M&V: Meeting New Challenges
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kW Engineering
November 15, 2016
Agenda

• Pay for Performance
• Normalized Metered Energy Consumption
• Evaluation Methodologies
• Needed Research
“The commission...shall, by September 1, 2016, authorize electrical corporations or gas corporations to provide financial incentives, rebates, technical assistance, and support to their customers to increase the energy efficiency of existing buildings based on all estimated energy savings and energy usage reductions, taking into consideration the overall reduction in normalized metered energy consumption as a measure of energy savings. Those programs shall include energy usage reductions resulting from the adoption of a measure or installation of equipment required for modifications to existing buildings to bring them into conformity with, or exceed, the requirements of Title 24 of the California Code of Regulations, as well as operational, behavioral, and retrocommissioning activities reasonably expected to produce multiyear savings.”
ALJ/CPUC Decision 16-08-019

Some issues clarified...

• Baseline policy is now existing conditions*
  • But statewide goals will be based on net savings

• No double-counting of to-code savings between incentive and C&S programs

• PAs can pay incentives based on gross savings
  • NMEC and RCT program designs
  • Encourages higher incentives for above-code portion

• Pay for Performance encouraged

• Measure life:
  • Non-Res Behavioral: 2 years
  • RCx and Operational: 3 years
Pay for Performance

Audit → Business Case → Approval & Financing

Specification & Procurement → Installation & Commissioning

Verification → Performance → Payment

Energy vs Time:
- Baseline Period
- Installation Period
- Performance Period

Savings
Risks

- Savings underestimated
  - Poor savings estimation
  - Estimates not based on data

- ECMs don’t perform
  - Misspecification of equipment
  - Poor installation, lack of commissioning

- Savings don’t last
  - Building operations change
  - Equipment not maintained

- Non-Routine Events
  - New loads added
  - Operations change
  - Occupancy changes

- Result:
  - Poor return on investment
  - Owners, Investors, Everyone Unhappy!
What P4P Requires

• Innovative program designs
  • Solution to cash flow issue
• Reliable and accurate meter-based M&V
• Consistent customer contact
What is?

...the overall reduction in normalized metered energy consumption as a measure of energy savings...

• Normalized Savings (per IPMVP)
  • Re-state baseline and performance period energy use to a common set of conditions (e.g. TMY)
Normalized Metered Energy Consumption

Pre-Install Period

Post-Install Period

Normalized Savings

Normalization Conditions (e.g. TMY)
NMEC Requirements

• 12 months pre and post data
  • Energy use and influencing parameters
• Baseline and performance period energy models
• Normalization conditions (e.g. TMY data)
• Account for non-routine impacts
A Closer Look: How Much Data?

NMSE (N=441) 12 month training

NMSE (N=470) 9 month training

NMSE (N=530) 6 month training

NMSE (N=537) 3 month training
A Closer Look: Model Accuracy

Certainty of savings is influenced by:

- Accuracy of baseline model (CV)
- Amount of savings (F)
- Number of baseline and post-install data points (n, m)

Want Savings Uncertainty \( \frac{\Delta E}{E} < 50\% \) (maximum)

Equation from ASHRAE Guideline 14 - 2002

\[
\frac{\Delta E_{save,m}}{E_{save,m}} = t \cdot \frac{1.26 \cdot CV \left[ \frac{n}{n'} \left( 1 + \frac{2}{n'} \right) \frac{1}{m} \right]^{1/2}}{F}
\]
A Closer Look: Non-Routine Events

• NRE Energy Impacts
  • Treated differently in baseline and performance periods
  • Quantified using measurements and engineering analysis
  • Factored into the ‘adjusted baseline’

• Framework for NRE assessment
  • Significance
  • Constant or variable
  • Temporary or permanent
M&V Tools

Public Domain

Universal Translator
M&V Analysis Module

LBNL Temperature and Time-of-Week Model

Energy Charting and Metrics Tool

Inverse Model Toolkit (RP 1050)

EMIS - Proprietary

ENERGY SAVVY

Building iQ

FIRSTFUEL
M&V 1.0 versus M&V 2.0

M&V 1.0: Monthly Data
- Linear regressions
- 12 months/data points per year
- Less Accuracy
- 12 mo. monitoring duration

M&V 2.0: Short-Time Interval Data
- Advanced analytics
- 8760 hourly points per year
- More Accuracy
- Shorter monitoring duration: 3 or 6 months
- Faster feedback on performance
- Applicable to subsystems
P4P/NMEC Best Applications

- ‘Predictable’ buildings, systems:
  Weather sensitive, regularly scheduled

- Multiple and interactive ECMs:
  Affecting many systems (HVAC, lighting, etc.)

- Deep savings projects:
  Savings are “above the noise” (> ~15%)

- Difficult to quantify ECMs:
  Controls retrofits, duct sealing, envelope upgrades, etc.

- ECMs using existing condition as baseline:
  RCx, behavioral
Screening for Program Success

- **Good buildings:**
  - Predictable operation

- **Bad buildings**
  - Requires intervention

- **Ugly buildings**
  - Cannot predict future use
New CA Meter-Based Programs

**HOPPs**
- SCE
  - Public Sector
- SoCalGas
  - Public Sector
  - Commercial Restaurant

**PG&E (AB 802)**
- Commercial Whole Building Performance (Q2 2017)

**PG&E**
- Residential pay for performance
- On-bill financing
Step 1: Project Level Savings (M&V)
  • Gross savings (Customer)
  • To & Above Code Savings (Regulatory)

Step 2: Attribution
  • Account for free-ridership

Step 3: Program Level Savings
  • Determines ‘additionality’ of savings
  • Program cost effectiveness
Methods: Treatment/Control Groups

- Project Level Savings (M&V)
  - Gross Savings with NMEC

- Net Effects
  - Free-ridership
  - To-code/above-code
  - Exogenous effects

- Program Level Savings
  - Combines above factors
  - Determines ‘additionality’ of savings

Typ. Of Residential Sector – high group populations
Needed Research (Partial List)

- How to estimate savings uncertainty without having a double Ph.D. in statistics and building science
  - Understand relationship of model fit, amount of data, and savings for short-time interval data
- Account for non-routine events
  - Directly from load data?
- How to define control groups for commercial sector
  - Enables programs to capture gross savings for customers and claim net savings to regulators
Questions?

Thank You,
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## Table 1. Adopted Default Baseline Policy for All Sectors

<table>
<thead>
<tr>
<th>Alteration Type</th>
<th>Delivery</th>
<th>Savings Determination</th>
<th>Shell &amp; Bldg System and Add-On Equipment</th>
<th>Behavioral, Retro-commissioning, and Operational</th>
<th>Normal replacement</th>
<th>Accelerated replacement and repair eligible</th>
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<tbody>
<tr>
<td>New construction, expansions, added load</td>
<td>Any</td>
<td>Any</td>
<td>Code</td>
<td>N/A</td>
<td>Code</td>
<td>N/A</td>
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<td>Existing buildings, including major alterations</td>
<td>Upstream &amp; Midstream</td>
<td>Any</td>
<td>Code</td>
<td>N/A</td>
<td>Code</td>
<td>N/A</td>
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<td></td>
<td>Downstream</td>
<td>Calculated</td>
<td>Existing</td>
<td>Existing</td>
<td>Code</td>
<td>Dual</td>
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<tr>
<td></td>
<td></td>
<td>Deemed</td>
<td>Existing</td>
<td>Existing</td>
<td>Code</td>
<td>Dual</td>
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<tr>
<td></td>
<td></td>
<td>NMEC</td>
<td>Existing</td>
<td>Existing</td>
<td>Existing, Program Design</td>
<td>Existing</td>
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<tr>
<td></td>
<td></td>
<td>RCT/ experimental</td>
<td>Existing</td>
<td>Existing</td>
<td>Existing</td>
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<tr>
<td>Non-building projects, including industrial and agricultural processes</td>
<td>Any</td>
<td>Any</td>
<td>N/A</td>
<td>Existing</td>
<td>Standard Practice</td>
<td>Dual</td>
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</tbody>
</table>
Recommendations:

• Standardization of M&V method for all projects
  • Regression method
  • Amount of data pre and post installation
  • Tighter model accuracy and uncertainty requirements

• Improve reporting requirements
  • Start and end dates of installation
  • Non-routine events
  • Modeling & savings analysis parameters

• Require functional performance testing or KPI tracking for affected systems

Option C: Whole Facility

Data Sources:
- Utility bills / AMI Data
- Local weather stations
- Regression analysis
- Ambient Temperature
- Time-of-Week
- Other?

\[ kWh_{\text{save}} = kWh_{\text{base}}(T_{\text{post}}) - kWh_{\text{post}}(T_{\text{post}}) \]
Monitoring Savings Persistence
M&V 1.0 – Monthly Data

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M&V 2.0 - Interval Data

- Advanced analytics
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Screen Shots of M&V 2.0 Capability

Image Source: Universal Translator 3
Illustration of Test Procedure
Percent Error (NMBE)

Total number of buildings in the test case

NMBE (N=441) 12 month training
NMBE (N=470) 9 month training
NMBE (N=530) 6 month training
NMBE (N=537) 3 month training

90th %ile 75th %ile Mean Median 25th %ile 10th %ile

Total number of buildings in the test case
Pay For Performance

[Graph showing pay for performance over time]

1. Q4 '12 to Q1 '13
2. Q2
3. Q3 to Q4
• Cumulative savings - continuous tracking & feedback