PILOTS: PRESENT AND FUTURE

Moderator: Diane Duva, Connecticut Department of Energy & Environmental Protection
Miles Ingram, Eversource
Jessica Granderson, Lawrence Berkeley National Laboratory
Claire Miziolek, NEEP
The Connecticut M&V 2.0 Pilot

**Funding**
- **DOE Funding:** $743,998
- **Cost Match:** $538,100 (72%)

**Project Goals:**
This project will test the use of advanced data analytics and collection tools (M&V 2.0) through a statewide pilot, and compare these findings with traditional M&V practices in terms of savings certainty, timeframe, and other aspects.

Inform and coordinate EM&V 2.0 learning and results with Regional organizations and US DOE Uniform Methods Projects.

**Impact:**
- Develop M&V 2.0 software tool standards and protocols
- Broad scale adoption and use of M&V 2.0 tools in CT based on pilot results
- State and regional education on automated versus traditional approaches to EM&V

**The Connecticut Project Team:**
- NH, NY, RI, VT, NEEP, LBNL
- Eversource Connecticut (utility)
- United Illuminating (utility)

**Stakeholders:**
- State energy offices, regulators, utilities, program administrators, evaluators, system planners, facility managers

**Objectives**

**Task 1:**
- Test advanced data collection/analytics tools in commercial and residential buildings.

**Task 2:**
- Track the process of using these tools and share results with states.

**Task 3**
- Assess how these M&V 2.0 tools can be integrated with traditional evaluation.

**Task 4**
- Regulators will expect these auto-M&V tools to be a valid method for determining energy savings.
Speakers

C&I Pilot:
Jessica Granderson, Lawrence Berkeley Labs
Miles Ingram, Eversource

Residential Pilot:
Claire Miziolek, NEEP
Connecticut Advanced M&V Pilots
November 7, 2018
Technical Goals

• Understand broad-scale suitability of M&V 2.0 based on customer load profiles

• Assess M&V 2.0 value proposition
  – How do savings compare with currently used methods?
  – What are the process needs? Streamlining?
  – What is the value of continuous feedback?

• Document findings, incorporate into application guidance
C&I PILOT SCREENING AND PROJECT SELECTION
Generalized Suitability of Advanced M&V

• Baseline models for 137 meters

• Model fitness target thresholds
  – $R^2 > 0.7$
  – $CV(RMSE) < 25$
  – NMBE between -0.5% and +0.5%

Source: LBNL RMV2.0 Tool
Generalized Suitability of Advanced M&V

• 71% of buildings could be modeled to meet all model fitness screening criteria – no model customization OAT and time only

• Consistent w experience with other data sets, which ranged ~70%-85%

<table>
<thead>
<tr>
<th>Screening Criteria</th>
<th>Sites Meeting Screening Criteria (n =137 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>R² &gt;0.7</td>
<td>111</td>
</tr>
<tr>
<td>CV(RMSE) &lt;25%</td>
<td>109</td>
</tr>
<tr>
<td>NMBE within -0.5% to +0.5% range</td>
<td>136</td>
</tr>
<tr>
<td>Sites Meeting All Screening Criteria</td>
<td>97</td>
</tr>
</tbody>
</table>

Quantity | %
---|---
111 | 81%
109 | 80%
136 | 99%
97 | 71%
M&V 2.0 Pilot Cohort

Selection criteria:

- CT *Energy Opportunities* participants (large commercial retrofit program)
- Participants with “pipeline” projects scheduled for installation
- Interval meter in place for at least 12 months
- Expected whole building savings >5%

<table>
<thead>
<tr>
<th>Business type</th>
<th>Measure type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grocery</td>
<td>Refrigeration</td>
</tr>
<tr>
<td>Grocery</td>
<td>Lighting (interior)</td>
</tr>
<tr>
<td>Grocery</td>
<td>Lighting (interior)</td>
</tr>
<tr>
<td>Aerospace &amp; Defense</td>
<td>Lighting (interior)</td>
</tr>
<tr>
<td>Office Building</td>
<td>Lighting (interior)</td>
</tr>
<tr>
<td></td>
<td>Cooling (VFD)</td>
</tr>
<tr>
<td></td>
<td>Heating (VFD)</td>
</tr>
<tr>
<td>Grocery</td>
<td>Lighting (interior)</td>
</tr>
<tr>
<td>Retail</td>
<td>Lighting (interior and exterior)</td>
</tr>
<tr>
<td>Office Building</td>
<td>Lighting (interior)</td>
</tr>
<tr>
<td></td>
<td>Cooling (EMS)</td>
</tr>
<tr>
<td></td>
<td>Motors</td>
</tr>
<tr>
<td>Museum</td>
<td>Lighting (interior)</td>
</tr>
<tr>
<td>Retail</td>
<td>Lighting (interior)</td>
</tr>
<tr>
<td>Grocery</td>
<td>Refrigeration</td>
</tr>
<tr>
<td>Insurance Office</td>
<td>Cooling (EMS)</td>
</tr>
<tr>
<td></td>
<td>Motors (Kitchen Fans)</td>
</tr>
<tr>
<td>Retail</td>
<td>Lighting (exterior)</td>
</tr>
<tr>
<td>State Prison</td>
<td>Lighting, Refrigeration, Heating, Cooling</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>Lighting, Heating, Cooling</td>
</tr>
</tbody>
</table>
Pilot Screening and Site Selection

- Baseline model fitness check, 34 pilot candidates

<table>
<thead>
<tr>
<th>Screening Criteria</th>
<th>Sites Meeting Screening Criteria (n = 34)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quantity</td>
</tr>
<tr>
<td>R² &gt;0.7</td>
<td>31</td>
</tr>
<tr>
<td>CV(RMSE) &lt;25%</td>
<td>28</td>
</tr>
<tr>
<td>NMBE within -0.5% to +0.5% range</td>
<td>34</td>
</tr>
<tr>
<td>Sites Meeting All Screening Criteria</td>
<td>28</td>
</tr>
</tbody>
</table>
Example Site: Met Fitness Criteria

Actual and fitted consumption data, and ambient temperature, for site EV-02

R² .85, CV(RMSE) 7%, NMBE 0%
Example Site: Did Not Meet Fitness Criteria

Actual and fitted consumption data, and ambient temperature, for site EV-17

$R^2 = 0.33$, CV(RMSE) 67%, NMBE 0.27%
TRADITIONAL M&V
Typical Approaches: Engineering and Billing Analysis

Pre-project:

• **Engineering analysis and review** (in-house and/or third-party)
• **Monthly billing analysis** (in-house)
  • **adjusted for weather** if measures are weather-dependent
  • **sanity check** of current end use vs. total consumption

Post-project:

• **Engineering analysis and review**, *adjusted for as-built conditions*
• **Selective billing analysis** (e.g., large custom projects, projects with changes at the site, projects with questionable pre-project analysis)
<table>
<thead>
<tr>
<th>Business type</th>
<th>Measure type</th>
<th>Estimated annual savings (kWh)</th>
<th>Estimated Savings, % of 2016 Annual Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grocery</td>
<td>Refrigeration</td>
<td>59,738</td>
<td>4.4%</td>
</tr>
<tr>
<td>Grocery</td>
<td>Lighting (interior)</td>
<td>409,097</td>
<td>13.9%</td>
</tr>
<tr>
<td>Grocery</td>
<td>Lighting (interior)</td>
<td>254,003</td>
<td>13.5%</td>
</tr>
<tr>
<td>Aerospace &amp; Defense</td>
<td>Lighting (interior)</td>
<td>49,013</td>
<td>2.3%</td>
</tr>
<tr>
<td>Office Building</td>
<td>Lighting (interior)</td>
<td>198,658 kWh</td>
<td>4.4%</td>
</tr>
<tr>
<td></td>
<td>Cooling (VFD) 50,024 kWh</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heating (VFD) 19,877 kWh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Office Building</td>
<td>Lighting (interior)</td>
<td>140,746</td>
<td>10.3%</td>
</tr>
<tr>
<td>Office Building</td>
<td>Lighting (interior and exterior)</td>
<td>175,348</td>
<td>1.3%</td>
</tr>
<tr>
<td>Office Building</td>
<td>Lighting (interior)</td>
<td>106,819 kWh</td>
<td>5.4%</td>
</tr>
<tr>
<td></td>
<td>Cooling (EMS) 39,248 kWh</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Motors, 631,587 kWh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Museum</td>
<td>Lighting (interior)</td>
<td>241,775</td>
<td>9.7%</td>
</tr>
<tr>
<td>Retail</td>
<td>Lighting (interior)</td>
<td>108,238</td>
<td>13.8%</td>
</tr>
<tr>
<td>Grocery</td>
<td>Refrigeration</td>
<td>66,805</td>
<td>5.2%</td>
</tr>
<tr>
<td>Insurance Office</td>
<td>Cooling (EMS) 658 kWh</td>
<td>20,805</td>
<td>0.3%</td>
</tr>
<tr>
<td></td>
<td>Motors (Kitchen Fans) 20,147 kWh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retail</td>
<td>Lighting (exterior)</td>
<td>33,730</td>
<td>3.6%</td>
</tr>
<tr>
<td>State Prison</td>
<td>Lighting, Refrigeration, Heating, Cooling</td>
<td>TBD – Project Delayed</td>
<td></td>
</tr>
<tr>
<td>Manufacturing</td>
<td>Lighting, Heating, Cooling</td>
<td>TBD – Project Delayed</td>
<td></td>
</tr>
</tbody>
</table>
Typical Approaches: Third Party “Traditional” EM&V

- **CT statute** requires EM&V to ensure that programs are cost effective, achieve optimal levels of savings, are administered efficiently, and comply with statutory requirements.

- **ISO-NE Forward Capacity Market** criteria for statistical precision and confidence of demand resources.

- **Insight** into factors driving savings discrepancies:

  ![Figure 1-3. Key Drivers Behind Electric Realization Rate](image_url)

  - **Discrepancy Category**:
    - Difference in baseline assumptions
    - Difference in calculation methodology
    - Difference in installed quantity
    - Difference in operating hours
    - Documentation differences
    - Difference in equipment load profiles
    - Measure not implemented

  - **Impact on Realization Rate (RR)**:
    - Negative Impact
    - Positive Impact
    - Overall Impact

<table>
<thead>
<tr>
<th>Discrepancy Category</th>
<th>Negative Impact</th>
<th>Positive Impact</th>
<th>Overall Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># Instances</td>
<td>Impact on RR</td>
<td>Impact on RR</td>
</tr>
<tr>
<td>Difference in baseline assumptions</td>
<td>7</td>
<td>-6%</td>
<td>12%</td>
</tr>
<tr>
<td>Difference in calculation methodology</td>
<td>4</td>
<td>-2%</td>
<td>0%</td>
</tr>
<tr>
<td>Difference in installed quantity</td>
<td>3</td>
<td>-16%</td>
<td>0%</td>
</tr>
<tr>
<td>Difference in operating hours</td>
<td>3</td>
<td>-1%</td>
<td>3%</td>
</tr>
<tr>
<td>Documentation differences</td>
<td>1</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Difference in equipment load profiles</td>
<td>7</td>
<td>-4%</td>
<td>20%</td>
</tr>
<tr>
<td>Measure not implemented</td>
<td>1</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Total</td>
<td>26</td>
<td>-31%</td>
<td>36%</td>
</tr>
</tbody>
</table>
Typical Approaches: Third Party “Traditional” EM&V

- Five pilot sites were sampled for a third-party evaluation, est. completion in 2019

- Methods include on-site metering and installation verification at a representative sample of sites, to produce statistical estimates of program-wide savings.
APPLICATION OF ADVANCED M&V
CT Savings Tracking (Example #1)

Motor/Lighting/Cooling Program calculated savings 5.4%
Meter-based savings 4% (168 days post)

“CUSUM” – Cumulative sum of savings over the post-retrofit period
CT Savings Tracking (Example #2)

Lighting
Program calculated savings 13.8%
Meter-based savings 15.3% (291 days post)
Investigating Changes in Savings Profile (Example #3)

- Lighting retrofit
- Calculated 314,259kWh annual savings
- Metered: 149,779kWh savings over 260-day period (1.4%)
Zooming in to the period when something changed ....

... and zooming in further...
REFLECTION
Advanced M&V Interim Outcomes

• Advanced M&V method works as expected

• Building a library of examples with diverse project types, facility types, and data characteristics

• Advanced M&V and associated tool visualizations allow for:
  – Early feedback on savings
  – Characterization of savings by hour/day/season
  – Investigation of possible NREs

• Model fitness metrics and charting support confidence, transparency in results

• Data increases visibility into performance, and questions about what we see
## Effort Required for Advanced M&V Pilot

<table>
<thead>
<tr>
<th>Approximate effort</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>75%</td>
<td>• Data investigation</td>
</tr>
<tr>
<td></td>
<td>• Cleaning</td>
</tr>
<tr>
<td></td>
<td>• Preparation</td>
</tr>
<tr>
<td></td>
<td>• Running model</td>
</tr>
<tr>
<td></td>
<td>• Clarifying issues</td>
</tr>
<tr>
<td>25%</td>
<td>• Interpretation</td>
</tr>
<tr>
<td></td>
<td>• Analysis</td>
</tr>
<tr>
<td></td>
<td>• Communication</td>
</tr>
</tbody>
</table>

Expect that at scale, in ‘production’ environment, less time on data cleaning, prep
Challenges: collecting interval data
- organizational barriers
- time consuming process for requests, cleaning, formatting
- data for certain sites not suitable for analysis
  - sites with retired/replaced meters
  - sites with distributed generation
    - kW delivered to customer
    - kW exported to the grid
    - total consumption

Solutions: Building the “data pipeline”
## PA Lessons Learned: Data and Analysis Challenges

### Where’s the project?

<table>
<thead>
<tr>
<th>Meters</th>
<th>Description</th>
<th>Projects*</th>
<th>Implications for measuring savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:1</td>
<td>Single building with single meter</td>
<td>Single project</td>
<td>Feasible, assuming savings are high enough (e.g., &gt;5%)</td>
</tr>
<tr>
<td></td>
<td>Multiple projects concurrent/overlapping</td>
<td>Multiple projects at separate time periods</td>
<td>Feasible to measure combined savings for all projects. Take baseline prior to first project.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Feasibility depends on total time span of projects and the time period between projects.</td>
</tr>
<tr>
<td>many:1</td>
<td>Multiple meters serve a single building</td>
<td>Project(s) affect whole building</td>
<td>Can combine readings from multiple meters into a single dataset for model analysis. See other comments for 1:1 meters relating to quantity and timing of projects.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Project(s) affect portion of building served by one of the meters</td>
<td>Could consider modeling just that meter, but need to consider if interactive effects of project are fully accounted for.</td>
</tr>
<tr>
<td>1:many</td>
<td>Single motor serves multiple buildings</td>
<td>Single project on a single building</td>
<td>Case-by-case basis. Unlikely that savings would be high enough to be identified at the meter level, and also less likely to establish a high quality model for multiple buildings on a single meter (unless they are all the same building type with the same operating conditions).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Single project affecting multiple buildings concurrently</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multiple projects</td>
<td></td>
</tr>
</tbody>
</table>

* A “project” may comprise one or more measures.
PA Lessons Learned: Data and Analysis Challenges

Interpret with care!

Consumption may be affected by:

- Changing occupancy/tenancy
- Changing hours of use
- Other efficiency projects
- Other non-routine events such as renovations, building additions, etc.

Monthly Consumption, Mall with Lighting Project
Efficiency? Or Amazon.com?
PA Value Proposition: Risk Mitigation & Streamlining

**RISK MITIGATION:** Quickly detect savings shortfalls, and target sites/contractors/measures for improvements:

- equipment performance
- behavioral issues (e.g., temperature setpoints, EMS programming, etc.)
- removal or replacement of efficient equipment

→ Address issues in advance of statutorily-required third-party evaluations

**STREAMLINED SAVINGS MEASUREMENTS:** Automated, continuous monitoring of savings

DATA IN → SAVINGS OUT
C&I Pilot: Next Steps

• Continue building the interval data pipeline
  ➢ IT team

• Define a process for which projects to analyze, when/with whom to share results
  ➢ Implementation and engineering teams

• Address operational issues on current project as needed (e.g., thermostat set points, EMS programming), and inform future projects, by identifying high & low performers
  • Contractors
  • Measure types
  • Facility types

• Continue assessing M&V 2.0 potential to streamline traditional EM&V
Next steps for CT M&V 2.0 Pilots: What goes in to a Residential Pilot?

Claire Miziolek, NEEP
Here’s where we are in the process

Beginning

Middle

End
What are we trying to do?

Big goals of residential pilot:

• Test out an M&V 2.0 tool

• Compare with “traditional” residential M&V
  – “qualitatively compare and contrast the approaches used in the residential automated M&V tools to other industry-standard methods and best practices”

• Track and document the process
  – Looking for any additional learnings, insights, benefits, or pitfalls from the process

• More modest staffing and time table than C&I
Questions we’re considering

• What data set/timing do we want to use?
• What program do we want to use?
• What are we comparing to?
• What tool should we use for the job?

What we might find...

• What is the time/cost/difficulty of an M&V 2.0 tool vs. traditional evaluation?
• What size of savings is detectable using M&V 2.0 tool?
• What insights can you learn? How much data do you need to see it?
• Does AMI provide more insights?
• For all-electric homes, could their M&V 2.0 analysis be useful for strategic electrification purposes?
KEEP
CALM
AND
STAY
TUNED
Questions?