M&V Applications and Approaches

Balancing Project Demands to Deliver an Accurate, Cost Effective, and Verifiable M&V Outcome

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Learning Objectives

1) Illustrating the shortfalls and advantages of Option A, Option B, Option C, and Option D

2) Properly matching the M&amp;V Approach to the Project in order to avoid common pitfalls

3) Reviewing examples of past experience for what has worked best, when and why
Agenda

Introduction

M&V – What and Why

M&V Applications in the Following Fields:
- Demand Response Programs
- Retrocommissioning for Utility Programs
- Retrocommissioning for Non-Utility Programs
- Commissioning for New Construction Projects

M&V Key Considerations

Questions
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M&V – What and Why

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M&V – What and Why

- Measurement & Verification Definition

“Best practice techniques available for verifying results of energy efficiency, water efficiency, and renewable energy projects.” - IPMVP

- M&V strives to ensure that parties with vested interests in the outcome of energy efficiency projects agree to and accept the results
M&V – What and Why

- Commonly Used M&V Protocols
  - International Performance Measurement & Verification Protocol (IPMVP)
  - North American Energy Standards Board (NAESB) - DR Specific
  - ASHRAE Guideline 14: Measurement of Energy and Demand Savings
M&V – What and Why

- M&V is a process driven approach to determine:
  - Energy Savings
  - Water Savings
  - Peak Demand Reduction
  - Dollar Savings
  - Incentive Amount
  - Demand Response Payments
  - Performance Contract Results
  - Achievement of LEED Credits
  - Greenhouse Gas Emissions Reductions
  - Other Utility or Resource Savings
Measurement and Verification (M&V) uses measured data along with other observations, assumptions, calculations, and documentation to define baseline performance, and to estimate improvements in performance that are attributable to the project.
M&V – What and Why

- The IPMVP Protocol has become a leading standard across energy industries
  - Many State and industry specific protocols are based on IPMVP

- 4 M&V Options Within the IPMVP Protocol:
  - **Option A**: Retrofit Isolation – Key Parameter Measurement
    - Partial field measurements on the specific system(s) along with stipulated parameters are used to determine energy savings
  - **Option B**: Retrofit Isolation – All Parameter Measurement
    - Metered energy use of the specific systems is used to determine energy savings
  - **Option C**: Whole Facility
    - Metered energy use measured at the whole building level is used to determine savings
  - **Option D**: Calibrated Simulation
    - Calibrated energy models of the whole building OR components/sub-facility are used to simulate energy use and determine savings
M&V – What and Why

- An Acceptable M&V Approach:
  - Develop regression equations from metered baseline data
    - Energy use with daily Mean OSA temperature and occupancy as independent variables
  - Calculate baseline annual energy use using TMY weather data
  - Implement commissioning or retrocommissioning project
  - Develop regression equations from metered post-project data
    - Energy use with daily mean OSA temperature and occupancy as independent variables
  - Calculate post-project annual energy use using TMY weather data
  - Subtract post project energy usage from baseline to calculate savings
  - What could be easier?
M&V – What and Why

- M&V balances project demands to deliver the most accurate, cost effective, and verifiable M&V outcome

  - **Accuracy**
    - An appropriate M&V approach acknowledges and properly utilizes key variables to achieve reasonable accuracy within acceptable levels of confidence

  - **Simplicity**
    - Simplicity in the M&V approach dictates a minimum investment in scope, schedule and budget to achieve valid results

  - **Integrity**
    - An integrity driven M&V approach is repeatable, reproducible, and transparent
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M&V in Demand Response

- M&V Approach in Demand Response is Determined By:
  - Utility Requirements
    - Threshold Requirements v. Reduction Requirements
  - Customer Load Profiles
    - Dynamic Load Profiles v. Static Load Profiles
  - Event Timeframe & Duration
M&V in Demand Response

- **Baseline Type I**
  - Baseline is based on previous days historical interval meter data and may reflect variables such as weather and calendar data
  - Performance is judged as “Dropping By”
  - Baseline shape is the average load profile, and applications include Averaging, Regression, Rolling Average or Comparable Day

- **Baseline Type II**
  - Similar approach as Baseline Type I but relies on statistical sampling where interval meter data is unavailable

- **Maximum Base Load**
  - A static Baseline is established based on averaged peak usage from previous year
  - “Dropping To” a committed consumption threshold validates compliance

- **Meter Before – Meter After**
  - Consumption profiles immediately prior to an event are compared to the profiles during an event
  - Typically only used for short events lasting under an hour
M&V in Utility Program Retrocommissioning

- **Representative Utility Programs**
  - UC/CSU IOU Monitoring Based Commissioning Program
  - PG&E Core Retrocommissioning Program
  - ComEd Retrocommissioning Program
The CSU/UC IOU Energy Efficiency Partnership is a statewide energy management program in California directing monitoring based commissioning procedures and services at thirty-three UC and CSU campuses in conjunction with four California Investor Owned Utilities (IOUs).

Program Directives:
- Implement an M&V Plan to install permanent whole-building meters on electricity, and piped utilities for each building.
- Implement a database program to monitor and evaluate whole-building trend data with a 10-year storage capacity.
- M&V Plan should be in accordance with IPMVP guidelines, the preferred M&V method in **Option C**, and other options may be used with justification.
- Baselines should be based on three months of data excluding January and July.
M&V in Utility Program Retrocommissioning

UC/CSU IOU Monitoring Based Commissioning

○ Option C Advantages
  ○ Standard Approach for wide-deployment across all utilities for a multitude of buildings benefitting MBCxA’s, campuses, and utilities
  ○ MBCxA can standardize data collection and analysis techniques

○ Caveats to an Option C Approach
  ○ Significantly dynamic or intermittent process loads may skew monitored data within either sampling period
  ○ Bad or poorly calibrated meters can ruin results
  ○ Case Study Example: Process Load driven buildings
    - College Student Laboratory where HVAC equipment represents approximately 12% of building peak electrical demand

○ Alternative approaches may be Option A, Option B, or Option D, but Option D is typically preferred
PG&E Core Retrocommissioning Program

- Pacific Gas & Electric’s Core RCx program is designed to provide technical and financial resources enabling RCx for the utility’s customers
- Program Directives:
  - The Customer agrees to an investment responsibility equal to the total implementation cost of all RCx measures identified having a simple payback less than or equal to one year, or $25,000, whichever is less.
  - Savings must be calculated per measure
- Program is EEM driven
- Because no specific option is mandated, web-hosted calculators, Option A, Option B, or Option D are all feasible
  - Savings must be presented on a measure by measure basis
  - Savings of any one measure will probably not be greater than 10%
  - Option D would allow model run iterations per measure
# M&V in Utility Program Retrocommissioning

## PG&E Core Retrocommissioning Program

<table>
<thead>
<tr>
<th>Measure Size</th>
<th>Initial Savings Calculation by Provider</th>
<th>Source of Initial Savings Submitted</th>
<th>Source of Final Savings Claimed</th>
<th>M&amp;V Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small (BOA Tool Applies)</td>
<td>Savings &lt; 75,000 kWh/yr or Savings &lt; 5,000 th/yr</td>
<td>BOA Tool Results</td>
<td>BOA Tool Results</td>
<td>Pre- and Post-Implementation Snapshot</td>
</tr>
<tr>
<td>Small (BOA Tool Does Not Apply)</td>
<td>Savings &lt; 75,000 kWh/yr or Savings &lt; 7,500 th/yr</td>
<td>Initial Savings Calculation by Provider</td>
<td>Initial Savings Calculation by Provider verified by snapshots</td>
<td>Pre- and Post-Implementation Snapshot</td>
</tr>
<tr>
<td>Medium</td>
<td>75,000 kWh/yr &lt; Savings &lt; 200,000 kWh/yr or 7,500 th/yr &lt; Savings &lt; 20,000 th/yr</td>
<td>Initial Savings Calculation by Provider</td>
<td>Initial Savings Calculation, Adjusted for Pre- and Post-Implementation Trends</td>
<td>Pre- and Post-Implementation Trend Logging</td>
</tr>
<tr>
<td>Large</td>
<td>200,000 kWh/yr &lt; Savings or 20,000 th/yr &lt; Savings</td>
<td>Initial Savings Calculation by Provider</td>
<td>Calculations Based on Pre- &amp; Post-Implementation Measurements</td>
<td>Pre- and Post-Implementation Trend Logging</td>
</tr>
</tbody>
</table>

*Table 7 of the RCx Investigation Report Handbook V1.2, RCx Submittals Guideline Companion; 04/11/2011*
ComEd Smart Ideas for Your Business Commercial Retrocommissioning

- ComEd’s RCx program offers energy analysis services to identify no-cost and low cost measures
- Program Directives:
  - Program participants commit to spend at least $10,000 or $20,000 (depending on project size) to implement identified and agreed-upon retro-commissioning measures (RCMs) resulting in a bundled package offering an estimated simple payback of one-and-a-half years or less based upon electric savings. Savings must be calculated per measure.
- Program is EEM driven
- Program requires Option A or Option B
  - Savings must be presented on a measure by measure basis
  - Savings of any one measure will probably not be greater than 10%
  - EEMs may be bundled to achieve maximum savings within payback requirements
M&V in Non-Utility Retrocommissioning

- RCxA must draft the most appropriate M&V Plan per the Project Scope, Project Budget, and Project Schedule:
  - Estimate the level of expected or available savings
  - Identify existing / proposed metering
  - Identify acceptable reporting tolerances
  - Identify key Independent Variables
    - Outside Air Temperature
    - Occupancy
    - Time-Of-Day (TOD) Building Use
    - Production Quantities in Manufacturing Plants
M&V in Non-Utility Retrocommissioning

- Identify if best results would be derived from a systems or whole building approach
- Use a process of elimination within the available options
  - Typically want to use Option A if possible to minimize cost of energy metering, look for constant load, constant use measures
  - If RCx impacts one specific metered system (e.g. a chiller replacement), it is almost always effective to use Option B
  - If many smaller systems are affected, if measures interact significantly, or if savings are greater than 10% of the whole building energy consumption, then Option C is most effective
  - Option D provides the greatest flexibility but at the greatest cost
M&V in Non-Utility Retrocommissioning

- Issues to keep in mind:
  - Do savings need to be shown per measure?
    - e.g. Are incentives available only for a subset of the measures?
  - Are there penalties if estimated savings or payback are not met?
  - Do measures have significant interactive effects?
    - e.g. Will lighting measures reduce electricity but increase mechanical heating loads?
  - Are baseline adjustments expected?
    - e.g. Offices that were vacant at the beginning of the projects are now occupied.
  - What seasonal, occupancy, or load variances expected?
  - All Options and approaches may be valid
    - RCxA should be aware of available incentives and any M&V requirements mandated by the funding source
    - RCxA should be aware of subsequent or ongoing persistent retrocommissioning requirements in order to enable future M&V efforts
M&V in New Construction Commissioning

- **Motivation** – determine the effectiveness of additional capital investment in building design, construction and commissioning for energy efficiency

- CxA must draft the M&V Plan using the most appropriate approach taking into account the Owner’s Project Requirements, Project Scope, Project Budget, and Project Schedule
  - Identify standard against which the building will be compared
    - e.g. ASHRAE 90.1, or local codes if more stringent (CA Title 24)
  - If a majority of building equipment and systems exceed the standard building, Option D is recommended
  - If only one or a few systems are expected to contribute to energy savings, Option B is recommended
  - Option C is not typically used because there is no building/baseyear for which trend data may be gathered
M&V in New Construction Commissioning

- Develop and implement a Measurement and Verification Plan consistent with LEED requirements if LEED certification is desired
  - 3 LEED Points available for an approved and implemented M&V Plan
    - LEED typically requires Option D, Savings Estimation Method 2
    - Option B may be permitted for buildings with simple systems
    - Only Option B and Option D may be used in LEED
  - Develop a process for corrective action if the results of the M&V process indicate that energy savings are not being achieved.
- Develop a baseline whole building energy model and simulate the effect of energy efficiency measures
- Include all necessary metering equipment and trend logging requirements in project construction documents
- Install metering equipment and set up trend logs during construction.
- Review sample trend logs to confirm data quality meets expectations.
- Conduct comparison of actual energy usage to modeled usage after one-year of post-construction occupancy
- Subtract the metered post-construction energy use from the energy use of the calibrated baseline model
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M&V Key Considerations

To balance Simplicity, Integrity, and Accuracy, consider the project’s starting point, the expected path of the project, and the final deliverables.

<table>
<thead>
<tr>
<th>ECM Project Characteristic</th>
<th>Suggested Option</th>
</tr>
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<tbody>
<tr>
<td>Need to assess ECMs individually</td>
<td>X X X</td>
</tr>
<tr>
<td>Need to assess only total facility performance</td>
<td></td>
</tr>
<tr>
<td>Expected savings less than 10% of utility meter</td>
<td>X X X</td>
</tr>
<tr>
<td>Multiple ECMs</td>
<td>X X X</td>
</tr>
<tr>
<td>Significance of some energy driving variables is unclear</td>
<td></td>
</tr>
<tr>
<td>Interactive effects of ECM are significant or unmeasurable</td>
<td>X X X</td>
</tr>
<tr>
<td>Many future changes expected within measurement boundary</td>
<td></td>
</tr>
<tr>
<td>Long term performance assessment needed</td>
<td>X X X</td>
</tr>
<tr>
<td>Baseline data not available</td>
<td></td>
</tr>
<tr>
<td>Non-technical persons must understand reports</td>
<td>X X X</td>
</tr>
<tr>
<td>Metering skill available</td>
<td>X X X</td>
</tr>
<tr>
<td>Computer simulation skill available</td>
<td></td>
</tr>
<tr>
<td>Experience reading utility bills and performing regression analysis available</td>
<td>X</td>
</tr>
</tbody>
</table>

Table 3: Suggested Options, IPMVP Vol I; 2007, p.54
M&V Key Considerations

- Create an M&V approach that balances accuracy, simplicity, and integrity
- Identify and Comply with any Program Requirements
- Maintain flexibility throughout the M&V process
- Results are more important than process
- CxA should be aware of subsequent or ongoing persistent retrocommissioning requirements in order to enable future M&V efforts
- Are results intended to serve as the basis for an Incentive application or to inform Energy Management decisions
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Thank You!

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