U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Advanced M&V ("M&V 2.0")

Lawrence Berkeley National Laboratory

PI: Jessica Granderson, Staff Scientist

JGranderson@lbl.gov

Project Summary

Timeline:

Start date: 2014

Planned end date: 2019

Key Milestones

1. Develop and apply tool testing procedure, 2015
2. Demonstrate M&V 2.0 tools on historic utility data, 2016
3. Launch live M&V 2.0 pilots with utilities, Q2 2017
4. Document state of industry positions on accuracy and reporting requirements for M&V 2.0 acceptance, Q3 2017

Budget

Total Project $ to Date:

- DOE: $1,585K ($380K spent last 12 mo.)
- Cost Share: $795K

Total Project $:

- DOE: $1,585K
- Cost Share: $855K

Key Partners:

Bonneville Power Administration (BPA)
Seattle City Light, Eversource, United Illuminating
Connecticut Department of Energy and Environmental Protection (CT DEEP)
Northeast Energy Efficiency Partnerships (NEEP)
Efficiency Valuation Organization (ECO)

Project Outcome:

Market adoption of meter-based approaches to determine energy efficiency (EE) savings at reduced time and cost, while maintaining or increasing the accuracy of the result.

Enabled through: Development and transfer to industry of test protocols to evaluate “M&V 2.0” methods; live pilots to prove value proposition; and establishment of acceptance criteria for use and reporting. [See MYPP, CBI Strategy 3]

Team - Partners

Pilots

- Utility implementation partners
- Co-funders
- Regional regulators, evaln. stakeholders

M&V Tool Testing

- EVO to implement online test portal
- Utility, software providers for beta testing (TBD)

Grounding Concepts

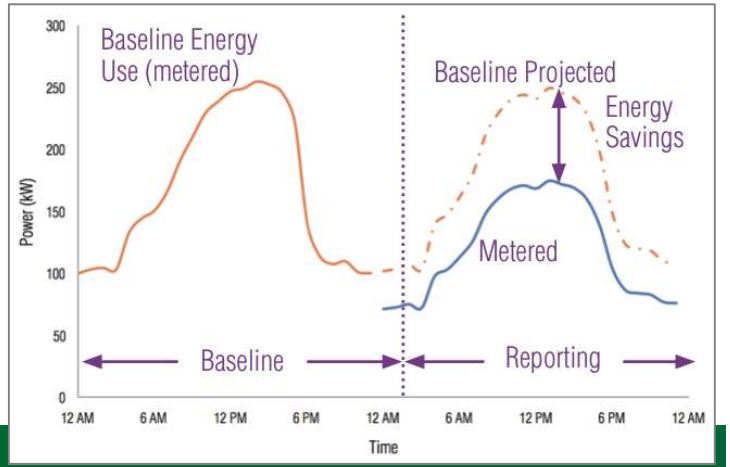
- **Traditional approaches to savings estimation, i.e. M&V**
  - Custom engineering calculations
  - Stipulated, deemed, average measure savings
  - Calibrated physics-based simulation modeling
  - Manual meter-based billing analysis

- **Utility program issues**
  - Different baselines for different measures, prior use not always appropriate
  - Attribution of meter-level savings to measures installed (adjustments)
  - Transparency, 3rd party review

$8B
2017 Utility investment in demand side management (>3% for M&V)

$7+B
2017 ESCOs Revenue (est.)

$.8B
2015 Building Analytics Market



Right: meter-based savings estimation – baseline energy use is mathematically modeled, projected to estimate consumption if the measure had never been implemented. Saving are the difference between actual metered and baseline projected use.

Challenge

Verification and evaluation of efficiency savings is expensive, time consuming; spectrum of approaches are used and custom calculations and stipulated savings are most prevalent

Growth in interval data and analytics tools that automate meter-based measurement and verification ("M&V 2.0") promise to reduce cost and time requirements, improve timeliness and realization, enable scale – BUT questions of accuracy and practical application hinder adoption

Related MYPP CBI Strategy:
Strategy 3: Harness the power of information for improvement, standardization, automation of M&V; develop a test protocol to analyze accuracy of algorithms.

Approach

2014-2015: Develop and apply test procedure to assess, compare accuracy of proprietary and open tools

M&V 2.0 sounds great but…
…how do I implement in a real program?
…how do I set requirements for rigor?
…how do I know whether an M&V tool is any good?

2016: Demonstrate software/methods using historical utility program data

2017: Initiate pilots on 'live projects, establish acceptance criteria and practitioner resources

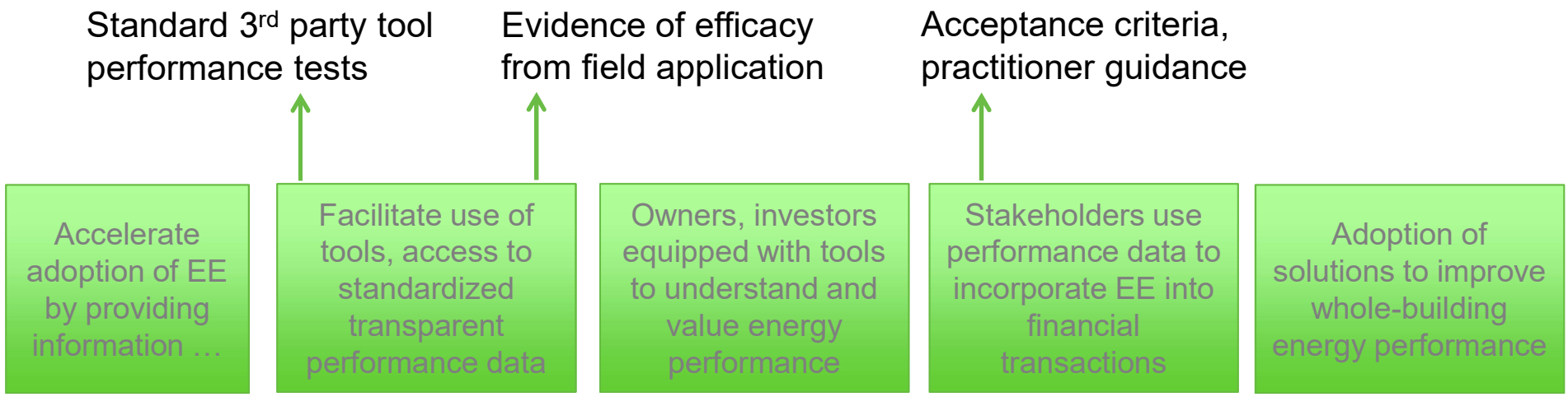
2018: Complete pilots, transfer tool testing to industry, initiate work to automatically address non-routine adjustments (attribution)

Work published at http://eis.lbl.gov/auto-mv.html

Impact

Scaled adoption of cost effective, accurate, meter-based savings estimation

Market growth from private capital injection in EE, due to higher confidence in EE savings results

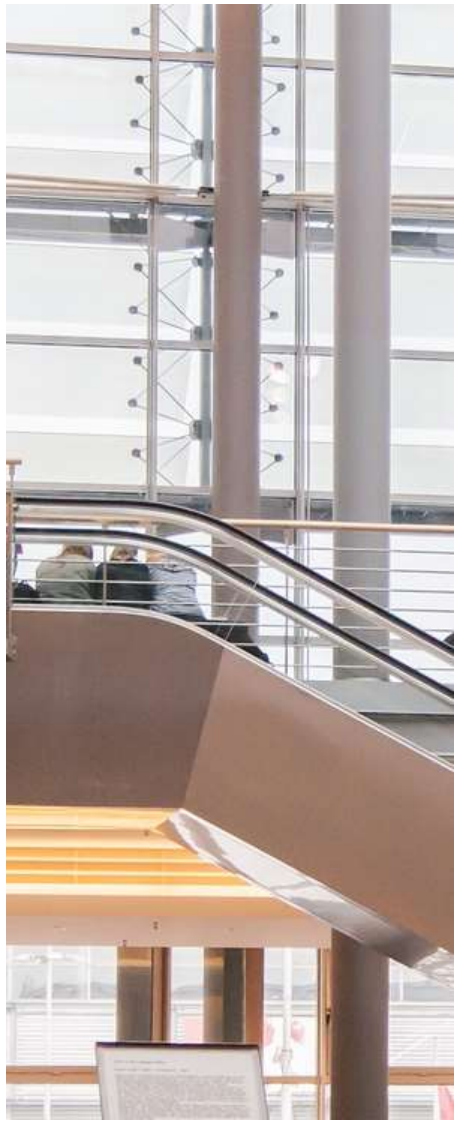


Above: Replication of CBI impact pathways from MYPP

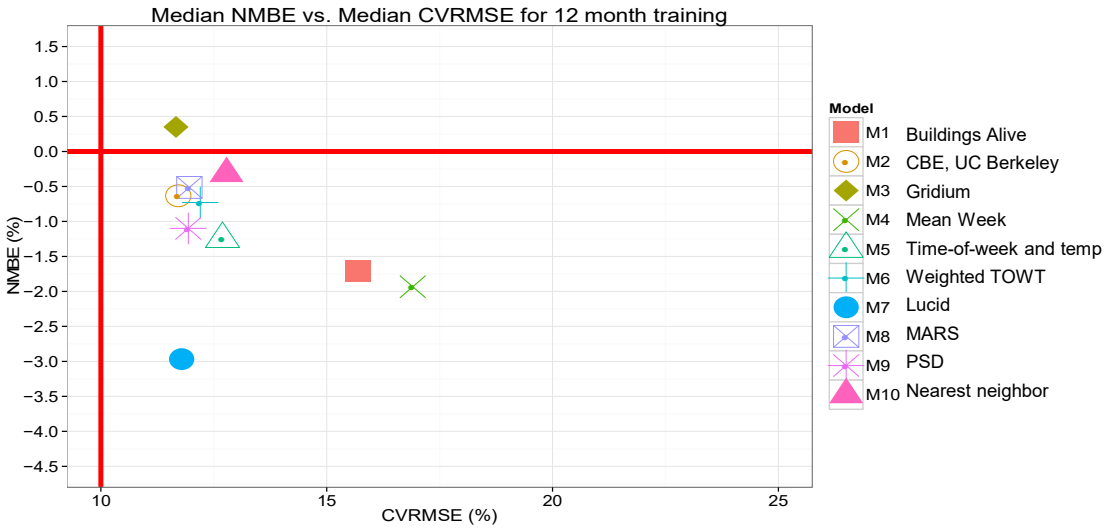
Progress Summary - Highlights

Highlights from that past year include:

- Developed prototype infrastructure to test M&V 2.0 tools
- Launched two M&V 2.0 pilots
- Developed non-routine event detection algorithm and added to open-source LBNL M&V tool
- Published guidance on accuracy and documentation requirements for M&V 2.0 and shared with stakeholders
- Engaged industry through national Stakeholder Adv. Group, participation in regional working groups, general outreach, 1-on-1 discussions with utilities, regulators, etc.



Progress – M&V 2.0 Tool Testing

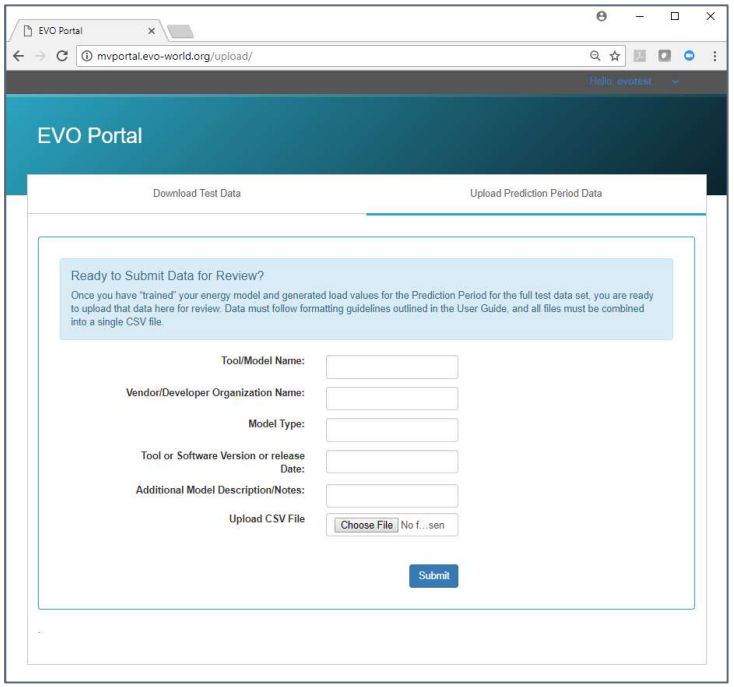


Prior LBNL Research

- Developed test method, selected key accuracy metrics
- 10 interval data models tested - 4 open, 6 proprietary
- Independent variables – time of day, day of week, outside air temperature

Development of M&V Tool Test Infrastructure

- Collaboration with EVO. Vision:
  - Commissions, utilities can vet tools/models
  - Developers can assess performance and improve
  - Inspire confidence in accuracy of methods
- Prototype online portal developed
- Test data obtained for >1000 sites (NW, Mountain, NE, E. regions)

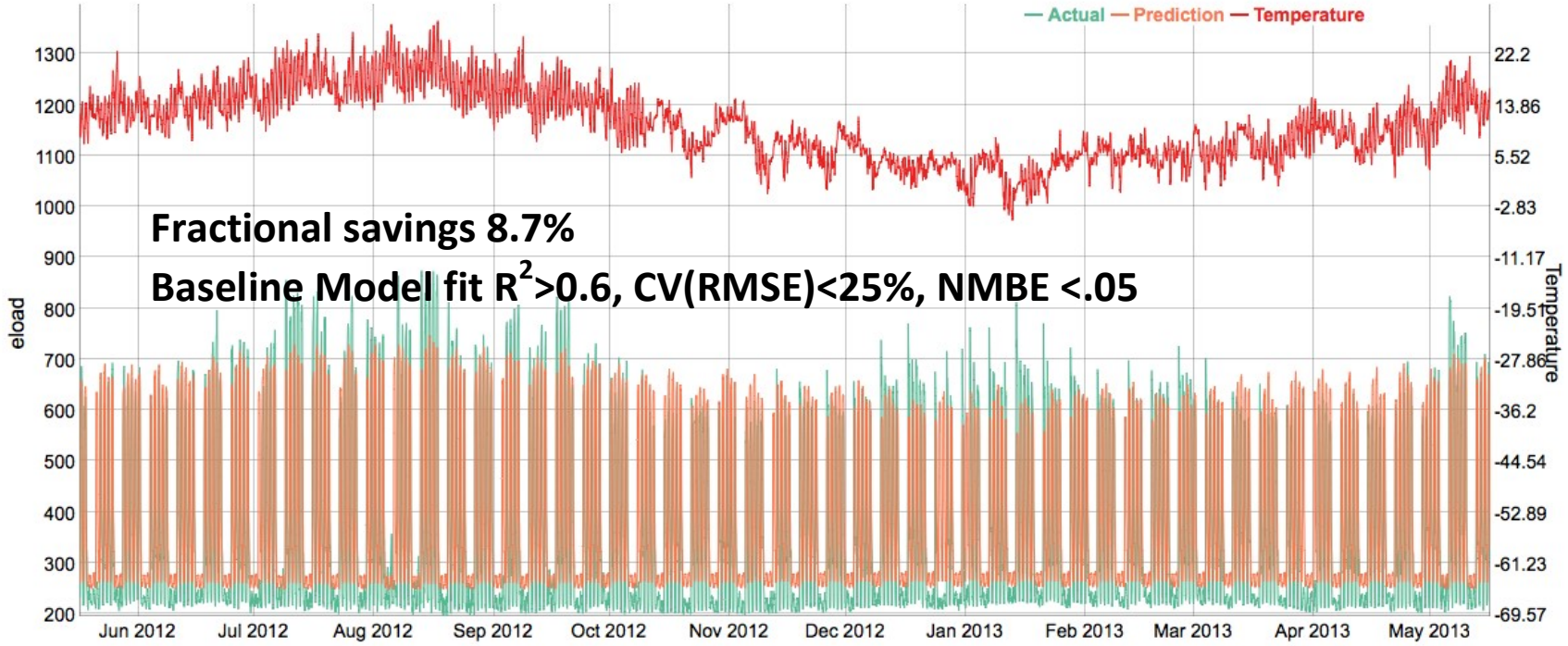


Progress – Industry Guidance

Worked with industry to establish consensus guidance for rigor, transparency for 3rd party review

- Did baseline model characterize baseline energy use well?
- Is savings uncertainty due to model error acceptable?
- Is coverage factor sufficient for a reliable counterfactual?
- Were non-routine adjustments identified and quantified appropriately?

Early Adoption by CA PUC, NYSERDA, Seattle City Light



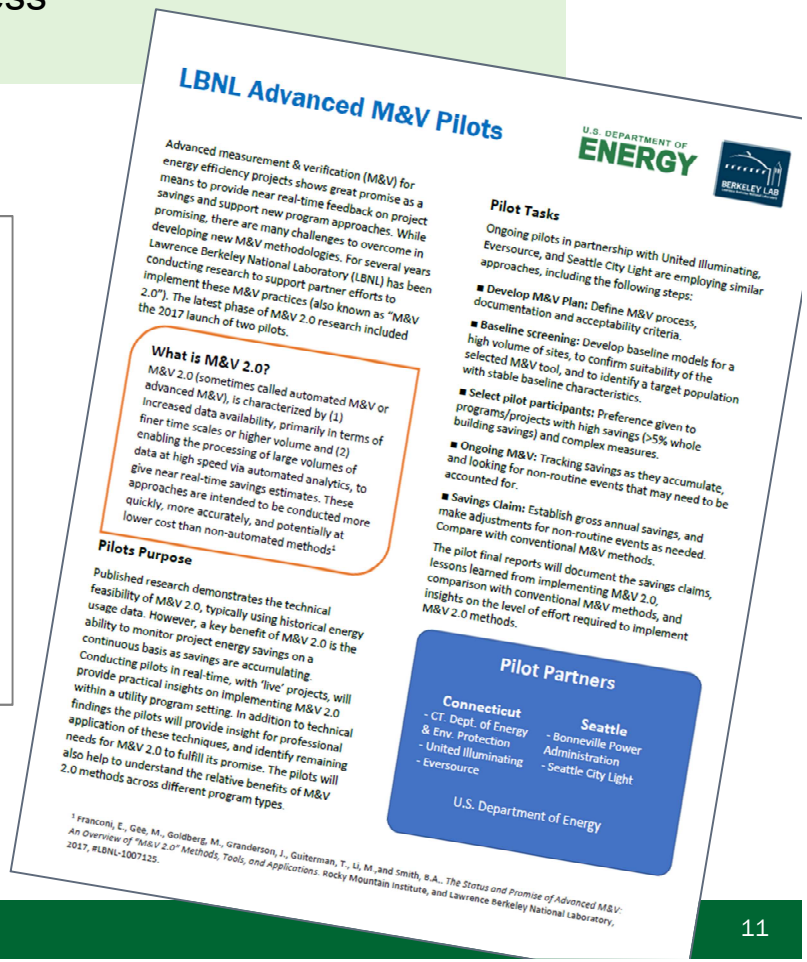
Above: Example of a plot showing metered data, the projected baseline model, the independent variable (temperature), and the fractional savings.

Progress – M&V 2.0 Pilots

M&V 2.0 Pilots

- Compare time, accuracy, cost, savings realization vs. traditional approaches
- NW and NE partners
- Screened >500 sites
- Selected 28 sites in CT; SCL site selection in progress
- Mix of retrocommissioning, controls, retrofit projects

Above: Example plot of actual vs. modeled baseline, from CT Pilot



LBNL Advanced M&V Pilots

U.S. DEPARTMENT OF ENERGY

Advanced measurement & verification (M&V) for energy efficiency projects shows great promise as a means to provide near real-time feedback on project savings and support new program approaches. While promising, there are many challenges to overcome in developing new M&V methodologies. For several years Lawrence Berkeley National Laboratory (LBNL) has been conducting research to support partner efforts to implement these M&V practices (also known as "M&V 2.0"). The latest phase of M&V 2.0 research included the 2017 launch of two pilots.

What is M&V 2.0?

M&V 2.0 (sometimes called automated M&V or advanced M&V), is characterized by (1) increased data availability, primarily in terms of finer time scales or higher volume and (2) enabling the processing of large volumes of data at high speed via automated analytics, to give near real-time savings estimates. These approaches are intended to be conducted more quickly, more accurately, and potentially at lower cost than non-automated methods[1]

Pilots Purpose

Published research demonstrates the technical feasibility of M&V 2.0, typically using historical energy usage data. However, a key benefit of M&V 2.0 is the ability to monitor project energy savings on a continuous basis as savings are accumulating. Conducting pilots in real-time, with 'live' projects, will provide practical insights on implementing M&V 2.0 within a utility program setting. In addition to technical findings the pilots will provide insight for professional application of these techniques, and identify remaining needs for M&V 2.0 to fulfill its promise. The pilots will also help to understand the relative benefits of M&V 2.0 methods across different program types.

Pilot Tasks

Ongoing pilots in partnership with United Illuminating, Eversource, and Seattle City Light are employing similar approaches, including the following steps:

- **Develop M&V Plan:** Define M&V process, documentation and acceptability criteria.
- **Baseline screening:** Develop baseline models for a high volume of sites, to confirm suitability of the selected M&V tool, and to identify a target population with stable baseline characteristics.
- **Select pilot participants:** Preference given to programs/projects with high savings (>5% whole building savings) and complex measures.
- **Ongoing M&V:** Tracking savings as they accumulate, and looking for non-routine events that may need to be accounted for.
- **Savings Claim:** Establish gross annual savings, and make adjustments for non-routine events as needed. Compare with conventional M&V methods.

The pilot final reports will document the savings claims, lessons learned from implementing M&V 2.0, comparison with conventional M&V methods, and insights on the level of effort required to implement M&V 2.0 methods.

Pilot Partners

Connecticut
- CT. Dept. of Energy & Env. Protection
- United Illuminating
- Eversource

Seattle
- Bonneville Power Administration
- Seattle City Light

U.S. Department of Energy

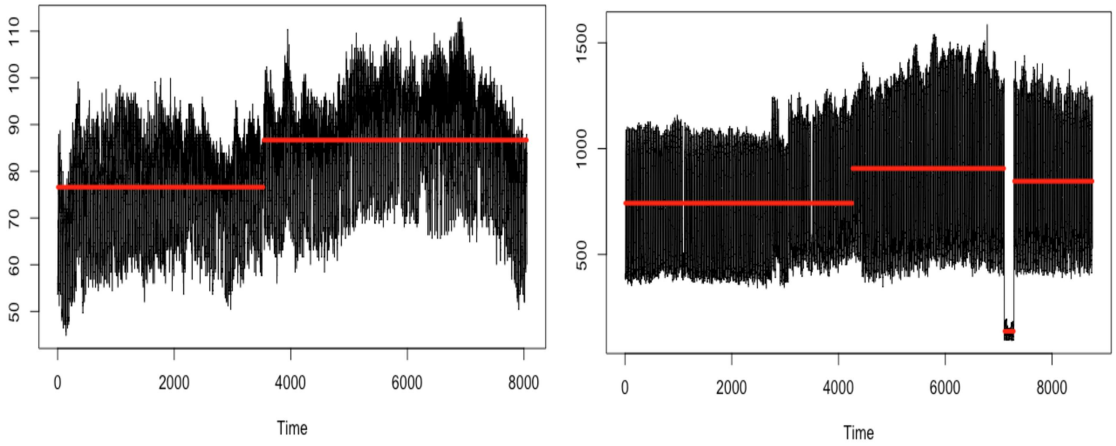
[1] Franconi, E., Gee, M., Goldberg, M., Granderson, J., Guiterman, T., Li, M.,and Smith, B.A., *The Status and Promise of Advanced M&V: An Overview of "M&V 2.0" Methods, Tools, and Applications*. Rocky Mountain Institute, and Lawrence Berkeley National Laboratory, 2017, #LBNL-1007125.

Right: Pilots Factsheet

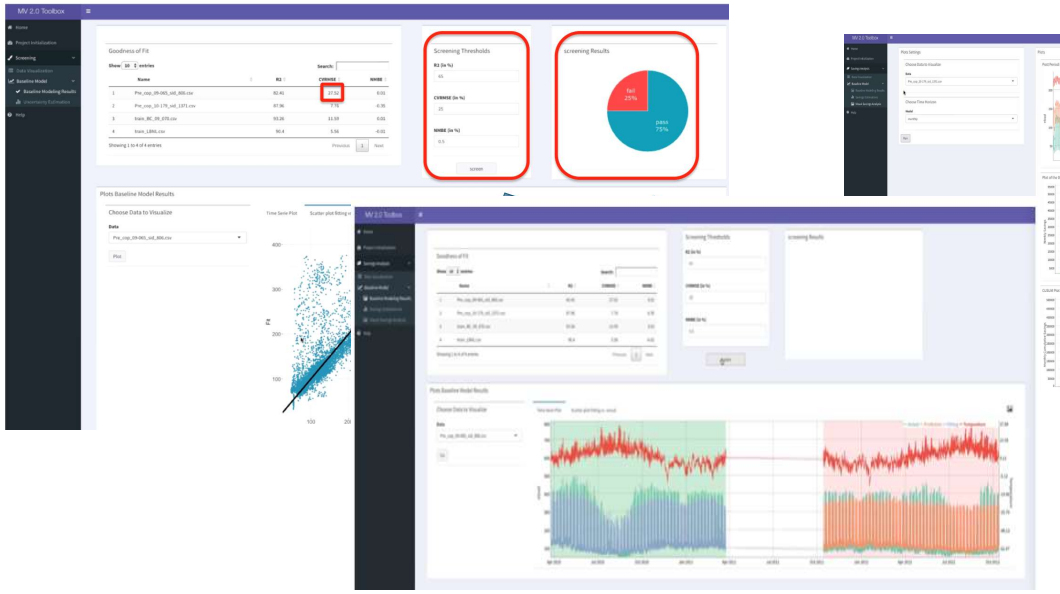
Progress – Non-Routine Events

Non-Routine Events (NREs)

- Changes in consumption that are not related to the installed measures or variables already normalized for
- **Goal:** Develop algorithms to automatically detect NREs and to quantify the impact on savings



Above: Example time-series hourly electric data, denoting non-routine events



Above: Screenshots of LBNL open-source M&V Tool, "RM&V"

Non-Routine Event Research

- NRE detection algorithm built into pen source tool, undergoing testing
- Automated non-routine adjustment method in early development

Stakeholder Engagement

National M&V 2.0 Stakeholder Advisory Group
(4 meetings to date)

Other industry connections:

- CalTrack 2.0 working group
- NEEP EM&V Forum
- NW Regional Technical Forum
- Missouri M&V 2.0 Stakeholder Committee
- Future Grid Coalition
- ASHRAE Guideline 14 Committee

Stakeholder Engagement - Outreach

- White papers, case studies, journal articles
- 2016-18: Presented at 17 outreach events with total ~1,000 attendees

Remaining Project Work and Future Plans

Online tool test portal
- Beta testing
- Final refinements
- Launch & disseminate

M&V 2.0 Pilots
- Track ongoing savings
- Implement mini-pilots
- Report and disseminate findings

Non-Routine Events
- Validate NRE detection algorithm, and refine as needed
- Finalize exploratory work on automated non-routine adjustment method
- Disseminate results

Guidance on accuracy and documentation
- Quarterly Stakeholder Advisory Group meetings
- Continue participation in industry collaborations
- Continue individual outreach

Future Plans:
- Scaled demonstration, market adoption to enable
  - Next generation holistic whole-building programs to deliver deep savings
  - Reliable cost effective savings estimation for increased confidence and investment in efficiency
  - With meter as foundation, ability to integrate energy, demand, cost savings, as EE, distributed energy resources, and transaction-based services converge

Thank You

Lawrence Berkeley National Laboratory
Jessica Granderson
Jgranderson@lbl.gov