Measurement and Verification of Energy Efficiency Projects

This is a limited version of the webinar slides for posting on EM&V Webinar Website, it does not include case studies

US EPA Webinar
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Presented by EVO with Steve Schiller and Steve Kromer

All of the past webinars slides, several webinar recordings and a resource list are at: www.emvwebinar.org

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Presenters and Resources

- Presenters
  - Steve Schiller, Schiller Consulting, Inc – steve@schiller.com
  - Steve Kromer, SKEE – jskromer@mac.com
  - Both of our speakers are Board Directors and Fellows of the Efficiency Valuation Organization (EVO), which oversees the International Performance Measurement and Verification Protocol (IPMVP) and related documents as well as the Certified M&V Professional (CMVP) Program
- Resources
  - Much of the material for this webinar is from the CMVP training program
  - Information on IPMVP and CMVP trainings can be found at: www.evo-world.org

Topics

- Definitions and Fundamental of M&V
- M&V Resources - IPMVP
- The IPMVP M&V Options
- M&V in Program Evaluation
- Common M&V Issues
- Examples of M&V Effort
- CMVP Training Opportunities

Objective for this webinar

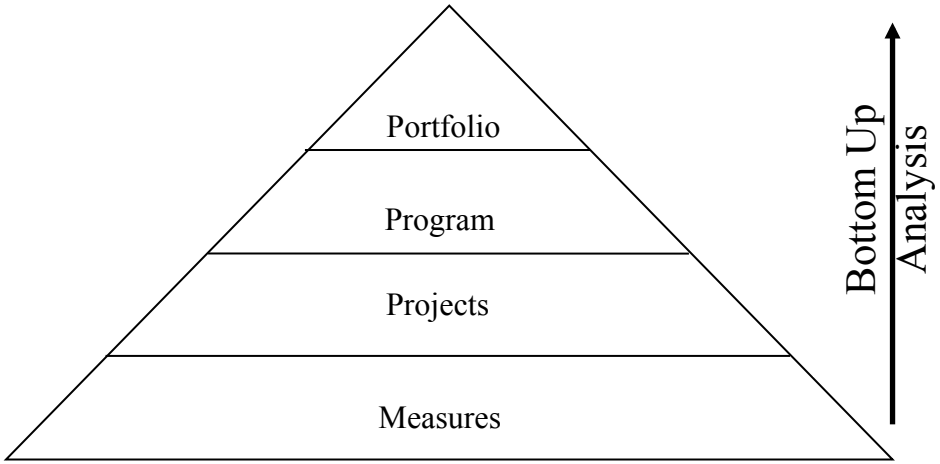
- Provide a basic working knowledge of M&V definitions, concepts and methods through introduction of M&V basics, the IPMVP and simple examples

- Provide reference for where to get more information, including further training

Definitions and Fundamental of M&V

Definitions: The Savings Hierarchy

- Fundamental savings unit is the measure, equipment or strategy that reduces energy use while maintaining or improving service
- Projects are coordinated activities to install one or more measures at a facility
- Programs are collections of similar projects that are intended to motivate customers in a specific market (a describable group of customers) to implement more energy efficiency
- Portfolios are multiple program initiatives in specific market sectors



Definitions: EM&V

- Evaluation - The performance of studies and activities aimed at determining the effects of a program or portfolio

- Measurement and Verification – Data collection, measurements, monitoring, and analysis associated with determining energy and demand savings from individual sites or projects. M&V can be a subset of program evaluation.

- EM&V - The term "evaluation, measurement, and verification" is frequently seen in efficiency evaluation literature. EM&V is a catchall acronym for determining both program and project impacts.

Purposes of M&V

1. Increase Energy Savings
2. Document financial transactions
3. Ultimately enhance ability to finance efficiency projects
4. Improve design, operations and maintenance
5. Account for variances from the utility budget
6. Support evaluation of efficiency programs
7. Educate facility users about their energy impacts
8. Improve score in Sustainability rating systems such as LEED (Leadership in Energy & Environmental Design).

"The" Purpose of M&V

Simply

M&V provides

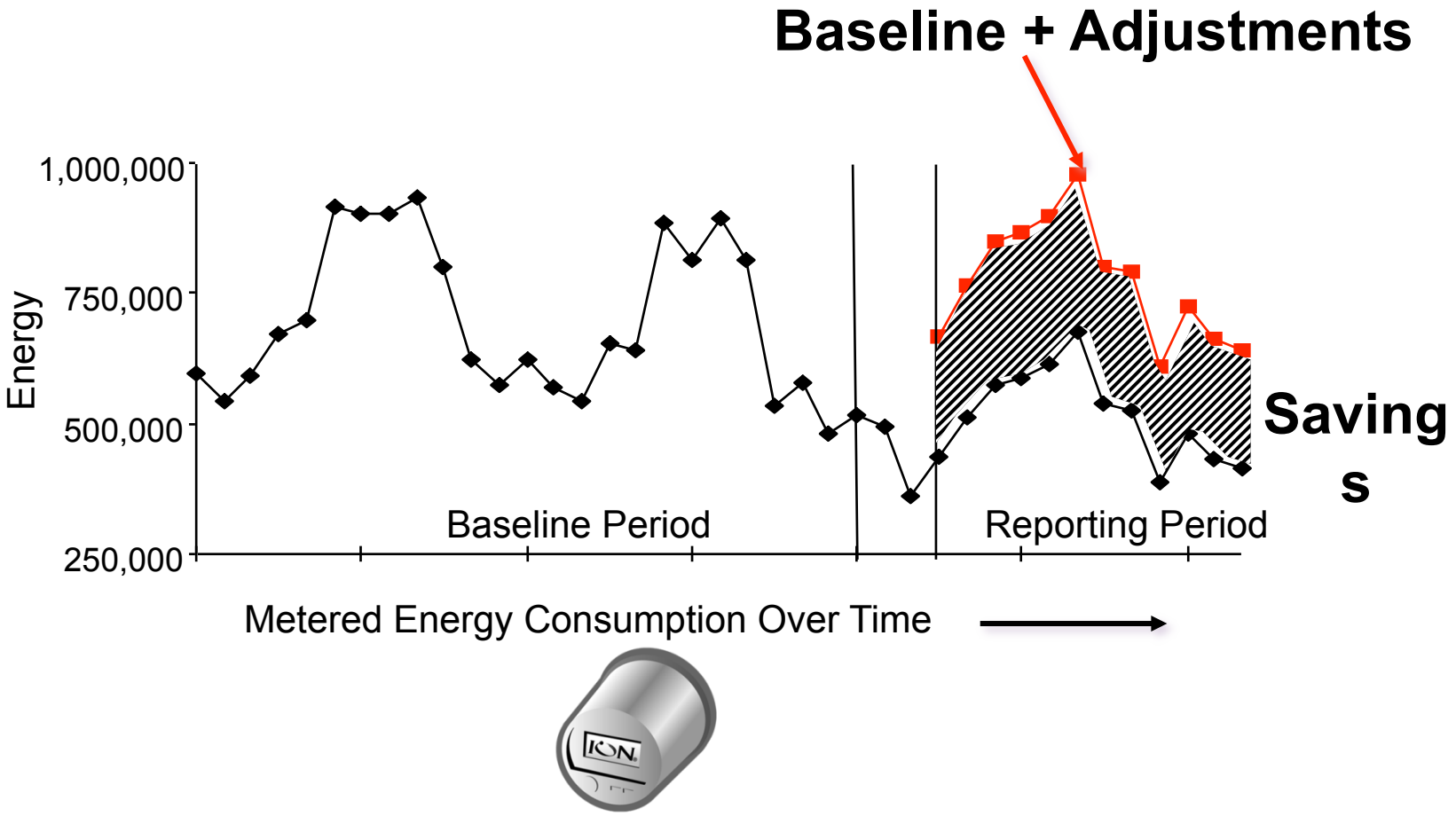
PROOF

of the effectiveness of energy management

We Do Not Measure Savings

- Savings are the absence of energy use
- We can *not* measure what we do not have
- We do ***not*** 'measure' savings
- We ***do*** measure energy use
- We *analyze* measured energy use to **determine** savings

M&V Defined in One Graph



M&V Basic Equation

Savings reported for any period

= Baseline Period energy

- Reporting Period energy

+/- *Adjustments*

Adjustments

Examples of why we need Adjustments:

- An energy retrofit at a factory was performed but plant production was also lower this year than last.
  - How much of the resultant cost reduction was due to the retrofit and how much was due to the production change?
- A heating system retrofit was performed in a building and each year the weather is different.
  - How much of the resultant cost reduction was due to the retrofit and how much was due to changes in weather?

Adjustments (continued)

Performance measurement requires an **"apples to apples"** comparison.

Baseline Period

Reporting

We adjust baseline and reporting period energy use to the **same** set of conditions, for valid comparisons.

Much of the Complexity of M&V is About Adjustments

- The Adjustments can be trivial, simple or complex.
- The extent of the Adjustments depends on:
  - need for accuracy
  - complexity of factors driving energy use
  - amount of equipment having its performance assessed (i.e. 'measurement boundary')
  - available budget

A Note About Energy 'Savings' Versus Energy 'Avoidance'

- Energy users usually want to know how much their bills would have been if they had not taken energy efficiency action. They want to know how much cost they avoided.
- To report avoided cost, M&V engineers adjust baseline period energy use to the conditions of the reporting period. They sometimes simply call cost avoidance 'savings,' at risk of confusion with accounting terminology.
- Accountants often use the word 'savings' to describe 'cost reductions.' They make no adjustments.
- So, when talking about 'savings' we have to be very careful to explain our meaning.
- We must report the common set of conditions (apples) we are using for stating "savings."

M&V Resource Documents

- IPMVP
- FEMP
- ASHRAE

Background – Why Were "Standards" Developed

- In the 70's, 80's and 90' investments in energy efficiency projects were less than expected due, in part, to the high uncertainty associated with future energy savings.
- Part of the problem was multiple and often inconsistent M&V protocols.
- These inconsistencies resulted in a patchwork of engineering approaches to efficiency installations and measurement of savings.

References - Resources - M&V

- **2010 International Performance Measurement and Verification Protocol (IPMVP). (www.evo-world.org)**
- 2000 Federal Energy Management Program M&V Guidelines. (http://ateam.lbl.gov/mv/)
- 2002 ASHRAE Guideline 14 Measurement of Energy and Demand Savings. (www.ashrae.org)
- 2007 NAPEE Model Energy Efficiency Program Impact Evaluation Guide

EVO – Home of the IPMVP

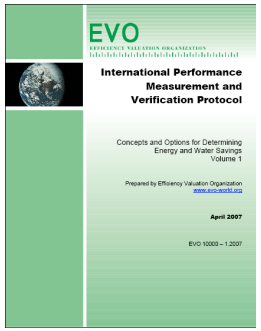
Efficiency Valuation Organization (EVO)

www.evo-world.org

- The home of the IPMVP
- A non-profit U.S. corporation
- Led by volunteers around the world

EVO Products and Services

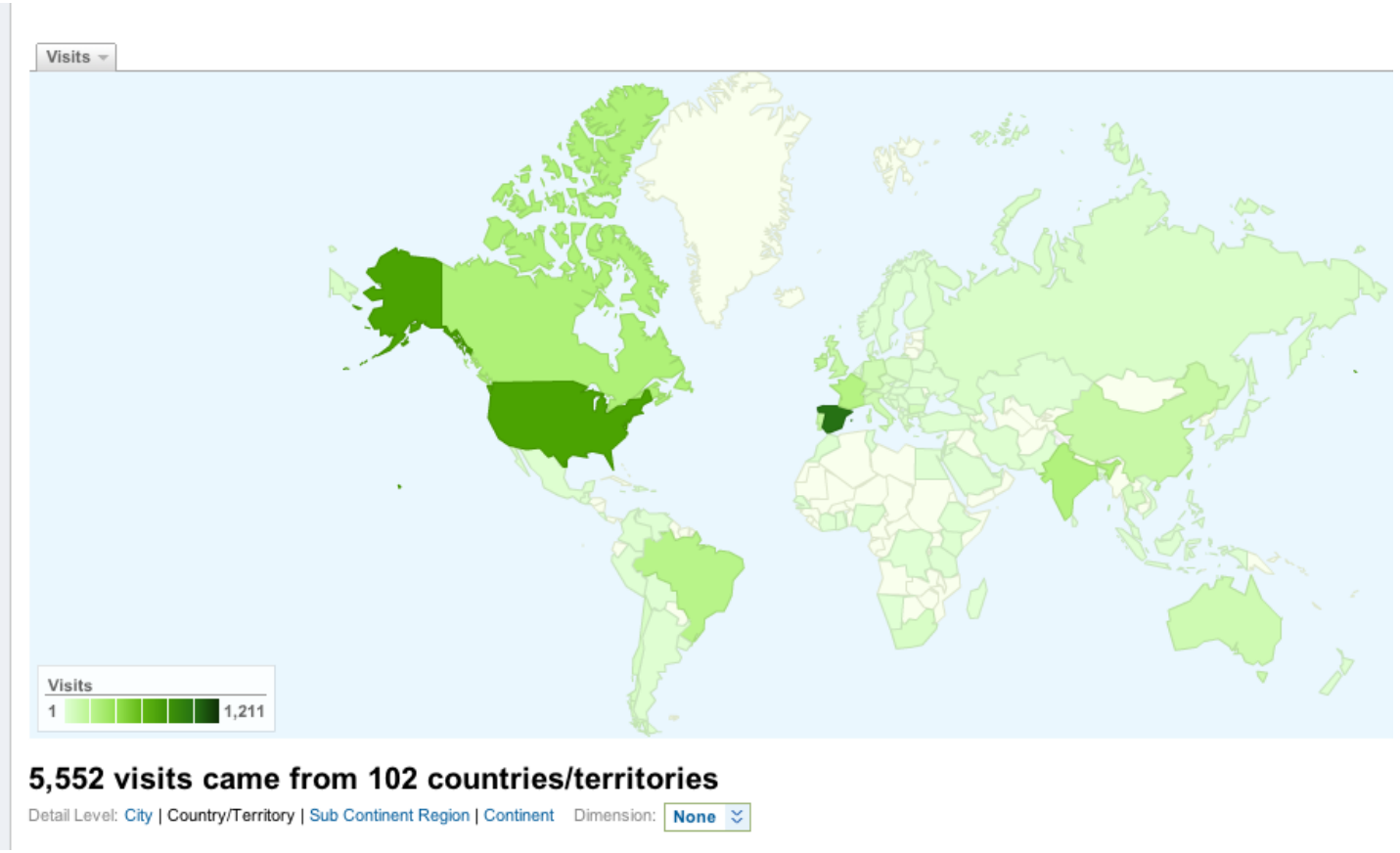
- **Protocols**
  - M&V (IPMVP)
  - Financing



- **Training, Certification**
  - Certification (CMVP) is joint effort with the Association of Energy Engineers

- **Building Community, Promoting Efficiency**
  - Subscriber services through www.evo-world.org: industry newsletter, library, discounts, pre-release access to public documents
  - World wide partnerships for communication, training and development

IPMVP User Base



Average 1000 downloads per month.
Translated into more than 10 languages over the last six years – now in 5th edition.

What is in the IPMVP

The IPMVP

- Is a framework of definitions and methods for assessing energy savings
- Was designed to allow users to develop a M&V plan for specific projects using the framework of definitions
- Was written to allow maximum flexibility in creating M&V plans that meet the needs of individual projects, but also adhere to the principles of accuracy, transparency and repeatability
- Is policy neutral

IPMVP Contents

- Introduction
- Definition and Principles of M&V
- M&V Framework and Options
- M&V Planning and Reporting
- Adherence with IPMVP
- Discussion of Common Issues
- References
- Definitions
- Appendix A: Examples
- Appendix B: Addressing Uncertainty

IPMVP does NOT cover

- Program evaluation (M&V is about project evaluation - which can be part of a program evaluation)
- Operations and maintenance or demand response
- Determining net savings
- Sample (site) selection for impact evaluation
- Design of meter and instrumentation systems
- Cost estimating of M&V activities

IPMVP is not a Cookbook

- It still needs careful application to each project.

The Efficiency Valuation Organization (EVO), in cooperation with the Association of Energy Engineers (AEE), has established the **Certified Measurement and Verification Professional** program with the dual purpose of:

-Recognizing the most qualified professionals in this growing area of the energy industry

-Raising the overall professional standards within the measurement and verification field

Upcoming Training Events

- **Two and a Half Day M&V Training Course Dates 2011 Scheduled with the Association of Energy Engineers: English**

- October 11-13, Chicago, IL, USA (En)
- October 26-28, Johannesburg, South Africa (En)
- November 15-17, Washington, DC, USA (En)
- September 26-28, Toronto, ON, Canada (En)
- October 24-26, Vancouver, BC, Canada)

Upcoming Training Events

Two and a Half Day M&V Training Courses : Non-English

- September 26-28, Murcia, Cartagena, Spain (Es)
- October 5-7, Paris, France (Fr)
- October 18-20, Santiago, Chile (Es)
- November 14-16, Geneva, Switzerland (Fr)
- December 14-16, Paris, France (Fr)

Measurement and Verification Approaches

- Verification
- IPMVP M&V Options
- Applying IPMVP

Two Components to Impact Evaluation:

1. Verify potential to generate savings
2. Determine savings

Example: Lighting Retrofit

- **Potential to Generate Savings:**

Before: 60 Watts/fixture

After: 13 Watts/fixture

- **Savings:**

Savings determined based on operating hours and lifetime of lamps

Example: New Car

- **Potential to Generate Savings:**

Before: 10 MPG

After: 50 MPG

- **Savings:**

Savings determined based on how many miles driven and lifetime of car

+ Verification - determining potential for savings

- This is to ensure that the measures installed are to specification and thus the projects included in a program have the potential to generate savings.
- This potential to generate savings can be verified through observation, inspections, and spot or short-term metering conducted immediately before and after installation.
- For some program evaluations all you need is verification and the use of a deemed savings value – but that is not M&V

IPMVP Summary of M&V Options

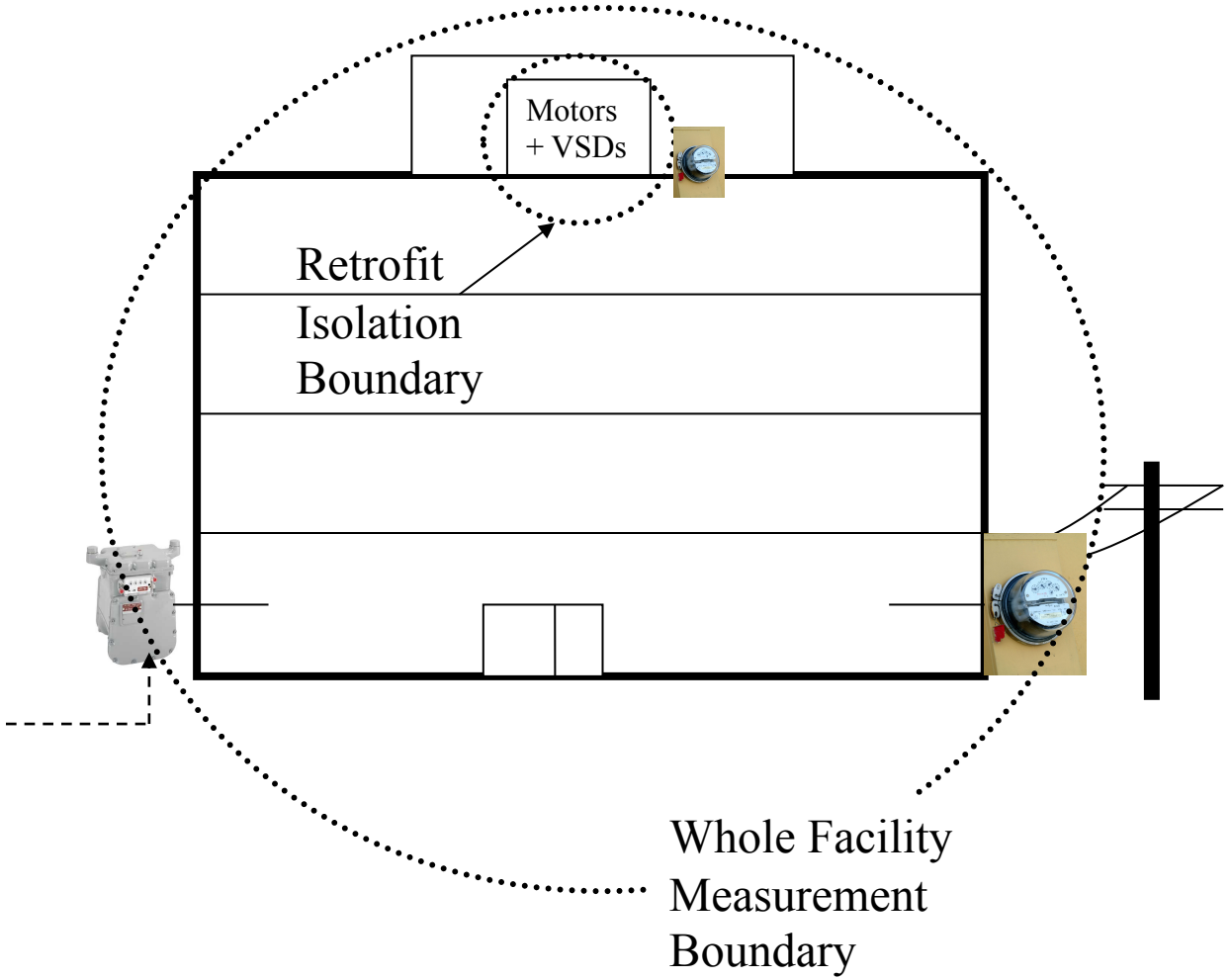
- The IPMVP has four M&V options: Options A, B, C, and D
- The options are generic M&V approaches for determining energy savings from projects – one is not better than another, just have different pros and cons
- Four options provide a range of approaches to determining energy cost avoidance, depending on the characteristics of the energy efficiency projects being implemented, and balancing accuracy in reporting with the cost of conducting M&V.

Options Are Organized as:

- Whole Facility Method - Measures all effects in the facility:
  - Retrofits AND other changes (intended and unintended)
  - Often uses the utility meter
  - Adjustments can be complex

- Retrofit Isolation Method - Measures the effect of the retrofit, only
  - Savings are unaffected by changes beyond the measurement boundary
  - Usually needs a new meter
  - Adjustments can be simple

IPMVP Options



Terminology:

- Retrofit Isolation – Option A or B
- Whole Facility – Option C or D

Two flavours of each method – to allow flexibility for various situations

IPMVP
Retrofit Isolation and Whole Facility

The Retrofit Isolation Options: Option A or B

Addresses only the retrofitted system -

- Ignores interactive effects beyond the boundary (although these may be independently addressed)
- Usually needs a new meter

The Whole Facility Options: Option C or D

Addresses all effects in the facility -

- Retrofits AND other changes (intended and unintended)
- Often uses the utility meter

IPMVP Options A-D

- Option A - Retrofit Isolation: Key Parameter Measurement

  Savings are determined by field measurement of the key performance parameter(s). Parameters(s) which are not measured are estimated. Estimated parameter(s) are based on engineering judgment, analysis of historical data, or manufacturer's data.

- Option B – Retrofit Isolation: All Parameter Measurement

  Builds upon Option A through the use of short-term or continuous metering of all major parameters.

- Option C -- Whole Facility

  Determine savings by examining overall energy use in a facility and identifying the impact of measures on total building or facility energy use. Requires comparison of facility-wide meters (typically utility meter) data before and after project installation.

- Option D – Calibrated Simulation

  Involves the use of software to create a model of a facility and its components and can be used to examine individual measures or entire facility savings. In order to assure accuracy the model is calibrated through comparing it with facility energy consumption or end-use monitored data.

Retrofit Isolation - Example

	Option A	Option B
Baseline measurement	400 kW	210,000 kWh
Post Retrofit measurement	300 kW	155,000 kWh
Estimated operating hours	500 hrs	
Avoided Energy	100 x 500 = 50,000 kWh	55,000 kWh

A – measure only some of the factors in energy computation equation

B – measure all major factors governing energy use

Whole Facility - Example

- Base Year Electricity Bill

July 2010	800,000 kWh

- Post-retrofit Electricity Bill

July 2011	600,000 kWh
Raw difference	200,000 kWh

- Adjustment for weather +100,000 kWh

- **Avoided Energy = 300,000 kWh**

Option D - Example

Consider the case of a new building, designed to be more efficient than some Standard.

- To prove how much better actual energy performance is than the standard:
- After full occupancy begins, gather actual utility metered data (= "calibration data").
- Prepare a computer simulation of the energy use of the same as built conditions.
- Compare simulated and actual energy use.

Option D - Example

- "Calibrate" (or adjust) the simulation until the differences are acceptable.
- The "CALIBRATED SIMULATION" now shows actual energy use of: **5,000,000 kWh**
- Modify this Calibrated Simulation to remove the energy efficiency enhancements (to reflect a building built to the Standard). Simulated "Standard" energy use is: **7,000,000 kWh**
- Avoided Energy = **2,000,000 kWh**

Option A – Retrofit Isolation: Key Parameter Measurement

Typical Application: Lighting retrofit where power draw is the key performance parameter that is measured periodically.

- Estimate operating hours of the lights based on building schedules and occupant behavior.

Option B - Retrofit Isolation: All Parameter Measurement

Typical Application: Variable-speed drive and controls installed on 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.

Option C – Whole Facility Energy Bill Analysis

Typical Application: Multifaceted energy management program affecting many systems in a facility.

- Measure energy use with the gas and electric utility sub-meters for a twelve month baseline period and throughout the reporting period.

Option D – Whole Facility Calibrated Simulation

Typical Applications: Multifaceted energy management program affecting many systems in a facility but where no meter existed in the baseline period - new construction

- Energy use measurements, after installation of gas and electric meters, are used to calibrate a simulation.
- Baseline energy use, determined using the calibrated simulation, is compared to either:
  - a simulation of reporting period energy use, or
  - actual meter data.

Applying IPMVP

- Regardless of the Option followed, similar steps are taken to determine savings:
  - Step 1: Develop a Project Specific M&V Plan
  - Step 2: Gather the baseline data (energy, demand and operating conditions)
  - Step 3: Verify the proper equipment/systems were installed and are performing to specification - *potential to perform*
  - Step 4: Gather post-retrofit measured data and compute energy and demand savings (and cost avoidance) as defined in the M&V Plan - *actual performance*
- A program M&V Manual can use this format and the IPMVP's guidance for setting policy specific requirements

M&V in Program Evaluation

Measurement and Verification in Program Evaluation

The M&V approach involves determining gross energy and/or demand savings by:

1a. Determining the savings of each project in a program

Or

1b. Selecting a representative sample of projects

2. Determining the savings of each project in the sample, using one or more of the M&V Options defined in the IPMVP

3. Applying the sample projects' savings to the entire population, i.e., the program

Example IPMVP Evaluation Application - California

- In the 2006 California Energy Efficiency Evaluation Protocols, IPMVP is referenced as the basis for planning M&V activities (for impact evaluations). M&V plans must adhere to the IPMVP.
- A basic level of M&V is defined as involving a statistically adjusted engineering model with metering/monitoring per IPMVP Option A.
- An enhanced level of rigor is also defined that would be based on IPMVP Options B (retrofit isolation) or D (calibrated simulation).
- Details are defined in a program M&V plan that is expected to be reviewed for adequacy on a case by case basis.

Common M&V Issues

The Big Issues of M&V

How good is good enough?

- This has always been the fundamental issue of M&V
- It is asking how certain does one have to be of savings estimate and is that certainty balanced against the amount of effort utilized to obtain that level of certainty?
- Not only should efficiency investments be cost-effective, but M&V investments should consider risk management principles and thus also balance the costs and value of information derived from EM&V (i.e., M&V should also be cost-effective).

As compared to what?

- First - Defining a baseline against which efficiency actions are compared for determining energy savings and whether attribution should be considered – the counter-factual
- Second – Establishing level of performance confidence and risk for efficiency relative to other options for reducing savings and risk of not getting the savings

M&V is About Risk Management

M&V Cost

Key factors affecting M&V Cost:

- Meter quality
- Number of independent variables to be monitored
- Frequency of measurement and reporting
- Length of the baseline and reporting periods
- Sample size, if all equipment is not measured
- Other uses for meter information, to share costs

M&V Cost vs Uncertainty

There is no *absolutely* correct savings number. There is always some uncertainty.

Decide how much uncertainty can you accept – or afford.

Each M&V effort finds its own balance between reporting uncertainty and cost, for each project.

How Much M&V Is Enough?

- Total annual cost to determine savings should normally be less than 10% of the annual savings. (This maximum might be exceeded for special situations.)
- 3-5% is a more common expenditure (for ESCO projects)
- 0% is often chosen (= "deemed savings"). No measurement means uncertain savings. This is NOT an IPMVP method