M&V for Pay for Performance Approaches: Update, Resources, and New Developments

Presentation to NW Energy Coalition

Olympia, WA

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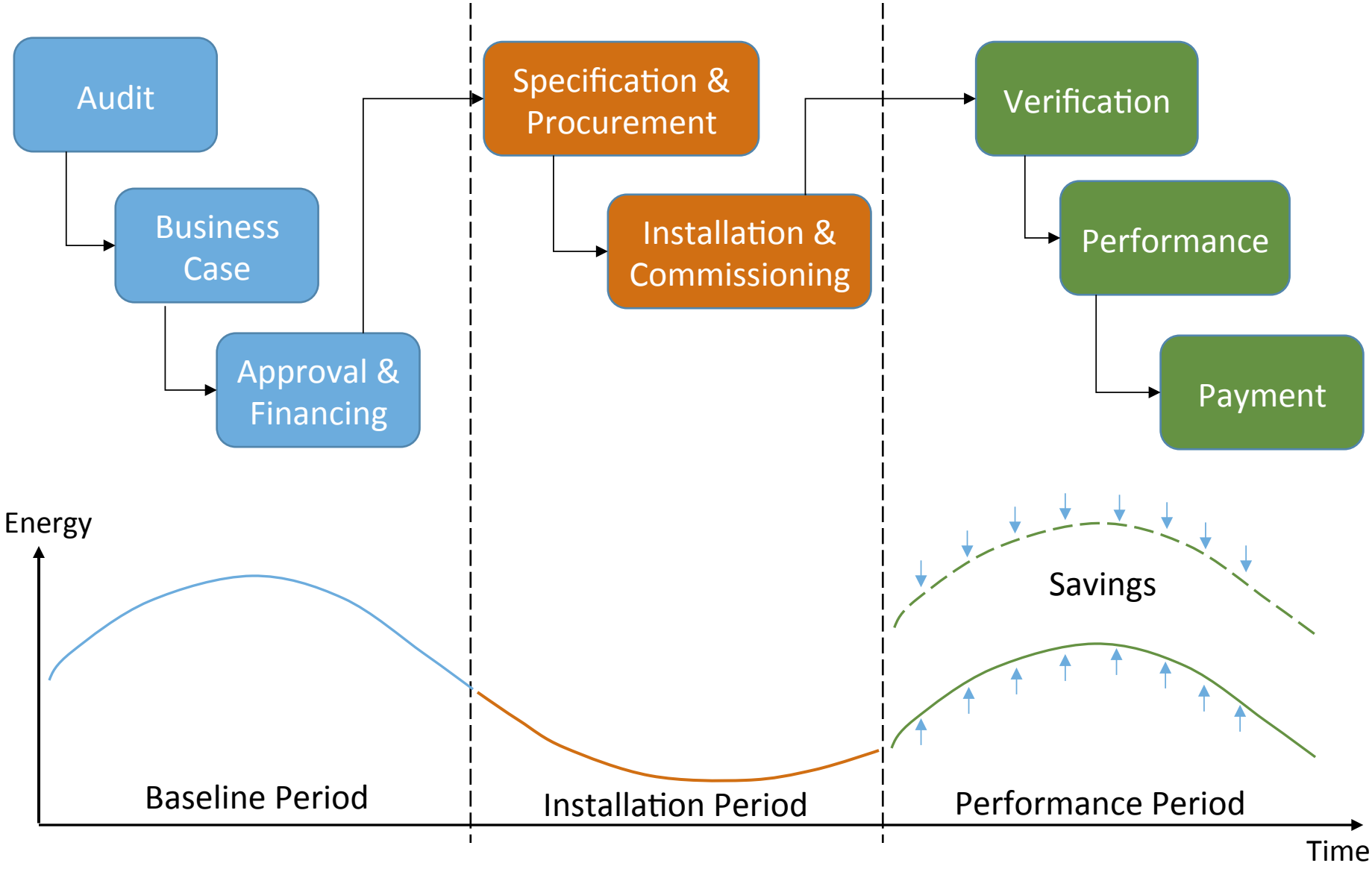
kW Engineering

Agenda

- Achieving Energy Efficiency
- Addressing Performance Risks with M&V
- New Developments
  - M&V 2.0
  - Tools
- LBNL Research
- Best Applications

Achieving Energy Efficiency



Risks

- Savings underestimated
  - Poor modeling
  - Estimates not based on data
- ECMs don't perform
  - Misspecification of equipment
  - Poor installation, lack of commissioning
- Savings don't last
  - Building operations change
  - Equipment not maintained
- Non-Routine Events
  - New loads added
  - Operations change
  - Occupancy changes
- Result:
  - Poor return on investment
  - Owners, Investors, Everyone Unhappy!

International Performance Measurement and Verification Protocol (IPMVP)

4 M&V Options:

- A: Key Parameter Measurement
- B: All Parameter Measurement

Retrofit Isolation

- C: Whole Facility
- D: Calibrated Simulation

Whole Building

Other guidelines: same options - different emphasis:
Technical methods – ASHRAE Guideline 14
Reporting Requirements – FEMP
Specific Applications -

Bonneville Power (best practices)
California Commissioning Collaborative (retro-commissioning)

Option A: Key Parameter Measurement

Lighting

- Measure fixture power
- Agree on hours of use estimations (owner controls operations)

$$kWh\downarrow save = (kW\downarrow base - kW\downarrow post) \times HRS\downarrow est$$

Best Applications

- Individual, Simple ECMs
  - Constant load & use
- Low Interaction Effects

Costs - Low

- Simple measurements
- Uncomplicated analysis

Risks are Shared:

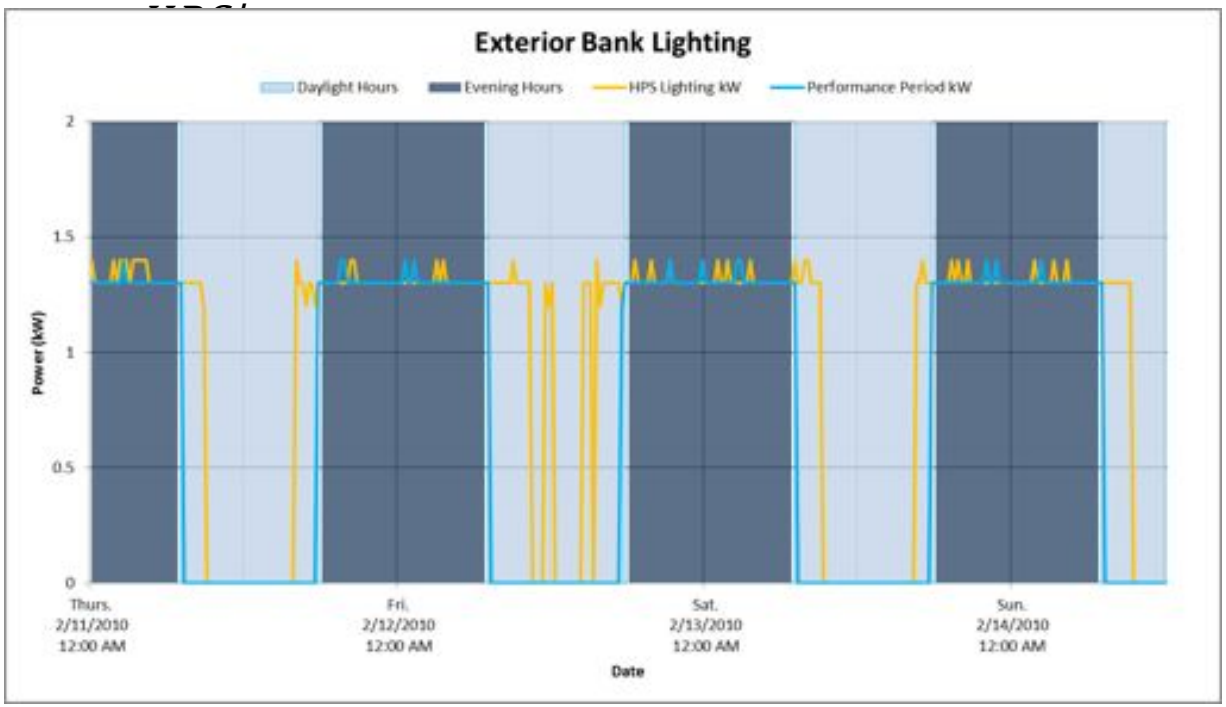
- ESCO responsible for performance (kW)
- Owner responsible for usage (HRS)

Option B: All Parameter Measurement

Lighting

- Measure fixture power & hours of use

$$kWh\downarrow save = (kW\downarrow base - kW\downarrow post) \times$$



Best Applications

- Interactive ECMs
- Variable load & use

Costs - Higher

- Much data required
- Extensive analysis
- Technical review

Risks:

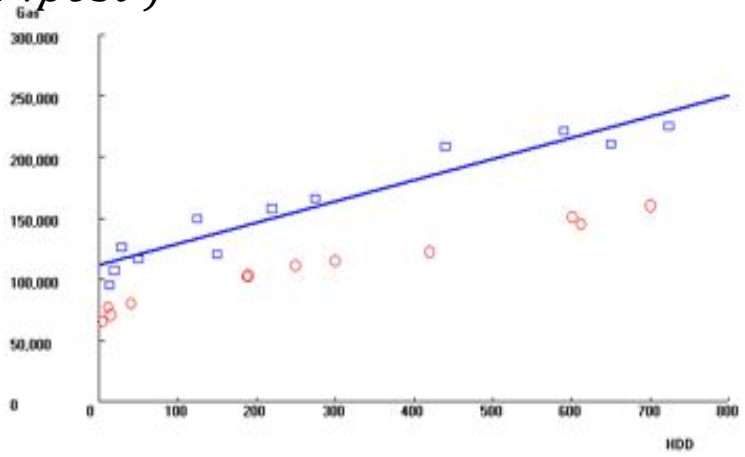
- Data collection errors
- Poor analysis

Option C: Whole Facility

Data Sources:
- Utility bills
- Local weather stations
- Production rates

Regression analysis
- HDD/CDD, production rate

$$kWh\downarrow save = kWh\downarrow base\ (T\downarrow post\ ) - kWh\downarrow post\ (T\downarrow post\ )$$

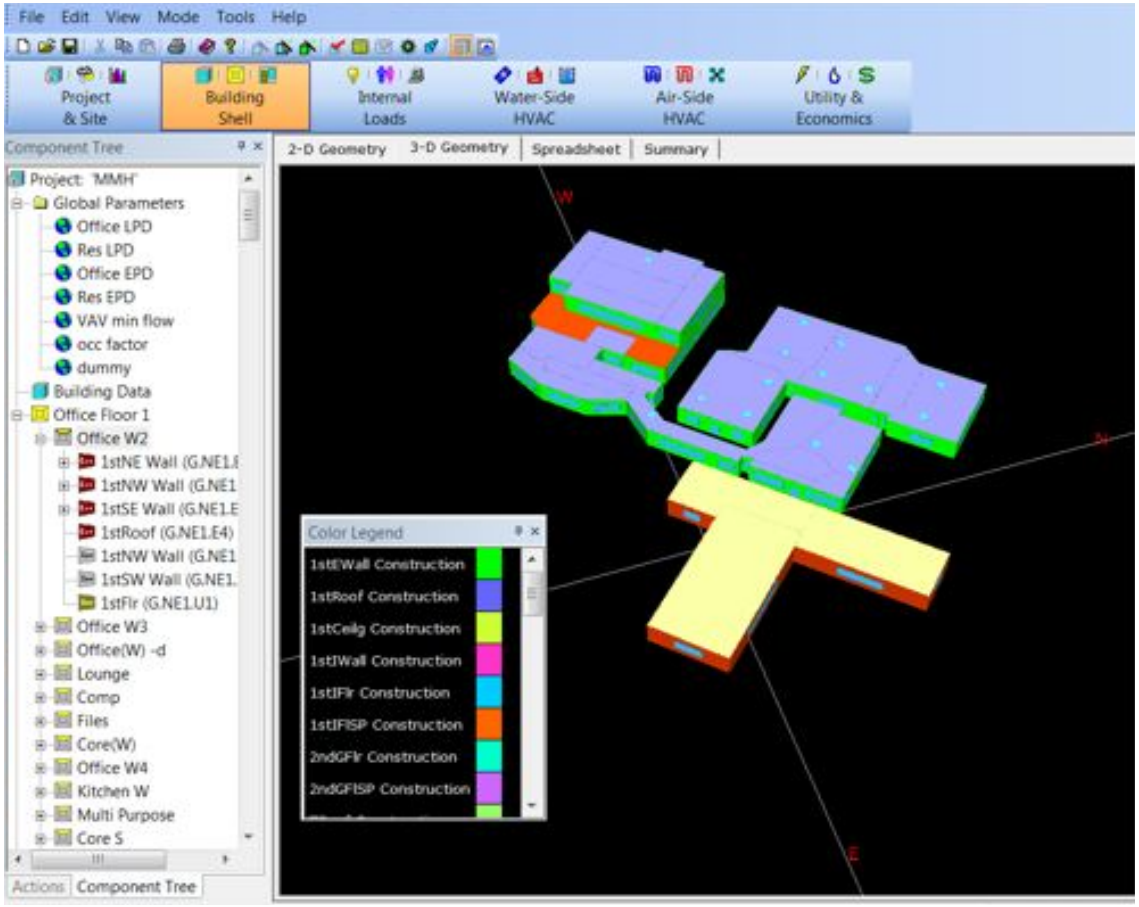


Best Applications
- Multiple, Interactive ECMs
- Savings > 15%

Costs - Low
- Available data
- Tools

Risks:
- Savings < 15%
- Non-Routine Events

Option D: Calibrated Simulation



Data Sources:

- As-Built Drawings
- On-site audits
- Utility bills
- Local weather stations
- Much more…

Requirements:

- Model calibration (varies)
- Experienced modelers
- Software
- Time

<u>Best Applications</u>

- Multiple, Interactive ECMs
- Savings < 15%

<u>Costs - High</u>

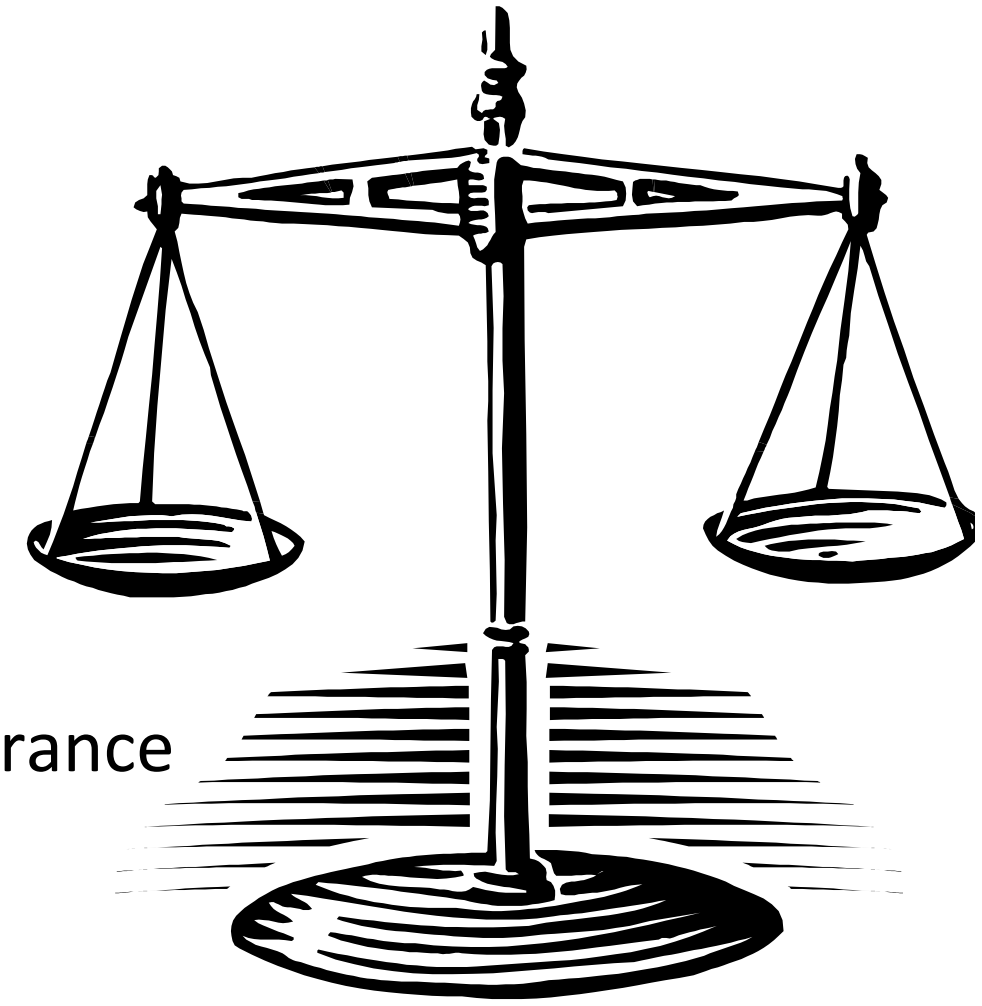
- High data requirements
- Expertise with tools

<u>Risks:</u>

- Model not correct
- Non-Routine Events

Key M&V Principle

- Rigor
- Accuracy
- Confidence
- Risk
- Quality Assurance



- Cost of Service
- Cost of Saved Energy

M&V 2.0

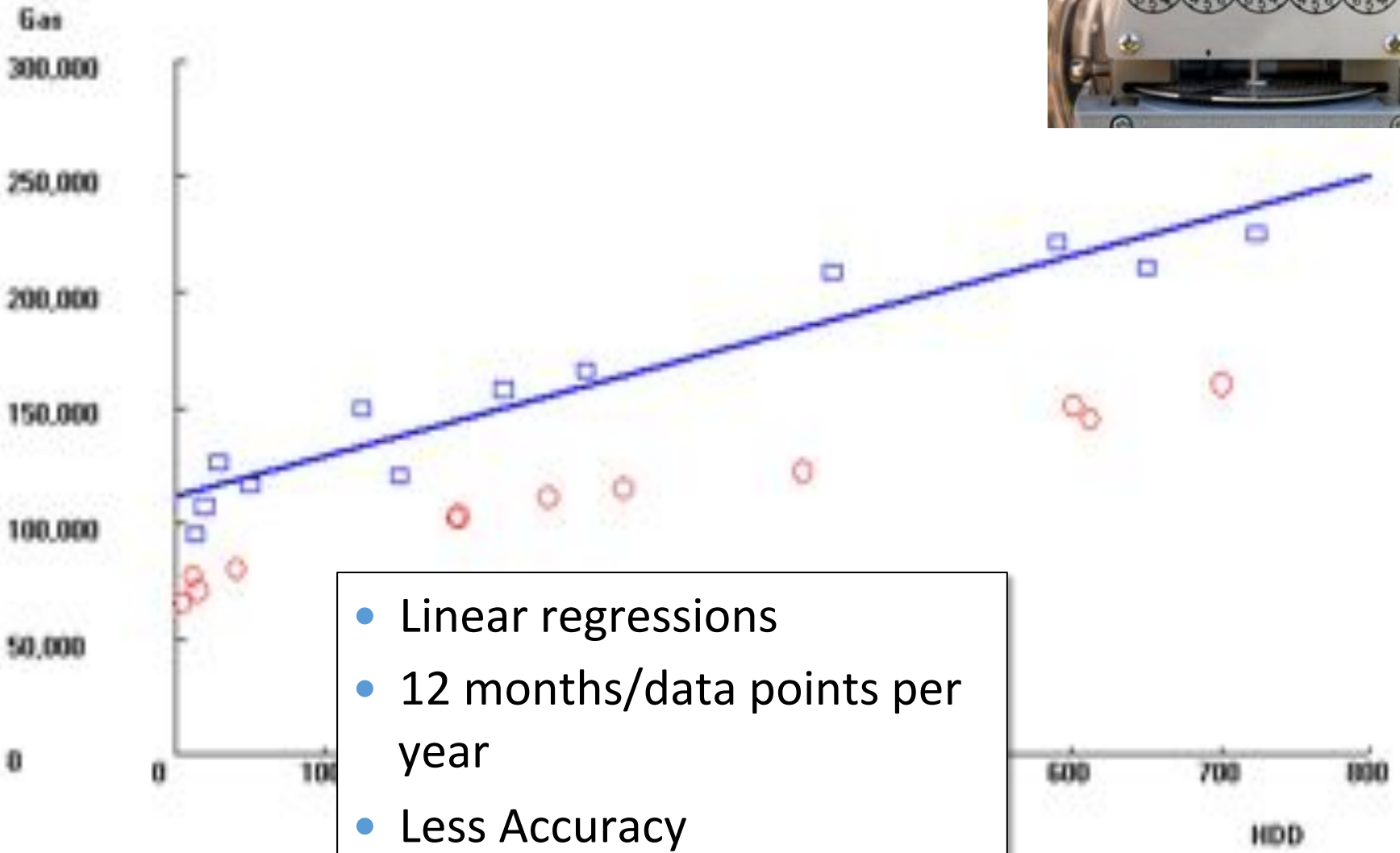
- Short-time interval data (e.g. 15 min, hour, day) and advanced analytics

Opt C. Whole Building

Opt. B Retrofit Isolation

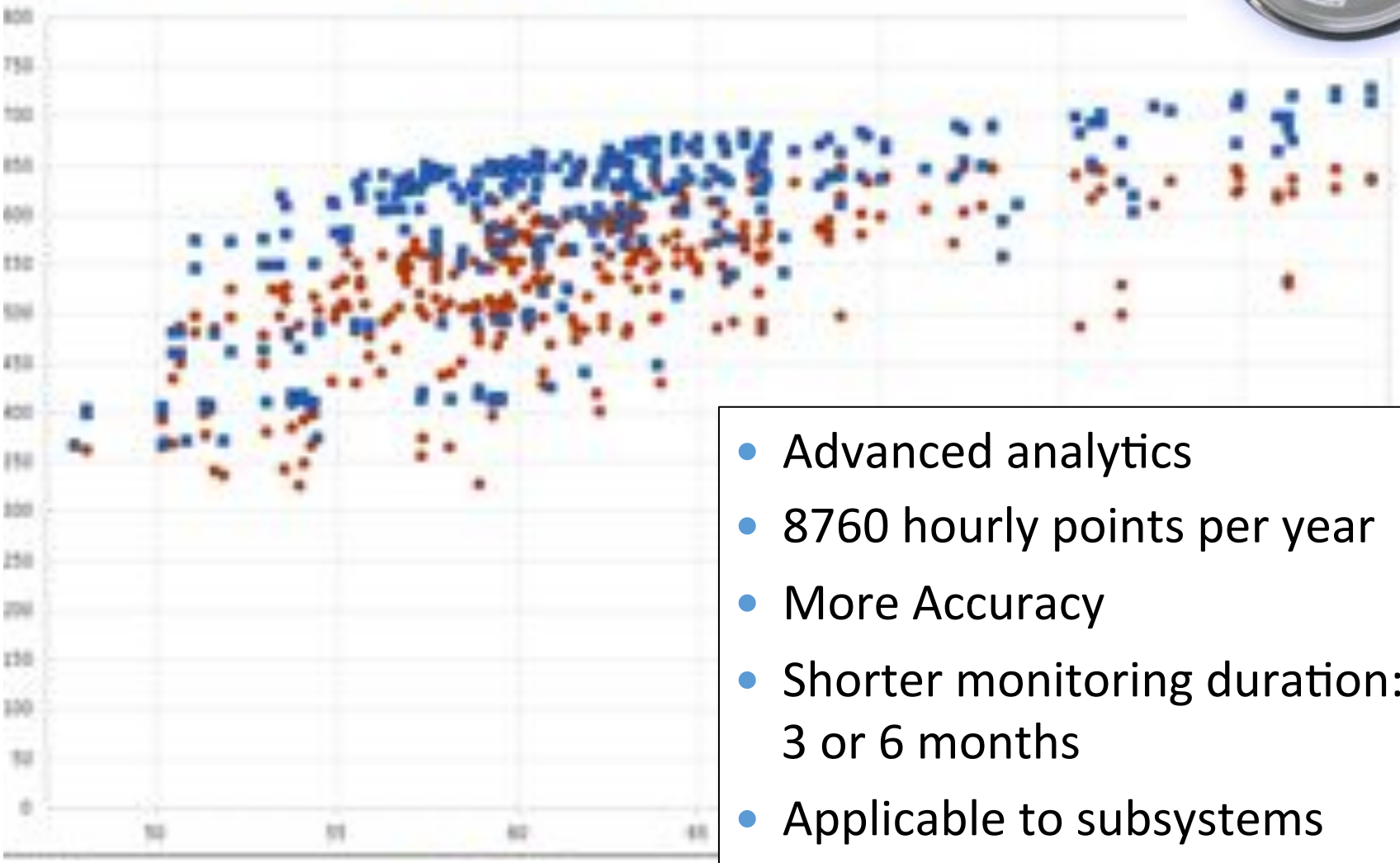
- Data Uses:
  - Building audits
  - ECM Commissioning
  - M&V
  - Performance tracking
- Potential
  - Lower cost – data collection and analysis tools
  - Rapid feedback –more customer awareness

M&V 1.0 – Monthly Data



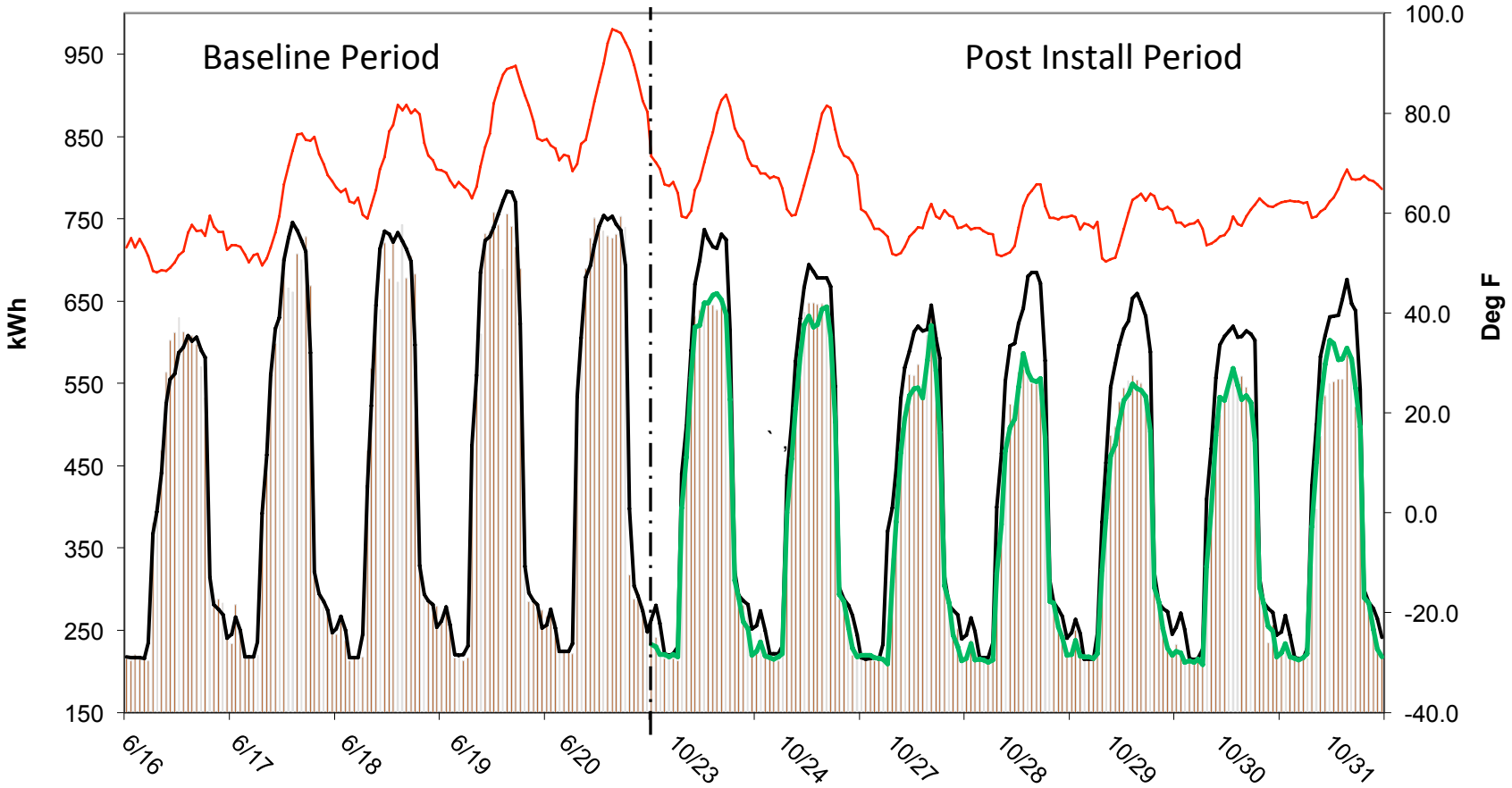
- Linear regressions
- 12 months/data points per year
- Less Accuracy
- 12 mo. monitoring duration

M&V 2.0 - Interval Data



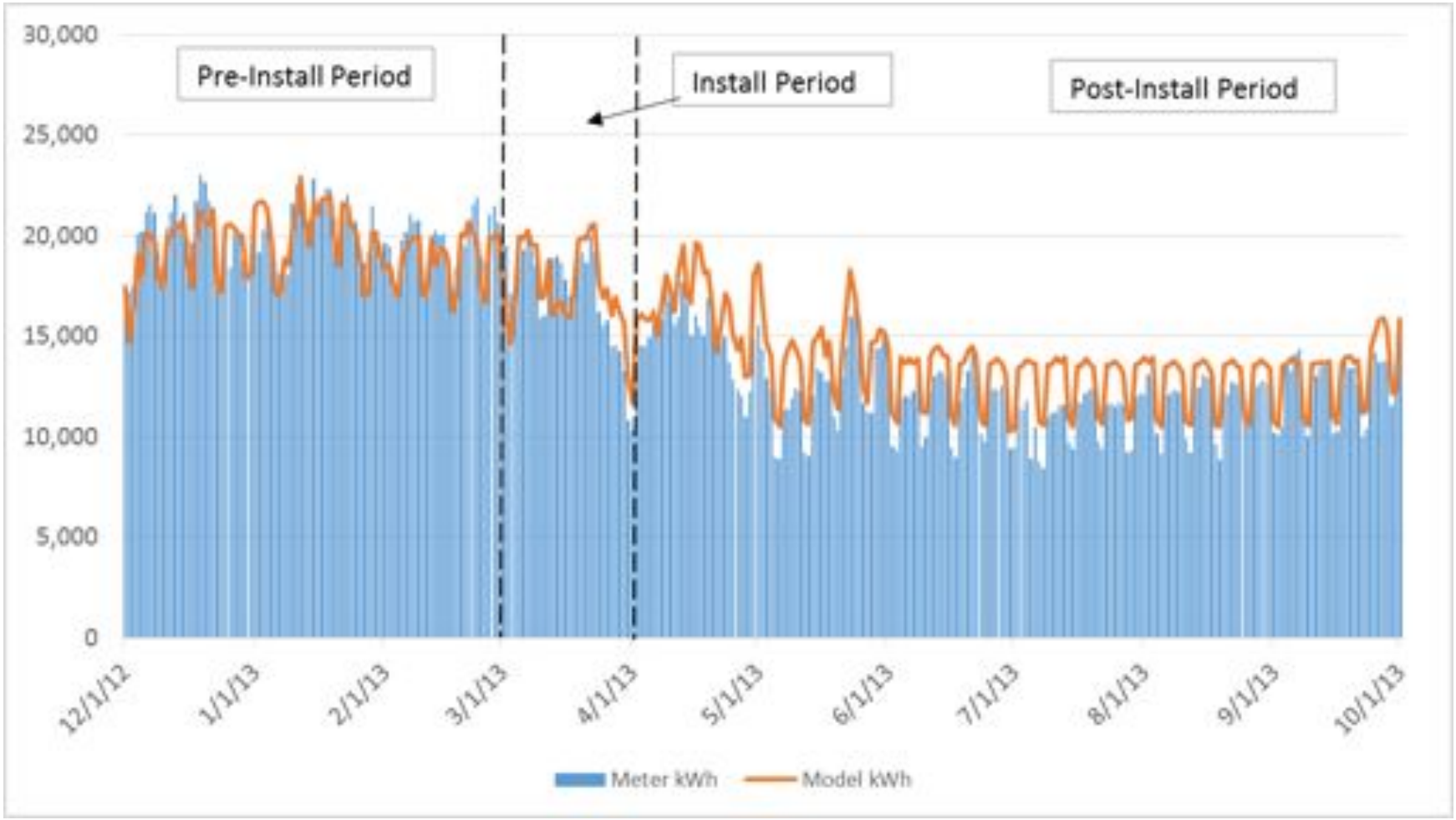
- Advanced analytics
- 8760 hourly points per year
- More Accuracy
- Shorter monitoring duration: 3 or 6 months
- Applicable to subsystems

Visualizing Savings



Source: Universal Translator v3

Monitoring Savings Persistence



M&V 2.0 Tools

Public Domain

Universal Translator

M&V Analysis Module

Energy Charting
and Metrics Tool

ASHRAE®

Inverse Model Toolkit (RP 1050)

EMIS - Proprietary

ENERGYSAVVY

BuildingIQ

FIRSTFUEL
BUILDING ENERGY ANALYTICS

C3

Screen Shots of M&V 2.0 Capability

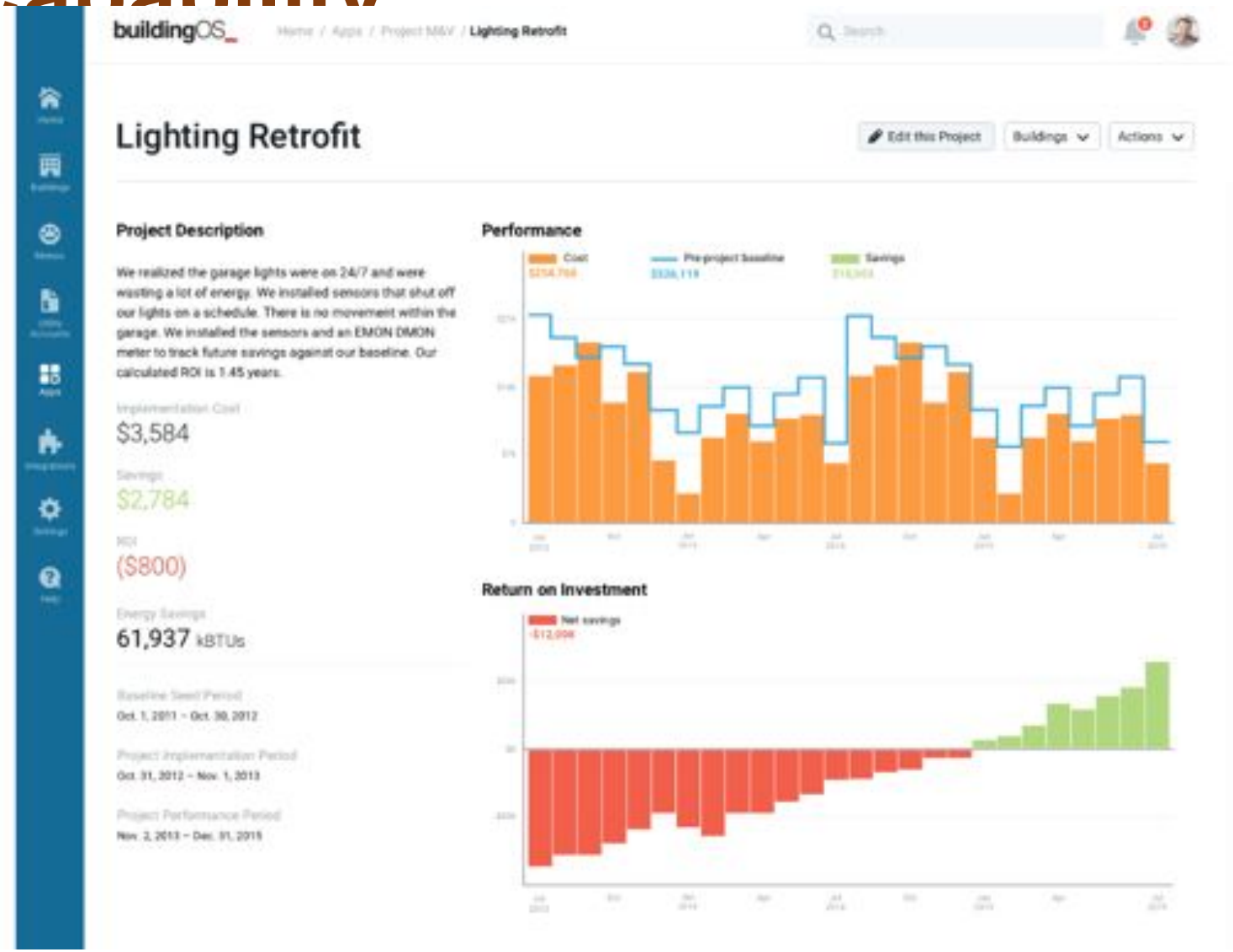


Image Source: Lucid

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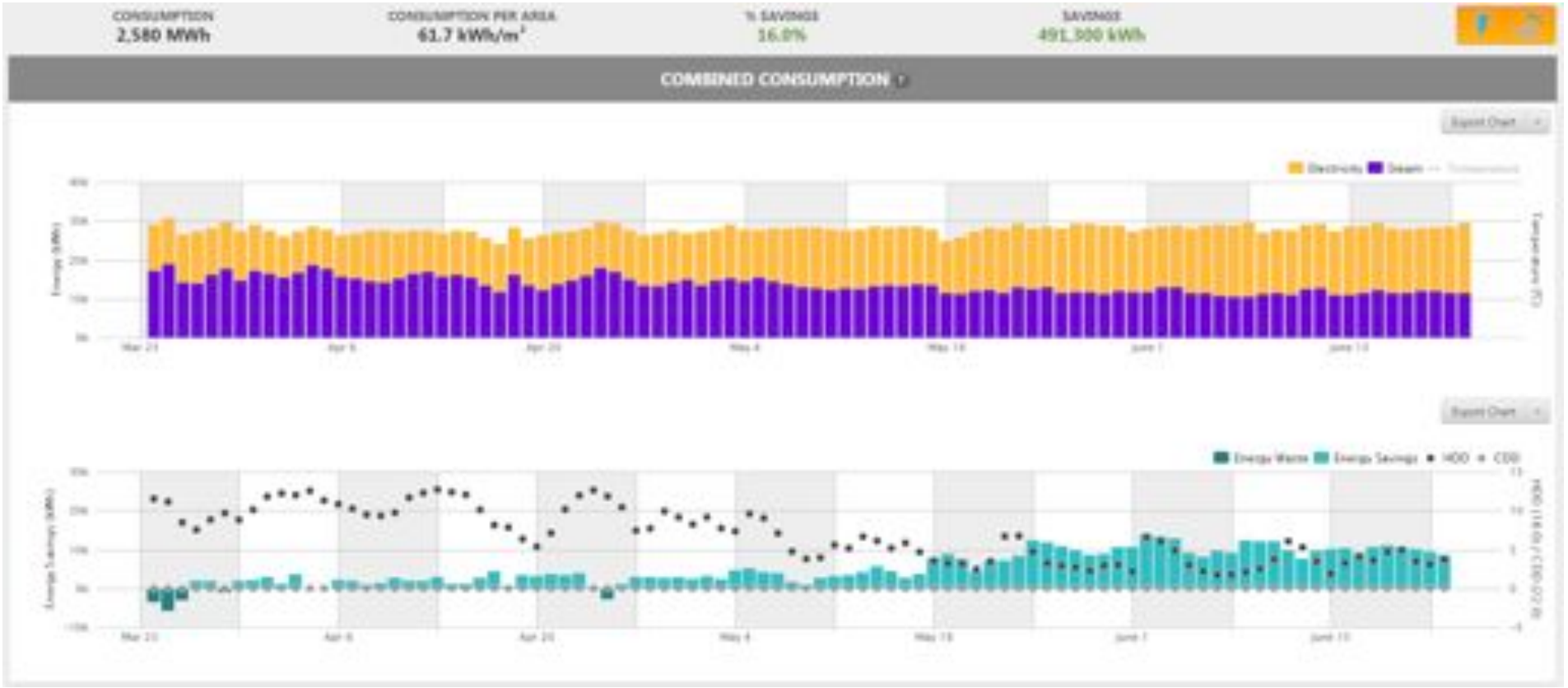

Image Source: EnerNOC

Screen Shots of M&V 2.0 Capability

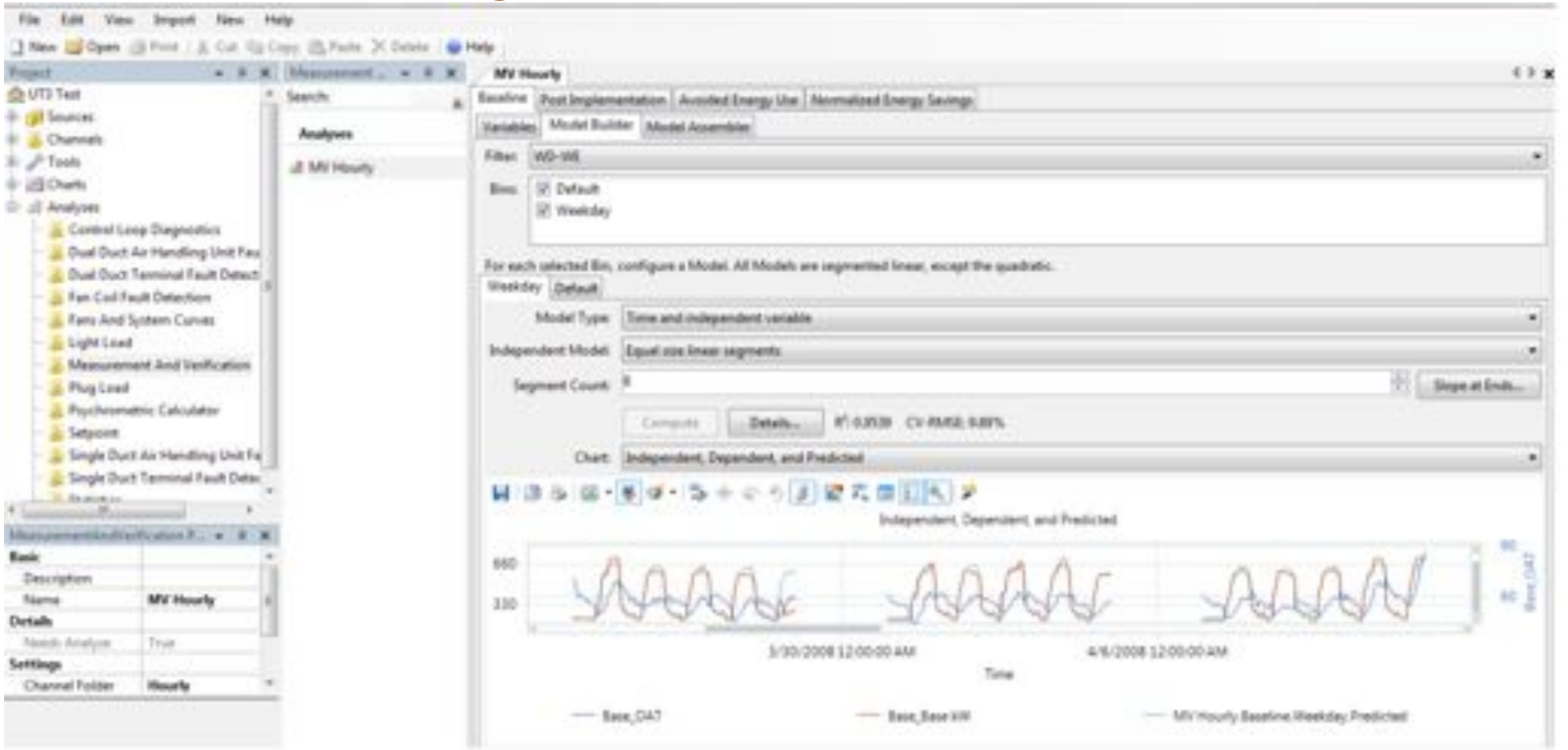

Image Source: Universal Translator 3

What is New About M&V 2.0? What is Not New?

- M&V 2.0 tools are built upon savings estimation techniques that have been used for decades
  - Comparison group analyses
  - Whole-building and submeter-based pre/post (Option C)
  - Calibrated simulation modeling (Option D)

- What's new is:
  - Degree of automation in data acquisition, and model creation
  - Granularity and volume of data can improve quality of result
  - Potential for continuous feedback
  - Integration of M&V capability with other analyses for operational efficiency
  - Software as a service offerings for owners, managers, program administrators

What are the Potential Benefits of M&V 2.0? What is the Value Proposition?

- Increase visibility, quickly obtain ongoing and interim results feedback
  - Increase savings and enhance customer experience?
  - Improve transparency and trustworthiness of EE savings?

- Automate parts of the process that computers do well, streamline data acquisition and processing
  - Reduce time and cost to quantify savings?
  - Maintain/improve accuracy in savings?
  - Increase throughput, number of projects going through the pipeline?

SCALE-UP

What Questions Are Being Asked*?

- How can we reduce the time and costs necessary to quantify savings?
- How can we know if a model or commercial tool is robust and accurate?
- How can we compare and contrast proprietary tools and 'open' methods?
- What test procedures can be used to evaluate model and tool performance, and which metrics are most important?
- Can I use a whole-building approach for my programs and projects?

***All are asked before a project is conducted; after a project, we want to know how much was saved, what was the uncertainty, how confident are we in those savings?**

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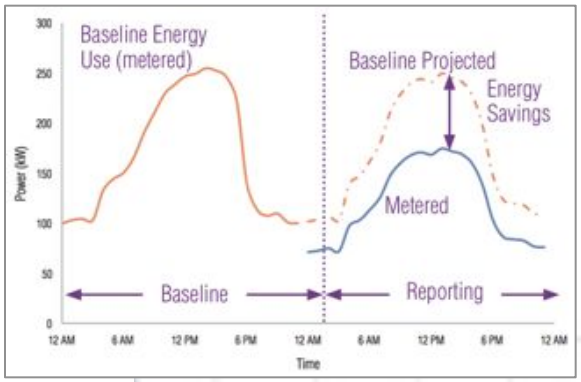
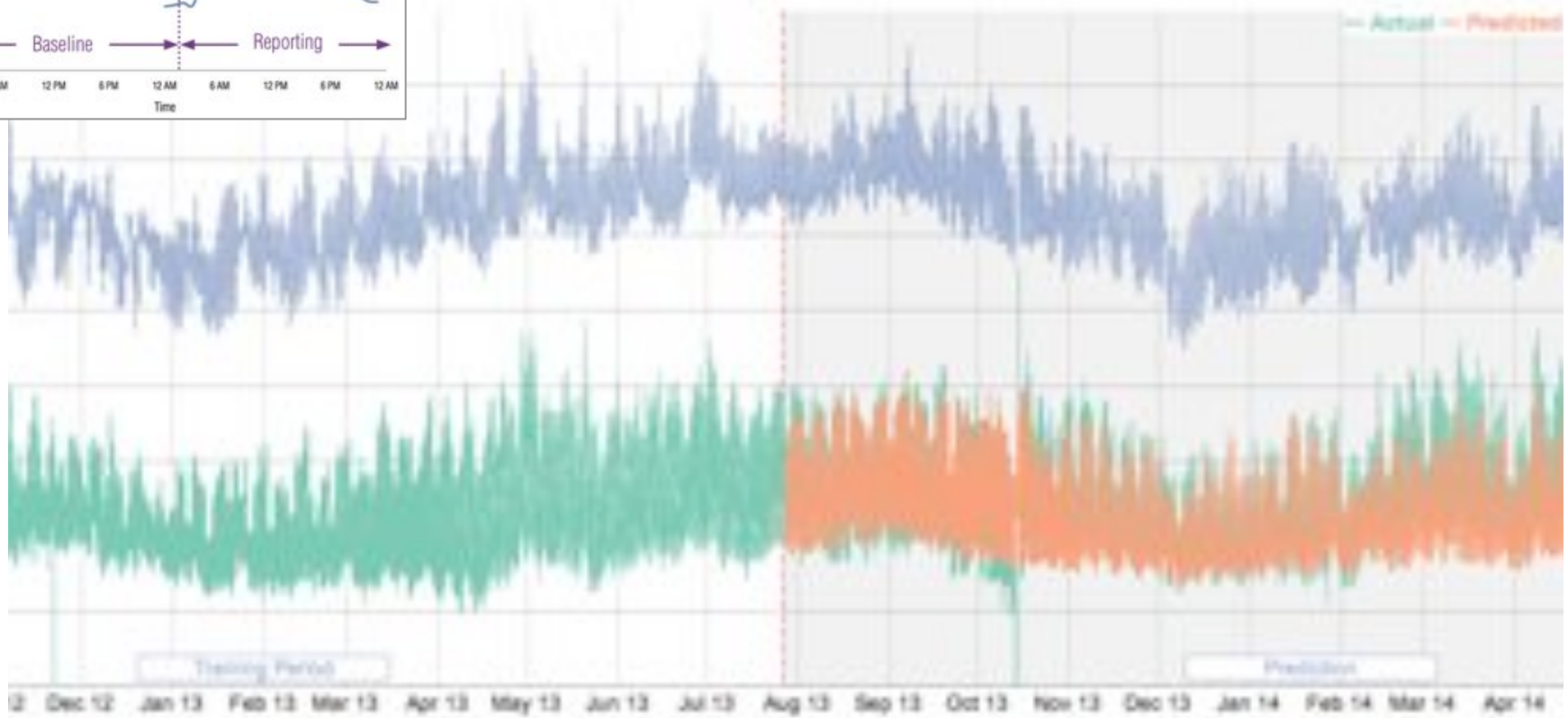
What Have We Done to Address These Questions?

- **Developed a testing procedure** to quantify baseline model accuracy
- **Solicited *new interval* baseline models** from industry, tools, and academic communities
- **Applied the test procedure** to evaluate model performance
- With advisory group **identified most critical performance metrics for M&V**
- **Developed conclusions regarding potential** for wider adoption of AMI data + analytics for M&V

Illustration of Test Procedure





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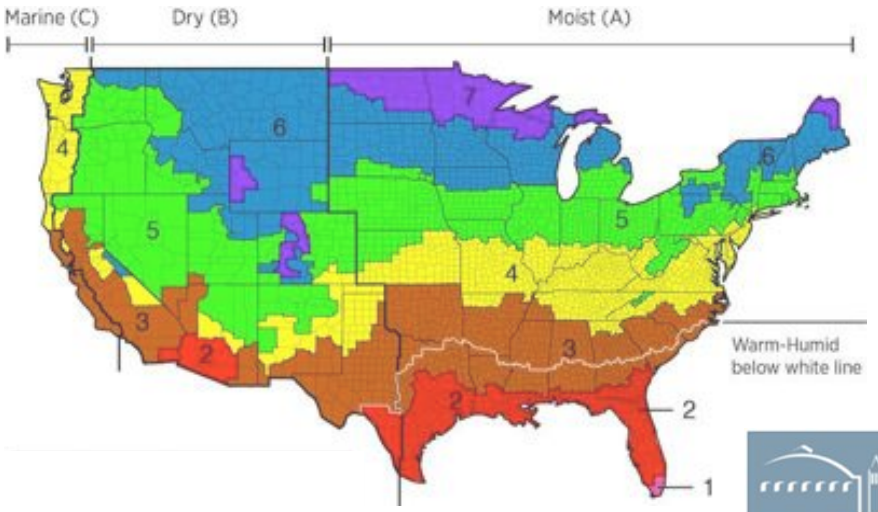
Test Data Set

- 537 commercial buildings
  - 15-minute electric load data
  - Outside air temperature based on zip code

- No *known* efficiency interventions, significant changes in operations, occupancy

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



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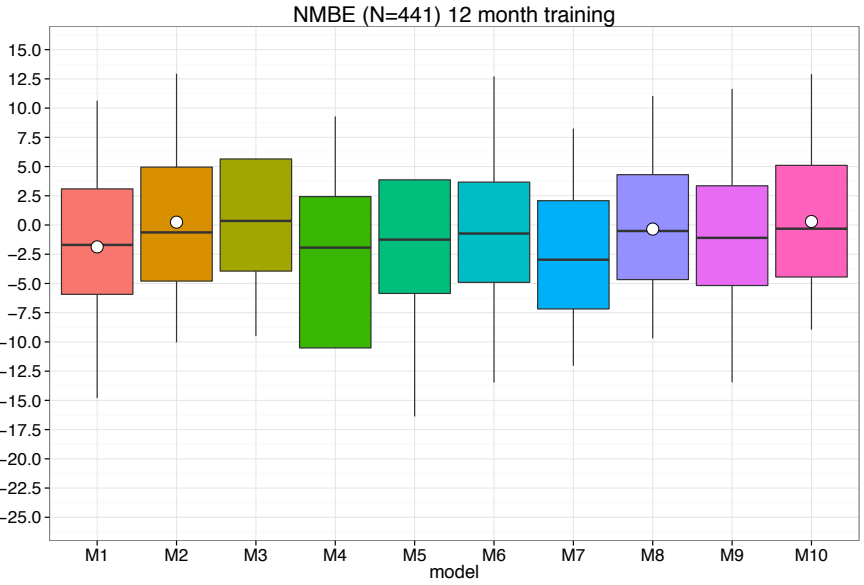
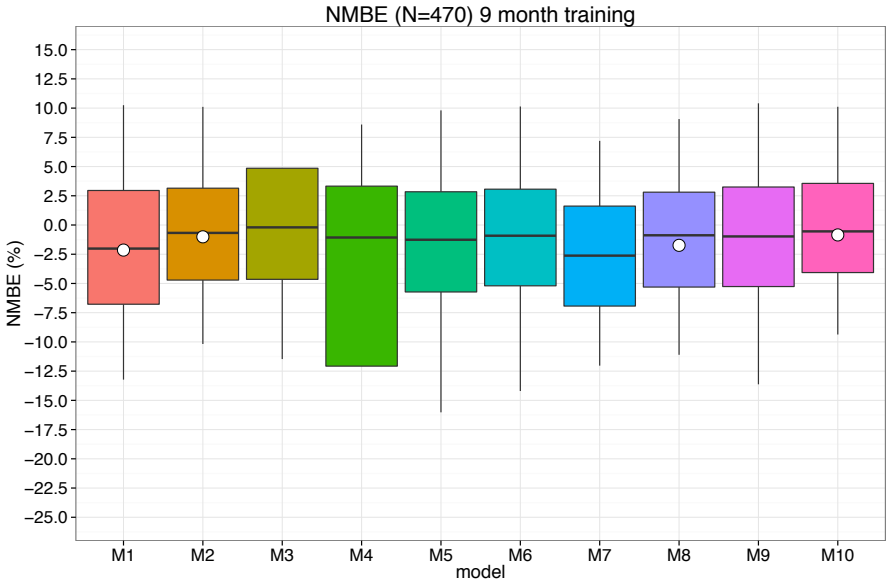
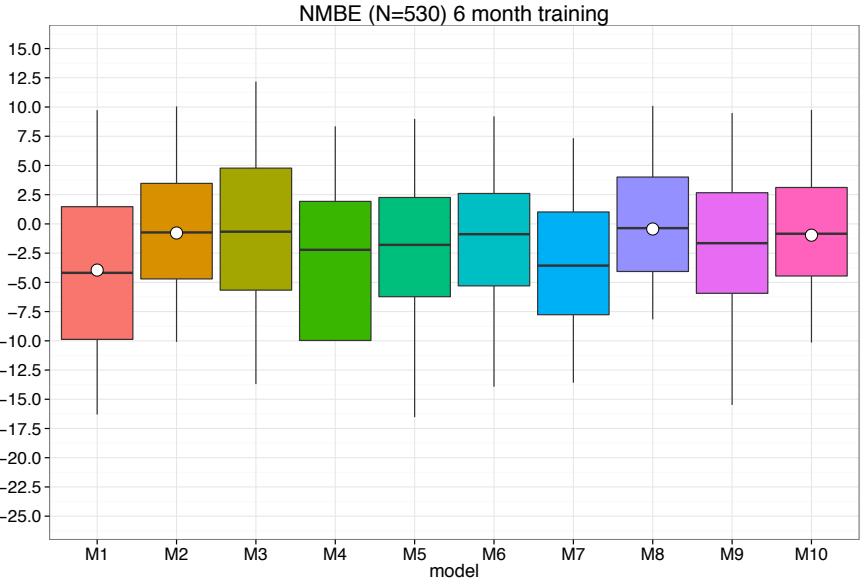
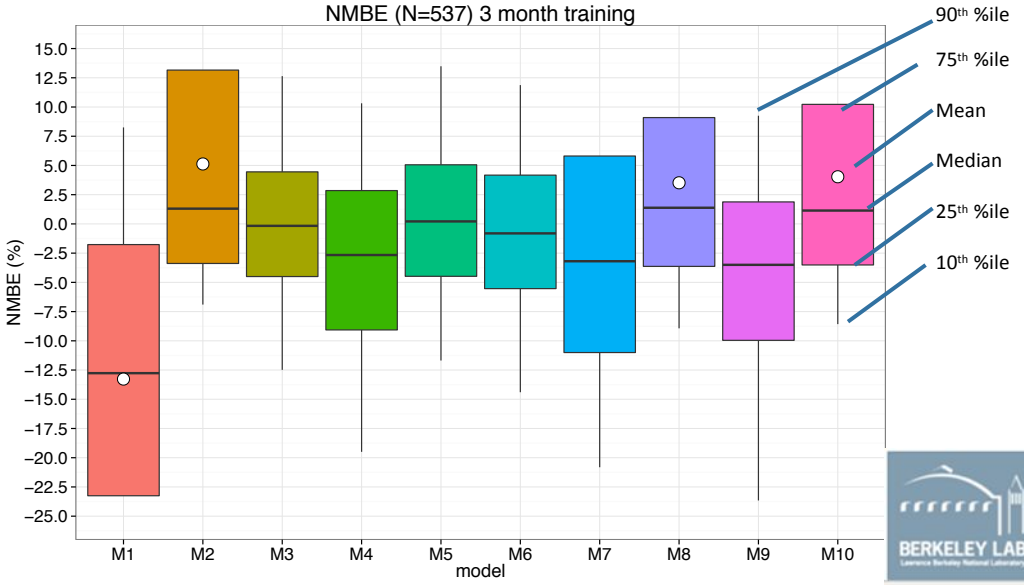
Percent Error (NMBE)

Total number of buildings in the test case









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Key Takeaways

- AMI data and interval data models/tools hold great promise to scale whole-building measured savings calculations
  - Reducing time and costs, improving or maintaining accuracy

- Errors in predicting energy are on the order of a couple of percent for many buildings and many models
  - This is the floor of performance from the *fully automated case*, with no 'non-routine' adjustments from an engineer

- 12 months pre/post data may not always be required for accurate whole-building M&V

- Models effectively meet ASHRAE guidelines in most cases

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Ongoing Work

- Demonstration of automated approaches with utilities/ programs, and implementers or analytics vendors
  - ☐Use data from buildings that have participated in whole-building (preferably) programs or pilots
  - ☐Apply automated M&V alongside whatever M&V plan was/is already in place
  - ☐Quantify savings with uncertainty and confidence
  - ☐Publish and case studies on effectiveness

LBNL is currently seeking utility/program and implementer or vendor partners who are interested in collaborating in this work. Please contact JGranderson@lbl.gov if you are interested in exploring this opportunity.

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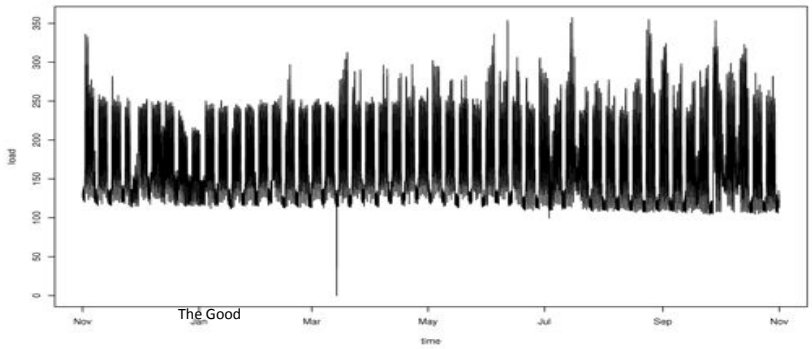
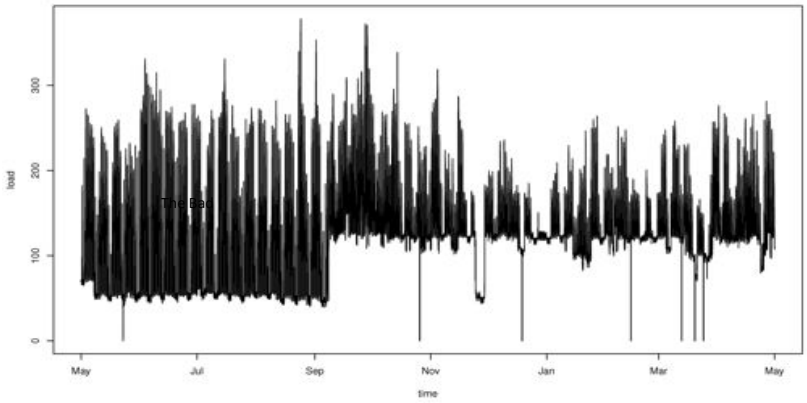
Predict/Forecast

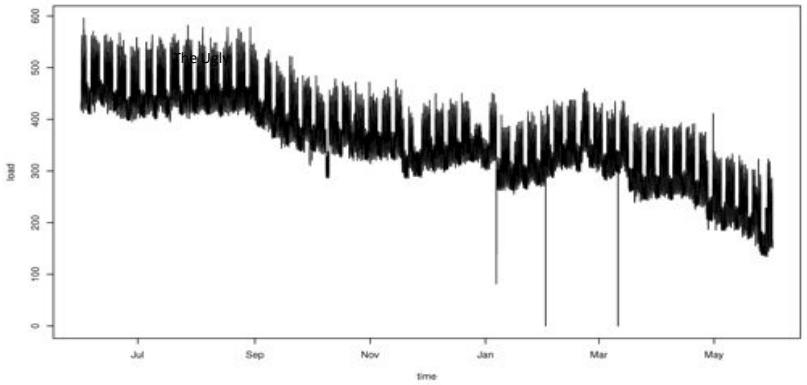
- Good buildings:
  - Predictable operation



- Bad buildings
  - Requires intervention



- Ugly buildings
  - Cannot predict future use



Best Applications – Meter-Based M&V

- 'Predictable' buildings, systems:
  Weather sensitive, regularly scheduled
- Multiple and interactive ECMs:
  Affecting many systems (HVAC, lighting, etc.)
- Deep savings projects:
  Savings are "above the noise"
- Difficult to quantify ECMs:
  Duct sealing, envelope upgrades, etc.
- ECMs using existing condition as baseline:
  RCx, behavioral
- SMB sector: other approaches not cost-effective

AB 802 & Meter-Based P4P

PG&E

- Commercial Whole Building Demonstration

Statewide

- UC/CSU/IOU Partnership MBCx Program

HOPPs

- SCE – Public Sector
- SoCalGas
  - Public Sector
  - Commercial Restaurant
  - Multi-family
- PG&E
  - On-bill financing
  - Residential P4P

Thank you!

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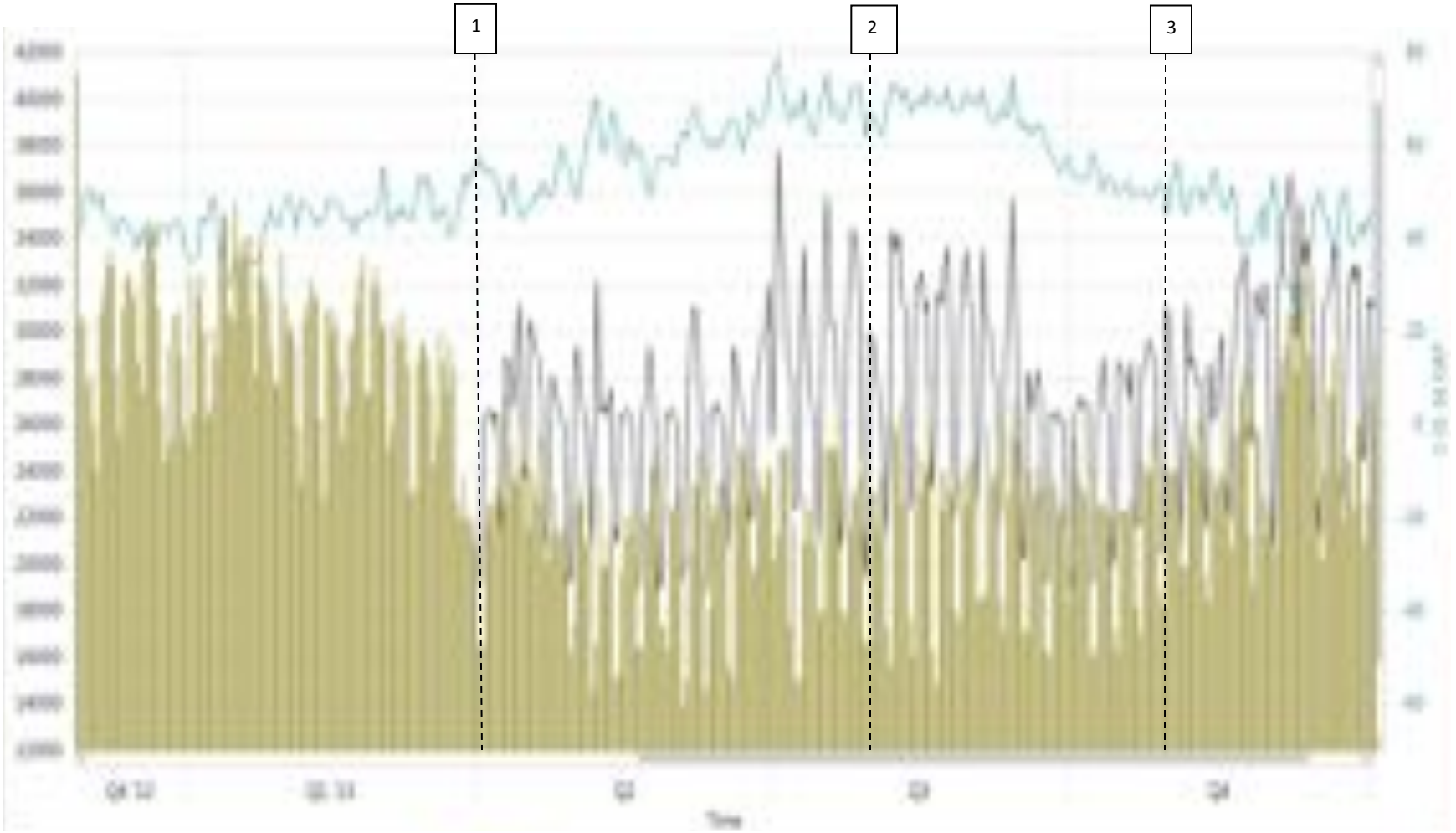
Meter-Based M&V Approach

- Total Savings: All ECM savings behind meter, including interactive effects and stranded potential
- Less Complex: few data streams required (energy, weather)
- Tools: public domain and vendor software
- Accurate: Enables estimate of accuracy
- Persistence Monitoring: Ongoing feedback on building performance
- Potentially Lower Admin Costs: standardization & automation reduces required time for savings analysis & technical review

Pay For Performance



EM&V Process Overlap

Step 1: Project Level Savings (M&V)

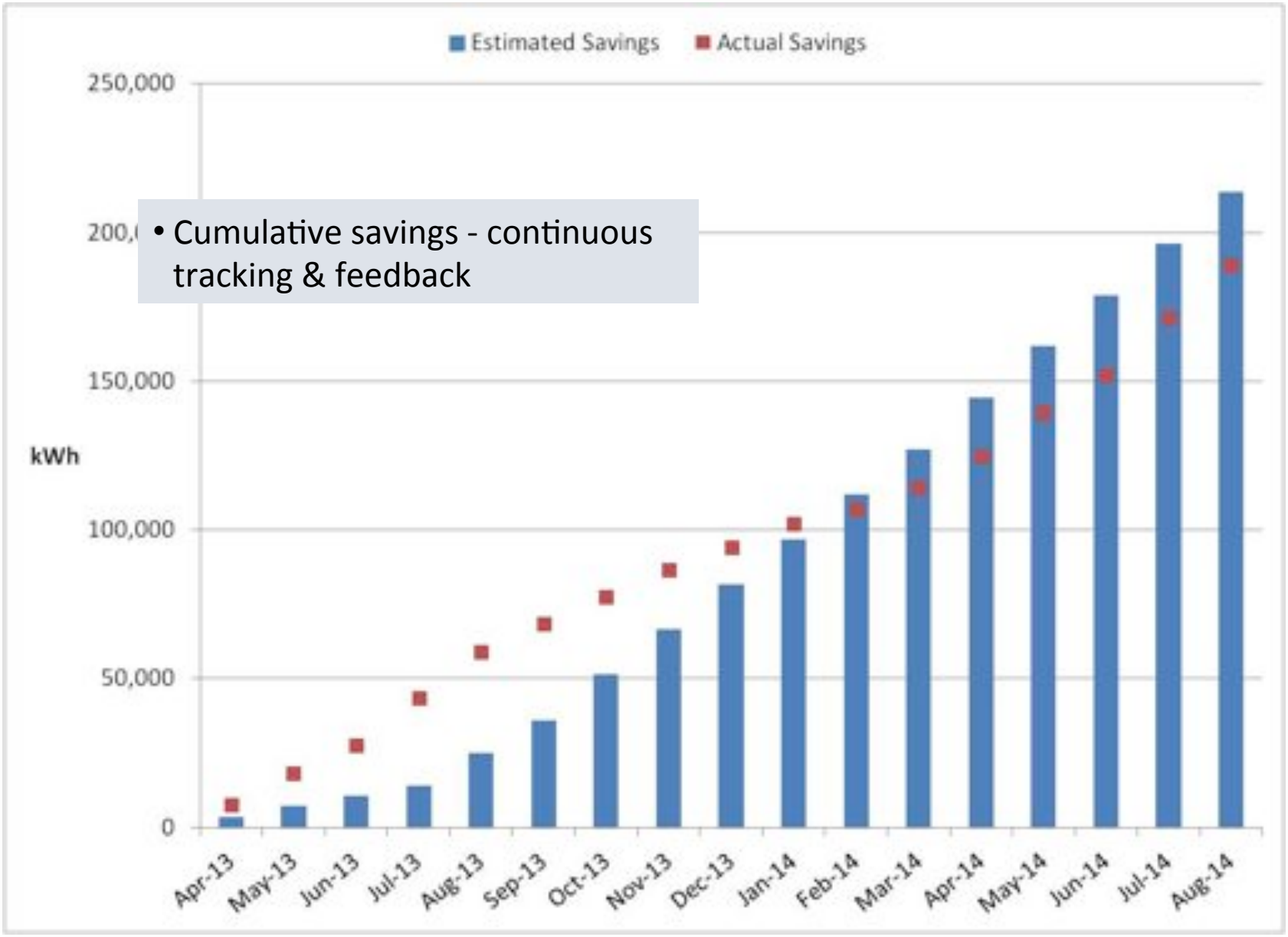
- Gross savings (Customer)
- To & Above Code Savings (Regulatory)

Step 2: Attribution

- Account for free-ridership

Step 3: Program Level Savings

- Determines ‘additionality’ of savings
- Program cost effectiveness


Estimated Savings
Actual Savings
250,000
200,
150,000
100,000
50,000
0
kWh
• Cumulative savings - continuous tracking & feedback
Apr-13
May-13
Jun-13
Jul-13
Aug-13
Sep-13
Oct-13
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