Outline

A. Role of Measurement & Verification (M&V) in energy efficiency, renewable energy, or demand response process
- M&V in project process
- M&V as quality assurance

B. Definitions and Concepts
- savings cannot be measured
- savings verification concepts
- measurement boundaries

C. Savings Calculation Fundamentals
- Energy savings = baseline energy – post implementation energy +/- adjustments
- Baseline energy use
- Adjustments to energy use
  - routine
  - non-routine

D. Measurement Boundary
- Building, system, component

E. Savings calculation methods
- measure assessment
- load and schedule characteristics
- empirical models (regressions)
- other: simulations, sampling

F. Application in IPMVP
- Four IPMVP Options

G. Sources of Data and Measurement Instruments
- Whole Building
- Building Subsystem
- Weather Data
- Measurement devices

H. Developing the M&V Plan

Measurement Tools & Verification of Savings Calculations

A. Role of Measurement & Verification in energy efficiency, renewable energy, or demand response process

A. Role of Measurement & Verification

- What is M&V?
- M&V within an energy efficiency, renewable, or demand response project
- Why M&V is important
- Uses of M&V
- Other benefits

What is Measurement & Verification?

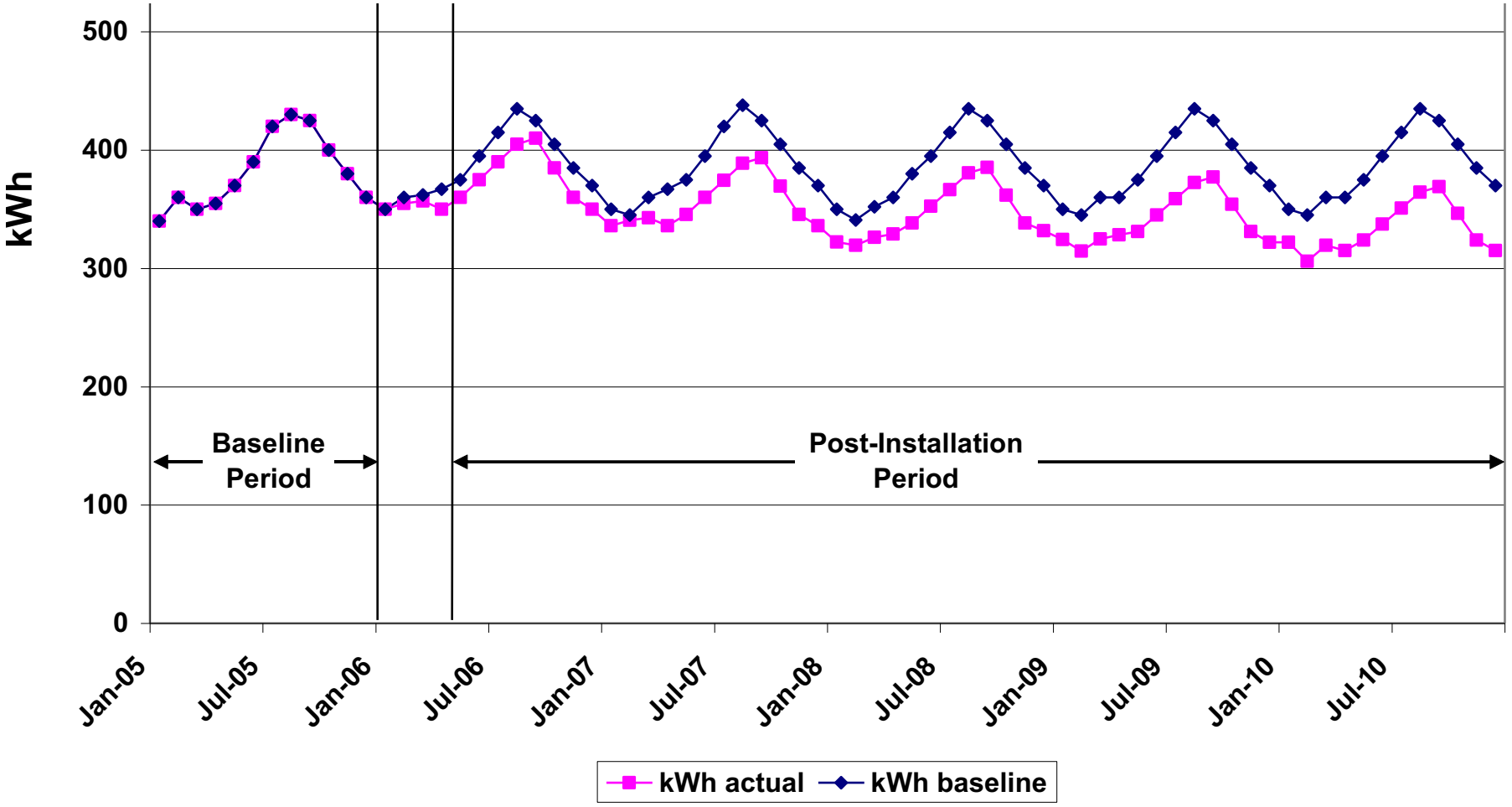
Formal definition is found in Chapter 2 of the International Performance Measurement & Verification Protocol, Volume I: www.evo-world.com.

"Measurement & Verification (M&V) is the process of using measurements to reliably determine actual savings created within an individual facility by an energy management program."

Measurement & Verification

- Energy savings cannot be measured, because it represents the *absence* of energy use.
- Savings are determined by making a fair comparison of energy use before and after a project is implemented.
- The comparison is fair if the baseline and post-installation energy use is made under the same set of conditions (i.e. weather, occupancy, etc.)

Conceptually 'Measuring Savings'



M&V Within a Project Process

- Based on an energy audit, a building owner decides to invest in an energy efficiency project because it will lower utility bills and has a high return on investment
- The owner is relying on the accuracy of the audit's savings calculations, and that the project will be installed correctly, and will generate savings
- The M&V process verifies whether or not the project yields the expected savings

Audit and M&V Process Comparison

Project Phase	Audit Activity	M&V Activity
1. Audit	- Prepare, conduct site visit	
	- Collect data and information	- Assess EEM impact
	- Identify EEMs, quantify savings and costs	- Define measurement boundary
	- Evaluate cost-effectiveness	- Collect baseline data
	- Deliver audit report	- Develop M&V Plan
2. Implementation	- Owner installs EEMs	
	- EEMS commissioned	
3. Verification		- Collect post-install data
		- Verify savings
		- Repeat

Why is M&V Important?

- Savings estimates from audits are of unknown quality – may be good or bad
- EEMs may not be correctly installed and result in no savings
- EEMs may be installed correctly but staff insufficiently trained on proper operation – savings quickly degrade

Why M&V Important?

- Provides rigorous 2nd check on savings
- To assure savings actually achieved
- To assure utility costs have gone down
- To assure a return on investment
- As a basis of payments to an ESCO

Uses of M&V

- As a Quality Assurance Process
  - Like 'savings insurance'
  - Rigorous – not a '2nd opinion'
  - Relies on measurements
  - Able to estimate savings uncertainty
- Payment basis for ESCO projects
  - ESCO guarantees savings, gets paid from owner's operations budget

Other Benefits of M&V

- Persistence of Savings
  - Provides periodic or continuous update on facility/equipment/EEM energy performance
- Facilitates 'Energy Awareness' for Owner & Occupants
  - Energy dashboards
- Basis for continuous energy improvement programs

BEST Center Curricula, Resources & Recordings

Academic Programs
Georgia Piedmont Technical College - Building Automation Systems
Milwaukee Area Technical College - Sustainable Facilities Operations
Laney College - Commercial HVAC Systems
City College San Francisco - Commercial Building Energy Analysis & Audits

Professional Development Materials, Presentations & Videos
National Institutes
Building Automation Systems Instructor Workshops
Webinars (e.g., BEST Talks)

Faculty Profile Videos
Reports & Case Studies
Marketing Resources

BEST
Building Efficiency for a Sustainable Tomorrow

NSF National Science Foundation