MEASUREMENT AND VERIFICATION GUILDELINES

# Overview

Measurement and verification (M&V) is the methodology, measurements, inspections, and mathematical calculations to determine before and after an energy performance contract is implemented (§90-4-1102(10), MCA). M&V may be for a single cost-saving measure or an entire building, depending on the M&V option selected. The M&V report may be for a single cost-saving measure or the entire project.

Montana statute requires M&V for a minimum of three years following completion of the energy performance contract (EPC) project. The cost for M&V is paid for by the Entity during the initial monitoring period. If there is a shortfall in savings for any year of this monitoring period, the qualified energy service provider (ESP) pays for M&V until 1) the guaranteed savings are met for consecutive years equal to the initial monitoring period or 2) the Entity and the ESP negotiate a settlement regarding the shortfall for all future years of the contract term.

The EPC will define the methods and options used for M&V. These are based on the latest version of the International Performance Measurement and Verification Protocol (IPMVP). FEMP has published M&V Guidelines: Measurement and Verification for Federal Energy Projects that includes procedures for applying the IPMVP.

The measurement and verification (M&V) process is divided into three phases:

1 Measurement and Verification Plan

2 Post-Installation M&V Plan and Report

3 Annual M&V Report

The phases are a progression from the investment grade audit (IGA) through the performance period of the contract. The later phases are dependent upon the earlier phases.

# Risk and Responsibility in M&V

One of the primary purposes of M&V is to reduce the risk of nonperformance to an acceptable level based on the Entity’s priorities and preferences. Risk refers to the uncertainty that the expected savings will be realized.

Fundamental principles that can be applied to the allocation of responsibilities in EPC contracts include:

* Logic and cost-effectiveness drive the allocation of responsibilities.
* The responsible party predicts its likely tasks and associated costs to fulfill its responsibilities and makes sure these are covered in the EPC or Entity’s budget.
* Any unforeseen costs are paid by the party that caused the costs or by the party responsible for that risk area.
* Stipulating certain parameters in the M&V plan can align responsibilities, especially for the items no one controls.

## Measured or Stipulated

Risks in achieving energy savings can be allocated to use and performance factors. Risk related to use stems from uncertainty in operational factors such as weather, hours of operation, user intervention, and equipment loads. Because the ESP often has no control over such factors, the ESP is usually reluctant to assume the risk. Risk related to performance factors is based more on measurements by the ESP. Although the measurements tend to shift some risk to the ESP, the M&V methodology often places the Entity at the greater risk.

The Entity generally assumes responsibility for the risk by either allowing baseline adjustments based on measurements or by agreeing to stipulated equipment operating hours or other use-related factors. By using stipulations, the ESP and Entity agree to a set value for a parameter for the term of the contract, regardless of the actual behavior of that parameter.

The use of stipulations is a way to reduce M&V costs and allocate risks. Stipulations used appropriately do not jeopardize the savings guarantee, the Entity’s ability to pay for the project, or the overall value of the project to the Entity. However, stipulations have the potential to shift risk to the Entity, and the Entity should understand the potential consequences before accepting them. Risk is minimized and optimally allocated through carefully crafted M&V requirements, including diligent estimation of any stipulated values.

Often stipulated values are based on undocumented values from the Entity or the ESP. Stipulated values with insufficient documentation should be avoided. Stipulated values must be based on reliable, traceable and documented sources of information, such as:

* Standard lighting tables from major manufacturers
* Equipment Manufacturer’s specifications
* Building occupancy schedules
* Maintenance logs
* Performance curves published by national organizations
* Weather data from government agencies
* Standard performance degradation curves

**Stipulated savings are not permitted as statute requires guaranteed savings to be measured.**  Cost-saving measures that have stipulated savings may be included in the EPC. However, their savings should not be considered in determining the cost-effectiveness of the project or in the verification of guaranteed savings.

## Risk and Responsibility Matrix

Risks and responsibilities are identified as part of the risk and responsibility matrix. The ESP is asked to describe their approach to reduce the risks associated with the project. Some of the requested matrix information is often found in other parts of the EPC contract, but this matrix helps to put the risk/responsibility information in one place.

To summarize the allocation of responsibility for key items related to M&V, the ESP should complete and include the matrix as part of the EPC contract.

## Impact of Measured versus Stipulated

Generally, the more parameters that are measured, the less uncertainty in the savings and consequently the risk to both the Entity and the ESP. However, with more measurements the cost for M&V is typically higher. Therefore, the ESP and the Entity must work together to optimize the risk-cost-benefit aspect of measurements.

## Examples of Measured and Stipulated in M&V

The Entity should be fully aware of the effect that measured and stipulated values have in the M&V process. Simply having a value measured does not mean that the resulting verification is accurate, or even reasonable. A few common examples will help address this issue.

**Lighting Replacement** – The typical M&V option is the IPMVP Option A: Retrofit Isolation: Key Parameter Measurement. The ESP will measure the wattage of a sampling of rooms or fixtures before and after the cost-saving measure is installed. The stipulated value is the hours of operation. The fixture savings are:

kW Savings = (Watts Before – Watts After) /1000 and

kWh Savings = kW Savings x Hours of Operation per Year

The total savings is the sum of the kW Savings and the sum of the kWh Savings for all fixtures. The total kW savings are then typically multiplied by 12 for annual kW savings.

Although this is common practice, a few points should be made to better manage the risk.

* + - 1. The sample for measurement should meet statistical requirements. Larger random sample sizes lead to less error.
			2. The stipulated hours of operation should be documented through data logging, observation, or according to operating schedules for the specific areas and agreed upon by the ESP and the Entity.
			3. Depending on the facility, the total kW savings should be multiplied by a diversity factor (a percentage of lights that are on at the same time) to keep the kW savings conservative.
			4. Depending on the seasonal facility use, the total kW savings should be multiplied by a factor to determine annual kW savings.
			5. Since interior lighting replacement reduces heat gain, there is an interaction with the HVAC system that requires an increase in heating energy and decrease in cooling energy. This interaction should be carefully evaluated. For example, a school may have cooling only for the office area. Cooling credit should only be for this area, not the entire school.
			6. If baseline power was not measured, then the hours of operation must be measured for this measure to adhere to Option A.

**Boiler Replacement** – The typical M&V option is Option A. The boiler efficiency is typically the measured value with boiler efficiency curves supporting as stipulated values. Another stipulated value is boiler (heating) load which is derived from utility data and often adjusted by bin weather data. The efficiency should be measured at multiple loads, which may be difficult to do under real conditions. Efficiency curves may be difficult to find, particularly for older equipment. Boiler loads are often determined by subtracting other loads (water heating, kitchen, etc.) from the total fuel energy. Bin weather data may include time of day, but typically not include day of the week. Also, morning warmup loads often are not considered. All these factors diminish the reliability and accuracy of the savings calculations, thereby increasing the risk.

If the boiler was the only end-user for the fuel or if the boiler was separately metered, then Option C: Whole Building may be more appropriate. Adjustments could be made for weather, but the methodology would need to be defined in the M&V plan.

**Conversion from Constant-Volume to Variable Air Volume** – This is a poor application for Option A and difficult for Option B: Retrofit Isolation: All Parameter Measurement, but the ESP will often use Option A to keep M&V costs down. The issues here can apply to several other common cost-saving measures to varying degrees.

The measured variable is typically the fan power measured once before the retrofit and at multiple points after the retrofit. The stipulated values are typically the hours of runtime at various loads. Bin weather data is often used to define hours at given loads. This would provide fan energy savings only. Since VAV conversion also affects heating and cooling energy, another measured value is necessary to measure and verify these savings. Fan heat gain, supply and mixed air temperatures, and outdoor air volume could be measured or trend logged. Applying these to a standard calculation for M&V is difficult and highly complex.

Option D: Calibrated Simulation is more appropriate for this measure, but requires much more measurement, and therefore, more cost. This option considers all interactions – heating, cooling, fan energy – when using appropriate simulation software.

# Measurement and Verification Plan

A preliminary M&V plan is developed for the Investment Grade Audit. In the EPC process this plan is formalized and included in the contract. The final version, which should have only minor changes, is presented after the cost-saving measures have been installed.

The M&V plan should be completed with a high level of detail. Measured values should be identified. Stipulated values should be documented and defined. Any adjustment factors (weather, occupancy, equipment changes, etc.) should be defined, including source and how they may affect savings calculations during the performance period. If a value or factor is not specifically identified, it may not be used in the savings calculations.

The M&V plan should include the following:

* Guaranteed savings in both units and dollars for each cost-saving measure and the total project.
* Risk and responsibility
* Baseline utility data and rates
* Performance period rate adjustment factors and any escalation rates
* Schedule and reporting of verification activities
* O&M requirements
* Construction period savings
* Status of rebates and incentives
* Dispute resolution
* Description of cost-saving measures
* Description of the M&V option for each cost-saving measure including:
	+ baseline development,
	+ measured and stipulated values,
	+ savings calculation methodology,
	+ adjustment factors and methodology

The department has developed an M&V plan outline based on the FEMP M&V Guidelines available on the website.

# Post-Installation M&V Requirements

Changes may occur during the implementation of the cost-saving measures that affect the savings, guarantee and potentially the M&V plan. These changes should be recorded and accounted for in the project. Measurements for the installed measures are made and must be reported. The M&V Plan should be updated to reflect these changes.

The Post-Installation Report includes a summary of all the changes made between the final proposal for the EPC contract and the as-built conditions. The report should include the detailed measurements, monitoring, and inspections that occurred as part of the project. Calculations should reflect this additional data. The ESP should prepare the Post-Installation Report as developed by the department.

# Annual M&V Reporting Requirements

Summarize the project including energy, water and operational cost savings (in dollars, units, and MMBTUs) for the annual reporting period, annual emission reductions and ENERGY STAR rating (if applicable). This summary information is useful for tracking and reporting on annual project performance.

The ESP should prepare the Annual M&V Report with format and content as presented in the Annual M&V Report Outline document.