M&V 2.0 Demonstrations

2017 Building Technologies Office Peer Review

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Jessica Granderson, jgranderson@lbl.gov
Lawrence Berkeley National Laboratory

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&V2.0 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: $1,360K ($305K spent last 12 mo.)
- Cost Share: $484K

Total Project $:

- DOE: $1,360K
- Cost Share: $857K

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)

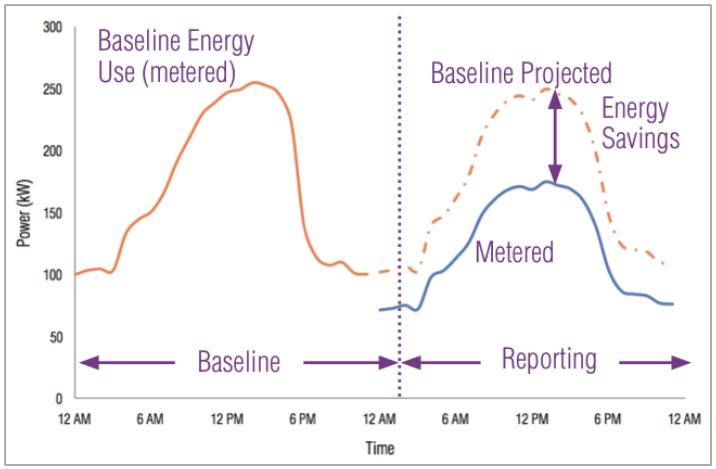
Project Outcome:

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]

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**
- Advanced M&V, i.e. M&V "2.0"
  - Automated meter analytics using software tools, more data, to streamline the process, provide more timely performance feedback
- 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



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.

Purpose and Objectives

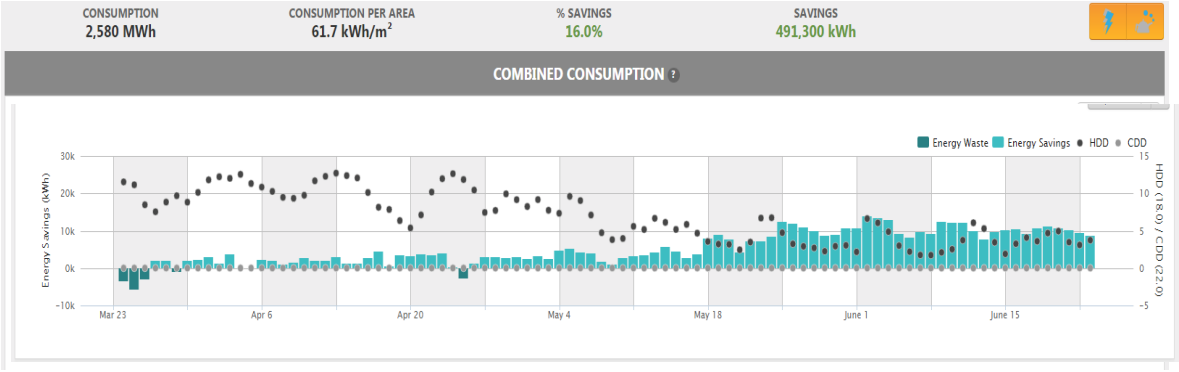
Problem Statement: Verification and evaluation of efficiency savings is expensive, time consuming; spectrum of approaches are used and custom calculations and stipulated savings are most prevalent.

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 - questions of accuracy and practical application.

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

Outcome: market adoption of meter-based approaches, increased confidence in energy savings, reduction in costs.

Right: Automated M&V from EnerNOC



Purpose and Objectives

Audience:

- Users and providers of M&V
- Utility, state, and private sector efficiency program administrators, implementers
- Energy efficiency program evaluators, regulators
- ESCOs (energy service companies)
- M&V 2.0 analytics vendors

Target Market

- Commercial buildings
- With installed smart meters (7.3M, as of 2015)
- Implementing EE projects or advanced O&M practices

*Over next ten years, *potential* for commercial building EE savings estimated at $1T – how can savings estimation scale accordingly?

$7.9B
2014 Utility investment in demand side management

$5.3B
2014 ESCOs Revenue

$0.8B
2015 Building Analytics Market

Purpose and Objectives

Impact of Project:

Near-term: transparent replicable test methods for M&V tools used by industry; early demonstration of M&V 2.0 w utility partners; documentation of time and cost savings, accuracy.

Intermediate: Scaled demonstration and dissemination of results to industry at large; tools and resources adopted to standardize practical application of M&V 2.0 methods.

Long-term: scaled adoption of cost effective, accurate, meter-based savings estimation; market growth from private capital injection, due to higher confidence in EE savings results.

Below: Replication of CBI Logic Model – objectives, activities, short- mid- and long-term outcomes

Approach

- 2014-2015: Develop test procedure to assess and compare predictive accuracy of auto-M&V tools; apply to evaluate proprietary and open tools
- 2016: Demonstrate software/methods using historical utility program data
- 2017: Pilots on 'live' projects, transfer test procedure to industry, establish acceptance criteria and practitioner resources

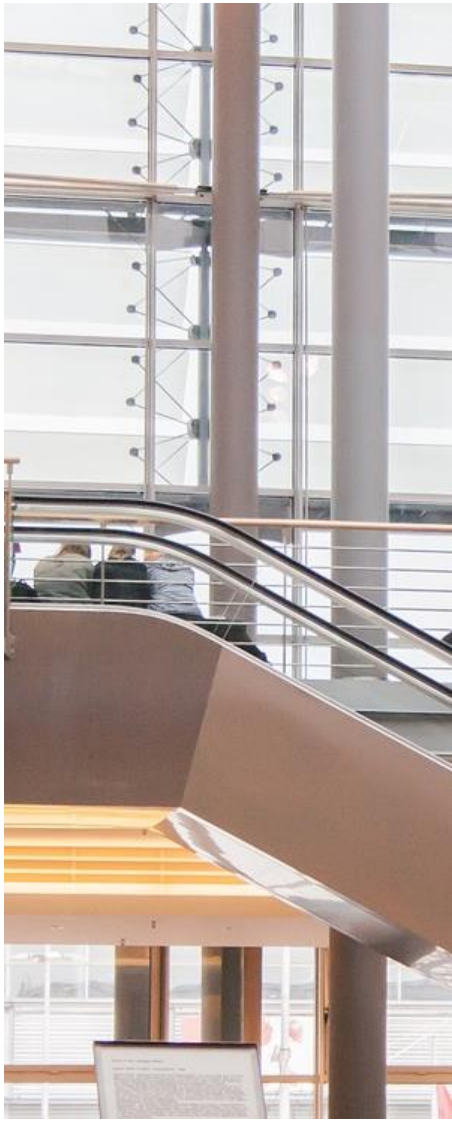
Key Issues: What are acceptable uncertainties and confidence levels for regulatory community? How good is good enough? How to handle non-routine adjustments, attribute meter savings to measures?

Distinctive Characteristics: Transparent testing and public piloting; providing cost, benefit and performance evidence, how-to guidance from pilots to address barriers to adoption.

Progress and Accomplishments

Accomplishments Summary:

- In discussion with Efficiency Valuation Organization to explore delivering tool testing protocols* to industry
- Supported 2 utilities and 1 regulator to partner in demonstrating models on real world program data**
- Initiated M&V 2.0 pilots with 2 utilities
- Initiated discussions with regulatory groups to identify accuracy, uncertainty, reporting requirements



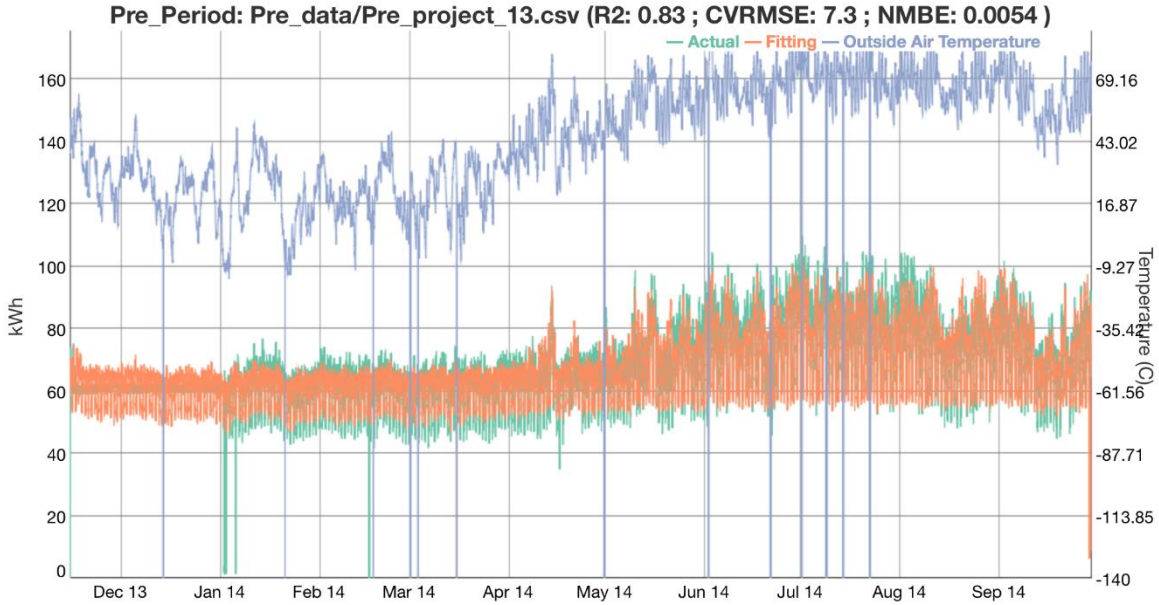
* Granderson, J, Touzani, S, Custodio, C, Sohn, M, Jump, D, Fernandes, S. 2016. Accuracy of automated measurement and verification (M&V) techniques for commercial buildings. Applied Energy 173: 296-308.

** Granderson, J, Touzani, S, Fernandes, S, Taylor, C. 2017. Application of automated measurement and verification to utility energy efficiency program data. Energy and Buildings, In Press.

Progress and Accomplishments

Application of M&V 2.0 to historic program data

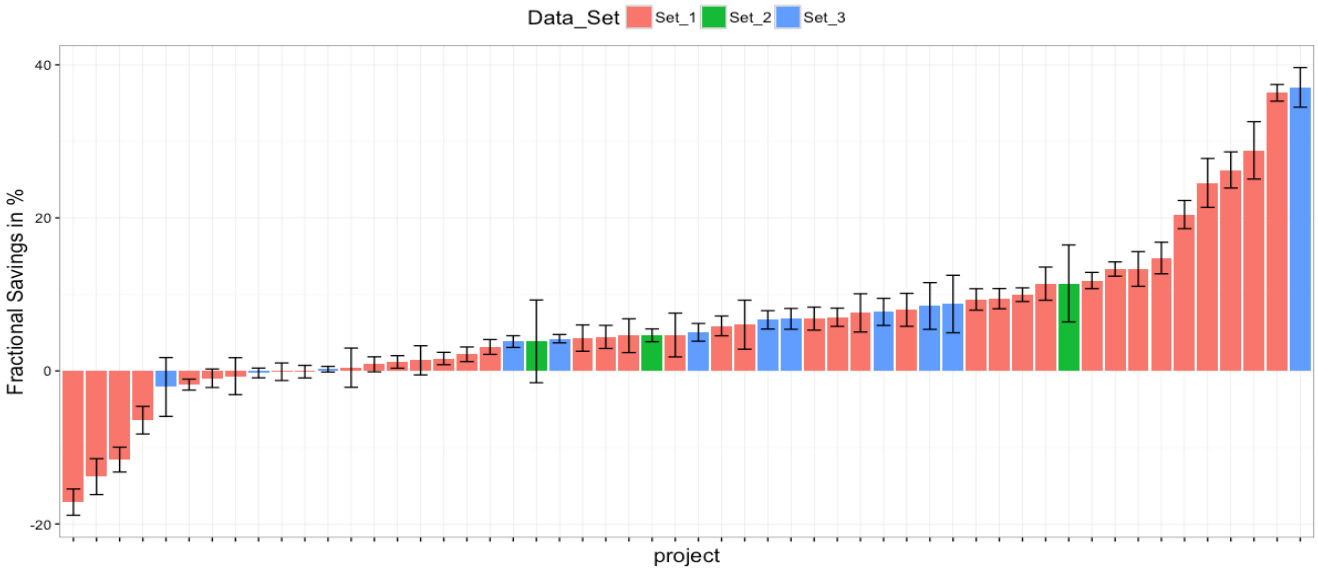
- Working with utilities, 70% of the buildings (n=77) were found to be well suited (statistical fitness) to automated characterization of baseline energy use
- Results indicated that M&V 2.0 can be used to accurately quantify whole-building savings, and that automation may offer time and cost savings advantages



Above: Example of a building well suited to automated baselining: high R^2, low coefficient of variation of the root mean squared error, low normalized mean bias error

Progress and Accomplishments

Application of M&V 2.0 to historic utility program data



Savings uncertainty ranges for each of 54 buildings, at 95% confidence level

AHSRAE Guideline 14 fractional svgs. uncertainty:

Statistical model fitness, (CV(RMSE)

Fractional, i.e., percent savings

Points in baseline period

Points in savings period

Desired confidence level

Fractional uncertainty should be <50% at 68% confidence

M&V 2.0 results exceeded this requirement

Data Set		Aggregated Fractional Savings with the Uncertainty Range	FSU	Fraction Meeting ASHRAE Guidance	Median of FSU At Building Level
Data Set 1	Screened for model fit, n = 39	[3.66; 3.96; 4.26]	7.6%	82%	27%
Data Set 2	Screened for model fit, n = 3	[4.54; 6.51; 8.47]	30.1%	66%	44%
Data Set 3	Screened for model fit, n = 12	[5.43; 6.14; 6.86]	11.7%	75%	23%

Progress and Accomplishments

Commercial M&V 2.0 Pilots: Design

Apply M&V 2.0 side-by-side with traditional M&V methods

→

Live pilots in strategic energy management, pay for performance, commissioning programs

- Comparison of 2.0 vs. traditional savings results
- 2.0 savings uncertainty, site and aggregate level
- Relative labor effort
- Benefit of continuous feedback from 2.0
- Open-source methods to advance commercial 2.0 products
  - Quantify model fitness, associated savings uncertainty
  - Auto-flag potential non-routine events
- Practitioner how-to application guidance
  - Where/how to use automation
  - When to use professional expertise
  - To maintain a quality result

Progress and Accomplishments

Regulatory and State Connections: Acceptance Criteria

- Support to CA PUC in guidance on M&V plans for meter based savings
- 2016 series of workshops with Northeast Energy Efficiency Partnerships (NEEP) EM&V Forum
- Engagement with Pacific Northwest regulatory community on acceptability requirements
- IL and VA workshops on use of M&V 2.0
- National Assocn. of Regulatory Utility Cmmsrs. Summer Meeting panel discussion on M&V 2.0

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Progress and Accomplishments

- **Market Impact:** Work being used and co-funded by multiple industry stakeholders, including
  - CA-PUC: In context of recent legislation requiring meter-based savings
  - State Energy Program, BPA, utilities: pilots tools and application resources
  - Multi-year engagement of CEE whole-buildings committee for knowledge transfer

- **Awards/Recognition**:
  - Invited to co-author RMI multi-stakeholder paper on current status and promise of M&V 2.0
  - Work cited in most recent NEEP industry brief

Project Integration and Collaboration

Project Integration:
Multi-disciplinary National Stakeholder Group convened to cross-inform national conversation and concurrent efforts, provide review

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Project Integration and Collaboration

Partners, Subcontractors, and Collaborators:

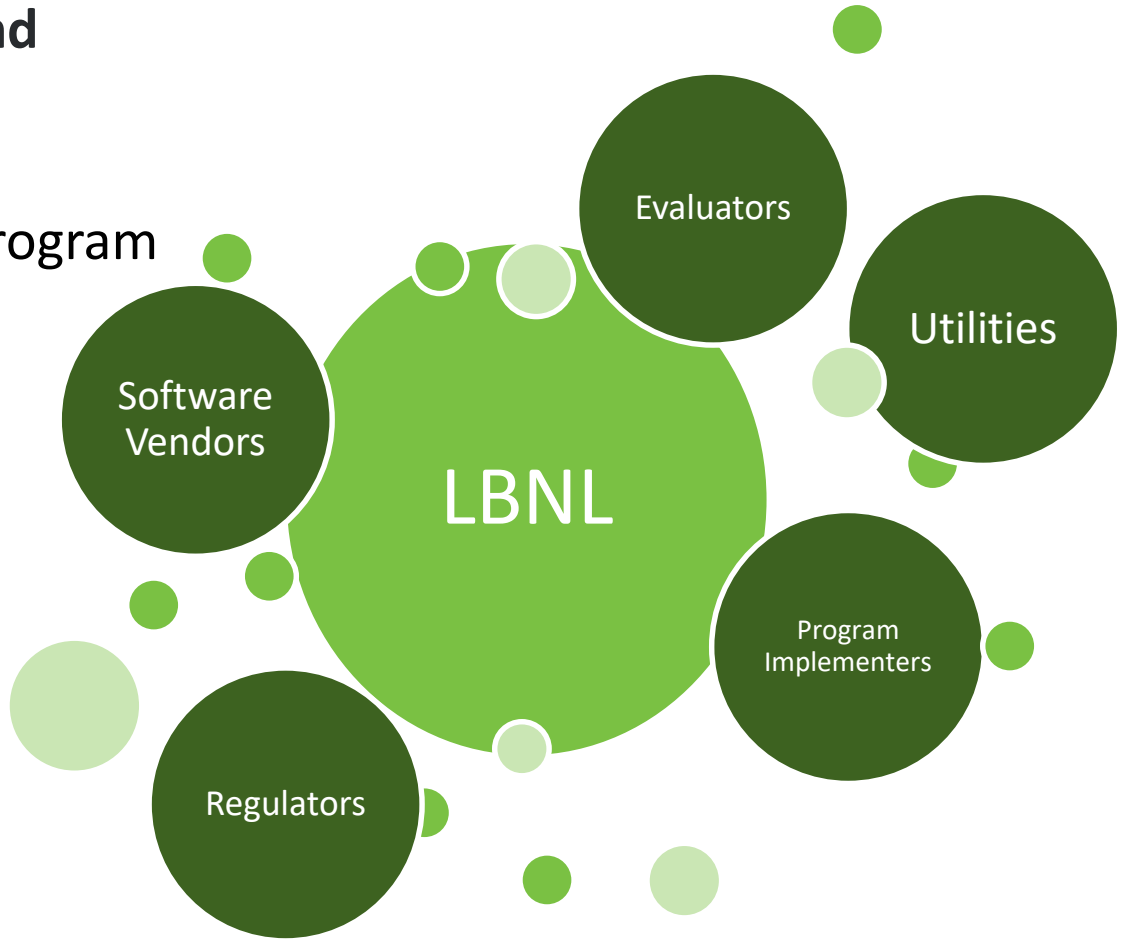
Pilot #1: DOE State Energy Program

- CT-DEEP
- United Illuminating
- Eversource
- NEEP
- Software provider (TBD)

Pilot #2: BPA

- Seattle City Light

EVO – Tool Testing



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Project Integration and Collaboration

Communications:

- White papers, case studies, journal articles
- Presented work at 8 outreach events with ~280 attendees

Organization	Event	Date
CEE	Summer Program Meeting	June 2016
NEEP	EM&V Forum Webinar	June 2016
ACEEE	Summer Study Technical and Informal Sessions	August 2016
CEE	Industry Partners Meeting	September 2016
NEEP	EM&V Forum Workshop	September 2016
VA EE Council	M&V 2.0 Workshop	October 2016
Seattle City Light	Scaling Pay for Performance Workshop	October 2016
Illinois Commerce Commission	M&V 2.0 Policy Session	February 2017

Next Steps and Future Plans

Next Steps:

- Monitor pilots and report on outcomes
- Continued industry outreach & CEE collaboration
- Document acceptability requirements
- Support transition of tool testing
- Quarterly stakeholder group meetings

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