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NEEA Residential Auto M&V Research

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Agenda

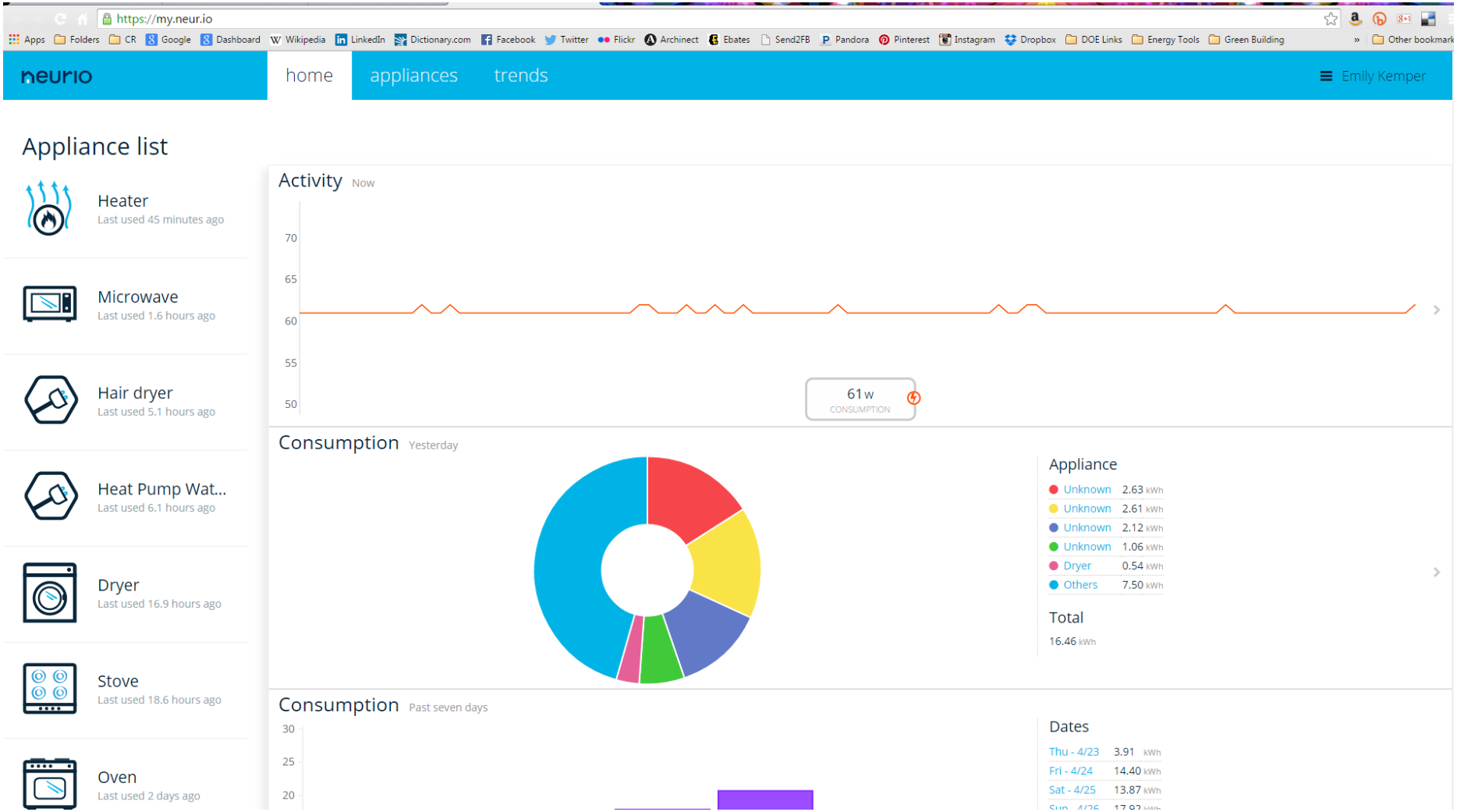
- Goals of the Research
- Literature Review
- HEMS Industry Research
- Data Analysis and Baseline Development
  - Individual Home Regression Analysis
  - Pooled Data Analysis
- Conclusions and Recommendations

Goals of the Research

Goals

- Why explore the automated M&V potential of hardware and software platforms for residential programs?
  - Interval data from smart meters is becoming more available and driving the development of consumer-facing analytical software
- What do HEMS have to do with it?
  - HEMS can provide an avenue to the data, and to communicate with both homeowners and utilities
  - HEMS *may* enable M&V

Can HEMS deliver savings?



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Goals

- This presents new opportunities:
  - To allow more variety and quicker onboarding of **program measures**
  - To determine **interim savings estimates** during program implementation
  - To provide **ongoing feedback** for utility customers
  - To support an array of **financial transactions** based on measured energy savings

Three parts to the Research

- Literature Review
  - What is out there? What has been done using interval data?
- HEMS Industry Research
  - Have any tech companies or manufacturers developed M&V tools in their devices or platforms?
- Data Analysis and Baseline Development
  - Individual Home Regression Analysis
  - Pooled Interval Data Regression Analysis

Findings From Literature Review

Lit Review: Major Observations

- Roughly 17 documents reviewed focused on **state of the art in residential M&V approaches**
- *Industry-recommended* sampling approach for evaluating residential BBEE programs **remains RCT**, but not always used
- Barriers include lack of access to interval data, lack of awareness of advanced M&V approaches, and the impact of occupant-controlled loads

Five Pilot Evaluations Using Whole Home Data

	RCT	Matched Control Group
Monthly	• PG&E Smart T-stat Field Assessment (2014)	• Cape Light Compact Legacy Cohort (2013)
Daily	• Google PowerMeter Evaluation (2012)	• Cape Light Compact Energize Cohort (2013) • PG&E HAN Evaluation (2013)
Interval: hourly or 15 minute or less	**None found: this is an opportunity**	

HEMS Industry Research

HEMS Industry Research

- Many technology platforms and device manufacturers are playing in the HEMS space
- …But, we discovered that most do not have M&V capabilities
  - 12 companies contacted
  - Six interviews conducted
  - Only two offer levels of M&V that might merit consideration for a utility program
  - No known platforms using real-time whole-home interval data to conduct utility program M&V

Tendril's ESM Platform

- Energy Services Management (ESM) Creates a whole building simulation according to IPMVP Option D, calibrated with monthly utility bills and other data
- ECMs applied in simulation and savings calculated as difference between energy use in the baseline and in the retrofit simulation models

EnergySavvy's Optix: Quantify

- Enables a "measure-as-you-go approach, measuring performance in real-time by combining usage, weather, and project data"
- Based on ASHRAE Guideline 14
- Variable balance point heating and cooling degree-day regression model applied on an individual home basis
- Used on 3000 homes thus far with monthly data

Data Analysis and Baseline Development

Individual Home Baseline Regression Modeling

- Objective: develop a specification for a robust baseline modeling approach
- Used two key metrics:
  a) Mean Bias Error (MBE)
  b) Detectable Percent Savings
- Used interval data provided by NEEA's Residential Building Stock Analysis (RBSA) metering study
  - 96 homes
  - NO program implementation on these houses

a) Mean Bias Error

- MBE denotes the percentage by which a regression model's predicted energy use differs from the actual consumption over a defined period.
  - A **positive MBE** means the modeled energy use for the period is higher than actual use, and a **negative MBE** means it is lower. An MBE value of zero is ideal.

Metrics Explanation

Metrics Explanation: MBE

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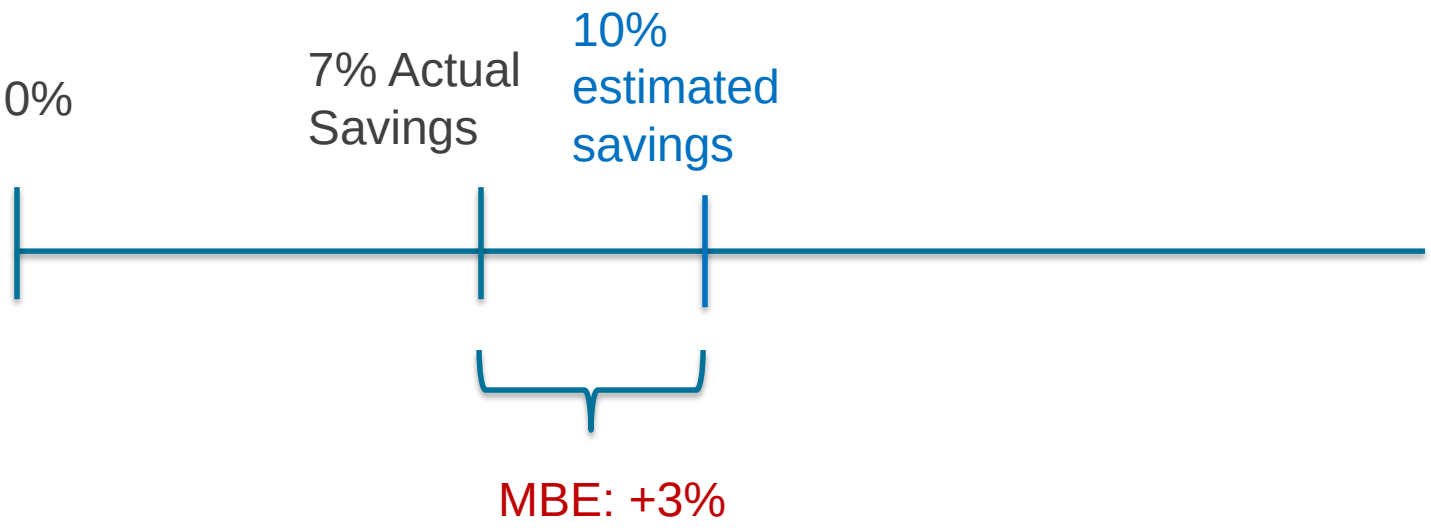
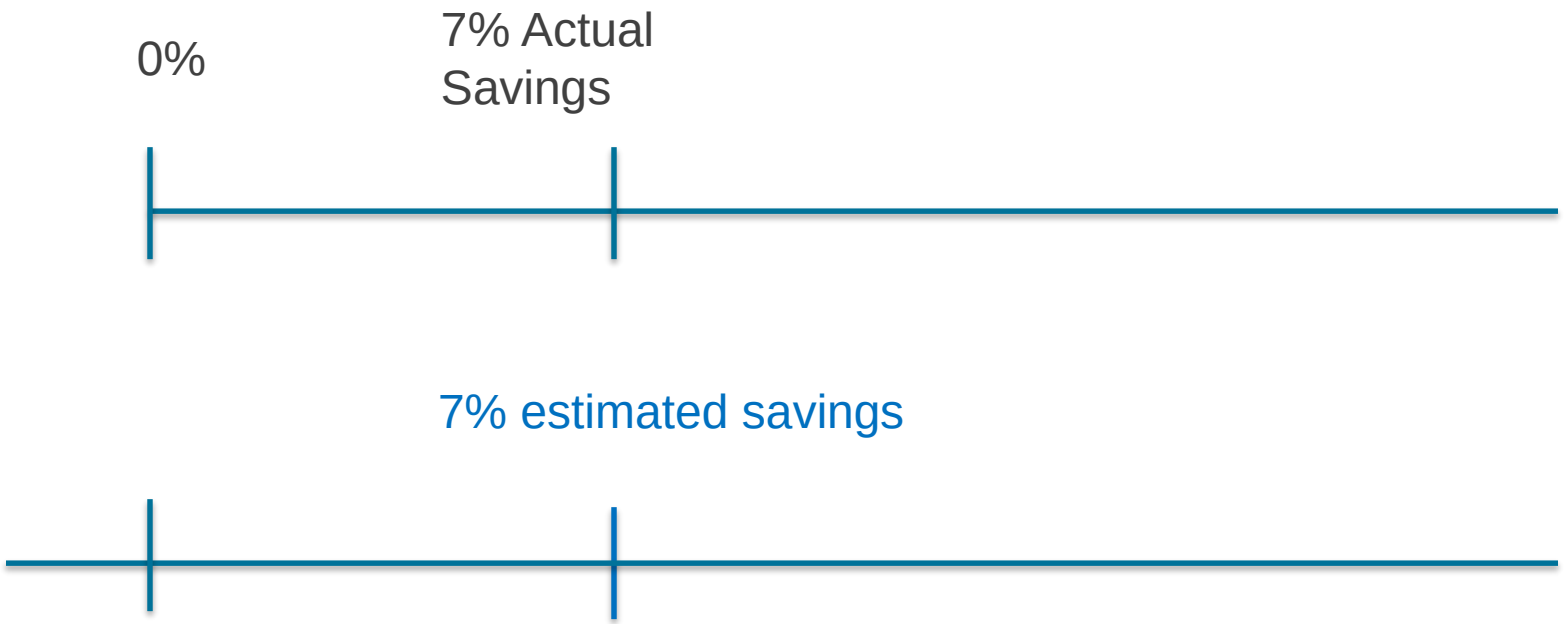


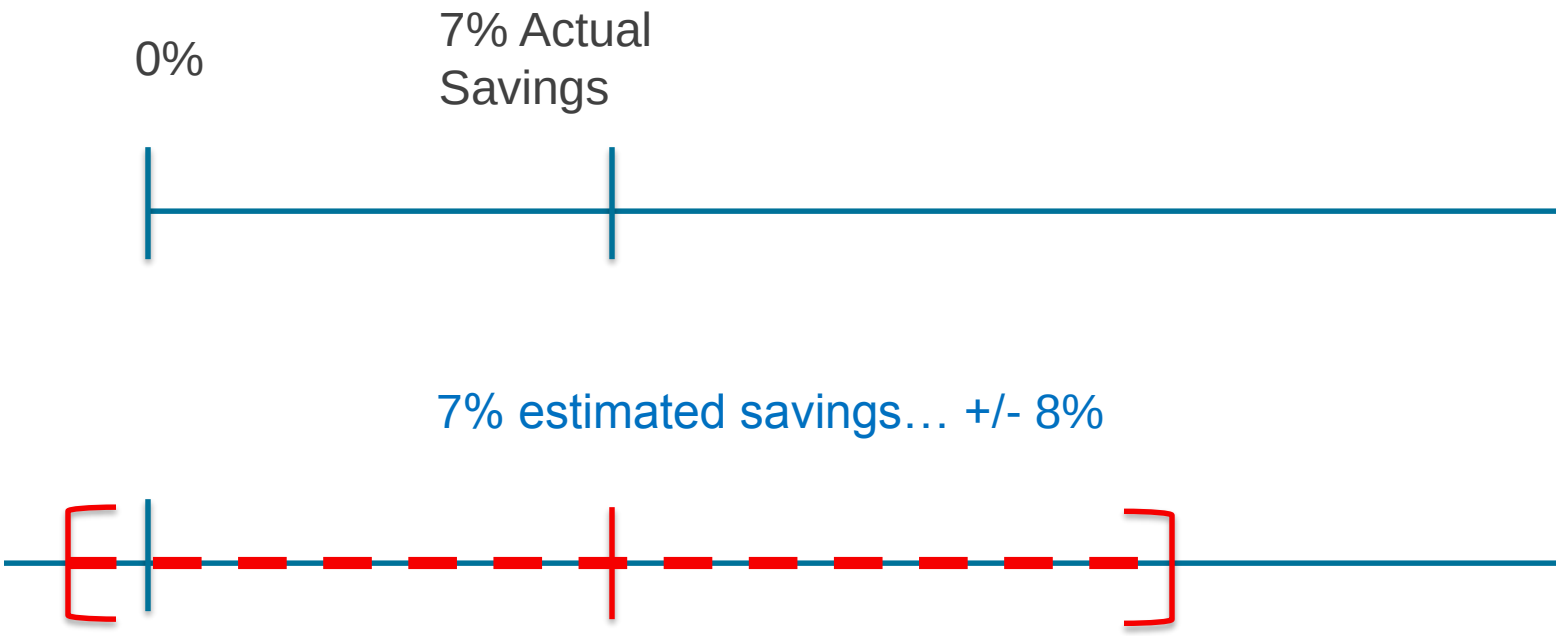
b) Detectable Percent Savings

- M&V approaches based on monthly energy regression modeling may generally be used when energy savings are at least 10% of whole-building energy use. An M&V method based on interval data modeling has the potential to detect a lower percent savings.
  - Meaning, using interval data might allow us to "see" smaller savings amounts

Metrics Explanation: Detectable Percent Savings



Metrics Explanation: Detectable Percent Savings



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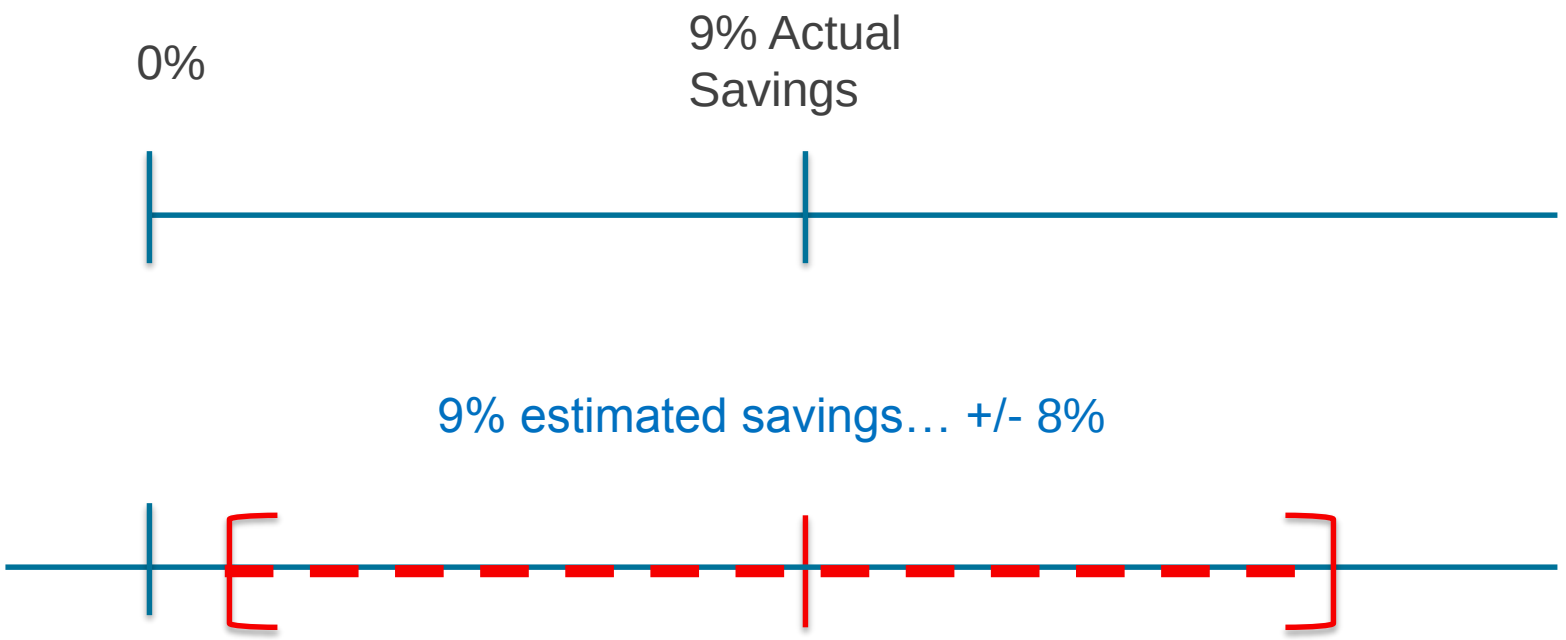
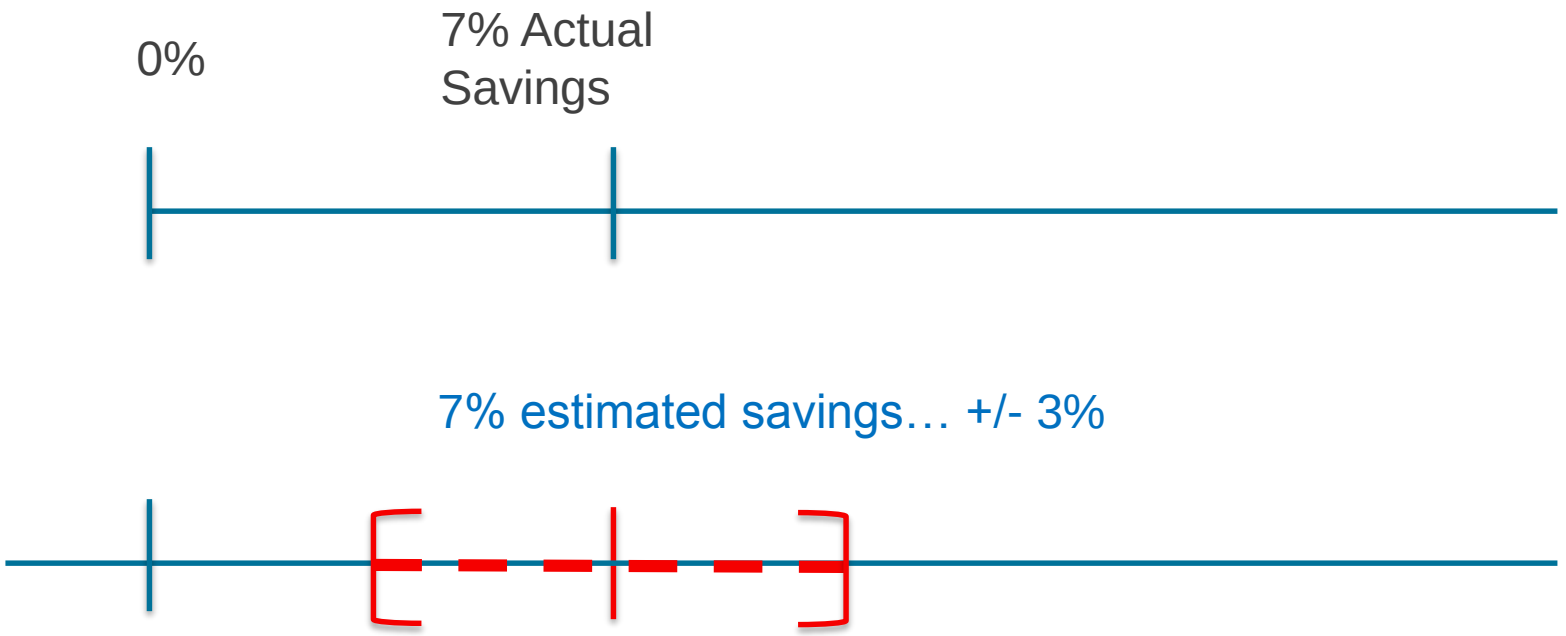
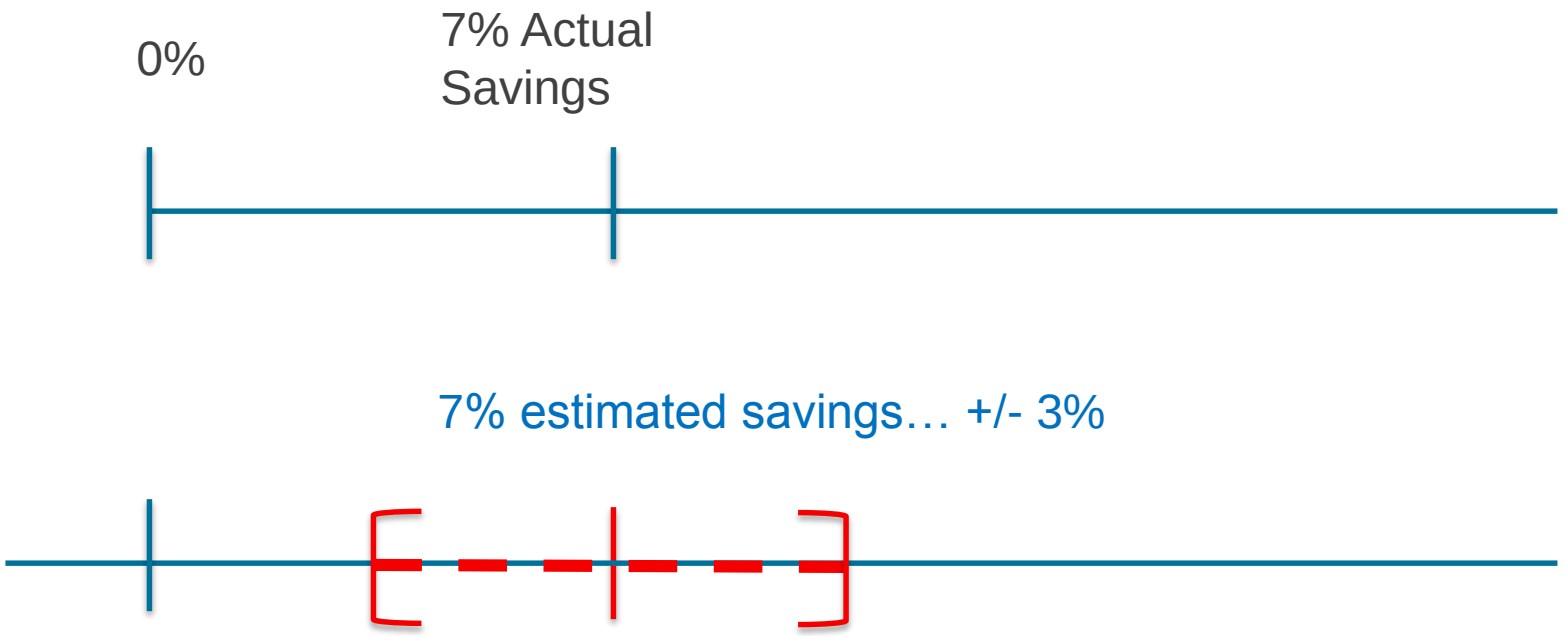


Percent savings needed: 8% (or more)

Metrics Explanation: Detectable Percent Savings



Metrics Explanation: Detectable Percent Savings



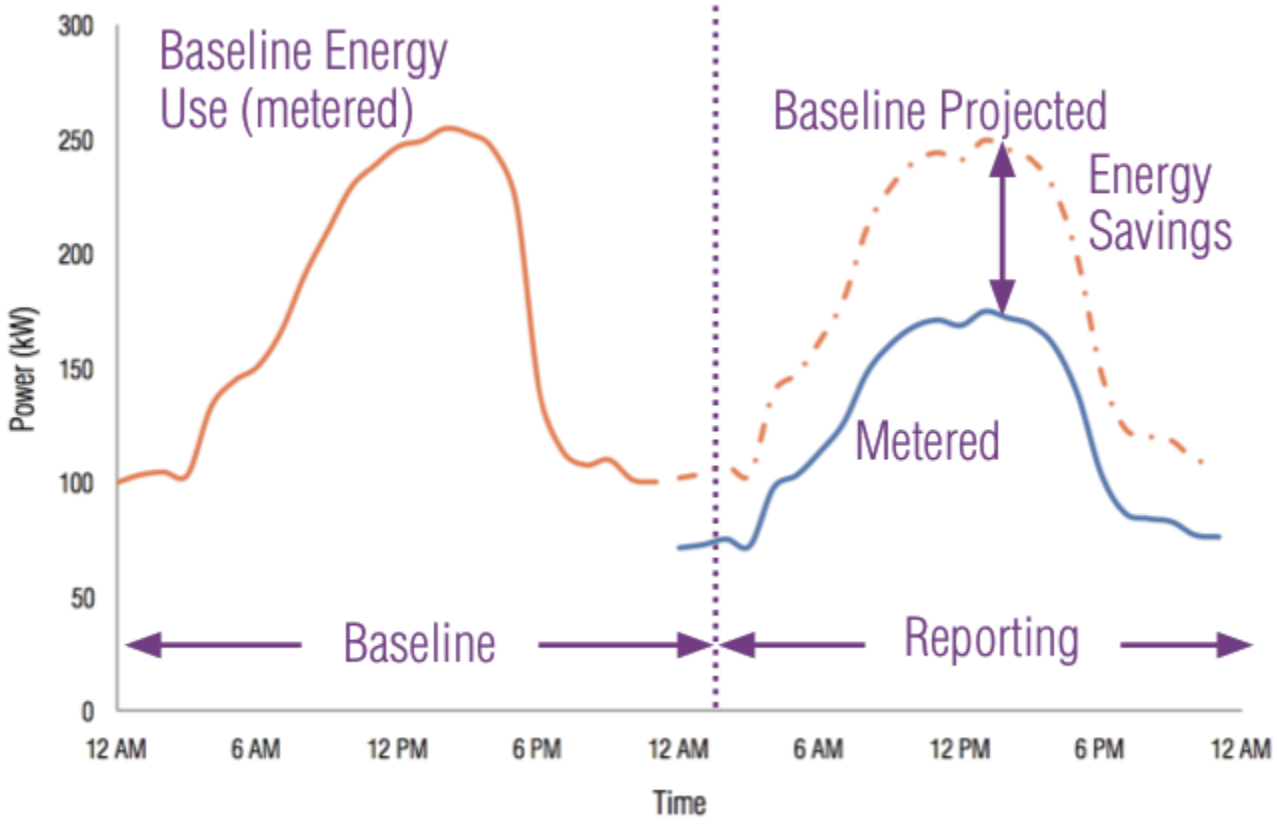
Percent savings needed: 3%

Methodology: Model Specification

- Multi-variate piecewise regression model using:
  - Air Temperature
  - Day of the Week
  - Time of Day
- Correction for Auto-correlation (outlined in ASHRAE Guideline 14 – 2002)
- **Avoided energy approach could not be used since there was no post-implementation data available**

Baseline Development

- *Error in reported savings is proportional to error in baseline/projected baseline*

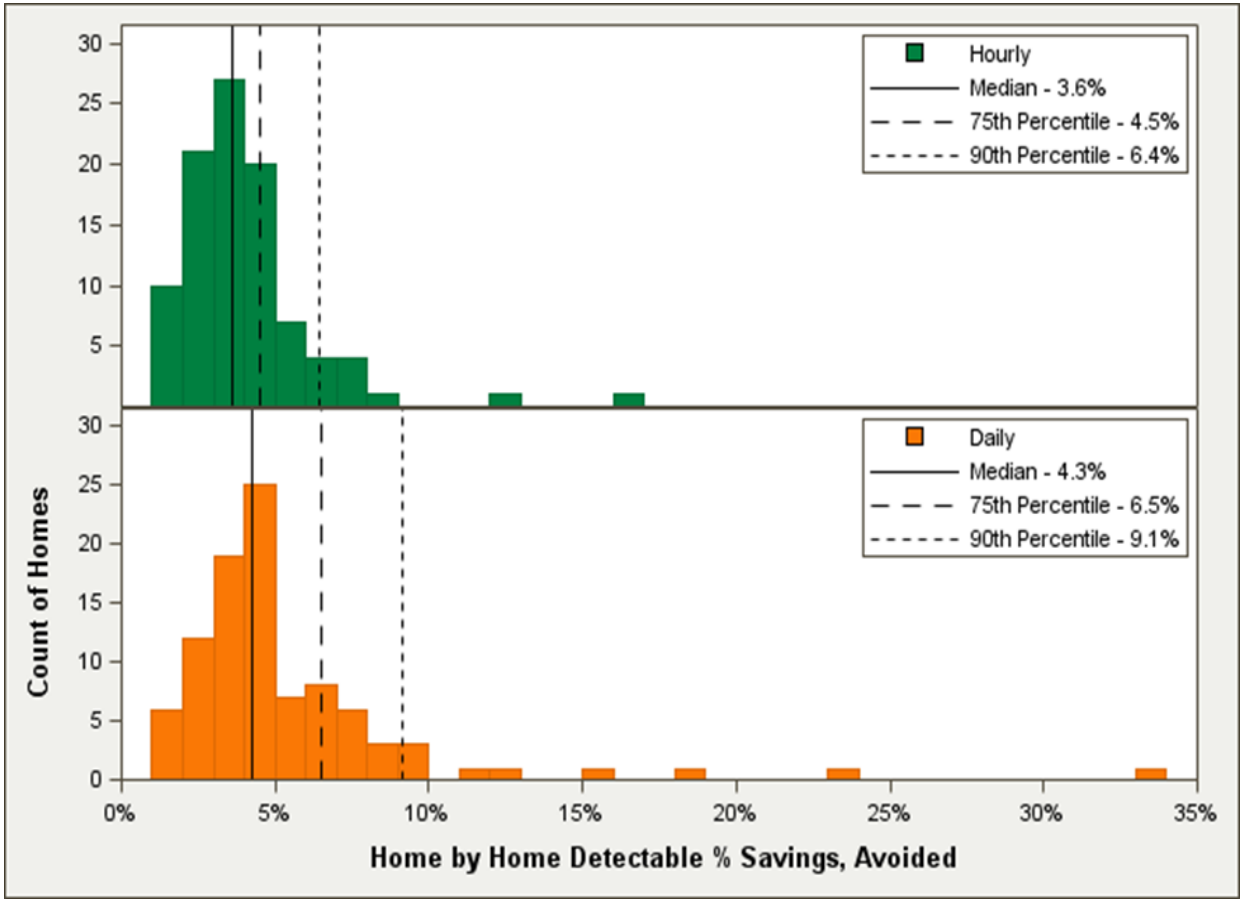


Findings

- Two separate datasets:
  1. Daily consumption: these models yielded a median value for detectable percent savings of 4.3%
  2. Hourly consumption: these models yielded a median value for detectable percent savings of 3.6%
- …Therefore, hourly models were used for subsequent analysis

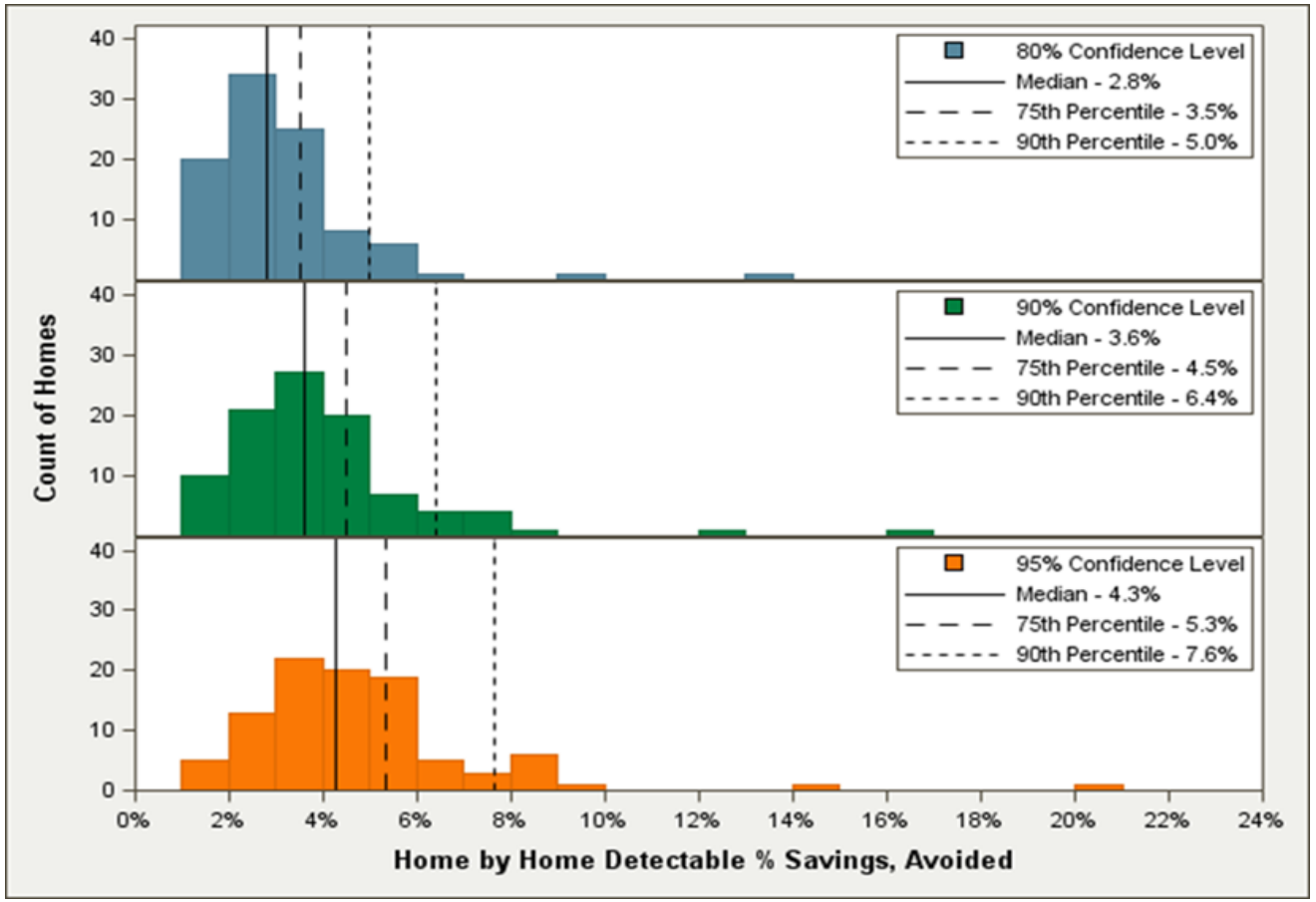
Detectable Percent Savings for Hourly and Daily Models

- At 90% Confidence Level



Detectable Percent Savings at Varying Confidence Levels

- Using Hourly Models



Impact of Part-Year Modeling and Seasonality

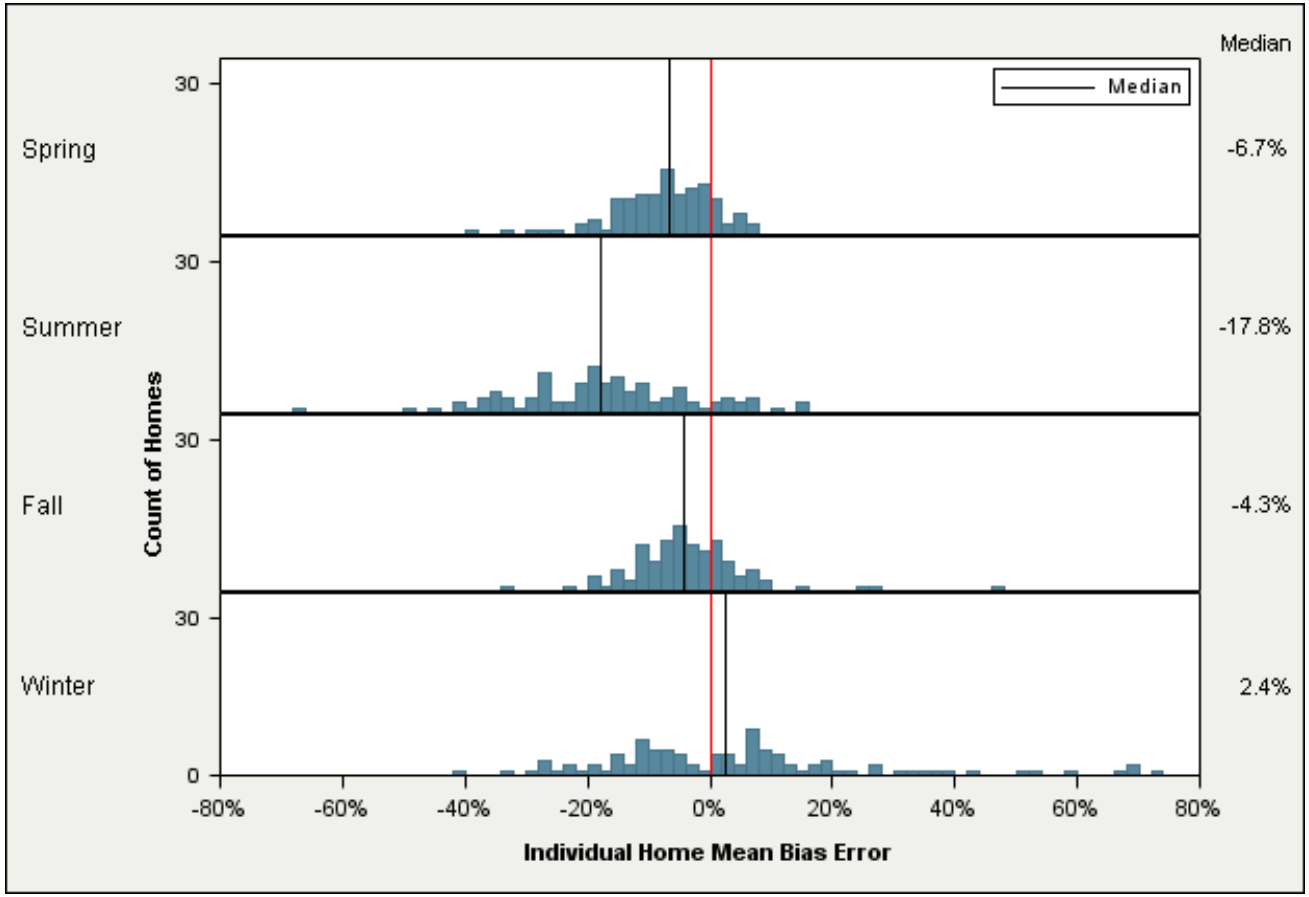
- The ability to develop an accurate regression using less than a year of interval data offers potential benefits over established M&V approaches that use monthly data and require a full year of data.
- Such an approach could reduce:
  - The delay for a utility to claim savings for a project
  - The delay for an owner to receive incentives (if dependent on measured savings)
  - The risk that other activities or projects affect energy consumption and interfere with M&V for the initial project

Using MBE to Gauge Part-year Analysis

- MBE is the more salient metric to examine for the part-year analysis, to determine the amount of bias introduced into the results by shortening the monitoring period
- Models created with three, six, and nine months of data

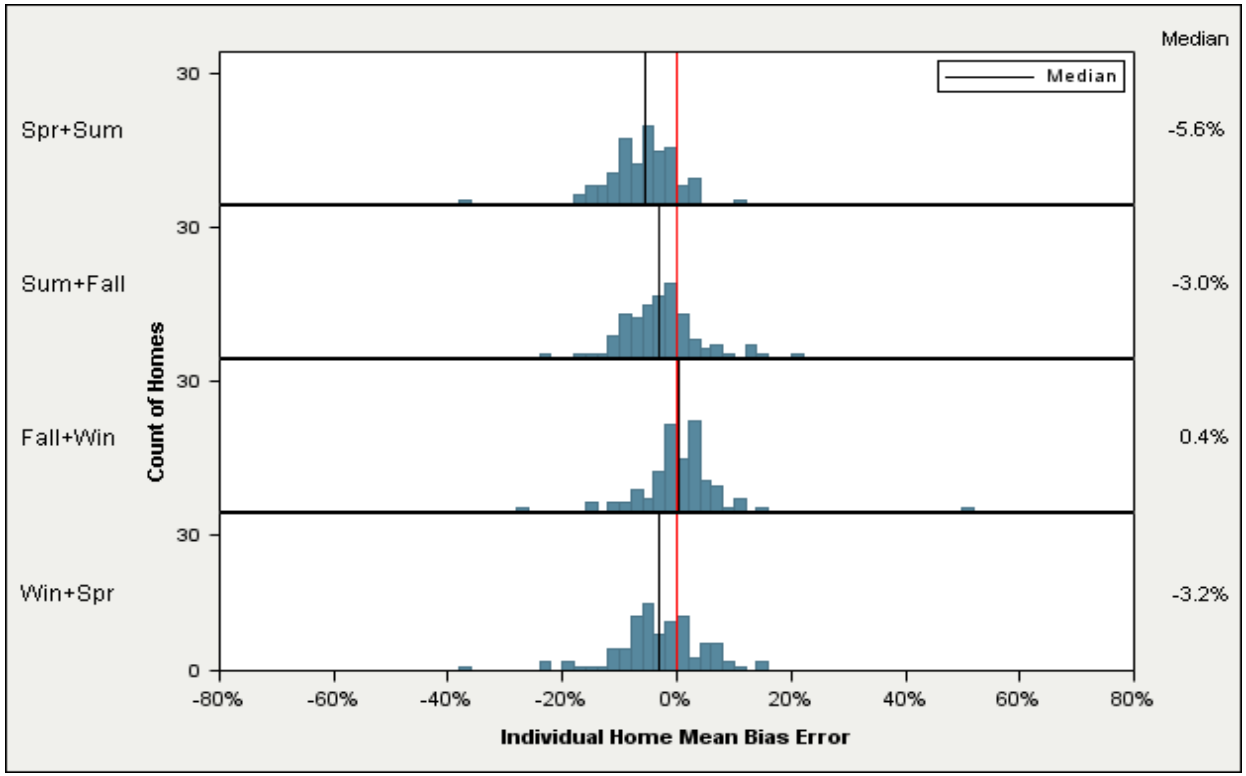
Three-month Model

- Median MBEs are far from zero



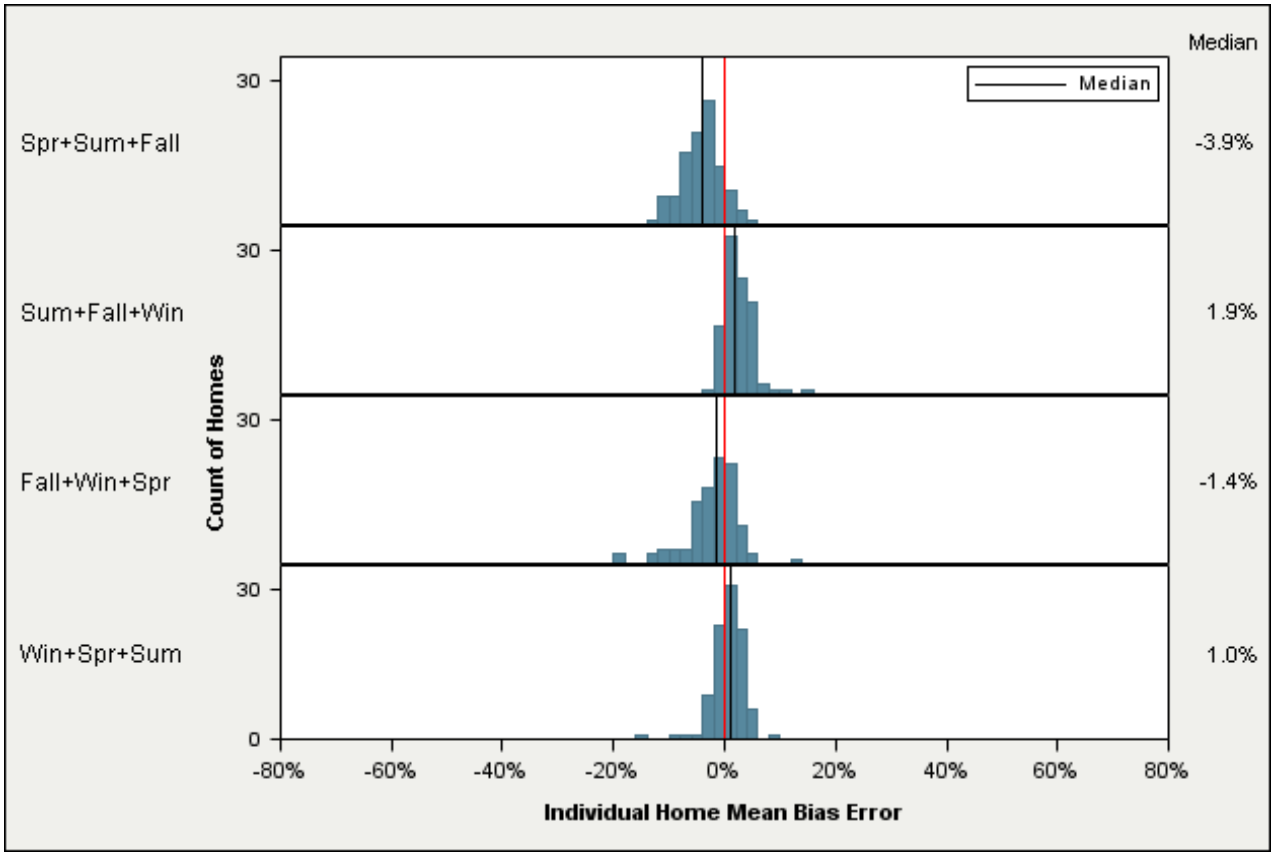
Six-month Model

- Improved median MBE may suffice to claim savings in certain types of programs



Nine-month Model

- Median MBE is close to zero and could be used to claim annualized savings above 4%



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Pooled Data Analysis

- Extra bonus topic covered in the report, but not in this presentation

Conclusions and Recommendations

Conclusions

- Higher confidence level means that higher project savings are needed in order to use an individual home regression approach
- M&V using interval data could have applications for a range of program types, including those with relatively low savings (such as BBEE)
- Using anything less than six months of data results in unacceptably high MBEs

Recommendations

- Conduct further analysis with more data!
  - Use second-year data from same data set
  - **Apply the modeling approach to a set of homes with measures installed using pre- and post-implementation interval data**
  - Further explore seasonal impacts and other key-factors affecting part-year regression modeling
- Gather information on stakeholder needs and requirements for an automated M&V solution using interval data

Where can I find this report?

- http://neea.org/docs/default-source/reports/baseline-energy-modeling-approach-for-residential-m-v-applications.pdf?sfvrsn=4
- Or, Google "**NEEA residential baseline energy modeling approach**"

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Thank you!