Protocols for Advanced M & V: Helping You See Clearly

Webinar

April 30, 2020

Welcome and Acknowledgments

- This webinar is brought to you as part of the "Standardized, Sustainable and Transparent EM&V – Integrating New Approaches" project

- Thank You to project funders:
  - U.S. DOE State Energy Partner Grant,
  - CT Department of Energy and Environmental Protection,
  - Lawrence Berkeley National Lab,
  - Northeast Energy Efficiency Partnerships, Inc.
  - Eversource and Avangrid (UI)
  - State Partners: NYSERDA, Vermont Department of Public Services, New Hampshire Public Utility Commission, Rhode Island Office of Energy Resources

Please note

Audience is muted: Please use Chat Box for questions

We will unmute for Q&A Session at end of webinar and distribute answers to questions if time is short

The webinar is being recorded

Introduction

Why are AM&V protocols and guidance important now?

Because

- The industry experience with AM&V is growing
- AM&V is an increasingly relevant tool for states to have in their mix – e.g. P4P program design, CA NMEC protocols, as support for time-differentiated savings impacts, customer engagement and climate goals
- New Efficiency Valuation Organization (EVO- IPMVP) best practice for AM&V offers global consistency and credibility
- Proper guidance and protocols will ensure that AM&V is used appropriately

Goals of Webinar

1. Share information on advanced M&V
   - Guidance and Protocols
2. Introduce new resources for advanced M&V
   - Available and Coming Soon
3. What role do protocols play in deploying advanced M&V in building analytics?
4. Future directions
   - More protocols work needed and Where AM&V is headed

Definitions

- Advanced M&V: Large data sets, near real-time, ongoing feedback, non-linear analytical methods, whole building meter-based savings calculations, frequent intervals. (Similar but different from traditional billing analysis and applicable to portfolios, some programs, and individual sites, for program implementation and evaluation).
- Protocols: Set of concepts and commonly accepted conditions ensuring credibility of a product. Technical details.
- Guidance: How to meet conditions set forth by protocols. Advice on best practices for applications. Often locally agreed upon.

Agenda and Presenters

- An Evaluation and Portfolio Perspective on AM&V
  - *Kevin Warren, Warren Engineering*
- A Program Planning Perspective: Software Protocols and AM&V Implementation Guide
  - *Eliot Crowe, Lawrence Berkeley National Lab*
- The Project Perspective: Technical Issues and New EVO Publications
  - *Lia Webster, Facility Energy Solutions*
- The State Perspective: Developing and Applying Guidance
  - *Carmen Best, Recurve*
- Future Directions!
- Q&A

Kevin Warren

Warren Engineering

An Evaluation and Portfolio Perspective on AM&V

Major Use Cases

- ESCOs or EMIS Providers
  - *Use interval data analysis to prove the savings from a building tune-up*
- Impact Evaluation
  - *Determine the savings from a utility program after it has happened or in real time*
- Program Implementation and Tracking
  - *Embedded into the program delivery process*

Ex-ante 2.0

- Pre/post billing analysis
- Continuous (or at least ongoing)
- All participants
- Embedded in program functions
- Used for more than just savings reconciliation
- Other methods may be used for estimating savings prior to measure installation (TRM, engineering calcs)

Program Characteristics that Influence the Ex-ante 2.0 Approach

- Do we care only about savings at the program-level (or average results for a large number of participants) or do we care about facility-level savings?
- Are participants relatively homogenous (residential) or relatively unique?
- What is the average value of the savings for each participant?

Relevant Prior Protocols

Savings = (Baseline Period Energy – Reporting Period Energy)
+/- Routine Adjustments +/- Non Routine Adjustments

Population	Applicable Sectors	Baseline Adjustment Technique	Protocols
Homogenous	Residential	Comparison group	• UMP Chapter 8 • SEE Action Impact Evaluation Guide
Heterogeneous	Nonresidential	NRA	• IPMVP • UMP Chapter 16 • UMP Chapter 19 • UMP Chapter 24

Flavors of Ex-ante 2.0

Ex-ante 2.0 Flavor	Treatment of NRAs
Population with Comparison	Embedded billing analysis with a comparison group
Population w/o Comparison	Embedded billing analysis without a comparison group
Embedded Option C	Embedded billing analysis of all participants while attempting to identify and quantify NRAs at high rigor.
Raw Site Level	No NRA

Do Ex-ante 2.0 Programs Require Evaluation?

Ex-ante 2.0 Flavor	Evaluation Approach
Population with Comparison	Review analysis, review comparison group
Population w/o Comparison	Comparison group analysis, difference of differences
Embedded Option C	• Sample (after reviewing CUSUMs and CRRs) • Use Option C for some but not all • For Opt C, high rigor verify NRAs, missing data, dates • Adjust baseline if not existing conditions • Calculate Realization Rates • Review reserved savings analysis, site visits, and/or M&V to answer "Why?"
Raw Site Level	

Ex-ante 2.0 Gives Evaluators New Tools

- Early feedback to programs
- Better information on the timing of savings
- New sampling methods using CRR and CUSUM
  - *CRR = Claimed-to-Reserved Ratio*

    Claimed (ex-ante) / Reserved
  - *CUSUM Plots*

Eliot Crowe

Lawrence Berkeley National Lab

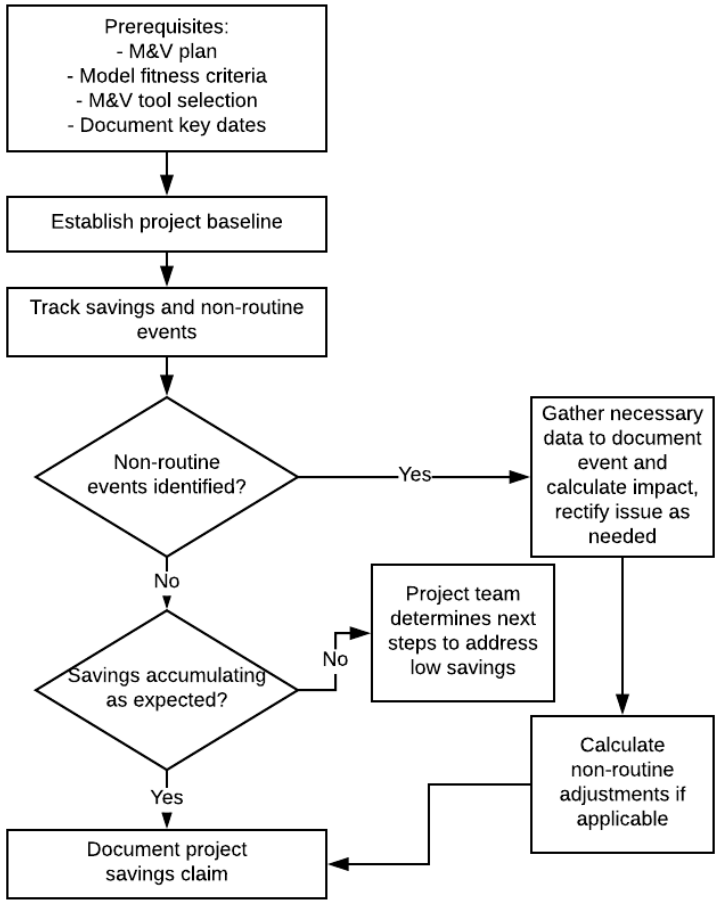
A Program Planning Perspective:

Software Protocols and AM&V Implementation Guide

Advanced M&V Process

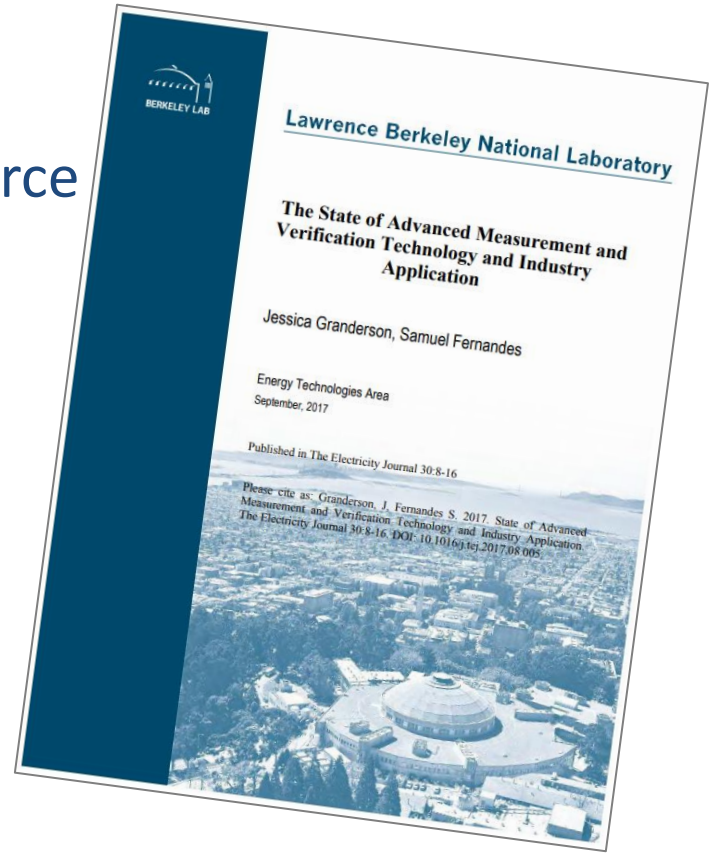
Implementation Resource Guide

- Overview
- Tools & methods
- Tool selection
- Data gathering & preparation
- Workflow
- Documentation guidance
- Getting started



M&V Tool Selection

- Many models/tools available
- Proprietary vs. transparent / open source
- Example free tools:
  - ECAM
  - RMV2.0
  - OpenEEMeter
  - Universal Translator
  - NMECR

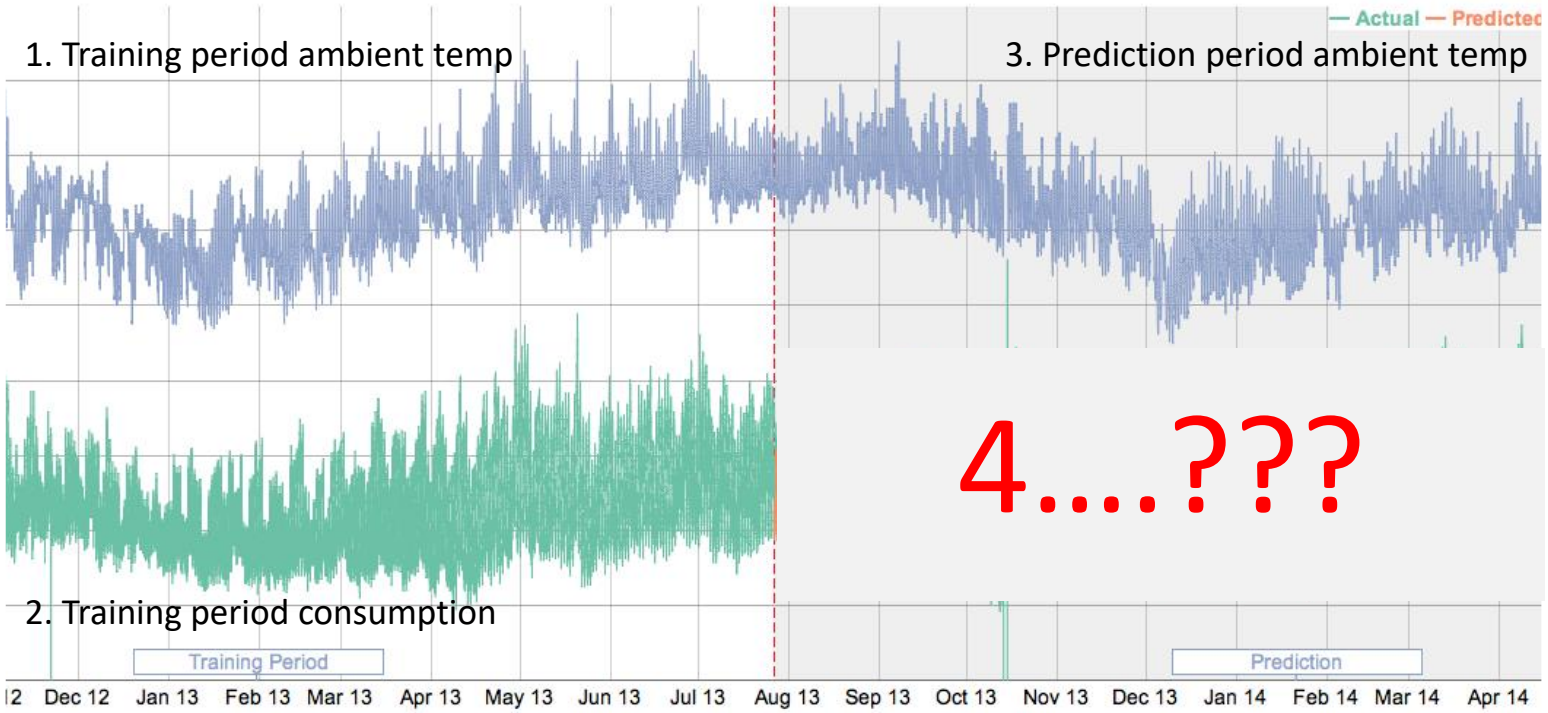


M&V Tool Selection

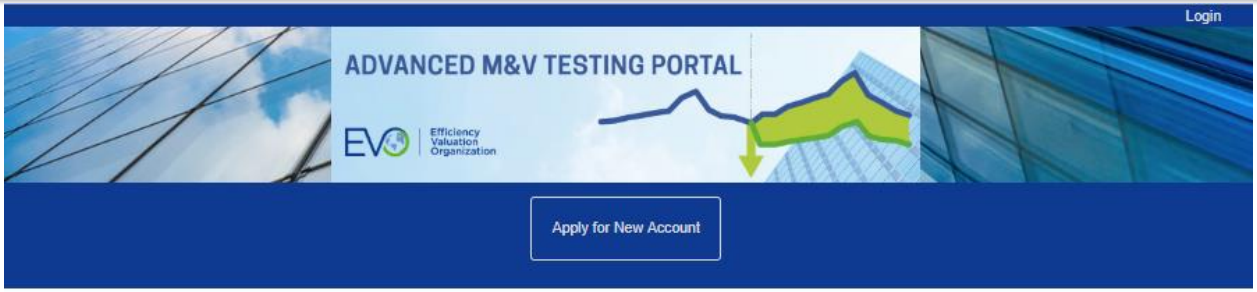
- Need to customize models?
- Can the tool be easily configured to output baseline model goodness of fit metrics?
- Need for individual building savings and aggregated?
- Is the tool capable of “batch mode” data input?
- Need to accommodate continuous meter data feeds?
- Any desired model inputs beyond weather and time?
- Has tool been vetted, for example in prior pilots, third-party testing, or by other means?
- Preference for additional features?
  - Customer dashboard
  - Opportunity ID
  - Project management features
  - Etc.

How do you test an M&V tool?

- **Predictive capability:** Out-of-sample testing
- **Robustness:** Use a test dataset covering many buildings
- **Trusted:** Ensure that test method/results do not allow for 'gaming' the test

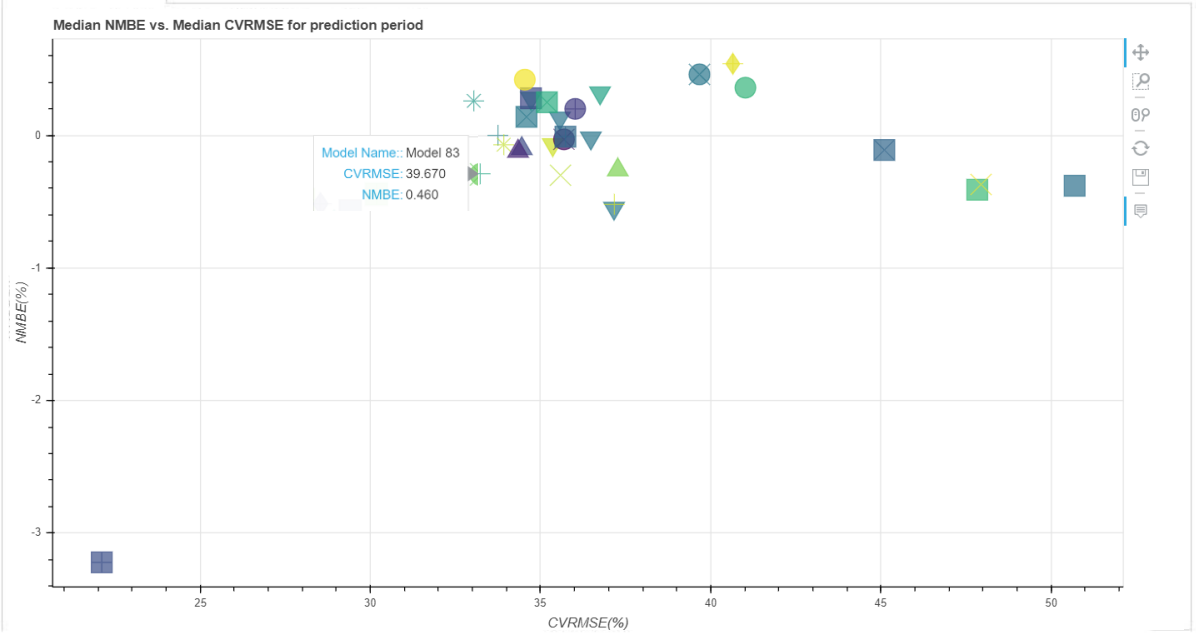


EVO Advanced M&V Testing Portal



Test Results

CVRMSE vs. NMBE | CVRMSE | NMBE

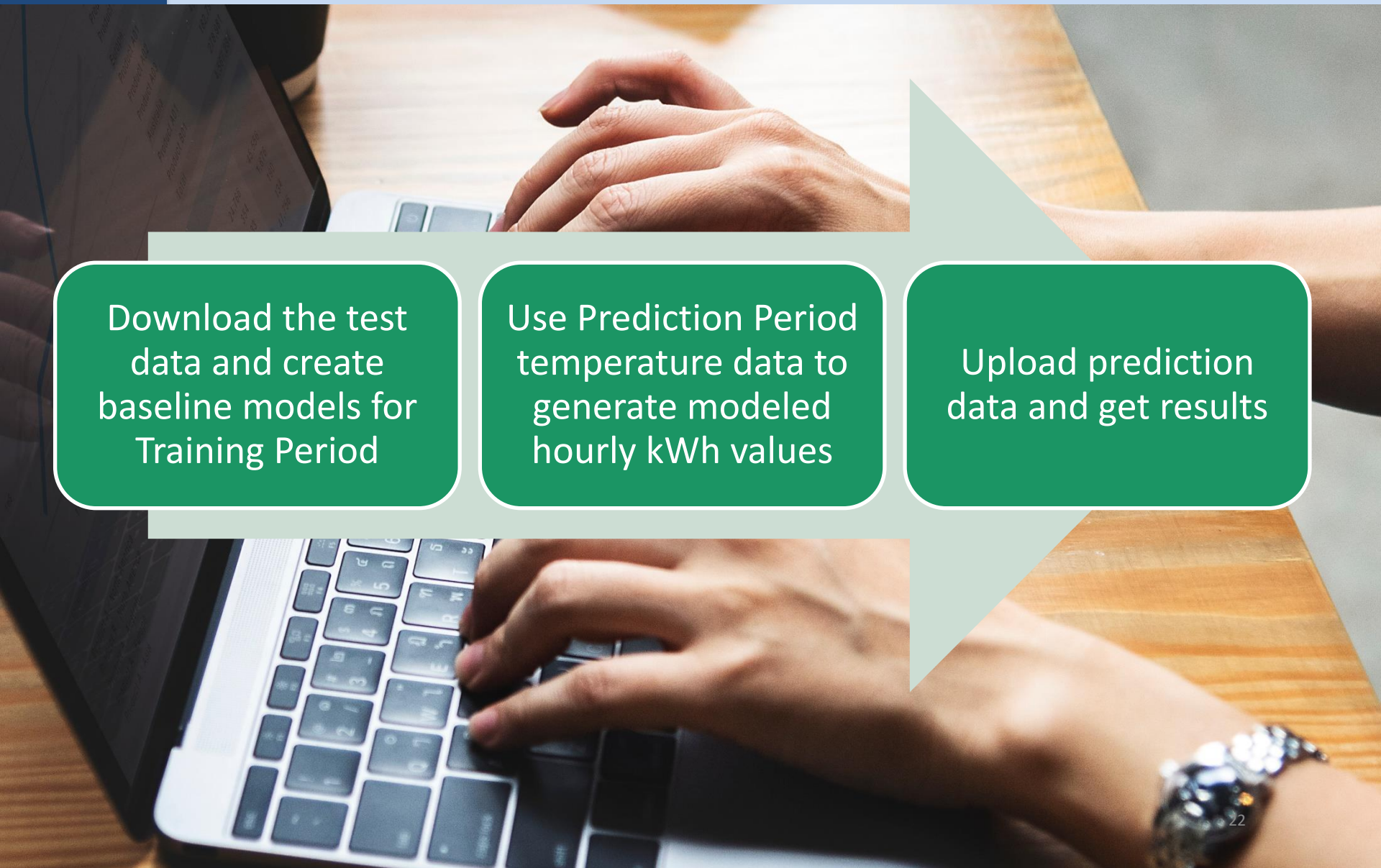


* This table includes both public and private model submissions. Identifying information has been hidden for private submissions.

Model Name	Test Date/Time
LBNL TOWT	April 17, 2019, 10:05 p.m.

BERKELEY LAB
Lawrence Berkeley National Laboratory

EVO Advanced M&V Testing Portal

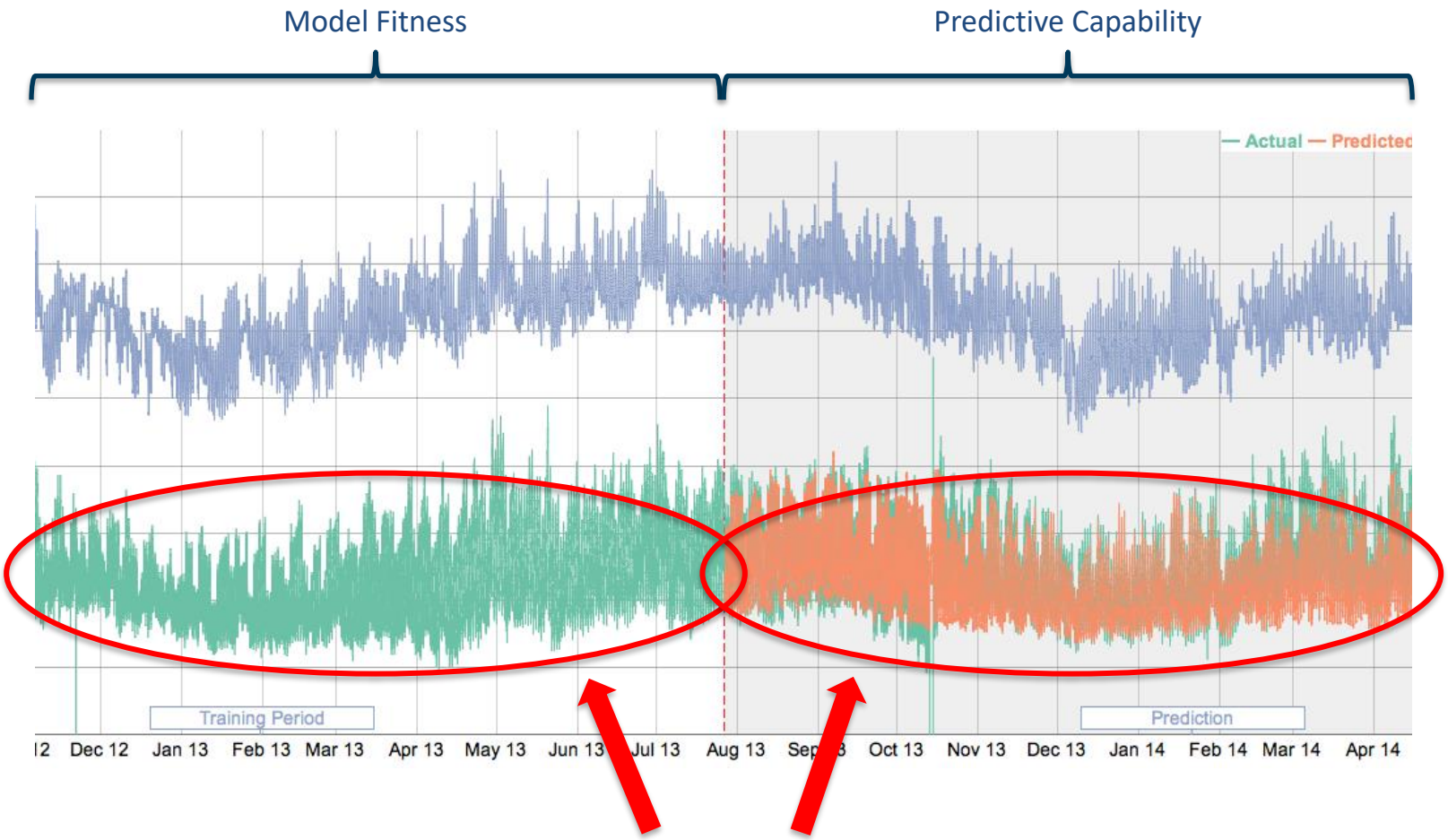


Download the test data and create baseline models for Training Period

Use Prediction Period temperature data to generate modeled hourly kWh values

Upload prediction data and get results

Test Metrics



Did I Pass?

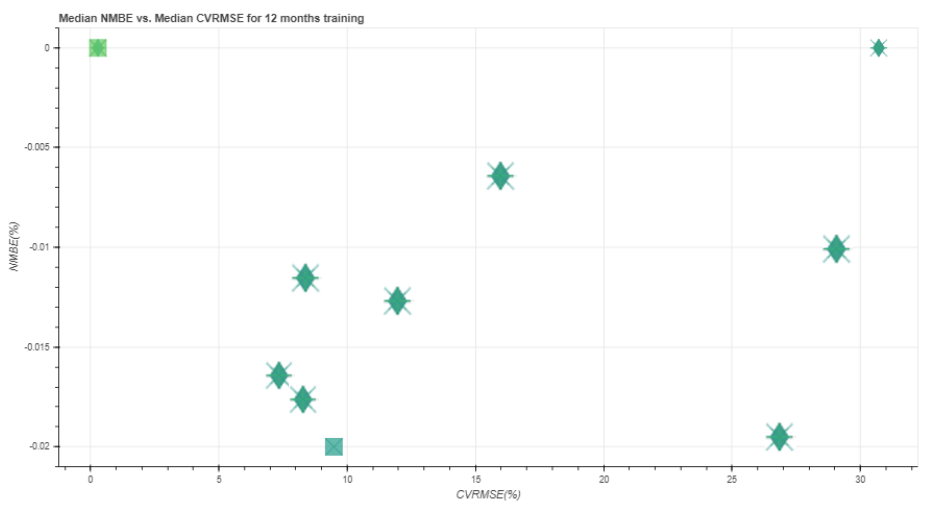
Result

Download Result

Test Date/Time:	May 29, 2018, 4:35 p.m.
Tool/Model Name:	LBNL TOWT
Vendor/Developer Organization Name:	LBNL
Model Type:	Linear Regression
Tool or Software Version or Release Date:	0.1
Additional Model Description/Notes:	

	CVRMSE	NMBE
25th Percentile	9.79	-0.21
Median	30.72	-0.0
75th Percentile	79.02	0.15

Test Results



http://mvportal.evo-world.org/

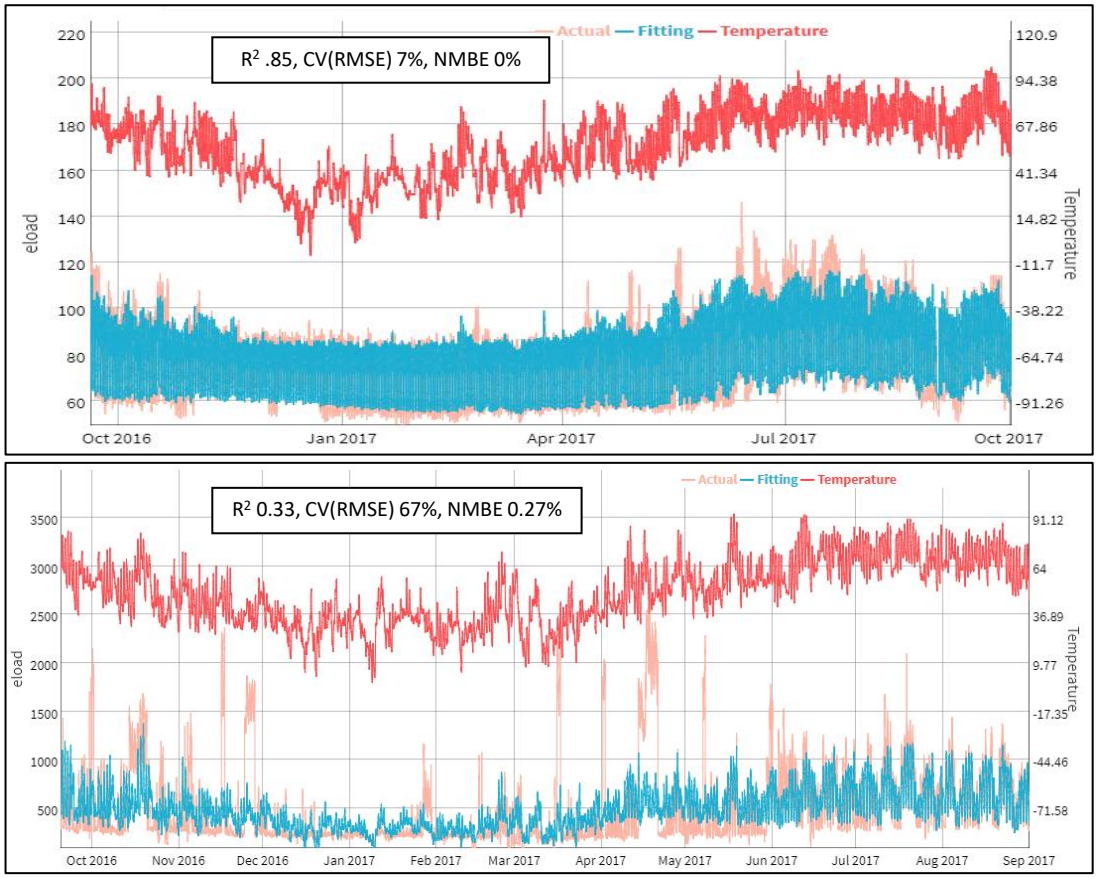
M&V Tool Testing

- Good tool = guaranteed results?

Baseline Model Fitness

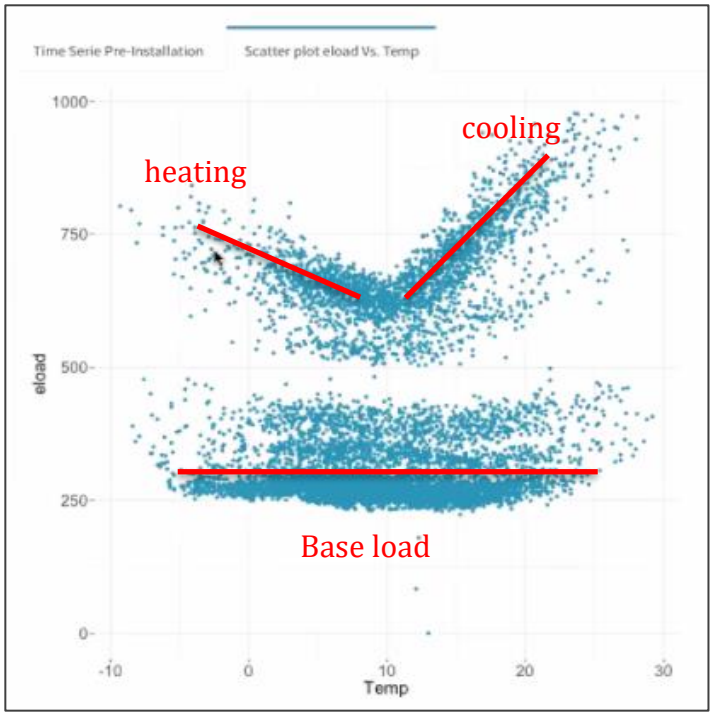
- R2, target >0.7
- CV(RMSE), target <25%
- NMBE, target <0.5%

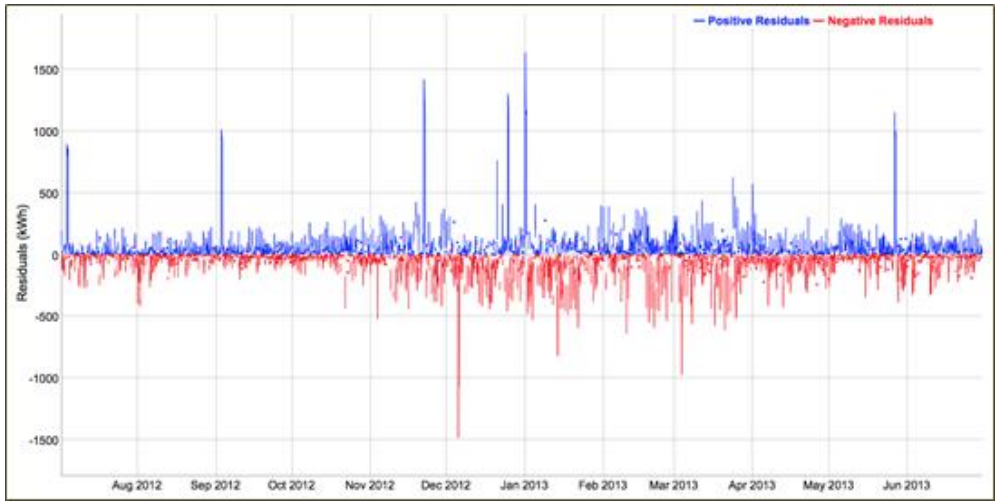
- (MAPE is another to consider)



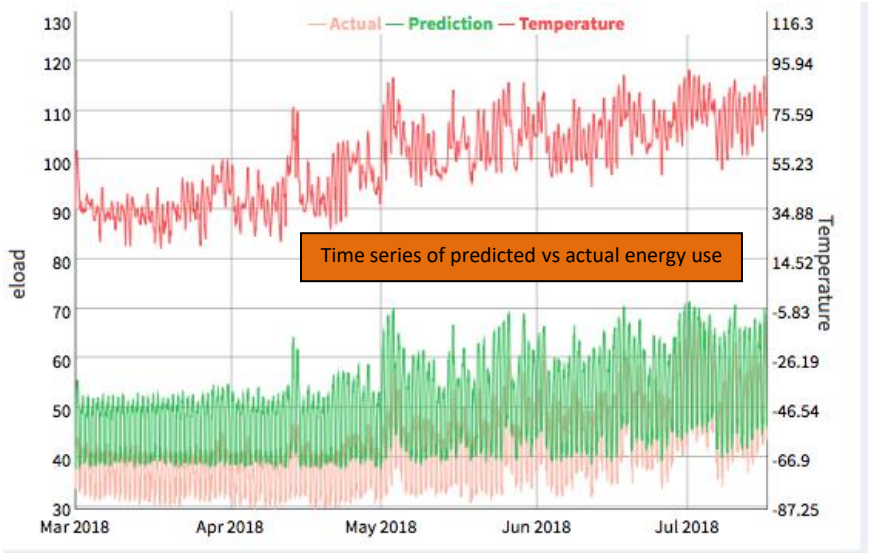
Other baseline considerations

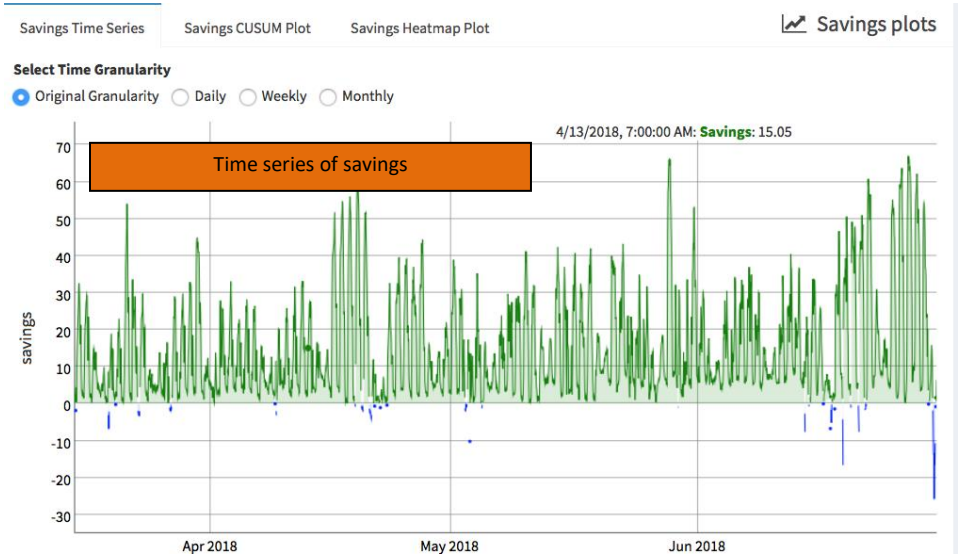
- Residuals / scatter chart
- Data management / meters
- Dates
- Weather data

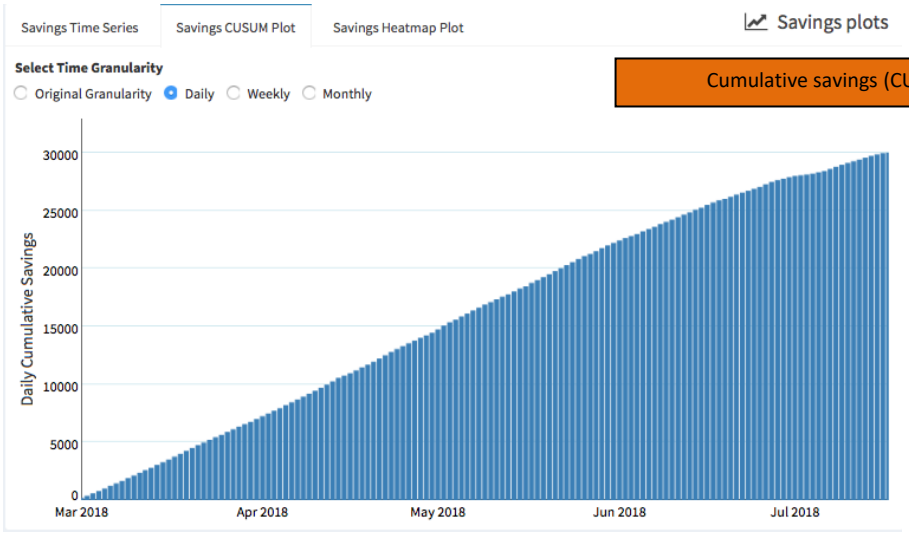




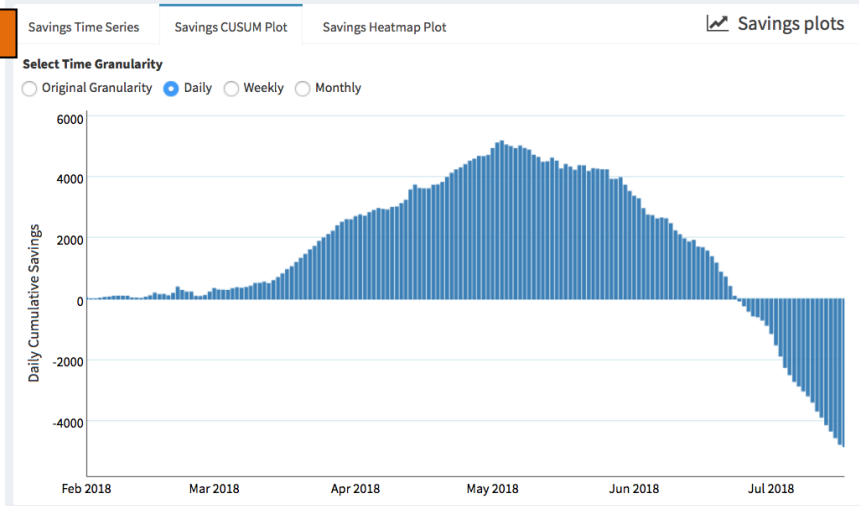
Savings Tracking and Visualization







Cumulative savings (CUSUM)



Lia Webster

Facility Energy Solutions

The Project Perspective:

Technical Issues and New EVO Publications

FACILITY
energy solutions

- AM&V Perspectives
- M&V and EM&V Protocols & Guidelines
- Technical issues in AM&V
- Areas under development
- Technical resources

AM&V Program Perspectives

Project Focused

- Commercial & Industrial sites
- Unique projects
- Technically rigorous
- M&V plan
- Non-Routine Adjustments
- Accurate site-level savings (Ex-ante)

Aggregated Approach

- Small Commercial & Residential
- Uniform population
- Generous acceptance criteria
- Control Groups
- Portfolio level savings

Impact Evaluation

- Sample of Projects
- External factors
- Program impacts
- Realization Rates
- Ex-post savings

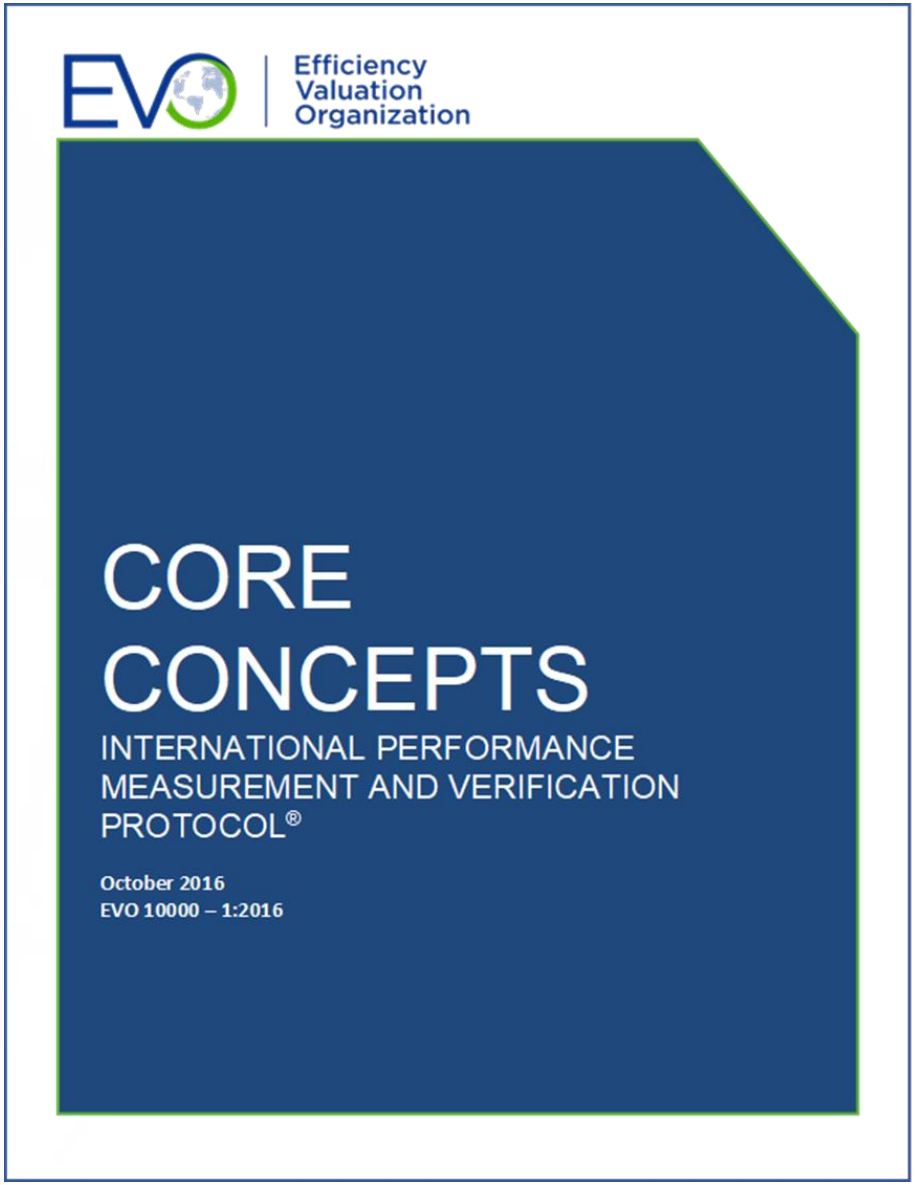
M&V Protocol

IPMVP:

- Used worldwide
- Provides M&V terms & definitions
- Framework to determine savings
- Defines 4 M&V approaches
- Focus on projects

ISO 17741 / 50001:

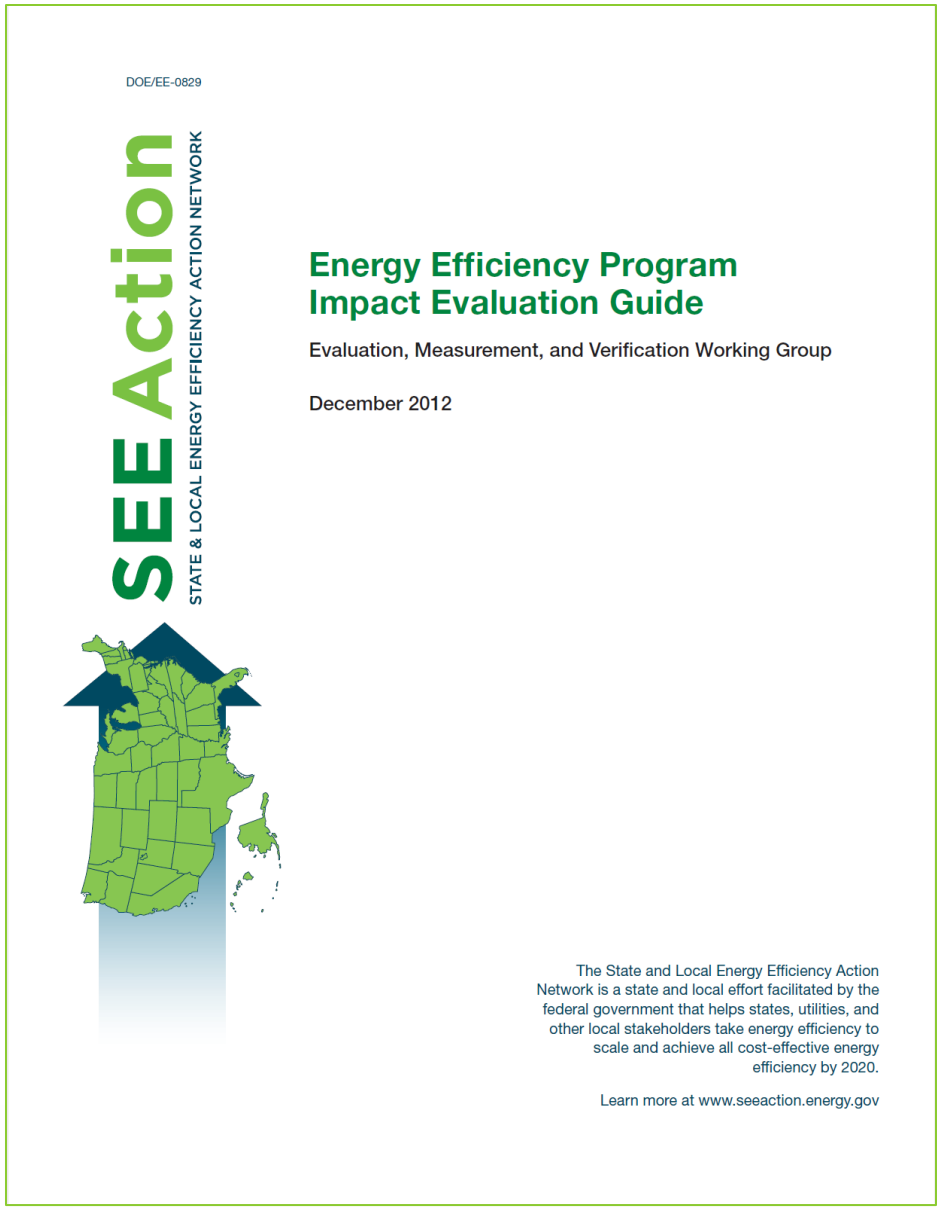
- Superior Energy Performance (SEP)
- Limited application to AM&V



EM&V Protocols

DOE SEE Action:

- Provides terms & definitions
- Focus on programs
- Framework to determine net & gross savings
- EM&V Approaches:
  - M&V Approach (IPMVP Options)
  - Deemed Savings
  - Large Scale Consumption Analyses (control groups)



EM&V Guidelines

DOE UMP

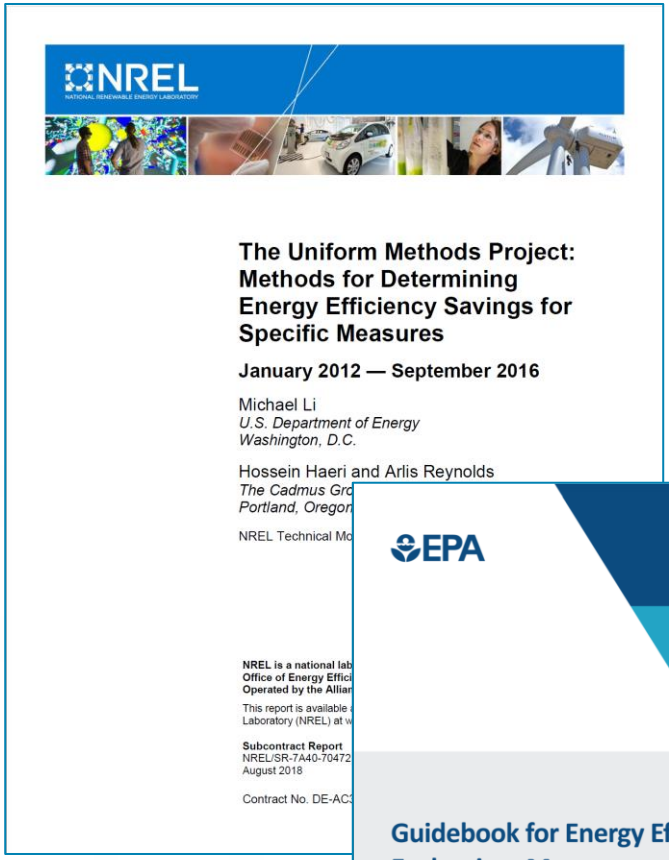
- Compilation of individual 'protocols'
  - 18 ECM specific, 5 'Cross-cutting'
- Focus on evaluation

EPA Guidebook on EM&V

- Compiles guidance from DOE
- Promotes best practices

State-by-State Guidance

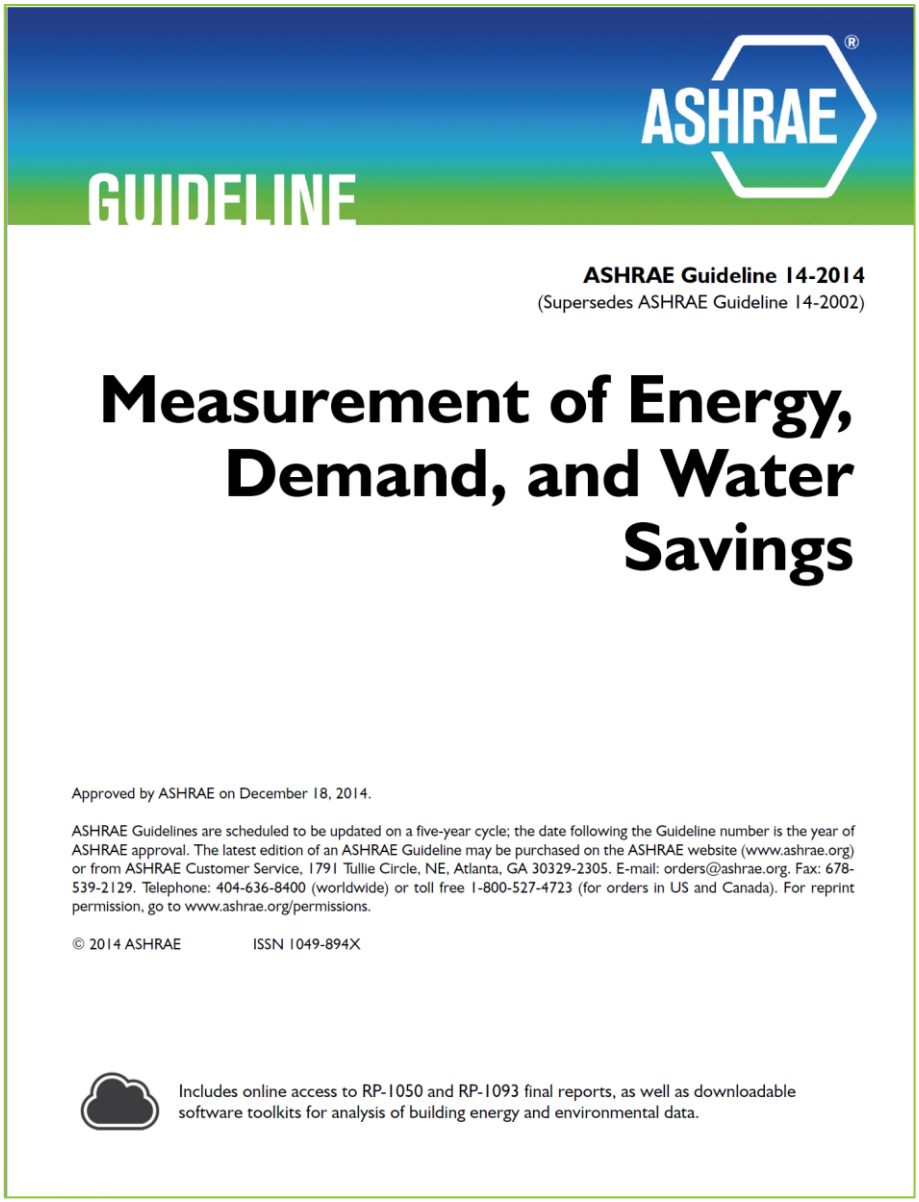
- CA Standard Practice Manual
- Technical Reference Manuals (TRMs)
- Public utilities commissions
- Other



M&V Guidelines

Based on IPMVP

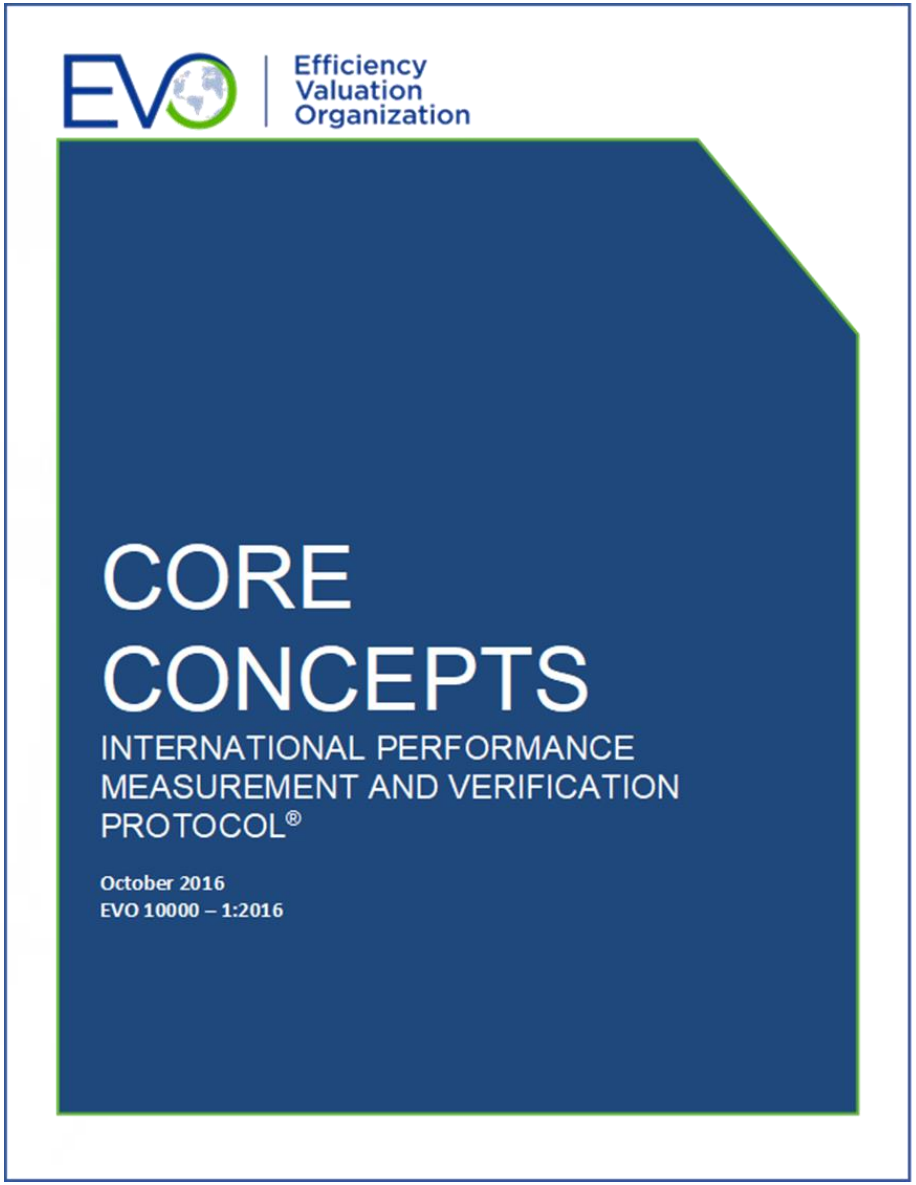
- ASHRAE Guideline 14
- M&V Guidelines for Federal Energy Projects (FEMP)
- Strategic Energy Management (SEM) MT&R Guidelines
- State and utility guidelines



M&V Requirements: IPMVP

IPMVP

Requirements for “Adherence”:



M&V Requirements: IPMVP

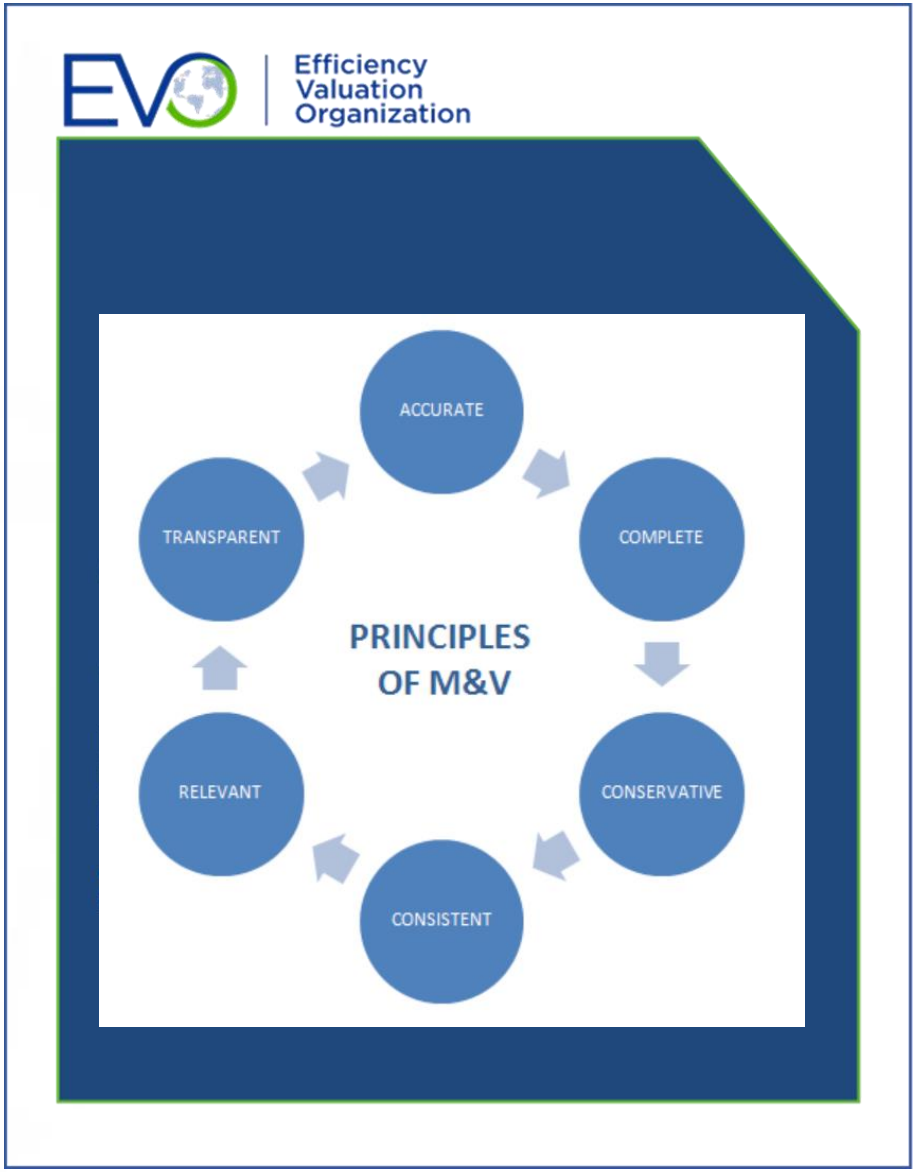
IPMVP

Requirements for "Adherence":

- Follow procedures & principles
- Detailed M&V plan & report
- Use IPMVP terminology & equations
- Consider Uncertainty in savings
- Operational verification

Option C: Whole Building specific:

- Regression modeling
- Energy data requirements
- Non-Routine adjustments



Advanced M&V industry is active!

P4P Utility Programs

- IOUs in California (NMEC)
- Seattle City Light
- NYSERDA / Con Ed
- BayREN (CA)
- Others…

AM&V Software

- ECAM
- LBNL RMV2.0
- Universal Translator (UT3)
- Gridium
- OpenEEMeter
- NMECR
- Others…

Ongoing Research

- Model types
- Uncertainty methods
- Efficacy of aggregated approaches
- Accuracy of adjustments
- NRE automated detection methods

Current AM&V Programs

State/ Province	Utility or Sponsor	Program Name	Sector
OR	Energy Trust of Oregon	Pay for Performance Pilot	Residential
CA	PG&E	Pay for Performance	
NY	NYSERSDA, Con Ed	Business Energy Pro - P4P Pilot	Small Commercial
NJ	State of NJ's Clean Energy Program	Pay for Performance Existing Buildings*	
CA	BayREN	Pay for Performance	Commercial
BC (Canada)	BC Hydro	Strategic Energy Management	
IL	ComEd and Nicor Gas	Strategic Energy Management	
DC	DC Sustainable Energy Utility	Pay for Performance (P4P)	
MI	DTE Energy	Strategic Energy Management	
VT	Efficiency Vermont	Deep Retrofit	
MA, RI	National Grid	Pay for Performance (MBCx & EBCx)	
WA	Seattle City Light	Deep Retrofit Pay for Performance	
CA	SoCalREN	Metered Savings Program	
WA, OR, ID, MT	BPA, Idaho Power, PacifiCorp, PSE	Strategic Energy Management	Commercial & Industrial
VT	Efficiency Vermont	Continuous Energy Improvement (SEM & EBCx)	
OR	Energy Trust of Oregon	Strategic Energy Management	
CA	SCE	SCE Public Sector Performance-Based Retrofit HOPs	
CA	PG&E	NMEC meter-based savings platform	

AM&V Software

Area	Feature
Model	Model Type(s)
	Variables & Inputs Used
	User Interface
	Level of User Adjustments
	Equations of Model(s) Shown
Energy Data Used	Interval Data Accepted
	Hourly
	Daily
	Monthly
Overview	Level of Automation
	Software Used
	Code Language
	Open Source
Tool Features	NRE detection
	Data Coverage Assessment / Limiting
	Performance Period Weather Data
	Residual Review for Autocorrelation
	Model Statistics Provided
Savings Type	Avoided Energy Use
	Normalized Savings

Free & Open Source Tools
ECAM
RMV2.0
OpenEEMeter
UT3 M&V Module
NMECR

Key considerations for AM&V

Application Issues

- Commercial vs. Residential
  - Building level vs. Population based
- Avoided energy use vs. Normalized savings
- Level of Automation
  - Costs
  - Periodic reporting vs. Dashboard
  - Need for customized models, QC
  - Energy data access and cleaning

Technical Issues

- Variations in M&V tool capabilities
- Need for customized models
- Savings uncertainty limitations
- Model acceptance criteria
  - "Bad" buildings
- Detecting Non-Routine events
- Making Non-Routine adjustments

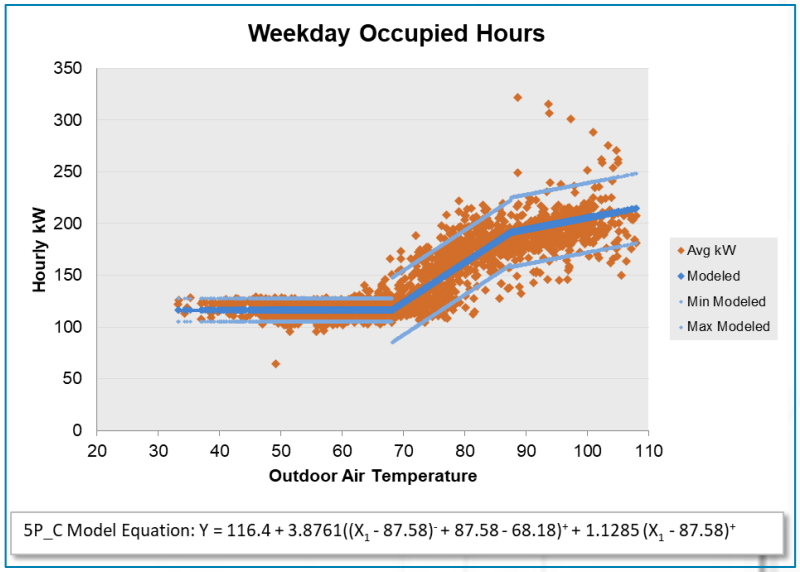
Variations in M&V Tools

Form of Models:

- Change-point Models
- Time of week and temperature
  - Variations
- Tools with multiple types of models

Data Used:

- Inclusion of Holidays
- Use additional variables (e.g., Occupied Sq. Ft.)
- Hourly, Weekly, or Monthly energy intervals



ECAM

Devil's in the details...*Savings Uncertainty*

Fractional Savings Uncertainty

- From ASHRAE G-14
- Based on concept that savings uncertainty decreases over time
- Auto-correlation problems with interval data
  - Correction factors
  - Under-estimates FSU

Model Goodness of Fit

- Use regression statistics
- Ensure quality modeling procedures
- Not as transparent as FSU
- Ensure savings are detectible

Mitigate Uncertainty & Maximize Savings

Reduce Saving Uncertainty

- Use stringent model acceptance criteria
- Screen for non-routine events
- Fall-back M&V Approach:
  - "Bad" buildings
  - Critical projects
- Avoided energy use
  - Less error than normalized savings
  - Includes extremes, reflects actual impacts

Mitigate Uncertainty & Maximize Savings

Reduce Saving Uncertainty

- Use stringent model acceptance criteria
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  - "Bad" buildings
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Increase Program Savings

- Accurate models capture lower levels of savings ~ more savings reported
- Lower % savings allowable ~ broader range of eligible projects
- More accurate models ~ better detection and remediation of non-routine events
- More accurate savings ~ higher realization rates

Minimize Uncertainty in Baseline Model

Industry Guideline	Model Fit Criteria			
	CV(RMSE)	R^2	NMBE	Other Requirements
ASHRAE G14 - Whole Building Performance Path	Varies. See FSU	None	< 0.005%	✓ Fractional Savings Uncertainty (FSU) < 50% annual savings at 68% confidence level[39] Note: FSU ~ f(Cv(RMSE), % savings, # baseline & reporting period points)
ASHRAE G14 - Whole Building Prescriptive Path	<25%	None	< 0.005%	✓ Expected savings > 10% ✓ Daily data is minimum interval ✓ Baseline model uncertainty, depends on length of reporting period: Energy < 20 – 30%, Demand < 30 – 40%
Superior Energy Performance (SEP) M&V Protocol	None	> 0.50	None	✓ F-test for overall model fit must have a p-value < 0.1 (i.e., the overall fit of the model is greater than the 10% significance level). ✓ All included relevant variables in the model shall have a p-value of less than 0.20. ✓ At least one of the relevant variables in the model shall have a p-value of less than 0.10.
BPA Regression for M&V: Reference Guide	A low value is desirable (often interpreted as 10% or 15%)	> 0.75*	< 0.005%	✓ p-value for independent variables <0.10 to 0.01 ✓ t-statistic for independent variables >1.96 (95% confidence level) ✓ F-statistic (used for entire model instead of individual variables; Larger the better.) ✓ Adjusted R-squared for multiple regression models. ✓ A low R^2 does not indicate a poor model; Professional judgment should be applied. (*) This is a rule of thumb value

Screen for Non-Routine Events (NREs)

Baseline Period:

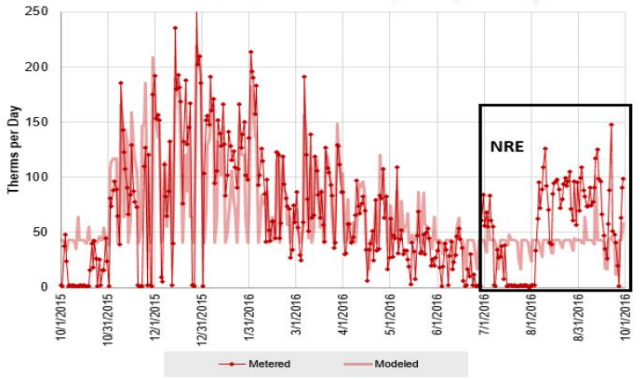
- Increased uncertainty in energy model

Implementation Period:

- Can obscure savings from ECMs

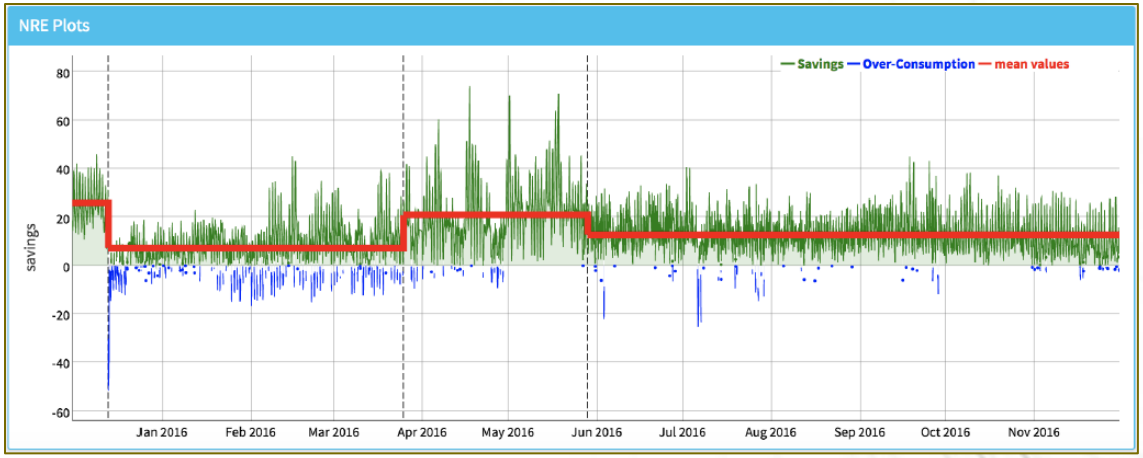
Reporting Period:

- Direct increase or decrease in Avoided energy use, or
- Added uncertainty in reporting period model



Areas of Ongoing Development

- Open-source software
- Methods for determining savings uncertainty
- Evaluation of aggregated approaches
- Automated detection methods NRE



RMV2.0

Technical Resources

Organization	Document
BPA	3_BPA_Regression for M&V: Reference Guide
BPA	7_BPA_Verification By Energy Modeling
ASHRAE	ASHRAE 14 - 2014
EVO	IPMVP Core Concepts
EVO	IPMVP Uncertainty Assessment Application Guide
EVO	IPMVP's Snapshot on Advanced Measurement & Verification
NW SEM Collaborative	SEM Energy Modeling Method Selection Guide
LBNL	Connecticut Department of Energy and Environment: Advanced Measurement and Verification (M&V) Implementation Resource Guide
Seattle City Light	Deep Retrofit Pay for Performance - A How-To-Guide & User Manual for Commercial Customers

IPMVP Application Guide on Advanced M&V Methods and Non-Routine Adjustments - *Coming soon!*

Thank you!

lwebster@facilityenergysolutions.com

Carmen Best

Recurve

The State Perspective:

Developing and Applying Guidance

RECURVE

SHAPE THE FUTURE OF ENERGY

DOE - NEEP Advanced M&V Webinar

Carmen Best, Director of Policy & Emerging Markets

April 30, 2020

ad·vanced

/ədˈvanst/

adjective

adjective: **advanced**

far on or ahead in development or progress.
"negotiations are at an advanced stage"

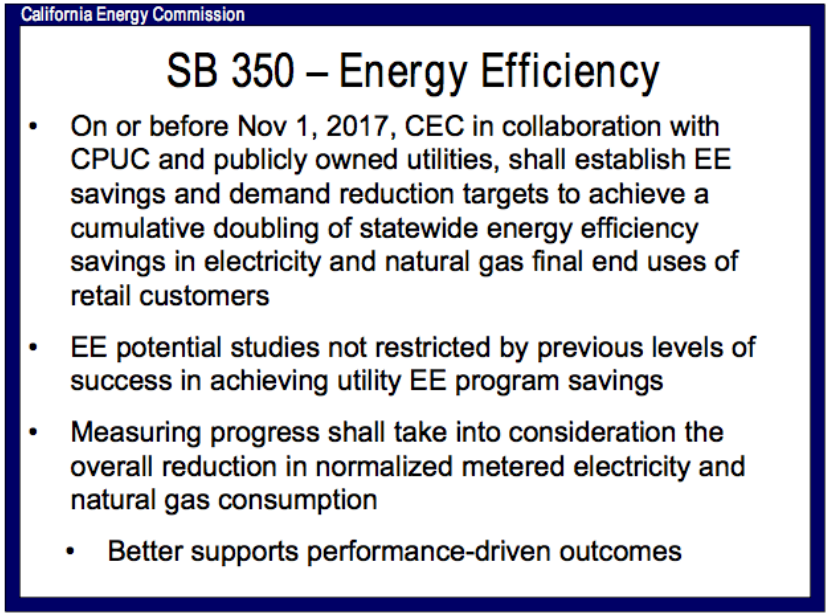
- new and not yet generally accepted.
  "his advanced views made him unpopular"

RECURVE

Advanced History of NMEC in California

Normalized
Metered
Energy
Consumption

Is a Means To Streamline and Scale EE to Double Energy Efficiency in California



"The energy efficiency savings and demand reduction . . . achieving the targets established pursuant to paragraph (doubling of EE by 2030) ***shall*** *be measured taking into consideration the* ***overall reduction in normalized metered electricity and natural gas consumption*** *where these measurement techniques are feasible and cost effective."*

– SB 350

RECURVE

CPUC Response in the NMEC Ruling

- The Ruling was modeled after the regulatory requirements for **behavior programs**.
- Intended to provide more **timely information** to customers, program administrators and regulators on performance **without significant re-casting of savings** on an ex post basis.
- **Upfront agreement and review of methods** appropriate for the program and in some cases for the specific project
- Process of advice letter review served as the "case law" **documenting the detailed direction on the proposals and methods** coming from the Commission.

Ruling on High Opportunity Programs and Projects - CPUC 2015

RECURVE

Advanced = Enabling Effective Application of M&V

RECURVE

M&V Protocols and standards . . .

IPMVP Option (**C**)

CALTRACK

ASHRAE ECAM

LFENERGY OPENEEMETER

Professional Guidance → **Reproducible Execution**

Time of Week & Temperature Model

BERKELEY LAB

The California Evaluation Framework (2004)

Protocols (2006)

California EM&V Framework Refresh Needs Assessment

Final Report

October 11, 2017

. . . enable settlement.

Revenue Grade = Transparent, Consistent, Repeatable

CALTRACK

- Standard M&V Calculation Methods
- Monthly, Daily, and Hourly
- Public Stakeholders Empirical Process
- www.CalTRACK.org

LFENERGY OPENEEMETER

- Python CalTRACK Engine
- Open Source Apache 2.0
- How It Works: https://goo.gl/mhny2s
- Code Repo: https://goo.gl/qFdW4P

RECURVE

Advanced = Enabling
Flexibility + Accountability

The Market is Complex

Meter-based Demand Flexibility is Technology and Business Model Agnostic

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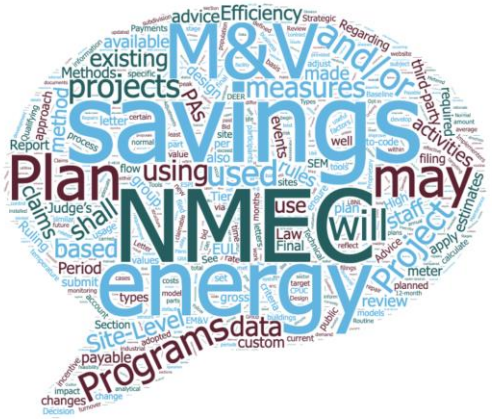
CPUC NMEC Rulebook 2.0 - Overview



Details the **Program Level Requirements** including:

- M&V plan requirements
- Payments & Incentives

General Requirements include detailed information on:

- Commission roles for review
- Tools, Methods, Analytical Approaches and Calculation Software
- Savings claims

Definitions & **Matrix of Approval Requirements**

Weinbar: [How to Make the New Mandatory NMEC Rulebook Work for Your Program]

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Population-Level NMEC

Program Fit	*Programs must meet the Population-level NMEC **regulatory and filing requirements** described in this document;*
Meter-Based	*Energy savings determinations are made using an NMEC approach based on pre and post-intervention **energy usage data observed at the meter***
Pre-Defined & Consistent	*Measurement methods and calculation software are **set before the program starts** (and not subsequently changed) and apply to all sites in a uniform fashion*

For More Detail: CPUC Releases Version 2.0 of the Meter-Based NMEC Rulebook

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Tools, Methods, Analytical Approaches & Calculation Software

Ex-post Evaluation:	...subject to Commission review of savings measurement methods and estimates, for purposes of program and/or project-level feedback and for purposes of ex-post impact evaluation
Savings Calculations:	All analytical methods, including tools, algorithms and software used in savings and incentive or compensation payment calculations, must be made available...
Measurement Period:	Savings determinations must be made by comparing at least 12 months of post-intervention energy consumption to at least 12 months of pre-intervention energy consumption.
Transparency:	Data, methods and calculations must be made available to the PAs well as the Commission and its impact evaluators.
Documentation and Replicability:	..methods used to calculate savings for NMEC programs must be documented...such that savings calculations are able to be replicated
Consistent, Pre-Set Method:	For Population-level NMEC programs, the specific measurement method(s) and calculation software must be determined before the program begins and applied uniformly...
Proprietary Methods & Software:	Savings measurement methods and calculation software that is public, and especially those that are open-source, benefit from a stakeholder vetting process that allows experts and practitioners to share their knowledge and use updated information to inform savings estimates.

Rulebook for Programs and Projects Based on Normalized Metered Energy Consumption

Version 2.0

Release Date: 7 January, 2020

*"**Proprietary Methods & Software**: Savings measurement methods and calculation software that is public, and especially those that are open-source, benefit from a stakeholder vetting process that allows experts and practitioners to share their knowledge and use updated information to inform savings estimates. The Commission has supported the development of public, open-source processes to develop NMEC methods (e.g. CALTRACK) and encourages stakeholders to engage in these open-source initiatives." p. 18*

CALTRACK

LFENERGY OPENEEMETER

Population NMEC M&V Plan & Compliance Checklist

Impact Evaluation Specification Comparison Group Methods

- Matching Approach & Criteria
- Statistical Metrics

RECURVE

ad·vanced **M&V**

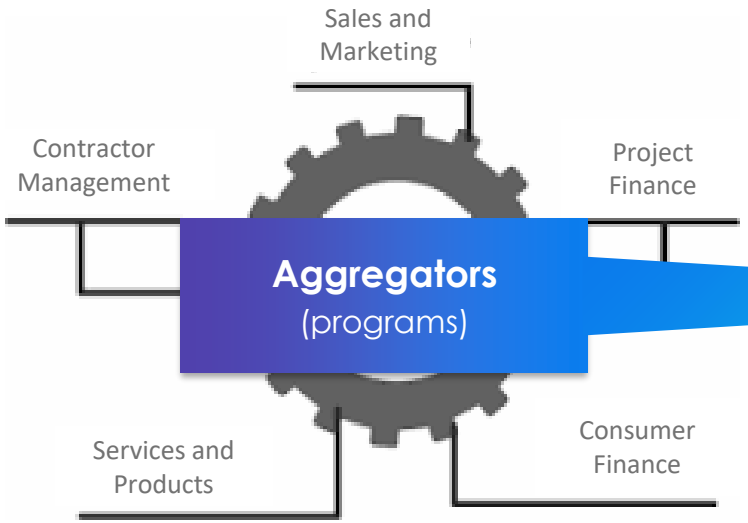
/ədˈvanst/

- Democratized **access** to impact evaluation results
- More **cost effective** delivery of demand side strategies with insights from M&V
- **Transparent**, consistent understanding of performance
- Incremental **improvements** in methods identified through practice
- **Scaled investments** in energy efficiency and other demand side strategies

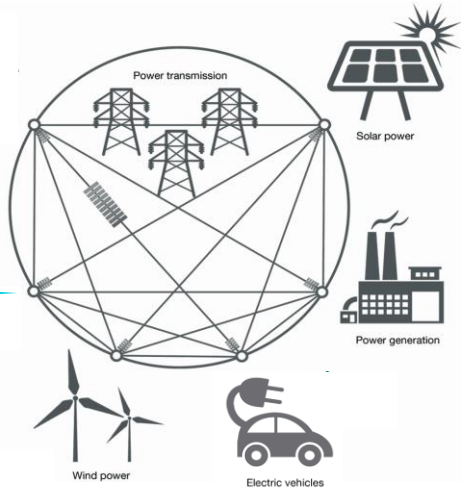
RECURVE

ad·vanced M&V =

/ədˈvanst/



DEMAND FLEXIBILITY



BUSINESS MODELS

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SHAPE THE FUTURE OF ENERGY

Carmen Best

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Director of Policy & Emerging Markets

DOE - NEEP Advanced M&V Webinar

April 30, 2020

Future Directions

Future Directions

- What guidelines are needed short term/long term?
- Future directions for AM&V?

THANK YOU!

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