# Impact Evaluations and Measurement and Verification

First we will focus on 'Gross Savings' Determination
- savings determined irrespective of why

# Impact Evaluation Concepts

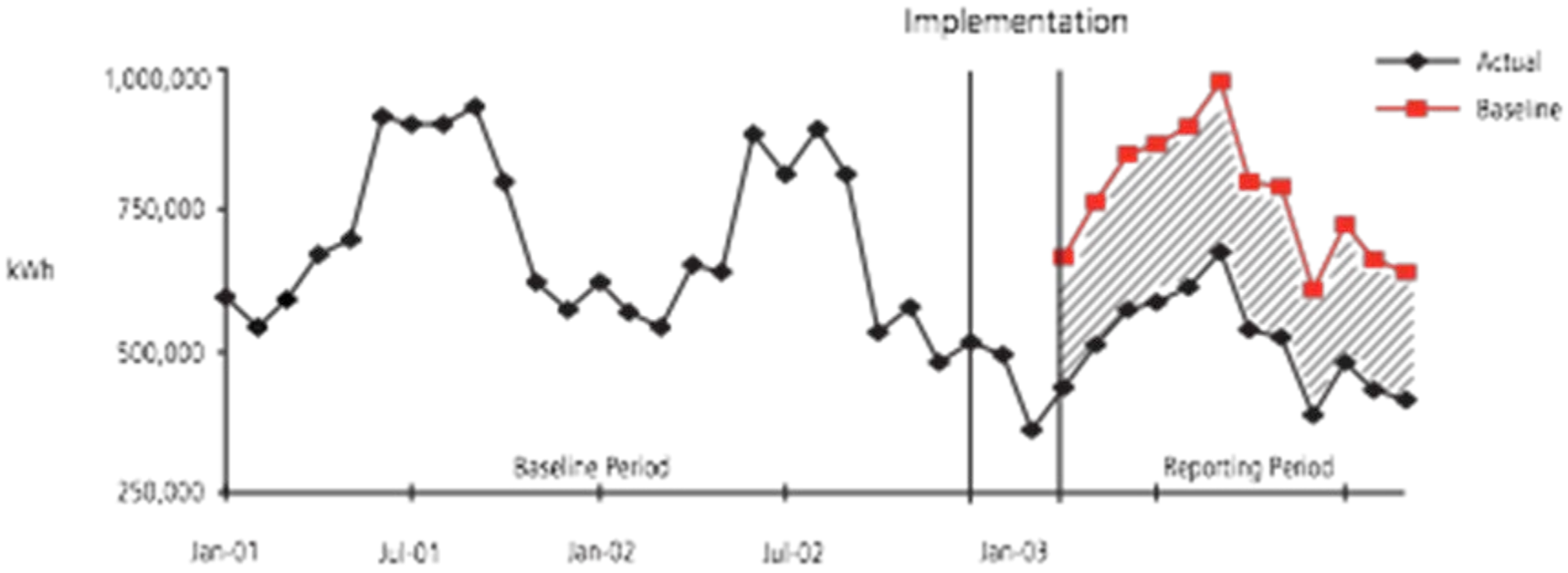
- Impact evaluations are used for determining directly achieved program benefits (e.g., energy and demand savings, co-benefits)
- Savings cannot be directly measured, only indirectly determined by comparing energy use after a program is implemented to what would have been consumed had the program not been implemented (i.e., the baseline)
- Evaluation attempts to measure "what did not happen."

$$\text{Impact} = \text{Actual}_{post} - \text{Projected}_{pre} \pm \text{Adjustments}$$

- It is an estimate, with uncertainty, thus fundamental questions are:
  - How good is good enough?
  - As compared to what?

# Determining Savings

## Comparison of energy use before and after a program is implemented



# Impact Evaluation Results Reported

- **Estimates of Gross Savings:**

  Gross energy savings are the change in energy consumption and/or demand that results directly from program-promoted actions taken by program participants regardless of the extent or nature of program influence on their actions.

- **Estimates of Net Savings:**

  Net energy savings refer to the portion of gross savings that is attributable to the program. This involves separating out the impacts that are a result of other influences, such as consumer self-motivation. Given the range of influences on consumers' energy consumption, attributing changes to one cause (i.e., a particular program) or another can be quite complex.

- **Estimates of Co-Benefits:**

  A co-benefit commonly documented and reported is avoided air emissions: the air pollution or greenhouse gases that would have been emitted if more energy had been consumed in the absence of the energy efficiency program.

# Two Components to M&V



- Verify potential to generate savings
- Determine savings

**Example: Lighting Retrofit -**

**Potential to Generate Savings:**
***Before***
100 Watts/fixture

***After***
23 Watts/fixture

**Savings:**
Savings determined using a variety of approaches how many fixtures and operating hours

# Approaches for Determining Gross Energy Savings

- Deemed savings that are based on historical and verified data, are applied to conventional energy efficiency measures implemented in the program.
- Statistical analyses of large volumes of metered energy usage data are conducted.
- One or more measurement and verification (M&V) options (A, B, C and/or D) from the IPMVP are used to determine the savings from a sample of projects. These savings are then applied to all of the projects in the program.

# Gross Savings: Deemed Savings Approach

- Deemed savings are used to define savings values for projects with well-known and documented savings values.
  - Deemed Measures values: For simple efficiency measures whose performance characteristics and use conditions are well known and consistent, a deemed savings approach may be appropriate
  - Deemed Calculated Measures. A slightly more complex approach to estimating savings is to use simplified, pre-defined calculations that employ a combination of deemed or "default" input assumptions with some site-specific inputs.
- The use of deemed values in a savings calculation is an agreement to accept a pre-determined value, irrespective of what actually "happens".
- Deemed values and deemed calculation approaches are often documented in a "Technical Reference Manual"

# Deemed Savings, Sources

- Deemed values, if used, should be based on reliable, traceable, and documented sources of information, such as:
  - Standard tables, from recognized sources, indicating the power consumption (wattage) of certain pieces of equipment that are being replaced or are being installed as part of a project (e.g., lighting fixture wattage tables)
  - Manufacturer's specifications
  - Building occupancy schedules
  - Maintenance logs
- When using deemed values, it is important to realize that technologies alone do not save energy; it is how they are used that saves energy

# When to Use Deemed Savings

Assessing a few key aspects of the project can drive decisions about whether to use stipulations and how to use them effectively in an evaluation plan:

- Availability of reliable information
- The project's likelihood of success in achieving savings
- Uncertainty of the stipulated parameter and its contribution to overall project uncertainty
- The cost of measurement

Several "rules of thumb" are:

- The most certain, predictable parameters can be estimated and stipulated without significantly reducing the quality of the evaluation results.
- Stipulating parameters that represent a small degree of uncertainty in the predicted result and a small amount of savings will not produce significant uncertainty concerns.
- Parameters should be measured when savings and prediction uncertainty are both large.
- Even if savings are high, but uncertainty of predicted savings is low, full measurement may not be necessary for M&V purposes.

# Gross Savings: Large-Scale Data Analysis Approach

- Large-scale data analysis applies a variety of statistical methods to measured facility energy consumption meter data (almost always whole-facility utility meter billing data) and independent variable data to estimate gross energy and demand impacts.
- Unlike the M&V whole-facility analysis option (IPMVP Option C) the meter analysis approach usually involves analysis of a census of project sites, versus a sample
- Types:
  - Time series comparison
  - Use of comparison group
  - Comparison group/time-series
- Most large-scale data analyses involve the use of comparison groups

# Large-Scale Data Analysis Equations

- **Time Series**

$$\text{Savings} = Q_{\text{pre-installation}} - Q_{\text{post-installation}}$$

- **Comparison Group**

$$\text{Savings} = Q_{\text{non-participants}} - Q_{\text{participants}}$$

- **Comparison Group – Time Series**

$$\text{Savings} = (Q_{\text{pre-installation}} - Q_{\text{post-installation}})_{\text{participants}} - (Q_{\text{pre-installation}} - Q_{\text{post-installation}})_{\text{non-participants}}$$

# Measurement and Verification Approach

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

- Selecting a representative sample of projects
- Determining the savings of each project in the sample, using one or more of the M&V Options defined in the IPMVP
- Applying the sample projects' savings to the entire population, i.e., the program

EVO

EFFICIENCY VALUATION ORGANIZATION

# International Performance Measurement and Verification Protocol

Concepts and Options for Determining Energy and Water Savings
Volume 1

Prepared by Efficiency Valuation Organization
135Hwww.evo-world.org

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# Summary


- Today, IPMVP is the leading international energy efficiency M&V protocol:
  - Still primarily operated as a volunteer organization - with document drafting and peer review technical committees
  - IPMVP has been translated into 10 languages and is used in more than 40 countries
  - Since going online, there have been more than 20,000 downloads of the IPMVP

- More information can be found at www.evo-world.org

# 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

## 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 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 Summary of 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
- 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.

# IPMVP
# Retrofit Isolation and Whole Facility

The Whole Facility Options: Option C or D

Addresses all effects in the facility -

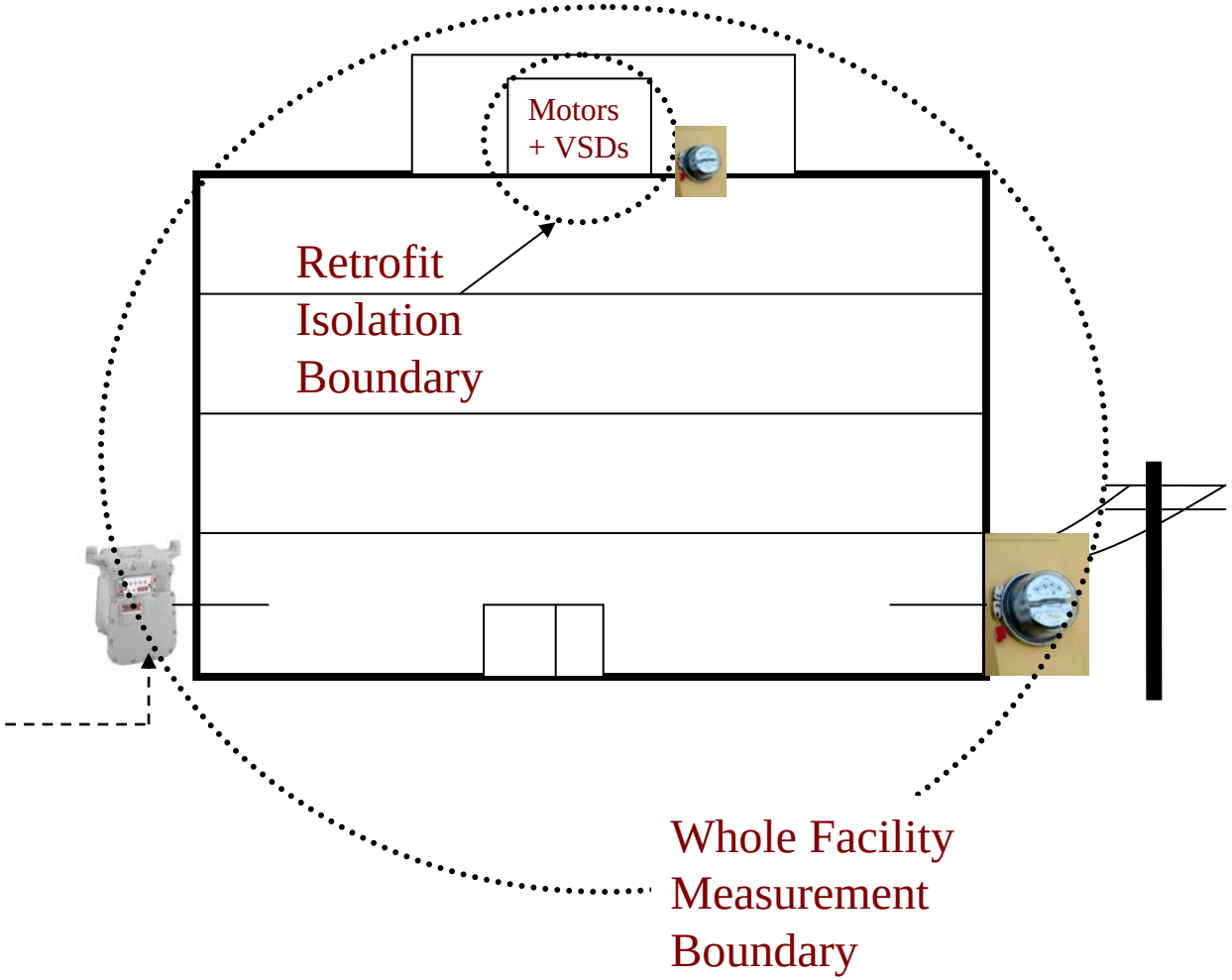
- Retrofits AND other changes (intended and unintended)
- Often uses the utility meter

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

# IPMVP Options



# 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

## Lighting Retrofit 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 kW x 500 hours = 50,000 kWh | 55,000 kWh |

# Whole Facility

## Lighting Retrofit Example

- Base Year Electricity Bill

| | |
|---|---|
| July 2005 | 800,000 kWh |

- Post-retrofit Electricity Bill

| | |
|---|---|
| July 2007 | 600,000 kWh |
| Raw difference | 200,000 kWh |

- Adjustment for meter reading period length and weather + 25,000 kWh

- Corrected Avoided Energy 225,000 kWh

# Calibrated Simulation

## Lighting Retrofit Example

- Simulated Base Year Electricity Use

  August 2005 — 456,000 kWh

- Simulated and Calibrated Base Year Electricity Use

  August 2005 — 479,000 kWh

- Post-retrofit Electricity Bill

  August 2007 — 400,000 kWh

- Avoided Energy — 79,000 kWh

# Option A - 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 - 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 - Typical Application

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.

# Option D - 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 "Typical" Combination for Determining Gross Savings

- Set of prescriptive programs use deemed savings values (e.g., residential CFLs and refrigerators)
- Set of prescriptive programs use deemed calculated approach with pre-defined equations, some deemed parameters, and ex-post site inspections for other parameters. (e.g., commercial ventilation fan measures)
- Another set of custom programs use M&V savings analyses (Options A, B, C and/or D) on a census of projects (e.g., industrial process measures)
- Residential weatherization/comprehensive retrofit program uses large scale billing data analyses

# Verification

## Two parts to EM&V: (1) determining potential for savings and (2) estimating actual savings

- Not all of the evaluation approaches require field inspections, but it is recommended that there be some physical assessment of at least a sample of the individual projects
- 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.
- Utilities will need to do this for their programs, irrespective of the role of the Independent Program Evaluator