International Performance Measurement and Verification Protocol for New Construction

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1. INTRODUCTION

Measurement and Verification (M&V) of energy savings accruing from energy efficiency measures has been a fundamental underpinning of the retrofit Energy Performance Contracting (EPC) industry since its beginnings almost two decades ago. In the typical EPC model the performance contractor is paid in some manner for its services based on the materialization of estimated energy or O&M savings. Clearly, it is necessary for the contracting parties to come to an agreement as to how these claimed savings are measured and verified. Over the years a wide variety of methodologies and protocols were developed to this end. However, these protocols were inconsistent and often incomplete, comprising a loose patchwork of widely varying approaches to M&V. As retrofit EPC gathered momentum in North America, the lack of consistent and uniform protocols for M&V became an impediment to the further acceptance and growth of the industry.

In 1994, the U.S. Department of Energy, with the support and participation of numerous private and public sector stakeholders, initiated the consensus development of a common and standard protocol for M&V of retrofit energy efficiency programs. This culminated in the 1996 publication of the North American Energy Measurement & Verification Protocol (NEMVP).

The 1996 NEMVP quickly received widespread acceptance by the retrofit EPC industry. However, with a growing awareness of the need to construct energy efficient buildings in the first instance, the NEMVP stakeholders turned their attention to new construction and the need for protocols which would provide a framework for the M&V of new buildings. A New Buildings sub-committee was struck in late 1996, and a new construction protocol was developed and included in the 1997

version, renamed the IPMVP. A second New Construction sub-committee was formed in 2000, and the protocol was updated, significantly simplified, and re-released as a supplement to the 2002 version of the IPMVP. At the time of writing the document was under final review by the IPMVP Technical Committee.

2. ISSUES AND CHALLENGES ASSOCIATED WITH NEW CONSTRUCTION M&V

In addition to the well-understood issues of proper technical and contractual documentation, commissioning, operational tracking, and other concerns common to both retrofit and new construction M&V, new buildings pose a unique and fundamental problem. The performance baseline used in retrofit M&V are usually derived from actual existing physical and operational conditions, typically supported by some level of historical performance data. Conversely, the performance baseline for new buildings is hypothetical and are generally not physically measurable. Hence, the primary challenge in developing the new construction protocol is not M&V of the as-constructed new building, but rather the establishment of meaningful and practical hypothetical baselines.

The notion of hypothetical new building performance baseline is certainly not new, as reflected by the numerous energy performance codes and standards that have been developed at all levels of professional and government jurisdiction. Similarly, building owners and designers commonly evaluate proposed energy efficiency features relative to some defined baseline, either code or market-derived. However, what *is* new is the definition of a standard protocol which specifies the methodologies by which these existing standards are used in baseline definition. Existing energy performance standards specify minimum or recommended building characteristics. However, they generally do not provide guidance as to how standards are translated into an actual estimated performance level (such as gross energy use or energy intensity per sq. ft.), and they seldom provide direction as to how the initial baseline model can be through the performance period during which the building often behaves in a stochastic fashion.

3. KEY ASPECTS OF THE IPMVP FOR NEW CONSTRUCTION

The structure of the new construction supplement of the IPMVP is in many respects analogous to the framework established for retrofit M&V. In fact, congruity with the IPMVP main volume was a committee directive. In general, the protocol addresses M&V basic concepts, baseline development and M&V program planning, and M&V options. Case study examples are also included.

3.1 Basic Concepts and Baseline Development

The fundamental premise of the protocol is the definition of Energy savings in new construction M&V as follows:

Energy Savings = Projected Baseline Energy Use – Post-Construction Energy Use

Post-Construction Energy Use is a measured quantity. The Projected Baseline Energy Use is determined by adjusting the baseline to account for operating conditions during the M&V period. The adjustments are derived from identifiable physical facts such as weather, occupancy, and system operating parameters. The M&V guideline for new buildings can be applied to individual Energy

Conservation Measures (ECMs) such as the installation of energy efficient motors and lighting systems or can be used to verify the performance of more complex systems up to and including the performance of the whole building.

The protocol does not prescribe or proscribe any particular baseline, instead leaving it up to the discretion of the protocol user and the unique requirements of different projects. However, guidelines are provided in the form of a menu of options and the user is counselled to consider appropriateness, rigor, and repeatability in the context of the M&V objectives. A workable baseline is a prerequisite to the success of any new construction M&V program. Suggested potential baselines range from energy codes to databases of comparable existing buildings. Analytical resources and tools for determining Projected Baseline Energy Use can range from simple engineering calculations for individual ECMs to hourly computer energy simulation for extensive and interrelated systems or whole-building energy strategies. Methods for measuring Post-Construction Energy Use similarly vary from single-point metering at the main utility (eg. natural gas and/or electricity) to comprehensive sub-metering systems.

3.2 New Construction M&V Options

The protocol defines four separate new construction M&V options which are somewhat analogous to the retrofit options provided in the main IPMVP volume. An overview of the options is provided below and a summary table (reproduced from the protocol document) is provided on the following page.

It is important to note that with the exception of Option C, all options are applicable to M&V projects ranging from individual isolated ECMs to whole-building performance analysis. The nature of the components or systems being measured and verified and the associated desired rigor are the main determinants in selecting an appropriate M&V option as opposed to sheer scope or size. To assist in this regard the protocol provides M&V planning guidelines as well as a process map to for the selection of an appropriate M&V option. The process map is reproduced following the options summary table.

3.2.1 Option A: Partially Measured ECM Isolation. This is the most rudimentary of the new construction M&V methods, and is suitable for simple end-use ECMs such as fixed-speed motors or lighting ballasts where the loads or operational profiles are relatively constant and/or predictable. The Post-Construction Energy Use of the component or ECM is physically measured. However, other parameters such as equipment schedule or loading are assumed and "stipulated" rather than physically measured. The Post-Construction Energy Use is then compared to the Projected Baseline Energy Use to determine savings.

3.2.2 Option B: ECM Isolation. Option B is similar to Option A, except that no stipulations are allowed under Option B. Measurement of all energy use and operating parameters is required. This option is suitable for ECMs and systems with varying loads such as variable speed fan and pump motors, chillers, boilers, etc.

3.2.3 Option C: Whole Building Comparison. Whole-building comparison determines the collective savings of all ECMs applied to the facility. Post-Construction Energy Use is measured at the level of the main utility meters. The Projected Baseline Energy Use is the energy use of similar

buildings without the ECMs or design enhancements.

The inclusion of this option in the protocol was the subject of considerable debate within the new construction sub-committee. It is suitable only for projects which do not require a high level of M&V rigor and where there is a statistically significant population of existing buildings which are physically and operationally similar. Even then, the potential for error renders this option appropriate for only the most cursory M&V programs.

3.2.4 Option D: Calibrated Simulation. Calibrated simulation can be used to determine the savings of individual ECMs, building systems, or the entire facility. Post-Construction Energy Use is measured by sub-metering or at the main utility meters. The Baseline Projected Energy Use is determined by energy simulation of the baseline under the post-construction operating conditions of the M&V period.

Calibrated simulation requires a very accurate energy simulation model of the as-designed ("design") building or systems as well as a similarly detailed simulation model of the baseline. The baseline model is often back-engineered from the design simulation. The design simulation is calibrated by modifying it to reflect any as-constructed changes and adjusting inputs to reflect actual operating conditions such as weather, occupancy, and equipment setpoints and schedules. The revised design energy use projections are compared to the measured Post-Construction Energy Use. Significant deviations are investigated and addressed, and corrections and adjustments applied to the design simulation model in order to achieve calibration are back-engineered into the baseline simulation. The true objective of the calibration process is not to calibrate the design simulation, but rather to develop an accurate baseline simulation, thereby minimizing the error in the Baseline Projected Energy Use.

This option is most suited to buildings with numerous ECMs that are highly interactive or where the building design is integrated and holistic, rendering isolation and M&V of individual ECMs impractical or inappropriate.

Table 1: Overview of New Construction M&V Options

M&V Option	How Savings Are Calculated	Typical Applications
A. Partially Measured ECM Isolation Savings are determined by partial 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. Some operating parameters are stipulated rather than measured.	Projected baseline energy use is determined by calculating the hypothetical energy performance of the baseline system under post-construction operating conditions.	Lighting system where power draw is periodically physically measured. Operating hours are stipulated.
B. ECM Isolation Savings are determined by full measurement of the energy use and operating parameters of the system(s) to which an ECM was applied, separate from the rest of the facility.	Projected baseline energy use is determined by calculating the hypothetical energy performance of the baseline system under measured post-construction operating conditions.	Variable speed control of a fan motor. Electricity use is measured on a continuous basis throughout the M&V period.
C. Whole Building Comparison Savings are determined at the whole-building level by measuring energy use at main meters or with aggregated sub-meters.	Projected baseline energy use determined by measuring the whole-building energy use of similar buildings without the ECMs.	Government agency wishes to determine order-of-magnitude savings level associated with a building design incentive program.
D. Calibrated Simulation Savings are determined at the whole-building or system level by measuring energy use at main meters or sub-meters.	Projected baseline energy use is determined by energy simulation of the baseline under the post-construction operating conditions.	Savings determination for the purposes of a new building Performance Contract, with the local energy code defining the baseline.

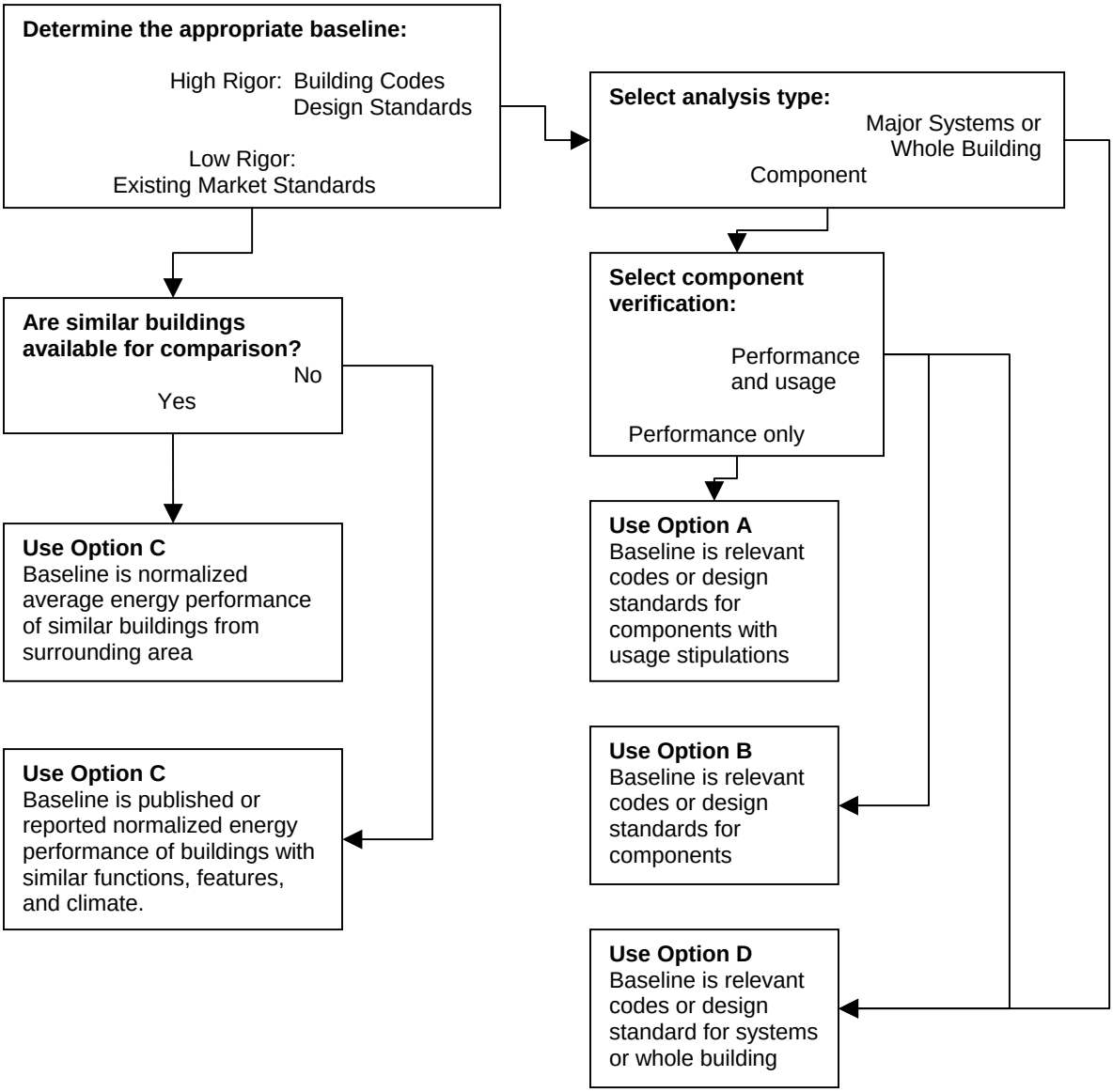

Figure 1 IPMVP New Construction Process Map

4. RELATIONSHIP OF THE IPMVP FOR NEW CONSTRUCTION TO OTHER STANDARDS AND PROTOCOLS

The protocol has an obvious relationship to a wide range of energy codes and standards which can assist in the development of the performance baseline of new buildings. The most prominent of these includes ASHRAE 90.1 and the Canadian Model National Energy Code for Buildings. A number of incentive or rating programs also address new construction M&V directly or indirectly, including the USGBC LEED (Leadership in Energy & Environmental Design) program, which specifically references the IPMVP.

Of particular interest is ASHRAE Guideline 14, which provides a standardized set of energy and demand savings calculation procedures, and addresses calibrated simulation in some detail. The new construction M&V guideline makes specific reference to this guideline in a number of sections.

The protocol provides a full reference list of current related programs, standards, and guidelines.

5. POTENTIAL APPLICATIONS OF THE IPMVP FOR NEW CONSTRUCTION

Since the release of the original new buildings section of the 1997 IPMVP, the intended audience of the protocol has grown to includes such diverse groups as:

- Project Developers
- Facility Owners and Managers
- Architects and Engineers
- Financial Institutions and Firms
- Government and Government Agencies
- Utilities
- Trade Organizations and other Non-Governmental Organizations
- ESCOs
- Researchers and Academics

Potential applications of the new construction protocol now include:

- General energy savings M&V and operational tracking/troubleshooting.
- New construction performance contracting.
- Performance-based incentive design fees.
- Tracking and validation of government and utility energy efficiency programs
- Validation of greenhouse gas emissions performance through M&V of energy use.
- General research and data acquisition on building energy performance.

As activity in the above areas increases, it is expected that the IPMVP for new construction will similarly see increasing adoption as various entities look for a standardized method of measuring and verifying energy savings.

The IPMVP is a public domain document. An electronic copy of the new construction M&V guideline can be downloaded from www.ipmvp.org starting in October 2002.

6.0 REFERENCES

US Department of Energy, Office of Energy Efficiency and Renewable Energy, 2000. International Performance Measurement & Verification Protocol.