BaaS
Building as a Service

FP7-ICT-2011-6: ICT Systems for Energy Efficiency
Small or Medium-scale Focused Research Project
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Deliverable 1.2:

Energy Saving Measurement and Verification Methodology to evaluate the BaaS solution

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Deliverable Summary Sheet

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Deliverable 1.2: Short Description

This deliverable presents a comparative overview of the main 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 BaaS projects.

Keywords: Measured and Verification, IPMVP, ASHRAE, KPI.

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Abbreviations and Acronyms

BaaS	Building as a Service
IPMVP	International Performance Measurement and Verification Protocol
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning
M&V	Measurements and Verification
ICT	Information and Communication Technologies
ECMs	Energy Conservation Measures
ESPCs	Energy Savings Performance Contracts
O&M	Operations and Maintenance
HVAC	Heating Ventilation and Air Conditioning
CV	Coefficient of Variance
CPUC-ED	California Public Utilities Commisions's Energy Division
CEC	California Energy commission
CADMAC	California's Measurement and Evaluation Protocols
NAESCO	National Association of Energy Services Companies
PGC	Public Goods Charge
RMSE	Root Mean Squared Error
FEMP	Federal Energy Project
RFP	Request for Proposals
DOE	Department of Energy
ESCO	Energy Service Company
BPG-M&V	Best Practice Guide to Measurement and Verification of Energy Savings
AEPCA	Australasian Energy Performance Contracting Association
IAccP	Innovation Access Program
CLUBS2E	Energy Efficiency Services Club
EPC	Energy Performance Contract
EVO	Efficiency Valuation Organization
KPI	Key Performance Indicators
HDD	Heating Degree Day

Executive Summary

This deliverable presents a comparative overview of the main measurement and verification protocols available on the market. The purpose of this document is to identify the best suited protocol to be the reference for BaaS project.

The first part of this deliverable consists of a brief description about methodologies for measurement and verification of energy savings; the protocols that will be reviewed are:

- ASHRAE Guideline 14-2002
- International Performance Measurement and Verification Protocol (IPMVP)
- California energy efficiency evaluation protocols: Technical Methodological and Reporting
- M&V Guidelines Measurement and Verification for Federal Energy Projects, Version 3.0
- A Best Practice Guide to Measurement and Verification of Energy Savings (PGG-M&V)
- Measurement and Verification Energy Efficiency Service

Then, making a comparative between methodologies and its main features will be explained how was concluded that IPMVP is the best suited protocol to be used on BaaS.

The second part makes an analysis of IPMVP and are assessed the 13 steps that should have the plan within the context of ICT. The development and implementation of the methodology for each demo site will be made on work package 6.

1 Introduction

The objectives of measurement and verification (M&V) are to provide an impartial, credible transparent and replicable process that can be used to quantify and assess the impacts and sustainability of projects. This section describes the concept of M&V and reviews the state of the art through different projects.

1.1 Purpose of Measure and Verification

M&V techniques can be used by facility owners or energy efficiency project investors for the following purposes [1]:

- Increase energy savings

Accurate determination of energy savings gives facility owners and managers valuable feedback on their energy conservation measures (ECMs). This feedback helps them adjust ECM design or operations to improve savings, achieve greater persistence of savings over time, and lower variations in savings.

- Document financial transactions

For some projects, the energy efficiency savings are the basis for performance-based financial payments and/or a guarantee in a performance contract. A well-defined and implemented M&V Plan can be the basis for documenting performance in a transparent manner and subjected to independent verification.

- Enhance financing for efficiency projects

A good M&V Plan increases the transparency and credibility of reports on the outcome of efficiency investments. It also increases the credibility of projections for the outcome of efficiency investments. This credibility can increase the confidence that investors and sponsors have in energy efficiency projects, enhancing their chances of being financed.

- Improve engineering design and facility operations and maintenance

The preparation of a good M&V Plan encourages comprehensive project design by including all M&V costs in the project's economics. Good M&V also helps managers discover and reduce maintenance and operating problems, so they can run facilities more effectively. Good M&V also provides feedback for future project designs.

- Manage energy budgets

Even where savings are not planned, M&V techniques help managers evaluate and manage energy usage to account for variances from budgets. M&V techniques are used to adjust for changing facility-operating conditions in order to set proper budgets and account for budget variances.

- Enhance the value of emission-reduction credits

Accounting for emission reductions provides additional value to efficiency projects. Use of an M&V Plan for determining energy savings improves emissions-reduction reports compared to reports with no M&V Plan.

- Support evaluation of regional efficiency programs

Utility or government programs for managing the usage of an energy supply system can use M&V techniques to evaluate the savings at selected energy user facilities. Using statistical techniques and other assumptions, the savings determined by M&V activities at selected individual facilities can help predict savings at unmeasured sites in order to report the performance of the entire program.

- Increase public understanding of energy management as a public policy tool

By improving the credibility of energy management projects, M&V increases public acceptance of the related emission reduction. Such public acceptance encourages investment in energy efficiency projects or the emission credits they may create. By enhancing savings, good M&V practice highlights the public benefits provided by good energy management, such as improved community health, reduced environmental degradation, and increased employment

1.2 Why should we measure and verify?

Implementing measurement and verification (M&V) strategies in energy performance contracts is required for instance in federal contracts in USA such as the Super Energy Savings Performance Contracts (Super ESPCs). Since energy savings are "guaranteed," the legislation requires he contractor to verify the achievement of energy cost savings each year.
There are many reasons to use M&V strategies that go beyond satisfying the law. Properly applied, M&V can:

- Accurately assess energy savings for a project,
- Allocate risks to the appropriate parties,
- Reduce uncertainties to reasonable levels,
- Monitor equipment performance,
- Find additional savings,
- Improve operations and maintenance (O&M),
- Verify that cost savings guarantee is met, and
- Allow future adjustments as needed

1.3 State of the Art

The European Commission promotes the use of ICT as one of the tools with more potential to improve energy efficiency. Aligned with this topic, where launched several calls for proposals and in the Third Call for Proposals under ICT PSP Work Programme 2009, whose objective was ICT for energy efficiency in social housing, there were selected three projects: 3e-HOUSES, E3SoHo and eSESH[2].

The three consortia were asked to work on the development of a methodology for energy saving measurement and we have taken into account this information for the development of this report. In these projects, methodologies of measurement and verification have been developed and applied to different building sectors, but as can be seen in Table 1, none of these projects has worked with non-residential buildings.

By providing this information, it is intended to ensure that each successive project understands, evaluates, and builds upon past work and that best practices are captured.

The European Commission is currently also funding projects that have rolled-out ICT solutions in and around public non-residential buildings. These projects have not yet developed a common way of assessing the energy savings potential of the solutions they deploy. The projects target energy efficiency control systems in hospitals, theatres, schools, town halls etc. but also roll out intelligent street lighting in order to save energy.

Table 1. Relevant Research Projects

Acronym	Description	Sector of Application. M&V
3e- HOUSES CIP-ICT-PSP [3]	3e-HOUSES project deals with the integration of the most established ICT technologies in social housing in order to provide an innovative service for energy efficiency.	Residential Sector. Social housing.
E3SoHo CIP-ICT-PSP [4]	Energy Efficiency in European Social Housing. The overall objective of E3SoHo Project is to implement and demonstrate in 3 Social Housing pilots an integrated and replicable ICT-based solution which aims to bring about a significant reduction of 25% of energy consumption in European social housing by providing tenants with feedback on consumption and offering personalised advice for improving their energy efficiency reducing the energy consumption and increasing the share of Renewable Energy Sources	Residential Sector. Social Housing
eSESH CIP-ICT-PSP [5]	Saving Energy in Social Housing with ICT. The project is developing a range of new ICT-based services for social housing tenants, to be evaluated in pilots across Europe. eSESH Advanced Energy Awareness Services (EAS) provide direct, timely and comprehensible feedback on energy consumption, enabling tenants to adapt their energy consumption behaviour. In addition, a comprehensive set of Energy Management Services (EMS) help reduce consumption peaks and optimise the timing of domestic consumption.	Residential Sector. Social Housing
DIRECTION EeB ENERGY [6]	DIRECTION Project aims at the creation of a framework of demonstration and dissemination of very innovative and cost-effective energy efficiency technologies for the achievement of very low energy new buildings.	New building
SEEDS **[7]**	The SEEDS project devotes its attention to improving energy efficiency in new and existing buildings, which encompasses the most diverse, largest and most cost-effective mitigation opportunities in buildings. Such an energy consumption reduction will be achieved with the development of ICT tools for the management of energy use in buildings and open spaces.	Residential and Commercial buildings.

1.4 Relation to other activities in the project

In the task 1.2, a methodology has been identified to record evidence of energy savings attributed directly to the BaaS system, as an isolated retrofit-measure.

This methodology will be implemented in WP6 to the pilot buildings provided by DALKIA.

2 Methodologies to Measure Energy Savings and Verification

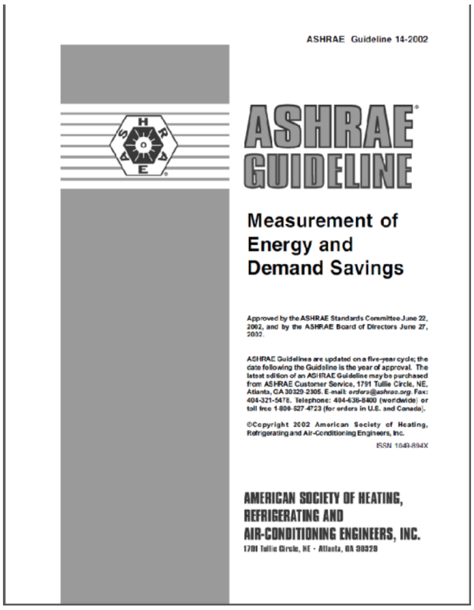
"Measurement and Verification¨ (M&V) is the process of using measurement to reliably determine actual savings created within an individual facility by an energy management program. Savings cannot be directly measured, since they represent the absence of energy use. Instead, savings are determined by comparing measured use before and after implementation of a project, making appropriate adjustments.

M&V activities consist of some or all of the following:

- Meter installation calibration and maintenance.
- Data gathering and screening.
- Development of a computation method and acceptable estimates.
- Computations with measured data.
- Reporting, quality assurance, and third party verification of reports

When there are some doubts about the outcome of a project, or no need to prove results to another party, applying M&V methods to calculate savings may not be necessary. However, it is still wise to verify (initially and repeatedly) that the installed equipment is able to produce the expected savings. Verification of the potential to achieve savings is referred to as operational verification, which may involve inspection, commissioning of equipment, functional performance testing and/or data trending. IPMVP-adherent M&V includes both operational verification and an accounting of savings based on site energy measurements before and after implementation of a project, and adjustments, as described above.

2.1 ASHRAE Guideline 14-2002. Measurement of Energy and Demand Savings



Guideline 14 was developed by ASHRAE to fill a need for a standardized set of energy (and demand) savings calculation procedures. The intent is to provide guidance on minimum acceptable levels of performance for determining energy and demand savings, using measurements, in commercial transactions [8]

ASHRAE Guideline14-2002 Measurement of Energy and Demand Savings is a reference for calculating energy and demand savings associated with performance contracts using measurements. In addition, it sets forth instrumentation and data management guidelines and describes methods for accounting for uncertainty associated with models and measurements. Guideline 14 does not discuss other issues related to performance contracting.

There is no direct way of measuring energy use or demand savings since instruments cannot measure the absence of energy use or demand. However, the absence of energy use or demand can be calculated by comparing measurements of energy use and/or demand from before and after implementation of an energy conservation measure (ECM).

Simple comparison by subtraction of post-retrofit energy use from the pre-retrofit quantity does not differentiate between the energy impacts of the ECM and those of other factors such as weather or occupancy. In order to assess the effectiveness of the ECM alone, the influence of these other complicating factors, such as weather and usage factors, must be removed.

This guideline addresses determination of energy savings by comparing before and after energy use and making adjustments for non-ECM changes that affect energy use. The basic method of this guideline is shown in Figure 1.

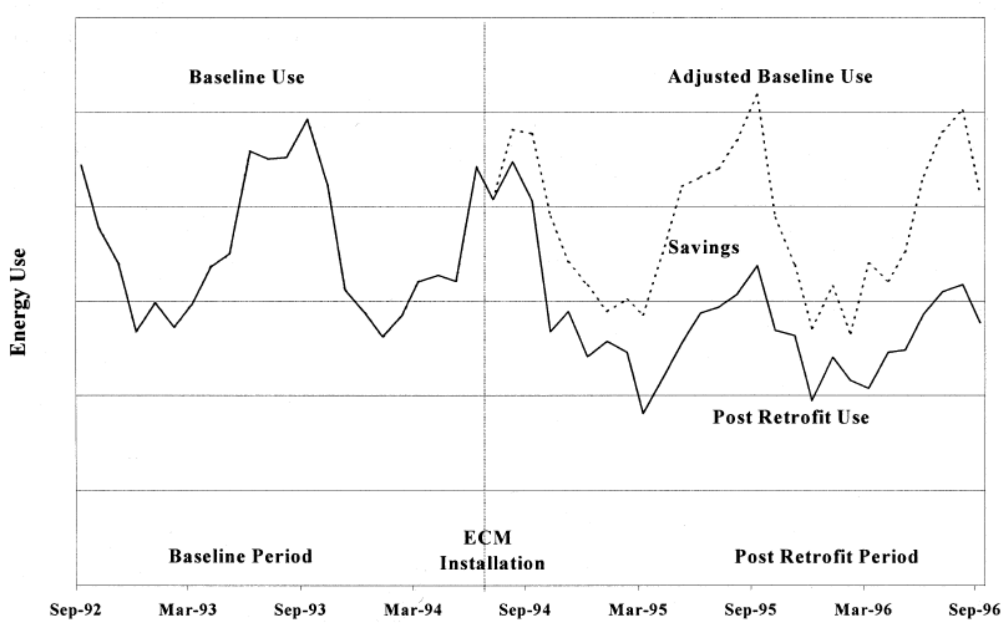


Figure 1. Determining savings

It involves projecting energy use or demand patterns of the pre-retrofit (baseline) period into the post-retrofit period. Such projection requires adjustment of baseline energy use or demand to different conditions of weather, occupancy, or other energy governing variables. Savings are then determined as:

Savings = (Baseline energy use or demand projected to Post-retrofit conditions) minus (Post-retrofit energy use or demand)

In this common form, the derived savings can also be considered as avoided energy use or demand, since if the retrofit had not taken place, the post-retrofit period energy use or demand would have been that much higher.

2.1.1 Approaches

The three approaches to determining savings use similar concepts in savings computation. They differ in their ways of measuring the actual energy use and demand quantities to be used in savings determination. This clause summarizes the three approaches for determining energy and demand savings on the following table.

Table 2. Approaches ASHRAE

Approaches	Description
Whole Building	The whole building approach uses a "main" meter to measure the energy flow to the whole building, a group of buildings, or separate sections of a building. Energy flow is usually electric, gas, oil, and thermal. ECMs may have been applied to one or more of the systems served by the meter. This approach may involve the use of monthly utility bill data or data gathered more frequently from a main meter.
Retrofit Isolation	The retrofit isolation approach uses meters to isolate the energy use and/or demand of the subsystems (e.g., lighting, chiller, boiler) affected by the ECM from that of the rest of the facility. These measurements may be made once before and once after the retrofit, periodically, or continuously. Savings derived from isolated and metered systems may be used as a basis for determining savings in similar but unmetered systems within the same facility providing they are subjected to similar operating conditions throughout the baseline and post-retrofit periods.
Whole Building Calibrated Simulation	The whole building calibrated simulation approach involves the use of a computer simulation tool to create a model of energy use and demand of the facility. This model, which is typically of pre-retrofit conditions, is calibrated or checked against actual measured energy use and demand data and possibly other operating data. The calibrated model is then used to predict energy use and demand of the post-retrofit conditions. Savings are derived by comparison of modeled results under the two sets of conditions or by comparison of modeled and actual metered results.

2.1.2 Selecting Relevant Independent Variables

The independent variables are basically the forcing functions of the energy-using system. A proper analysis of any system requires that the most significant independent variables be identified, measured over the periods of interest, and then considered in any savings computation. Examples of significant independent variables include weather, occupancy, the number of items produced in an industrial facility, and the occupancy rate of a hotel. Variables that are unaffected by the retrofit but that are expected to change between or during the baseline and post-retrofit periods should be tested for their significance to savings uncertainty.

Selection of independent variables that substantively affect energy use and/or demand requires full understanding of how the facility uses energy and how the ECM acts on this energy use. All reasonable variables should be tested, using such parameters as the "t-test" to determine which variables are substantive.

2.1.3 Selecting the Baseline Period

Generally the period immediately before retrofit is preferred as the baseline period since its operations are most likely representative of the post-retrofit period. Also, since operating conditions of the most recent period are most easily remembered by operating staff, the most recent period is least likely to introduce bias or error from unaccounted for factors.

The range of conditions encountered by the affected energy-using system(s) should govern the length of the baseline period. Baseline periods, which span all modes of system operation (e.g., summer and winter or maximum and minimum hotel occupancy) are needed to reduce uncertainty in computed savings.

Where more than a continuous 12 months of data are available, caution should be exercised to ensure that no time period is overrepresented. Balanced representation of all operating modes can be achieved by restricting baseline periods to an integral number of continuous 12-month periods (e.g., 12, 24, 36 months), not partial years (e.g., 13, 22, 30 months).

2.1.3.1 Documenting Baseline Condition

During the post-retrofit period there may be changes in the design or use of the building that invalidate the baseline model. In order to provide a proper basis for future adjustments, appropriate operating conditions during the baseline period shall be recorded. The conditions to be recorded depend on the facility and its operation and the methods to be used to detect changes. However, the types of information normally required as a minimum are:

- occupancy pattern, density, schedule, and type, for each of the typical seasons
- throughput or other plant loads on typical and average days in each operating mode
- operating schedules and key set points of energy-using systems for all operating modes
- spot measurements under known operating conditions, where separate circuits serve distinct types of constant loads
- no-routine functions of the facility, their dates and impacts on operations
- the nature and timing of any breakdown of significant energy-using equipment
- equipment nameplate data, except where changes are likely to be easily noticed and documented, for example, addition of more space or new services

When the only way to determine that a change has happened beyond the known retrofit(s) is to re-audit all the equipment, then all baseline equipment nameplates must be recorded before retrofit. Where there is a possibility of future equipment removal, replacement, or addition, without the full knowledge of the parties interested in the savings determination, a record shall be made of the make and model of all significant energy-using equipment in place during the baseline period. Baseline conditions shall be recorded for all the energy-using systems served by the meters to be used in the savings determination.

2.1.4 Setting the Duration of the Post-Retrofit Measurement Period

Variables used in computing savings shall be measured over a period of time that is long enough to:

- Encompass all operating modes of the retrofitted system(s),
- Span the full range of independent variables normally expected for the post retrofit period, and

- Provide the intended level of certainty in the reported savings.

2.1.4.1 Selecting Measurement Equipment

All meters for measuring energy use, demand, or independent variable introduce some error. Meter error can be a significant factor affecting the uncertainty in computed savings. The number and location of the measurement devices also influence the level of uncertainty. The costs of the measurement equipment should be assessed in the measurement and verification plan

2.1.4.2 Weather Data

Where a nearby weather station is unavailable, a more distant station may be used if its weather pattern is well correlated to the pattern at the particular facility, even if the total heating or cooling conditions are somewhat different. If on-site measurement of temperature is used, the data shall be recorded in the pre-retrofit and post-retrofit periods using the same instruments, at the same location. It is also

2.1.5 Approach Specific Requirements

There are four compliance paths for the three approaches. Each path has its own requirements as described below. Since some of the requirements are similar but not identical, Table 3 presents a summary of the key path specific compliance requirements.

2.1.5.1 Whole Building Prescriptive Path

This path shall be used when no uncertainty calculations are included with savings reports. Compliance with this path requires the following:

a. Expected savings shall exceed 10% of measured whole building (or relevant submetered portion of whole building) energy use or demand.
b. The baseline period shall span a continuous period of at least 12 months without any gaps in energy use or demand or independent variable data.
c. There shall be a minimum of nine valid measured data points in the baseline data.
d. No data points shall be eliminated from the baseline period.
e. The baseline model shall have a maximum CV(RMSE) of 20% for energy use and 30% for demand quantities when less than 12 months' worth of post-retrofit data are available for computing savings. These requirements are 25% and 35%, respectively, when 12 to 60 months of data will be used in computing savings. When more than 60 months of data will be available, these requirements are 30% and 40%, respectively.
f. The algorithm for savings determination shall comply with net determination bias.
g. Savings shall not be reported for post-retrofit periods without valid measured data.
h. Measured hourly or more frequent data shall be averaged to intervals of at least one day in length.

2.1.5.2 Whole Building Performance Path

Compliance with this path requires the following:

a. The baseline data shall span the normal full range of all independent variables under normal facility operations.

b. Reasons shall be reported for data gaps, data elimination, or estimation of any actual measured data in the baseline or post-retrofit periods. No more than 25% of the measured data shall be excluded.
c. Where multiple similar facilities of one owner are involved, uncertainty and confidence calculations shall include the impact of any sampling techniques used.
d. The algorithm for savings determination shall comply with net determination bias test.
e. With each annual savings report, show at least the level of uncertainty and confidence interval in the savings determined during the post-retrofit period.
f. The level of uncertainty must be less than 50% of the annual reported savings, at a confidence level of 68%.

2.1.5.3 Retrofit Isolation Performance Path

Compliance with this path requires the following:

a. The baseline data shall span the normal full range of all independent variables expected to occur under normal facility operations.
b. A technique identified in Annex E shall be used.
c. Reasons shall be reported for data gaps, elimination or estimation of any actual measured data in the baseline or post-retrofit periods.
d. Estimation of missing data shall use actual data points that span the typical range of independent variables.
e. Where energy use measurement is less than continuous, periodic measurements shall be made of demand, and operating periods of relevant equipment shall be recorded continuously.
f. Where multiple similar systems at one facility are involved, uncertainty and confidence calculations shall include the impact of any sampling techniques used.
g. The algorithm for savings determination shall comply with net determination bias test.
h. With each annual savings report, show at least the level of uncertainty and confidence interval in the savings determined during the post-retrofit period.
i. The level of uncertainty must be less than 50% of the annual reported savings, at a confidence level of 68%.

2.1.5.4 Whole Building Calibrated Simulation Performance Path

Compliance with this path requires the following:

a. The simulation tool used to develop models for buildings shall be a computer-based program for the analysis of energy use in buildings. It shall be commercially available or in the public domain. The tool shall be able to adequately model the facility and ECM(s), performing calculations for each hour of the time period in question, e.g., for a one-year period the model shall perform 8,760 hourly calculations. In addition, it shall be able to explicitly model at least the following:
    - 8,760 hours per year,
    - Thermal mass effects,
    - Occupancy and operating schedules that can be separately defined for each day of the week and holidays,
    - Individual set points for thermal zones or HVAC components,
    - Actual weather data
    - User-definable part-load performance curves for mechanical equipment, and
    - User-definable capacity and efficiency correction curves for mechanical equipment operating at non-rated conditions.

b. Provide a complete copy of the input data, indicating which data are known and which are assumed. Report the source of all data described as "known," and assess its level of uncertainty.
c. Report the name and version of simulation software used
d. Report the source and accuracy of the calibration data.
e. Calibration data shall contain at a minimum all measured monthly utility data from 12 bills spanning at least one year.
f. The computer model shall have an NMBE of 5% and a CV(RMSE) of 15% relative to monthly calibration data. If hourly calibration data are used, these requirements shall be 10% and 30%, respectively.
g. With each savings report, show at least the level of uncertainty and confidence interval for the annual savings determined during the post-retrofit period.
h. The level of uncertainty must be less than 50% of the annual reported savings, at a confidence level of 68%.

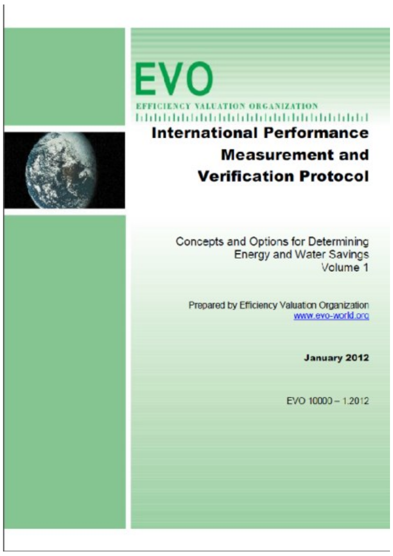
Table 3. Path Specific Compliance Requirements

		Minimum Requirements for Each Path			
		Whole Building		Retrofit Isolation	Whole Building Calibrated Simulation
		Prescriptive	Performance	Performance	Performance
1	Measured data available from:	Baseline and post – retrofit	Baseline and post-retrofit	Baseline and post-retrofit	Baseline and/or post-retrofit. Report source and accuracy
2	Energy use measurement type	Continuous	Continuous	Note 3	Continuous
3	Minimum period spanned by baseline data	12 months	Full range	Full range	12 months
4	Minimum number of valid data points	9			12
5	Allow elimination of data?	No	Explain Max 25%	Explain	
6	Algorithm for saving determination	Determination bias< 0.005%	Net determination bias <0.005	Net determination bias <0.005	
7	Baseline model uncertaintly	Note 1			Note 2
8	Experted savings	>10%			
9	Uncertaity analysis		Required	Required	Required
10	Number and type of ECM	>1 or complex	>1 or complex	1	>1 or complex
11	ECM interaction with energy use of the rest of building	Can be significant	Can be significant	None	Can be adequately simulated
12	Special skills of personnel				Five years' computer simulation experience
13	Maximum level of uncertainty		50% of annual reported savings at 68%	50% of annual reported savings at 68%	50% of annual reported savings at 68%

			confidence	confidence	confidence
14	Use of sampling	Not allowed	Note 4	Note 5	Not allowed
15	Minimum data interval	1 day			
16	Modeling tool				Simulation (hourly if include demand), public domain in commercially available, plus, report version number and provide input file.
17	Allow estimate of post-retrofit data	No	From data spanning missing data	From data spanning missing data	From data spanning missing data

	Notes
1	For<12 month post-retrofit savings reporting period length: max 20%(energy use), 30% (demand) For 12-60 month post-retrofit savings reporting period length: max 25% (energy use), 35%(demand) For >60% month post-retrofit savings reporting period length: max, 30% (energy use), 40% (demand)
2	For monthly calibration data 15% and NMBE 5% For hourly calibration data 30% and NMBE 10%, if used.
3	If energy use measurement is not continuous, periodically measure demand and continuously record operating periods of relevant equipment.
4	Multiple similar facilities, providing sampling error in included in savings uncertainty calculation
5	Multiple similar systems at one facility, providing sampling error is included in savings uncertainty calculation

2.2 International Performance Measurement and Verification Protocol (IPMVP)



The International Performance Measurement and Verification Protocol (IPMVP) Volume I is a guidance document describing common practice in measuring, computing and reporting savings achieved by energy or water efficiency projects at end user facilities. The IPMVP presents a framework and four measurement and verification (M&V) Options for transparently, reliably and consistently reporting a project's saving [1] . M&V activities include site surveys, metering of energy or water flow(s), monitoring of independent variable(s), calculation, and reporting. When adhering to IPMVP's recommendations, these M&V activities can produce verifiable savings reports.

The IPMVP is intended to be used by professionals as a basis for preparing savings reports. Each user must establish its own specific M&V Plan that addresses the unique characteristics of the project. The IPMVP is not a standard and thus there is no formal compliance mechanism for this document. Adherence with the IPMVP requires preparation of a project specific M&V Plan that is consistent with IPMVP terminology. It must name the IPMVP Option(s) to be used, metering monitoring and analysis methods to be used, quality assurance procedures to be followed, and person(s) responsible for the M&V.

Energy, water or demand savings cannot be directly measured, since savings represent the absence of energy/water use or demand. Instead, savings are determined by comparing measured use or demand before and after implementation of a program, making suitable adjustments for changes in conditions.

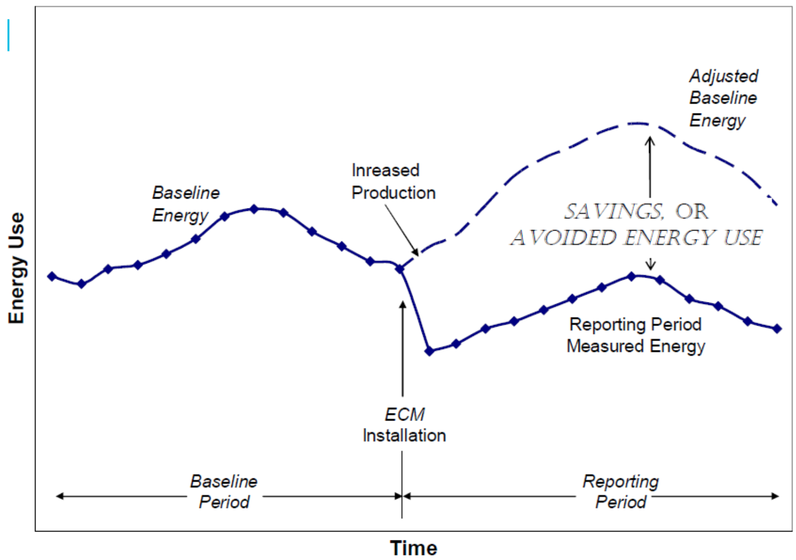


Figure 2. Energy Consumption

As an example of savings determination process, Figure 2 shows the energy-usage history of an industrial boiler before and after the addition of an Energy Conservation Measure (ECM) to recover heat from its flue gases. At about the time of ECM installation, plant production also increased.

To properly document the impact of the ECM, its energy effect must be separated from the energy effect of the increased production. The "baseline energy" use pattern before ECM installation was studied to determine the relationship between energy use and production.

Following ECM installation, this baseline relationship was used to estimate how much energy the plant would have used each month if there had been no ECM (called the "adjusted-baseline energy"). The saving, or 'avoided energy use' is the difference between the adjusted-baseline energy and the energy that was actually metered during the reporting period.

Without the adjustment for the change in production, the difference between baseline energy and reporting period energy would have been much lower, under-reporting the effect of the heat recovery.

It is necessary to segregate the energy effects of a savings program from the effects of other simultaneous changes affecting the energy using systems. The comparison of before and after energy use or demand should be made on a consistent basis, using the following general equation:

Savings = (Baseline – Period Use or Demand – Reporting- Period Use or Demand ± Adjustments.

The "Adjustments" term in this general equation is used to re-state the use or demand of the baseline and reporting periods under a common set of conditions. This adjustments term distinguishes proper savings reports from a simple comparison of cost or usage before and after implementation of an energy conservation measure (ECM). Simple comparisons of utility costs without such adjustments report only cost changes and fail to report the true performance of a project. To properly report "savings," adjustments must account for the differences in conditions between the baseline and reporting periods.

The baseline in an existing facility project is usually the performance of the facility or system prior to modification. This baseline physically exists and can be measured before changes are implemented. In new construction, the baseline is usually hypothetical and defined based on code, regulation, common practice or documented performance of similar facilities. In either case, the baseline model must be capable of accommodating changes in operating parameters and conditions so "adjustments" can be made.

2.2.1 Baseline Period

The baseline period should be established to:

- Represent all operating modes of the facility. This period should span a full operating cycle from maximum energy use to minimum.
- Fairly represent all operating conditions of a normal operating cycle. For example, though a year may be chosen as the baseline period, if data is missing during the selected year for one month, comparable data for the same month in a different year should be used to ensure the baseline record does not under represent operating conditions of the missing month.

- Include only time periods for which all fixed and variable energy-governing facts are known about the facility. Extension of baseline periods backwards in time to include multiple cycles of operation requires equal knowledge of all energy-governing factors throughout the longer baseline period in order to properly derive routine and non-routine adjustments
- Coincide with the period immediately before commitment to undertake the retrofit. Periods further back in time would not reflect the conditions existing before retrofit and may therefore not provide a proper baseline for measuring the effect of just the ECM.

ECM planning may require study of a longer time period than is chosen for the baseline period. Longer study periods assist the planner in understanding facility performance and determining what the normal cycle length actually is.

2.2.2 Reporting Period

The user of the savings reports should determine the length of the reporting period. The reporting period should encompass at least one normal operating cycle of the equipment or facility, in order to fully characterize the savings effectiveness in all normal operating modes.

Some projects may cease reporting savings after a defined "test" period ranging from an instantaneous reading to a year or two. The length of any reporting period should be determined with due consideration of the life of the ECM and the likelihood of degradation of originally achieved savings over time.

Regardless of the length of the reporting period, metering may be left in place to provide feedback of operating data for routine management purposes and specifically to detect subsequent adverse changes in performance.

If reducing the frequency of savings measurement after initial proof of performance, other on site monitoring activities could be intensified to ensure savings remain in place.

2.2.3 Basis for Adjustments

The adjustments term shown in Equation should be computed from identifiable physical facts about the energy governing characteristics of equipment within the measurement boundary. Two types of adjustments are possible:

2.2.4 Routine Adjustments

For any energy-governing factors, expected to change routinely during the reporting period, such as weather or production volume. A variety of techniques can be used to define the adjustment methodology. Techniques may be as simple as a constant value (no adjustment) or as complex as a several multiple parameter non-linear equations each correlating energy with one or more independent variables. Valid mathematical techniques must be used to derive the adjustment method for each M&V Plan.

2.2.5 Non-Routine Adjustments

For those energy-governing factors which are not usually expected to change, such as: the facility size, the design and operation of installed equipment, the number of weekly production shifts, or the type of occupants. These static factors must be monitored for change throughout the reporting period.

2.2.6 IPMVP Options

IPMVP provides four Options for determining savings (A, B, C and D). The choice among the Options involves many considerations including the location of the measurement boundary (If it is decided to determine savings at the facility level, Option C or D may be favored. However if only the performance of the ECM itself is of concern, a retrofit-isolation technique may be more suitable (Option A, B or D).

2.2.6.1 Option 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. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the measured parameter, and the length of the reporting period. Parameters not selected for field measurement are estimated. Estimated 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. Measurement frequency ranges from short-term to continuous, depending on the expected variations in the measured parameter, and the length of the reporting period. Parameters not selected for field measurement are estimated. Estimated can based on historical data, manufacturer's specifications, or engineering judgment. Documentation of the source or justification of the estimated parameter is required. The plausible savings error arising from estimation rather than measurement is evaluated.

How Savings are Calculated:

Engineering calculation of baseline and reporting period energy from:

- Short-term or continuous measurements of key operating parameter(s).
- Estimated values.
- Routine and non-routine adjustments as required.

Typical applications.

A lighting retrofit where power draw is the key performance parameter that is measured periodically. Estimated operating hours of the lights based on facility schedules and occupant behavior.

2.2.6.2 Option 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.

How Savings Are Calculated

Short-term or continuous measurements of baseline and reporting-period energy, and/or engineering computations using measurements of proxies of energy use.routine and non-routine adjustments as required.

Typical Applications

Applications 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 in the baseline period this meter is in place for a week to verify constant loading. The meter is in place throughout the reporting period to track variations in power use.

2.2.6.3 Option 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.

How Savings Are Calculated

Analysis of whole facility baseline and reporting period (utility) meter data. Routine adjustments as required, using techniques such as simple comparison or regression analysis. Non-routine adjustments as required.

Typical Applications

Multifaceted energy management program affecting many systems in a facility. Measure energy use with the gas and electric utility meters for a twelve month baseline period and throughout the reporting period

2.2.6.4 Option D. Calibrated Simulation

Savings are determined through simulation of the energy use or 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.

How Savings Are Calculated

Energy use simulation, calibrated with hourly or monthly utility billing data. (Energy end use metering may be used to help refine input data.)

Typical Applications

Multifaceted energy management program affecting many systems in a facility but where no meter existed in the baseline period. Energy use measurements after installation of gas and electric meter are used to calibrate a simulation. Baseline energy use determined using the calibrated simulation, is compared to a simulation of reporting period energy use.

In Figure 3 it showed the process to select the IPMVP option based on the full set of project conditions, analysis, budgets and professional judgment.

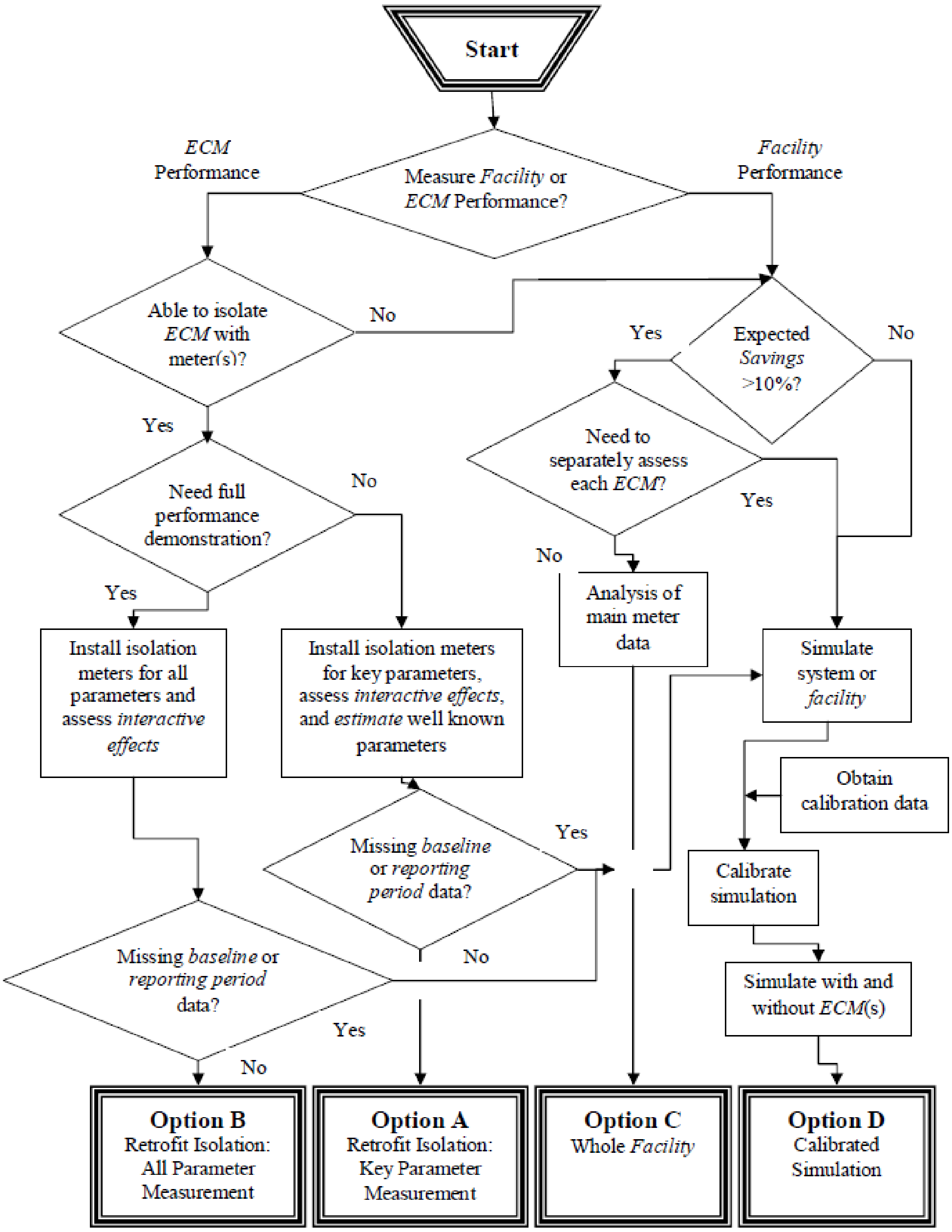
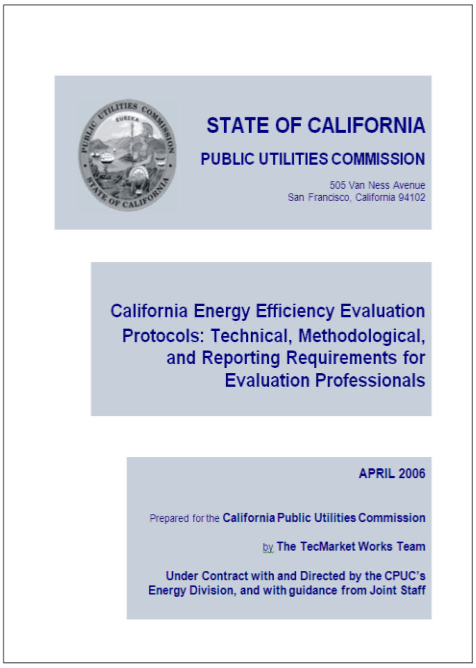


Figure 3. Option Selection Process.

2.3 California energy efficiency evaluation protocols: Technical Methodological and Reporting


STATE OF CALIFORNIA
PUBLIC UTILITIES COMMISSION
505 Van Ness Avenue
San Francisco, California 94102

California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals

APRIL 2006

Prepared for the California Public Utilities Commission
by The TecMarket Works Team
Under Contract with and Directed by the CPUC's Energy Division, and with guidance from Joint Staff

This document is to be used to guide the efforts associated with conducting evaluations of California's energy efficiency programs and program portfolios launched after December 31 [9], 2005. The Protocols are the primary guidance tools policy makers will use to plan and structure evaluation efforts and that staff of the California Public Utilities Commission's Energy Division (CPUC-ED) and the California Energy Commission (CEC) (collectively the Joint Staff), and the portfolio (or program) administrators (Administrators) will use to plan and oversee the completion of evaluation efforts. The Protocols are also the primary guidance documents evaluation contractors will use to design and conduct evaluations for programs implemented after December 31, 2005. This chapter provides an introduction to, and overall guidance for, the use of specific Protocols.

The Protocols are significantly grounded in the *California Evaluation Framework* of June 2004 (*Evaluation Framework)*. The Protocols reference the *Evaluation Framework* and other documents that provide examples of applicable methods. The requirements for conducting evaluation studies, however, are always those stated in the Protocols, which take precedence over other evaluation guidance documents, unless otherwise approved or required by the CPUC. That is, these Protocols are the primary evaluation guidance documents for all types of evaluations presented in these Protocols, however this is not to be construed as limiting the ability of the CPUC or the Joint Staff to evaluate items in addition to or beyond those identified in these Protocols or to use evaluation processes and procedures beyond those presented in these Protocols. While these Protocols are the key guiding documents for the program evaluation efforts, the CPUC and the Joint Staff reserve the right to utilize additional methodologies or approach if they better meet the CPUC's evaluation objectives and when it serves to provide reliable evaluation results using the most cost-efficient approaches available. In addition, the Protocols should be considered a "living" document that may need to be updated and revised from time to time as standard evaluation approaches evolve and as Joint Staff and Administrators gain experience using the Protocols. The CPUC will determine when an update is necessary and what process will be used to complete any updates that the agency deems necessary. Protocol users should always confirm that they are referring to the most recently CPUC-approved and -adopted version, which can be found on the CPUC website.

During the period of 1994 to 1997, California's measurement and evaluation protocols (sometimes referred to as the CADMAC Protocols) referenced the National Association of Energy Services Companies (NAESCO) standards for measurement and verification in Appendix H as a resource for M&V activities. The NAESCO protocols were the precursors to the International Performance Measurement and Verification Protocols (IPMVP) 136 established by the US Department of Energy in 1996. The California Energy Efficiency Policy Manual,137 first published in 2001 and revised in 2003, references the IPMVP, directing evaluators to "reference the appropriate IPMVP option" and "state any deviations from [the] IPMVP approach" when developing evaluation plans for programs by the Public Goods Charge (PGC).

2.3.1 Baseline Period

- For early equipment replacement (retrofit) programs, the pre-existing and still functioning equipment replaced during program participation defines the baseline. Pre-program energy consumption may be adjusted to reflect changes in equipment or building operations not related to the program.
- For equipment that is being replaced at the end of its useful life (i.e., in all situations where the customer would have been replacing the equipment in the absence of the program), standard-efficiency new equipment defines the baseline. The program's purpose in these cases is to induce customers to do the replacement with a higher-efficiency alternative than they would have selected in the absence of the program.
- For operations and maintenance (O&M) programs (such as air conditioning tune-up or retro-commissioning programs), the existing condition of the equipment or existing O&M procedures define the baseline. Pre-program energy consumption may also be adjusted to reflect changes in equipment or building operations not related to the program.
- For new construction programs, the California Energy Efficiency Standards (Title 24) that define minimum standards for new construction, and Appliance Efficiency Regulations (Title 20) are used as the baseline. For program attributes not addressed by Title 20 or Title 24 (such as grocery store refrigeration systems), a "common practice" study may be conducted to establish the program baseline. Pre-program energy consumption data cannot be measured in new construction since the building does not exist. The energy implications of the baseline building characteristics are generally calculated using a building energy simulation program.

2.3.2 M&V Plan

A measurement and verification plan should be developed for each site included in the M&V study. These individual site plans should be filed with the final EM&V report at the conclusion of the project. The purpose of the plan is to identify the data needs and analysis procedures prior to collecting the field data. The overall components of the M&V plan are listed below.

2.3.2.1 Identify Goals and Objectives

The goals and objectives of the M&V activity at a particular site are stated in the plan and may include the following:

- Verification of measure installation
- Verification of proper operation of measures
- Measurement of specific parameters required for energy savings calculations
- Metering energy consumption and demand for energy savings calculations

2.3.2.2 Specify Building Characteristics

Building characteristics are listed in the plan to help future users of the data understand the context of the monitored data. The building characteristics description should include:

- General building configuration and envelope characteristics (particularly the energy-related characteristics)
- Building occupant information (number of occupants, occupancy schedule, activities)
- Internal loads (lighting, appliances, plug and process loads)
- Type and quantity of energy-using systems and control set points
- Changes in building occupancy or operation during the monitoring period that may affect results

Besides the general building or facility description, a description of the energy conservation measures and their respective projected savings should also be included

2.3.3 Selecting and M&V Approach

This chapter provides several options for M&V studies. The options follow the terminology used in the IPMVP.

Option A - Partially Measured Retrofit Isolation. Savings under Option A are determined by partial field measurement of the energy use of the system(s) to which an energy conservation measure (ECM) was applied separate from the energy use of the rest of the facility. Measurements may be either short-term or continuous. Partial measurement means that some parameter(s) affecting the building's energy use may be stipulated, if the total impact of possible stipulation error(s) is not significant to the resultant savings. Careful review of ECM design and installation will ensure that stipulated values fairly represent the probable actual value. Stipulations should be shown in the M&V Plan, along with analysis of the significance of the error they may introduce. Savings are estimated from engineering calculations using short-term or continuous post retrofit measurements and stipulations. A typical application of Option A is a lighting retrofit, where pre/post fixture watts are stipulated from a standard fixture wattage table, and operating hours are derived from short-term measurements of fixture run-time.

The best applications for Option A include:

- Measures with constant loads
- Measures with small anticipated impact overall (low risk measure)
- Measures with small anticipated impact relative to the energy recorded at the billing meter
- Measures where interactive effects are small and can be ignored 150
- Measures where baseline adjustments to whole-building data could be problematic
- Studies where uncertainty in the deemed parameters is acceptable

Option B - Retrofit Isolation. Savings are determined by field measurement of the energy use of the systems to which the ECM was applied separate from the energy use of the rest of the facility. Short-term or continuous measurements are taken throughout the post-retrofit period. Savings are estimated from engineering calculations using short term or continuous measurements. A typical application of Option B is a variable frequency drive applied to a constant speed pumping application. Pre-retrofit power consumption is measured with a hand-held power meter (or short-term metering to confirm constant power draw), and post-retrofit power consumption is short-term metered along with some relevant independent quantity (such as fluid or ambient temperature). The relationship between power and the independent variable is used to project long-term post-retrofit energy consumption from the short-term measurements.

The best applications for Option B include:

- Measures with small anticipated impact relative to the energy recorded at the billing meter
- Measures where interactive effects are small and can be ignored
- Measures where baseline adjustments to whole-building data could be problematic
- Buildings where sub meters already exist to isolate the energy use of affected systems
- Situations where metering added under Option B would have additional benefit to the building operators, offsetting the cost
- Projects where measure level impact information is desired

Option C - Whole Facility. Savings are determined by measuring energy use at the whole-facility level. Short-term or continuous measurements are taken throughout the post-retrofit period and compared to 12 to 24 months of pre-retrofit data. Savings are estimated from an analysis of whole-facility utility meter or sub-meter data, using techniques ranging from simple comparison to regression analysis. This approach is very close in concept to a billing analysis, but may contain baseline adjustment factors that are specific to each building addressed under this option.

2.3.3.1 Billing Data Collection

Issues with Option C are similar to those encountered when conducting a statistical billing analysis:

- Data may need to be normalized to account for meter read dates
- Missing data or estimated billing may confound the analysis
- Interval demand data from demand-recording meters may be available from the serving utility, but special permission and billing data release permission from the customer or a consultant non-disclosure agreement with the customer's utility will likely be required
- Account information and billing addresses may not match the site studied. During on-site verification activities, recording the meter numbers of all meters affected by the project will help identify the correct billing record

2.3.3.2 Comparison Models

Simple comparison models look at the monthly billing data (corrected for meter read dates) during the pre- and post-retrofit period, and derive savings as a simple subtraction of the pre- and post-period data. These comparisons are appropriate only for no-weather dependent measures where the hours of operation and other factors influencing energy consumption besides the energy efficiency measure remain constant during the pre- and post-retrofit period.

Adjustment Factors

Adjustment factors are generally added to the models to account for differences in the pre- and post-retrofit periods that can affect energy consumption outside of the impact of the installed measures. Adjustments are usually made based on weather, hours of occupancy, and building operating mode (e.g. heating or cooling seasonal operating mode). Adjustments for additions of new process loads (such as the addition of a new computer center to an office building), changes in process output (such as widgets produced or hamburgers sold), and occupied floor space may also be required. Weather adjustments may be based on heating and cooling degree days, humidity, and/or temperature.

Analysis Techniques

Simple regression analysis can be used with daily or monthly consumption data. Models developed to predict energy savings from interval data should use daily rather than hourly data to control the number of independent variables and reduce uncertainty. The interval of the weather data used to make the adjustments must be compatible with the billing data; e.g. daily weather data may be needed to calculate weather adjustments to monthly data to correspond to the billing read dates. Monthly models should use pre-retrofit data in full year increments to avoid bias (by capturing all seasonal effects): e.g., 12 or 24

Baseline Model Selection Criteria

Criteria for developing and selecting baseline energy consumption models under Option C are:

- Extrapolation range - Apply data that are within 90% of the minimum value and 110% of the maximum values used to develop the baseline model.
- Expected savings should exceed 10% of the whole-building energy consumption.
- Baseline period should span at least 12 months, and contain at least 9 data points. Data should be included in full-year increments (e.g. 12, 24, or 36 months) to reduce weather-induced bias
- The IPMVP specifications for Option C models require the Coefficient of Variation of the Root Mean Squared Error (CV(RMSE)) to be less than or equal to 20% on energy and 30% on demand.

Criteria for developing and selecting baseline energy consumption models under Option C are:

Extrapolation range - Apply data that are within 90% of the minimum value and 110% of the maximum values used to develop the baseline model.

- Expected savings should exceed 10% of the whole-building energy consumption.
- Baseline period should span at least 12 months, and contain at least 9 data points. Data should be included in full-year increments (e.g. 12, 24, or 36 months) to reduce weather-induced bias.

Best applications of Option C include:

- Projects where whole-building rather than measure-specific results are permissible
- Projects where the measures do not lend themselves to retrofit isolation – such as shell measures
- Projects where interactive effects need to be included.

Option D - Calibrated Simulation. 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 skill in calibrated simulation. Savings are estimated from energy use simulation, calibrated with hourly or monthly utility billing data, and/or end use metering.

Billing Data

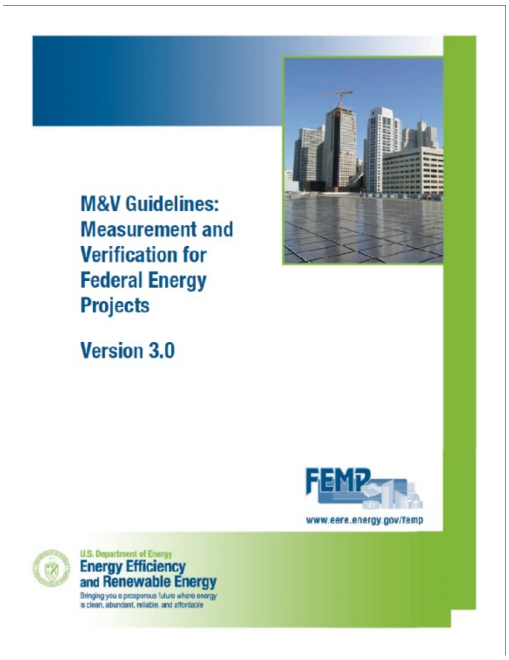
Historical utility billing data from a one or two year period can be used to check model results for gross errors. Billing data can give some insight into building energy use through a process of elimination, as described below.

- Estimate combined lighting, equipment and fan energy use from billing data for months not requiring mechanical cooling, primarily in systems equipped with economizers and non-electric heating.
- Estimate annual cooling energy from the difference between the non-cooling and cooling month energy consumption.
- Estimate annual heating consumption when heating is the only significant nonelectric fuel end use.
- Estimate hot water consumption from billing data during the non-heating season when heating and hot water are served by a non-electric energy source.
-

Best applications of Option D include:

- Projects where the expected impacts are greater than the expected modeling error
- Projects where measure-specific results are desired
- Projects where the measures do not lend themselves to retrofit isolation – such as shell measures
- Projects where interactive effects need to be included
- New construction projects, where the baseline must be simulated rather than measured
- Complicated HVAC control measures
- Commissioning and O&M programs

2.4 M&V Guidelines Measurement and Verification for Federal Energy Projects, Version 3.0



The Federal Energy Project (FEMP) [10] M&V Guideline contains specific procedures for applying concepts originating in the IPMVP. The Guideline represents a specific application of the IPMVP for federal projects. It outlines procedures for determining M&V approaches, evaluating M&V plans and reports, and establishing the basis of payment for energy savings during the contract. These procedures are intended to be fully compatible and consistent with the IPMVP.

The principal purpose are:

It serves as a reference document for specifying M&V methods and procedures in delivery orders, requests for proposals (RFPs), and performance contracts.

It is a resource for those developing project-specific M&V plans for federal ESPC projects, especially under DOE's Super ESPC contract mechanism.

The FEMP M&V Guideline contains specific procedures for applying concepts originating in the IPMVP. The Guideline represents a specific application of the IPMVP for federal projects. It outlines procedures for determining M&V approaches, evaluating M&V plans and reports, and establishing the basis of payment for energy savings during the contract. These procedures are intended to be fully compatible and consistent with the IPMVP.

Facility energy (O&M or water) savings cannot be measured, since they represent the absence of energy use. Instead, savings are determined by comparing the energy use before and after the installation of conservation measure(s), making appropriate adjustments for changes in conditions.

The "before" case is called the baseline. The "after" case is referred to as the post-installation or performance period. Proper determination of savings includes adjusting for changes that affect energy use, but that are not caused by the conservation measure(s). Such adjustments may account for changes in weather, occupancy, or other factors between the baseline and performance periods. The general equation used to calculate savings is:

Savings = (Baseline Energy – Post Installation Energy) ± Adjustments

2.4.1 Approaches

The measurement and verification (M&V) protocol mandated for projects conducted under the Super Energy Savings Performance Contract (Super ESPC) is the Federal Energy Management Program (FEMP) M&V Guidelines: Measurement and Verification for Federal Energy Projects. The FEMP Guidelines are an application of the International Performance Measurement and Verification Protocol (IPMVP). Both of these guidelines group M&V methodologies into four general categories: Options A, B, C, and D. The options are generic M&V approaches for energy and water saving projects.

M&V approaches are divided into two general types: retrofit isolation and whole-facility. Retrofit isolation methods look only at the affected equipment or system independent of the rest of the facility; whole-facility methods consider the total energy use and de-emphasize specific equipment performance. One primary difference in these approaches is where the boundary of the energy conservation measure (ECM) is drawn, as shown in Figure 4 . All energy used within the boundary must be considered. Options A and B are retrofit isolation methods; Option C is a whole-facility method; Option D can be used as either, but is usually applied as a whole-facility method.

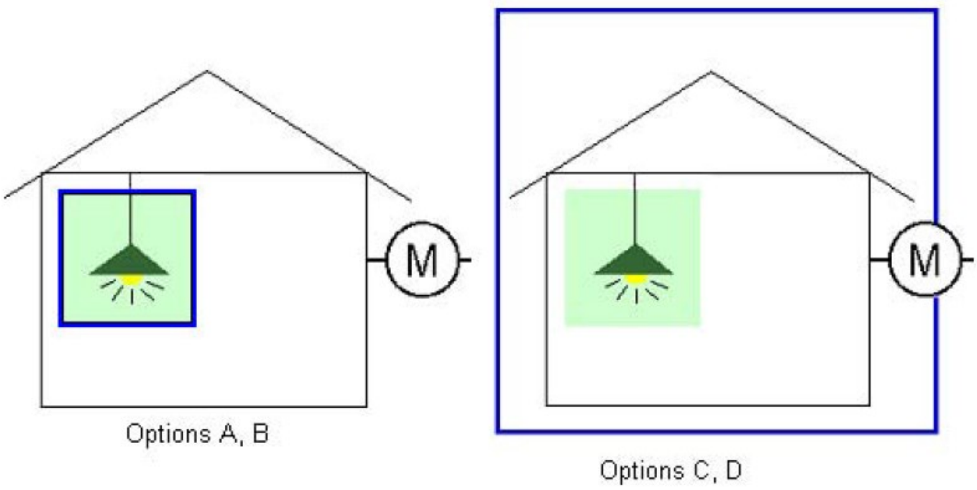


Figure 4. Retrofit Isolation (Option A and B) vs Whole – Facility M&V Methods (Options C and D)

Each option has advantages and disadvantages based on site-specific factors and the needs and expectations of the agency. While each option defines an approach to determining savings, it is important to realize that savings are not directly measured, and all savings are estimated values. The accuracy of these estimates, however, will improve with the number and quality of the measurements made.

2.4.2 *Option A - Retrofit isolation with key parameter measurement*

M&V Option A involves a retrofit or system level M&V assessment. The approach is intended for retrofits where key performance factors (e.g., end-use capacity, demand, power) or operational factors (e.g., lighting operational hours, cooling ton-hours) can be spot- or short-term-measured during the baseline and post-installation periods. Any factor not measured is estimated based on assumptions, analysis of historical data, or manufacturer's data.

2.4.3 *Option B - Retrofit isolation with all parameter measurement*

M&V Option B is a retrofit isolation or system-level approach. The approach is intended for retrofits with performance factors (e.g., end-use capacity, demand, power) and operational factors (lighting operational hours, cooling ton-hours) that can be measured at the component or system level and where long-term performance needs to be verified. It is similar to Option A, but uses periodic or continuous metering of all energy quantities, or all parameters needed to calculate energy, during the performance period. This approach provides the greatest accuracy in the calculation of savings, but increases the performance-period M&V cost.

2.4.4 *Option C - Whole-building data analysis*

M&V Option C involves whole-facility utility or sub-meter data analysis procedures to verify the performance of retrofit projects in which whole-facility baseline and performance period data are available. Option C usually involves collecting historical whole-facility baseline energy use and related data and continuously measuring whole-facility energy use after ECM installation. Baseline and periodic inspections of the equipment are also needed. Energy savings under Option C are estimated by developing statistically representative models of whole-facility or sub-metered energy consumption (i.e., therms and/or kWh). This method confirms total energy savings, but does not measure the savings from individual components.

2.4.5 *Option D - Calibrated simulation*

Option D involves whole facility or system analysis procedures to verify the performance of retrofit projects using calibrated computer simulation models. Computer simulation is a powerful tool that allows an experienced user to model the building and mechanical systems in order to predict building energy use both before and after the installation of ECMs. The accuracy of the models is ensured by using metered site data to describe baseline and/or performance period conditions. Carefully constructed models can provide savings estimates for the individual ECMs on a project. More elaborate models generally improve the accuracy of savings calculations, but increase costs. A calibrated simulation of a building, however, can be utilized to easily evaluate savings from other potential improvements.

Option D is especially useful where a baseline does not exist (e.g., new construction or major building modification) or the factors responsible for savings are not easily measured (e.g., reduced solar gain and heat loss through new windows).

2.4.6 *Selecting Relevant Independent Variables*

An independent variable is a parameter that is expected to change regularly and has a measurable effect on the energy use of a system or building. Typical independent variables that drive energy consumption that can be incorporated in regression models include outdoor temperature, other weather parameters (e.g., heating or cooling degree days), occupancy, operating hours, and other variable site conditions.

Data on independent variables may be from a third party or may be tracked using onsite data collection, depending on their nature. Weather data are typically more reliable when supplied by an independent source, but should be validated with site data to ensure applicability

Once the data have been collected, the mathematical model that is used to predict the baseline (or performance period) energy use is developed. The model should make intuitive sense—the independent variables should be reasonable and the coefficients should have the expected sign (positive or negative) and be within an expected range or magnitude.

2.4.7 *Selecting the Baseline Period*

Since energy savings must be determined by comparing energy use before and after a retrofit, the characterization of the pre-retrofit or baseline conditions is critical. Defining the baseline consists of identifying the performance and operating factors that influence energy consumption, and determining their values through observations and measurements.

Regardless of the M&V option or method used, the baseline conditions for all projects and ECMs must be adequately defined. Typically, the ESCO will define the baseline conditions during the Investment Grade Audit, but the federal agency may define baseline conditions.

The purpose of establishing the baseline conditions is to:

- Define the baseline sufficiently for purposes of calculating savings
- Document the baseline conditions in case operational changes occur after ECM installation that mandate adjustments to the performance period baseline energy use

Baseline conditions include physical, operational, and energy use data on the facility and systems. Baseline conditions are typically determined through surveys, inspections, and spot and short-term metering activities. Typically, pre-installation metering is conducted for a period of time required to capture all operating conditions of affected systems and/or processes.

Physical conditions that should be documented include equipment inventories, locations, nameplate data, system design features, and building occupancy. The key operational conditions include control strategies, set points, operating schedules, condition of equipment, loads, maintenance procedures used, peripheral equipment conditions, and weather. Energy use data that constitute the baseline may include utility billing data, sub-metered system data, and utility rate structures.

Although only a portion of a facility's systems may be included in the ESPC project, it may be appropriate to document the site conditions for other key energy using systems. This is especially true if a whole-building M&V approach (Option C or D) is being used. Often, changes outside the scope of the ESPC project at a large facility can affect the overall energy consumption at a site and may warrant an adjustment.

2.4.8 Setting the Duration of the Post-Retrofit Measurement Period.

Post-installation measurement and verification activities are conducted by both the ESCO and the federal agency to ensure that proper equipment/systems were installed, are operating correctly, and have the potential to generate the predicted savings. Verification methods include surveys, inspections, spot measurements, and short-term metering.

The Post-Installation Report includes:

- Project description
- Detailed list of installed equipment
- Details of any changes between the Final Proposal and as-built conditions, including any changes to the estimated energy savings
- Documentation of all post-installation verification activities and performance
- measurements conducted
- Performance verification—how performance criteria were met
- Documentation of construction-period savings (if any)
- Status of rebates or incentives (if any)
- Expected savings for the first year

For projects using certain M&V, the post-installation verification is the most important M&V step, because any measurements to substantiate the savings guarantee are made only once. For some measures, where equipment performance and energy savings are not expected to vary significantly over time, post-installation measurements may be the primary source of data used in the savings calculations.. Thereafter, inspections are conducted to verify that the potential to perform exists.

To determine energy savings, some measurement processes need to be conducted to identify the pre-retrofit and post-retrofit conditions. These measurements typically include energy consumption and energy-related variables. Metering issues that should be considered in preparing a project-specific M&V Plan are discussed below.

A project-specific M&V Plan should demonstrate that any metering and analysis will be done in a consistent and logical manner and with a level of accuracy acceptable to all parties. Metering and monitoring reports must specify exactly what was measured, how and when the measurements were made, what meter or meters were used, and who conducted these measurements.

2.4.9 Approach Specific Requirements

Option A can be applied when the most critical M&V issue is identifying the potential to generate savings, including situations in which:

- The magnitude of savings is low for the entire project or a portion of the project to which Option A can be applied.
- The risk of not achieving savings is low or ESCO payments do not need to be directly tied to actual savings.

Option B, retrofit isolation, is typically used when any or all of these conditions apply:

- For simple equipment replacement projects with energy savings that are less than 20% of total facility energy use, as recorded by the relevant utility meter or sub-meter
- When energy savings values per individual measure are desired

- When interactive effects are to be ignored or are estimated using estimating methods that do not involve long-term measurements
- When the independent variables that affect energy use are not complex and excessively difficult or expensive to monitor
- When sub-meters already exist that record the energy use of subsystems under consideration (e.g., a 277 V lighting circuit, a separate sub-meter for HVAC systems)

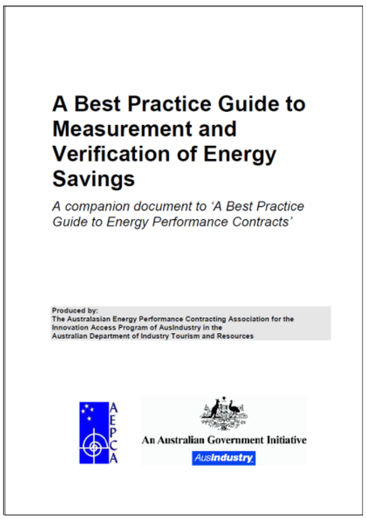
Options C, billing analysis, is typically used when any or all of these conditions apply:

- For complex equipment replacement and controls projects
- When predicted savings are relatively large (greater than 10% to 20%) as compared with the energy use recorded by the relevant utility meter or sub-meter
- When energy savings values per individual measure are not desired 5-4 M&V Guidelines 3.0 FEMP
- When interactive effects are to be included
- When the independent variables that affect energy use are complex and excessively difficult or expensive to monitor.

Option D, calibrated simulation, is used in situations similar to Option C, or in addition when any or all of these conditions apply:

- When new construction projects are involved.
- When energy savings values per measure are desired.
- When Option C tools cannot cost-effectively evaluate particular measures or their interactions with the building when complex baseline adjustments are anticipated

2.5 A Best Practice Guide to Measurement and Verification of Energy Savings (BPG-M&V) (Australian)


A Best Practice Guide to Measurement and Verification of Energy Savings

A companion document to 'A Best Practice Guide to Energy Performance Contracts'

Produced by:
The Australasian Energy Performance Contracting Association for the Innovation Access Program of AusIndustry in the Australian Department of Industry Tourism and Resources

AEPCA

An Australian Government Initiative

AusIndustry

This Best Practice Guide to Measurement and Verification (BPG-M&V) [11] was produced by the Australasian Energy Performance Contracting Association Inc. (AEPCA) with the support of the Innovation Access Program (IAccP)managed by the AusIndustry.

The information in this Guide is based primarily on the March 2002 revised edition of Volume 1 of the International Performance Measurement & Verification Protocol (IPMVP), entitled "Concepts and Options for Determining Energy and Water Savings". The IPMVP documents are regarded internationally as the "bible" of M&V. The IPMVP is the culmination of many years of development of M&V concepts and methodologies through the cooperation of international experts and practitioners. It has been widely adopted internationally and "has become the de-facto protocol for measurement and verification of performance contracts".

This Guide draws heavily from the information in IPMVP Volume 1, adapting the information, adding additional contextual and explanatory material to assist understanding and use of the concepts, methodologies and processes presented in the IPMVP Volume 1. The use of this Guide will encourage a wider readership and adoption of the M&V concepts and methodologies described in the IPMVP.

This Guide also draws heavily from the information in ASHRAE Guideline 14-2002 and the U.S. Department of Energy's Federal Energy Management Program (FEMP) M&V Guidelines Version 2.2. The FEMP M&V Guidelines are based on the IPMVP but provide additional guidance to U.S. Federal Agencies on the application of the IPMVP to their specific energy savings projects. The ASHRAE Guideline 14- 2002 provides detailed process and technical information on the "measurement of energy and demand savings".

The BPG-EPC refers readers for M&V guidance to the IPMVP 1997 and the draft release of ASHRAE Guideline 14P, which were available at that the time of writing the BPG-EPC. Since then the March 2002 revision of IPMVP Volume 1 and the final version of ASHRAE Guideline 14-2002 have been released. A major purpose of this Guide is to make users of the BPG-EPC aware of the updated versions of IPMVP and ASHRAE 14, the key changes to guidelines, terms and definitions, and the additional guidance that is currently available.

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.

2.5.1 Options

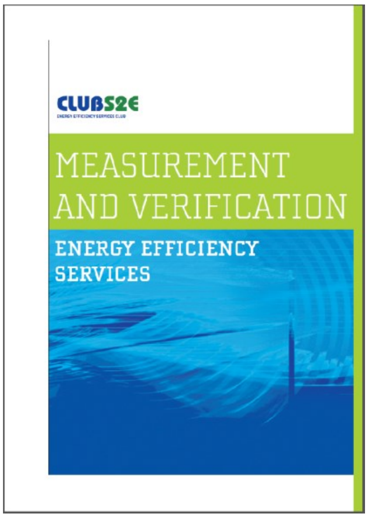
There are four generic M&V Options – Options A, B, C and D. The savings outcomes produced by the four M&V Options have varying levels of savings uncertainty and M&V costs.

All M&V Options are based on the same concept of determining savings by comparing energy use measured after the retrofit to the estimated post-retrofit energy without the retrofit. A particular Option should be chosen based on the project-specific features of each energy savings project. Each Option has advantages and disadvantages based on project-specific factors and on the expectations and requirements of the specific project.

Option A: Is used at the individual retrofit or system level. It is commonly used for specific ECMs involving retrofitting of specific components such as lighting, motors, variable speed drives, and chillers. The fundamental factors that drive energy savings are changes in “performance” (efficiency, capacity, demand, power, etc) and/or “operations” (usage, lighting operational hours, etc). For example, savings for a lighting retrofit could be achieved by using more efficient lamps to reduce the watts required to provide a specific amount of light (change in performance factor), and/or by using lighting controls to reduce the operating hours (change in operations factor). Option A is mainly intended for retrofits where either “performance” or “operations” factors can be spot or short-term measured before and after the retrofit and the other factor can be stipulated (not measured)

Savings = ((Number of Operating Hours) Before Retrofit --(Number of Operating Hours) After Retrofit) X Stipulated (kW/Fixture x No of Fixtures)

2.6 Measurement and Verification Energy Efficiency Services (France)



This Guide is an initiative of CLUBS2E (Energy Efficiency Services Club) [12], whose founding members are the professional federations and unions representing the leading companies in the Energy, Building, Industry and Energy Efficiency Services sectors. It refers to Directive 2006/32 of 5 April 2006 which promotes energy end-use efficiency and energy services to all the Member States of the European Union.

It complements CLUBS2E's "Energy Efficiency Services" Guide with respect to the Measurement and Verification (M&V) of guaranteed performance. Like its predecessor, this Guide is also intended for manufacturers, owners and tertiary and residential asset managers (blocks of flats) in the public or private sector. It is designed to help them obtain a formal guarantee of reduced energy consumption and improved energy efficiency in the buildings and infrastructures for which they are responsible. It is also intended for specialists, as an introduction to the methodologies recommended for implementing Energy Performance Measurement and Verification Plans (PMVP). However, the players in the field must not consider it to be a substitute for the IPMVP. It should on no account be read instead of the IPMVP.

The purpose of this document is to propose a methodology to guarantee the projected energy savings on a contractual basis.

It therefore:

- Recommends the implementation of energy efficiency Measurement and Verification (M&V) procedures;
- Explains the choice of balance that can be achieved between cost and accuracy, according to the procedure adopted and its parameters;
- Specifies, by documenting the latter, how to draw up the M&V Plan, which must be appended to the Energy Performance Contract (EPC).

The methodology was chosen following a survey of the practices in countries with Energy Efficiency Services (S2E) benchmarks and of those currently in use in France, in order to determine whether they were applicable. As a result of this survey, CLUBS2E, in conjunction with ADEME, chose a set of documents that are widely recognized at international level. An appropriate solution to the challenge posed by the use of a formal framework, whilst at the same time preserving the flexibility inherent in the variability of S2E projects, is found in an international energy efficiency M&V protocol, the IPMVP (International Performance Measurement and Verification Protocol). This protocol constitutes the methodological reference document for the present Guide.

As the IPMVP was intended for professionals in the measurement and energy fields, it seemed necessary to integrate it into a documentary context for the purposes of presentation and assistance with its implementation. Such is the intention of this Guide, to which examples of applications have been added.

- The Guide presents the IPMVP and its four options A, B, C, D, in accordance with the economic, technical and legal contexts of the S2E project.
- An actual case, which is explained in the appendix to this Guide, and the downloadable electronic collection of application examples illustrate how M&V Plans derived from the French professional culture and market can be implemented, with the aim of making it easier to adopt the IPMVP protocol.

2.7 Comparative between M&V Protocols

On Table 4 to Table 7, it's made a comparative among different M&V protocols and its main characteristics.

Table 4. Comparison Option A M&V Protocols.

	ASHRAE	IPMVP	CALIFORNIA	FEMP	AUSTRALIAN	FRANCE
Approach	-	**Option A: Retrofit Isolation : Key Parameter Measurement**	**Option A: Partially Measured Retrofit Isolation**	**Option A— Retrofit Isolation with Key Parameter Measureme nt**	**Option A – Partially Measured Retrofit Isolation**	**OPTION A: IPMVP**
Measured data	-	Measurement key parameter Baseline and post-retrofit	Measurement key parameter Baseline and post-retrofit	Same IPMVP	Same IPMVP	Same IPMVP
Energy use measurement type	-	short-term or continuous measurements of key operating parameter(s); and or estimated values	short-term or continuous measurements of key operating parameter(s); and or estimated values	Same IPMVP	Same IPMVP	Same IPMVP
Minimum period spanned by baseline	-	Full range	Full range	Full range	Same IPMVP	Same IPMVP
Baseline model uncertainty	-	-	-	-	-	-
Expected savings	-	<10%	<10%	Same IPMVP	Same IPMVP	Same IPMVP
Uncertainty analysis	-	-	-	-	-	-

Maximum level of uncertainty	-	10% of annual reported savings at 90% confidence	50% of annual reported savings at 68% confidence		Same IPMVP	Same IPMVP
Cost	-	M&V costs are less than 10% of the average annual savings being assessed	1-3% of annual measure cost savings	1-5% of annual measure cost savings	Same IPMVP	Same IPMVP

Table 5. Comparison Option B M&V protocols

	ASHRAE	**IPMVP**	**CALIFORNIA**	**FEMP**	**AUSTRALIAN**	**FRANCE**
Approach	**Retrofit Isolation**	**Option B: Retrofit Isolation: All Parameter Measurement**	**Option B: Retrofit Isolation.**	**Option B— Retrofit Isolation with All Parameter Measurement**	**Option B – Retrofit Isolation**	**OPTION B: IPMVP**
Measured data	Baseline and post-retrofit	Measurement all parameter Baseline and post-retrofit	Measurement all parameter Baseline and post-retrofit	Measurement all parameter Baseline and post-retrofit	Same IPMVP	Same IPMVP
Energy use measurement type	Periodically measure demand and continuously recorded operation periods of relevant equipment	Periodically measure demand and continuously recorded operation periods of relevant equipment	Same Option Retrofit, ASHRAE	Same IPMVP	Same IPMVP	Same IPMVP
Minimum period spanned by baseline	Full range	Full range	Full range	Full range	Same IPMVP	Same IPMVP
Baseline model uncertainty	-	R^2>0,75, CV < 5%,	-	Same IPMVP	Same IPMVP	Same IPMVP
Expected savings	-	<10%	<10%	Same IPMVP	Same IPMVP	Same IPMVP
Uncertainty analysis	Required	Required	Required-	Required	Required	Required
Maximum level of uncertainty	50% of annual reported savings at 68% confidence	10% of annual reported savings at 90% confidence	50% of annual reported savings at 68% confidence	Same IPMVP	Same IPMVP	Same IPMVP
Cost	1-3% of annual	M&V costs are	3-15% of	3-10% of	Same IPMVP	Same IPMVP

	measure cost savings	less than 10% of the average annual savings being assessed	annual measure cost savings	annual measure cost savings		

Table 6. Comparison Option C M&V protocols

	ASHRAE	IPMVP	CALIFORNIA	FEMP	AUSTRALIAN	FRANCE
Approach	**Whole Building**	**Option C:Whole Facility**	**Option C:Whole Facility**	**Option C – Utility Data Analysis**	**Option C – Whole Facility (Building)**	**OPTION C: IPMVP**
Measured data	Baseline and post-retrofit	Baseline and post-retrofit	Baseline and post-retrofit	Same ASHRAE	Same IPMVP	Same IPMVP
Minimum period spanned by baseline	12 Months	12 Months	12 Months	12 Months	Same IPMVP	Same IPMVP
Baseline model uncertainty	For 12 month post retrofit: CV<20% energy use, CV<30% demand For 12 -60 month post retrofit: CV<25% energy use, CV<35% demand For > 60 month post retrofit: CV<30% energy use, CV<40% demand	R^2>0,75, CV < 5%,	Same ASHRAE	Same ASHRAE	Same IPMVP	Same IPMVP
Expected savings	>10%	>10%	>10%	Same IPMVP	Same IPMVP	Same IPMVP
Uncertainty analysis	Required	Required	Required	Required	Required	Required
Maximum level of uncertainty	50% of annual reported savings at 68%confidence	10% of annual reported savings at 90% confidence	50% of annual reported savings at 68% confidence	Same IPMVP	Same IPMVP	Same IPMVP
Cost	-	M&V costs are less than 10% of the average annual savings being assessed	1-10% of annual measure cost savings	1-10% of annual measure cost savings	Same IPMVP	Same IPMVP

Table 7. Comparison Option D M&V protocols

	ASHRAE	IPMVP	CALIFORNIA	FEMP	AUSTRALIAN	FRANCE
Approach	**Whole Building Calibrated Simulation-**	**Option D. Calibrated Simulation**	**Option D. Calibrated Simulation**	**Option D—Calibrated Computer Simulation**	**Option D – Calibrated Simulation**	**OPTION D: IPMVP**
Measured data	Baseline and/or post.retrofit. Report source and accuracy.	Post-retrofit	Post-retrofit	Same IPMVP	Same IPMVP	Same IPMVP
Minimum period spanned by baseline	12 months	12 months	12 months	12 months	Same IPMVP	Same IPMVP
Baseline model uncertainty	Monthly data: RMS error 15% NMBE 5% Hourly data: RMS error 30% NMBE 10%	For monthly calibration data 15% and NMBE 5%	Same ASHRAE	Same ASHRAE	Same IPMVP	Same IPMVP
Expected savings	-	<10%	<10%	Same IPMVP	Same IPMVP	Same IPMVP
Uncertainty analysis	Required	Required	Required	Required	Required	Required
Maximum level of uncertainty	50% of annual reported savings at 68% confidence	10% of annual reported savings at 90% confidence	50% of annual reported savings at 68% confidence		Same IPMVP	Same IPMVP
Cost	-	M&V costs are less than 10% of the average annual savings being assessed	1-3% of annual measure cost savings	1-5% of annual measure cost savings	Same IPMVP	Same IPMVP

On Table 4 it has been made a comparison of option A between different protocols, where it can see that ASHARE do not have this option, the level of uncertainty at IPMVP is more strict that other protocols. Besides FEMP, BPG –M&V and CLUBS2E are based on IPMVP.

On Table 5 it has made a comparison of option B between different protocols, where it can see that the level of uncertainty at IPMVP is more strict that other protocols. Besides FEMP, BPG – M&V and CLUBS2E are based on IPMVP and ASHRAE specific it that the cost of the implementation is between 1-3% of annual measure cost savings and IPMVP should be less than 10%.

On Table 6 it has made a comparison of option C between different protocols, where it can see that the baseline model uncertainty on IPMVP is more strict with CV< 5% that ASHRAE. Besides FEMP, BPG -M&V and CLUBS2E are based on IPMVP.

On Table 7 it has made a comparison of option D between different protocols, where it can see that the level of uncertainty at IPMVP is more strict that other protocols. Besides FEMP, BPG -M&V and CLUBS2E are based on IPMVP.

After a brief description of the protocols and make the comparison between the main features of options of the different protocols of M&V (ASHRAE 14-2002, IPMVP 2012, California energy efficiency evaluation 2006, FEMP 3.0, BPG-M & V Australian and CLUBS2E) is seen as much of them are based on both IPMVP and ASHRAE.

In light of this analysis, 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. Beside IPMVP is stricter with the uncertainties, measurements and it is being widely adopted by national and regional government agencies and by industry and trade organizations to help increase investment in energy efficiency and Achieve environmental and health benefits by creating a standard and unbiased method to estimate energy savings and reducing the risk for the investors.

3 Assessment of IPMVP options in the context of ICT

3.1.1 Constant demand – IPMVP Options A and B

The simplest assumption of how demand in a building would develop without the intervention is that demand for energy in a building is constant. If demand is constant, the intervention would reap savings perhaps by making the conversion of primary energy into the heat, cool, electricity.

The energy saving measurement methodology for this case is simplicity itself. Energy savings can simply be measured by the change in energy consumption before and after the intervention.

Given 24/7 constant demand with no stochastic variability, only one measurement would be needed. More measurements and some averaging might be needed if the measurement apparatus exhibits error - or because the energy conversion efficiency of the ICT application varies over time.

In the industrial settings addressed by IPMVP there may be examples of constant demand, e.g. a pump operates continuously at the same load while production plant is in operation.

In cases of constant demand it may not even be necessary to make any measurement in situ. IPMVP Option A captures this allowing that the manufacturer's specified efficiency improvement in a light is used for the savings calculation and that this is acceptable to the ESCO contracting partners.

Even in IPMVP, however, situations of varying demand have a central role. Production processes may not run at the same capacity all the time may be shut down etc. A pumping operation may take place at regular intervals, not continuously. Measurement of savings from an intervention which involves installing a more efficient pump may need only one measurement, but this needs to take 11 place at a point where demand is known to be equal to the comparison value from before the intervention – the "constant loading" mentioned in Option B.

This mode of thought led to the development of the options A and B in IPMVP. A corollary to Options A and B is that any energy saving intervention planned or executed would be in no need of an ICT project to prove the saving level in a statistically representative sample.

Options A and B therefore seem to be uninteresting in the context of BaaS.

3.1.2 Modelling variable demand – Option D

IPMVP also deals with less simple cases, where demand varies in a less predictable way, where there is no repeated pumping cycle in which a point of equal demand can be identified. For example, even when production is running at the same capacity, flows of raw materials or heating processes may vary in demand due to variation in input temperatures of the raw materials, their specific weight, consistency etc. This demand variability is a major cause of the complexity of methodology proposed under IPMVP.

In a machine production environment, the factors causing variability of demand are often accessible and even measurable. Where the processes under consideration are well understood, one solution is to model the variability. However, if an accurate model can be set up, this must contain parameters encapsulating the energy saving, and once set up, no additional measurements would be needed, certainly not over a 12 month operation period.

Again, Option D seems to be uninteresting in the context of BaaS pilot.

3.1.3 Variable demand as a result of the ICT application – Option C

In the tertiary sector, an assumption of constant demand (Option A) or cyclically predictable demand (Option B) or another demand structure which can be fully modeled (Option D) cannot usually be made. In the ESCO contracting situation, the ESCO will not implement interventions which change demand; responsibility for changing levels of demand will be contractually assigned to the user organization and the commercial impact as well. If energy consumption rises not because of poor performance by the solution provider but because of increased demand, the ESCO will typically want this corrected – adjustments have to be made to correct the demand and the energy saving to what it would have been under constant (or contractually agreed) demand. Thus IPMVP, supplying solutions into this contractual relationship, bases all options on the usual separation of demand (user organization responsibility) and supply (ESCO responsibility).

Nevertheless, the approach offered in IPMVP as Option C is certainly applicable in an ICT context. This option does not assume constant energy demand or that energy demand variation can be accurately modeled. Option C is a before-after comparison. The IPMVP approach in Option C still 12 carries the notion of fully repeated cyclical variation in demand. This is exposed in the notion of an "operating cycle", (IPMVP, Vol. 1, p15), however, with some adjustments the approach is still applicable to ICT pilots.

3.2 Developing a Measurement and Verification (M&V) Plan: The 13 Step IPMVP Process.

An M&V Plan is necessary to ensure an efficiency and successful IPMVP process. Chapter 5 of IPMVP Volume 1 suggests a 13 step planning process to:

- align the ECM intent with stakeholder expectations
- establish the means to measure the ECM
- establish the means to assess the ECM
- identify and discuss boundary conditions
- determine reporting and quality requirements

In the following pages, the 13 Step Process is described. *Italic* is used to indicate text taken directly from IPMVP which will be the definition of each steps. Normal text is then used to describe how this step may be considered in the context of ***BaaS***.

1. ***ECM Intent*** *Describe the ECM, its intended result, and the commissioning procedures that will be used to verify successful implementation of each ECM. Identify any planned changes to conditions of the baseline, such as unoccupied building temperature settings.*

In the context of BaaS*:* The energy conservation measures (ECMs-A.S) under investigation are a suite of ICT-enabled energy efficiency services appropriate for tertiary sector. They was defined taking into account the opinion and contributions of end users (Dalkia) and all the partners of this Consortium, On BaaS D1.1 [13] every A.S is described.

- Temperature Control Strategies.
- Temperature and Humidity Control Strategies
- Temperature, Humidity and others (air quality, stratification) Control Strategies.
- Advanced Control System.
- Rates to estimated consumption and others variables (Energy, Economy).

2. ***Selected IPMVP Option and Measurement Boundary.*** *Specify which IPMVP Option, defined in Chapters 4.8 – 4.10, will be used to determine savings. This identification should include the date of publication or the version number and Volume number of the IPMVP edition being followed (IPMVP Volume I EVO 10000-1:2012), for example). Identify the measurement boundary of the savings determination. The boundary may be as narrow as the flow of energy through a pipe or wire, or as broad as the total energy use of one or many buildings. Describe the nature of any interactive effects beyond the measurement boundary together with their possible effects (see Chapter 4.4).*

How considered in BaaS: BaaS will customize solutions from a suite of services for each pilot employing a general methodology. ICT and ICT-enabled savings will come from multiple sources and Option C is appropriate because we will influence on the behavior over all building.

3. ***. Baseline: Period, Energy and Conditions.*** *Document the facility's baseline conditions and energy data, within the measurement boundary. (In energy performance contracts, baseline energy and baseline conditions may be defined by either the owner or the ESCO, providing the other party is given adequate opportunity to verify them.) An energy audit used for establishing the objectives of a savings program or terms of an energy performance contract usually provides most if not all of the baseline documentation needed in the M&V Plan. This baseline documentation should include:*

    a) Identification of the baseline period (Chapter 4.5.1)

    b) All baseline energy consumption and demand data

    c) All independent variable data coinciding with the energy data (e.g. production rate, ambient temperature)

    d) All static factors coinciding with the energy data:

- *Occupancy type, density and periods*
- *Operating conditions for each baseline operating period and season, other than the independent variables. (For example, in an industrial process, baseline operating conditions might include product type(s), raw material type, and number of production shifts per day. In a building baseline operating conditions might include light level, space temperature humidity and ventilation levels. An assessment of thermal comfort and/or indoor air quality (IAQ) may also prove useful in cases where the new system performs differently than the old inefficient system. See IPMVP Volume II.)*
- *Description of any baseline conditions that fall short of required conditions. For example, the space is under-heated during the baseline, but the ECM will restore the desired temperature. Details of all adjustments that are necessary to the baseline energy data to reflect the energy-management program's expected improvement from baseline conditions.*
- *Size, type, and insulation of any relevant building envelope elements such as walls, roofs, doors, windows.*
- *Equipment inventory: nameplate data, location, condition. Photographs or videotapes are effective ways to record equipment condition.*
- *Equipment operating practices (schedules and setpoints, actual temperatures and pressures)*
- *Significant equipment problems or outages during the baseline period.*

The baseline documentation typically requires well-documented audits, surveys, inspections and/or short-term metering activities. The extent of this information is determined by the measurement boundary chosen or the scope of the savings determination.

Where whole-facility M&V methods are employed (Chapter 4.9 or 4.10), all facility equipment and conditions should be documented.

How considered in BaaS:

Building energy use can be significantly affected by weather conditions. Typically, a whole year of baseline data is needed to define a full operating cycle. Regarding pilot building it has information about occupancy, electric, architectural sketched and historical energy consumption.

4. ***Reporting Period Identify the reporting period****. This period may be as short as an instantaneous measurement during commissioning of an ECM, or as long as the time required to recovering the investment cost of the ECM program (See Chapter 4.5.2).*

In the context of BaaS: Will implement a same period that baseline period. On D1.1 has defined they key performance indicator (KPI) that they will used how surveillance tool save energy.

5. ***Basis for Adjustment.*** *Declare the set of conditions to which all energy measurements will be adjusted. The conditions may be those of the reporting period or some other set of fixed conditions. As discussed in Chapter 4.6, this choice determines whether savings are reported as avoided energy (4.6.1) or as normalized savings (4.6.2).*

How considered in BaaS: Savings will be reported as avoided energy use and linked to actual weather conditions. Adjustments will include:

- External temperature
- Temperature & humidity indoor
- Atypical shutdown due to service or maintenance (central power plant)
- Any modification in the building or technical parts of the energy system

6. ***Analysis Procedure.*** *Specify the exact data analysis procedures, algorithms and assumptions to be used in each savings report. For each mathematical model used, report all of its terms and the range of independent variables over which it is valid.*

In the context of BaaS: *On T6.3 "Implementation of M&V methodology in each Pilot: M&V Plan, Baselining and Reporting"* deals with the monitoring, data analysis, and energy saving assessments. This work package will begin once monitoring commences at the pilots and data becomes available. Calculations will be primarily driven by the selected key performance indicators.

7. ***Energy Prices.*** *Specify the energy prices that will be used to value the savings, and whether and how savings will be adjusted if prices change in future (See Chapter 8.1).*

In the context of BaaS: Rates and tariff schedules vary from country to country. Tariff schedules will be reported (e.g. day, night, rates). Weighted averages for each utility type will be calculated over the baseline period for each utility type. In particular for electricity, this will enable the determination of the average price paid by the consumer to be able to capture the benefit of peak avoidance or tariff adjustments.

8. ***Meter Specifications.*** *Specify the metering points, and period(s) if metering is not continuous. For non-utility meters, specify: meter characteristics, meter reading and witnessing protocol, meter commissioning procedure, routine calibration process, and method of dealing with lost data (see Chapter 8.11.1).*

In BaaS: On Task 6.2 will be defined of monitoring plan for each pilot building.

9. ***Monitoring.*** *Responsibilities Assign responsibilities for reporting and recording the energy data, independent variables and static factors within the measurement boundary during the reporting period.*

In BaaS: On Task 6.2 will be defined of monitoring plan for each pilot building.

10. ***Expected Accuracy.*** *Evaluate the expected accuracy associated with the measurement, data capture, sampling and data analysis. This assessment should include qualitative and any feasible quantitative measures of the level of uncertainty in the measurements and adjustments to be used in the planned savings report (See Chapter 8.3 and Appendix B).*

In BaaS: To be determined once data analysis begins. Accuracy will be benchmarked against utility meters and bills.

11. ***Budget.*** *Define the budget and the resources required for the savings determination, both initial setup costs and ongoing costs throughout the reporting period.*

In BaaS will vary for each pilot building.

12. ***Report Format.*** *Specify how results will be reported and documented (see Chapter 6). A sample of each report should be included.*

In BaaS: The reporting format should have information about save energy, energy consumption and conclusions BaaS solution implementation.

13. ***Quality Assurance.*** *Specify quality-assurance procedures that will be used for savings reports and any interim steps in preparing the reports.*

3.2.1 Independent and Dependent Variable

Other important point to develop before introducing the methodology is the definition of the dependent and independent variables:

Independent Variables: An independent variable is a parameter that is expected to change regularly and have a measurable impact on the energy use of a system or facility.

Common independent variables are weather, production volume, occupancy…When reference is made to an independent variable; the implication is that it has an impact on demand. Some such variables can be easily measured – e.g. ambient temperature – but others may be more difficult to measure.

A common independent variable is Heating Degree Day (HDD). This is a measurement designed to reflect the demand for energy needed to heat a building. It is derived from measurement of outside air temperature.

Dependent Variable: Characteristics of a building or its use which is the target of an intervention. Here the main focus is (reduction in) energy consumption,

In before-after comparison, the actual energy saving caused by an Energy Saving Intervention (ESI) is estimated from the difference between consumption after the intervention (ESI) and the consumption which would have taken place under the same demand conditions without the ESI.

Table 8: Key Performance Indicator. Energy [13]

Technical Energy	Key Performance Indicator	Unit
Global	Net Energy Consumed Electric (NECE)	kWhe
Global	Net Energy Consumed Thermal (NECT)	kWht
Cooling	Summer Cooling Loads (SCL)	kWh
Heat	Winter Heating Loads (WHL)	kWh
Global	Net Fossil Energy Consumed (NFEC)	kWh
Global	Primary Energy Consumed (PEC)	kWh
Global	Net Energy Performance (NEP)	%
Global	Primary Energy Savings (PES)	kWh
Global	Generation Consumption Effectiveness Index (GCEI)	
Global	Primary Energy Savings Percentage (PESP)	%

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