M&V 2.0 Demonstrations

2016 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: 2018

Key Milestones:

1. Evaluate M&V 2.0 model performance, 6/15
2. Recruit utility partners for M&V 2.0 Demo, 12/15
3. Implement M&V 2.0 with partners, 4/15

Budget:

Total Project $ to Date:

- DOE: $1,060K

Key Partners:

Quantum Energy Services & Technologies, Inc. (Quest)
Large Western Regulatory Body
Large Northeastern Program Implementer
Western Canadian Utility

Project Outcome:

Develop test protocols to evaluate automated "M&V 2.0" methods; enable market adoption of these meter-based approaches to determine energy efficiency (EE) savings at reduced time and cost, while maintaining or increasing the accuracy of the result. [See MYPP, CBI Strategy 3]

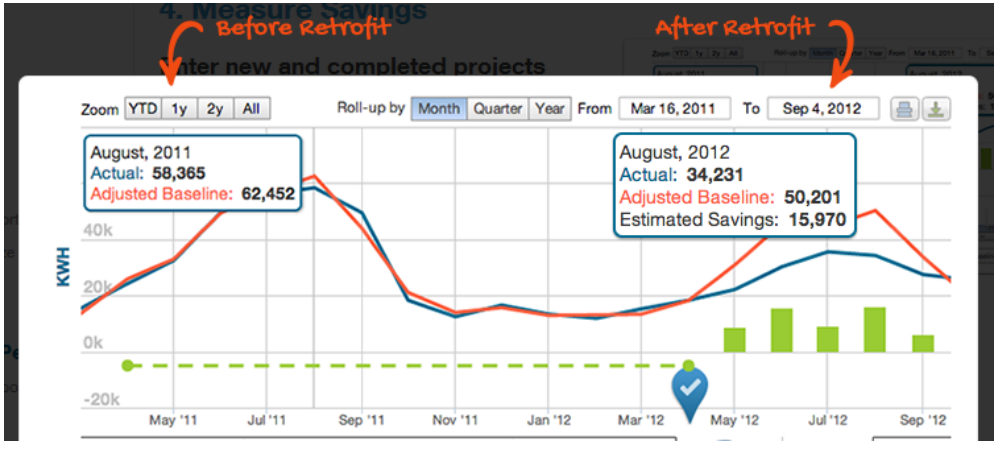
Purpose and Objectives

Problem Statement: Savings verification for efficiency programs and projects is expensive, time consuming; spectrum of approaches are used; custom calculations and stipulated savings 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, but questions of accuracy and practical application remain.

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



Right: Automated M&V from Noesis

Purpose and Objectives

Target Market and Audience: Users and providers of M&V

Utility, state, and private sector efficiency program administrators, implementers

Energy efficiency program evaluators, regulators

ESCOs (Energy Services Companies)

M&V2.0 analytics vendors

*Over next ten years, *potential* for commercial building EE savings estimated at $1T

$7B
2012 Utility investment in demand side management

$6B
2013 ESCOs Revenue

$0.8B
2015 Building Analytics Market

Purpose and Objectives

Impact of Project:

Near-term: transparent replicable test methods for open and proprietary M&V tools/algorithms; performance accuracy results for M&V2.0 tools -- test methods and results published and being used by industry.

Intermediate: early demonstration of M&V 2.0 w utility partners; documentation of time and cost savings, accuracy; scaled demonstration and disseminate of results to industry at large.

Long-term: scaled adoption of cost effective, accurate, meter-based savings estimation

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

Accelerate adoption of EE by providing information …	Facilitate use of tools, access to standardized transparent performance data	Owners, investors equipped with tools to understand and value energy performance	Stakeholders use performance data to incorporate EE into financial transactions	Adoption of solutions to improve whole-building energy performance

Approach

Approach:
Develop test methods based on statistical cross-validation against large test data sets, determine *general* predictive robustness

Demonstrate robust models/tools on partners' program data from specific buildings, including savings uncertainty and confidence

Use findings as proof points to facilitate scaled demonstrations, engage regulatory community, generate confidence for broad uptake

Key Issues: What are acceptance uncertainties and confidence levels for regulatory community? How good is good enough? (We've not done this for stipulated savings, and engineering calculations.)

Distinctive Characteristics: Transparent testing of proprietary M&V 2.0 tools; quantification of uncertainty in savings estimations; reduction of time and costs through automation; meter-based.

Progress and Accomplishments: Summary

Accomplishments:

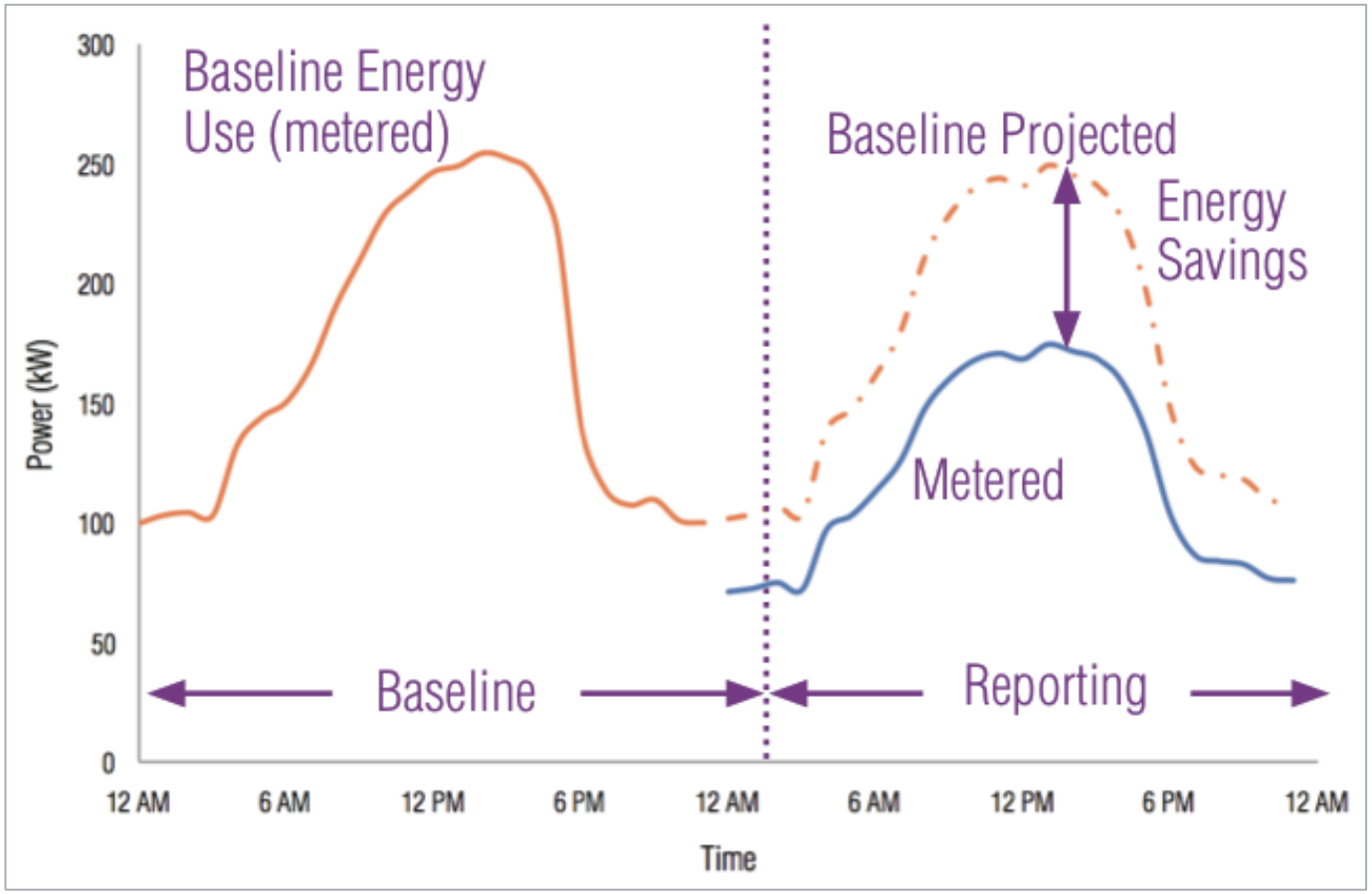
Published test procedure and results of model/tool predictive accuracy tests across 10 developers, open and proprietary

Engaged utility/implementer teams to partner in demonstrating models on program data

Launched series of workshops to engage regulatory community in dialogue on acceptance criteria

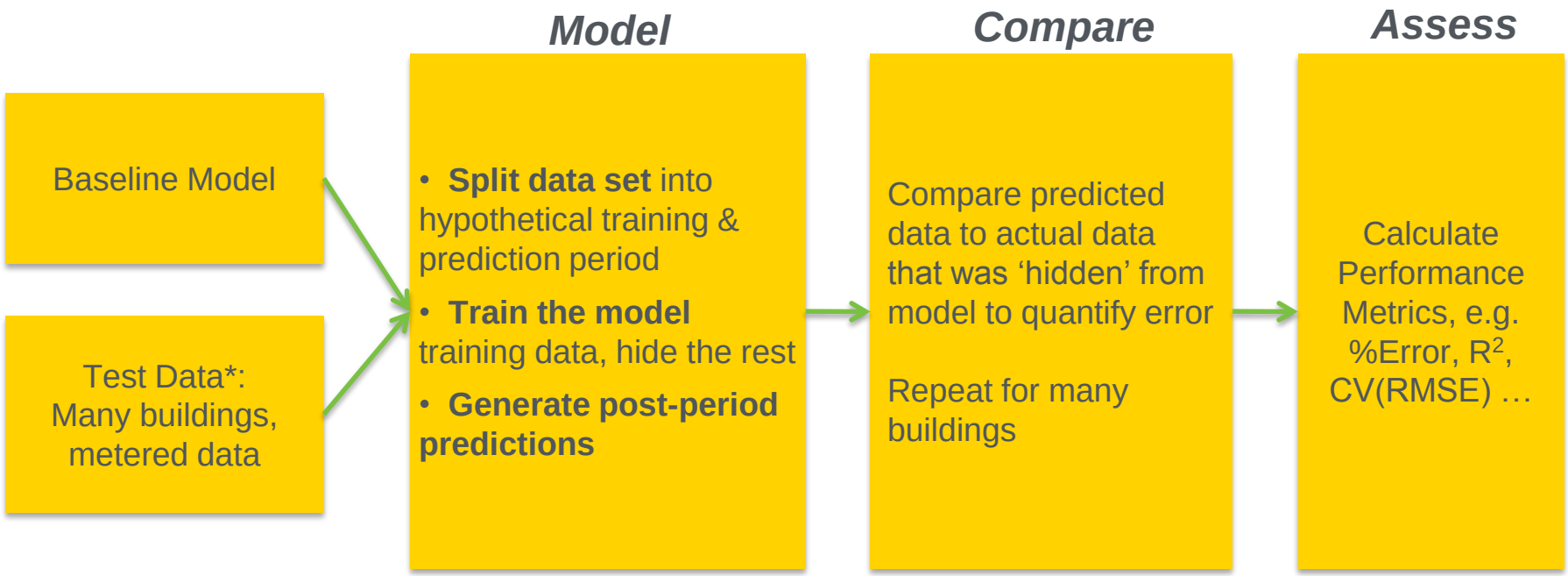
Accomplishments: Background on M&V Use Case

IPMVP Option C (or B)
If the baseline projection is inaccurate, the savings estimation is inaccurate



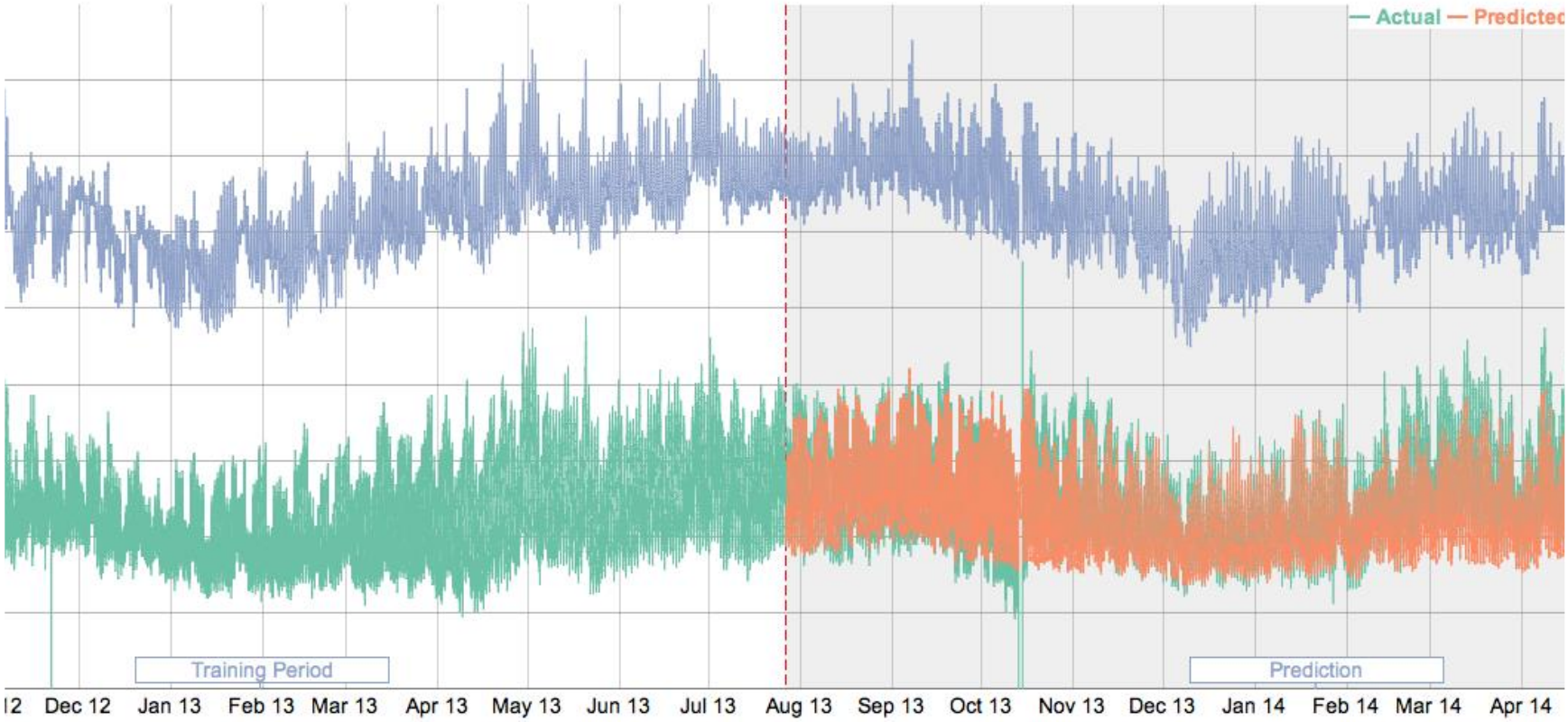
Accomplishments: M&V Model Test Procedure

Statistical Cross-Validation Using Large Test Data Sets



*No efficiency interventions, retain ground truth

Accomplishments: Illustration of Test Procedure



Accomplishments: Model Testing Scope

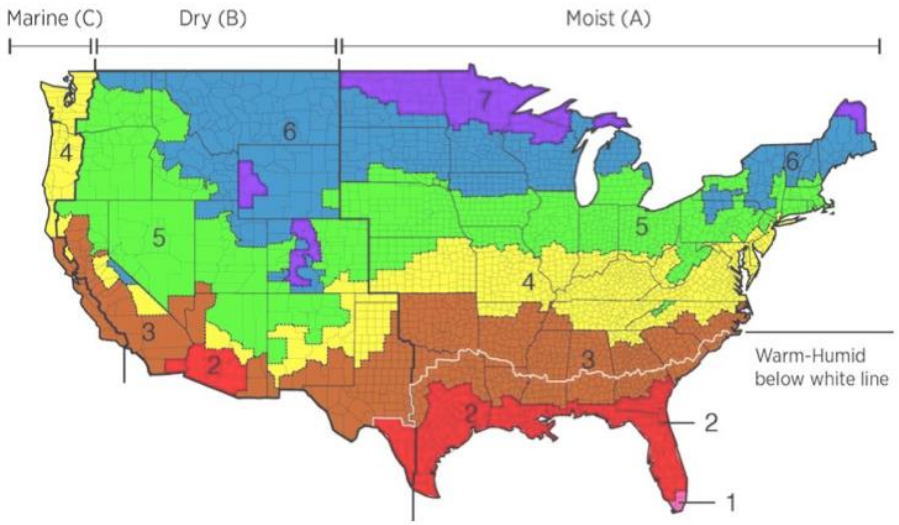
10 interval data models tested - 4 open, 6 proprietary

Mix of mathematical approaches, e.g. nearest neighbor, adv. regression, principle component analysis, hybrid combined methods

Independent variables – time of day, day of week, outside air temperature, i.e. most commonly available data

Data set = 537 commercial buildings, 15-min electric load data, temperature based on zip code

Model Developers:
- Buildings Alive
- Gridium
- Lucid
- Performance Systems Development
- UCB Center for Built Environment



Above: Most data from CA Zone 3, and Wash DC Zone 4; some from Seattle Zone 4

Accomplishments: General Testing Results, Key Takeaways

Errors in predicting energy are small for many buildings and many models - for 12-mo training and 12-mo prediction, the standard for whole-building M&V

Average median percent error ~-1.2%

Range of median errors is ~-3% to 0.4%

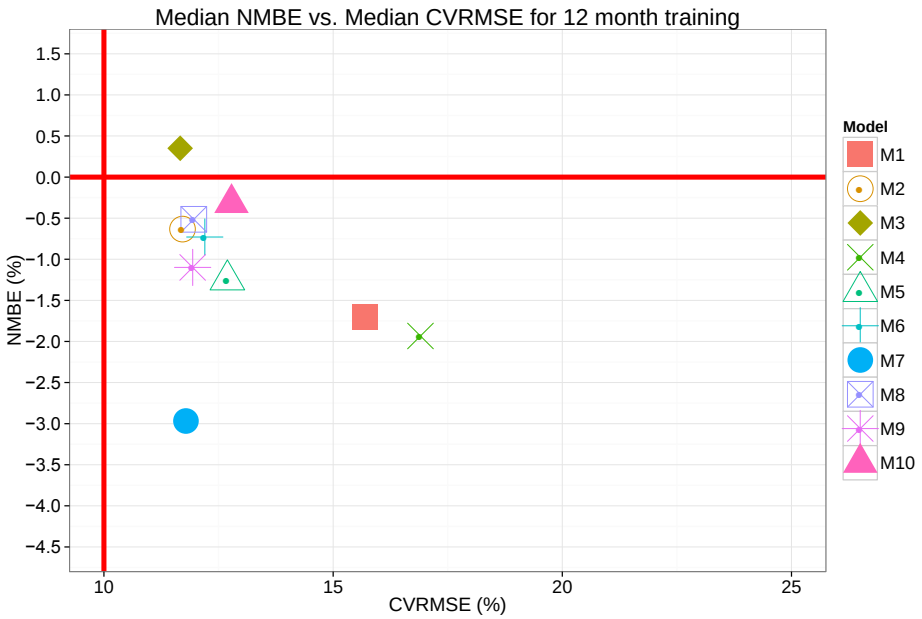
This is the floor of performance from the *fully automated case*, with no engineering oversight, adjustments

No clear winner across the 10 models tested

Models effectively meet ASHRAE guidelines

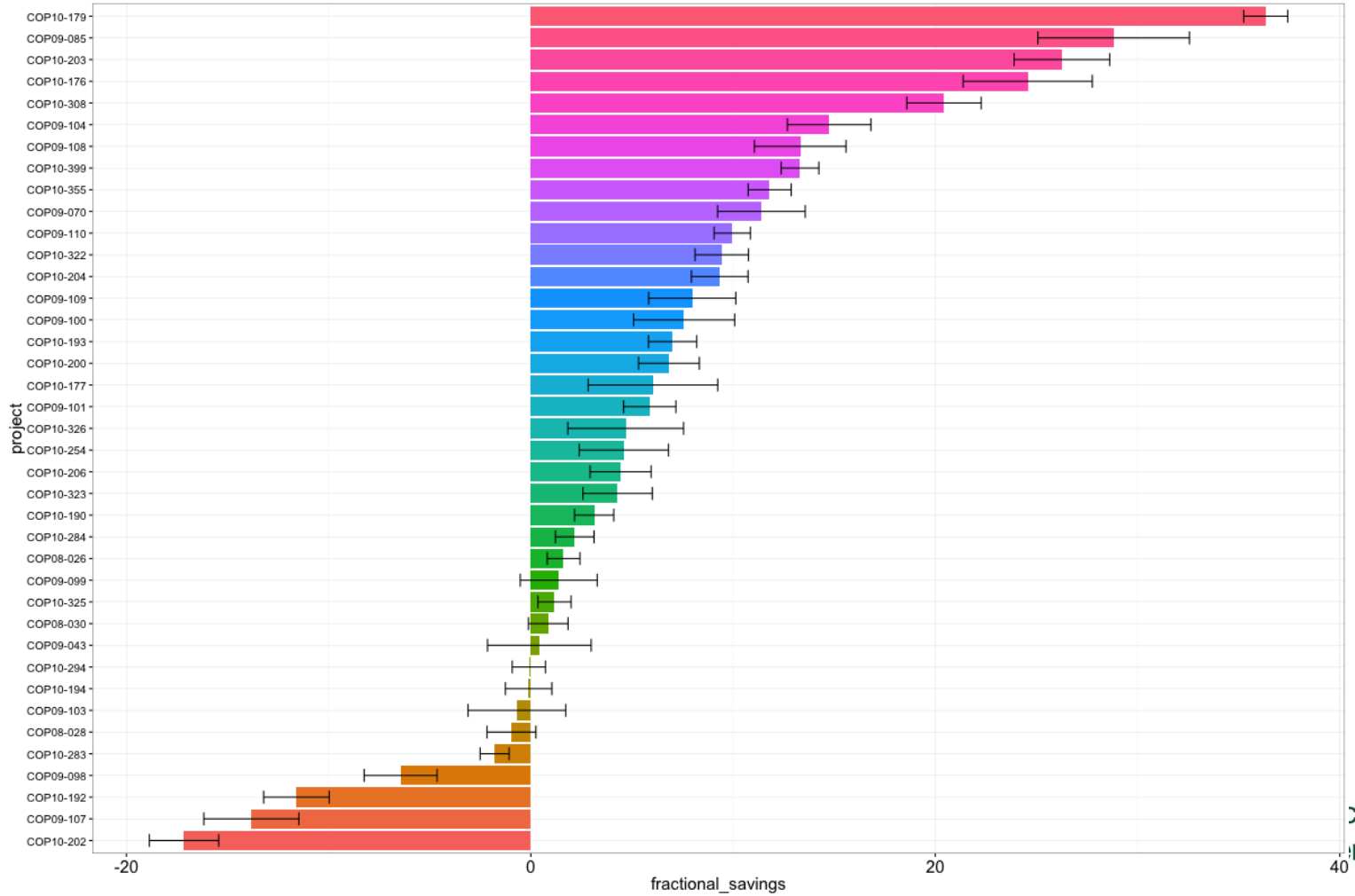
→ Models perform quite well overall

Right: Model NMBE vs. CV(RMSE) for 12-months prediction, 12-month training, the industry standard for whole-building M&V



Accomplishments: Initial Results from Utility Demo

- 39 buildings, RCx program, savings& uncertainty at 95% confidence
- Portfolio aggregate: 3.96% within rang {3.66%,4.26%} w conf = 95%
- Much higher than ASHRAE requirements



Progress and Accomplishments

Market Impact: Work being used by CA-PUC in context of recent legislation requiring meter-based savings; dissemination to target audience (n= ~400) through extensive outreach.

Awards/Recognition: Work cited in NEEP and ACEEE white papers, results and testing principles built into Consortium for Energy Efficiency Savings Estimation Guidebook reference for program administrators

Project Integration and Collaboration

Project Integration: Success in this effort requires close collaboration with industry – M&V 2.0 vendors, program administrators, implementers, evaluators, regulators.

Partners, Subcontractors, and Collaborators:

Collaborators	Stakeholder Type	Role
Gridium, Lucid, Perf. Syst. Dev., Buildings Alive, UC Berkeley, others	M&V analytics vendors, developers	Contributed models for testing, audience for results
Itron, Cadmus, DVG-GL, others from TAG	Utility EE program admin, evaluation, implementation	Technical advisory group, peer review, audience for results
Consortium for Energy Efficiency, member utilities	Utility program administrators	Audience for results, advance princinples
Quantum Energy Services and Technology	EE program implementer, M&V experts, R&D	Subcontractor

Project Integration and Collaboration

Communications: Work presented at 11 conferences, workshops and web/seminars in last year

Webinar to REEOs, ESCOs, utilities, implementers, evaluators, tool vendors	July 2015
International Energy Program Evaluation Conference	August 2015
Department of Energy, Energy Exchange	August 2015
American Council for an Energy Efficiency Economy, Energy Efficiency As a Resource	September 2015
National Association of ESCOs, National Conference	November 2015
Northwest Energy Efficiency Alliance, Product Council	November 2015
American Council for an Energy Efficiency Economy, Intelligent Efficiency	December 2015
Consortium for Energy Efficiency, Winter Program Meeting	January 2016
California Public Utilities Commission, AB802 Workshop	January 2016
Northeast Energy Efficiency Partnerships (NEEP), EM&V Forum Day-Ahead Workshop	March 2016
American Council for an Energy Efficiency Economy, Market Transformation	March 2016

Next Steps and Future Plans

Next Steps and Future Plans:

Complete demonstration of high performing models in partnership with utilities and implementers, publish case studies of results

Continue engagement of regulatory community to establish accuracy acceptance criteria

Transfer testing procedure to an independent entity for ongoing software tool validation, ASHRAE? Other organization?

Recruit and conduct national-scale demonstration

REFERENCE SLIDES

Project Budget

Project Budget: $1,060K from FY14 through FY16

Variances: None

Cost to Date: $745K (through Feb 2016)

Additional Funding: None

Budget History					
FY 2014 – FY 2015 (past)		FY 2016 (current)		FY 2017 – FY 2018 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$860K	-	$200K	-	$200-350K	$200-500K

Project Plan and Schedule