

# Assessment of Automated Measurement and Verification Methods

2014 Building Technologies Office Peer Review

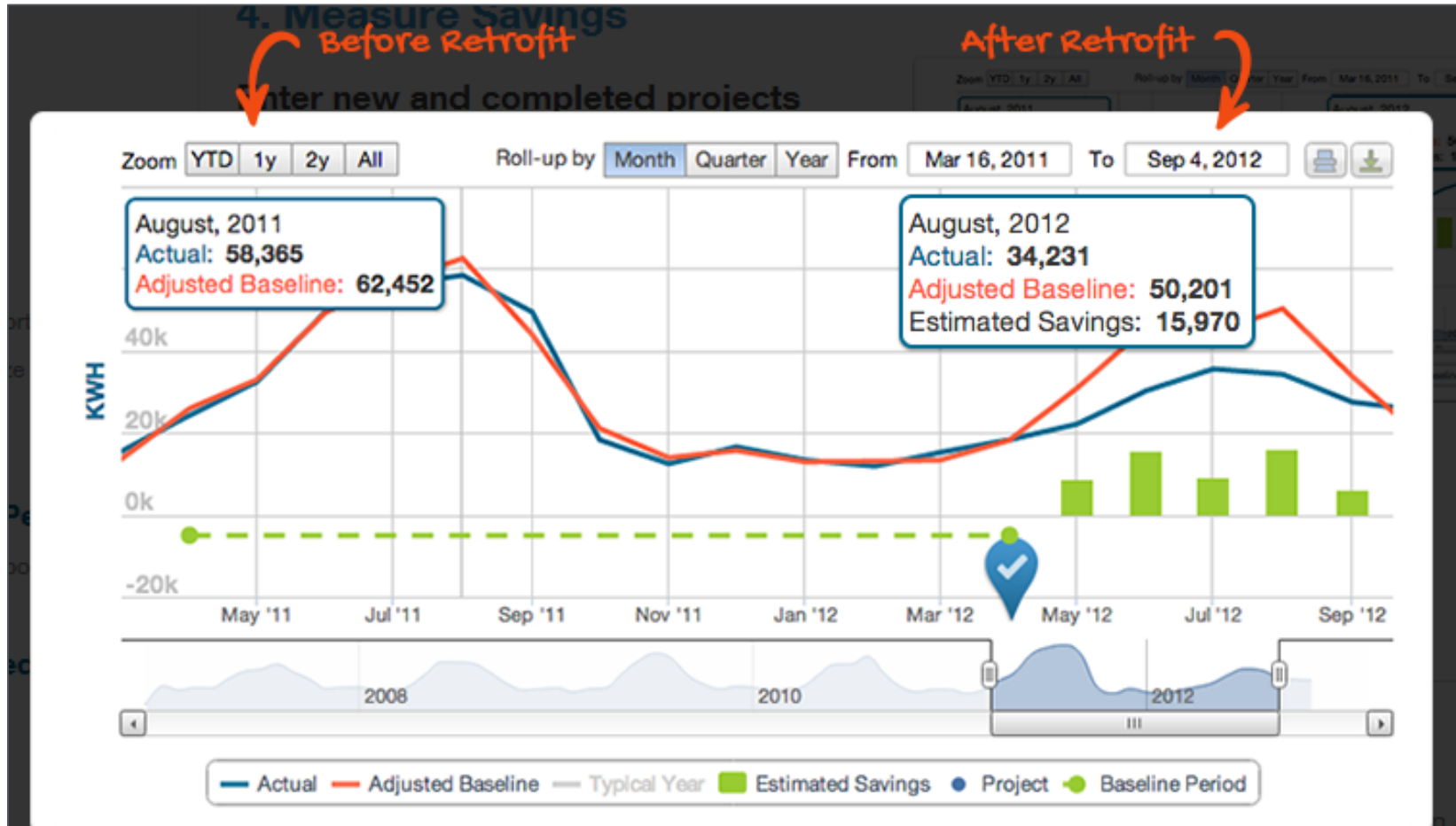


Image from Noesis Energy

# Project Summary

## Timeline:

Start date: November 2013

Planned end date: April 2015

## Key Milestones

1. Solicit novel M&V methods from developers, to test and demonstrate (7/14)
2. Develop test procedures with industry input from 8+ stakeholder orgs and Adv Gp (9/14)
3. Report on use of test procedures to determine accuracy of developers' methods, presentation to relevant industry groups (4/15)

## Budget:

Total DOE \$ to date: \$605K

Total future DOE \$: TBD

## Target Market/Audience:

Market = commercial buildings, in future residential and possibly industrial

Audience = utility programs, evaluators, M&V agents, ESCOs, enterprise E mgrs, analytics tools vendors

## Key Partners:

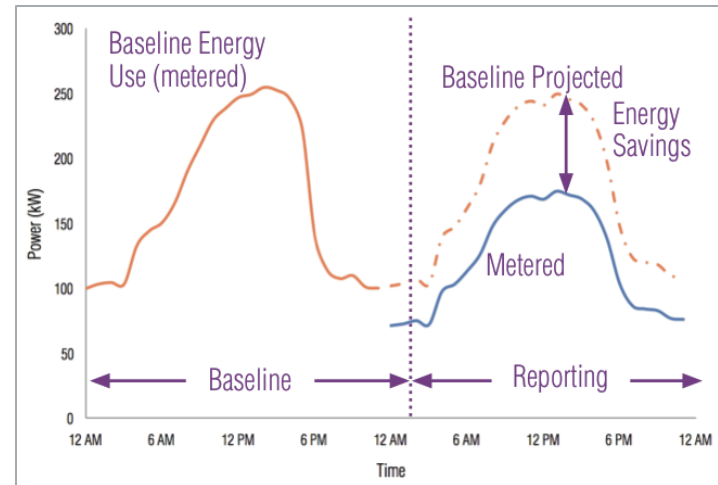
Quantum Energy Services & Technology	Pacific Gas & Electric
M&V technology developers	Consortium for Energy Efficiency

## Project Goal:

Enable delivery of streamlined M&V, leveraging smart meters, devices, analytics; reduce costs, time, maintain/improve accuracy.

# Purpose and Objectives

**Problem Statement:** Common approaches to quantify savings often rely on *estimates and calculations*; actual *measured approaches* are costly (3-7% of project costs), difficult to scale, and incur questions of accuracy, trustworthiness.



## Target Market and Audience:

Target market = utility programs alone represented 40,000 GWh electr savings and 360 million therms gas savings in 2011 [CEE]

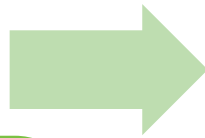
Audience = utility programs, evaluators, M&V agents, ESCOs, enterprise energy managers, analytics tools vendors (res and industrial in future)

# Purpose and Objectives

**Impact of Project:** Efficiency industry transitions to a point savings are routinely and cost-effectively measured and verified; ability to conduct M&V with confidence builds trust in the savings from efficiency

## Today

- **Small savings**, single-measure, modest programs **can get lost in noise**
- Site-by-site M&V, **costly, difficult to scale, questions of accuracy**
- M&V by EMIS done in a **black box** – no disclosure of accuracy



## Promise of Tomorrow

- **Whole building multi-measure programs** deliver **deeper savings**, including O&M, behavioral measures
- **System and device-level savings** from self-reporting energy consuming hardware
- **Cost-effective M&V, automated at scale**
- **Accuracy** of baseline models, uncertainty in savings are **disclosed**

# Purpose and Objectives

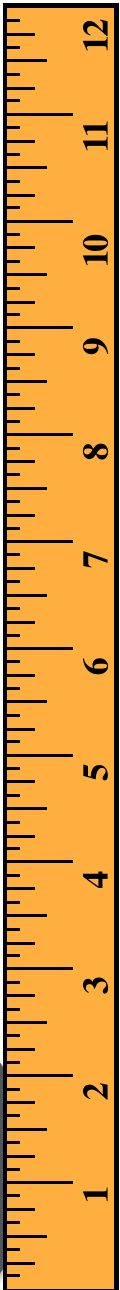
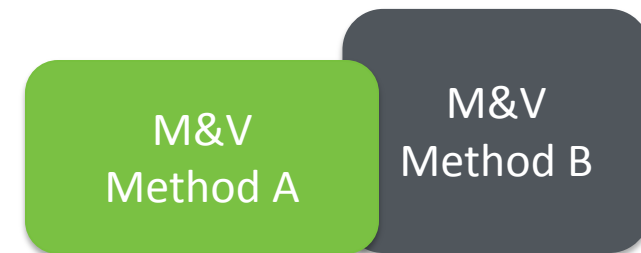
## Project Outcome:

Replicable procedure to test and verify accuracy of automated M&V baseline models and tools

Demonstrated use of procedure to evaluate accuracy of new methods for automated M&V; ability to compare one method to another

\*Provides industry means to answer questions such as - is this tool accurate enough for my programs, and the buildings in my portfolio?

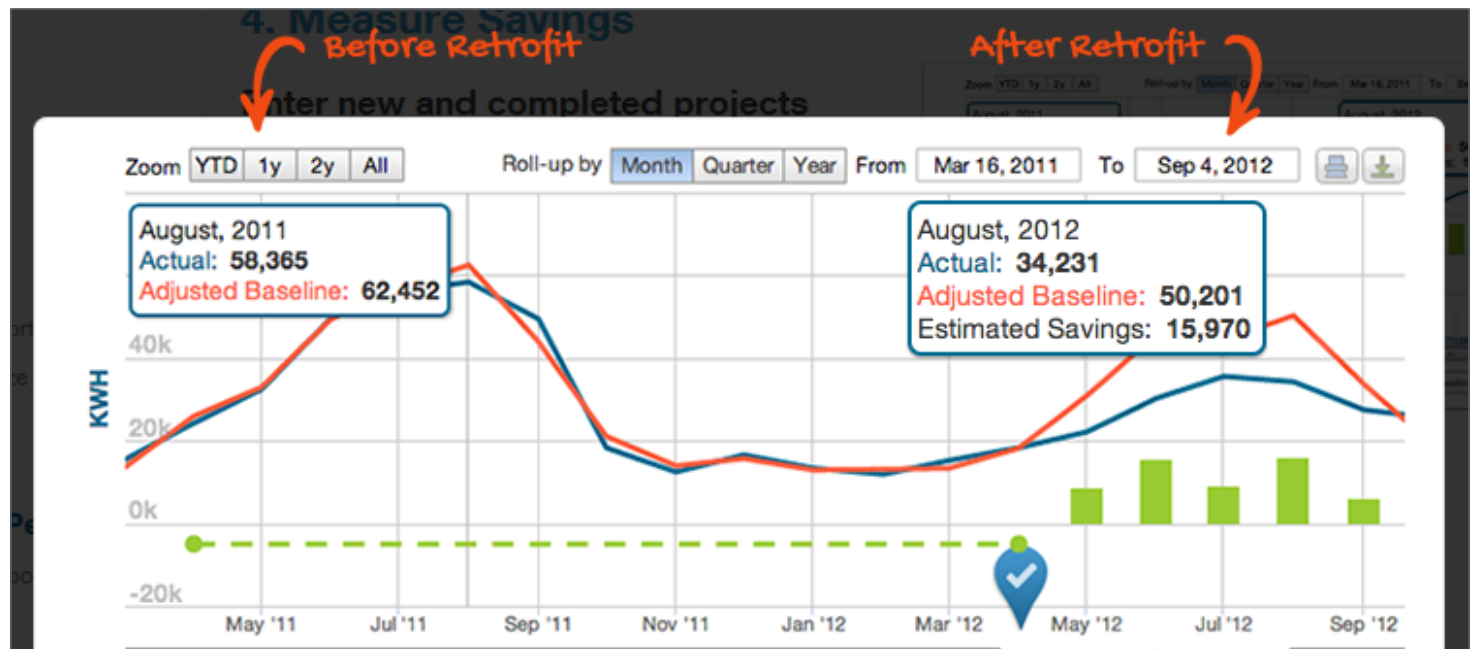
\*Provides practitioners the ability to streamline current practices, dramatically reducing time and costs



# Purpose and Objectives

## 2. Impact path:

- a. Near-term, awareness that M&V can be streamlined and scaled, emerging tools and models can be validated
- b. Intermediate-term, results are piloted by early adopter utilities, project implementers, ESCOs, M&V agents, and energy managers
- c. Long-term, success from leading-edge early adopters provides proof points needed for widespread adoption; openly reviewed algorithms using interval data become the industry norm. This builds confidence in the savings from efficiency projects, making efficiency more attractive to energy markets, financial markets, and individual building owners



# Approach

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**Approach:** Develop objective test procedures, demonstrate with emerging models and tools that automate M&V, disseminate results for industry adoption

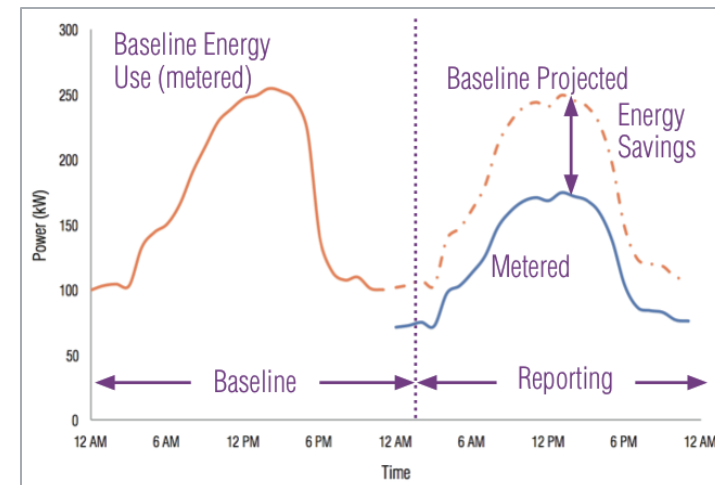
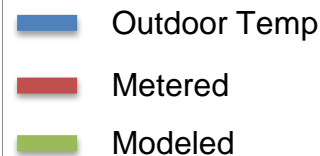
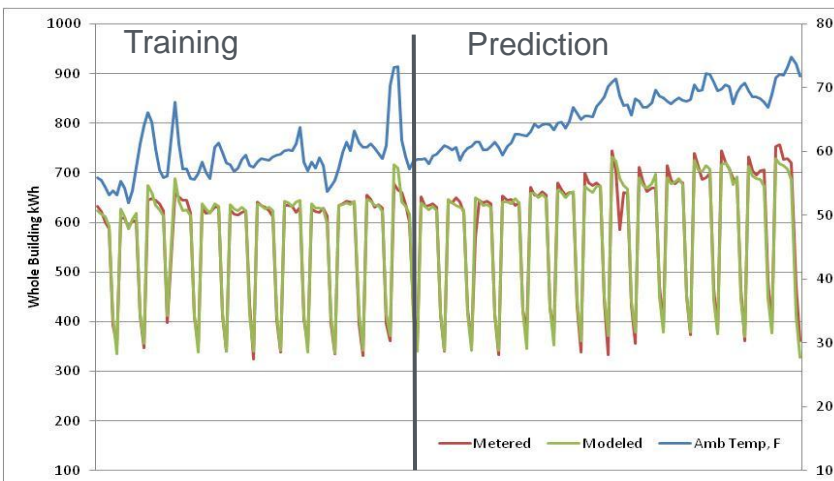
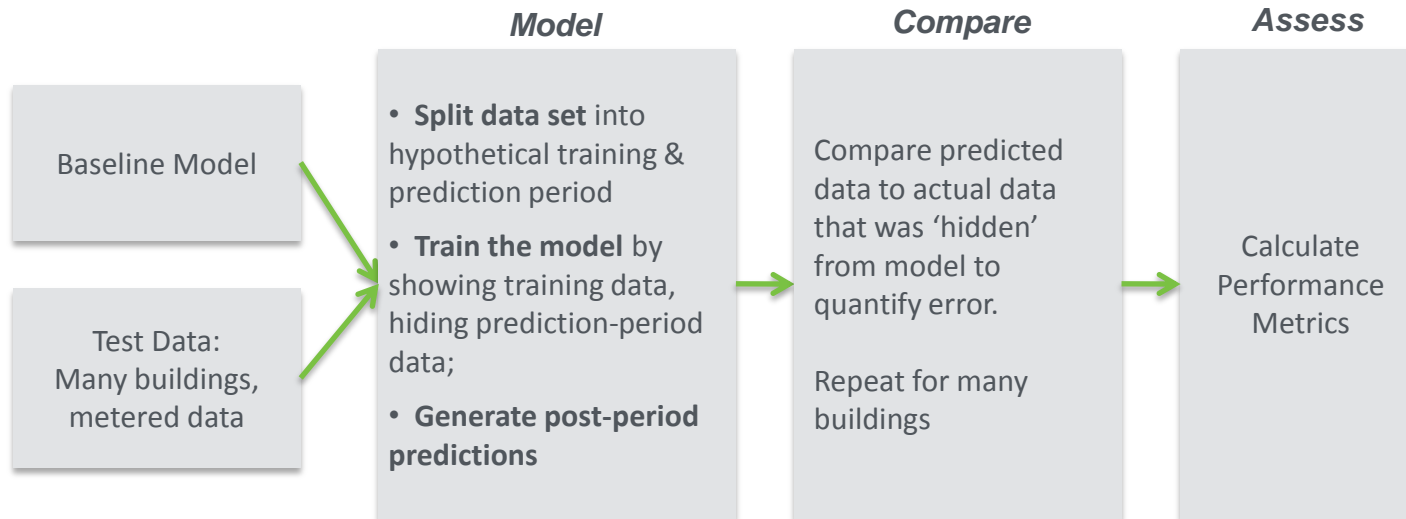
**Key Issues:** Analytical tools that promise to streamline M&V through automation have arrived; industry needs confidence in their accuracy, robustness, and rigor

**Distinctive Characteristics:** Integrating statistical cross-validation with large sets of interval data (n=100s) to characterize predictive accuracy over diverse time horizons

Contrast with earlier efforts such as ASHRAE shootouts, resources such as Guideline 14 that focus on single buildings, often presume monthly data, and on model fitness in the 'pre' or training period

# Progress and Accomplishments

- 4-step statistical cross-validation test procedure with large test datasets and goodness of fit and other performance metrics





# Progress and Accomplishments

## Accomplishments:

Demonstration of test procedure using public domain whole-building M&V models, representative data set of 100s of buildings from PG&E territory

Use of results by PG&E to pre-qualify tools for inclusion in innovative whole-building program targeting 20% savings

Extensive ongoing stakeholder outreach



# Progress and Accomplishments

## 12-mo training or 'pre' and 12-mo prediction or 'post'

Model	10%	25%	50%	75%	90%	Mean
Mean Week	0.82	2.21	4.82	9.63	19.42	8.40
Monthly CDD and HDD	0.69	2.09	4.53	10.03	19.38	8.46
Day, Time, and Temperature	0.69	2.17	4.51	9.26	19.41	8.42
Day and Change Point	0.73	2.02	4.70	9.22	18.84	8.24
Time of Week and Temperature	0.82	2.21	4.82	9.63	19.42	8.40

- Aggregation of buildings into a portfolio of ~40 buildings reduces mean total error to 1-4%
- Except monthly models, reduce training period to 6mo, ~maintain accuracy
- Public domain models provide a performance benchmark for new/proprietary
- These results are for fully automated case!
- Consider tradeoffs between cost and accuracy, automation vs engineering expertise, and ability to streamline with a mix of both

\*Results for representative sample of 100s of buildings from PG&E service territory

# Progress and Accomplishments

**Market Impact:** To-date, Pacific Gas and Electric and Consort. for Energy Efficiency are key users of these results, for application in whole-building programs

1. Deep stakeholder engagement to raise awareness of automated M&V methods, and their value to the industry, to accelerate impact (see Project Integration and Collaboration Table)
2. Working with program administrators and other stakeholders to identify most important metrics and opportunities for applying advanced M&V
3. Refining test procedure to apply more broadly to whole-building as well as system-level M&V “2.0” approaches

# Project Integration and Collaboration

## **Project Integration:**

Coordinated with parallel EMIS work to help program administrators and enterprises understand analytical tool offerings and capabilities

Creates testing procedures that can validate new M&V methods for inclusion in the Uniform Methods Project

Supports DOE interest in strategic energy management (e.g. ISO50001), and savings verification from adoption of SEM programs, facilitating future expansion in the commercial sector

Supports program administrators to deploy whole-building programs that go beyond single measures

## **Partners, Subcontractors, and Collaborators:**

PG&E early funder, adopter of R&D outcomes

QuEST, subcontractor and R&D partner

# Project Integration and Collaboration

Organization	Event	Date
CEE Whole Buildings Committee	Industry partners meeting, Winter meeting day-ahead workshop, ongoing committee meetings	September 2013, January 2014, ongoing
SEE Action EM&V Working Group	Working group meetings	December 2013, May 2014
CA PUC	EM&V Quarterly Meeting	March 2014, September 2014
ACEEE	Market Transformation, Summer Study paper and informal session	March 2014, August 2014
ESource	Emerging Technologies Leadership Group, Annual Forum,	April 2014, September 2014
AESP	Brown Bag seminar, Summer Conference, National conference	May 2014, August 2014, February 2015
NEEA, NEEP, MEEA	Webinar	May 2014
Analytical tool vendors	Webinar	May 2014
ASHRAE	Summer Meeting panel session	June 2014
Greenbuild	M&V Panel Session	October 2014
IEPEC	Annual Conference	September 2015

# Next Steps and Future Plans

Spring/summer focus to exercise test procedure and compile data sets for performance evaluation of system-level M&V (Option B) methods

## 2014 Development Plan



July:

Solicit novel M&V methods to test and demonstrate



September:

Necessary test datasets acquired, compiled into database



December:

Complete initial performance evaluation of developers' methods



April:

Publish, present test procedures and evaln results

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# REFERENCE SLIDES

# Project Budget

**Project Budget:** \$605K

**Variances:** None

**Cost to Date:** \$110K

**Additional Funding:** Cost share of ~200K from preliminary work on this topic, conducted under funding from Pacific Gas and Electric

## Budget History

FY2013		FY2014 (current)		FY2015 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
N/A	N/A	\$605K	\$200K, PGE	\$0K	\$0K



# Project Plan and Schedule

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Project original initiation date & project planned completion date

- Project kicked off in October FY2014
- Planned completion date, April FY2015

Schedule and Milestones

- All deliverables and milestones to-date have been completed
- No slipped milestones or deliverables

Q1 FY2014 go/no-go on workplan was passed; future go/no-gos on details of industry-vetted and co-developed testing procedure, successful solicitation and selection of new M&V methods to test

Past, current, and future work described in Gantt charts on following slides

# Project Plan and Schedule

Project Schedule												
Project Start: October 2013	Completed Work											
Projected End: April 2015	Active Task (in progress work)											
	◆ Milestone/Deliverable (Originally Planned) use for missed milestones											
	◆ Milestone/Deliverable (Actual) use when met on time											
	FY2013				FY2014				FY2015			
Task	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)
<b>Past Work</b>												
N/A, new project												
<b>Current/Future Work</b>												
Q1 Go/No-go Deliverable: detailed project workplan					◆							
Q2 Milestone: present concept at first two of 6-10 industry events						◆						
Q3 Go/No-go Deliverable: draft report convering testing proceudure, and industry feedback aquired to-date							◆					
Q3 Go/No-go Deliverable: solicitation for methods to test and developer guidelines, for DOE approval							◆					
Q3 Milestone: present concept at at least two more industry events, convene first TAG meeting								◆				
Q4 Go/No-go Milestone: developers and methods selected for testing								◆				
Q4 Milestone: hold second TAG meeting, present concept at last of 6-10 industry events									◆			
Q4 Milestone: test dataset organized into queriable db									◆			
Q1 Milestone: complete initial evluation of methds, using test proceudre										◆		
Q2 Deliverable: report documenting performance accuracy of each M&V method tested											◆	
Q3 Deliverable: present final findings to TAG and relvant industry groups												◆