# M&V 2.0 Demonstrations

2017 Building Technologies Office Peer Review

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

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# 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) |

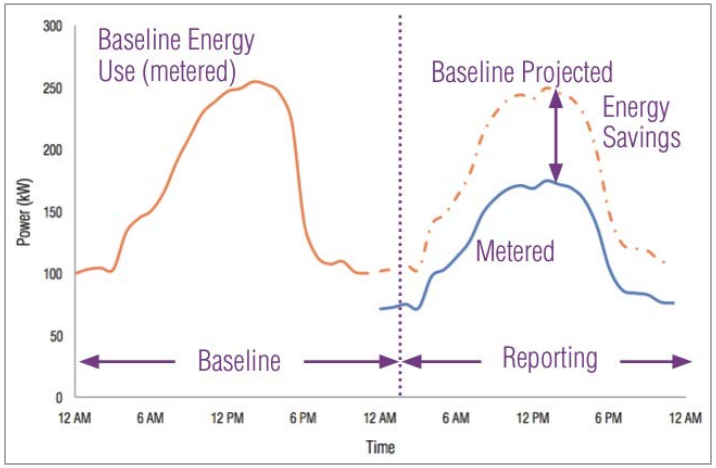
**Project Outcome**:

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

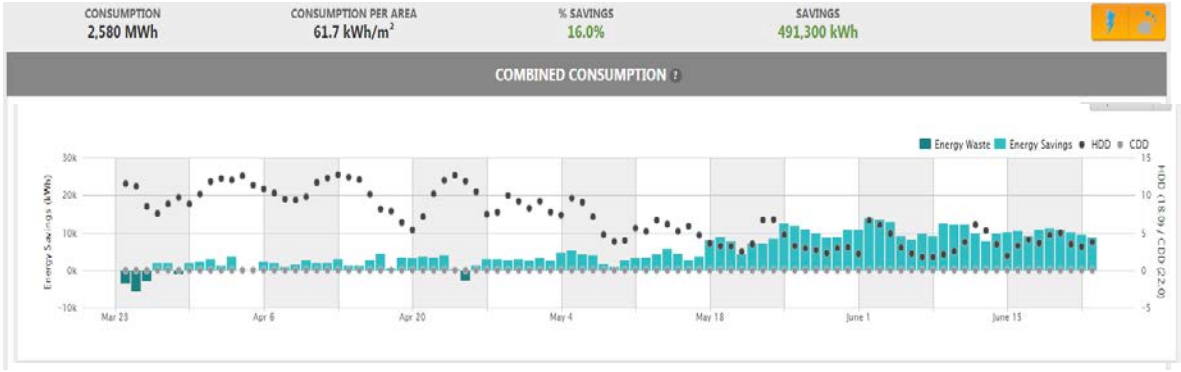
**Problem Statement**: Verification and evaluation of efficiency savings is expensive, time consuming; spectrum of approaches are used and custom calculations and stipulated savings are most prevalent.

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

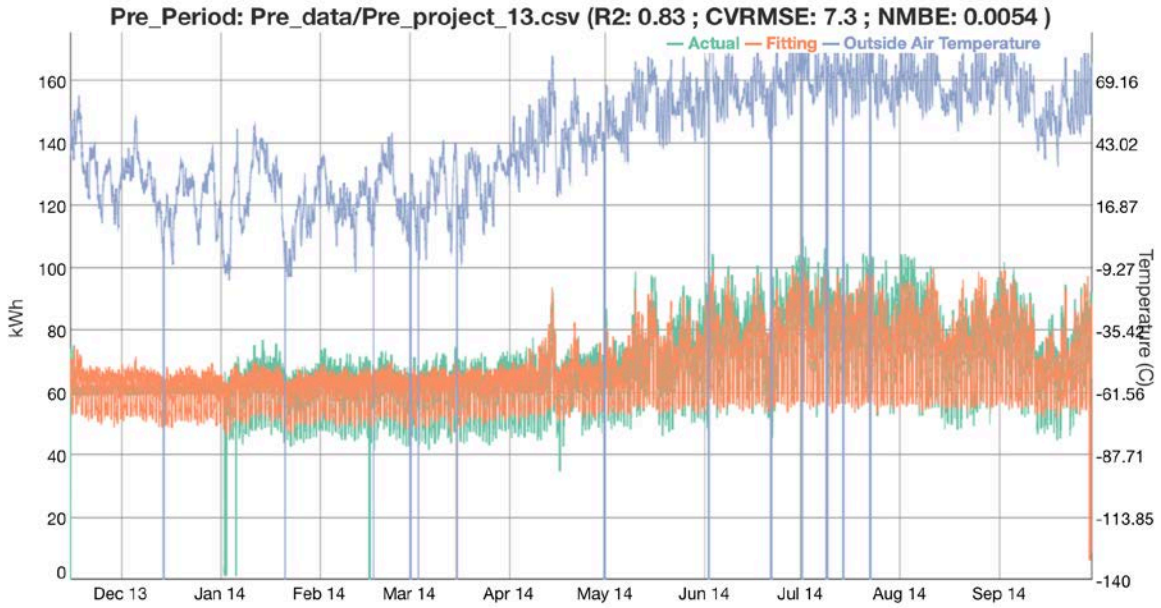
* Granderson, J, Touzani, S, Custodio, C, Sohn, M, Jump, D, Fernandes, S. 2016. Accuracy of automated measurement and verification (M&V) techniques for commercial buildings. Applied Energy 173: 296-308.

** 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

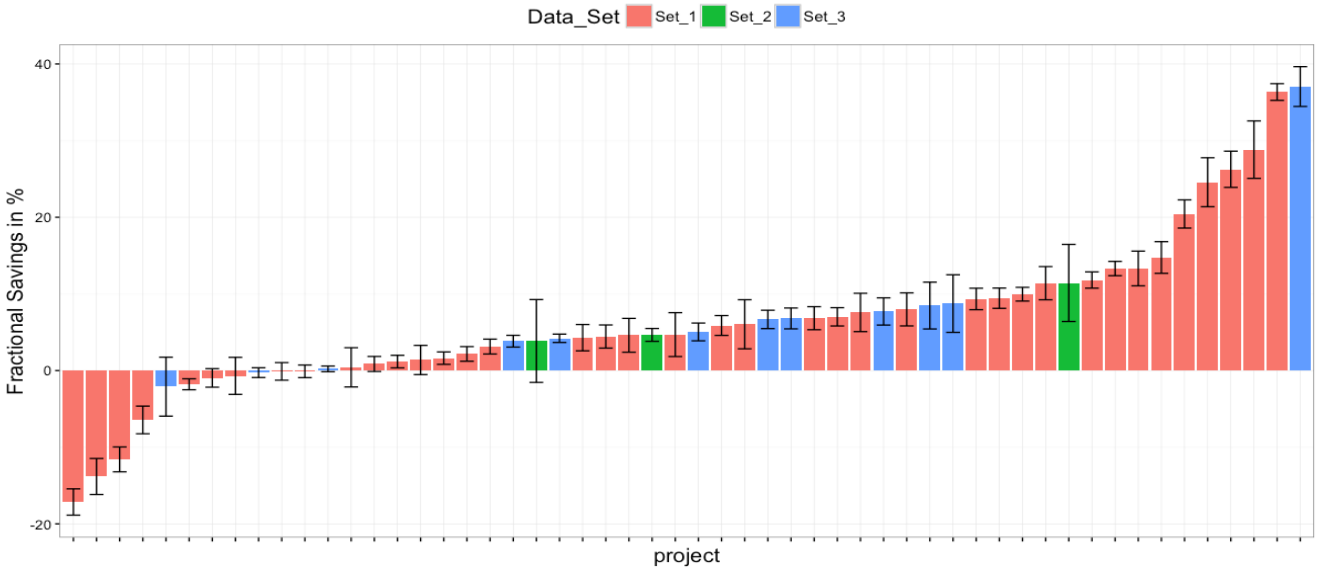
- Working with utilities, 70% of the buildings (n=77) were found to be well suited (statistical fitness) to automated characterization of baseline energy use
- Results indicated that M&V 2.0 can be used to accurately quantify whole-building savings, and that automation may offer time and cost savings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

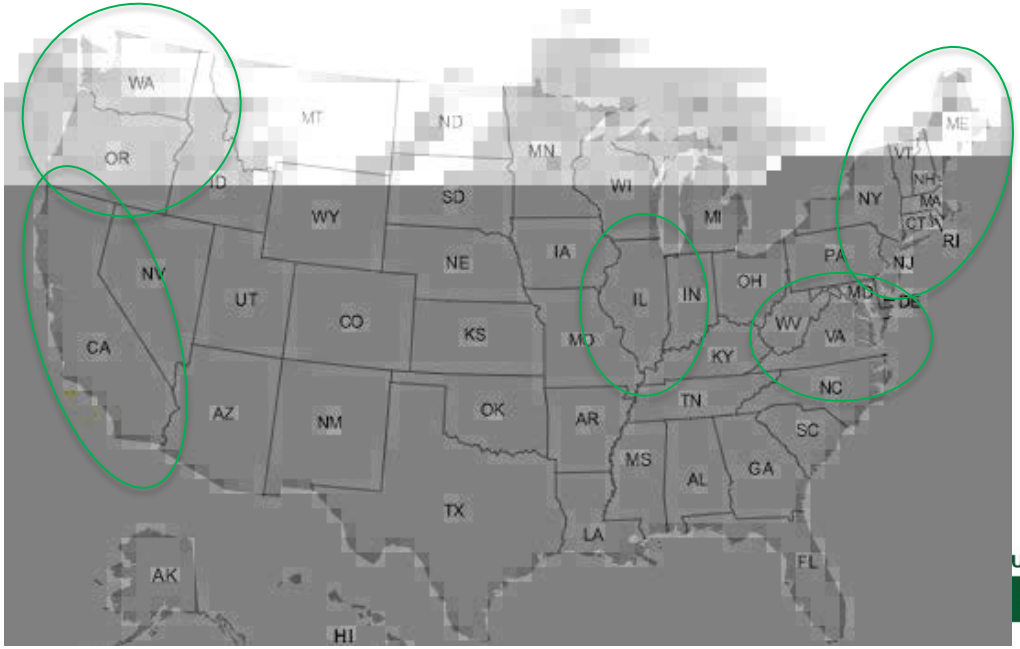
**Live pilots in strategic energy management, pay for performance, commissioning programs**

- **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



# 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
















# Project Integration and Collaboration

**Partners, Subcontractors, and Collaborators**:

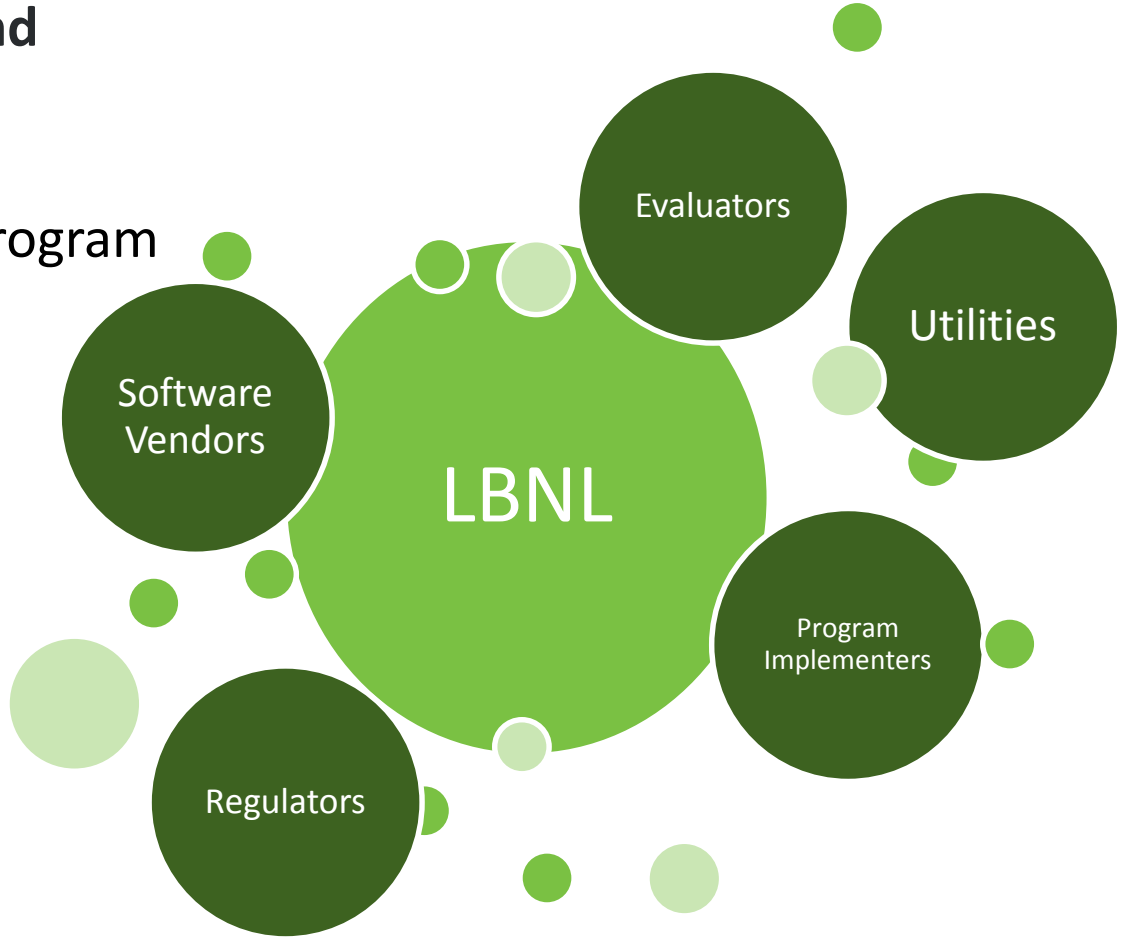
Pilot #1: DOE State Energy Program

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

Pilot #2: BPA

- Seattle City Light

EVO – Tool Testing



# 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

# REFERENCE SLIDES

# Project Budget

**Project Budget**: $1,360K BTO funding from FY14 through FY17

**Variances**: None

**Cost to Date**: $1,064 BTO costs (through Jan 2017)

**Additional Funding**: $857 cost share leverage via BPA and DOE SEP projects

| Budget History | | | | | |
|---|---|---|---|---|---|
| FY 2014– FY 2016 (past) | | FY 2017 (current) | | FY 2018 – FY 2019 (planned) | |
| DOE | Cost-share | DOE | Cost-share | DOE | Cost-share |
| $1060K | N/A | $300K | $484K | TBD | $373K |

# Project Plan and Schedule

| Project Schedule | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project Start: FY '14 | | Completed Work | | | | | | | | | | | |
| Projected End: FY '18 | | Active Task (in progress work) | | | | | | | | | | | |
| | ● | Milestone/Deliverable (Plan) | | | | | | | | | | | |
| | ● | Milestone/Deliverable (Actual) | | | | | | | | | | | |
| | | FY2015 | | | | FY2016 | | | | FY2017 | | | |
| Task | | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| **Past Work** | | | | | | | | | | | | | |
| Q3 FY '15 Milestone: Complete initial evalution of M&V 2.0 models obtained under FY '14 solicitation | | | | ● | | | | | | | | | |
| Q1 FY '16 Milestone: Document co-development of utility resources and activities and outcomes to date from ongoing CEE engagement in a memo to BTO | | | | | | ● | | | | | | | |
| Q2 FY '16 Milestone: Recruit at least 2 utilities to use M&V 2.0 | | | | | | ● | | | | | | | |
| Q2 FY '16 Milestone: Completion of the first FY '16 industry outreach events | | | | | | | ● | | | | | | |
| **Current/Future Work** | | | | | | | | | | | | | |
| Q1 FY '17 Milestone: National Stakeholder Group convened and FY'17 schedule planned | | | | | | | | | | ● | | | |
| Q1 FY '17 Go/No-Go Decision: M&V 2.0 pilots planned or underway | | | | | | | | | | ● | | | |
| Q2 FY '17 Milestone: Industry organization has agreed to deliver M&V 2.0 tool testing | | | | | | | | | | | ● | | |
| Q3 FY '17 Milestone: Documentation of industry positions on accuracy, uncertainty, reporting | | | | | | | | | | | | ● | |
| Q4 FY '17 Milestone: Publish pilot findings | | | | | | | | | | | | | ● |