Seminar 10 – How Optimization and Performance Based Modeling Techniques Lead to Success

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Comparison of Projected to Realized Savings for Projects that Participated in a Modeling-Based Incentive Program

Learning Objectives

- Provide an overview of modeling methods of district cooling ice storage systems for model predictive control
- Provide a comparison of regression, neural network and physical models of district cooling ice storage systems for optimal operation
- **Discuss correlation of energy savings projections produced by calibrated energy models following ASHRAE Guideline 14 and realized energy savings measured and verified using IPM&VP Option C: Whole Building Comparison for a large sample of projects**
- **Understand project characteristics that may cause discrepancies between energy model savings projections and realized energy savings**
- Recognize the energy saving potential via retrofitting building enclosure of existing medium office buildings.
- Understand the effectiveness of different building enclosure retrofitting approaches.
- Identify the performance criteria and retrofitting options which offer significant energy saving.

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Outline/Agenda

- Overview of Pay-for-Performance Incentive Program
- Study goals and methodology
- Patterns in the accuracy of projections, and analysis
- P4P Simulation Guidelines
- Conclusions

Pay-for-Performance (P4P) Program Overview

- Targets existing commercial and industrial buildings
- Requires comprehensive scope of work to reduce overall source energy consumption by at least 15%.
- Relies on a network of approved providers including engineering consulting firms, ESCOs, and other trades with demonstrated experience in energy efficiency projects.
- Projects must comply with Minimum Performance Standards, which set minimum efficiency requirements for various equipment.

P4P Incentive Structure

Incentive #1: Energy Reduction Plan (ERP)

- Paid upon completion of Level 2/3 audit and approval of an ERP, which documents projected energy savings from the proposed retrofit based on IPMVP Option D: Calibrated Energy Simulation.

Incentive #2: Construction Completion

- Paid upon installation of recommended measures.

Incentive #3: Savings Verification

- Paid upon verification of achieved savings following IPMVP Option C: Whole Building Comparison.
- Incentive #3 is “trued-up” based on achieved savings so that the total incentive reflects the Program’s incentive structure.

Study Goals

Gauge accuracy of savings projections

Identify patterns affecting projection accuracy

Inform incentive program design

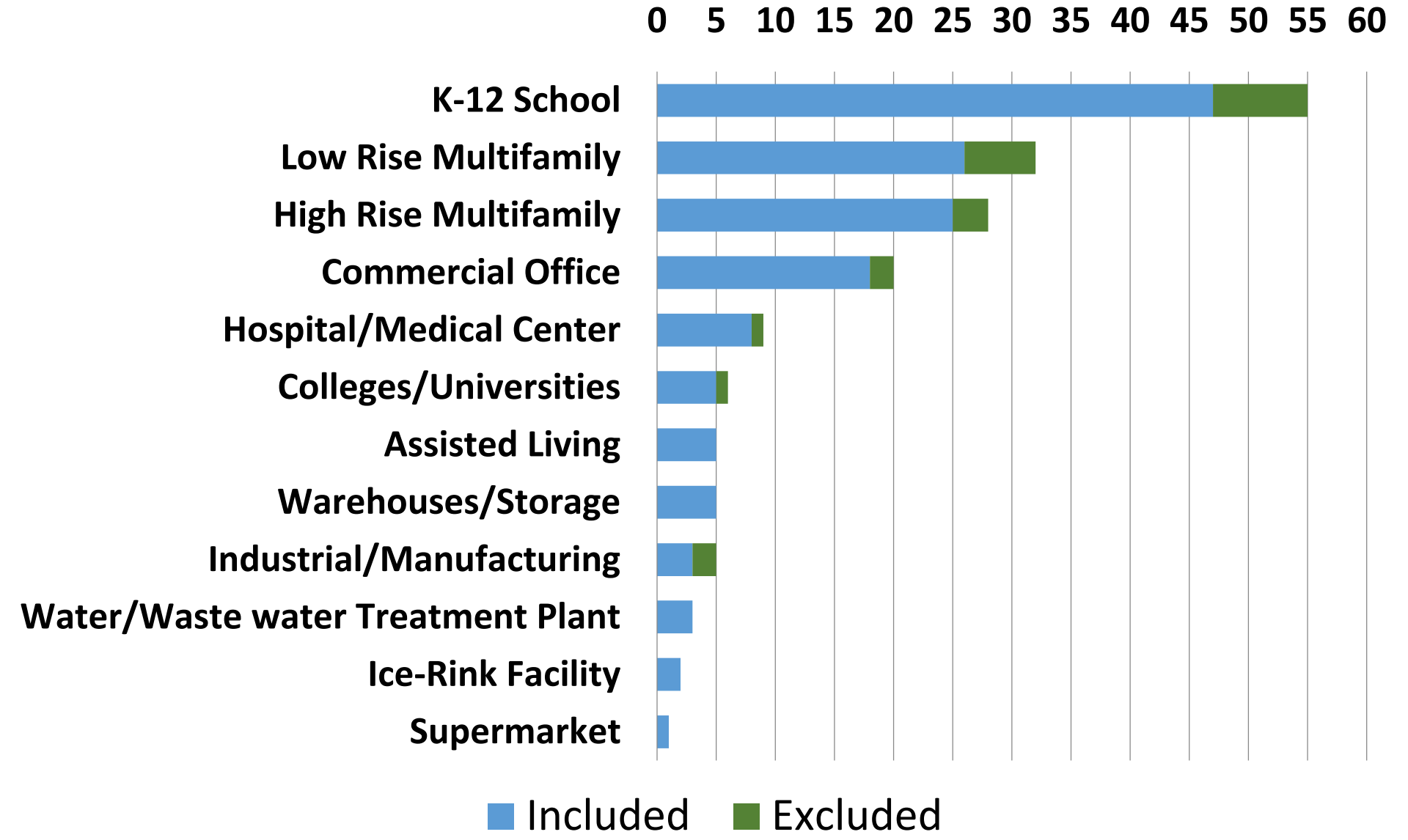
Inform submittal review strategies

Evaluated Data Set

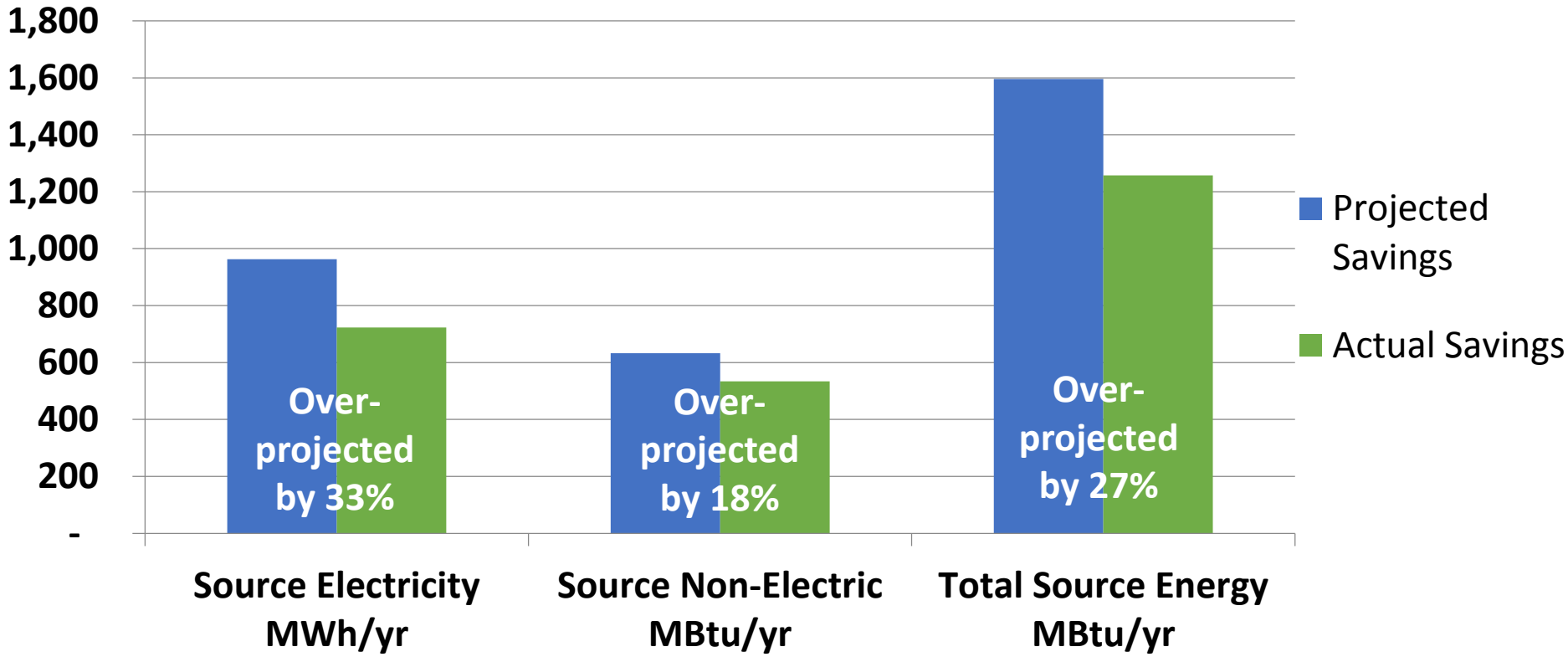
- All projects that submitted annual post-retrofit utility bills were initially considered.
- Removed projects that did not have valid, verified data, or complete set of bills.

	All Projects	Selected Sample
Projects	171	148
Companies	44	41
Simulation Tools	6	6
Building Types	17	17

Evaluated Projects by Building Type



Overall Trends: Projected Vs. Realized Savings



Projected Savings are based on the calibrated simulation

Actual (Realized) Savings are the difference between pre-retrofit and post-retrofit utility bills normalized for weather

Realized Savings Uncertainty

For some projects, post-retrofit energy use was affected by factors unrelated to the installed measures, increasing uncertainty of the realized savings.

Example 1: Construction Unrelated to P4P Measures

- School with large addition constructed at the same time when measures were installed
- Post-installation bills included the combined use of renovated portion and addition

Example 2: Changes in Occupancy and Operation

- Retrofit included no measures related to service water heating or cooking gas
- Usage on the associated meters changed substantially between pre- and post-retrofit periods, possibly due to changes in occupancy (e.g. student housing)

Realized Savings Uncertainty (continued)

Example 3: Change in weather between pre- and post-retrofit periods

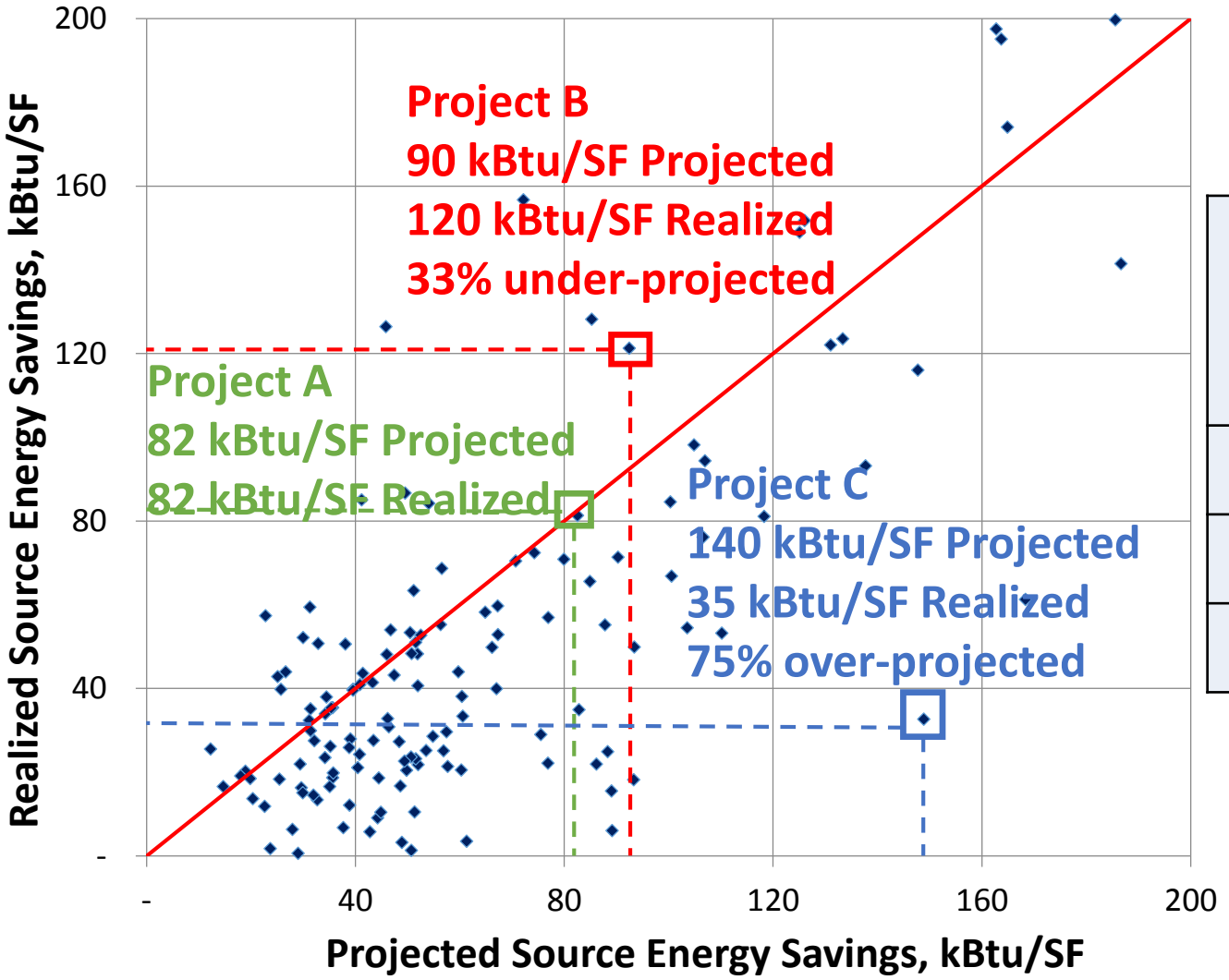
- Low-rise multifamily project included substantial improvements to envelope and heating system.
- Projected (simulated) heating energy savings were based on the Typical Meteorological Year (TMY) during pre-retrofit period.
- P4P *realized savings* are calculated based on the savings realized during post-retrofit period.
- If winter during post-retrofit period was much warmer compared to TMY (which is often the case!), realized savings during that year will be significantly lower than was projected.

Sources of Discrepancies

- Site data collection issues
- Energy modeling issues
- Measure installation / maintenance issues
- Uncertainty in determining realized savings (e.g. data anomalies).

What are the patterns in the accuracy of projected savings?

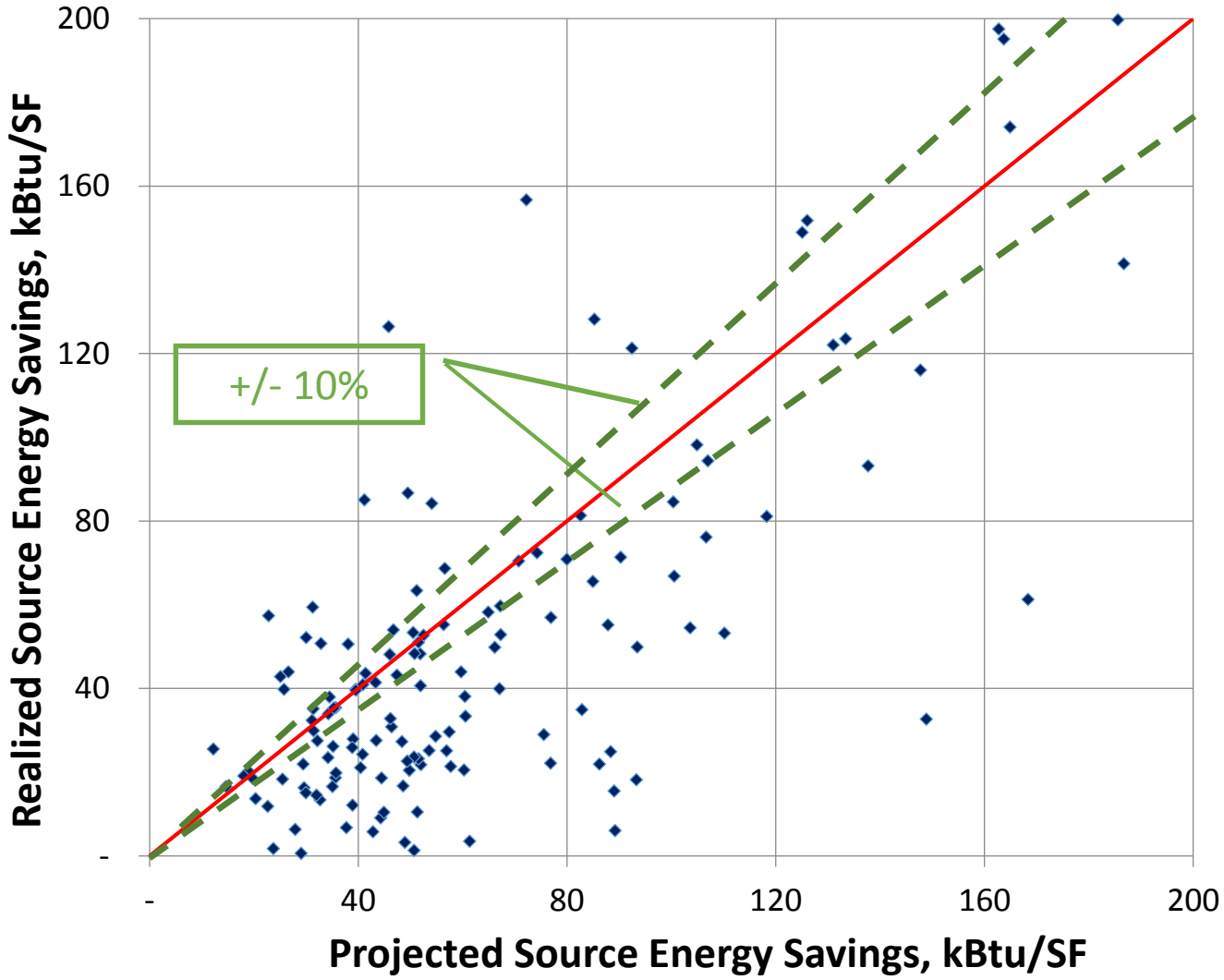
Annual Source Energy Savings - All Fuels



Average Savings kBtu/SF

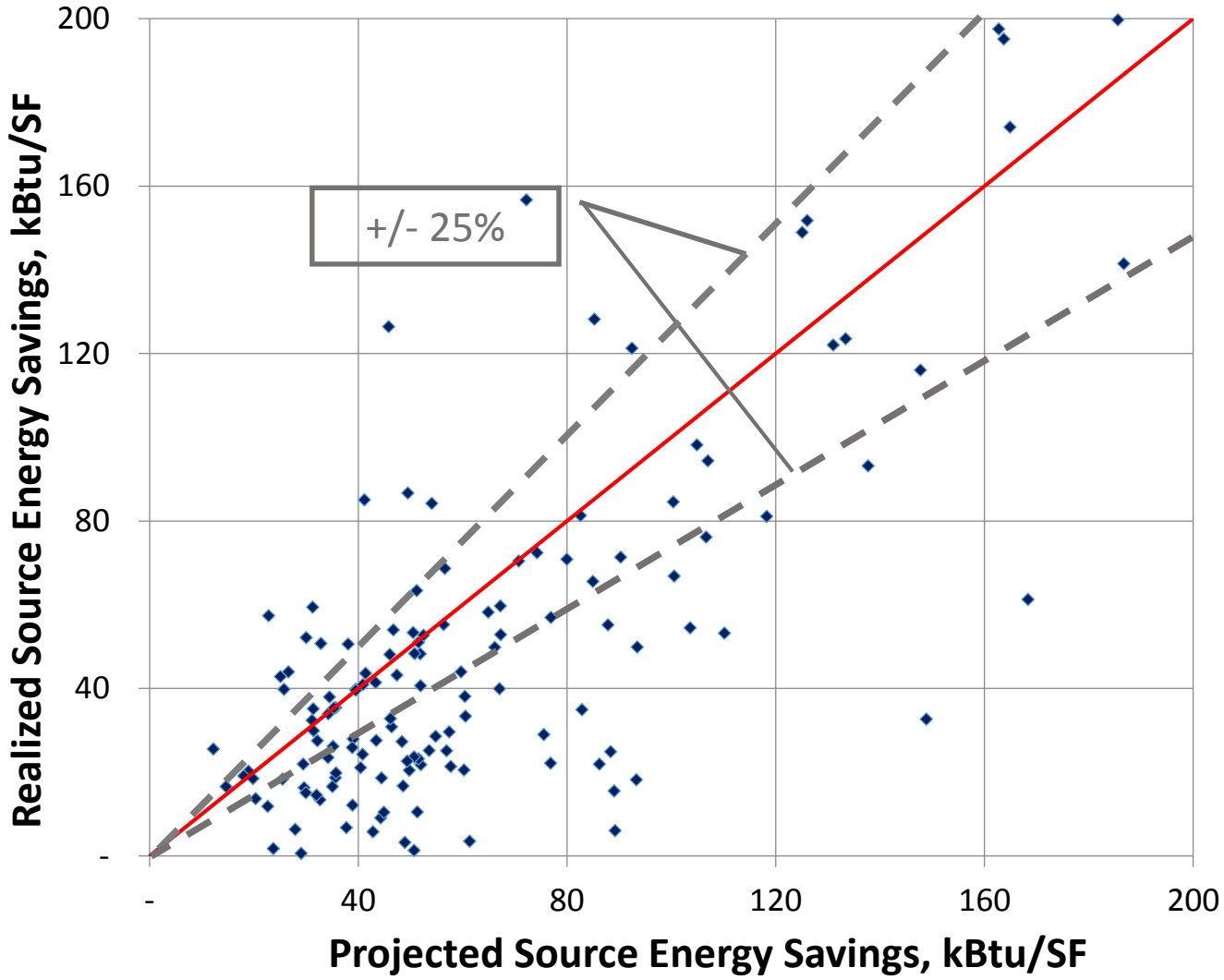
	Projected	Realized
Electric	48	37
Other	22	19
Total	70	56

Savings Projection Error



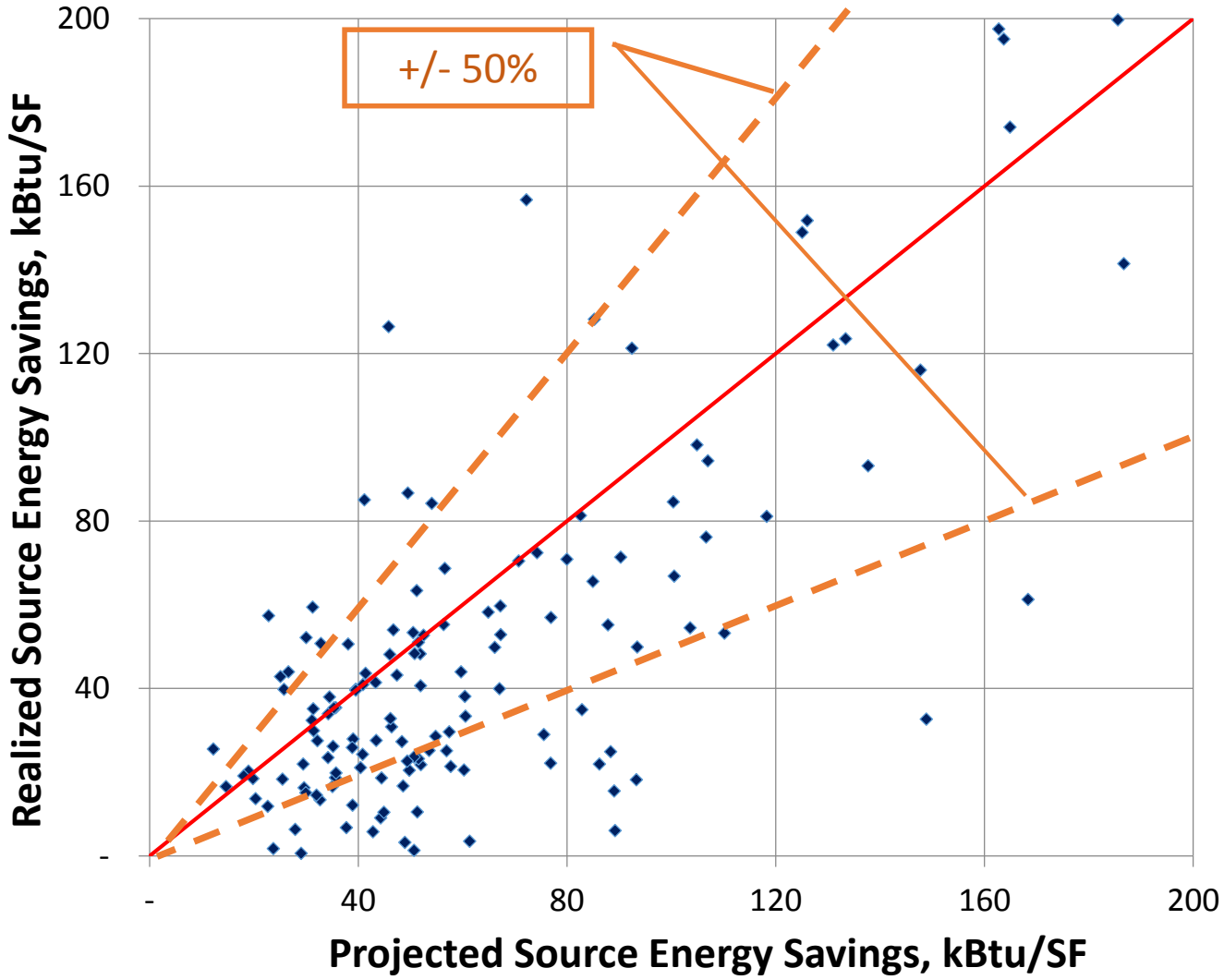
Percentage of Projects in Each Accuracy Band	
Within 10%	21 %

Savings Projection Error



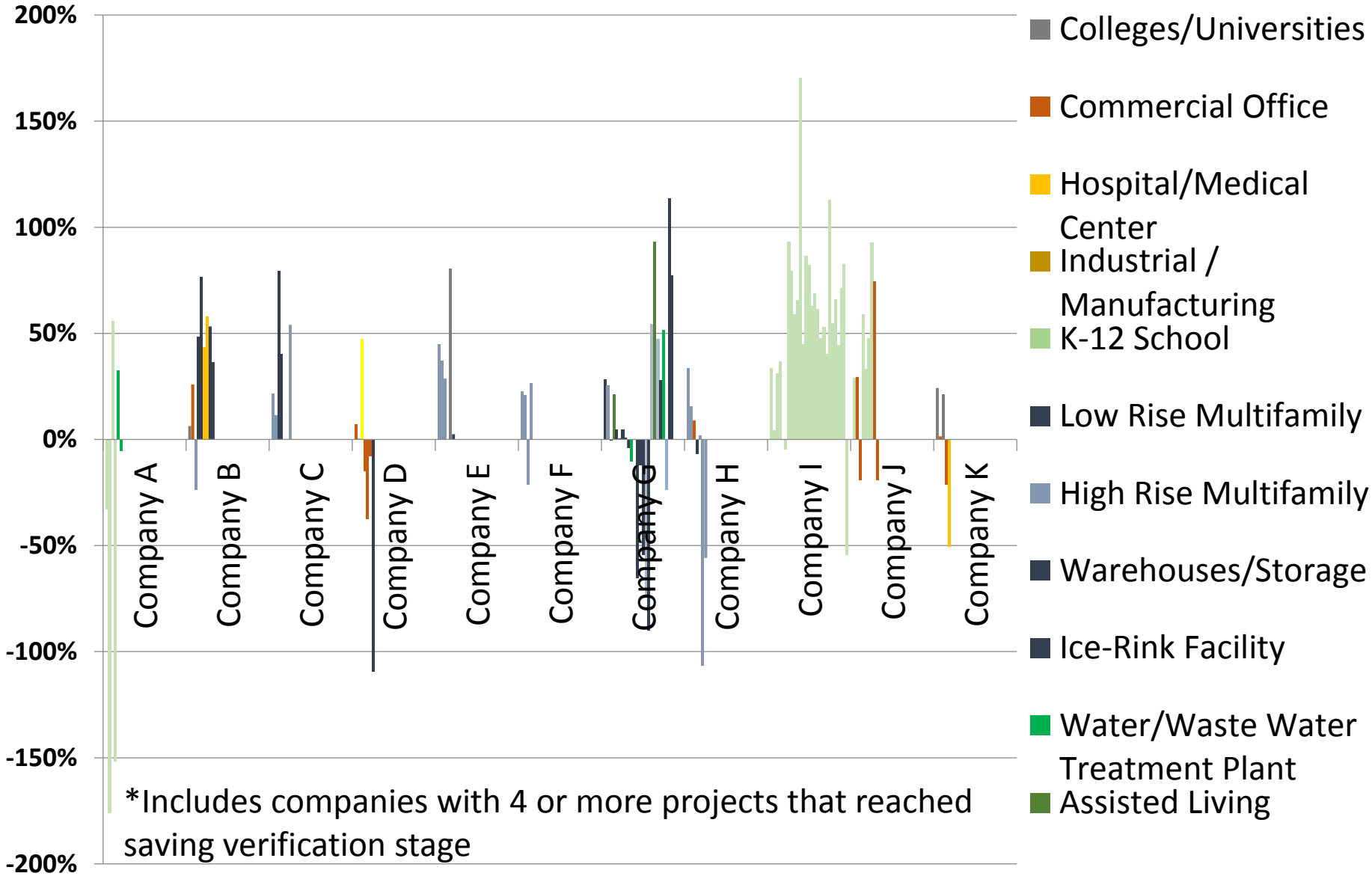
Percentage of Projects in Each Accuracy Band	
Within 10%	21 %
Within 25%	39%

Savings Projection Error



Percentage of Projects in Each Accuracy Band	
Within 10%	21 %
Within 25%	39%
Within 50%	63%

Projection Error by Company*

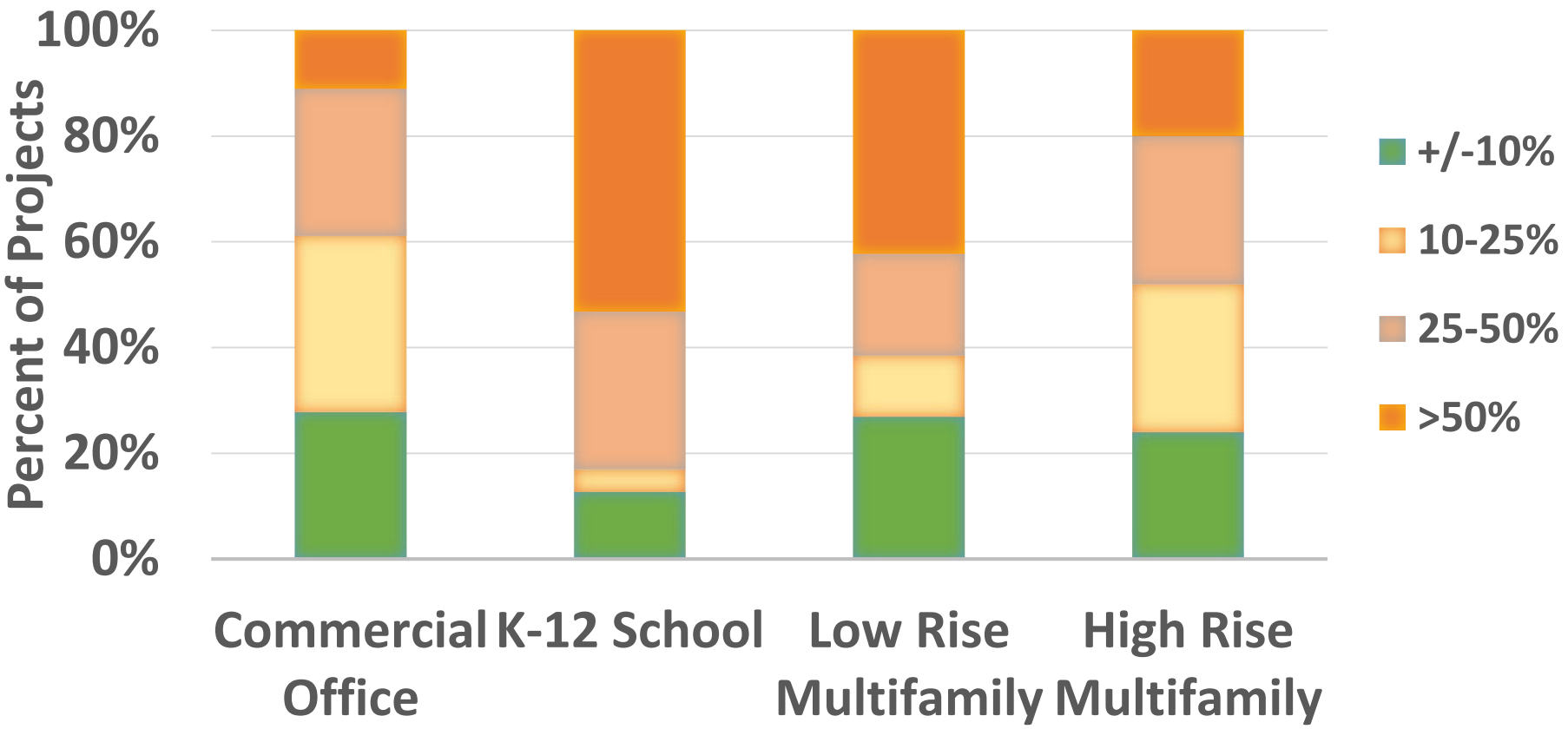


*Includes companies with 4 or more projects that reached saving verification stage

Error by Company

	% of Projects with Projection Error >50%	Average Over-Projection %	# of Projects	Predominant Project Type	ESCO?
Company A	50%	-76%	6	K - 12 Schools	No
Company B	33%	34%	9	LR Multifamily	No
Company C	40%	31%	5	HR Multifamily	No
Company D	14%	-16%	7	Office	No
Company E	20%	28%	5	HR Multifamily	No
Company F	0%	12%	4	HR Multifamily	No
Company G	38%	9%	24	LR Multifamily	No
Company H	29%	-16%	7	HR Multifamily	No
Company I	63%	55%	27	K - 12 Schools	Yes
Company J	33%	36%	9	K - 12 Schools	Yes
Company K	20%	-5%	5	University	No

Savings Projection Error by Building Type*

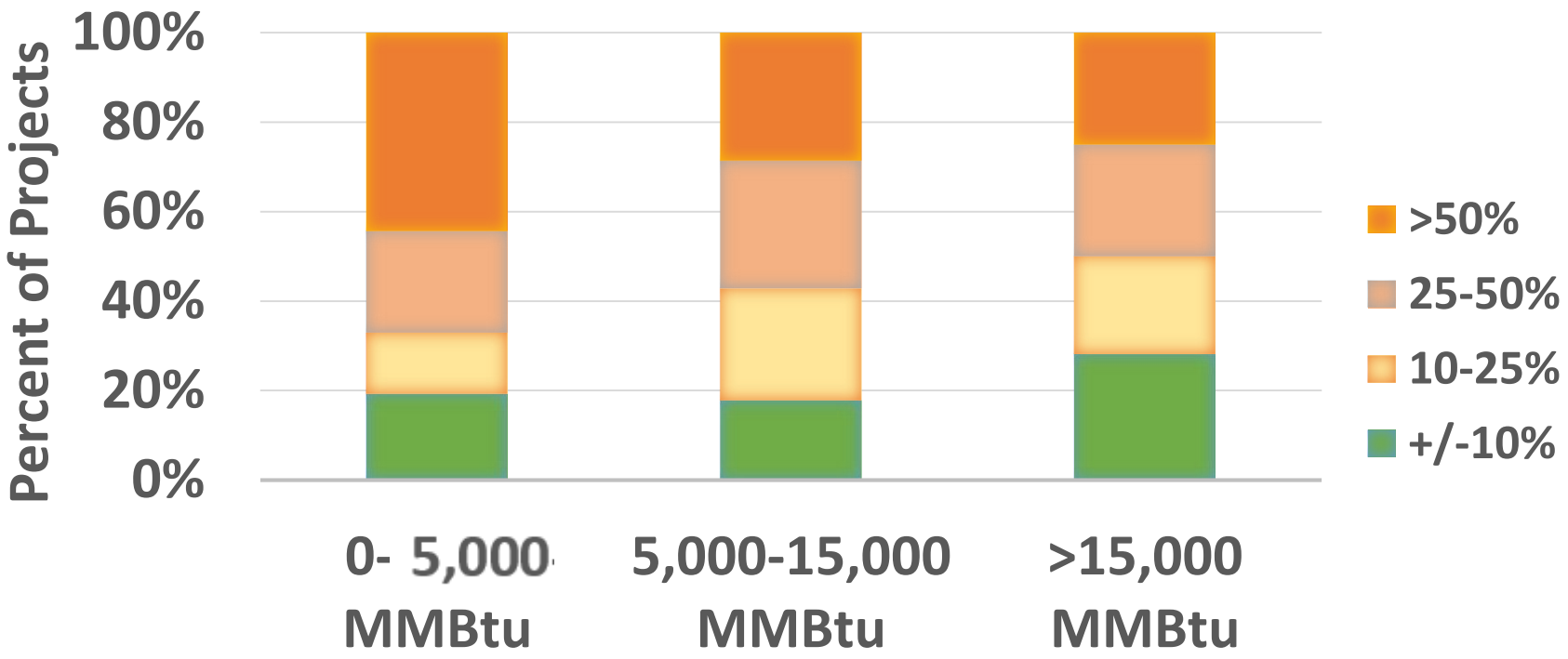


*Included building types with 18 or more projects

What Is Different About Schools?

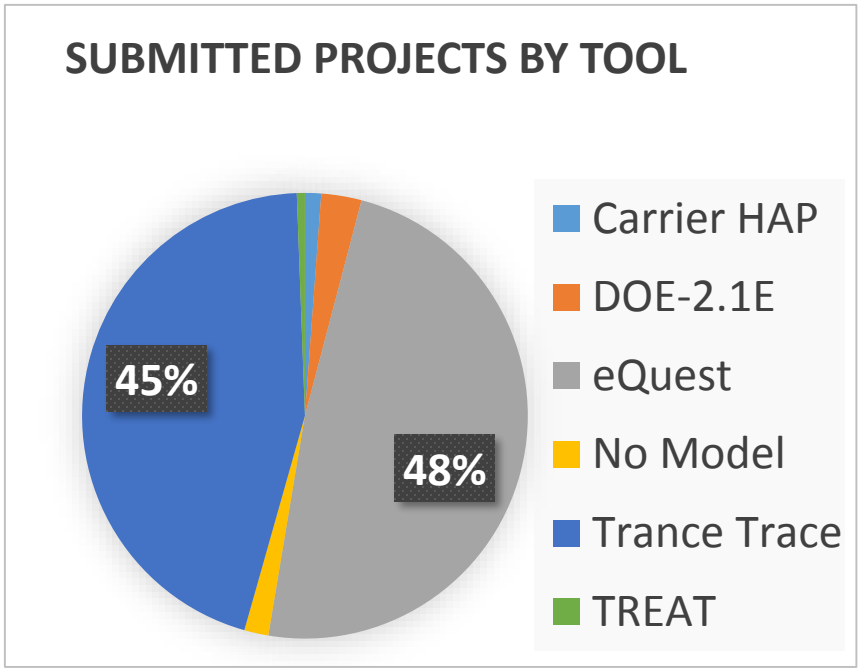
- One company accounts for 27 out of 47 (57%) K-12 school projects
- Companies with the majority of school projects are also manufacturers/installers of HVAC controls
- Most schools projects have HVAC control ECMs that account for 25-40% of the total projected savings
- Existing conditions for control measures are difficult to establish, which increases uncertainty of savings projections.
- Nearly all schools in the data set have performance contracts with guaranteed savings.

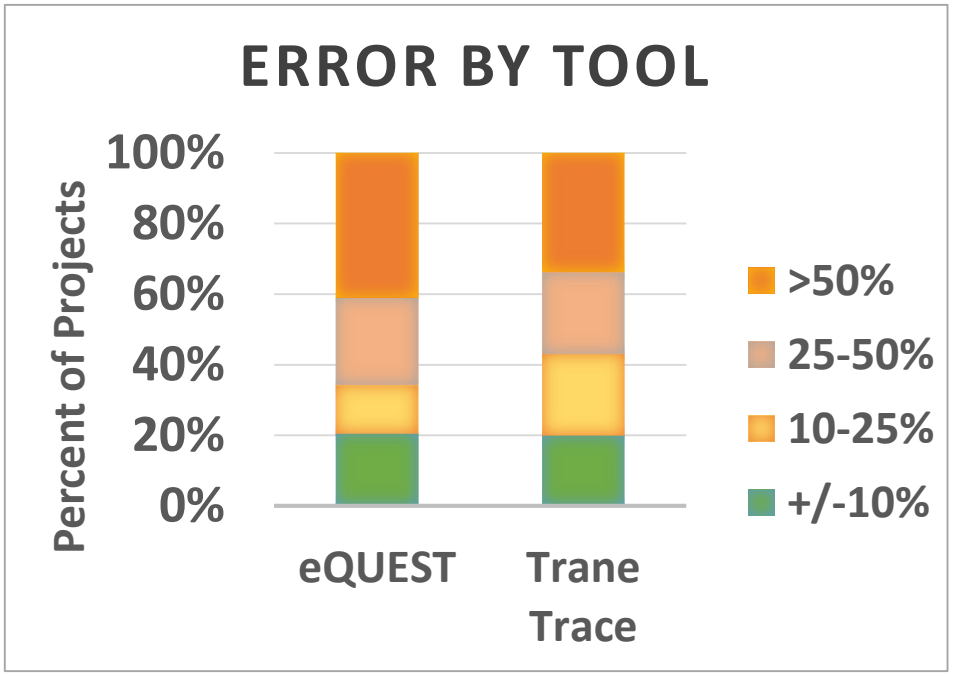
Error by Magnitude of Projected Savings



- Projects with higher projected savings are more accurate, in spite of increased complexity
- These projects receive higher Incentive #2, and are reviewed more rigorously
- Projected savings often decrease by 20-40% as a result of the program reviews

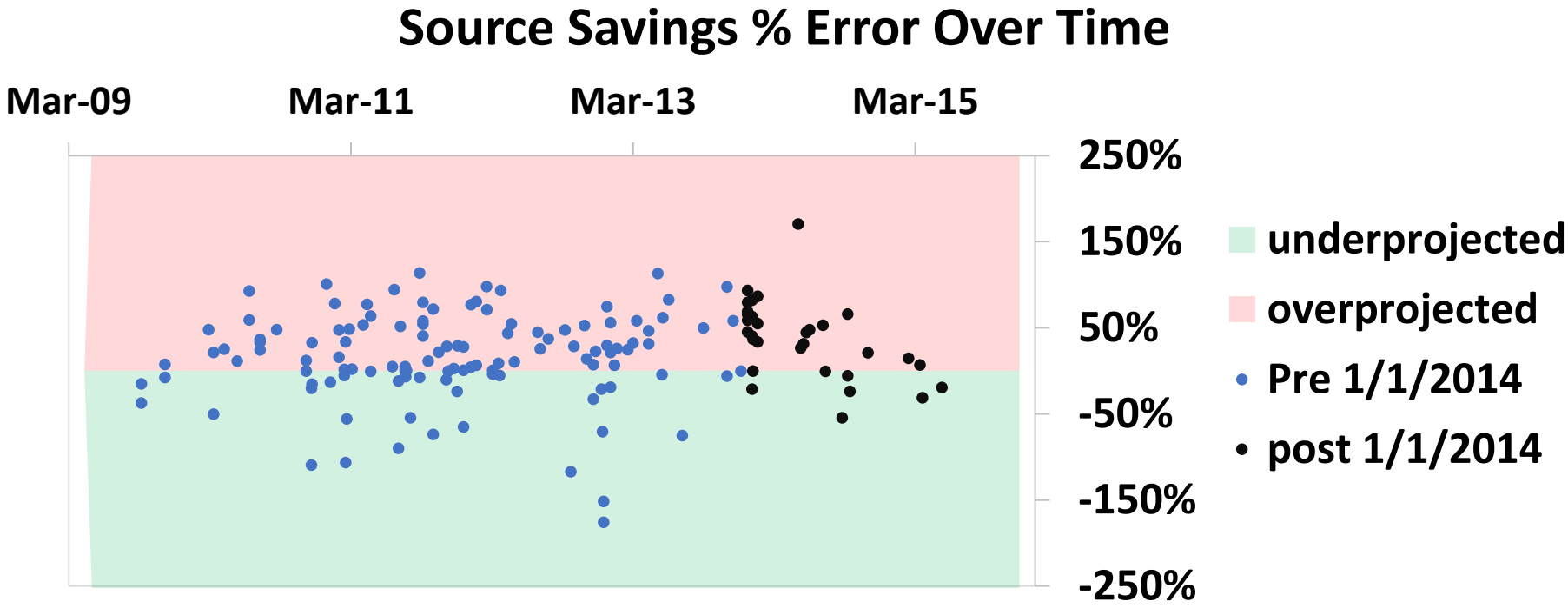
Software Tools





- Fewer eQUEST projects with savings projections within +/- 50%, but more eQUEST projects with savings projections within +/- 10%
- Company with the least accurate projections used Trane Trace
- Modeler matters more than the simulation tool

Improved Accuracy Overtime

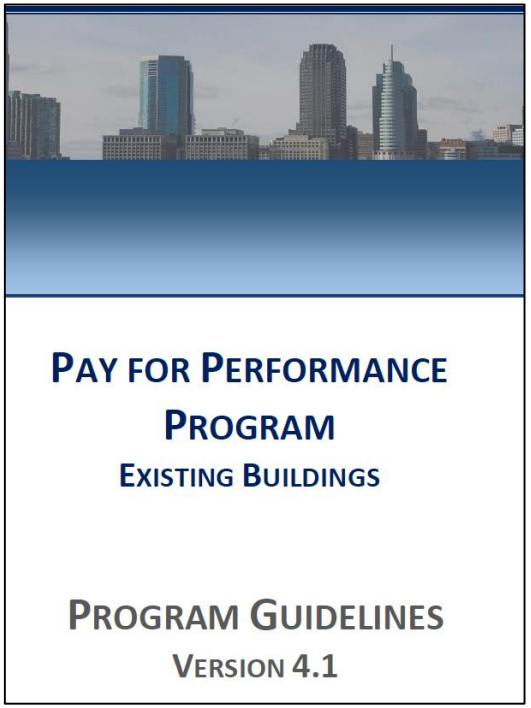


- Decrease in scatter (error) on more resent projects
- Significant changes to P4P technical requirements in January 2014.
- Annual updates to the program guidelines, and monthly trainings for participating consultants.

P4P Simulation Guidelines

- Based on ASHRAE Guideline 14 and IPMVP
- Model calibration rules with the **focus on Energy Conservation Measures (ECM)**

  - The key parameters that drive ECM savings must be based on site measurements
  - Require using conservative estimates if direct measurements of impactful parameters that drive ECM savings were not performed.



Sample ECM Modeling Requirements

- Calculator to estimate air-leakage reduction from common air-sealing measures
- Prescribed limits on HVAC equipment efficiency de-rating due to age
- Limits on reduction in lighting runtime due to new lighting controls
- Thermostat setback limits
- Limits on plug and process load reduction

Considerations to Reduce Over/Under Projections

- Discuss results with companies that consistently over-project savings
- Continue maintaining Simulation Guidelines
- Require additional monitoring and/or commissioning for certain measures
- Require regular check-in during post-retrofit period, to catch anomalies or under-performance early.
- Improve methodology for calculating realized savings to better account for changes unrelated to installed ECMs
- Be more proactive to collect and analyze project data to evaluate company and program performance.

Conclusions

- Overall, realized source energy savings exceed 15% program target
- There is a significant difference between projected and realized savings for many projects
- P4P “true-up” incentive ensures accountability and fair distribution of funding to projects
- There is a significant difference in the accuracy of projections from company to company
- Evolution of P4P technical requirements, submittal review practices, and on-going participant training helps improve projection accuracy

Bibliography

Christopher DeAlmagro, BEMP, Member[1], Maria Karpman, BEMP, Member[2] and Valentina Rozanova, P.E[1]. 2017. Comparison of Projected to Realized Savings on Projects that Participated in a Modeling-Based Incentive Program. Presented at the 2017 Building Performance Analysis Conference, Atlanta, Georgia, September 27-29.

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QUESTIONS?

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