Energy Efficiency Measurement and verification in South Africa for bigEE

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Table of contents

Abbreviations and acronyms

Abbreviation/acronym	**Description**
EE	Energy Efficiency
POET	Performance, Operation, Equipment, and Technology
BAT	Best Available Technology
PI	Post-implementation
SANS	South African National Standards
M&V	Measurement and Verification
CFL	Compact Fluorescent Lamp
LED	Light-emitting Diode
CT	Current Transformer
VT	Voltage Transformer
IPMVP	International Performance Measurement and Verification Protocol
ECM	Energy Conservation Measure
CDM	Clean Development Mechanism
CHP	Combined Heat and Power
UNFCCC	United Nations Framework Convention on Climate Change
COP	Coefficient of Performance

The objective of this energy efficiency (EE) document is to provide useful information of the best available technologies (BAT) of existing plug devices in office buildings in the South African and international markets.

1 Purpose

This report summarises the best available technology (BAT) in measurement and verification (M&V) of building energy performance. The BAT of M&V in building energy efficiency is introduced under a technology, equipment, operation, and performance (POET) framework. Typically, the major M&V technologies include the measurement, sampling and modelling techniques. The equipment refers to the measurement instruments used for M&V purpose. The operation of M&V in South Africa is revealed in various M&V business models and case studies under different incentive energy conservation programmes. In addition, the performance of the M&V functions is discussed in terms of its accuracy, completeness and relevance, conservativeness, consistency, and transparency.

In the rest of this report, a brief introduction to M&V is given in terms of its definition followed by a review of national and international M&V guidelines and protocols. Afterwards, three major M&V techniques are summarised namely the M&V measurement, sampling and modelling techniques. The M&V best practice in South Africa is discussed in order to highlight the advantageous development of the M&V market and its major contribution to various energy efficiency programmes. The key M&V performance indicators are given thereafter.

In this section, the concept of M&V is introduced followed by a brief review of the national and international M&V standards and protocols, which are widely applied to guide the international M&V practice.

1.1 What is M&V

M&V is defined as a process of using measurement to accurately and reliably determine the savings delivered by an ECM in the international performance measurement and verification protocol (IPMVP) [1].

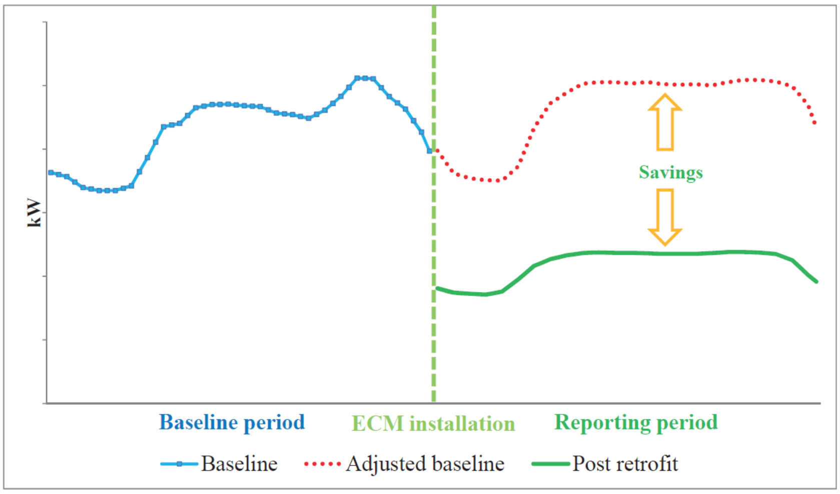

Figure 1: Illustration of M&V principles

The general M&V principle is illustrated in Figure 1. The M&V activities can be briefed as “cut once and measure twice” [2]. As shown in Figure 1, installation of an ECM cuts the project cycle into two periods, one is the baseline period and the other is the reporting or post-implementation (PI) period. In the baseline period, the energy usage is measured and taken as the M&V baseline. With the effects of the ECM, energy consumption is expected to be reduced at the PI period. The actual energy consumed at the PI period is also measurable for savings determination. Practically, various conditions may affect baseline energy use from one time period to the next, including weather, building occupancy, and production volume. From the M&V point of view, the electrical energy savings must be calculated under the same set of conditions. In practice, savings are most frequently reported under the PI conditions. In such cases, the M&V baseline needs to be adjusted under the PI conditions, which represents the energy that would have been consumed had the ECM not been installed, known as adjusted baseline. Determination of the savings is thus not straightforward as the adjusted baseline under the PI conditions does not physically exist and therefore cannot be measured. Thus the IPMVP defines energy savings as

$$Energy\ savings\ =\ Baseline\ energy\ use\ -\ Actual\ energy\ use \pm Adjustments$$

or straightforwardly written as

$$Energy\ savings\ =\ Adjusted\ baseline\ energy\ use\ -\ Actual\ energy\ use$$

1.2 National and International M&V Guidelines and Protocols

The best M&V practices are conducted with the guidance of various M&V guidelines, protocols and standards at national and international levels.

Originating in the USA, the IPMVP has evolved into a worldwide standard for M&V and is used in more than forty countries [1]. Clear definitions of terminologies and heavy emphasis on consistent, transparent methods are the core precepts of the IPMVP. It also offers best-practice methods for measuring and verifying the results of ECMs including fuel saving measures, load shifting and energy reductions through installation or retrofit of equipment, and/or modification of operating procedures, water efficiency, and renewable-energy projects in both private and public facilities. Moreover, the IPMVP has established a systematic M&V framework, in which four different M&V methodologies namely, Option A: retrofit isolation (key parameter measurement); Option B: retrofit isolation (all parameter measurement); Option C: whole facility measurement; and Option D: calibrated simulation are presented to accommodate energy conservation projects with different characteristics. The four M&V options enable the user flexibility of savings assessment in terms of both cost and methodologies. A particular M&V option is chosen based on the expectations for EE project performance uncertainties and other project specific features. The options are different, but none of the options is necessarily more expensive or more accurate than the others. Each has advantages and disadvantages based on site specific factors, and the customers' needs and expectations. The IPMVP has been proven effective in addressing the baseline establishment and savings verification issues for various energy conservation projects over the past 20 years [3].

In addition to the IPMVP, there have been considerable efforts to define standards and best practices that increase the performance of energy efficiency projects and make the savings realised more predictable and repeatable. Although these M&V guidelines are specifically designed for various programmes in different regions or countries, such guidelines are inherently similar to the IPMVP. For instance, the Federal Energy Management Program (FEMP) has released its own document for measurement and verification [4]. It provides guidelines and methods to measure and verify the savings from federal agency performance contracts. It contains standard procedures to quantify the savings resulting from EE equipment, renewable energy, co-generation, water conservation, and improved operation and maintenance projects.

Similarly, American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Guideline 14-2002 [5] was developed to assist the measurement and verification of energy and demand savings in pre-retrofit and post-retrofit applications. The ASHRAE M&V guideline provides a specific compliance path for a few M&V approaches, which include information on uncertainty analysis, regression analysis, measurement systems and equipment, and case studies. The NAPEE EM&V [6] describes a structure and several model approaches for calculating energy, demand, and emission savings resulting from facility (non-transportation) EE programmes that are implemented by cities, states, utilities, companies, and similar entities. This guideline categorises the EE evaluation into impact evaluation, process evaluation, and market effects evaluation while the guideline itself focuses on impact evaluation in which concepts and approaches for estimating the gross savings, net savings, avoided emissions and co-benefits are provided.

In South Africa, the national M&V standard SANS 50010 [7] and the Eskom M&V guidelines [8] provide standard approaches to measurement and verification of energy savings and energy efficiency with the assurance that actual savings should always be more than or equal to the reported savings.

2 M&V Technology

2.1 M&V Measurement Techniques

For the savings calculation on various ECM-affected facilities or systems, one of the most adequate options can be suitably chosen in terms of measurement boundary, accuracy, and cost considerations. As mentioned previously, the four IPMVP M&V measurement approaches namely the M&V Options A-D are introduced in detail as follows to accommodate energy conservation projects with different characteristics.

Option A - Retrofit Isolation: Key Parameter Measurement. Savings under Option A are determined by partial field measurement of the energy usage that can be isolated from the energy use of the rest of the facility. Measurements may be either short-term or continuous. Partial measurement means that only part of the key parameters that affects the system energy use to be measured with some other parameters stipulated in case total impact of possible stipulation errors is not significant to the final savings. Better understanding of the operation philosophy of the ECM will ensure that stipulated values fairly represent the real value. Stipulation details need to be provided in the M&V plan, along with necessary uncertainty analysis.

Option B - Retrofit Isolation: All Parameter Measurement. Savings under Option B are determined by full field measurements of the energy use that can be isolated from the energy use of the rest of the facility. Short-term or continuous measurements are taken over the measurement periods. Savings are determined by engineering calculations using measurements. Comparing to Option A, Option B is usually more costly but brings higher accuracy on the determined savings.

Option C - Whole Facility. Savings are determined by measuring energy use at the whole facility level. This approach is usually chosen when impact of a single ECM cannot be isolated on component level or multiple ECMs are installed with interactive effects on each other. However, Option C is limited to projects whose expected savings are greater than 10% of the metered energy baseline. Short-term or continuous measurements are usually taken over both the baseline and PI periods. Savings are estimated from an analysis of whole facility metering data, either by simple comparisons or regression analysis. This approach usually contains facility specific baseline adjustment factors.

Option D - Calibrated Simulation. Option D is a comprehensive calibrated simulation, whereby computer simulations for the system performance are conducted to calculate energy savings. Savings are determined through simulation of the energy use of components or the whole facility. Simulation routines should be demonstrated to adequately model actual energy performance measured in the facility. This option usually requires considerable skills in calibrated simulation, which is usually believed to be the most costly approach for M&V practice, especially when simulation models are not available.

In summary, Options A and B focus on the performance of specific ECMs and involve measuring the energy use of systems affected by each ECM, separately from that of the rest of the facility. Before and after measurements are compared to determine savings. Options C and D assess the energy savings at the facility level, when the ECM cannot not easily measured in isolation from the rest of the building. Option C assesses savings by analysing utility bills before and after the implementation of an ECM. Option D uses simulations of equipment or facilities, when baseline or PI data are unreliable or unavailable. Generally, Option D requires more time and skill and is more costly than the other three options A, B and C. Although the four M&V methods are discussed in detail in [1], it is still difficult to find a proper M&V method or plan for a complex energy project so that the reported performance is accurate enough. Selection of a best M&V option represents a balance between accuracy and cost. Improvements to the M&V approach are introduced iteratively, with the incremental M&V costs compared to a reduction in savings uncertainty.

2.2 M&V Sampling Techniques

This section reviews a number of the most popular sampling approaches in the M&V practice, followed by a brief discussion on the sample size determination.

Simple Random Sampling - Simple random sampling, or random sampling without replacement, is a sampling design in which n distinct units are selected from the N units in the population in such a way that every possible combination of n units is equally likely to be the sample selected [9, 10]. Simple random sampling is suited to homogeneous populations. The cost under simple random sampling could be higher than other sampling approaches when the population is large and geographically dispersed.

Stratified Random Sampling - For the stratified random sampling, when the studied population is not homogeneous but instead consists of several subgroups which are known/thought to vary, then it is more representative to take a simple random sample from each subgroups separately. The subgroups are called strata. When stratifying the population, no population element can be excluded and every element must be assigned to only one stratum. Stratified random sampling is most applicable to situations where there are obvious groups of population elements whose characteristics are more similar within groups than across groups.

Systematic sampling - Systematic sampling is a statistical method to randomly select elements from an ordered sampling frame. One typical systematic sampling strategy is the equal-probability method, in which every lth element in the ordered sampling frame is selected, where sampling interval l is calculated as:

$$l = population\ size\ (N)/sample\ size\ (n).$$

Using this approach, each element in the population has a known and equal probability to be selected. The M&V practitioners shall ensure that the chosen sampling interval does not hide a pattern to ensure the randomness. The starting point must also be randomly selected. Systematic sampling is only applicable when the targeting population is logically homogeneous, since the systematic sample units are uniformly distributed over the population.

Clustered sampling - Clustered sampling refers to a sampling technique where the population is divided into sub-groups (clusters), and the sub-groups are randomly sampled, rather than sampling the individual elements. The data are collected on all the individual elements in the selected subgroups.

In contrast to stratified sampling, where the element of interest is grouped into a relatively small number of homogeneous segments, cluster sampling is used when “hierarchical” groups are evident in a population, such as villages and households within villages, or buildings and appliances within buildings.

Multi-stage sampling—Multi-stage sampling is a more advanced form of cluster sampling. Measuring all the elements in the selected clusters may be prohibitively expensive, or not even necessary. With multi-stage sampling, the cluster units are often referred to as primary sampling units and the elements within the clusters as secondary sampling units. In contrast to cluster sampling where all of the secondary units are measured, in multi-stage sampling data are collected for only a sample of the secondary units. Multi-stage sampling can be further extended to three or more stages. For example, one might group the population into complexes, then buildings, and finally lighting fixtures.

As provided in standard statistics text books [9], the initial sample size n_0 to achieve certain confidence and precision level of homogeneous population is calculated by

$$n_0 = \frac{z^2 CV^2}{p^2},$$

where z denotes the abscissas of the normal distribution curve that cut off an area at the tails to give desired confidence level, also known as the z-score, and p is the relative precision. For the 90/10 criterion, z=1.645 for 90% confidence and p=10% as the allowed margin of error. CV is defined as the standard deviation of the metering records divided by the mean. CV is a positive value and a larger CV value corresponds to a higher sampling uncertainty.

2.3M&V Modelling Techniques

Existing M&V studies have proposed various baseline modelling techniques that can be applied to the M&V best practice. These baseline modelling techniques generally include stochastic models, regressions models, and calibrated simulation models.

For example, [11] has proposed a normative energy model based on Bayesian calibration, which is able to model the energy consumption patterns in large sets of buildings efficiently with quantifiable uncertainties associated with model parameters. The study [12] documents a general statistical methodology to assess the accuracy of baseline energy models, for the M&V of whole building energy savings.

Regression models have been widely applied to develop baseline models for the M&V purpose with detailed model identification and validation by the uncertainty indicators of coefficient of determination (R^2) and coefficient of variation of root mean square error (CVRMSE). The study [13] evaluates the performance prediction ability and model suitability of 11 empirically-based performance models for centrifugal water chillers. The results of [13] provide important reference values for selecting empirically-based performance models for energy analysis, energy efficiency measurement and verification for in centrifugal water chiller systems. In [14], two different modelling methodologies are applied to the CHP plant: thermodynamic modelling and artificial neural networks (ANN). Satisfactory results are obtained with both modelling techniques, confirming good capability of the models for predicting plant behavior and their suitability for baseline energy consumption determining purposes.

As alternative solutions to the regression models, energy baselines are determined by computer intelligent simulations of energy usage of the whole facility. Simulation routines are calibrated to predict an energy usage and demand pattern that reasonably matches the actual energy consumption. Caution is warranted, as this option typically requires considerable skill in calibrated simulation and considerable data input; so the process can be quite costly. For example, [15] presents a systematic and automated way to calibrate a building energy model that can be used for M&V of building retrofit projects, predictions of savings from energy conservation measures, and commissioning building systems. In addition, [16] has proposed a consistent, practical approach to enhance the model performance of the IPMVP Option D by using the visual inspection methods, parametric studies, and the optimisation method.

3 M&V Equipment

The major M&V equipment refers to the measurement instruments that are applied for the M&V practice. Two major concerns of the M&V equipment are the measurement instrument specifications and calibration.

3.1 Measurement Instrument Specifications

Given different nature of the energy efficiency projects, various factors may need to be measured with a certain level of accuracy for the M&V purpose. In this section, the most common parameters that are measured during the M&V process are reviewed, including electrical parameters, temperature, liquid flow, pressure and thermal energy [1].

3.1.1 Electrical parameters

- AC current: current transformer (CT) with typical accuracy <1%, not for use where power factor is less than 100% or sinewave distortion;
- AC voltage: voltage leads or potential transformer (PT) ;
- AC power (watt) and AC energy (watt hours): true RMS watt meter, necessary for inductive loads such as motors, ballasts, or circuits with harmonics from components such as a variable speed drive;
- Runtime (hours): measure and record equipment operating periods, for equipment with a constant power usage rate when on.

3.1.2 Temperature

- Resistance temperature detector (RTD), widely used to measure air and water, take care to compensate for different lead length;
- Thermocouple, narrow range suited to thermal energy metering, signal amplifiers required.

3.1.3 Liquid flow

- Intrusive meters:
    - Differential pressure: accuracy level: 1-5% of max reading;
    - Positive displacement: accuracy level: <1%;
    - Turbine, hot tap insertion turbine: accuracy level: <1%;
    - Vortex shedding: accuracy level: high.
- Non-intrusive meters:
    - Ultrasonic: accuracy level: <1%;
    - Magnetic;
    - Bucket & stop watch: spot flow measurement.

3.1.4 Thermal energy

- Packaged flow and temperature logging and computation, uses accurate flow and temperature sensors, accuracy level <1%.

3.2 Measurement Instrument Calibration

In South Africa, all meters used for M&V purpose under different energy efficiency programmes shall be delivered calibrated at a SANAS accredited facility, and the meter supplier / calibration facility shall apply a “TESTED” sticker to the meter before delivery [17].

4 M&V Operation: Best practice in South Africa

The M&V activities are operated under different types of business models in South Africa. In addition, individual M&V projects are conducted in terms of different building energy efficiency technologies.

4.1 M&V Business Models

4.1.1 Eskom M&V Business Model

Under the Eskom EEDSM programmes, the major participants in the M&V process are the project sponsors, ESCo, end users, and M&V body as shown in Figure 2.

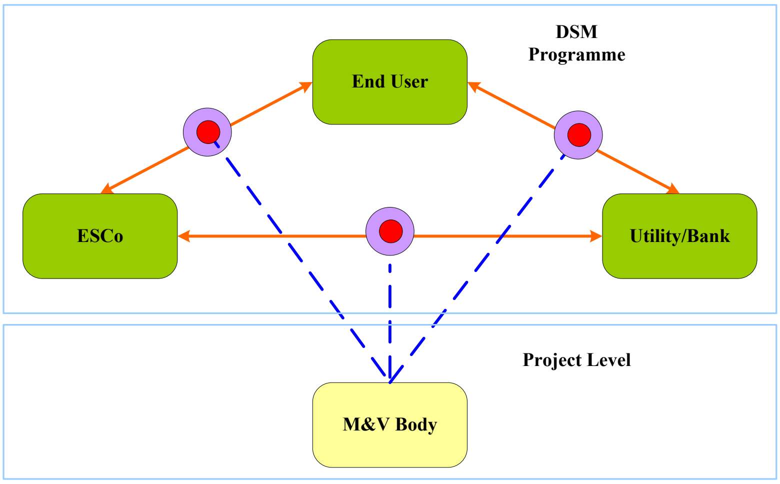

Figure 2: M&V business model participants

The following Eskom M&V business models have been implemented in the South Africa EEDSM market.

4.1.1.1 Mass Rollout Programme

- Registration requirements: expected demand savings are between 1 MW and 5 MW;
- Funding model: standard rebate rate per EE device, including CFLs, LEDs, geyser timer, heat pump water heater, solar water heater, pool pump timers, and EE showerheads;
- M&V reporting period: 3 years;
- Terms of savings: peak demand reduction and electricity savings.

4.1.1.2 Old ESCo Model

- Registration requirements: expected demand savings exceed 1 MW;
- Funding model: Eskom supports ESCo project by funding up to 100% of the financial benchmark value for EE project with various technologies as listed below;

Technology	Benchmark project value (million Rand per MW savings)
Lighting & HVAC	Up to 5.2m/MW
Hot Water	Up to 6.3m/MW
Demand Response	Up to 3.9m/MW
Compressed Air	Up to 4.4m/MW
Process Optimisation	Up to 5.2m/MW
Other	Up to 5.2m/MW

- M&V reporting period: 5 years;
- Terms of savings: electricity peak demand reduction.

4.1.1.3 Standard Offer

- Registration requirements: expected demand savings are between 50 kW and 5 MW for the technologies: building management systems, hot water systems, industrial and commercial solar water heating systems, process optimization, and lighting;
- Funding model: standard rebate rate will be paid per kWh savings realized, i.e., R 0.55/kWh for LED installations, and R 0.42/kWh for other technologies;
- M&V reporting period: 3 years;
- Terms of savings: demand reduction and energy savings during weekdays, between, 6:00-22:00.

4.1.1.4 Standard Product

- Registration requirements: expected demand savings are between 1 kW and 100 kW;
- Funding model: standard rebate rate per EE device, including lighting, heat pump and solar water heater, and EE showerheads;
- M&V reporting period: 1 years;
- Terms of savings: peak demand reduction and electricity savings.

4.1.1.5 Performance Contract

- Registration requirements: minimum expected energy savings over 3 years are 30 GWh;
- Funding model: if the project is over-performing, then R 0.55/kWh for verified savings during high-rate period, and R 0.10/kWh for verified savings during low-rate period; if the project is under-performing, then R 0.42/kWh for verified savings during high-rate period, and R 0/kWh for verified savings during low-rate period;
- M&V reporting period: 3 years;
- Terms of savings: peak demand reduction and electricity savings.

4.1.1.6 New ESCo Model

- Registration requirements: expected demand savings exceed 500 kW;

- Funding model: The new ESCO Model's payment structure is designed to remunerate verified demand savings and payment is based on evening peak demand reduction achieved per 3-month period (12 equal payment periods over the 36 months of the contract);
- M&V reporting period: 3 years;
- Terms of savings: electricity peak demand reduction.

4.1.2 12L M&V Business Model

The M&V business model for SANEDI's 12L Tax Incentive programme is introduced as follows:

12L Tax Incentive M&V Model

- Registration requirements: All forms of energy, i.e., electricity, gas, diesel, waste heat, etc. will be considered under 12L tax incentive but exclude energy generated from renewable sources or co-generation. No concurrent claim is allowed. Measurement instruments must be calibrated by SANAS accredited labs;
- Funding model: tax reduction calculated in terms of R 0.95/kWh or kWh equipment savings verified by a SANS Accredited M&V inspection body will be awarded;
- M&V reporting period: 24 month (12 month baseline period+12 month performance assessment period);
- Terms of savings: energy savings.

4.1.3 Other M&V Business Model

There are other M&V business funders such as South African municipalities, local utilities and private sector companies. Most of them generally follow a similar structure of the Eskom M&V business model.

4.2 M&V Practice for Various Technologies

The M&V best practice for lighting, water heating, and air conditioning technologies are discussed in this section. The major M&V activities such as project boundary determination, metering and sampling plan, baseline development, baseline modeling and adjustment, and savings calculation are provided.

4.2.1 Project scope

- Lighting: replacements of fluorescent lamp, ballasts, CFL, LED lighting retrofits, and installations of motion sensors;
- Water heating: installation of heat pump or solar water heaters;
- Air conditioning: installation of new air conditioners or occupancy sensors, change temperature set point.

4.2.2 M&V boundary

- Individual lighting, water heating, and air conditioning devices are taken as a sub-boundary;
- The project boundary is the summation of all the sub-boundaries.

4.2.3 Metering and sampling plan

- Measurement option: retrofit isolation: key parameter measurement.
    - Lighting: rated power, operating hours, lux level;
    - Water heating: hourly power consumption, ambient temperature, tested COP, inlet water and outlet water temperature, hot water usage, hot water temperature set point;
    - Air conditioning: hourly power consumption, ambient temperature, tested COP for both the old and new device, temperature set point.
- Sampling plan:
    - sample size to be determined cost-effectively;
    - stratified sampling approach with consideration of the following key factors;
    - lighting: CV of daily energy consumption;
        - water heating: tank size, geographic locations;
        - air conditioning: room function.

4.2.4 Baseline load profiles

- Lighting
    - Lighting percentage load profile can be developed by the normalization against the measured total kW. The percentage load profiles may be different over weekdays and weekends;
    - Per lamp load profile can be developed by the normalization against the measured lamp population. The per lamp load profiles are different in terms of locations and lighting specifications.
- Water heating
    - Baseline load profiles per geyser, in terms of different geographic locations and ambient temperature.
- Air conditioning
    - Percentage load profiles to be developed in terms of different operating schedules and room functions

4.2.5 Baseline model and baseline adjustment

- Lighting
    - Baseline model: product of lighting system power and operating schedule;
    - Baseline adjustment factors: lighting population, operating schedule.
- Water heating
    - Baseline model: data driven model in terms of per geyser load profile and units of retrofitting, or physical model established from first principle;
    - Baseline adjustment factors: COP, number of units of retrofitting, ambient temperature, heating/cooling degree days.
- Air conditioning
    - Baseline model: data driven model in terms of percentage load profile of different room function type and total installation capacity, or physical model established from first principle;

- Baseline adjustment factors: COP, number of units of retrofitting, ambient temperature, heating/cooling degree days, operating schedule, occupancy rate, etc.

4.2.6 Savings calculation

- Savings are the difference between the adjusted baseline and actual energy/demand consumption post retrofitting.

5 M&V Performance

The major M&V performance indicators are its accuracy, completeness, conservativeness, consistency, relevance, and transparency.

5.1 Accuracy

The M&V accuracy requirements in terms of confidence and precision levels of different energy efficiency programmes in various regions and organizations are summarised and listed as follows. M&V reports should be as accurate as the M&V budget will allow. The optimal M&V plan can be designed to achieve the maximum accuracy with given M&V budget.

Region/organization	Project type	Confidence (%)	Precision (%)
IPMVP [1]	All	90%	10%
FEMP [4]	All	80%, 90%	10%, 20%
ISO New England [18]	All	80%	20%
Minnesota [19]	All	90%	10%
PJM Interconnect [20]	All	90%	10%
CDM [21-22]	Large scale	95%	5%
	Small scale	90%	10%
California [23]	Basic rigour	90%	30%
	Enhanced rigour	90%	10%
Ontario, Canada [24]	Large projects	90%	20%
	Retrofit projects	90%	10%
	DSM	90%	5%

5.2 Completeness and Relevance

Completeness and relevance of the M&V reports are evaluated via:

- The project boundary covers all the project scope;
- Only savings within the project boundary are reported and accounted for.

5.3Conservativeness

As required by most M&V guidelines [2, 4, 7-8], the savings reported by the M&V process must be conservative in terms of the following perspectives:

- Where judgments are made about uncertain quantities, M&V procedures should be designed to under-estimate savings.
- Uncertainty shall be taken into account such that more accurate measurement or a more rigorous M&V process cannot invalidate the result. In this context, invalidating a result means that ***lower*** savings are reported.

5.4Consistency

The following criteria are expected to improve the consistency of the M&V activities in evaluation building energy performance.

- The same M&V standards and protocols to be used for one specific EE programme;
- The M&V professionals are qualified under the basic requirements in conducting the M&V activities.
- The measurement instruments that are used for M&V satisfy the same specification and calibration procedure.
- “Consistent” does not mean “identical”, but differences of the M&V results obtained from different M&V protocols, M&V professionals and M&V instruments must be controlled as minimal.

5.5 Transparency

In the South African M&V practice, transparency is ensured by the following procedure:

- M&V reports are shared with all project participants with some key M&V deliverables to be approved and signed off by all stakeholders such as the M&V plan and the baseline reports;
- The reported M&V results are repeatable.
- M&V reports and all supporting documents in terms of raw metering data, and project database are kept as records for future reference.

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Your guide to energy efficiency in buildings.

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bigEE is an international initiative of research institutes for technical and policy advice and public agencies in the field of energy and climate, co-ordinated by the Wuppertal Institute (Germany). It is developing the international web-based knowledge platform bigee.net for energy efficiency in buildings, building-related technologies, and appliances in the world's main climatic zones.

The bigee.net platform informs users about energy efficiency options and savings potentials, net benefits and how policy can support achieving those savings. Targeted information is paired with recommendations and examples of good practice.

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