



# Overcoming Barriers to M&V for Commercial Energy Management Programs

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# Agenda

- ▶ Overview of M&V Options
- ▶ Challenges to M&V for Commercial Energy Management Programs
- ▶ Select Challenges in Depth

# M&V Options

- ▶ Engineering Calculations with Verification (non-IPMVP)
  - Standard practice: ~ 90% custom projects
- ▶ Retrofit Isolation Methods (IPMVP)
- ▶ Whole-Building Methods (IPMVP)

# Engineering Calculations (ex-ante)

## A Baseline Operation w/ IGV

Air Volume Flow Rate Profile %	Speed %	IGV Power Ratio [Note 1] %	Power kW	Annual Energy Use kWh/Yr
100%	100%	109%	12.8	51
98%	100%	105%	12.3	74
96%	100%	102%	12.0	96
94%	100%	99%	11.6	267
92%	100%	96%	11.3	362
91%	100%	93%	10.9	436
89%	100%	90%	10.6	244
87%	100%	87%	10.2	602
85%	100%	85%	10.0	750
83%	100%	84%	9.9	782
81%	100%	83%	9.7	1,358
79%	100%	81%	9.5	1,055
77%	100%	80%	9.4	808
75%	100%	78%	9.2	1,003
74%	100%	77%	9.0	801
72%	100%	76%	8.9	454
70%	100%	74%	8.7	835
68%	100%	73%	8.6	774
66%	100%	73%	8.6	697
64%	100%	71%	8.3	1,212
62%	100%	70%	8.2	869
60%	100%	69%	8.1	1,013
58%	100%	68%	8.0	1,048
57%	100%	67%	7.9	940
55%	100%	66%	7.8	562
53%	100%	65%	7.6	1,284
51%	100%	65%	7.6	958
50%	100%	65%	7.6	1,041
50%	100%	65%	7.6	1,467
50%	100%	65%	7.6	631
50%	100%	65%	7.6	509
50%	100%	65%	7.6	456
50%	100%	65%	7.6	319
50%	100%	65%	7.6	152
50%	100%	65%	7.6	122
50%	100%	65%	7.6	122
50%	100%	65%	7.6	84
50%	100%	65%	7.6	122
50%	100%	65%	7.6	23
			12.8	24,379

## D Proposed Operation w/o IGV, w/ VFD High Limit & w/ VFD Modulation

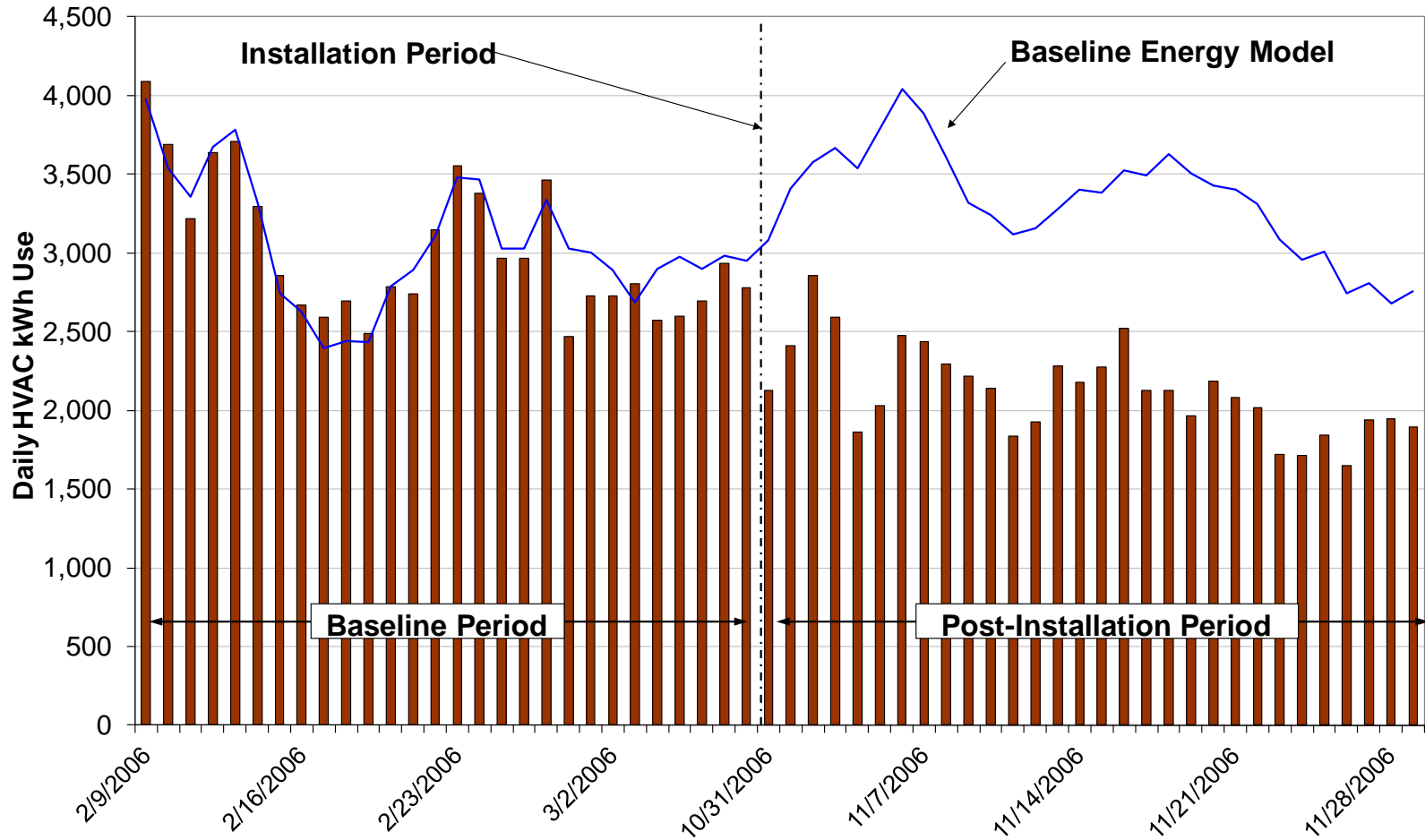
Air Volume Flow Rate Profile %	Speed w/ VFD Modulation %	VFD Power Ratio [Note 2] %	Power w/ VFD Modulation kW	Annual Energy Use kWh/Yr
100%	89.3%	71%	9.1	36
98%	87.6%	68%	8.4	50
96%	85.9%	64%	7.7	62
94%	84.2%	63%	7.3	168
92%	82.6%	60%	6.8	218
91%	80.9%	57%	6.2	248
89%	79.2%	56%	5.9	136
87%	77.5%	53%	5.4	319
85%	75.8%	50%	5.0	375
83%	74.1%	49%	4.9	387
81%	72.5%	46%	4.5	630
79%	70.8%	44%	4.2	466
77%	69.1%	43%	4.0	344
75%	67.4%	40%	3.7	403
74%	65.7%	38%	3.4	303
72%	64.0%	37%	3.3	168
70%	62.3%	34%	3.0	288
68%	60.7%	32%	2.8	252
66%	59.0%	30%	2.6	211
64%	57.3%	28%	2.3	336
62%	55.6%	26%	2.1	223
60%	53.9%	24%	1.9	238
58%	52.2%	23%	1.8	236
57%	50.5%	21%	1.7	202
55%	48.9%	19%	1.5	108
53%	47.2%	19%	1.4	237
51%	45.5%	17%	1.3	164
50%	44.7%	16%	1.2	164
50%	44.7%	16%	1.2	232
50%	44.7%	16%	1.2	100
50%	44.7%	16%	1.2	80
50%	44.7%	16%	1.2	72
50%	44.7%	16%	1.2	50
50%	44.7%	16%	1.2	24
50%	44.7%	16%	1.2	19
50%	44.7%	16%	1.2	19
50%	44.7%	16%	1.2	13
50%	44.7%	16%	1.2	19
50%	44.7%	16%	1.2	4
			9.1	7,603

Savings = 24,379 – 7,603 =  
16,776 kWh annually

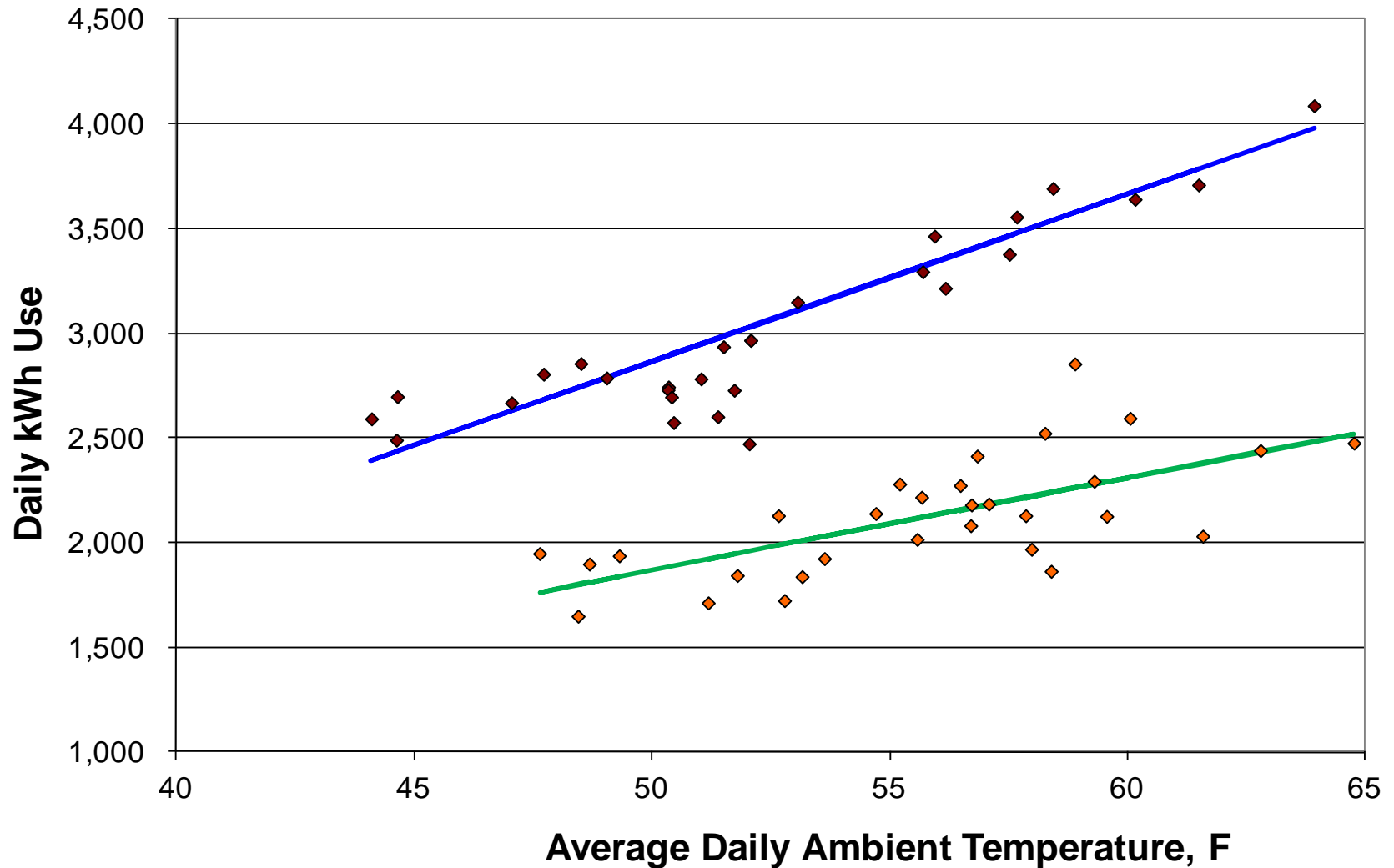
Note:

- estimate is prior to install
- accurate?
  - data quality
  - analysis
  - assumptions

# Measurement & Verification



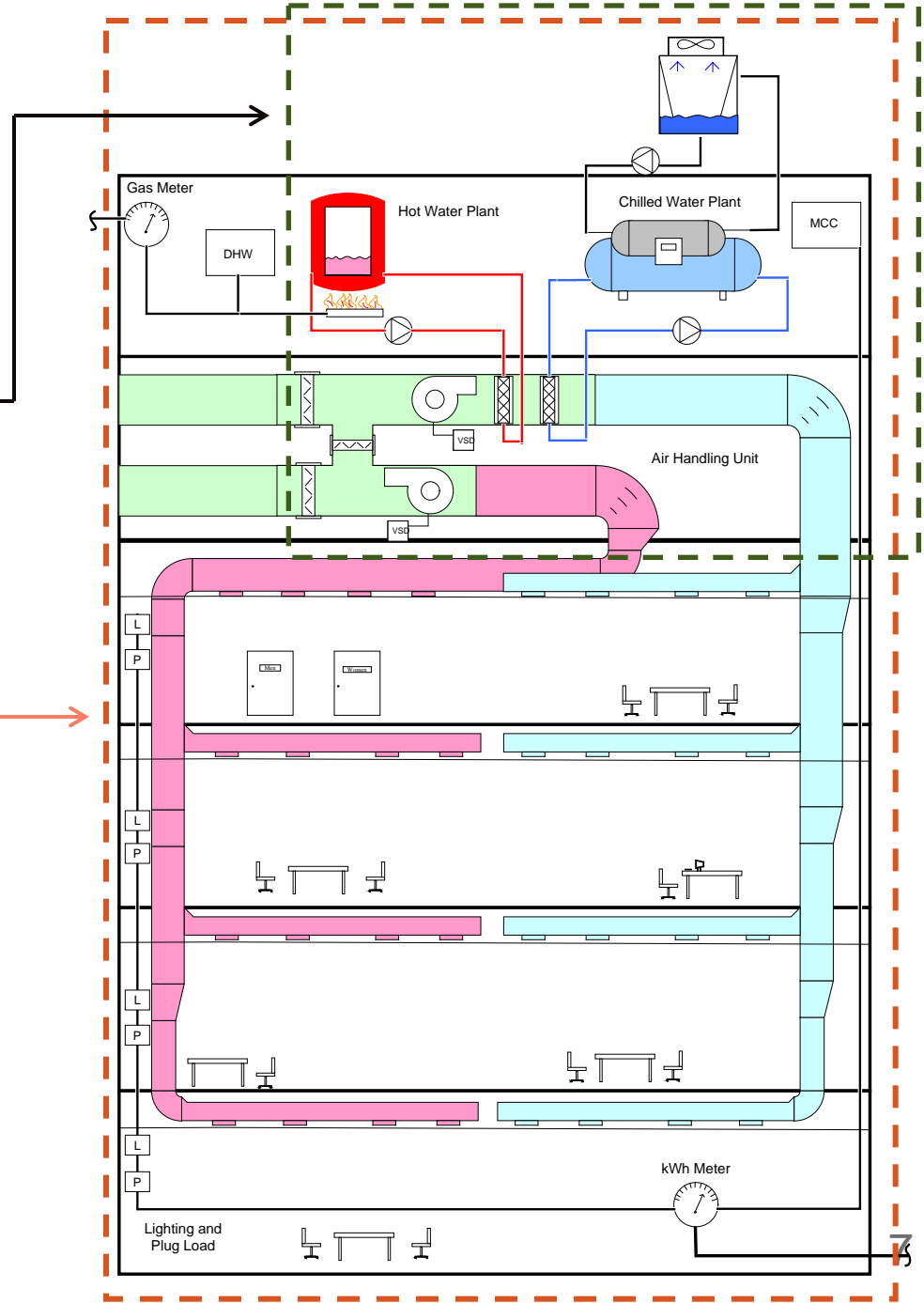
# Measurement & Verification, cont.



# Measurement Boundaries

▶ Retrofit Isolation

▶ Whole Building

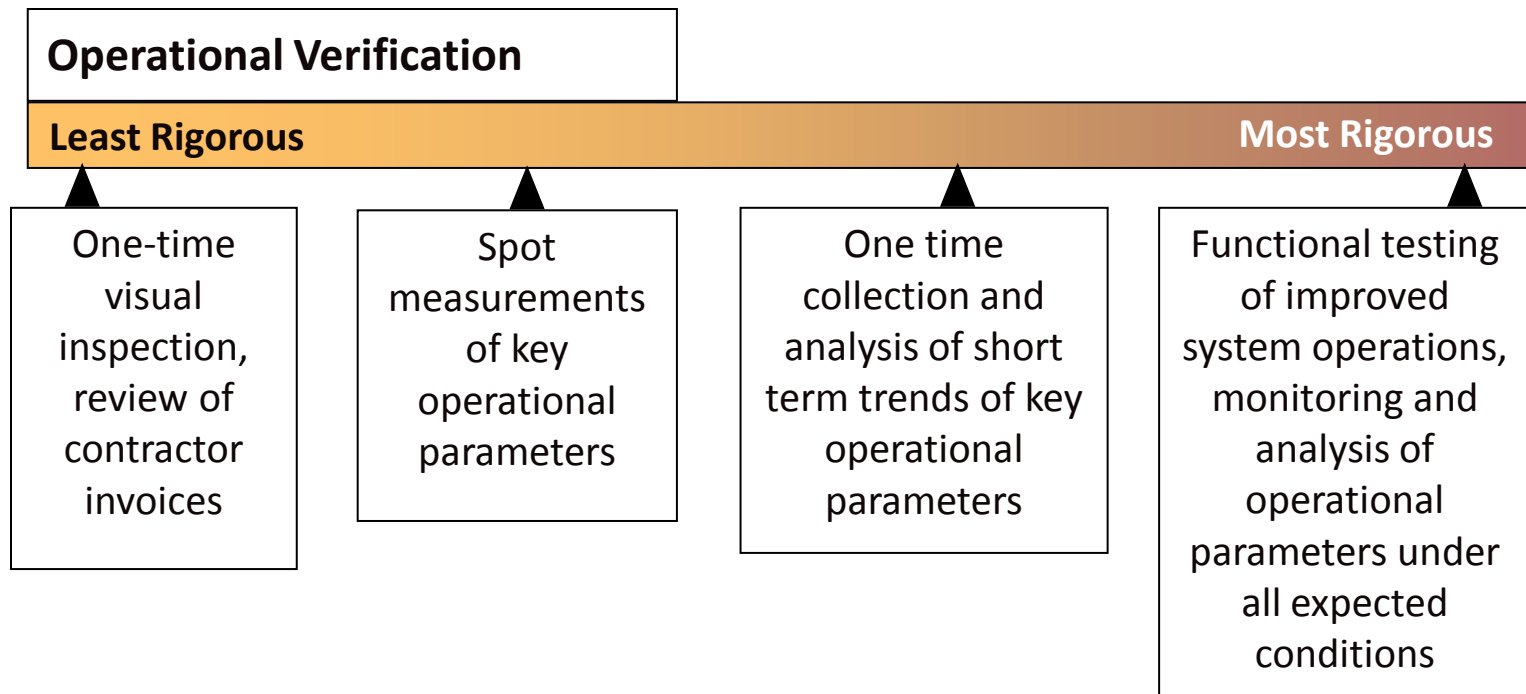


# Verification Requirements – 2 parts

- 1) Verify potential to perform (operational verification)
  - ECMs are installed correctly
  - Operate correctly
  - Have potential to generate savings
  
- 2) Verify actual performance (quantify savings)

# Operational Verification

## ◀ Visual inspection to full commissioning



# Characteristics of Good M&V Plans

- ▶ Well organized, standard format
- ▶ Description of baseline
- ▶ Impact of ECMs
- ▶ Clear description of verification methodology and planned post-installation activities
- ▶ Description of Savings Report Contents

# Comparison of Methods

## ▼ Engineering Calculations

- Results prior to implementation
- Extensive data and information
- Many assumptions
- Unable to provide savings uncertainty
- No standards, only best practices

## ▼ Whole Building Method

- Results after implementation
- Relatively few data and information required
- Provides savings uncertainty
- Standards and guidelines available

# Benefits of Whole Building M&V

- ▶ Better savings estimate at the meter
- ▶ Accounts for system/measure interactions
- ▶ Captures squishy behavioral savings
- ▶ Lower cost than measure isolation or calibrated simulation
- ▶ Same approach for different building types
- ▶ Commensurate with building management practices

# Whole-Building Method: Interval Data

## ▼ Interval Data

- More data allows shorter collection periods
- Lower uncertainty in energy models and savings
- Can apply approach in buildings with lower savings

## ▼ Monthly Data

- Typically only 12 months baseline data available
- Need equivalent amount of data after ECM installation
- Higher uncertainty – 15% “rule of thumb”

# Challenges

- ▼ Availability and Amount of Data
- ▼ Skills, Experience, and Tools
- ▼ Savings Uncertainty
- ▼ Regulatory Requirements
- ▼ Savings Attribution

# Challenge: Data Availability and Amount

## ▼ Data Sources

- 15-min interval data from TOU meters
- Local weather station (e.g. airport)
- TOU meters rare in smaller buildings
- Interval gas meters = exception, not rule

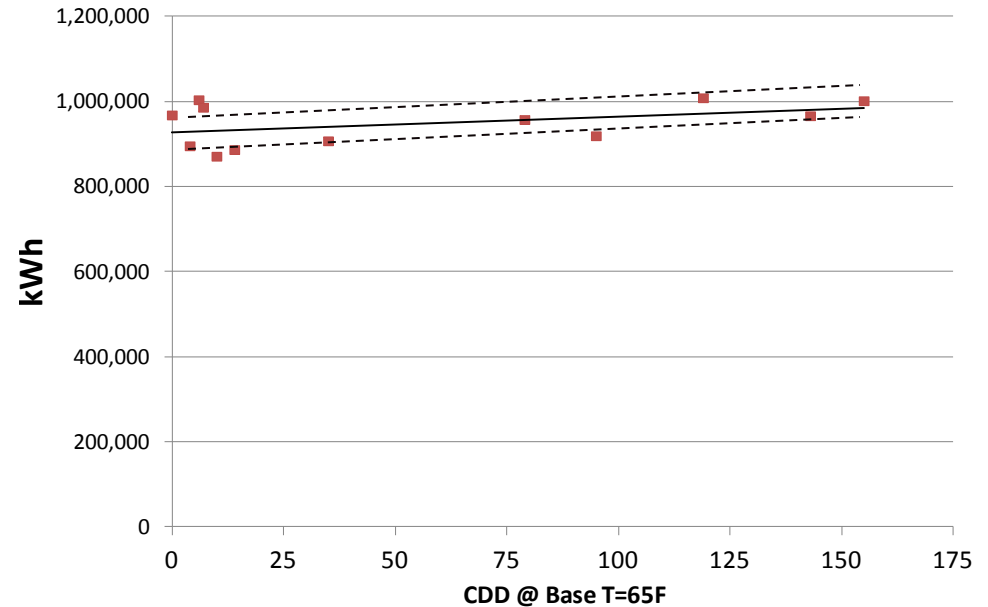
## ▼ Energy Model Requirements

- Energy and temperature over widest range possible
- Data over period when ECMs have most impact
- Similar requirements in post-installation period

# Example: No TOU Meter

## ▼ Monthly data baseline

- Model  $\Delta E = 15\%$



## ▼ Options:

- OK if Savings  $\gg 15\%$
- Install TOU Meter
- Use Engr Calcs or Retrofit Isolation
  - Verify with monthly data

# Strategies: Add Metering

## ▼ Whole-Building Meters

- Electric – 15 minute interval data



## ▼ Interval gas data (pulse counter)

- Bolt-on pulse meter
- Face plate replacement



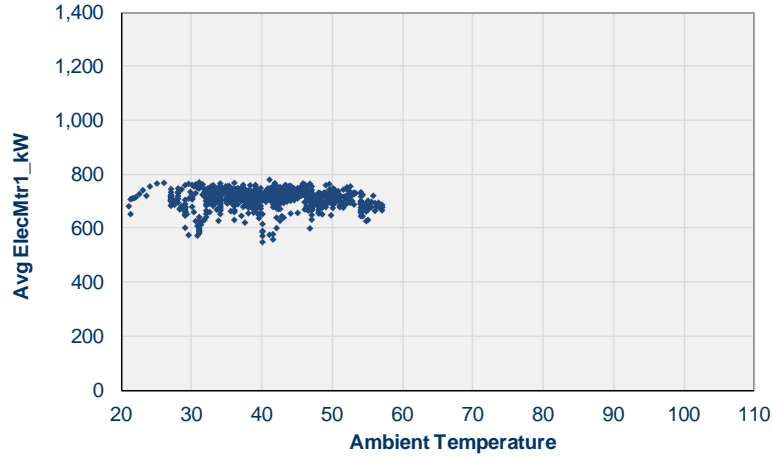
## ▼ Smart Meters

## ▼ Contractor

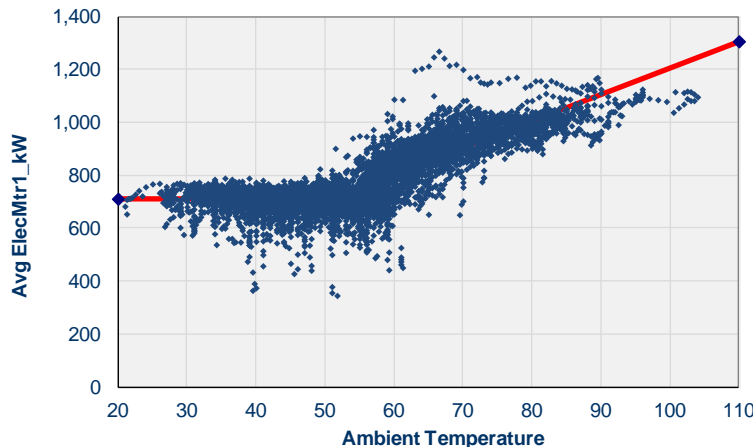
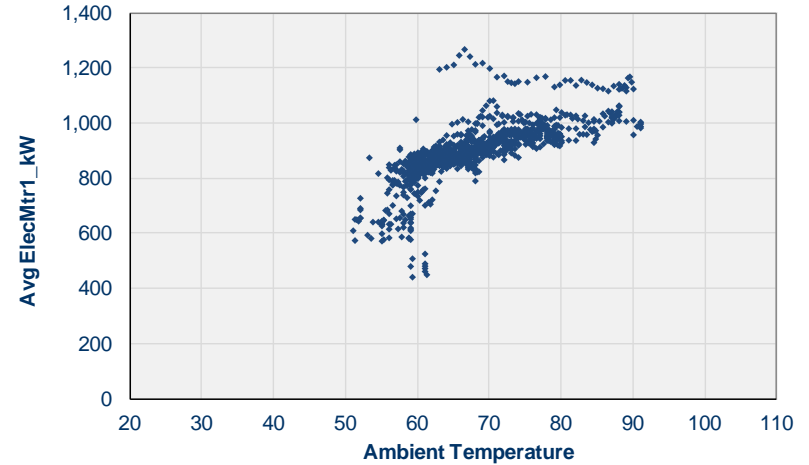
- NYSERDA Program w/ Northwrite
- BC Hydro Program w/ Pulse Energy

# Example: Amount of Data

1 Month Winter



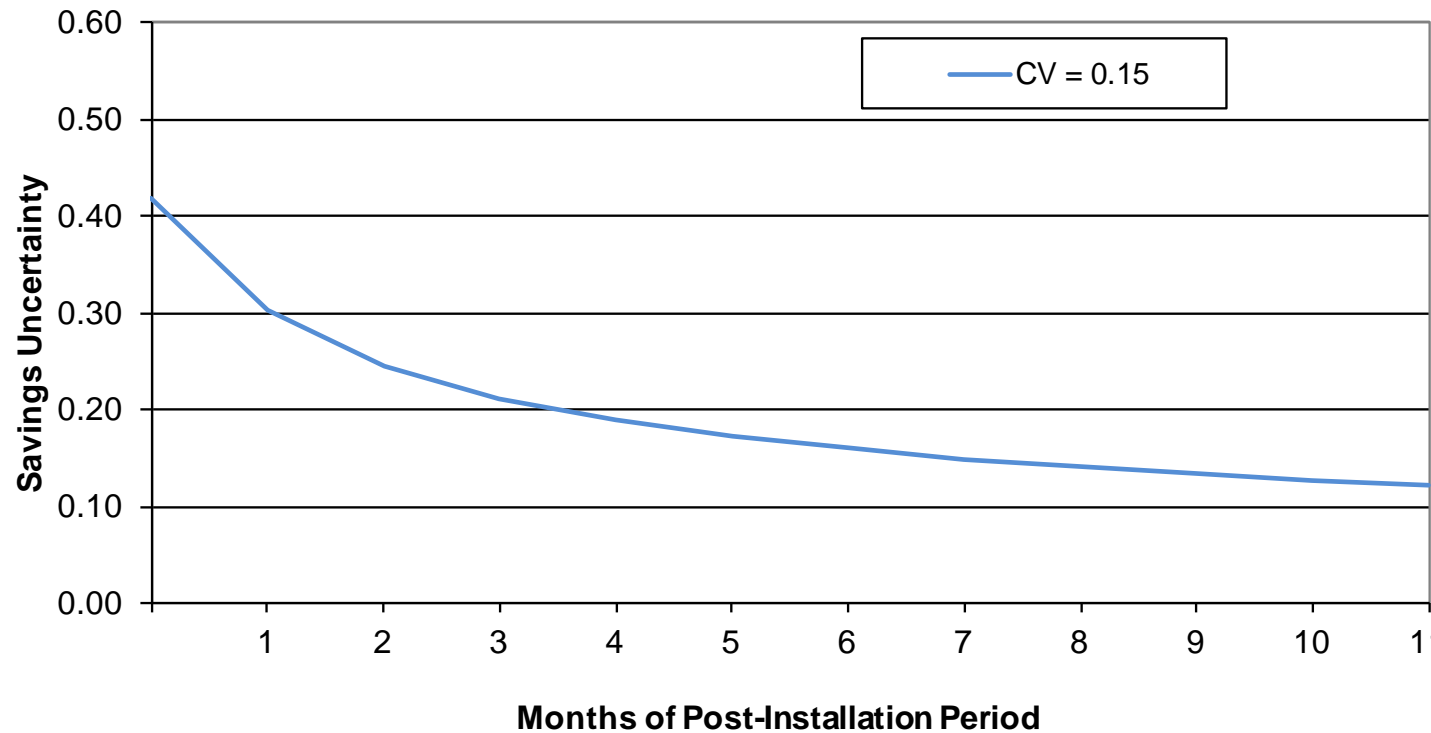
1 Month Summer



Complete  
Characterization

# Example

- ▶ Savings uncertainty decreases as collected data increases



# Implications

- ▼ Buildings without TOU meters and archive systems
  - Longer program lead times
  - Added costs to install meters and systems
  - Added data quality control requirements
  - Use monthly data if savings large

# Challenge: Skills, Experience and Tools

## ▼ Data preparation

- Merge data
- Perform quality checks

## ▼ Analysis

- Influence of operation periods
- Regression analysis

## ▼ Savings Analysis

- Collect and manage post-install data
- Savings and uncertainty analysis

## ▼ Operational Verification

# Example - Regression Models

## ▼ General Procedure

- Plot data
- Select model type (1-P, 2-P, 3-P Cooling, etc.)
- Select change point
- Perform regressions (averages where needed)
- Calculate CV & NMBE
- Adjust change point
- Perform new regressions
- Calculate CV & NMBE, compare with run #1
- Iterate to lowest CV & NMBE

# Example: Uncertainty Assessment

## ▼ Precision and Confidence Levels

n-p	68% Confidence	80% Confidence	90% Confidence	95% Confidence
5	1.00	1.48	2.02	2.57
10	1.00	1.37	1.81	2.23
15	1.00	1.34	1.75	2.13
20	1.00	1.33	1.73	2.09
25	1.00	1.32	1.71	2.06
infinite	1.00	1.28	1.65	1.96

## ▼ Fractional Savings Uncertainty , $\Delta E_{save,m}/E_{save,m}$

- For “weather models with correlated residuals”

$$\frac{\Delta E_{save,m}}{E_{save,m}} = t \cdot \frac{1.26 \cdot CV \left[ \frac{n}{n'} \left( 1 + \frac{2}{n'} \right) \frac{1}{m} \right]^{1/2}}{F}$$

# Strategies for Increasing Skills

## ▼ Guidelines

- CCC Verification of Savings Guideline [www.cacx.org](http://www.cacx.org)

## ▼ Tools and Training:

- Data preparation
  - Energy Charting and Metrics Tool
  - Universal Translator
- Regression analysis (change point)
  - Public
    - ASHRAE Inverse Model Toolkit (RP 1050)
  - Private (incl. uncertainty analysis)
    - Energy Explorer (University of Dayton)
    - QuEMS (QuEST Energy Modeling Spreadsheet)

# Tools

## ◀ CEC Research Project

- Add Interval data energy modeling capability to PG&E's Universal Translator
  - [www.utoonline.org](http://www.utoonline.org) (UT is free)
- Leverage UT's data preparation capability
- Enable complete M&V savings analysis
  - Using energy modeling method
- Apply to whole-building or systems data
- Availability: March 2013

# Implications

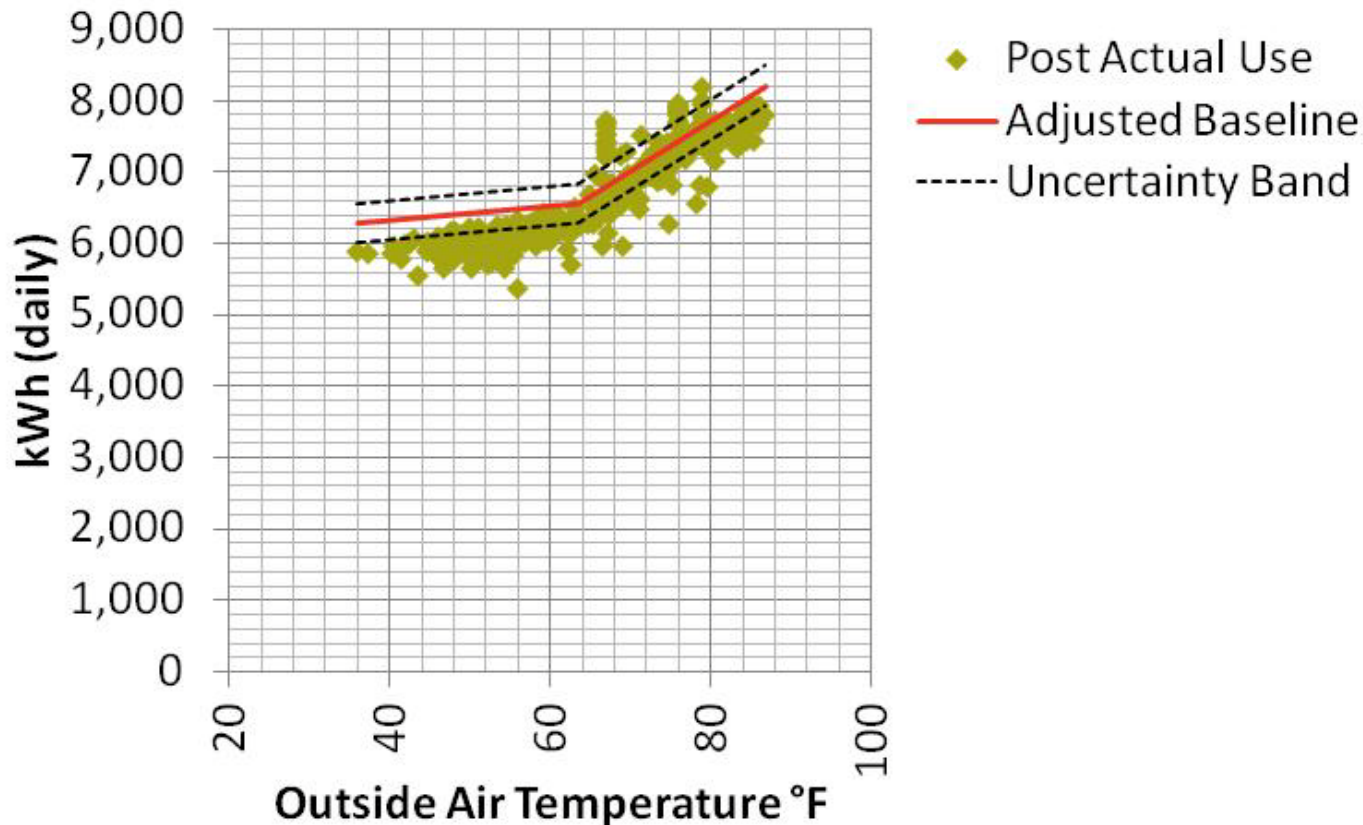
- ▶ Training is needed:
  - WB baseline modeling
  - Operational verification
  - Improve consistency of approach
- ▶ Tools are needed:
  - Speed up process
  - Allow more service providers
  - Improve project consistency
  - Standardize analysis

# Challenge: Savings Uncertainty

- ▶ Threshold of savings needed for certainty
- ▶ More data scatter or “noise” requires higher percent savings needed to estimate savings
- ▶ Dependent on the confidence target (e.g. 90%, 80%)

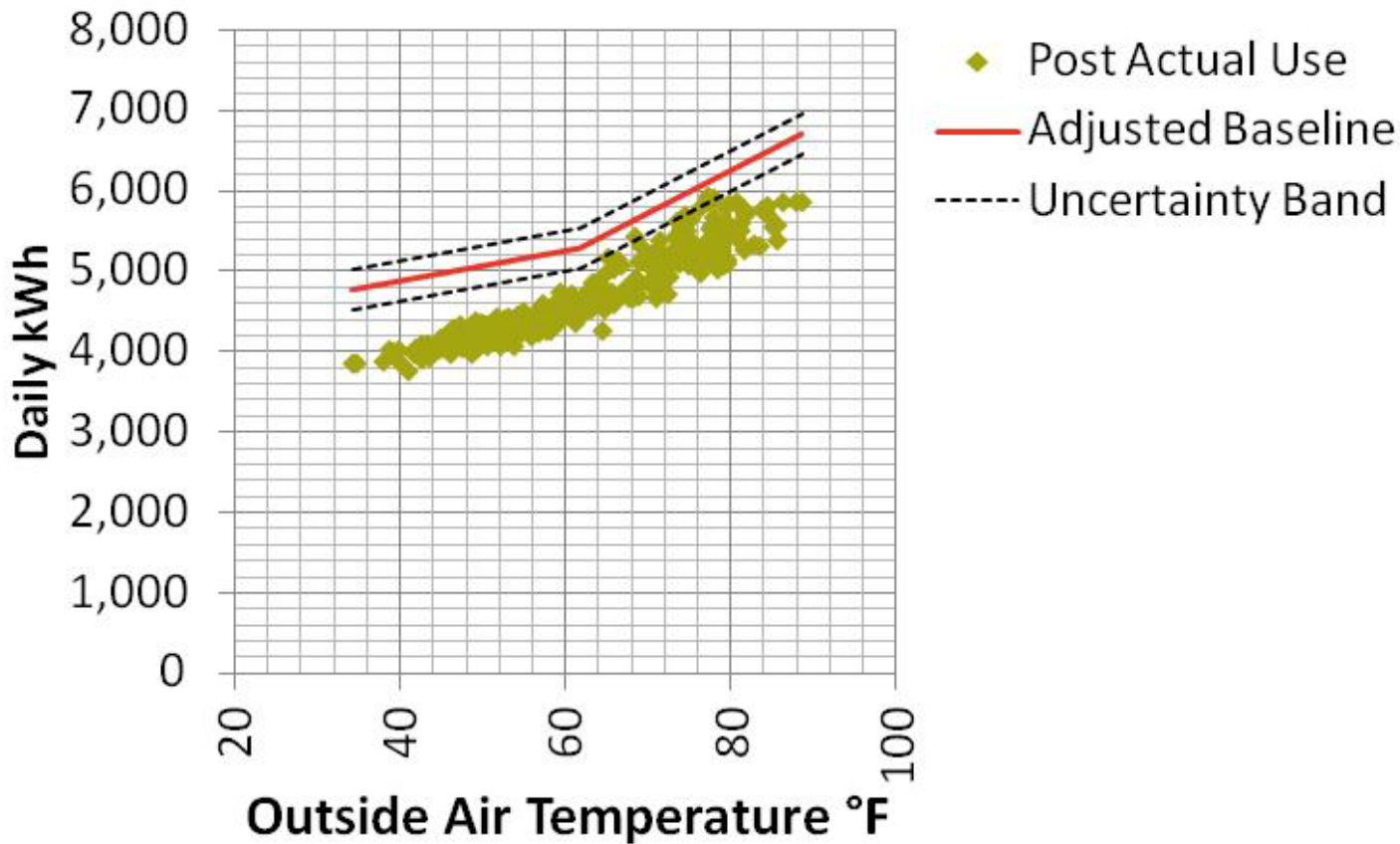
# Savings Uncertainty Program Example

◀ Grocery Store with ~4% savings



# Savings Uncertainty Program Example

▼ Grocery Store with ~14% savings



# Savings Uncertainty

## Strategies for Overcoming Barriers

- ▼ Screen expected percent savings
  - Set a reasonable fall back plan if percent savings not high enough, or
  - If most projects are screened out, select another savings verification approach
- ▼ Target a specific population with high savings potential
- ▼ Relax confidence interval requirements
  - For example, from 90% confidence to 80%
- ▼ Ensure amount of data is adequate (length of monitoring pre and post)

# Strategy: Relax Confidence Interval

Store	% Savings	90% Confidence	80% Confidence
Store 1	14.3%	✓	✓
Store 2	3.8%		
Store 3	5.3%		✓
Store 4	5.0%		✓
Store 5	6.9%	✓	✓

# Savings Uncertainty Implications

## Benefits

- ▶ Focusing program will ease implementation
- ▶ Screening by expected savings improves consistency of approach and results

## Risks

- ▶ Relaxing requirements could conflict with evaluator standard

# Challenge: Regulatory Requirements

- ▶ Reporting individual measure savings
- ▶ Direct link between savings and measure implementation (see Attribution)
- ▶ One-time incentives instead of ongoing payments for continuous improvements

# Regulatory Requirements

## Strategies for Overcoming Barriers

- ▶ Conduct pilots to prove approach
- ▶ Identify where to place in the portfolio (e.g., market transformation initiative)
- ▶ Work with regulators to determine approval or implementation process
  - Careful planning to determine requirements and eligibility
- ▶ Select other M&V approaches

# Regulatory Requirements Examples

## ▼ Northwest

- Regional Technical Forum approves approaches
- Convene subcommittee develop requirements

## ▼ New York

- NYSERDA Innovative Opportunities Pilot
- Market transformation approach to different savings requirements

## ▼ California

- Collaboration among industry groups for EBCx programs
- California Commissioning Collaborative coordinating discussions with the CPUC

# Regulatory Requirements Examples

## Benefits

- ▶ Reduce risk for full program roll out
- ▶ Benefit from pilot successes and mistakes
- ▶ Open dialog about next generation programs

## Risks

- ▶ Long process
- ▶ Non-whole building M&V approaches may not capture full behavior savings

# Challenge: Savings Attribution

- ▶ Program overlap may increase double-counting risk
- ▶ Changes occur in building operation or other activities that impact energy use
  - Tenants move out or in
  - Space changes use
- ▶ Whole building M&V does not provide individual measure savings

# Savings Attribution: Strategies for Overcoming Barriers

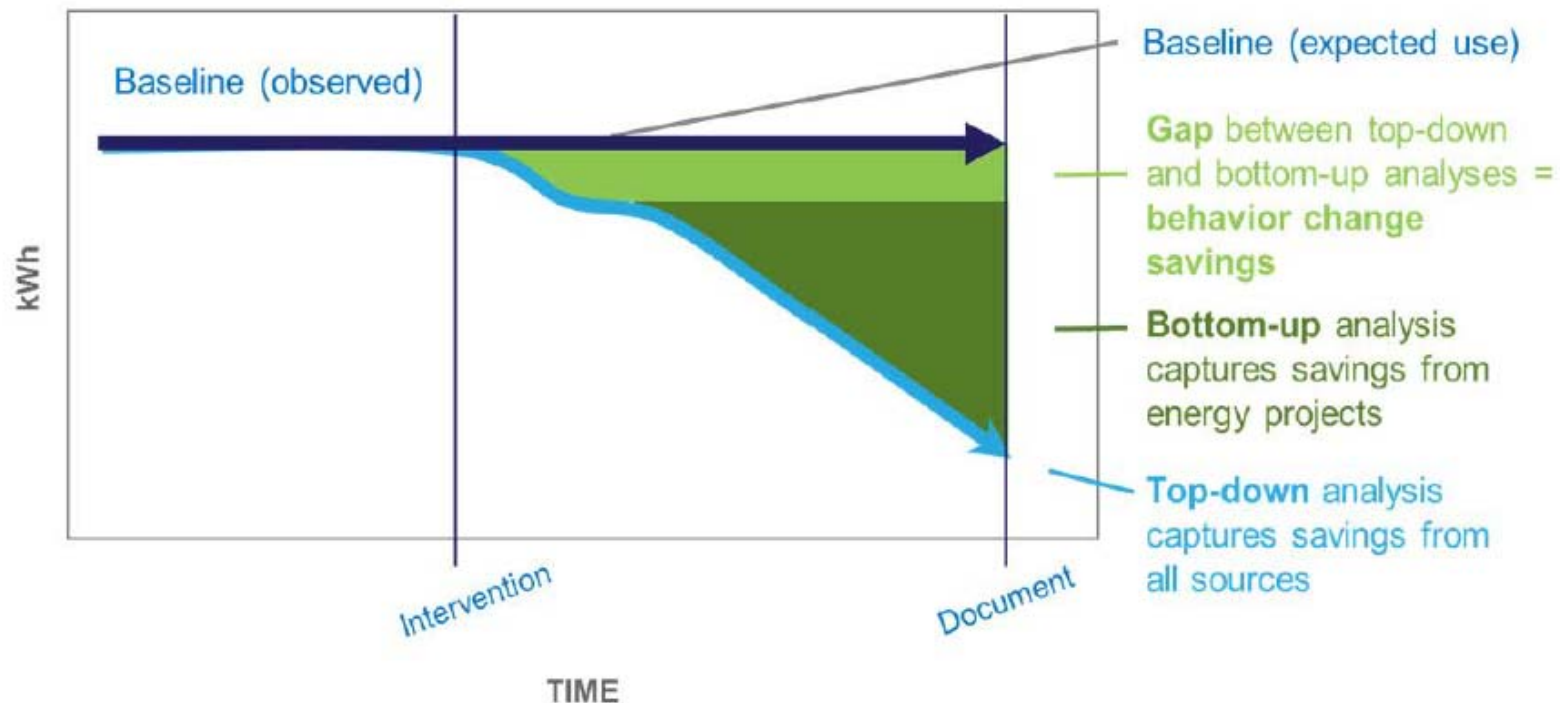
- ▶ Pre-plan and combine program participation options
- ▶ Account for building changes
  - Good record keeping
  - Accurate model specification
- ▶ Operational verification to confirm measure is properly installed and functional
- ▶ Top down, bottom up analysis

# Savings Attribution: Example

## Industrial Example

- NEEA's Continuous Energy Improvement

Figure 1. Bottom-Up and Top-Down Interaction



# Savings Attribution: Example

- ▶ Grocery store pilot
  - Combined controls and retrofit program
  - No changes during program period
- ▶ High confidence in correlation between savings and energy efficiency activities



# Savings Attribution: Implications

## *Benefits*

- ▶ More clear participation requirements and channels
- ▶ Good record of building activity and measure installation
- ▶ Better continuous feedback on energy performance

## *Risks*

- ▶ Different paradigm in savings accounting – may need proof of concept to show viability