R&D for M&V 2.0

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Outline

- Background
- Motivating industry questions and R&D approach
- Results highlights
- Ongoing and future work

A diversity of savings estimation approaches is used today

Approach	Meter based?	Net or Gross?	Program/measure sweet spot
Randomized control trial, encouragement designs	Yes, with other data	Usually Net	Programs w large numbers: residential, behavioral, small savings/site
Deemed, stipulated	Not directly	Gross, Net in some cases	Efficient equipment replacement/installation
Calculated	Not typically	Gross, Net	Custom industrial and large commercial; new construction
Calibrated simulation modeling (IPMVP Option D)	No (except the calibration)	Gross, Net	Retrofit, large commercial
***Normalized whole-building, isolation (IPMVP Option C, maybe B)**	**Yes**	**Gross**	**Commercial, multi-measure, interactive effects, operational measures**

***This is the focus of the R&D efforts presented here**

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Where are meter-based approaches most appropriate?

- ‘Predictable’ buildings
  - Weather sensitive, regularly scheduled
- Projects with multiple and interactive measures
  - Affecting several building systems (HVAC, lighting, etc.)
- Difficult to quantify measures

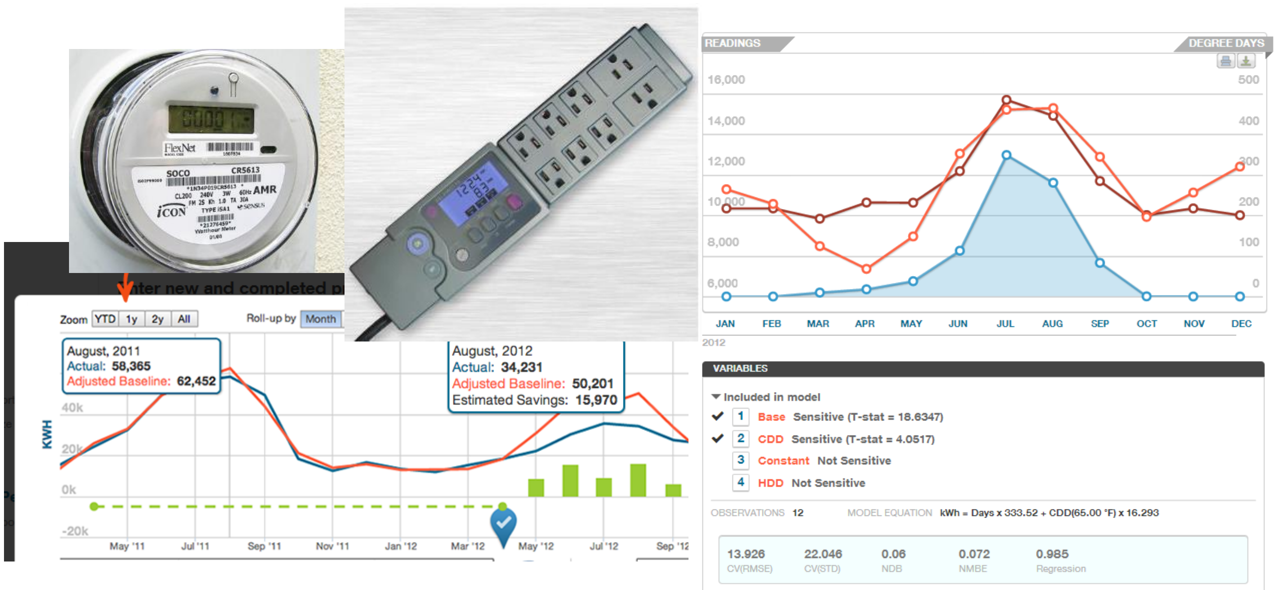
  Duct sealing, envelope upgrades, etc.
- Projects with larger savings, ‘above the noise’
- Measures using existing condition as baseline
  - Retrocommissioning, behavioral, operational

Promising opportunities associated with meter-based M&V approaches

- Enabling delivery of whole-building programs that combine strategies for deep savings
- Enabling pay-for-performance programs
- Scalability and streamlining
  - Reduce labor time and costs
  - Maintain an accurate result
  - Quickly obtain ongoing and interim results
  - Increase throughput, number of projects

What is M&V2.0?

- Generally understood as: use of interval meter data, analytics, computation at scale
  - to streamline the M&V process through semi/automation
- Delivered in proprietary tools, ‘open’ algorithms



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Screen shots of M&V 2.0 tools

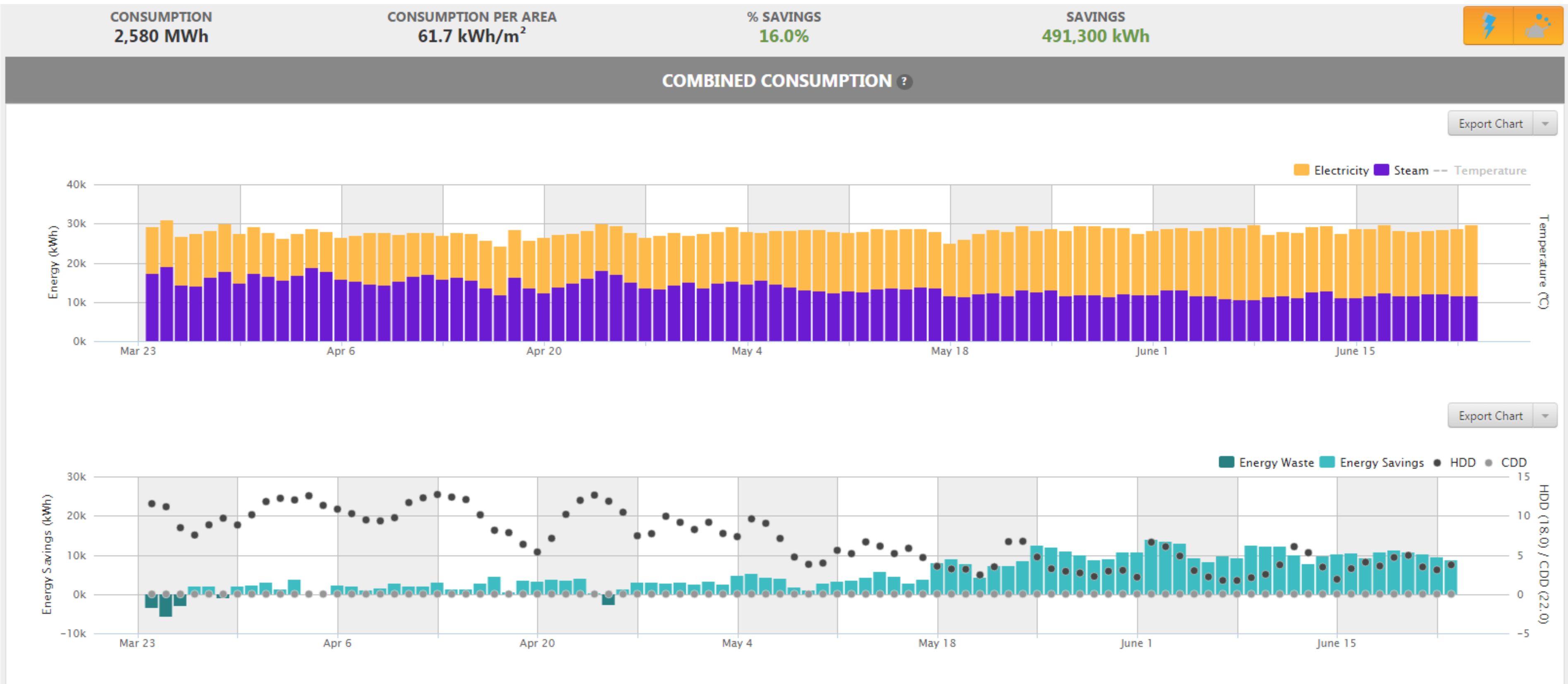

Image Source: EnerNOC

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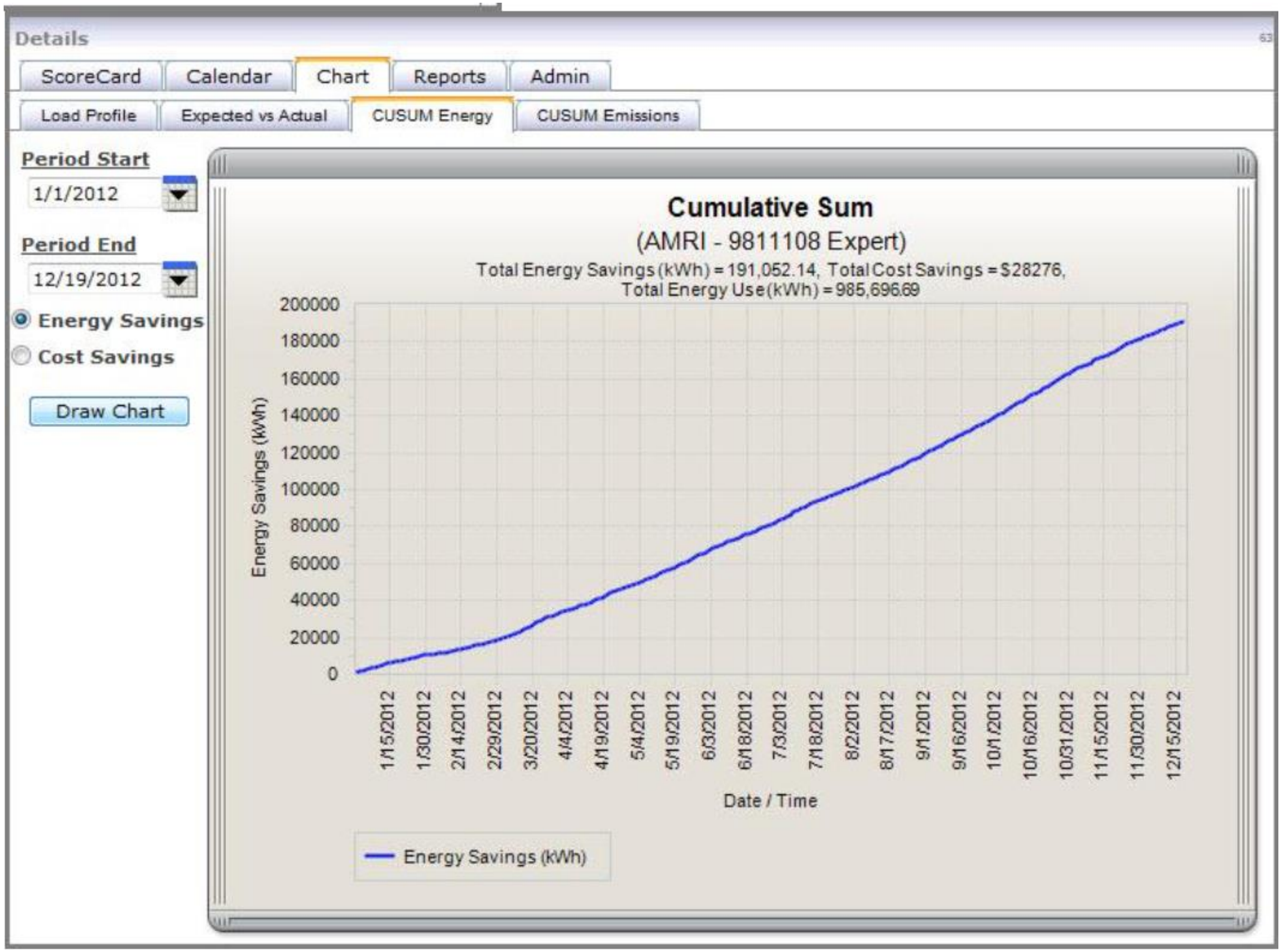

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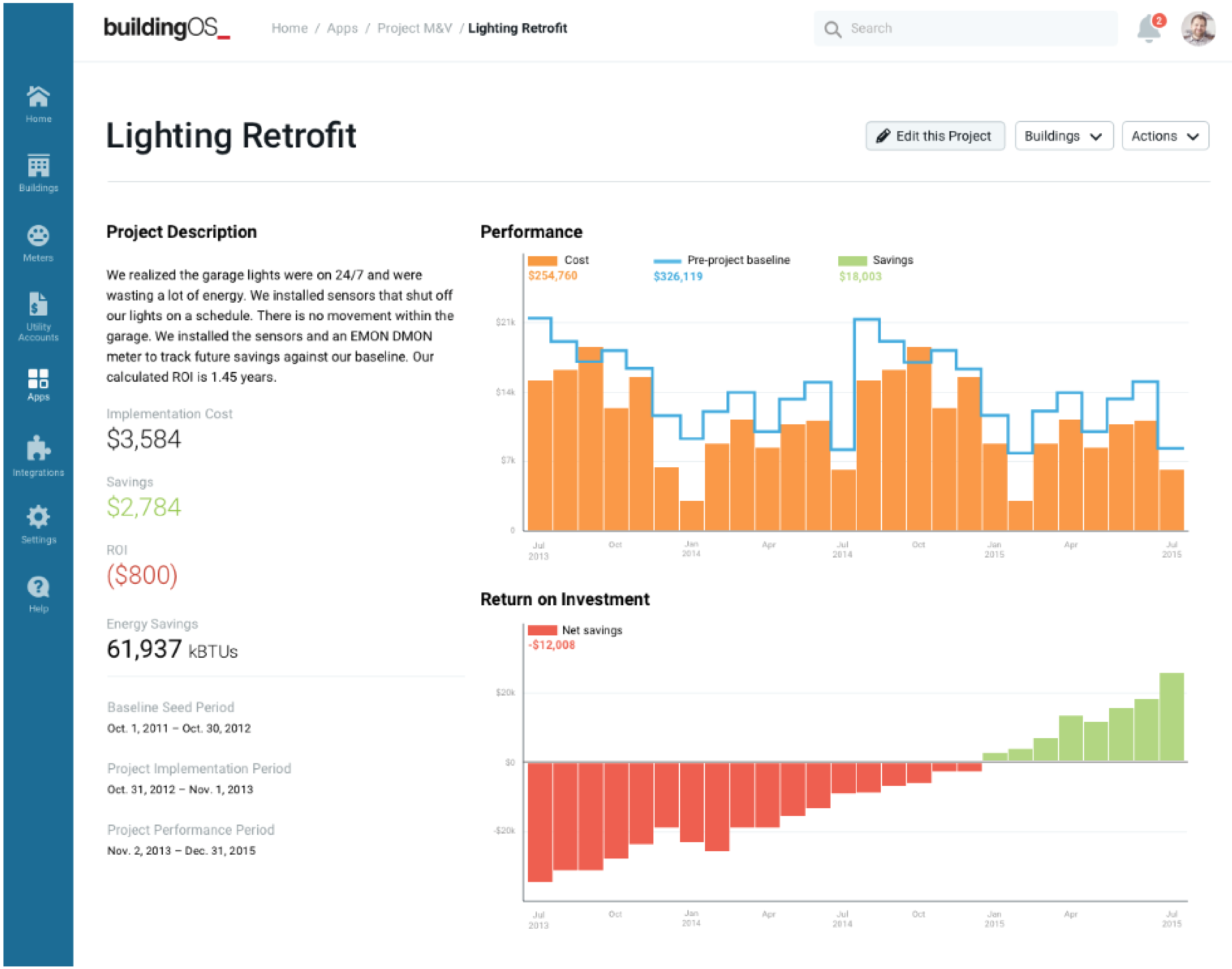

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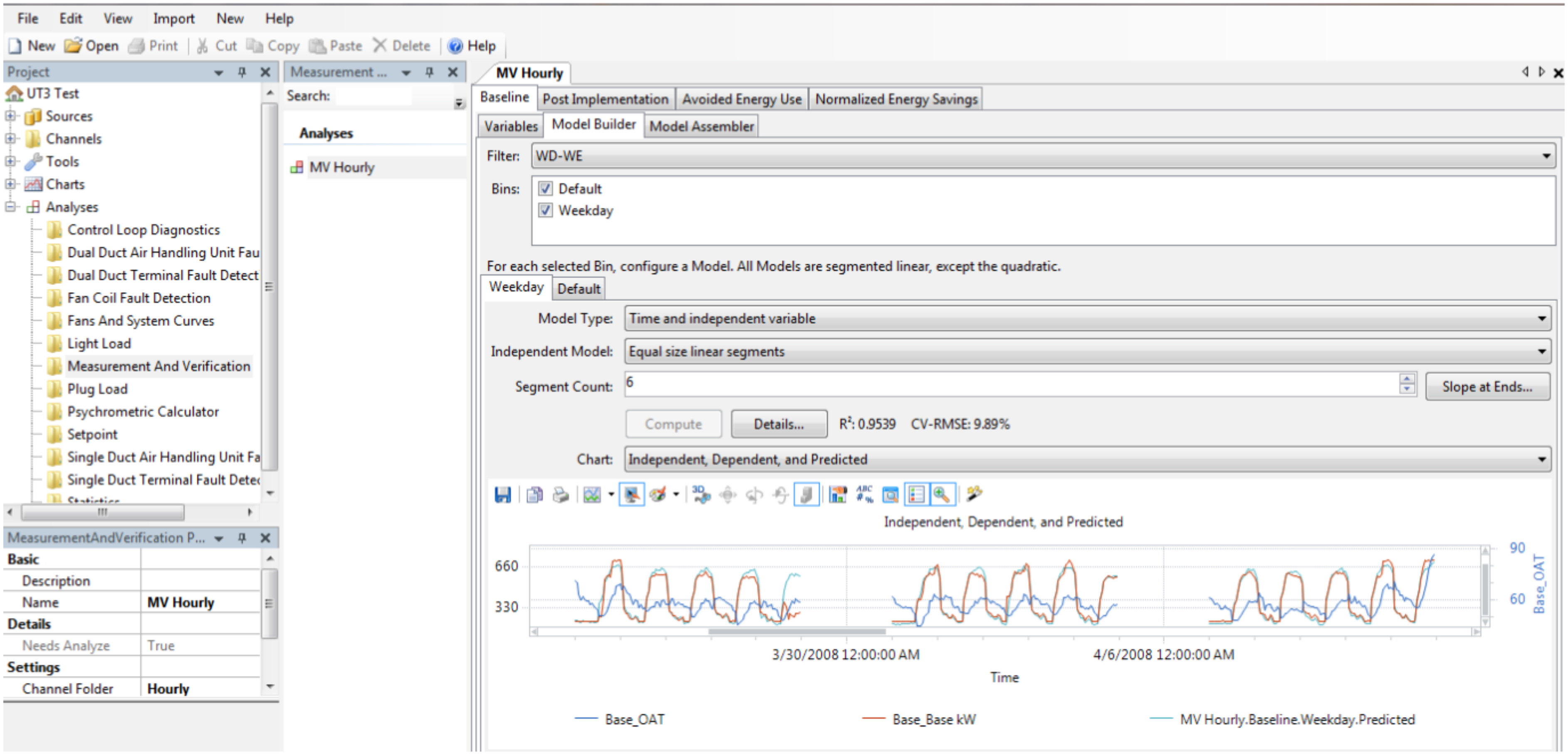

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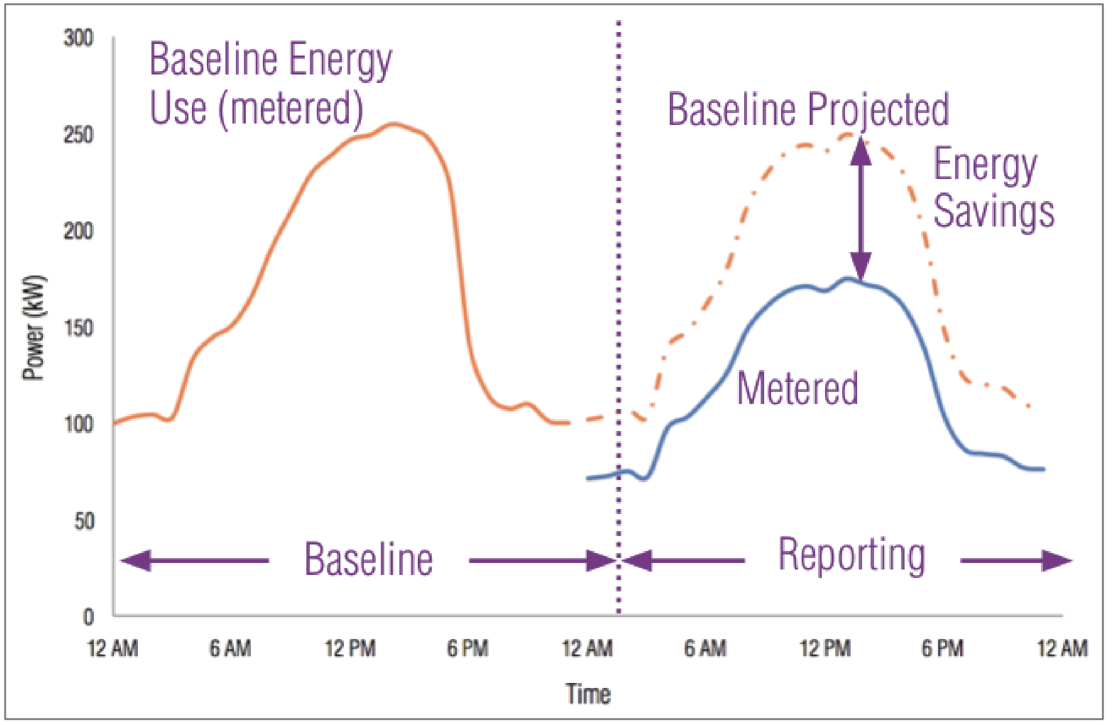
How are meter based savings quantified?



Metering at whole-building (Option C), or submetered measure isolation level (Option B)

In M&V2.0 tools baselines are automatically created with meter and weather data feeds

User enters date of measure implementation, savings are calculated by the tool

Motivating Industry Questions and R&D Approach

Industry questions motivate LBNL's R&D

- Are these proprietary tools reliable?
- How can I verify their accuracy and compare them?
- Are proprietary tools any better or worse than standard regressions?
- Even if a tool is generally robust, how do I know that it will work for my specific projects or program?
- How "big" do my savings have to be to use these approaches?
- How do I know that a robust tool was applied to generate a quality result?

Four-step R&D approach to answer these questions

1. Population-level (many buildings) M&V2.0 testing to verify general, overall robustness

2. 'Off-line' demonstration of promising models with historic utility program data

3. Identification of reporting requirements and quantitative acceptance criteria for savings claims

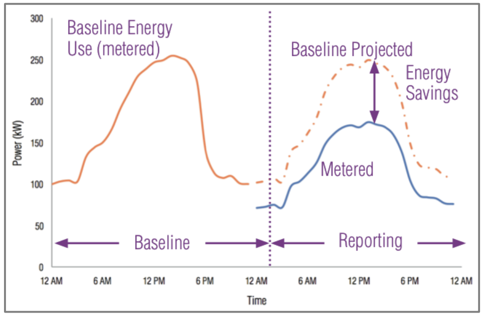
4. Larger demonstrations on 'live' programs

Test → Demonstrate → Scale

1. Population-level, general testing

- Validate M&V 2.0 tools/models against large test data sets (n=100s) from real buildings of various types, from different climates

- Determine accuracy in predicting 1 yr of whole-building energy use with 1 yr (or less) of meter and weather data



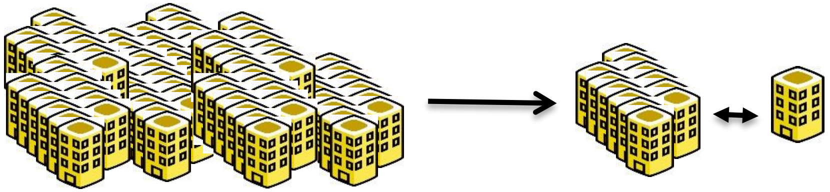
- Document distributions of errors; fraction of buildings for which models predict with low error, given only weather and interval meter data

- Compare proprietary models to ‘open models’ using standard procedure and metrics

2. Demonstration with historic program data

- Given tools that generally predict energy well, use them to automatically quantify savings

- Develop practitioner workflows to leverage automation while retaining accuracy of the savings result
  - Many, but not all buildings are 'predictable'
  - Gross savings at the meter may not be gross savings due to the measure, i.e., non-routine adjustments may be needed
  - Uncertainty analysis can be used quantify *accuracy of the savings results when applied to specific projects/buildings/programs*
    - Complementing *general assessment of predictive accuracy*



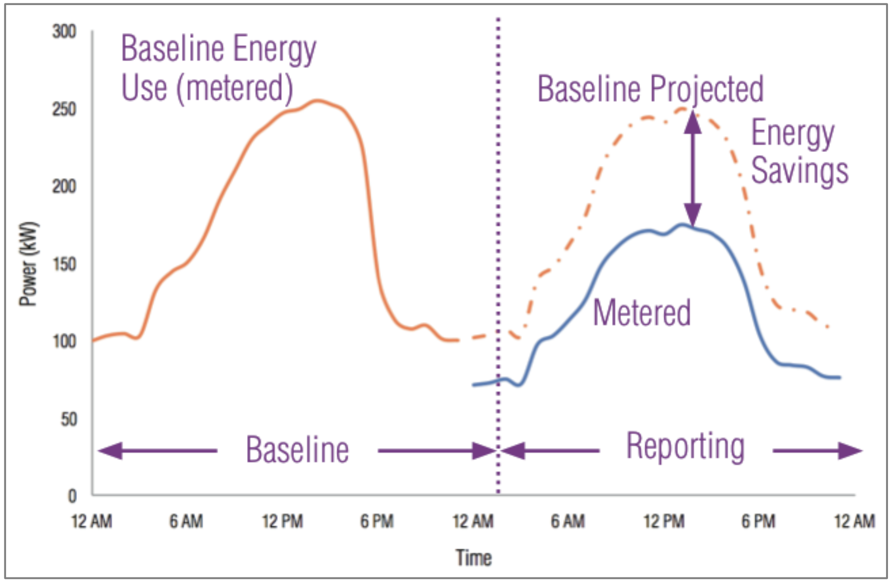
Non-routine adjustments and savings uncertainty

Savings = (Baseline Projected Use) – (Metered Use) +/- (Non-Routine Adjustments)

Accuracy in savings driven by accuracy of baseline projection and NR Adjustments

M&V2.0 tools do not commonly flag need for NR adjustments, or calculate savings uncertainty beyond normalizing for the inputs that are metered

Practitioners need workflows to address these issues to maintain and document a credible result



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3. Acceptance criteria and reporting requirements

- New tools and model improvements are constantly being developed
  - Is there value for an industry body or agency to test and validate M&V tools?

- With M&V2.0 we now have the data to quantify uncertainty in gross savings at the project and aggregated portfolio level
  - *Capacity market bids, utility-wide net*: 90% confidence, **savings** +/- 10%
  - *ASHRAE building-level gross*: 68% confidence, **fractional** savings +/-50%
  - M&V2.0 is on track to equal existing requirements

- How can a practitioner document that they have ‘done it right’, i.e., applied tools appropriately, and correctly quantified uncertainty?
  - What is needed for transparency and evaluation of gross savings claims?

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Questions on Approach? (Results Are Next)

1. Population-level (many buildings) M&V2.0 testing to verify general, overall robustness

2. ‘Off-line’ demonstration of promising models with historic utility program data

3. Identification of reporting requirements and quantitative acceptance criteria for savings claims

4. Larger demonstrations on ‘live’ programs

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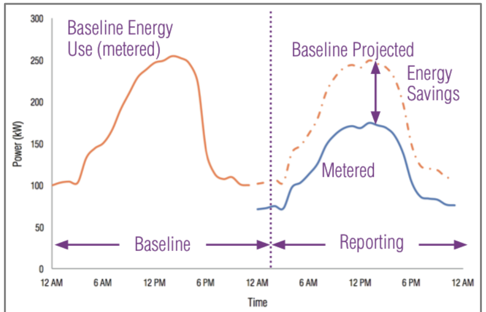
Results Highlights

1. Population-level, general testing

- Tested accuracy of baselines projection in proprietary tools and open standard models against data set from 500-600 untreated buildings
- Given 12mo whole building interval data, predicted 12mo of energy use
  - Within {-1, 5}% error for a full half of the buildings, CV(RMSE) well within ASHRAE Guidelines, errors even smaller when aggregating buildings into portfolio
- No attempts to refine models based on expertise, knowledge of buildings, additional variables
  - Floor of predictive accuracy
- Test procedure published, used by PG&E to prequalify tools for pilot, available for use by others



2. Demonstration with historic program data

- Data from 51 buildings that underwent RCx and in some cases retrofits

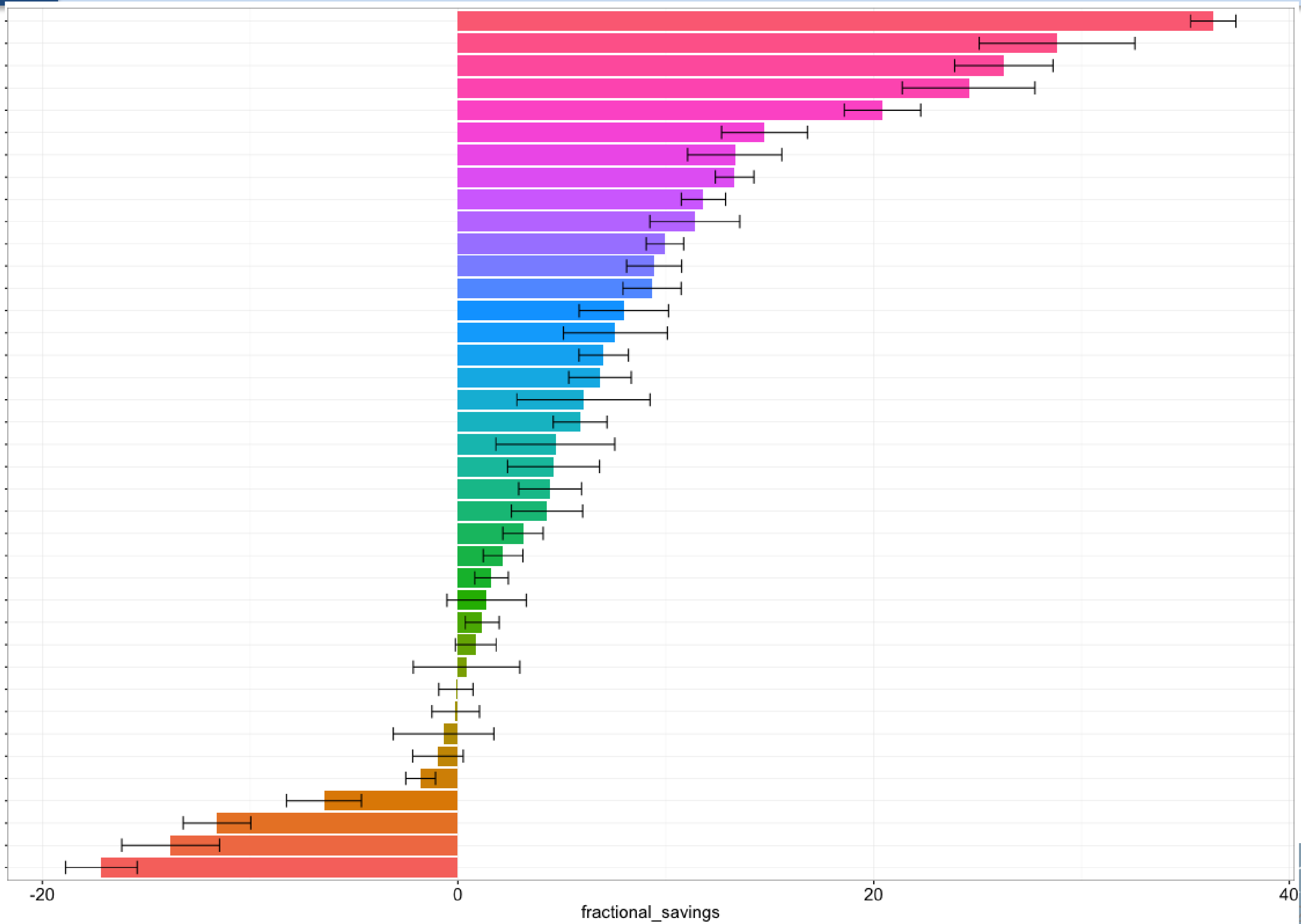
- Preliminary workflow, drawing from ASHRAE Guideline 14
  - Auto fit the model to data from measure pre-period
  - Auto compute goodness of fit metrics R^2, CV(RMSE) and NMBE from the pre-period and the fit model
  - Set aside buildings w/ $R^2 > 0.6$ or CV(RMSE) $< 25\%$;
    - these will require data inspection, and engineering expertise to determine whether a better fit can be obtained through adjustments or tailoring
  - For 'good' buildings auto compute savings using M&V2.0 tool
  - Automated quantify uncertainty savings for each building
  - Aggregate savings and uncertainties for each building, to determine portfolio-level results

Findings from applying this workflow

- Of the 51 buildings, 39 'passed' the goodness of fit tests and ASHRAE guidance
- Of the 12 that did not 'pass', 5 had incorrect documentation of measure implementation date; models can quickly be refit

- For this data set, 44 of 51 buildings look to be well-suited to automated analysis; 7 may require more manual investigation
  - In this program, baseline period was carefully 'tended' for static conditions

Uncertainty analysis



Savings uncertainty ranges for each of 39 buildings, at 95% confidence level

Uncertainty analysis

- 32 of 39 individual buildings satisfied/exceeded ASHRAE uncertainty requirements

- At portfolio-level for the aggregate of the 39 buildings, at 95% confidence level
  - Savings = 3.96% within confidence interval of [3.66%; 4.26%]
  - Aggregate *far* exceeds ASHRAE guidance for sufficiency

Answers to industry's questions

- Are proprietary tools reliable? How can I verify their accuracy? Are they any better or worse than standard regressions?
  - Standard replicable test procedure and metrics used to show that *many* models predict within a few percent for *many* buildings

- Even if a tool is generally robust, how do I know that it will work for my specific projects or program?
  - Use test procedures and automated tools to quickly assess with participant or candidate participant load shapes
  - Ongoing LBNL demonstrations, beyond the first 51 projects

- How "big" do my savings have to be to use these approaches?
  - Results suggest that with interval data we can go beyond the 10% rule of thumb established with monthly data

- How do I know that a robust tool was applied to generate a quality result?
  - Ongoing work in practitioner workflows and acceptance criteria

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Questions on Results Highlights?

Ongoing and Future Work

Ongoing, current work (through Sept.)

- Analyze more historic program data with partners
  - Continue developing suggested practitioner workflows
  - Understand portion of buildings for which automation is possible with high confidence, low uncertainty
- Begin engaging regulatory and evaluation community for dialogue on acceptance criteria

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Future work

- Transfer of M&V2.0 tool testing procedure (general predictive accuracy) to industry for formalized, ongoing use
- Establish acceptance criteria and documentation requirements.
- Explore methods for auto-identification of non-routine adjustments, standardize
- Conduct larger demonstrations of M&V 2.0 in 'live' programs

Thank You!

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For more detailed reports and presentations: eis.lbl.gov