the one that contributes the most to the uncertainty in the energy savings calculations. The unmeasured parameters are based on the best-available information. Parameters that are not measured are considered *stipulated* and are held constant during the performance period. For example, energy savings from a lighting retrofit would be based on the periodic *measurement* of operating hours and *stipulated* fixture wattages values from a standard table.

The FEMP M&V Guide was released in 2000, and prior to the release of latest version of IPMVP in early 2001. It is intended to be an application of IPMVP, but the presence of M&V methods LE-A-01 (lighting efficiency), LC-A-01 (lighting controls), CH-A-01 (chiller retrofit), and WCM-A-01 (water conservation measures) allow the use of entirely stipulated (i.e. unmeasured) values. These methods are now not consistent with the IPMVP guidelines since they do not require periodic measurements of at least one parameter. In all cases, Option A still requires annual verification activities to demonstrate the *potential to perform*.

Although the FEMP M&V Guide is intended to be an application of IPMVP, the two protocols have differing intents. IPMVP intends that M&V should minimize the uncertainty in the savings estimate; FEMP intends that risk be allocated to the responsible party and the development of the M&V plan takes that into account by requiring the contractor to continuously monitor variables for which the contractor is responsible (e.g. a performance/efficiency variable). FEMP also allows for more flexibility and discretion in selecting an appropriate and low-cost M&V approach. Using stipulated values for determining savings can be a practical, cost-effective way to minimize M&V costs. When used appropriately, stipulation does not jeopardize the savings guarantee, the customer's ability to pay for the project, or the value of the project to the government. It does, however, shift some risks to the customer. These risks should be thoroughly and properly understand by the customer before accepting them. Risk is minimized through carefully crafted M&V requirements including diligent estimation of the stipulated values.

While the protocols and guides provide general guidance on the M&V approach and the key attributes of a good M&V plan, they cannot provide more specific guidance because the M&V requirements of different programs are unique and have to be addressed at the program level. The next two documents were developed to provide detailed guidance to the contractors working under the FEMP's Super Energy Saving Performance Contracting (Super ESPC) program.

3.2 FEMP M&V Plan Outline

The *FEMP M&V Plan Outline* (FEMP, 2004a) was developed by the Federal M&V Team[4] and is recommended for use in the development of all measurement and verification plans in FEMP's Super ESPC projects.

The M&V plan is the most important item in an energy savings performance contract. The project specific M&V plan includes project-wide items, and details for each ECM, including:

- Details of baseline conditions and data collected
- Documentation of all assumptions and sources of data
- What will be verified
- Who will conduct the M&V activities
- Schedule for all M&V activities
- Discussion on risk and savings uncertainty
- Details of engineering analysis performed
- How energy and cost savings will be calculated
- Detail any operations & maintenance (O&M) cost savings claimed
- Define O&M reporting responsibilities
- Define content and format of all M&V reports (Post-Installation, Commissioning, Annual or periodic)
- How & why the baseline may be adjusted

[4] Federal M&V Team consists of M&V experts from federal agencies, DOE's national research laboratories, and ESCOs who come together to address key M&V issues facing the federal ESPC program and develops guidance documents, tools, training materials to help standardize M&V requirements and reporting across all the federal agencies.

3.3 FEMP Annual M&V Reports

The *FEMP Annual Report Outline* (FEMP, 2003a) was developed by the Federal M&V Team as a recommended report template for periodic performance reports in federal ESPC projects.

At the end of each year during the performance period, the contractor submits an Annual Performance Report to demonstrate that the savings have been achieved. For Super ESPCs, M&V only needs to show that the overall savings guarantee has been met, not determine 'actual' savings for each ECM.

The Annual Report should include sections on the:

- Results/documentation of performance measurements and inspections
- Realized savings for the year (energy, energy costs, O&M costs, other)
- Comparison of actual savings to the guaranteed amounts
- Details of all analysis and savings calculations, including commodity rates used
- Summary of operations and maintenance activities conducted
- Details of any performance or O&M issues that require attention

4.0 M&V as a Risk Management Tool

While M&V started as a specialized topic under energy efficiency, in recent times it is starting to combine financial risk management with engineering analysis. The early drivers for developing a good M&V plan as part of any energy efficiency projects were as follows:

- Enhance the level of energy savings and ensure their persistence over a long term;
- Reduce project risks;
- Encourage better project engineering;
- Help demonstrate and capture the value of reduced emissions from energy efficiency and renewable energy investments.

One of the reasons M&V has become more important especially in third-party financed performance based projects is because it helps facilitate allocation of risks between the two parties. The general approach should be to identify the short and long term risks to maintaining the proper function and the savings of the retrofits, and then to determine a cost effective approach to minimizing these risks through the development of an M&V plan and other clauses in the contract. Allocation of risk is accomplished through carefully crafted M&V strategies. A good M&V plan should reduce risk to the contractor on savings disagreements and interrupted payments and should assure the client that the guaranteed savings will be realized.

As shown in the Figure 2, "Risk" in the M&V context refers to the uncertainty that expected savings will be realized. The red arrow demonstrates that there is a range associated with the calculation of baseline energy consumption, savings determination, and even ESCO payment, which is based on the actual realization of the energy savings.

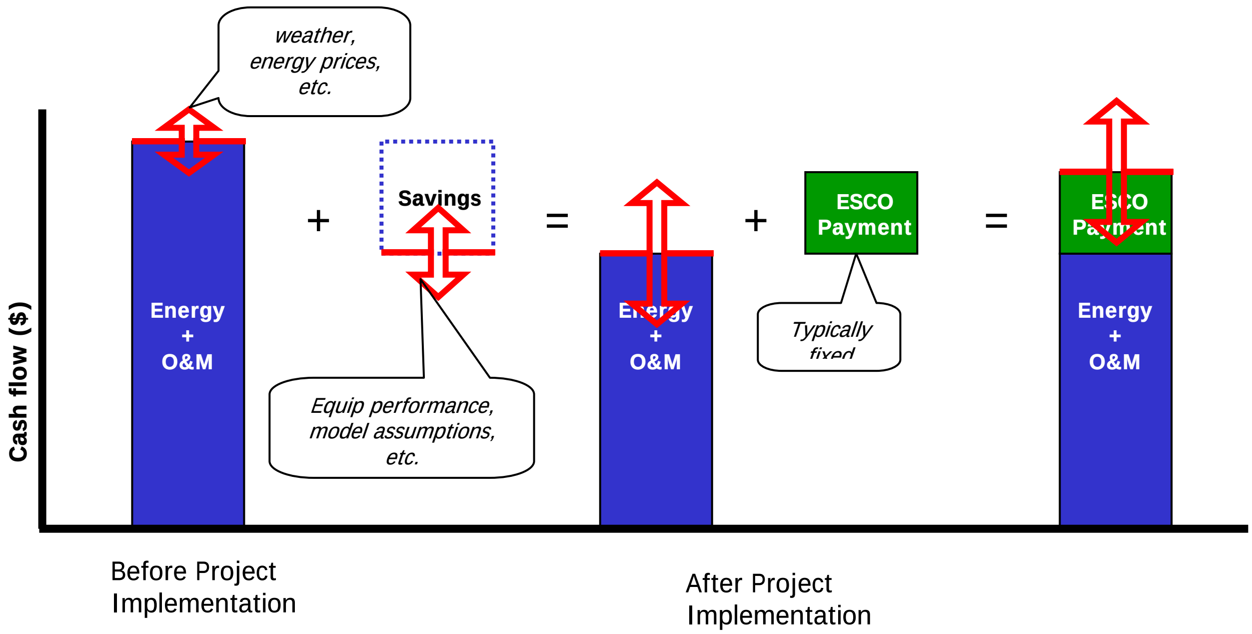

Fig. 2: Uncertainties Associated with Determination of Energy Savings in the ESPC Model

Assumption of risk implies acceptance of the potential monetary consequences. Both ESCOs and agencies are reluctant to assume responsibility for factors they do not control, and measuring some parameters while others in the M&V plan can match up responsibilities. Since determination of energy savings is dependent on both the performance and usage factors, it is important to allocate the responsibility of both performance and usage parameters during the project planning stages because that will have a significant bearing on the M&V approach selected in the plan.

Performance risk is the uncertainty associated with characterizing a level of equipment performance. The ESCO is ultimately responsible for selection, application, design, installation, and maintenance of the equipment and typically assumes responsibility for achieving savings related to equipment performance. To validate performance, the ESCO must demonstrate that the equipment is operating as intended and has the potential to deliver the guaranteed savings. On the other hand, usage factors such as lighting operating hours and thermostat setpoints are typically under the customer's control. Risk related to usage stems from uncertainty in operational factors. For example, savings fluctuate depending on weather, how many hours equipment is used, user intervention, or maintenance practices. Since ESCOs often have no control over such factors, they are usually reluctant to assume usage risk. The customer generally assumes responsibility for usage risk by either allowing baseline adjustments based on measurements, or by agreeing to stipulate equipment operating hours or other usage-related factors.

As discussed in Figure 1: M&V Planning Flowchart and the accompanying discussions, more attention is now focused on identifying all the risk elements and how they can affect the development of the M&V plan. This has resulted in a much broader discussion of risk elements, allocation of those risks, and how the M&V approach can help in mitigating those risks. This has major implications for how the M&V plan is developed. FEMP has developed a Risk/Responsibility matrix (FEMP, 2004b) that identifies major risk elements in an energy savings performance contract and requires that the ESCO and the customer agree on a plan to manage those risks. A similar approach is recommend in all contracts where M&V forms the basis of future payments. A brief discussion of these risk elements (grouped together in three major categories) is provided below for readers to get a better understanding of the relationship between these risk factors and M&V. These risk elements have been excerpted from FEMP's Risk and Responsibility matrix document (FEMP, 2004b).

4.1 Financial Risks

Interest Rates: This is one of the major parameters that determine the viability of a project. Although neither party has much control over prevailing interest rates, the timing of the contract (as well as the time it takes to finalize the contract) can have significant impact on the total cost of the project. Clarifying when the interest rate is locked in, and if it is a fixed or variable rate will be helpful. It should also be clear whether there are any pre payment penalties for total of partial payoff the loan. *M&V plan will not affect the financial risks associated with interest rates.*

Energy prices: Neither the Contractor nor the customer has significant control over actual energy prices but it has tremendous implications for the M&V plan and the projected savings. For calculating savings, the value of the saved energy may either be constant, change at a fixed inflation rate, or float with market conditions. If the value changes with the market, falling energy prices place the contractor at risk of failing to meet cost savings guarantees. If energy prices rise, there is a small risk to the customer that energy saving goals might not be met while the financial goals are. If the value of saved energy is fixed (either constant or escalated), the customer risks making payments in excess of actual energy cost savings. Clarifying how future energy costs will be treated helps in adopting a uniform policy towards savings calculations from the very beginning and answering any questions that will crop up at a later date. *In a nutshell, the energy prices used in the M&V plan will determine the overall magnitude of energy savings, which can influence the resources available for the M&V of the energy savings for the project.*

Construction costs: In general, the contractor is responsible for determining construction costs and defining a budget. In a fixed-price design/build contract, the customer assumes little responsibility for cost overruns. It is important to clarify design standards and the design approval process (including changes) and how costs will be reviewed. *M&V plan will not affect the financial risks associated with construction costs.*

M & V costs: The customer assumes the financial responsibility for M & V costs directly or through the Contractor. If the customer wishes to reduce M & V costs, it may do so by accepting less rigorous M & V activities with more uncertainty in the savings estimates. Clarify what performance is being guaranteed (equipment performance, operational factors, energy cost savings) and that the M & V plan is detailed enough to satisfactorily verify it. *This will have a major bearing on the M&V approach selected for the project because the number of parameters that can be measured and the frequency of measurements, analysis required to support reasonable use of stipulated values will be affected by the resources available for developing the M&V plan, measurement and subsequent analysis.*

Major changes in facility: The customer controls major changes in facility use, including closure. Clarify responsibilities in the event of a premature facility closure, loss of funding, or other major change. *This can significantly alter the baseline that is used for energy savings determination and proper documentation of the major changes in facility is critical to avoid disagreements between the two parties.*

4.2 Operational Risks:

Operating hours: The Customer generally has control over the operating hours. Increases and decreases in operating hours can show up as increases or decreases in "savings" depending on the M & V method (e.g. operating hours times, improved efficiency of equipment vs. whole building, utility analysis). Clarify if operating hours are to be measured or stipulated and what the impact will be if they change. If the operating hours are stipulated, the baseline should be carefully documented and agreed to by both parties. *The M&V plan must be developed to account for the risks associated with the variation in operating hours and who has control over them.*

Load: Equipment loads can change over time. The customer generally has control over hours of operation, conditioned floor area, intensity of use (e.g. changes in occupancy or level of automation). Changes in load can show up as increases or decreases in "savings" depending on the M & V method. Clarify if equipment loads are to be measured or stipulated and what the impact will be if they change. If the equipment loads are stipulated, the baseline should be carefully documented and agreed to by both parties. *The M&V plan must be developed to account for the risks associated with the variation in equipment load and its contribution to the overall energy savings calculation.*

Weather: A number of energy efficiency measures are affected by weather. Neither the Contractor nor the customer has control over the weather. Changes in weather can increase or decrease "savings" depending on the M & V method (e.g. equipment run hours times efficiency improvement vs. whole building utility analysis). If weather is "normalized," actual savings could be less than payments for a given year, but will "average out" over the long run. Clearly specify how weather corrections will be performed. *Weather can have a profound influence on the successful (or unsuccessful) realization of energy savings and the M&V plan must clearly lay out the conditions under which weather will be normalized and the assumptions/technique that will be used during the process.*

4.3 Performance Risks

Equipment performance: Generally the Contractor has control over the selection of equipment and is responsible for its proper installation, commissioning, and performance. Generally the Contractor has responsibility to demonstrate that the new improvements meet expected performance levels including specified equipment capacity, standards of service, and efficiency. Clarify who is responsible for initial and long-term performance, how it will be verified, and what will be done if performance does not meet expectations. *The M&V plan must be developed to account for the risks associated with the variation in equipment performance and its contribution to the overall energy savings calculation.*

Operations: *Responsibility for operations is negotiable and, in general, will impact performance. Clarify responsibility for operations, the implication of equipment control, how changes in operating procedures will be handled, and how proper operations will be assured.*

<u>Maintenance & Repair:</u> Responsibility for maintenance and repair is negotiable and, in general, will impact performance. *Clarify how long-term maintenance and repair will be assured, especially if the party responsible for long-term performance is not responsible for maintenance (e.g. Contractor provides maintenance checklist and reporting frequency). Clarify who is responsible for equipment overhaul or repair to maintain operational performance throughout the contract term.*

<u>Equipment Replacement</u>: *Responsibility for replacement of contractor-installed equipment is negotiable, however it is often tied to project performance. Clarify who is responsible for replacement of failed components or equipment throughout the term of the contract. Specifically address potential impacts on performance due to equipment failure. Life of equipment is critical to project performance during the contract term. Specify expected equipment life and warranties for all installed equipment. Clarify what will be done if inadequate maintenance or repair impact performance or results in warranty being void.*

5.0 Future Issues/Direction

Recent successes in energy-efficiency performance contracting and the development of standard M&V protocols, has made it possible to quantify energy savings (Negawatts) and structure financial deals based on the magnitude of energy savings. The presence of NOx and SOx trading market in the US and emerging carbon trading market across the globe are a couple of avenues to monetize quantified energy savings and in the process improve the return on investment on energy efficiency projects.

Although the energy efficiency community will not set the rules of trading, it is important to work with the environmental authorities and protocol development groups. It is expected that the authorities will establish rules in areas such as: rights of ownership, liability, disclosure/reporting, fungibility, certification, accuracy, baseline, additionality/surplus, double counting, etc. They must do this for all sorts of projects, not just energy efficiency projects, for many different types of trading philosophies. The energy efficiency community needs to understand how to present EE actions for claiming emission credits from reduced energy consumption trade.

More guidance on the following topics will help energy efficiency project developers to claim the benefits associated with reduced emissions from the implementation of energy efficiency projects:

a) Important of standardization to gather data and report savings;
b) Development of a baseline model to distinguish between average and marginal energy consumption;
c) Length of baseline period;
d) Different approaches for the M&V of energy savings and how to deal with the uncertainties inherent in different approaches;
e) Discussion on additionality criteria vis-à-vis EE projects;
f) Selection and application of appropriate emission factors to convert units of energy saved to units of emissions saved.

Much would depend on the environmental authorities around the world and the regulations that are put in place. It is imperative that the knowledge and experience gained from quantifying energy savings be put to good use to quantify emissions reductions from energy efficiency projects.

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References:

American Society of Heating, Refrigeration and Air Conditioning Engineers (2002). “Guideline 14 - Measurement of Energy and Demand Savings.” American Society of Heating, Refrigeration and Air Conditioning Engineers, Atlanta, GA.

American Society of Heating, Refrigeration and Air Conditioning Engineers (2004). “Procedures for Commercial Building Energy Audits.” American Society of Heating, Refrigeration and Air Conditioning Engineers, Atlanta, GA.

Federal Energy Management Program (2002). "Detailed Guidelines For FEMP M&V Option A." US Department of Energy. Electronic copy available at http://ateam.lbl.gov/mv.

Federal Energy Management Program (2003a). "FEMP Annual Report Outline." Electronic copy available at http://ateam.lbl.gov/mv.

Federal Energy Management Program (2003b). "FEMP M&V Planning Tool." Electronic copy available at http://ateam.lbl.gov/mv.

Federal Energy Management Program (2004a). "FEMP M&V Plan Outline." Electronic copy available at http://ateam.lbl.gov/mv.

Federal Energy Management Program (2004a). "FEMP Risk and Responsibility Matrix." Electronic copy available at http://ateam.lbl.gov/mv.

Federal Energy Management Program (2000). "M&V Guidelines: Measurement and Verification for Federal Energy Projects (version 2.2)." US Department of Energy, DOE/GO- 102000-0960. Electronic copy available at http://www.eere.energy.gov/femp/financing/espc/contract_tools.html.

IPMVP (2001a). “Volume I – Concepts and Options for Determining Energy and Water Savings.” International Performance Measurement & Verification Protocol, Inc., Washington, DC. Electronic copy available at www.ipmvp.org.

IPMVP (2001b). “Volume II – Concepts and Practices for Improved Indoor Environmental Quality.” International Performance Measurement & Verification Protocol, Inc., Washington, DC. Electronic copy available at www.ipmvp.org.