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Global Importance of Measurement and Verification in Energy Conservation

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Abstract

Measurement and Verification (M & V) is the rule of the game in Energy Conservation Projects where the mode of the payment is "Pay as you save" and the modus operandi is "Performance Contracting". International Measurement and Verification Protocol (IPMVP) has four M & V protocols that are being practised by Energy Servicing Companies (ESCO) in developed countries for evaluating the performance of any energy conservation project. This paper highlights the importance of the M & V protocol.

1. Introduction

Since energy conservation has become an essential activity for any nation at the backdrop of world's known fossil fuel reserve and global warming [1,2,3], it has become very important to accurately evaluate the performance and validate the outcome of any Energy Conservation Measures (ECM) implementation [4]. M&V is the process of planning, measuring, collecting, and analyzing data for the purpose of verifying and reporting energy savings within an individual facility resulting from the implementation of ECMs [5].

Energy conservation is the decision and practice of using less energy. Turning off the light when you leave the room, unplugging appliances when they are not in use and

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walking instead of driving are a few of the many examples of energy conservation. M & V demonstrates how much energy the ECM has avoided using, rather than the total cost saved. The latter can be affected by many factors, such as energy prices [6]. The M & V process enables the energy savings delivered by the ECM to be isolated and fairly evaluated [7].

2. Measurement and Verification (M&V) and International Performance Measurement and Verification Protocol (IPMVP)

It is always a recommended option to measure and verify the energy savings coming out from the installation of any new equipment or implementation of an energy-efficient system. Energy savings are not easy to measure directly because that involves the measurement of energy that is not being used. Measurement and verification (M&V) include the process of planning, measuring, collecting, and analyzing data to verify the performance of energy savings. It is the process of quantifying energy savings originating from one or several energy conservation measures (ECM) in an existing building [33].

The Department of Energy in partnership with the Efficiency Valuation Organization (EVO) has developed the International Performance Measurement and Verification Protocol (IPMVP) to provide a framework and standard for M&V. IPMVP has now become the most widely recognized protocol in the world with many participating organizations around the globe. This paper aims to understand more about the Measurement and Verification protocol and its importance.

3. Research Methodology

3.1 Research Design

The data and background info for this study has been collected through intense literature review and best Measurement and Verification practices in the energy industry worldwide. The literature review is equivalent to conducting a research study [39, 40, 46]. Review Methodology further serves as a basis for knowledge development [25, 26, 47]. Since the paper aims to identify the trends to serve as a basis for knowledge development, the same approach is present study's review methodology [40, 41, 43]. With help of the information collected from the literature interviews, content analysis was done in the study using three major themes which focussed on - why measure and verify, the purpose of International Performance Measurement and Verification Protocol (IPMVP), application of IPMVP, and IPMVP Protocols [36, 37].

3.2 Selection

Websites of agencies responsible for Measurement and Verification (M & V) in the energy sector in different countries were listed using an internet search. The focus was on the M&V practices being followed in different countries under the IPMVP protocol. Research papers on the topic similar and relevant topics were also identified

for studying. Relevant information including the application of IPMVP in different energy-related sectors and local protocols being followed was copied and tabulated. The relevance of information was separately evaluated; any disagreement was resolved through mutual discussion and agreement by two evaluators (authors of the study) in the pre-assessment stage [12, 16, 17].

3.3 Data collection and analysis

The information collected was categorized under the four themes - why measure and verify, purpose of International Performance Measurement and Verification Protocol (IPMVP), application of IPMVP, and IPMVP Protocols. Information on best practices in industry and academia was also recorded. Information collected was tabulated, analyzed, interpreted, and conclusions were drawn.

4. Literature Review

Out of the many research papers searched, information collected from the relevant research papers. All such papers are listed under References. Different websites surfed to get relevant information are tabulated in the Table 1.

Table 1: Literature review (Websites surfed)

Sr.	Country	Agency and Website
1	Global	EFFICIENCY VALUATION ORGANIZATION https://evo-world.org/en/products-services-mainmenu-en/protocols/ipmvp
2	Canada	Natural Resources Canada's CanmetENERGY https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/canmetenergy/files/pubs/NRCan_MV_Overview_Report.pdf
3	UK	Energy Project Verification Limited https://epv-uk.com/international-performance-measurement-and-verification-protocol-ipmvp
4	Kenya	Kenya Accreditation Service https://www.kenas.go.ke/inspection-and-verification/
5	Australia	Energy Efficiency Council https://www.eec.org.au/for-energy-efficiency-providers/training-certification/m-v-training#/m-v-training
6	Europe	European Commission DG JRC https://e3p.jrc.ec.europa.eu/articles/monitoring-and-verification
7	South Africa	Measurement and Verification Community of South Africa (MVCSA) https://www.saeeconfed.org.za/mvcsa/

5. Data Interpretation and Discussions

5.1 Why Measure and Verify?

M&V encompasses the implementation of processes for measuring the energy performance of systems, technologies, and / or strategies linked to building energy consumption and efficiency and verifying performance against expected targets. Inherently, M&V presupposes the use of monitoring equipment and energy-saving calculations [8,9,10]. M&V is particularly vital in performance-based contracts, where a third-party contractor guarantees the performance of the implemented energy-saving measures and the installed equipment [11,12,13]. However, the feedback obtained from M&V, apart from allowing the evaluation of the adopted energy efficiency measures, benefits multiple aspects related to the design and operation of buildings.

5.2 Purpose of IPMVP

Efficiency Valuation Organization (EVO) publishes the International Performance Measurement and Verification Protocol (IPMVP) to increase investment in energy and water efficiency, demand management and renewable energy projects around the world [14,15,16]. The IPMVP promotes efficiency investments by the following activities.

- IPMVP documents common terms and methods to evaluate performance of efficiency projects for buyers, sellers and financiers. Some of these terms and methods may be used in project agreements, though IPMVP does not offer contractual language.
- IPMVP provides methods, with different levels of cost and accuracy, for determining savings either for the whole facility or for individual energy conservation measures (ECM).
- IPMVP specifies the contents of a M&V protocol. This M&V protocol adheres to widely accepted fundamental principles of M&V and should produce verifiable savings reports. M&V Plan must be developed for each project by a qualified professional.
- IPMVP applies to a wide variety of facilities including existing and new buildings and industrial processes.

5.3 Application of IPMVP

The reliability of the M&V depends on the design and implementation of a reliable monitoring scheme and on coordinated planning of all actions that should be performed for measuring, evaluating, and verifying performance [17,18,19]. M&V requires planning and the coordination of various actions, a complicated process to begin with, but supported through well-established protocols—the more prominent being the International Measurement and Verification Protocol (IPMVP).

The IPMVP sets the principles, terminology, and standard practices for M&V and has been developed to provide a robust basis for the assessment of savings from energy efficiency, water efficiency, demand management and renewable energy programs [20]. Given the zero-energy building (ZEB) rise, a measurement and verification protocol specifically for net-ZEB has been produced. This protocol's motivation rose from the need to provide a structured proposal for measuring and verifying the net-ZEB status considering the lack of a universally accepted definition [35].

IMVP provides an overview of current best practice techniques available for verifying results of energy efficiency, water efficiency, and renewable energy projects [21,22,23,24]. It defines standard terms and suggests best practice for quantifying the results of energy efficiency investments and increasing investment in energy and water efficiency, demand management and renewable energy projects.

5.4 Benefits of Using IPMVP

IPMVP's history since 1995 and its international use bring the following benefits to programs that adhere to IPMVP's guidance. Substantiation of payments for performance [25,26]. Where financial payments are based on demonstrated energy or water savings, adherence to IPMVP ensures that savings follow good practice [38, 42]. An IPMVP-adherent savings report allows a customer, an energy user or a utility, to readily accept reported performance. ESCOs whose invoices are supported by IPMVP-adherent savings reports, usually receive prompt payments.

- Lower transaction costs in an energy performance contract. Specification of IPMVP as the basis for designing a project's M&V can simplify the negotiations for an energy performance contract.
- International credibility for energy savings reports, thereby increasing the value to a buyer of the associated energy savings.
- Enhanced rating under programs to encourage or label sustainably designed and / or operated facilities.
- Help national and industry organizations promote and achieve resource efficiency and environmental objectives [27]. The IPMVP is widely adopted by national and regional government agencies and by industry organizations to help manage their programs and enhance the credibility of their reported results.

5.5 IMPVP Process Timeline

IMPVP protocol should be planned and implemented in step-by-step time bound manner with clearly spelt out activities [28]. Failure to implement a protocol properly for M & V purpose will have an adverse effect on any ECM's performance leading to failing the energy conservation project. Figure 1 highlights the steps and activities that should be followed as a guideline for implementing any M & V protocol.

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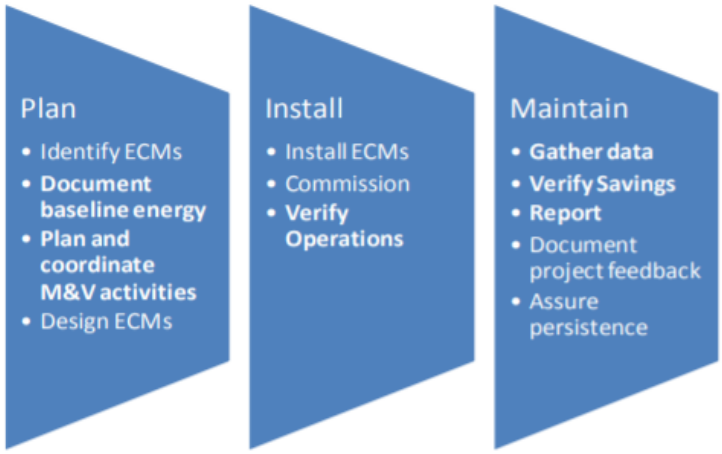

Figure 1: Process Timeline

5.6 IPMVP Protocols

IMPVP has four standard protocols, and these are for very specific purpose applications. Therefore, selection of the right protocol is key to the success.

A. **Retrofit Isolation: Key Parameter Measurement** - Savings are determined by field measurement of the key performance parameter(s) which define the energy use of the ECM's affected system(s) and / or the success of the project [29]. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the measured parameter [30], and the length of the reporting period. Parameters not selected for field measurement are estimated. Estimates can be based on historical data, manufacturer's specifications, or engineering judgment. Documentation of the source or justification of the estimated parameter is required [31]. The plausible savings error arising from estimation rather than measurement is evaluated.

B. **Retrofit Isolation: All Parameter Measurement** - Savings are determined by field measurement of the energy use of the ECM-affected system. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the savings and the length of the reporting period [32,1].

C. **Whole Facility -** Savings are determined by measuring energy use at the whole facility or sub-facility level. Continuous measurements of the entire facility's energy use are taken throughout the reporting period.

D. **Calibrated Simulation** - Savings are determined through simulation of the energy use of the whole facility, or of a sub-facility. Simulation routines are demonstrated to adequately model actual energy performance measured in the

facility. This Option usually requires considerable skill in calibrated simulation.

5.7 Training personnel in M&V and IPMVP Protocols

EVO conducts many training programs on a regular basis including one-day training to introduce the basics concepts of M&V and the IPMVP. This program is designed for management, financial, regulatory, and technical professionals who want a basic understanding of the role of M&V in supporting energy efficiency retrofits and investments. However, more training for energy sector professionals is required including those at frontline [34, 44, 45,].

6. Conclusions

M & V is as important as the selection and implementation of any ECM for energy conservation in any facilities. Wrongly measured parameters will be misleading and will create confusion in interpreting the outcome leading to disagreement between the ESCO and the customer. Many energy conservation projects have failed in the past in many applications mainly due to inappropriate / un-reliable M & V. If any energy conservation project must see the end of the tunnel, then it is very important to plan and implement the M & V correctly with a budgetary provision in the project.

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