Natural Resources Canada's CanmetENERGY

Overview of Different Measurement and Verification (M&V) Protocols

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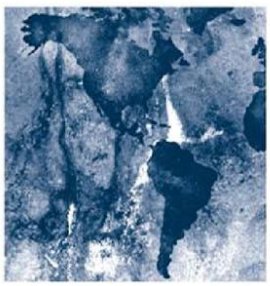



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SUMMARY

This document presents a comparative overview of the different measurement and verification protocols available on the market. The purpose of this document is to identify the protocol best suited to be a reference for Natural Resources Canada's recommissioning projects.

In light of this analysis, we can recommend volume I of the International Performance Measurement and Verification Protocol (IPMVP). Volume I is the only document that received considerable support for its development and was peer-reviewed by specialists from several countries before assuming its current form. It is supported by an international organization–Efficiency Valuation Organization (EVO)–that is devoted to its development and ensures protocol continuity. The IPMVP has the clear advantage when compared to the Federal Energy Management Program (FEMP) Guideline, which is supported by an American federal project for which no assurance can be given on protocol maintenance to the end of the program. Given the number of downloads, the number of references that appear in specialized reviews and the program evaluation protocols (for example, the California framework for DSM programs), we conclude that the IPMVP is the reference protocol. Moreover, it is available in French, which is an additional asset in the Canadian context. Volume I of the IPMVP offers a structure and content that can be used with the broadest range of projects. It presents M&V principles and concepts in a general way and can be easily consulted by inexperienced users. The flexible structure of the M&V plan included in this protocol can be easily adjusted to different existing recommissioning projects.

According to Econoler, this is the best protocol to verify the savings resulting from these projects. It compares favourably to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) protocol, which is not widespread, mainly because of the extremely high restrictions required in evaluating and discussing uncertainties. The IPMVP is also more universal in its application than the FEMP Guideline. Econoler believes, however, that certain elements of the FEMP Guidelines version 2.2 would be an excellent complement to the IPMVP because of the different examples and the report structure that it includes in the savings observed in the buildings. These examples focus mainly on equipment replacement, but can be used as a model for some measures that target operations and optimal equipment management. The new Australian protocol does not add any new ideas to the measurement and verification concept and is more of a review of the other protocols under this study.

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LIST OF ABBREVIATIONS AND ACRONYMS

AEPCA	Australasian Energy Performance Contracting Association
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
DOE	Department of Energy
ESCo	Energy service company
EVO	Efficiency Valuation Organization
FEMP	Federal Energy Management Program
IAccP	Innovation Access Program
EEM	Energy efficiency measure
M&V	Measurement and verification
NEMVP	North American Energy Measurement and Verification Protocol
IPMVP	International Performance Measurement and Verification Protocol
RCx	Recommissioning
NRCan	Natural Resources Canada

PREFACE

Pierre Langlois is a renowned expert with over 20 years of experience in the energy sector. He is considered to be a leader in developing and implementing new financial procedures in energy efficiency, particularly in the start up and operation of energy service companies (ESCo) in industrialized, transition and developing countries. He is also recognized worldwide as a specialist in measurement and verification of energy savings generated by projects.

Through his international experience, he has worked in over 35 countries on projects launched or financed by many international institutions. He has sat on several ESCo boards of directors throughout the world. Since 2006, he has been the Vice Chair of the Efficiency Valuation Organization (EVO).

Many of his activities at Econoler were honoured with awards, including the Clean Technology Award 2000 offered by the Climate Technology Initiative (organization headed by the International Energy Agency and the Organisation for Economic Co-operation and Development) during the Hague Climate Change Convention (Conference of the Parties 6).

1 BACKGROUND

Continuous optimisation is a systematic procedure to ensure that a building's electromechanical systems operate at minimum according to the design criteria but above all according to real needs. RCx is an overall systems verification process applied to existing buildings to determine improvements to make to the operations and maintenance plan and to implement those improvements to ensure continued performance over time. The process aims to ensure the proper functioning of the building's systems. Recommissioning optimizes not only how the equipment and systems work, but also how the systems work together. Although recommissioning can include recommendations for major improvements, the priority is building operation. This process is not an alternative to major repair work; in fact, major problems must be corrected before the recommissioning can begin.

Traditional energy audits highlight equipment replacement or energy improvement possibilities, whereas recommissioning explores opportunities for low-cost operation and maintenance improvements and optimal material management.[1]

In this context, the purpose of this document is to present a literature review of the different protocols available and to recommend the best protocol to use as a reference for future RCx projects. The protocol selected must be simple and offer an overall approach to enable initiators to verify energy savings resulting from their projects.

[1] http://oee.nrcan.gc.ca/Publications/infosource/Pub/ici/eii/M143-3-1-2005-e.cfm?attr=20

2 REVIEW OF EXISTING PROTOCOLS

Special planning is required to measure and verify savings from energy savings performance contracts and the implementation impacts of energy conservation measures or RCx. Several resources provide very useful information on measurements and verification (M&V). Among them, three are known worldwide and offer the most used protocols on the market.

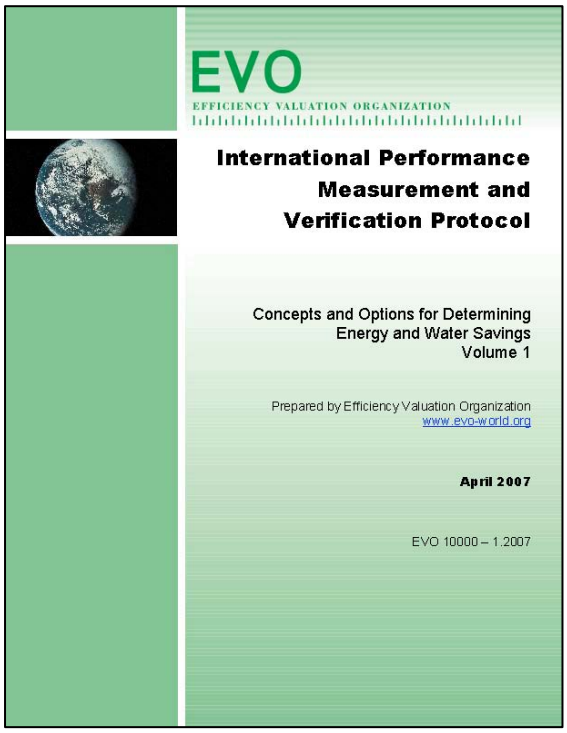
First, there is the International Performance Measurement and Verification Protocol (IPMVP) developed by EVO, a private not-for-profit company. EVO is an organization supported by a group of subscribers from all corners of the world. It presents three publications available on its Website. Volume I: Concepts and Options for Determining Energy and Water Savings is most relevant to us because it presents the M&V approaches.

Second is the FEMP (Federal Energy Management Program) M&V Guidelines version 2.2 from the U.S. Department of Energy (DOE). This protocol was edited to provide guidelines to support the work of ESCos or other contractors on energy efficiency projects in American federal buildings.

Lastly, ASHRAE also has a M&V protocol. ASHRAE is an international company with over 50,000 members and chapters in several countries. It is a world leader in the field of heating, refrigeration and air conditioning and has developed several related standards and guidelines used by most professionals.

A literature review of these three protocols is presented in the following section, as well as a review of a lesser known fourth protocol from Australia. The section that follows compares these protocols.

2.1 IPMVP VOLUME I



Developed by a volunteer committee under the U.S. DOE in 1994, the first version of this protocol was released in 1996 under the name North American Energy Measurement and Verification Protocol (NEMVP). At the time, investments in energy efficiency were low because of the considerable uncertainty about energy savings. The different measurement and verification protocols that existed were for the most part inconsistent, which increased doubt about savings computations. To reduce this uncertainty, an international protocol was established describing the different methods to determine the water or energy savings of an energy efficiency project.

To date, the IPMVP is in its fourth version, translated into more than 11 languages and is distributed for free throughout the world. Since 2001, the committee in charge of the IPMVP has developed into EVO, a not-for-profit organization to improve the protocol's content and promote its use.

Volume I of the IPMVP is a support document, describing the common practices of savings measurement, calculations and follow-up of energy or water efficiency projects for each final user. The IPMVP presents one structure and four M&V options to evaluate a project's savings in a transparent, reliable and coherent way. M&V activities include on-site studies, energy or water flow measurements, follow-up of independent variable(s), calculations and reports. The M&V activities produce verifiable savings reports when they comply with the IPMVP.[2]

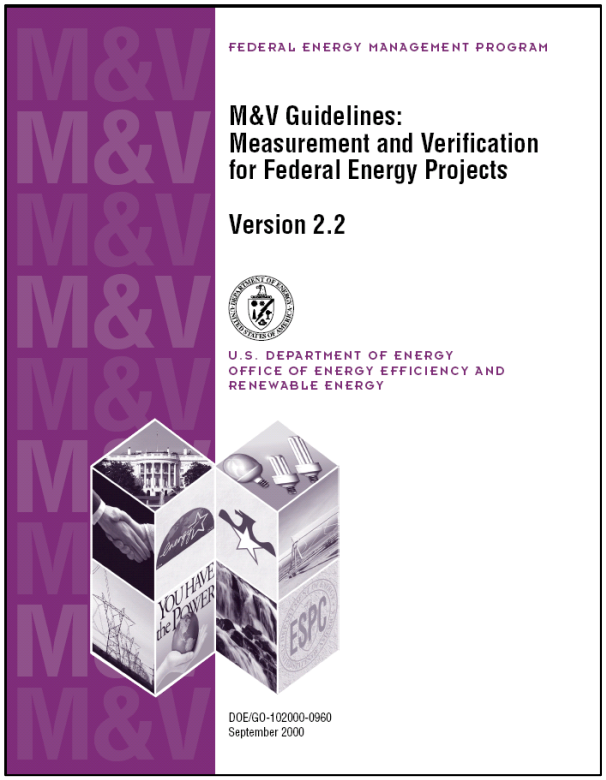
Volume I presents the four possible approaches and includes examples for each. It also presents the M&V principles, the structure of a M&V plan and explanations on measurement boundaries, adjustment bases, measurement period and reporting.

[2] IPMVP volume I 2007

Table 1: Approaches based on IPMVP volume I

Approaches	Description
Option A – Retrofit Isolation: Key Parameter Measurement	This approach requires the field measurement of the key performance parameters that define the energy use of systems affected by the energy conservation measures (ECM). The energy savings are calculated using the field measurements of key parameters and the estimation of other parameters. These estimates can be based on historical data or manufacturer's specifications.
Option B – Retrofit Isolation: All Parameter Measurement	Similar to option A, except that all parameters necessary for calculating EEM energy savings must be measured.
Option C – Whole Facility	For this approach, the energy savings are determined by measuring energy use at the whole facility or sub-facility level. The gas and electric utility meters from energy suppliers are used for the savings calculations to determine the baseline.
Option D – Calibrated Simulation	This approach uses a calibrated simulation using professional software and applies to the whole facility or sub-facility. The software models the building's performance and calibrated simulations are used to determine the targeted system's energy use.

2.2 FEMP M&V GUIDELINES VERSION 2.2



The 1992 *Energy Policy Act* and Executive Order 13123 require that federal buildings must reduce their energy consumption by 2010. Following this policy, FEMP was launched within the U.S. DOE to help federal agencies reduce their buildings' costs. To reach its objective, FEMP encourages the use of technical and investment experts from the private sector through performance contracts.

FEMP M&V Guidelines version 2.2 was developed to provide specific methods and directives for the measurement and verification of energy savings obtained from a performance contract targeting a federal building. It contains procedures and guidelines for quantifying the savings resulting from cogeneration, renewable energy, water conservation and energy efficiency equipment projects.

The different measurement and verification methods outlined in the Guidelines version 2.2 are presented in the following table.

Table 2: Approaches based on FEMP M&V Guidelines version 2.2

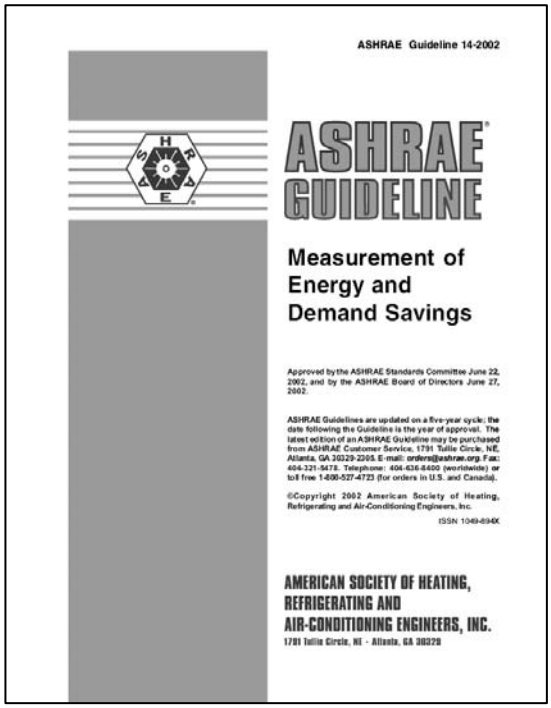
Approaches	Description
Option A – Key Parameter Measurements	This method applies to the system affected by the energy conservation measures implemented. To calculate the energy savings, certain parameters will be measured and other will be estimated using the building's history or the manufacturer's specifications. Estimates alone can be used for this option as well, but the measurement of parameters is strongly recommended.
Option B – All Parameter Measurement	This method applies to the system affected by the energy conservation measures implemented. All necessary parameters must be measured to calculate the energy savings.
Option C – Utility Data Analysis	This method applies to an entire facility. The energy savings are calculated using the energy suppliers' meters.
Option D – Calibrated Computer Simulation	This method can apply to an entire facility or to the subsystems affected by the energy conservation measures. Energy savings are measured using a simulation based on engineering estimates, equipment changes and the building's utility meters data.

Based on the conditions of each case, the project manager must choose the option that best describes the situation and use the method provided to prove the savings of the energy conservation measures implemented.

The last update of FEMP M&V Guidelines version 2.2 was presented in September 2000. After an investigation revealed that option A was used the most, a detailed guide for applying option A was developed and offered to the public in May 2002. These documents are distributed for free on the DOE Website, in English only.[3]

[3] http://www1.eere.energy.gov/femp/

2.3 ASHRAE GUIDELINE 14



The first public version of this guideline was proposed by ASHRAE in April 2000 following the establishment of a special committee in 1993 to work on savings verification. It was developed to standardize the savings computations resulting from energy conservation and reduction measures. The guideline provides a minimum level deemed acceptable for the measurement and verification of energy savings used based on commercial transactions.

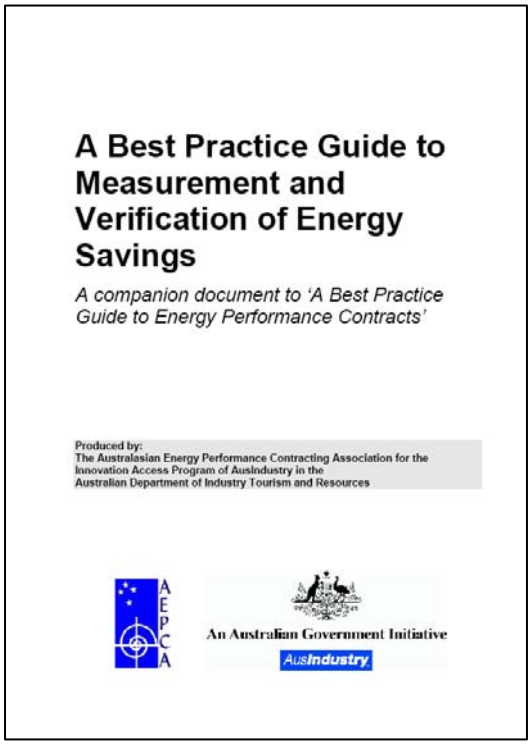
This protocol was developed by a group of technical experts in the association. It outlines different approaches, parameters required and procedures to follow. The appendix includes documentation on measurement instruments, uncertainty estimates, regression analysis techniques and examples of approaches for different systems. The guideline is exhaustive and technically in-depth.

The ASHRAE Guideline 14 provides three different approaches to calculate savings resulting from an energy conservation measure. These approaches are outlined in the following table.

Table 3: Approaches based on ASHRAE Guideline 14

Approaches	Description
Entire Building	This approach uses the main utility meter, usually installed by the electricity, gas, oil or hot water supplier. The energy savings measures can affect one or more of the building's subsystems. Use of the billing history is often necessary to define the baseline.
Retrofit Isolation	This approach uses measurement equipment to isolate the energy used by the subsystems affected by the energy conservation measure. The baseline is determined using measurements noted before the installation of the ECM. All parameters must be measured.
Calibrated Simulation of the Entire Building	This method applies to an entire building and uses computer simulation software to create a consumption and energy demand model for the building. The parameters affected by the ECM are changed in this model to obtain the resulting energy savings.

2.4 AUSTRALIA BPG-M&V



This guide was produced in 2004 by the Australasian Energy Performance Contracting Association (AEPCA) with the support of the Innovation Access Program (IAccP). AEPCA is an association that represents the specialized industry in energy savings performance contracts in Australia. This guide encourages the development of energy efficiency projects in Australia, a very important objective for the AEPCA.

This guide is primarily based on IPMVP volume I (version 2002) and uses the same approaches: options A, B, C and D. It is also based on the ASHRAE and FEMP guidelines. This guide describes the M&V structure and the methods and procedures used to determine energy savings with an acceptable uncertainty rate.

COMPARISON

To best compare these protocols, we must examine their history and those who developed them. The IPMVP and FEMP guidelines are both the product of the DOE. The IPMVP was ordered by the DOE to replace the plethora of existing protocols, most of which were inconsistent. The IPMVP was developed to include the different approaches possible and become an international reference. At the same time, the Department of Energy was initiating a vast energy management program for federal buildings. Based on the IPMVP, a document was produced to provide guidelines and the necessary approaches for the measurement and verification of savings resulting from energy savings performance contracts in federal buildings. FEMP M&V Guidelines version 2.2 are based on the IPMVP but mainly target the situations and modifications in government buildings. The ASHRAE Guideline 14 was made public in 2000 but a private version has existed since 1993, which makes it the oldest.

The approaches break down into three main categories: calibrated simulation, entire site and retrofit isolation. The three protocols essentially present the same approaches, with a few different details, for the retrofit isolation approach. It is acknowledged that the IPMVP offers a more general approach and structure, that the FEMP Guidelines are a specific application of the IPMVP for federal buildings and that the ASHRAE complements the IPMVP in being more technical.

The differences of each protocol are presented below.

IPMVP volume I

This document presents an overview of the best practices available to verify energy savings resulting from energy efficiency, water conservation and renewable energy projects within a commercial or industrial building. The IPMVP provides definitions and a structure to assist any user, inexperienced or expert, in developing a M&V plan for a project. The protocol also presents a section on savings uncertainty and examples for each approach.

Its approach to retrofit isolation requires at minimum that the key parameters be measured–the other parameters can be estimated.

This protocol is the most widespread and a French version is available free on the EVO Website.

FEMP M&V Guidelines version 2.2

This document is essentially an application of the IPMVP for federal buildings. It provides the guidelines required to achieve a minimum accepted energy savings measurement level for a commercial transaction based on this saving. This protocol also provides more detailed guidelines and examples than the IPMVP on the approaches applicable to certain energy conservation measures normally found in the federal sector. It aims to provide drafting guides and specific measurement plans adapted to the most common measures implemented in a building. Other protocols simply present a general framework for developing a measurement approach and preparing plans for each specific

project. It also contains a complete section on water conservation, presented according to the different approaches.

The FEMP retrofit isolation approach enables all primary and secondary parameters to be estimated. The detailed guide on the application of option A presented in 2002 promotes the measurement of parameters, but using estimates alone is still permitted. Neither of the other protocols allows this type of approach.

This protocol is available free on the FEMP Website, in English only. It is used almost exclusively in the United States for very specific projects, whereas the other two protocols have an international scope. The new version, Guidelines 3.0, is expected in 2008. This version will align with option A of the IPMVP by requiring the measurement of key parameters. It will also offer additional guidelines for the selection of the most appropriate approach and additional information on the content of an M&V plan.

ASHRAE Guideline 14

This document is more technical than the other two. In addition to outlining the various approaches possible, it includes a section describing the measurement instruments, measurement techniques and instrument calibration. The appendix includes all the explanations and formulas necessary to determine the savings uncertainty, regression analysis techniques and detailed examples using the different approaches. This document is a more expanded and technical version of the IPMVP and not easily used by those inexperienced in M&V.

This protocol requires that an uncertainty analysis be introduced and discussed for each measurement plan. This requirement was very poorly received by the community at the time that the protocol was introduced because it went much farther than what the market was ready to accept as a procedure. We can even say that the technical uncertainty aspects have only become current issues in the past few years and the IPMVP protocol provides elements to consider these aspects in designing measurement plans, without being specific. The M&V specialists community largely rejected this document, which was downloaded only around 200 times in the first five years of its existence. These are very low numbers when compared to the IPMVP, which is downloaded 200 times a week.

According to ASHRAE, the retrofit isolation approach requires all parameters to be measured–no estimations are permitted. Examples of this approach for different equipment (pump, fan, chiller, boiler, lighting) are included in the appendix.

This protocol is available in English only on the ASHRAE Website for approximately $80.

Australia BPG-M&V

This document is an almost exact copy of the IPMVP. It uses the same options and is based on the ASHRAE and FEMP guidelines for the section on uncertainty and cost evaluation of M&V benefits. The BPG-M&V primarily focuses on energy savings performance contracts in its approaches. A three-

page section outlines how this guide can be used for projects other than energy savings performance contracts.

It is available for free in English only on the AEPCA Website. [4]

[4] http://www.aepca.asn.au/

RECOMMENDATION

In light of the comparative analysis of the different M&V protocols and standards available on the market, we can recommend the document that best meets Natural Resources Canada's needs for its RCx projects.

To our knowledge, the IPMVP volume I is the only document currently available in French and offers a structure and content that can be used for the broadest range of projects. It presents M&V principles and concepts in a general way and can be easily consulted by inexperienced users. It also presents a flexible M&V plan structure that can be easily adjusted to different RCx projects.

We believe that this protocol is best suited to verify the savings resulting from an RCx project. We believe, however, that certain elements of FEMP M&V Guidelines version 2.2 would be an excellent complement to the IPMVP because of the different examples and the report structure included on the savings measures observed in buildings. These examples focus mainly on equipment replacement, but can be used as a model for some measures that target operations and optimal equipment management.

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