Measurement Tools & Verification of Savings Calculations

B. Definitions and Concepts

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- What is the common M&V terminology?
- What are its core concepts?

Definitions

- Avoided energy use
  - The reduction in energy use in the period after EEMs are installed. It is the difference in energy use the building or system would have used and the amount it actually used in the post-install period
- Normalized savings
  - The amount of savings that would have been achieved had the facility or equipment operated under another set of conditions other than the post-installation period. Both baseline and post-installation energy use are normalized to another set of conditions – such as long term average weather conditions

Definitions, cont.

- Adjustments to energy use
  - Adjustments are made to either baseline or post-installation energy use to assure a fair calculation of savings, and that savings are due to the installed EEMs, an not due to weather, changes in occupancy, and so on.
- Energy Efficiency Measure (EEM)
  - An EEM improves the energy utilization of equipment or systems within a facility. It may be one or multiple improvements at a time.

Definitions, cont.

- Baseline Energy
  - The energy use occurring during the baseline period without adjustments (IPMVP def.)
- Baseline period
  - The period of time chosen to represent the operation of the facility or systems prior to the implementation of an EEM. Typically the baseline period includes a full cycle of operation when energy use is influenced by various conditions

Definitions, cont.

- Measurement Boundary
  - An imaginary boundary drawn around equipment or systems of interest in the analysis. Such boundaries may include the whole facility, specific affected systems, or specific affected equipment. All energy uses within the measurement boundary must be measured or reliably estimated
- Interactive effects
  - Energy savings or penalties created by an EEM but not measured within the measurement boundary

Ex-Ante Savings Estimates

- Audit requirement, provides owner with critical information on which EEMs to implement
  - Which EEMs provide most savings
  - Which EEMs are most cost effective
  - Etc.
- Provides basis of long-term energy management plan
- However…

Savings Can Only Be Estimated

- Energy savings cannot be measured because they are the *absence* of energy use. Savings can only be estimated.
- Audit savings estimations:
  - These are "ex-ante" meaning estimated prior to implementing any project
    - No before-after comparison possible
    - Such estimates require assumptions about energy use/equipment performance after the EEMs are installed
  - Audit economics and facility access may dictate use of rough estimation methods, 'deemed' savings, little site data
  - Even the most thorough, data-driven analysis may be in error because no one can predict the future
  - Uncertainty analysis typically not performed on ex-ante estimations – no way to understand risk

EEMs May be Installed Incorrectly

- Savings estimates may be correct, but:
  - the wrong equipment may be installed
  - equipment may be installed incompletely or incorrectly,
  - controls may be incorrectly programmed
  - the equipment is not properly commissioned
  - and so on

EEMs May be Defeated Quickly

- Operators may lack training on how to operate the new equipment
- Comfort complaints may cause operators to improperly operate equipment or revert to baseline practices
  - Example: daylight sensors may dim lights, still providing required light levels, but occupants unused to new lighting effect complain. Operator overrides daylight dimming controls.

Savings Quality Assurance Needed

- Methods:
  1. "Sanity check" such as checking the percent savings versus the total energy use of system or facility
  2. Alternate savings calculations – savings may be estimated using a completely different method
  3. Peer Review of savings estimates, data and method. Checks for proper application of principles, correct data, correct interpretations and assumptions
  4. Correcting ex-ante savings estimates with post-install data – verifies assumptions on how systems and equipment performs post-installation
  5. Measurement and verification (M&V) – using energy use measurements before and after installation, adjusting to same conditions, and estimating savings

Industry Standard M&V

- International Performance Measurement and Verification Protocol
  - Internationally recognized standard
  - Started in US to develop guidelines for savings for ESCO contracts
  - www.evo-world.org
- American Society of Heating Refrigeration and Air-conditioning Engineers (ASHRAE) Guideline 14-2002 Measurement of Energy and Demand Savings
  - www.ashrae.org

Practical Guidelines

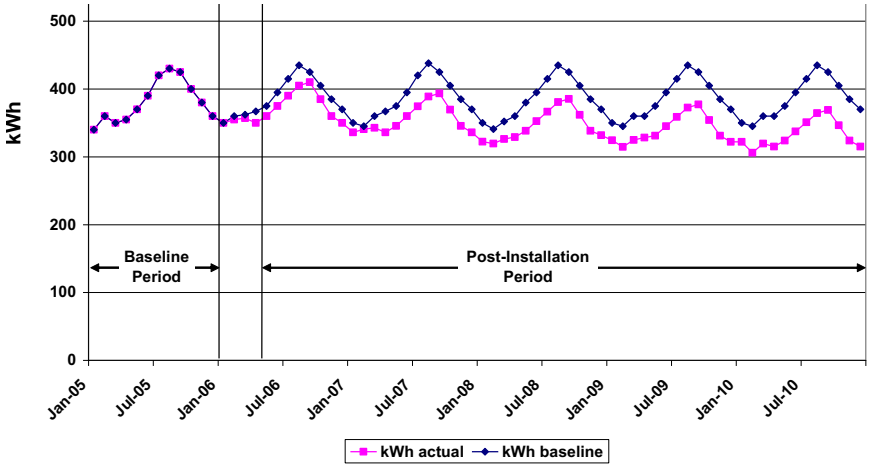
- Several Exist:
  - Guidelines for Verifying Existing Building Commissioning Project Savings
    - www.cacx.org California Commissioning Collaborative
    - 4 methods:
      - Engineering calculations with verification
      - End-use metering
      - Energy modeling using interval data
      - Computer simulation
  - Federal Energy Management Program M&V Protocol
  - www.ateam.lbnl.gov

Practical Guidelines

- Bonneville Power Administration
  - Practical guidance for verifying savings for retrofits, EBCx, in multiple sectors
  - www.conduitnw.org
  - Various guides and guidelines:
    - Verification by Equipment or End-Use Metering
    - Verification by Energy Modeling
    - Regression Guide
    - Sampling Guide

IPMVP M&V

- Fundamental concept:
  - Relies on direct measurements of energy use before and after EEMs are installed in a system or facility.
- Baseline or post-installation (or both) energy use is adjusted to the same set of conditions, before calculating savings

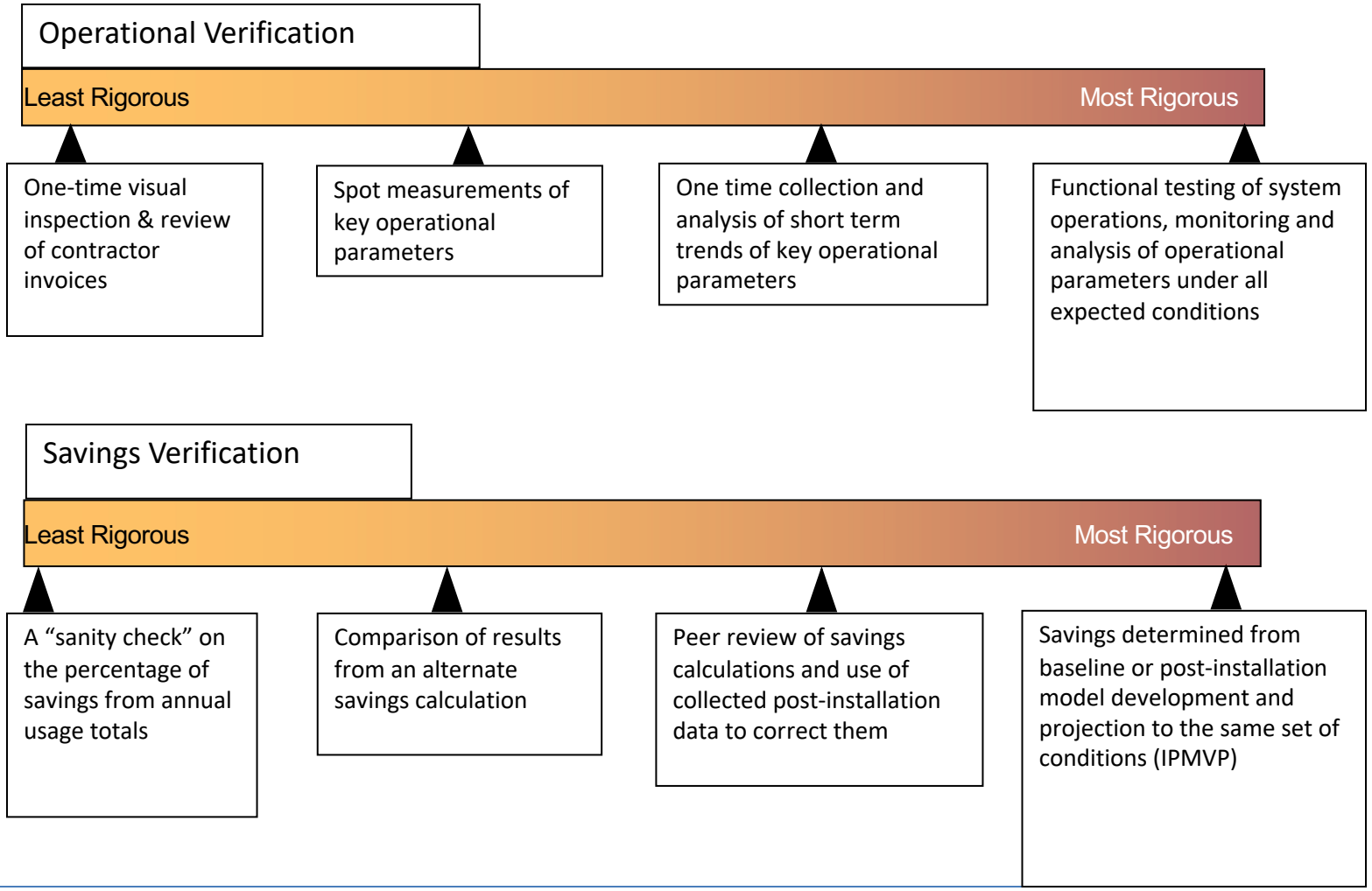


IPMVP Requirements – 2 parts

1) Operational Verification
   – Verify potential to perform (commissioning)
     - ECMs are installed correctly
     - Operate correctly
     - Have potential to generate savings

2) Savings Verification
   - Quantify actual savings

IPMVP Requirements



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
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NSF National Science Foundation