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Measurement & Verification: At the Core of Energy Performance Contracting

ABSTRACT

The energy transition calls for rational use of all forms of energy, and resulting energy savings must be credibly validated with recognized Measurement and Verification (M&V) techniques. This is particularly important for projects performed under the Energy Performance Contracting (EPC) business model. M&V activities are at the core of Energy Efficiency (EE) projects realized by Energy Savings Companies (ESCOs). Furthermore, the M&V process must follow a structured framework that allows repeatability and adequate validation of the energy savings.

The world's most reckoned M&V framework is the International Performance Measurement and Verification Protocol (IPMVP), first published in 1996 by the Efficiency Valuation Organization (EVO) www.evo-world.org. The strength of the IPMVP lies in its flexibility. Indeed, it offers four different options that can be used based on the context of each project: two focusing on measuring specific and isolated Energy Conservation Measures (ECM), and two on the impact of multiple ECMs on the building as a whole. M&V is as much a science as it is an art. It cannot be automated or otherwise be reduced to ticking predetermined boxes into a checklist.

An EPC requires that all stakeholders (clients, ESCOs, financing parties) have trust that the evaluation of the savings on which the payments are based is valid and accurate. Contrary to what is often believed, M&V in the context of an EPC project can be done by any party that has the expertise to do so. Often in EPC projects, project's M&V is done by the involved ESCO and subsequently validated by the facility owner. Alternatively, it can be performed by an indepedant third party. Indeed third party may be helpful to ensure agreement of measurement validity. But regardless of who does the M&V, only skilled and educated experts can play a meaningful and valuable role within an EPC project.

Introduction

For decades, specialists worldwide have estimated cost-effective investments in energy efficiency (EE) in billions of dollars annually. Yet only a fraction of this vast potential has been exploited. The EPC business model, implemented by ESCOs, has long been identified as a method to deliver the large-scale implementation of EE projects. Since an EPC implies that the remuneration of an ESCO will be tied in some ways to the performance of the implemented projects, it requires that parties involved have a high level of trust in the information on which the payments are based. To create such confidence in EPCs, building owners and financiers need some hardcore evidence of their benefits. EPC is an innovative EE projects implementation scheme where M&V plays a crucial role in demonstrating that energy savings will be sufficient to meet project costs.

M&V – An essential tool to enable the use of Energy Performance Contracting

EEprojects in genrral and EPC projects more specifically usually rely on two main elements:

- a performance component that is directly related to the efficiency of the equipment installed
- the operation of this equipment, essentially reflecting how the facility owner uses such equipment.

In an EPC, each contracting parties has access to different knowledge. Indeed, ESCOs naturally know more about equipment performance than the owner or the financier and are in an excellent position to take the retrofit performance risks. On the other hand, building managers has knowledge and control over operational issues such as usage, hours of operation, occupancy, etc. Thus, facility's owner are naturally well-positioned to take responsibility for the operational risks associated with an EE project. Finally, when a third-party financier provides project funding, it has specific information regarding financial investment risks and tolerance factors.

In an EPC project, the contracting parties agree to pool their knowledge into a business transaction and share the cost-benefits of an EE project so that all parties involved win. In that sense, EPC addresses asymmetrical information – one of the most important barriers to EE – by pooling the information in a contractual arrangement and optimally allocating various risks to the party best suited to take them.

M&V activities are at the core of EPC projects realized by ESCOs. They are based on business transactions between parties that include i) an owner where the project is implemented, ii) an ESCO taking care of the project design and implementation, and, iii) sometimes, a third-party financier. Establishing the performance of EE projects and specific equipment may be challenging. Hence the need to rely on well-performed M&V activities. M&V is the process of planning, measuring, collecting, and analyzing data to verify and report energy savings resulting from implementing an ECM.[1] But, energy savings are by definition the absence of energy use and subsequently cannot be directly measured. However, energy use can be measured. M&V, therefore, represents the process of analyzing measured energy use before and after a retrofit project to determine savings.

M&V is fundamental to EPCs because the ESCO remuneration is based at some level or totally on the project's performance. To create the necessary trust factor needed for such a scheme to work, the M&V process must

M&V and deemed savings*

The M&V process consists of establishing a baseline period energy use and subtracting the measured energy use after implementing an energy conservation measure to determine energy savings. These savings are then adjusted as needed through engineering calculations to determine verified savings. The M&V approach must account for the level of accuracy required, the complexity of factors driving energy use, the amount of equipment involved, the level of energy cost savings at risk, and the available budget.

At the opposite end of this structured M&V approach are deemed or stipulated energy savings. Deemed or stipulated savings are derived from *estimates* of energy consumption. Deemed savings do not include measuring and verifying energy savings because it does not contain any post-implementation measurements. Therefore, any reference to deemed savings reflecting realized savings is not adherent with the generally accepted global M&V principles and best-recognized practices, such as the ones contained in the IPMVP.

Deemed savings can be used in some limited cases in the context of EPC. However, they cannot be at the core of the M&V process, a necessary condition for establishing an EPC. In other words, deemed savings can not be a surrogate for an M&V process.

(*) https://evo-world.org/images/corporate_documents/EVO_Deemed_Savings_Position_OCTOBER_2019.pdf

[1] *Core concepts – International Performance Measurement and Verification Protocol. EVO 10000-2016*. Section 3 "Terms & Definitions".

be based on an indepently developed and recognized methodology and structured framework that allows repeatability, transparency, and adequate validation option of the energy savings for all stakeholders.

Building confidence on EPC M&V with a globally recognized protocol

Until the second half of the 1990s, the underlying concepts and methods for project-level performance assessments were loosely defined in various protocols and guidelines. Eventually, a need emerged to rationalize M&V activities, and the Efficiency Valuation Organization (EVO) was created to develop and maintain the IPMVP. The protocol was established by a worldwide consensus in 1996 and quickly became the gold standard for M&V and the reference in EPC projects as it went hand-in-hand with the emergence and growth of the ESCO industry.

The strength of the IPMVP framework relies on its flexibility. Its framework offers four different options: two focusing on the measurement of specific and isolated ECMs, and two on the impact of multiple ECMs on the building as a whole when the isolation of particular ECMs is not possible or practical.

In EPCs, the choice of an IPMVP option is driven by many factors, including M&V cost and the level of precision needed by the parties involved in a project. Other considerations, such as the type of performance contract (mostly shared or guaranteed savings), will also influence the rigor of the M&V process.

Option A and B

In Option A and Option B, only the performance of a specific ECM is of concern. These options are generally well suited for EPCs, particularly when considering the performance and operations responsibilities assigned to the ESCO and the facility owner.

For the ESCO, M&V activities are usually straightforward since meters are added for isolation purposes. In context, interactive effects between the ECM and other facility equipment can be either measured or assumed immaterial and thus ignored. From the facility owner's perspective, additional benefits may arise since the meters installed to isolate the ECM can be used for operational feedback. For example, the collected data could potentially be used in a split savings scheme with the tenants.

Option C and D

Option C is usually considered more simple and less costly since it assesses the energy performance of an entire facility

Table 1 – IPMVP Options (Summary)

IPMVP Option	Definition	How Savings are Calculated	Typical Applications
A. Retrofit-Isolation: Key Parameter Measurement	Savings are determined by field measurement of the key parameter(s), which define the energy consumption and demand of the EEM's affected system(s) or the success of the project.	Engineering calculation of baseline period energy and reporting period energy from: short-term or continuous measurements of key parameter(s) and estimated values	A lighting retrofit where the power draw is the key parameter measured and lighting operating hours are estimated based on facility schedules and occupant behavior.
B. Retrofit-Isolation: All Parameter Measurement	Savings are determined by field measurement of the energy consumption and demand and related independent, or proxy variables of the EEM affected system.	Short-term or continuous measurements of baseline and reporting period energy, or engineering computations using measurements of proxies of energy consumption and demand.	Application of a variable speed drive and controls to a motor to adjust pump flow. Measure electric power with a kW meter installed on the electrical supply to the motor, which reads the power every minute.
C. Whole Facility	Savings are determined by measuring energy consumption and demand at the whole facility utility meter level.	Analysis of the whole facility baseline and reporting period (i.e., utility) meter data.	Multifaceted energy management programs affecting many systems in a facility.
D. Calibrated Simulation	Savings are determined through simulation of the energy consumption and demand of the whole facility or a sub-facility.	Energy consumption and demand simulation, calibrated with hourly or monthly utility billing data.	Multifaceted energy management programs affecting many systems in a facility but where no meter existed in the baseline period.

and therefore relies on energy data typically comimg from utility bills.It has to be noted that it is often not the reality. From a purely technical perspective, this option is well adapted for projects where multiple ECMs are installed – which is usually the case of retrofits where savings are expected to be significant – typically higher than 10 % of the total facility energy used before the implementation of ECMs. Options C is also preferable when interactive effects between different ECMs are substantial – a situation that would make M&V with either Option A or Option B very complex and/or cost inneficient.

However, Option C is often ill-suited for EPC projects with an extended contractual period. The longer the contractual period, the higher the risks and costs are associated with the need to adjust the savings calculation.[2]

Finally, Option D is used in the absence of historical energy consumption data and involves computer simulation. Its application requires a specific skill set. This option is also applied where multiple ECMs are implemented. Option D is often used for new construction, and since EPC projects are mostly retrofits of existing facilities, it is not generally considered. Nonetheless, calibrated simulation techniques, typically used in Option D M&V, are increasingly used in combination with other IPMVP options.

Selecting the best option

The selection of an M&V option in the context of EPC projects depends on the context in which the EE project is implemented (type of facility, type of ECMs implemented, etc.) and must consider the level of uncertainty and related accuracy expected from the savings calculation and the length of the contractual arrangement. Reducing the uncertainty and improving the accuracy becomes a balancing act between the M&V expenditures and the payments made under an EPC.[3]

In the United States, it was recently observed that EPC projects performed in US Government facilities are increasingly relying on Option B and C and less on Option A. From 1998 to 2008, 70.2 % of total projects' value followed Option A and 18.2 % a mix of Option B and C. For the period 2016-2019, these proportions were 46.2 % and 52.5 %, respectively, marking a clear trend towards more comprehensive and rigorous M&V. This trend towards more ambitious M&V reflects the increased installation of generation units in facilities (including renewable) along with efficiency measures, and by deep retrofit projects with multiple, interactive ECMs.[4]

Other European experiences show that specific ECMs implemented in the industrial sector mainly relied on Options A and B, reflecting the nature of subsidies programs targeting particular energy usage. As observed in the United States, when EE programs target buildings with multiple ECMs, Option C has been mainly preferred to consider interactive effects between ECMs. More recently, many new public projects in France are undergoing Option C and D M&V.[5]

M&V is neither complex nor expensive

Despite the flexibility of the four IPMVP options, some claim that M&V is not practical, too expensive, and even impossible have been raised, and the use of deem savings has been promoted in some countries in the context of EPC projects. Proponents of M&V options adherent to the IPMVP on their side base their analyses on a structured cost-benefit approach. Let us have a closer look at these claims:

- Not practical or reliable. It is possible to validate the amount of efficiency gained by using M&V best practices. Although M&V may never be 100% accurate, it has the merit of providing a reliable, repeatable, transparent, and verifiable standardized method needed for any specific purpose while still being conservative.
- Too expensive. The cost of M&V can be adapted to each EE and EPC project and varies based on the required precision level and the investment size. The typical M&V cost is around 3 to 5% of a project's capital cost, impacting the internal rate of return (IRR) of EE and EPC projects by only about 1%. It thus has little or no impact on the economic basis for an investment decision.
- Not possible. While it is true that developing and implementing M&V plans on EE projects may sometimes be complex and can be technically challenging for many to do, it is fundamentally wrong to assume it is impossible to do. M&V is always possible. In most cases, and with the appropriate skills and knowledge, developing and implementing an M&V plan is relatively easy to do.

[2] For an extended discussion on routine and non-routine adjustments for option C, please see: *IPMVP Application Guide on Non-Routine Events and Adjustments, EVO 10400-1:2020.*

[3] In the FEMP M&V Guidelines 4.0 used for federal government EPC projects in the United States, it is stated that the *"…choice and use of a specific option are determined by the level of M&V rigor required to obtain the desired accuracy level in the savings determination and are dependent on the complexity of the project, the potential for changes in performance, each energy conservation measure's saving value, and the project's allocation of risk between the ESCO and the customer."*

[4] Coleman, P., Earni, S., Slattery, B. and Walker, C., 2020. M&V in ESPC: The U.S. Federal Experience and Implications for Developing ESPC Markets. In: energise 2020 ENERGY INNOVATION FOR A SUSTAINABLE ECONOMY. [online] Hyderabad, India: Alliance for an Energy Efficient Economy (AEEE), pp.216-221.

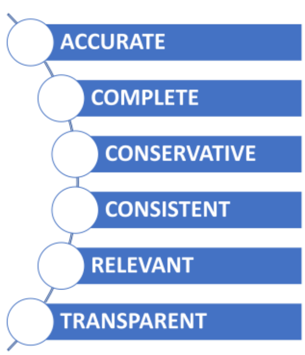
[5] Magnet, Daniel. Personal communication on projects conducted in Switzerland, France and Belgium. September 1, 2021.

M&V Principles[6]

Good M&V practice in the context of EPC projects is not different from any other usage of M&V and is therefore based on six fundamental principles. M&V must be accurate, complete, conservative, consistent, relevant, and transparent.

The accuracy of measured savings should be evaluated and agreed to by the ESCO and the facility owner (and the financing party if applicable) as a part of the project development and reflected in the M&V Plan. Of course, M&V costs should be modest relative to the monetary value of the savings being evaluated and at the same time be consistent with the financial implications of over or under-reporting a project's performance. Professional judgment must be exercised, and consideration of all reasonable factors that affect accuracy is a guiding principle of IPMVP.

To be complete, the reporting of energy savings should consider all effects of a project. M&V activities to be integrated into the EPC process outlined in the M&V Plan will indicate which effects should be quantified through measurement while estimating others. This will depend mainly on which IPMVP option is selected and the desired level of accuracy sought.



To remain realistic, and where judgments are made about uncertain quantities, M&V procedures should be designed to estimate as precisely as needed the savings, so they are not overstated responsibly and therefore be considered conservative. This means that an assessment of a project's impact should be made to assure its energy-saving benefits are reasonable and conservative, considering the level of confidence in the estimation.

Measured energy savings and the reporting of a project's energy performance should be consistent and comparable across different types of EE projects, various energy management professionals for any project, different periods for the same project, or EE projects and new energy supply projects. However, we should keep in mind that "consistent" does not mean identical since it is recognized that any empirically derived report involves judgments that may not be made identically by all reporters.

M&V activities must also focus on the most relevant factors. The savings determination should be based on current measurements and information about the facility where the project occurs. This determination of saving effort must measure the performance parameters of concern or that are least well known, while other less critical or more predictable parameters may use estimated values.

Finally, all M&V activities must be transparent and should be clearly documented and fully disclosed. Full disclosure should include a presentation of all of the elements of an M&V Plan and saving reports. Data and information collected, data preparation techniques, algorithms, spreadsheets, software, assumptions used, and analysis should follow standard practices as closely as possible, be well formatted and documented – such that any involved party or outside quality assurance reviewer can understand how the data and analysis conformed to the M&V Plan and savings reporting procedures.

No EPC without M&V and no M&V without an M&V plan[7]

No pilot would take a plane without first consulting the maintenance logbook, checking the fuel level, preparing a flight plan. Similarly, nobody should enter into an EPC contract without first checking that the proposed technologies are proven, that the technical team has the necessary skills to realize the EE project, and that the contract includes a detailed M&V strategy to develop adapted plans to be accepted by all concerned parties prior to the implementation of the project.

The M&V Plan is the ESCO and facility owner's (and all other stakeholders) operational guide throughout an EE project's performance period. Such a plan is site-specific; it states which IPMVP option has been retained and details the M&V method used for each ECM. Most importantly, the M&V Plan will provide a well-defined baseline energy use that will be the foundation of the whole M&V process. This must be done before implementing the ECMs, as the baseline cannot be measured after the fact. The M&V Plan will also provide a clear description of the calculation and verification methods used to measure the energy use during the performance period.

[6] This section draws heavily on section chapter 4 of the *IPMVP Core Concepts – EVO 10000 – 1:2016*.

[7] See Appendix 1 for more details.

As mentioned before, energy savings are the absence of energy used and cannot be measured and are thus "unknown." Therefore, they must be calculated with as much precision as possible, considering there will always be a certain level of uncertainty. There will always remain a residual risk that cannot be "controlled" by either party. These are risks associated with different aspects of the project including weather conditions, fluctuating energy prices, disasters, pandemics, etc. These risks are thus assumed to be evenly shared between the building owner and the ESCO. In addition to helping manage the risks, an adequate EPC M&V Plan(s) will minimize a project's uncertainty. In performance contracting, it is because of this uncertainty that ESCO will usually guarantee the savings at 80-85% of projected savings for projects.

M&V needs expertise

We discussed earlier the notion of information asymmetry between the ESCO and facility owners. This is particularly relevant when we consider who takes responsibility for the conduct of M&V. The M&V principles stated above must be attended with adequate skills by individuals who will exercise their professional judgment. There are two approaches to performing M&V in EPCs.

M&V in the context of EPC can be done by any party that has the expertise to do so. Often in EPC projects, the M&V is done by the ESCO and subsequently validated by the facility owner. This is the case because the ESCO has more experience in performing energy savings determinations. While it is reasonable to think that ESCOs have M&V experts on staff, it is likely not true for the customer. Hence, M&V performed by the ESCO may be perceived as biased by customers and can often limit the use of EPC as such clients may be reluctant to use such schemes that they perceived to be not impartial. Thus, the ESCO's customer should consider retaining a third-party expert or project facilitator's services to assist during the design, implementation, and performance phases of an EE project. Such assistance may include the initial review of the M&V Plan(s) and potentially analyzing subsequent savings reports.

Alternatively, it can be performed by an indepedent third party. An EPC requires that both parties believe that the information on which the payments are based is valid and accurate. An experienced indepedent third party may be helpful to ensure agreement of measurement validity. Should conflicts arise over the project payback period, this third party can help resolve differences. Third-party savings verifiers are typically engineering consultants with experience and knowledge in verifying savings, EE technologies, and, where relevant, in reviewing energy performance contracts.

EPC’s project M&V cannot be automated or otherwise be reduced to ticking predetermined boxes into a checklist. Between the ESCO, the customer, and the third-party financier (when applicable), only skilled and educated experts can play a meaningful and valuable role within an EPC project.

There are different levels of education needed for individuals involved in M&V. As a starting point, knowledge and understanding of the IPMVP framework, M&V concepts, and IPMVP options are required and necessary for many situations but not sufficient in others.

In many cases, particularly in the context of EPC projects, professionals must demonstrate practical skills in applying the IPMVP, particularly in the preparation of M&V plans and in exercising their professional judgment when needed. Solid expertise of interactive effects between EEMs and competencies in performing and analyzing investment-grade audits are also required for third-party experts.

Advanced and specialized M&V training is also necessary for different types of projects. For example, performing M&V for industrial processes and manufacturing applications is different than M&V for buildings. An expert in industrial M&V may not have sufficient knowledge to perform M&V in facilities and vice versa.

Capacity building is therefore crucial for ESCOs, facility owners and managers, and third parties involved in financing EPC projects. The role of M&V advisors and experts should not be underestimated for successful EPCs.

Conclusion

Facility owners around the world are increasingly challenged by energy transition concerns while confronted by rising energy needs. The implementation of ECMs allows for curbing rising energy costs while strongly contributing to the needed decarbonization of our economies. EPC has proven to be very effective in implementing EE projects in all type of facilities. M&V plays a crucial role in EPC as it demonstrates how the energy savings are linked to the remuneration of the ESCO implementing the project.

M&V in the context of EPC is neither complex nor expensive when conducted within a rigorous framework. The IPMVP offers four options to reflect the context in which an EPC project is undertaken and consider the level of uncertainty and related accuracy expected from the savings calculation. Conducted by experts who follow the six M&V principles and establish M&V plans adherent to the IPMVP, M&V then becomes a risk reduction strategy for all parties involved in EPCs.

EPC will continue to grow worldwide and be successful as long as M&V is performed and conducted based on state-of-the-art knowledge and expertise. The need to develop M&V expertise within all stakeholders' teams will become more and more critical to enable the growth of EPC and enable the mechanism to play its role in the global energy transition and reduction of carbon emission reductions.

APPENDIX 1
IPMVP ADHERENT M&V PLAN[8]

A key component towards IPMVP adherence involves developing a clear and transparent project-specific M&V Plan that describes various measurements and data to be gathered, analysis methods employed, and verification activities conducted to evaluate the performance of a measure or a project. An adherent M&V Plan will help ensure that the measure or the project can realize its maximum potential and that the savings can be verified with adequate certainty. For EPC projects, an adherent M&V Plan that defines how savings will be verified needs to be developed and agreed to as part of the final contract approval and before installing the project EEMs. This M&V Plan is essential to prove that the contractual savings guarantee has been met and validate associated payments. A typical M&V Plan will contain 14 sections as described below.

1. Facility and Project Overview

M&V Plan should provide an overall description of the facility and the proposed project and a list of all the measures included as part of the project. This section should also include references to any energy audit reports or other analyses used to scope the project.

2. ECM Intent

This section of the M&V Plan should provide a clear understanding of each measure's scope and intent. At a minimum, this section should include a description of the EEM, how it saves energy and the expected savings.

3. Selected IPMVP Option and Measurement Boundary

The M&V Plan needs to specify the IPMVP option used to evaluate savings. This section also needs to identify the measurement boundary for saving determination. The boundary may be as narrow as the energy flow through a pipe or wire or as broad as the total energy consumption and demand across many facilities. This section should also describe the nature of any interactive effects beyond the measurement boundary and their possible impact on project savings. Quantified interactive effects should also be included in this section with appropriate justification.

4. Baseline: Period, Usage, and Conditions

This section of the M&V Plan documents the facilities or system's baseline utility demand and consumption and corresponding influencing parameters within each measurement boundary. The baseline description must be well-documented. The baseline data may come from many sources, such as short-term metering or spot measurements or other sources such as manufacturer specification sheets. The selected M&V Option determines the extent of the needed information, measurement boundary chosen, or the savings determination scope.

5. Reporting Period

The reporting period is a selected interval for evaluating and quantifying the post-installation performance of the measure. The M&V Plan shall identify the reporting periods for the evaluation of the measure or the project. It may be for a short period right after the installation of the measure to ensure that the measure is performing as intended, or it could be a long time at periodic intervals such as a year, multiple years, or other periods. In a performance contract, the performance period refers to the duration of the project guarantee and includes numerous reporting periods. Usually, the contractor must regularly report on the project's performance and the EEMs for the entire performance period.

6. Basis for Adjustment

The operating conditions that affect energy consumption may differ between the baseline and reporting periods. It is essential to make adjustments to account for these changes in operating conditions. The M&V Plan should outline how the baseline and/or reporting period energy consumption and demand will be adjusted to allow for valid comparison and saving calculation.

7. Calculation Methodology and Analysis Procedure

The M&V Plan needs to specify data analysis procedures, model descriptions, and assumptions to calculate savings for each reporting period. For each model used, identify and define all relevant variables and other model-related terms.

8. Energy Prices

The M&V Plan should also specify the utility prices or tariffs used to calculate the cost savings associated with the measure or project and how the monetary value of savings will be adjusted if utility prices change during the life of a measure or a project. The plan should clearly define and report any assumed or stipulated values such as inflation and/or escalation rates, utility price increases, or other variables that affect M&V results.

9. Meter Specifications

The plan should specify the metering points used to gather M&V data that includes spot and continuous metering. For non-utility meters, the M&V Plan should include specific information such and meter type, make, model and characteristics, meter specification (including accuracy and precision0, meter reading protocol, commissioning procedure, calibration process, and method of dealing with lost data and data transfer.

[8] This section reflects the content of the *IPMVP Core Concepts – EVO 10000 – 1:2016*.

10. Monitoring Responsibilities

The plan should assign responsibilities for collecting, analyzing, archiving, and reporting the data. Management of M&V data should be assigned to the party that is qualified to efficiently and effectively access, manage, and provide data sets. Monitored data that must be managed includes energy data, independent variables, static factors within the measurement boundary, periodic inspection findings, etc.

11. Expected Accuracy

The M&V Plan should include the expected accuracy associated with the measurement, data capture, sampling, and data analysis. This assessment should include qualitative and feasible quantitative measures related to the level of uncertainty in the measurements and describe adjustments used in the planned savings report.

12. Budget

The M&V Plan should include the budget and the resources required for saving determination, costs for the initial setup, and ongoing tasks for evaluating, documenting, and reporting the performance for each reporting period.

13. Report Format

The plan should specify how results will be reported and documented for each reporting period, including reporting frequency.

14. Quality Assurance

The M&V Plan should include quality-assurance procedures and processes used for the baseline and post-retrofit M&V data collection, calculations, saving reports, and any interim steps in preparing reports. Quality assurance should include inspections at regular frequencies to ensure that the measure and equipment continue to operate per the contract.