



AABC Commissioning Group

AIA Provider Number 50111116

## **The Case for Cx: Updated Landmark Study Shows Evolution of Cx Costs & Benefits 2004-2018**

Course Number: CXENERGY1925



***Eliot Crowe***

***Lawrence Berkeley National Lab***

April 17, 2019

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

This course is registered with **AIA**



# Course Description

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Evan Mills' 2004 study *"Building Commissioning A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions"* is considered the seminal work articulating the cost/benefit of commissioning. It is routinely cited by building owners and Cx providers to make the case for implementing Cx in new and existing buildings, and by policymakers as key background for deployment programs. Lawrence Berkeley National Laboratory has updated the study with new results and findings and this presentation covers the data developed in what is now the world's largest resource of Cx cost and benefit data for commercial buildings.

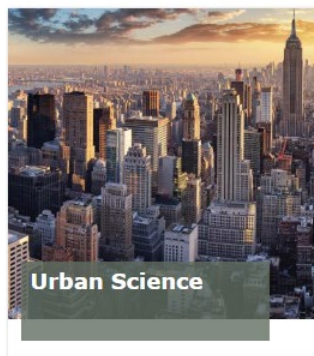
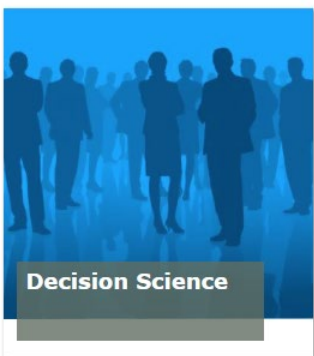
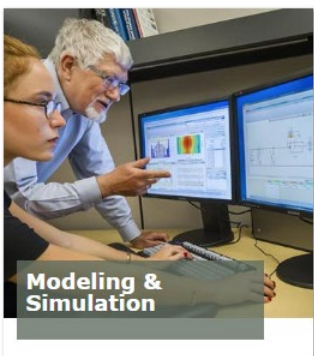
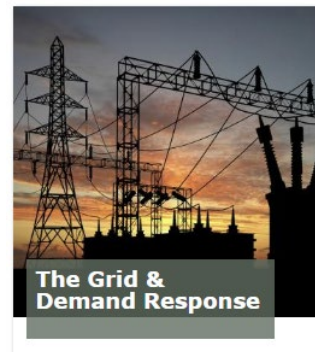
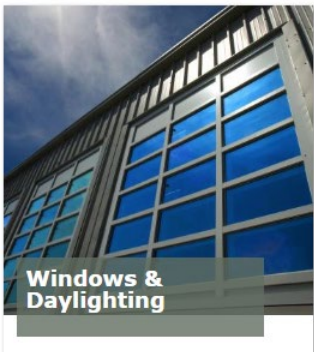
# Learning Objectives

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At the end of the this course, participants will be able to:

1. Learn about the latest information on energy savings and costs associated with EBCx, NCCx based on the largest available database of Cx data.
2. Understand the current state of the Cx practices as it pertains to Cx scope, systems affected, owner motivations for pursuing Cx, non-energy benefits, and other key attributes.
3. Learn about the degree to which current trends in commissioning, such as ongoing and monitoring-based commissioning, are taking hold.
4. Understand the methods and difficulties in gathering accurate data on commissioning projects.

# Building Technology Research at Berkeley Lab



# Prior Cx Cost Benefit Studies

## THE COST-EFFECTIVENESS OF COMMERCIAL BUILDINGS COMMISSIONING A Meta-Analysis of Existing Buildings and New Construction in the United States

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HANNAH FRIEDMAN<sup>2</sup>  
TEHESIA POWELL<sup>3</sup>  
NORMAN BOURASSA<sup>1</sup>  
DAVID CLARIDGE<sup>3</sup>  
TUDI HAASL<sup>2</sup>  
MARY ANN PIETTE<sup>1</sup>

<sup>1</sup>Lawrence Berkeley National Laboratory  
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<sup>3</sup>Energy Systems Laboratory, Texas A&M University

November 23, 2004

LBNL - 56637

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An electronic version of this document and data forms are available at  
<http://eetd.lbl.gov/emills/PUBS/Cx-Costs-Benefits.html>

## Building Commissioning

*A Golden Opportunity for Reducing Energy Costs and  
Greenhouse Gas Emissions*

Evan Mills, Ph.D.  
Lawrence Berkeley National Laboratory  
Berkeley, CA 94720 USA

Report Prepared for:  
California Energy Commission  
Public Interest Energy Research (PIER)

July 21, 2009

For a downloadable version of the report and supplementary information, visit:  
<http://cx.lbl.gov/2009-assessment.html>

Sponsored by the California Energy Commission, Public Interest Energy Research Program, through the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

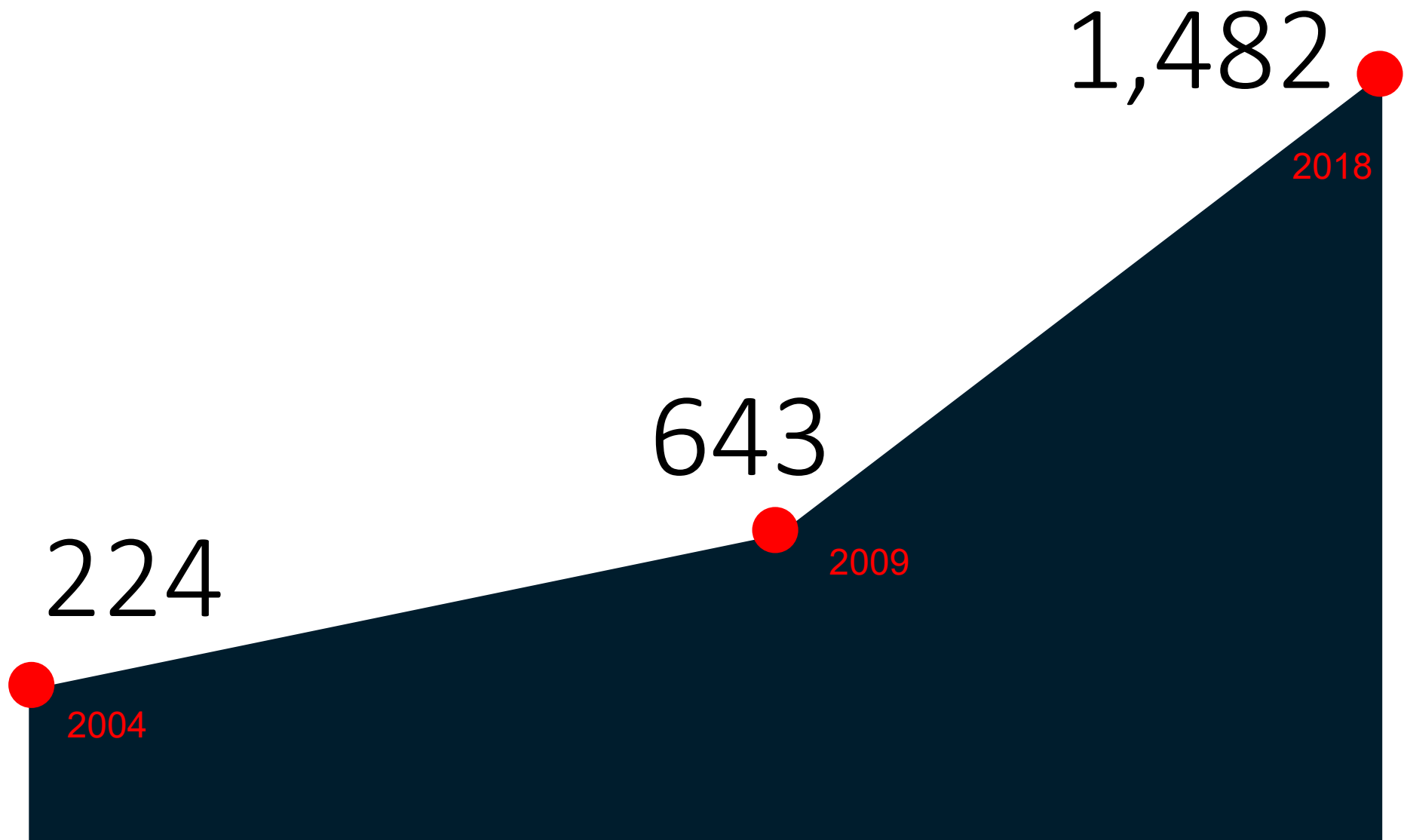


# Acknowledgements

- Study funding
  - U.S. Department of Energy
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  - Jessica Granderson
  - Eliot Crowe
  - Evan Mills
  - Claire Curtin
- Data providers for the study include:
  - Building Commissioning Association
  - ComEd
  - BC Hydro
- Support for data analysis review
  - Building Commissioning Association
- Complementary market survey
  - Building Commissioning Association

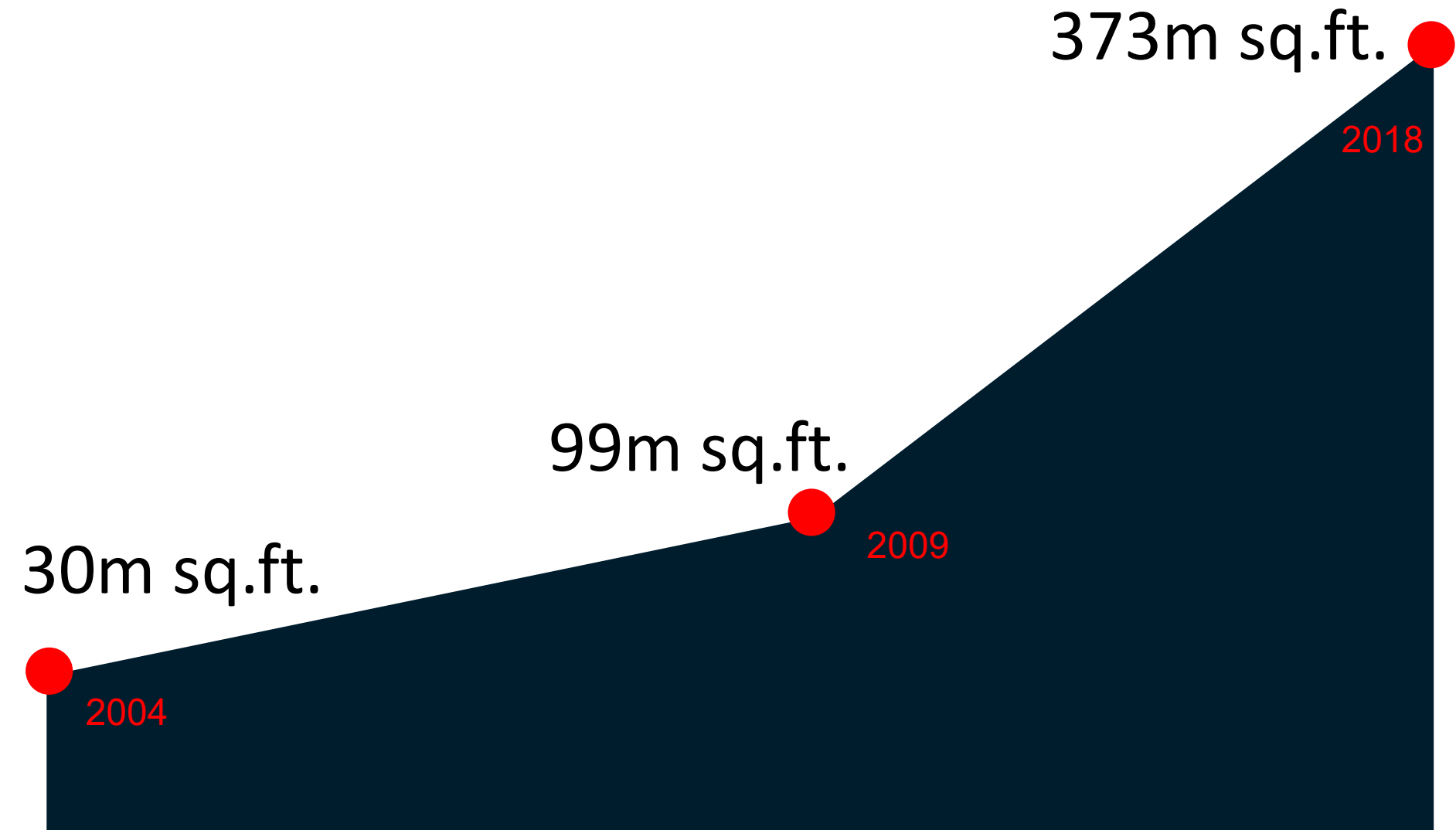


# Number of Buildings in Study (cumulative)



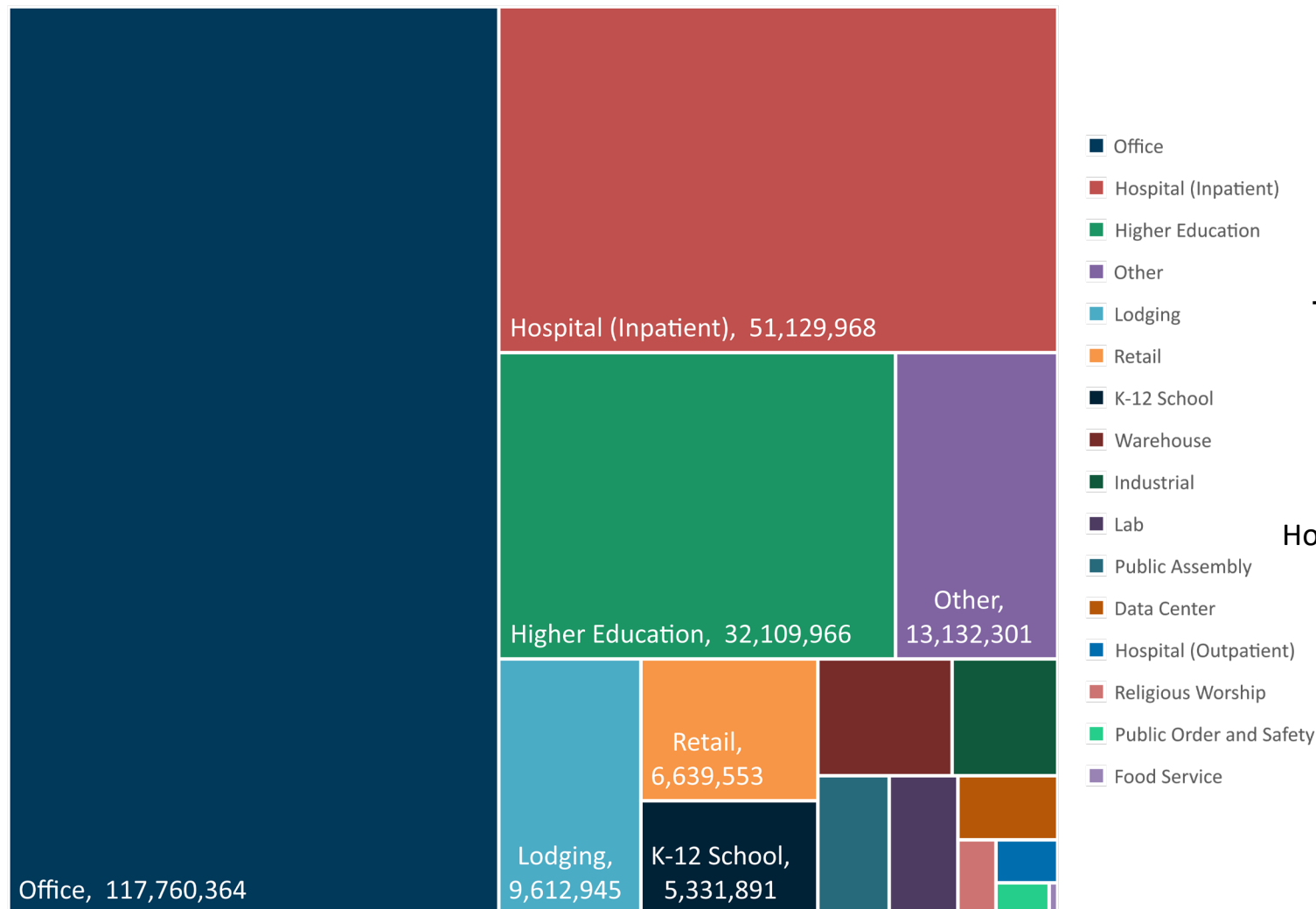


# Study Square Footage (cumulative)



# Market Sector Distribution: EBCx

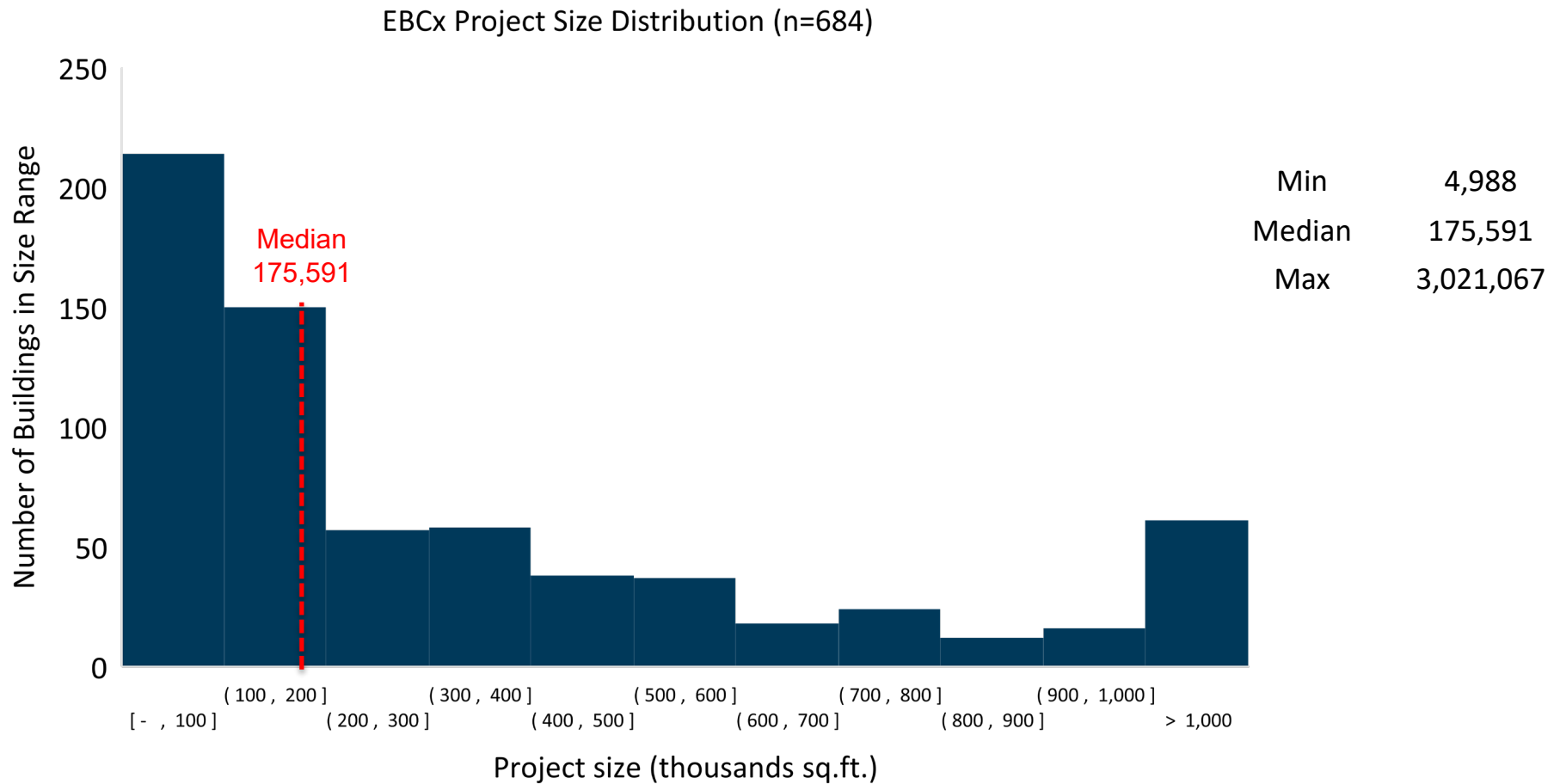
Market Segment, Square Footage, 2018 (EBCx)(Total 251,942,788sq.ft.)



## Top 4 categories in 2009

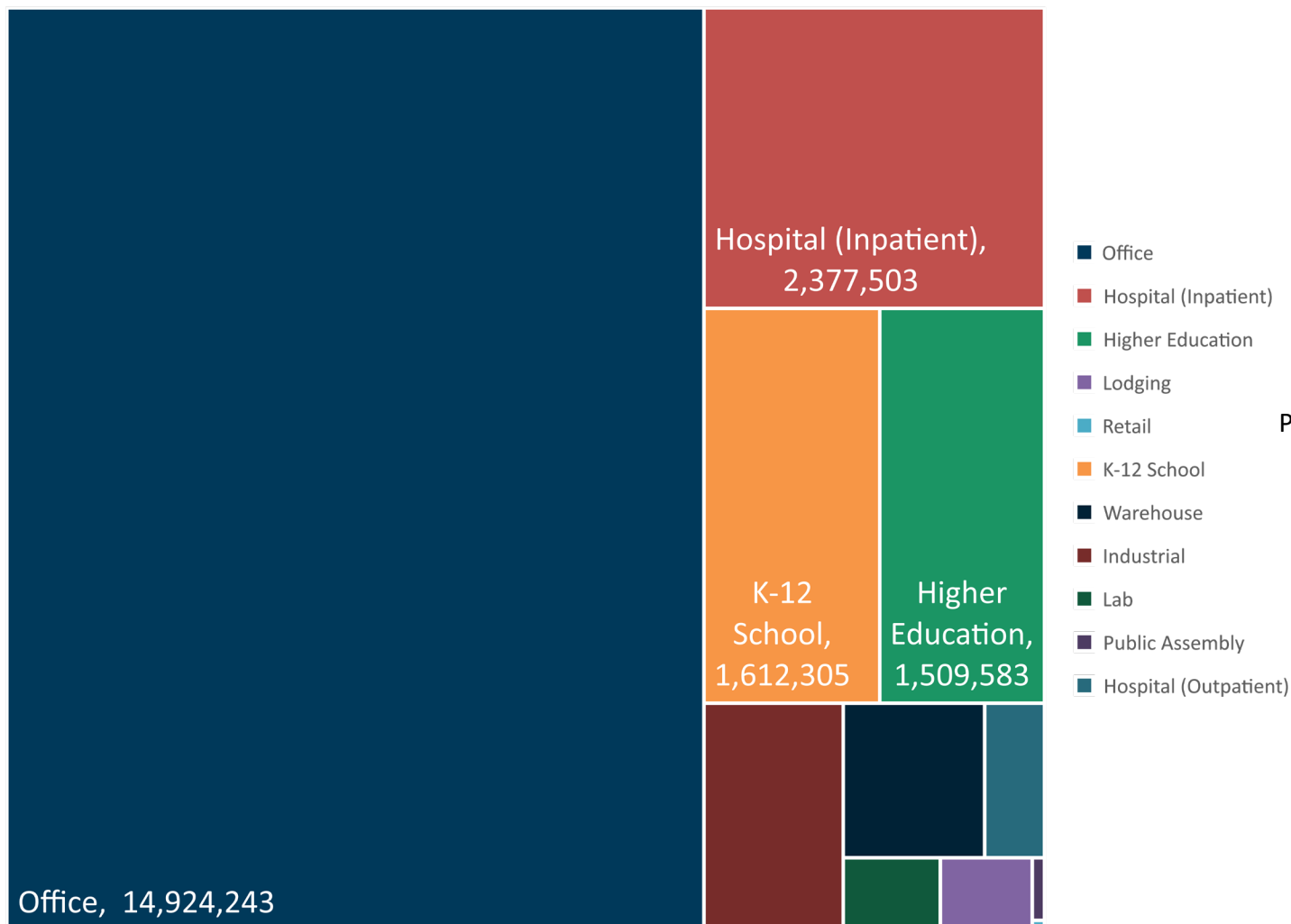
Office	44%
Higher Ed	13%
Lodging	11%
Hospital (Inpatient)	8%

# Project Size Distribution: EBCx



# Market Sector Distribution: NCCx

Market Segment, Square Footage, 2018 (NCCx)(Total 22,217,059 sq.ft.)

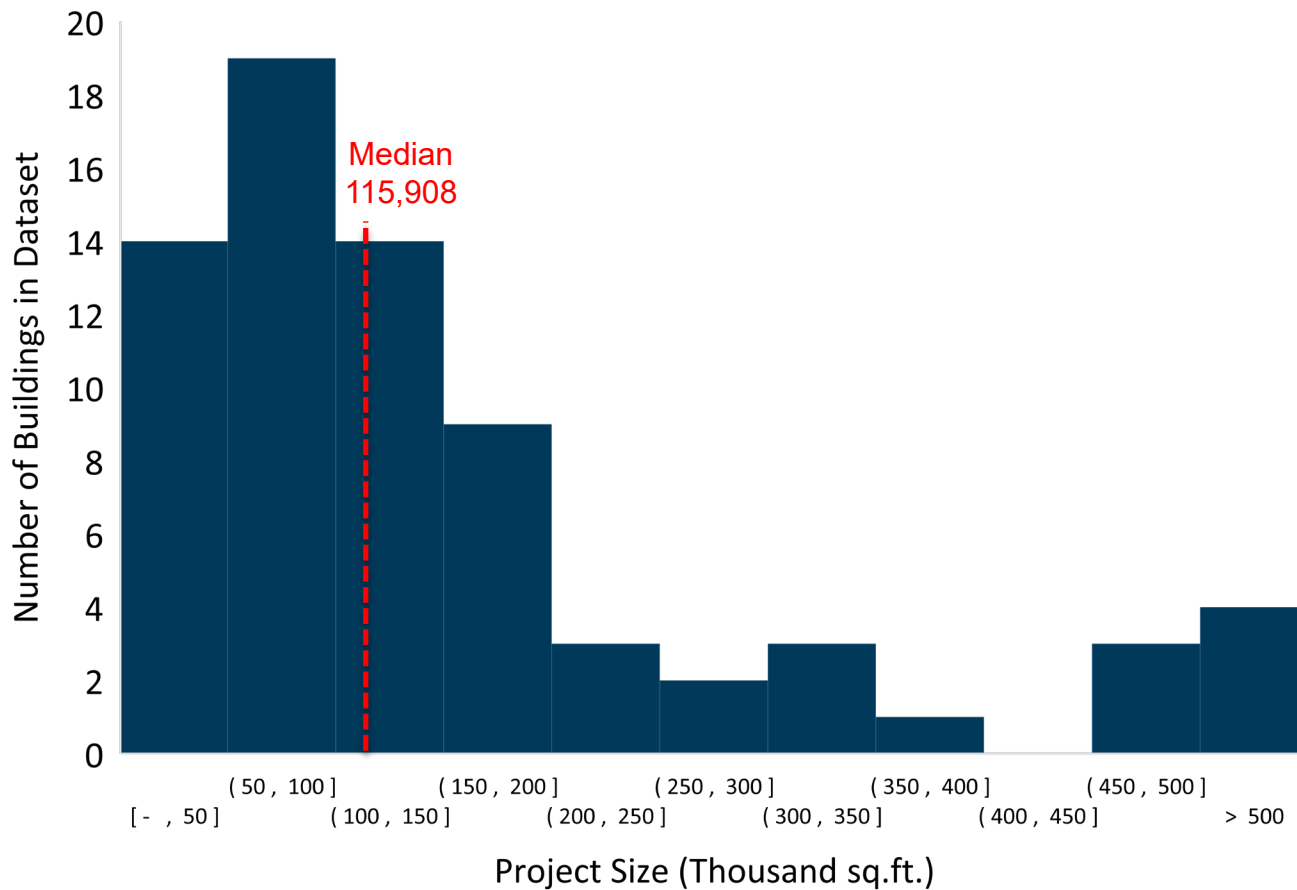


## Top 3 categories in 2009

Public Order/Safety	26%
Laboratory	22%
Office	10%

# Project Size Distribution: NCCx

NCCx Project Size Distribution (n=71)



Min	2,700
Median	115,908
Max	3,500,000

# Sample Composition: Summary

- Significantly larger dataset compared to prior studies
- EBCx dataset largely drawn from 2 US states and British Columbia
- NCCx dataset spread more evenly across many states
- Office, hospital (inpatient), and education comprise the largest portions of both EBCx and NCCx datasets

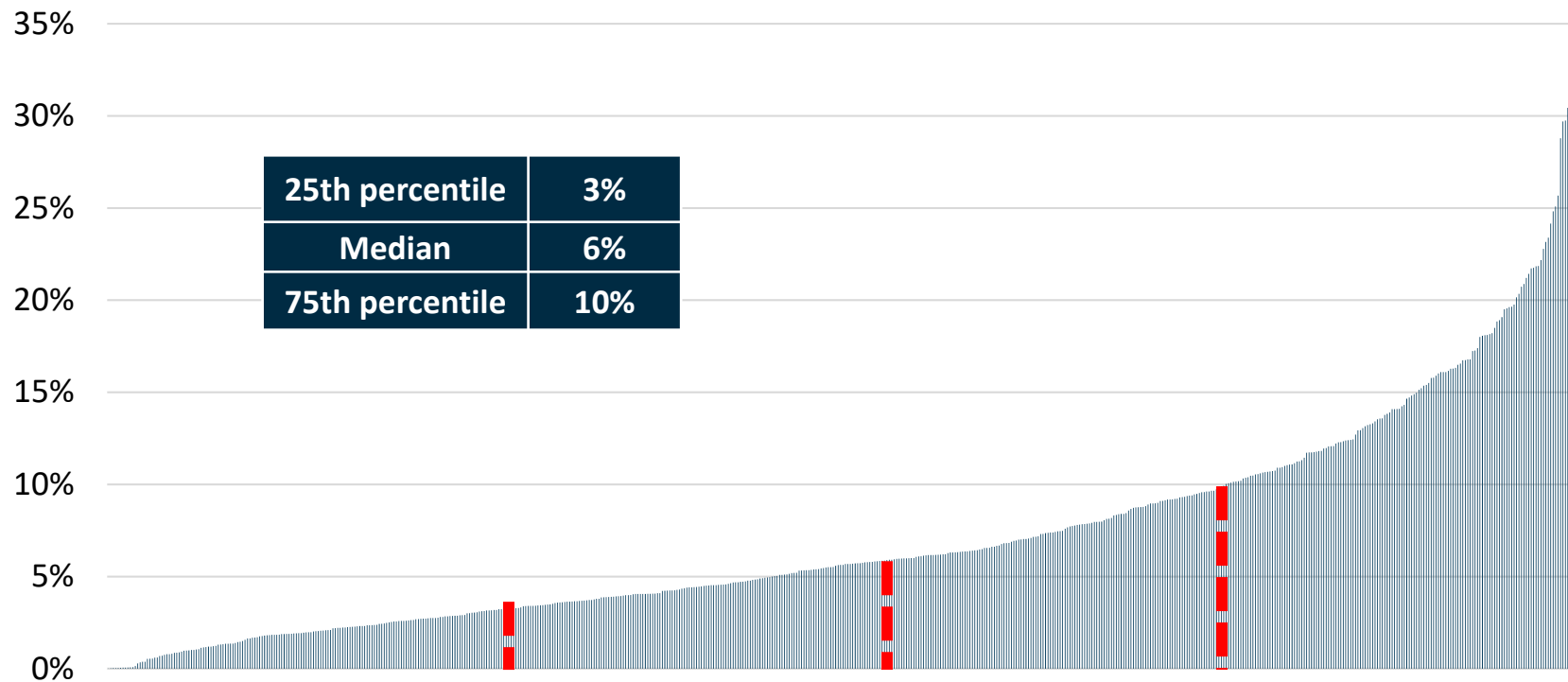


# **EBCX COSTS, SAVINGS, AND PAYBACK**

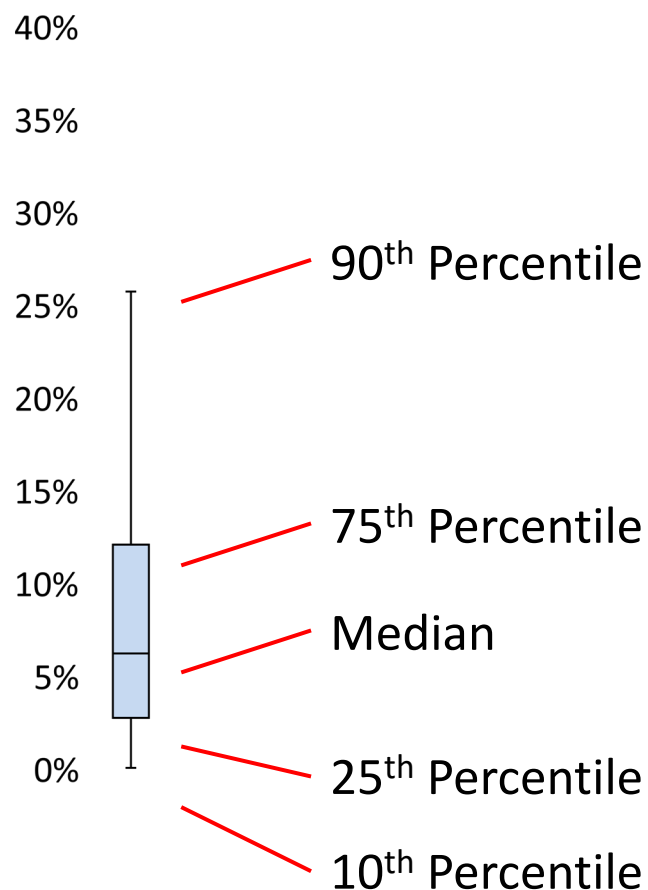


# EBCx Percent Savings

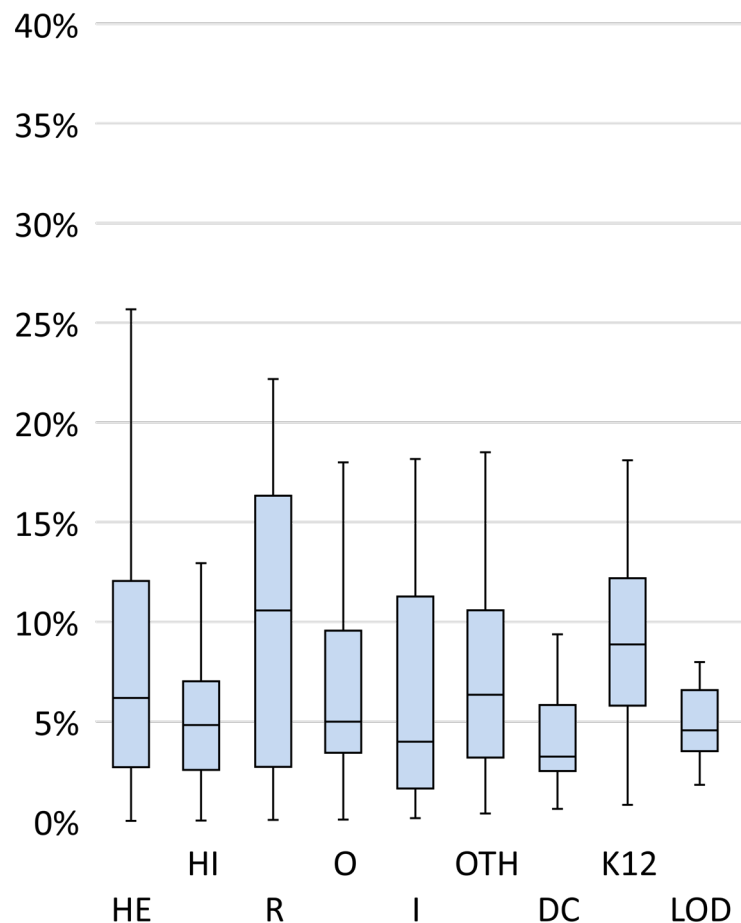
EBCx Percent Savings (Source Energy)(n=519)



# EBCx Percent Savings by Market Segment



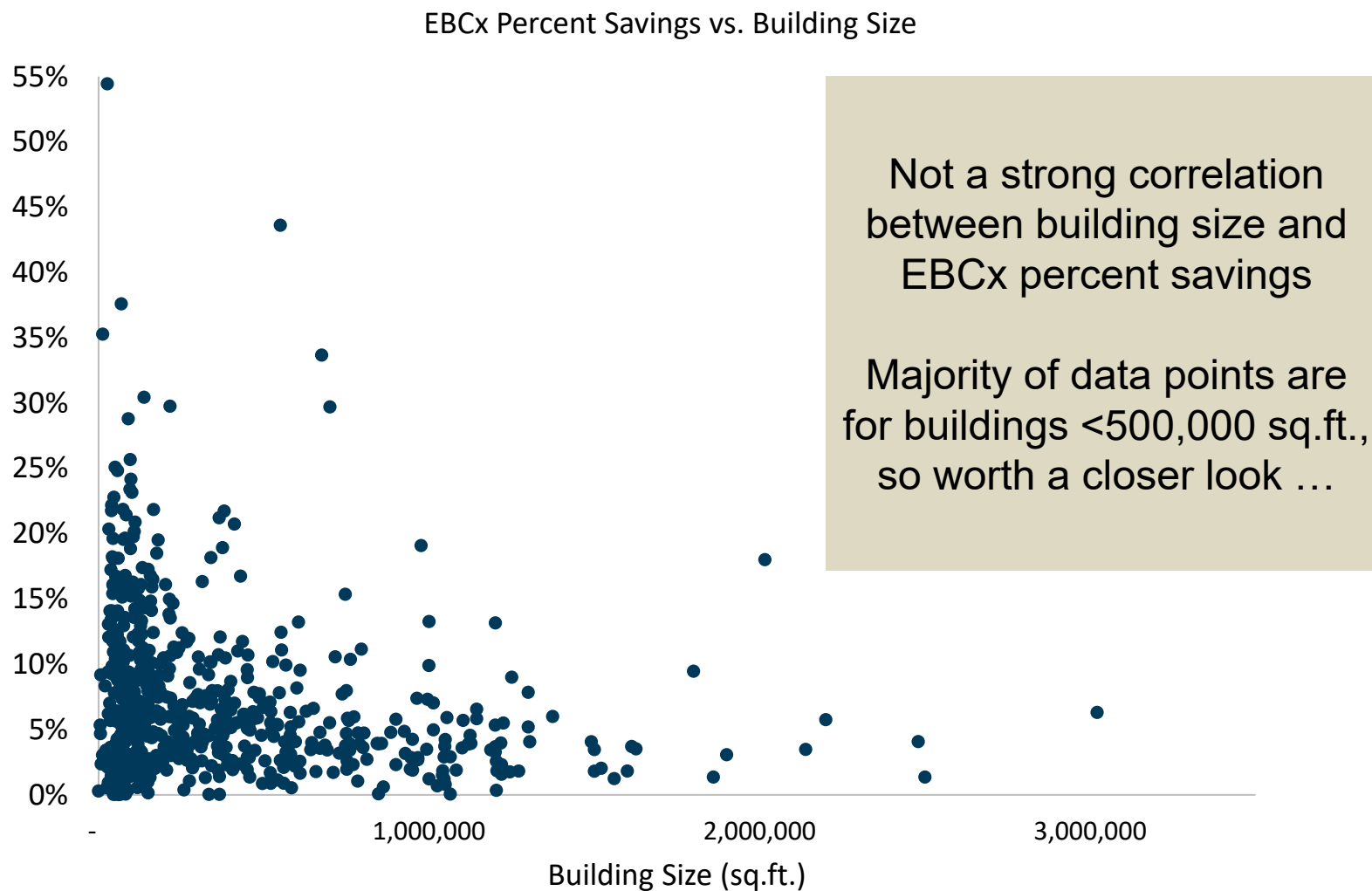
# EBCx Percent Savings by Market Segment



## Sample Size

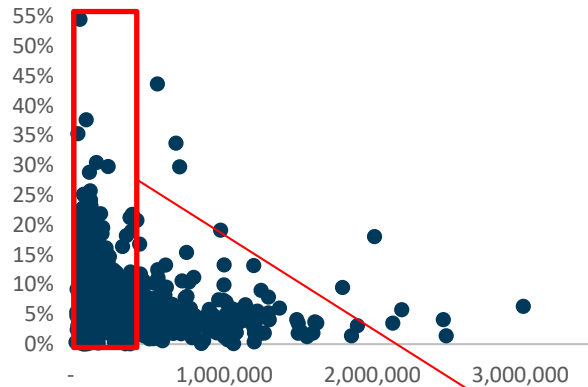
HE	Higher Ed.	112
HI	Hospital (Inpatient)	115
R	Retail	30
O	Office	194
I	Industrial	10
OTH	Other	42
DC	Data Center	15
K12	K-12 School	42
LOD	Lodging	17

# EBCx Percent Savings by Building Size



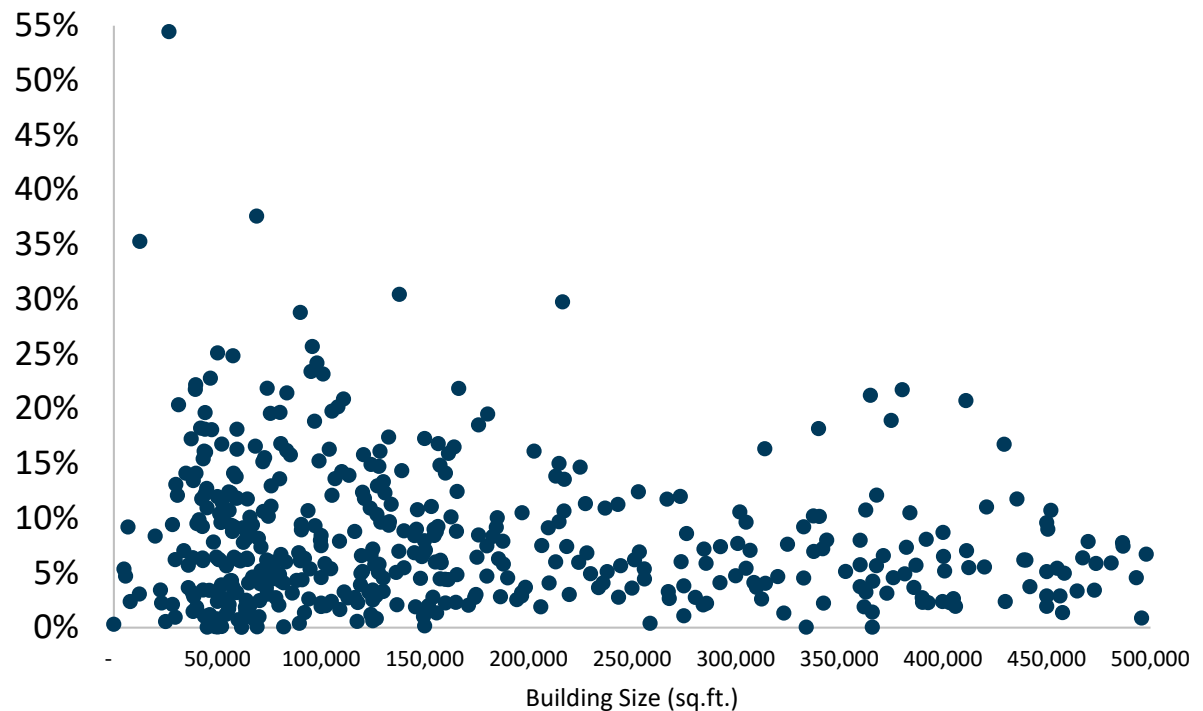
# EBCx Percent Savings by Building Size

EBCx Percent Savings vs. Building Size



Zooming in to buildings  
<500,000 sq.ft., still no  
strong correlation  
between EBCx percent  
savings and building size

EBCx Percent Savings vs. Building Size (<500,000sq.ft)



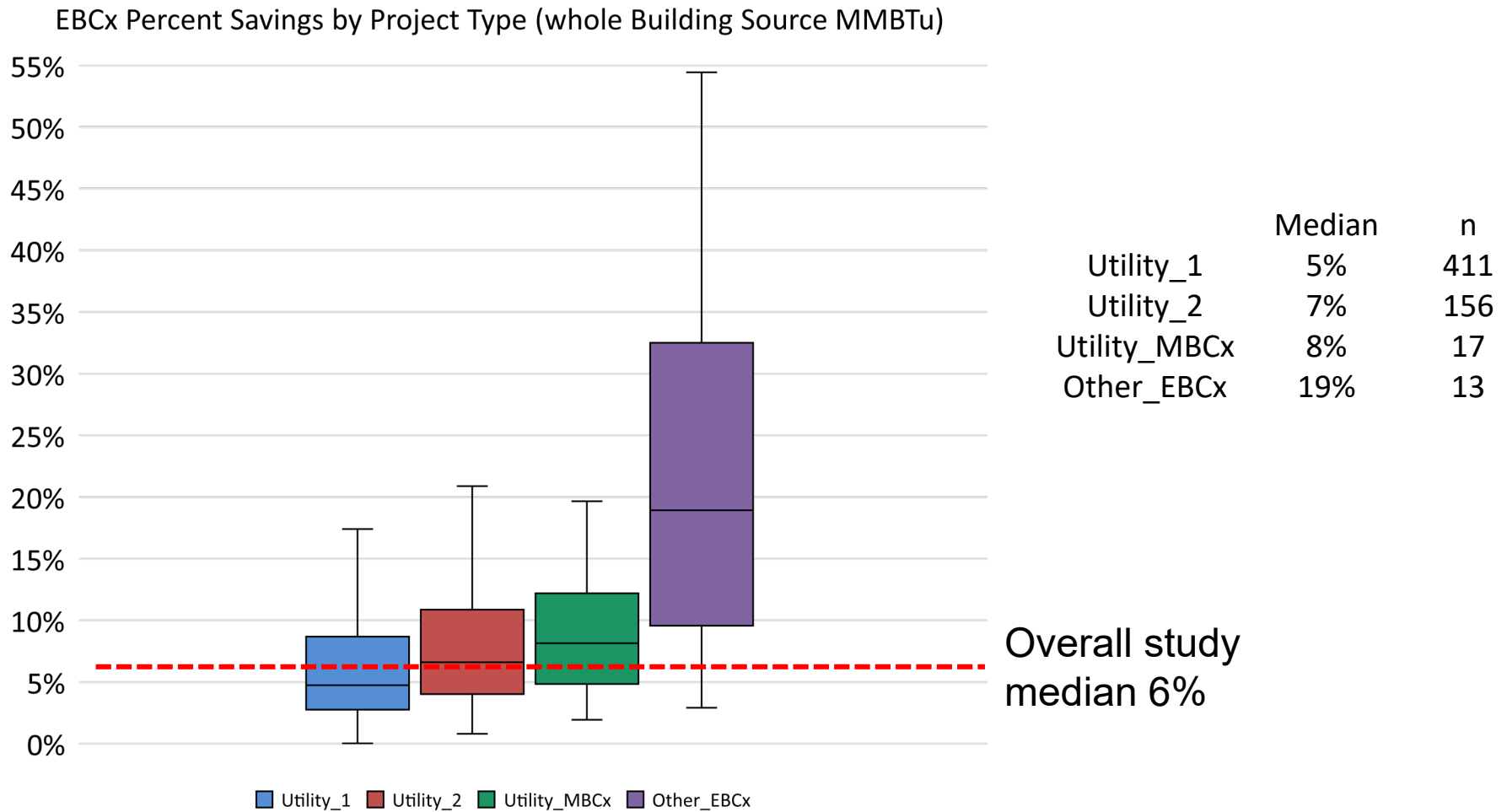


# EBCx Percent Savings by Project Type

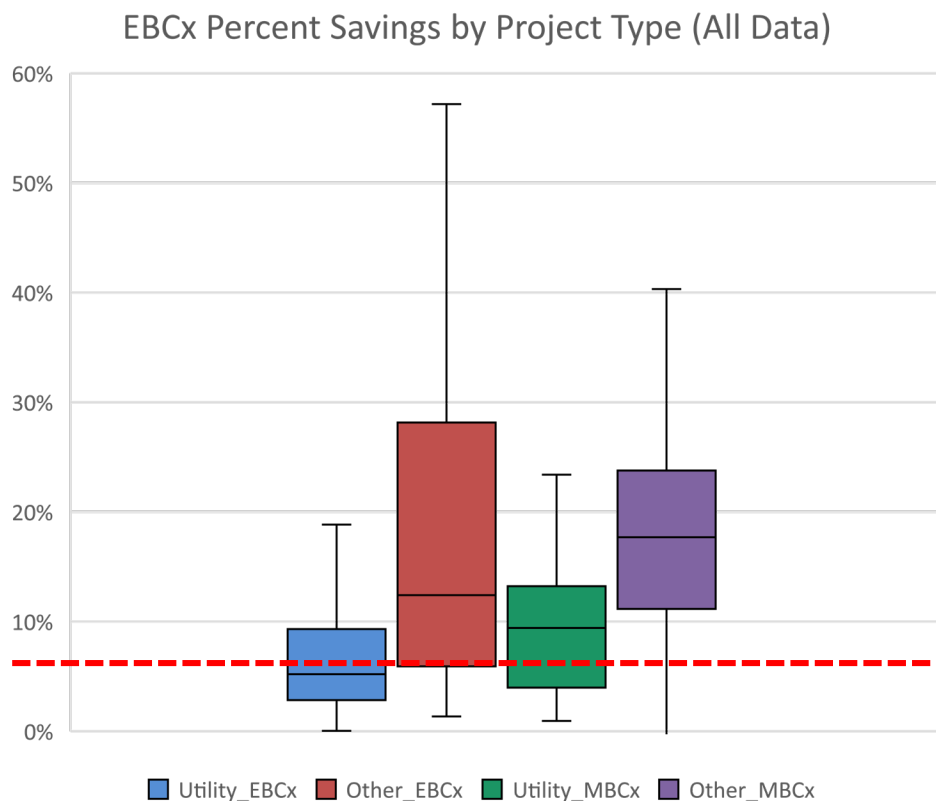
## Project Type Characteristics

- **Utility EBCx Projects:**
  - Standardized scope, focused on energy savings
  - High rigor applied to review of savings estimates
  - Typically restricted budgets, but customer may have cash incentive to install measures
- **Utility MBCx Projects:**
  - Similar to Utility EBCx, but with additional budget/effort to install metering, and possibly a longer engagement period to uncover more measures
- **“Other”:**
  - Services offered direct to customers by commissioning firms. May target outcomes beyond energy savings (e.g. comfort). Scrutiny on savings calculations varies. Budget determined on a case-by-case basis.

# EBCx Percent Savings: 2018



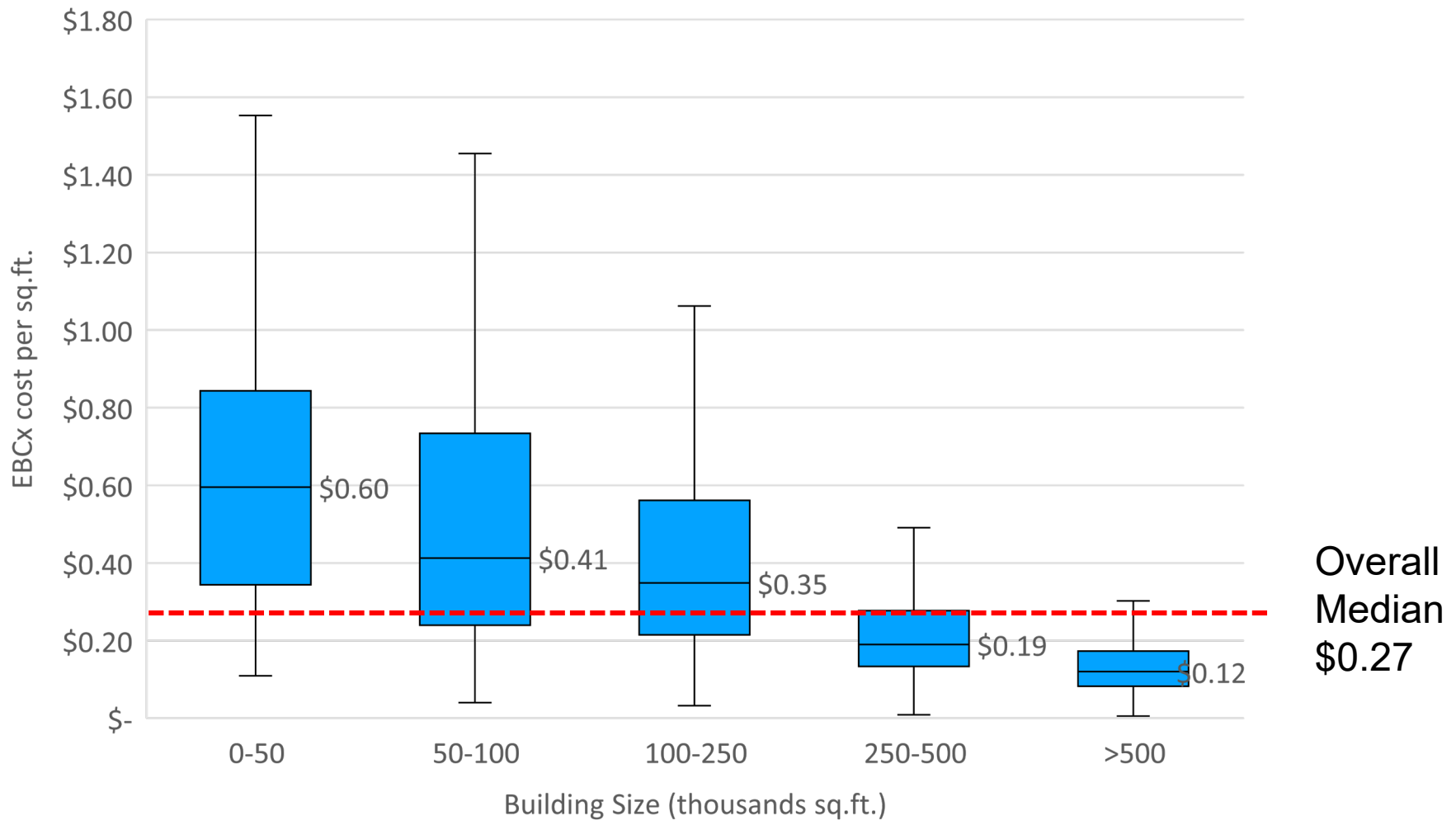
# EBCx Percent Savings: All Data Combined



	Median	n
Utility_EBCx	5%	533
Utility_MBCx	9%	41
Other_EBCx	12%	67
Other_MBCx	18%	40

Overall  
Median 6%

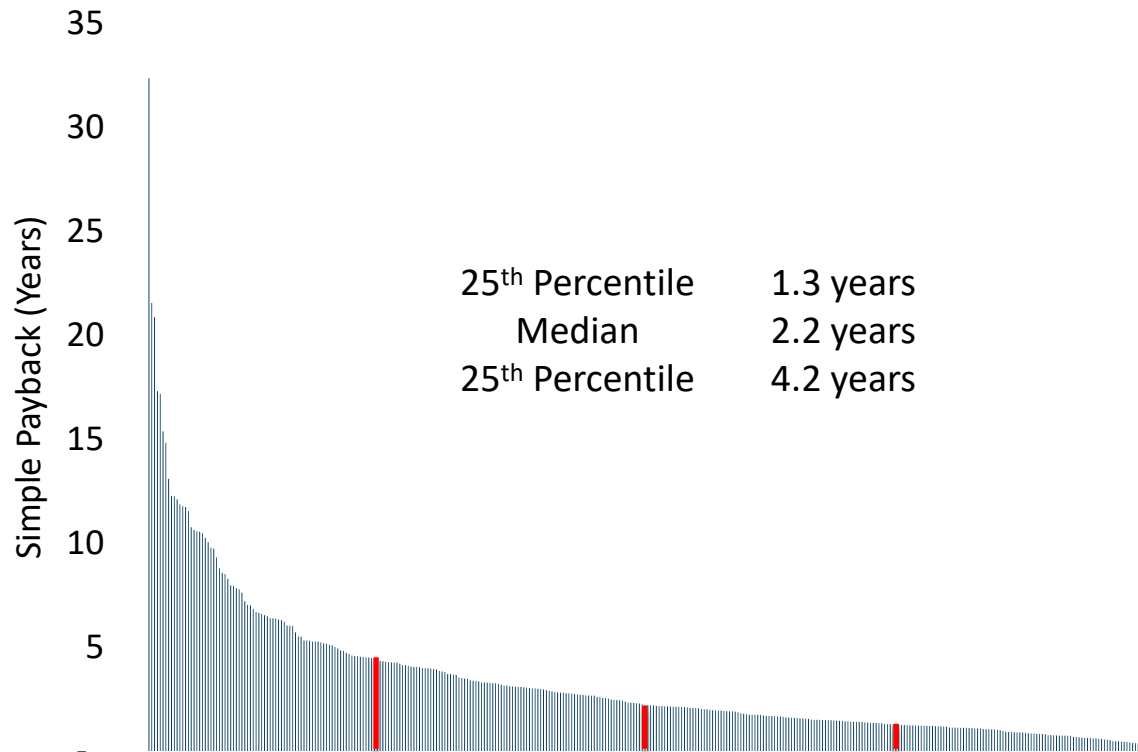
# EBCx Cost by Building Size





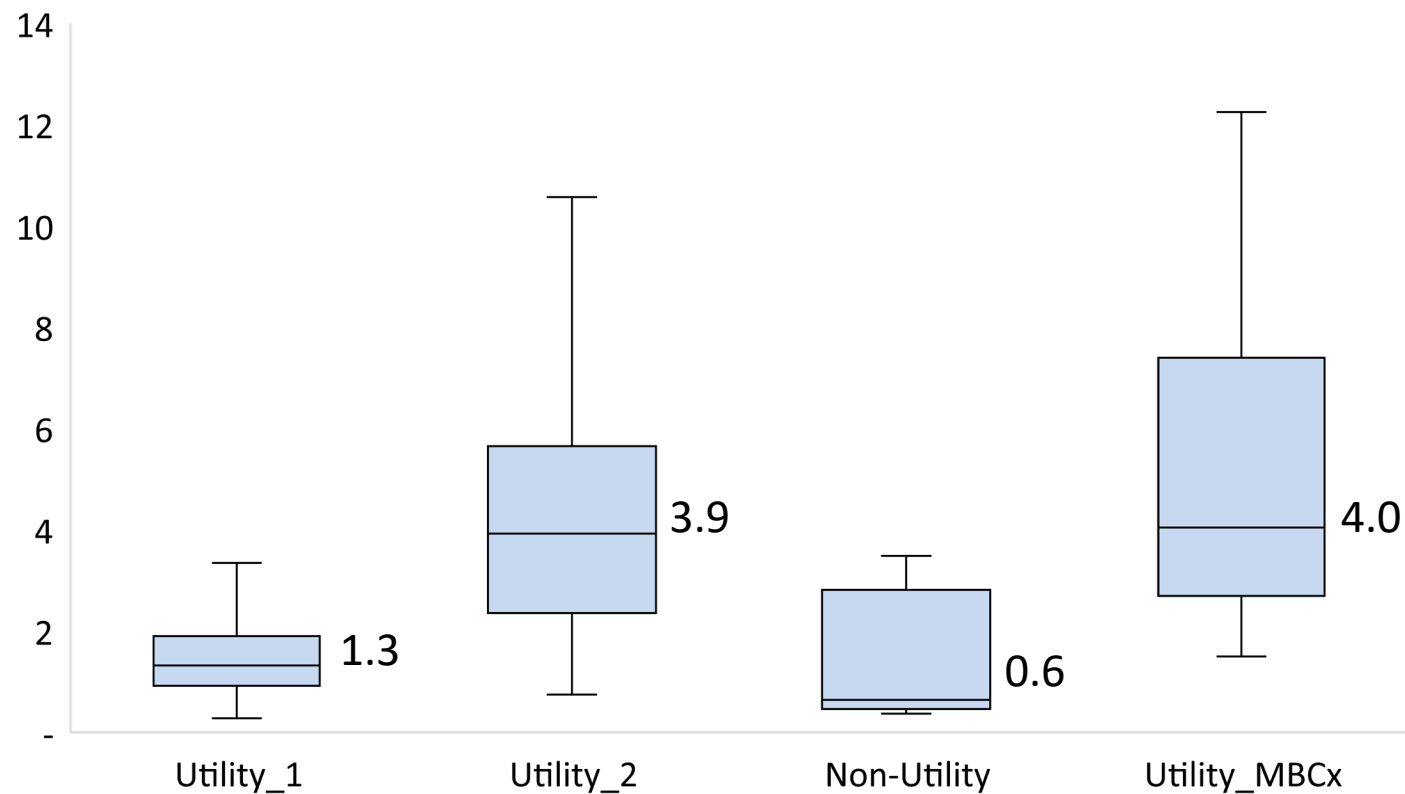
# EBCx Simple Payback

EBCx Simple Payback (Years)(n=356)



# EBCx Simple Payback by Project Type

EBCx Simple Payback (years) by Data Source (Adjusted to 2017, using Standard Energy Prices)(n=355)





# Headline EBCx Metrics: All Data



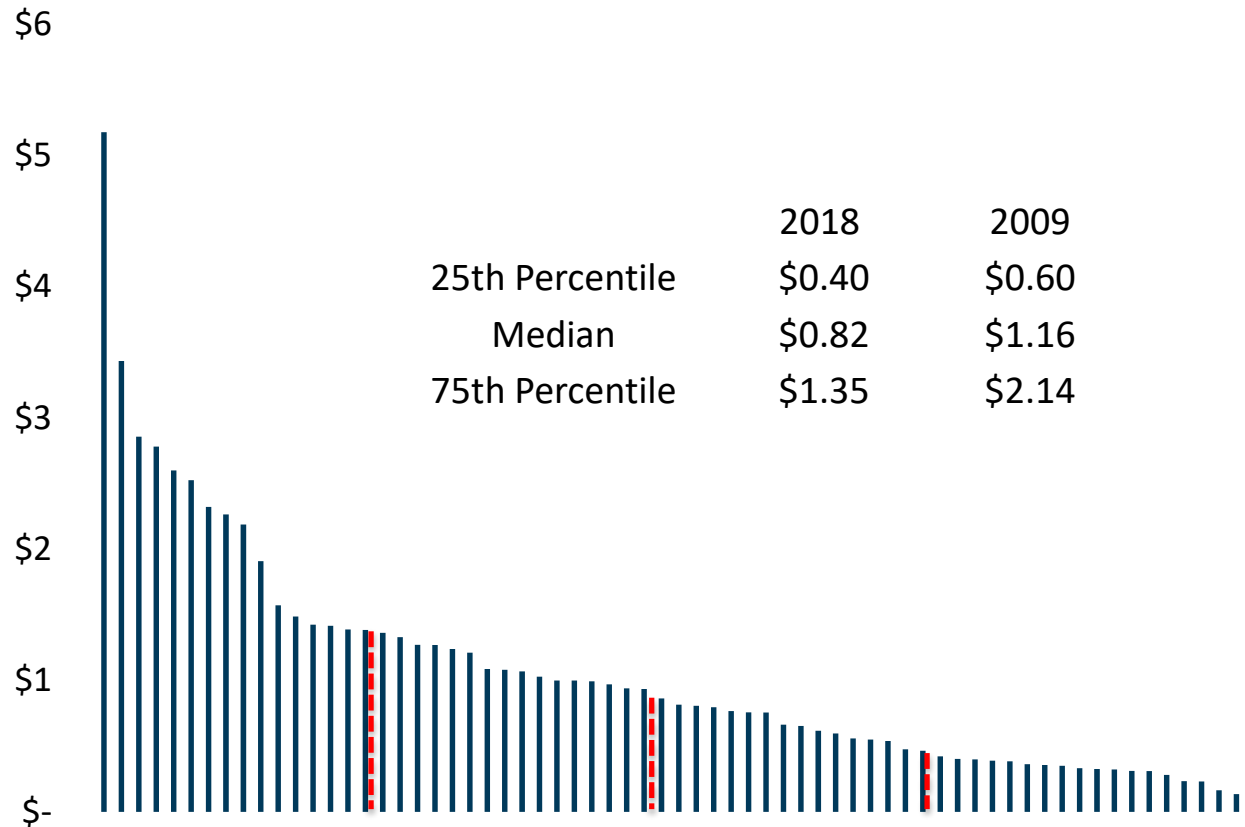
Metric	Median	Typical Range
Energy Savings	6%	3%-11%
EBCx Cost	\$0.27/sq.ft	\$0.15-\$0.56
Simple Payback	1.7 yr	0.8 – 3.5 yr

## **NCCX COSTS**

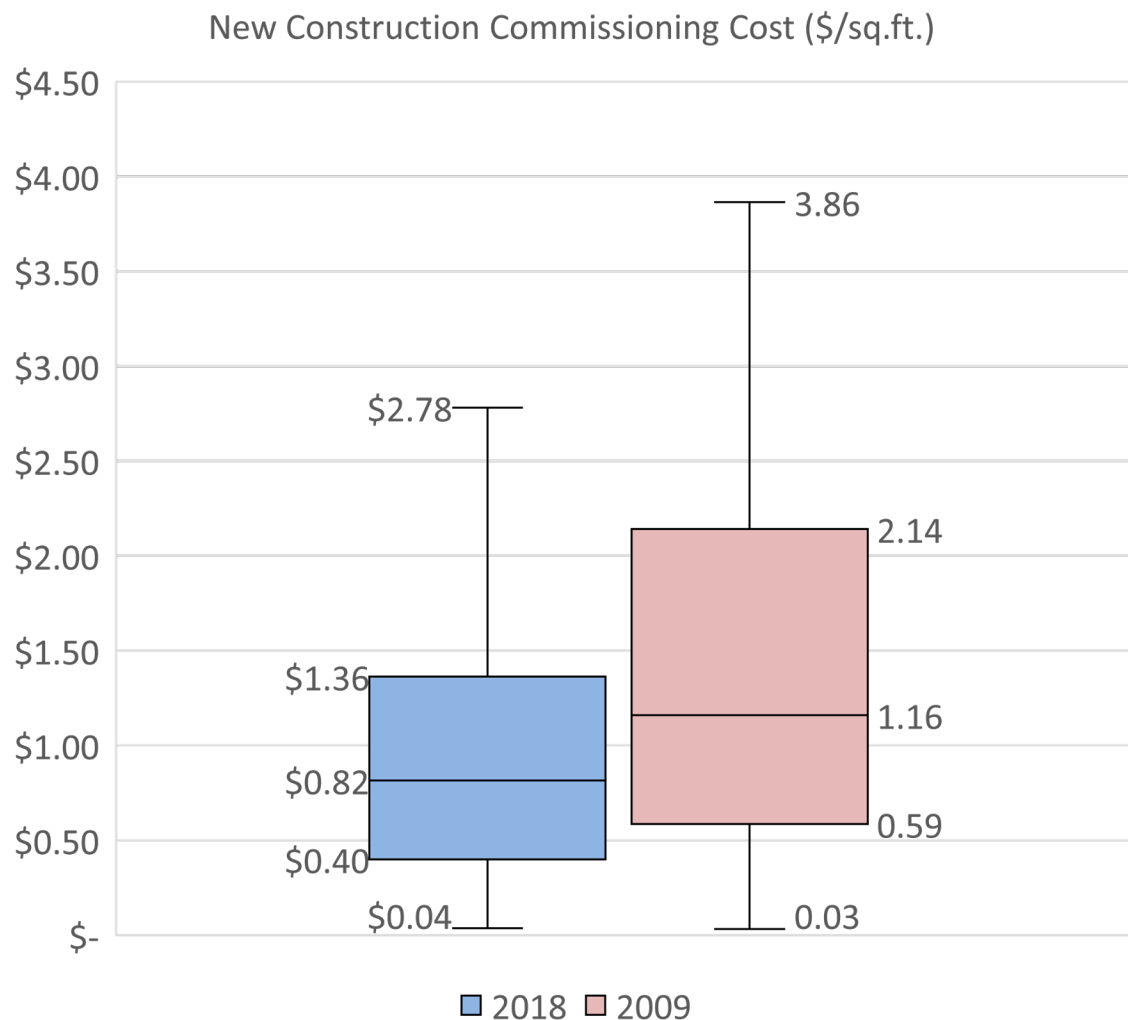


# NCCx Cost per Square Foot

New Construction Commissioning Cost  
(\$2017/sq.ft.)(n=67)

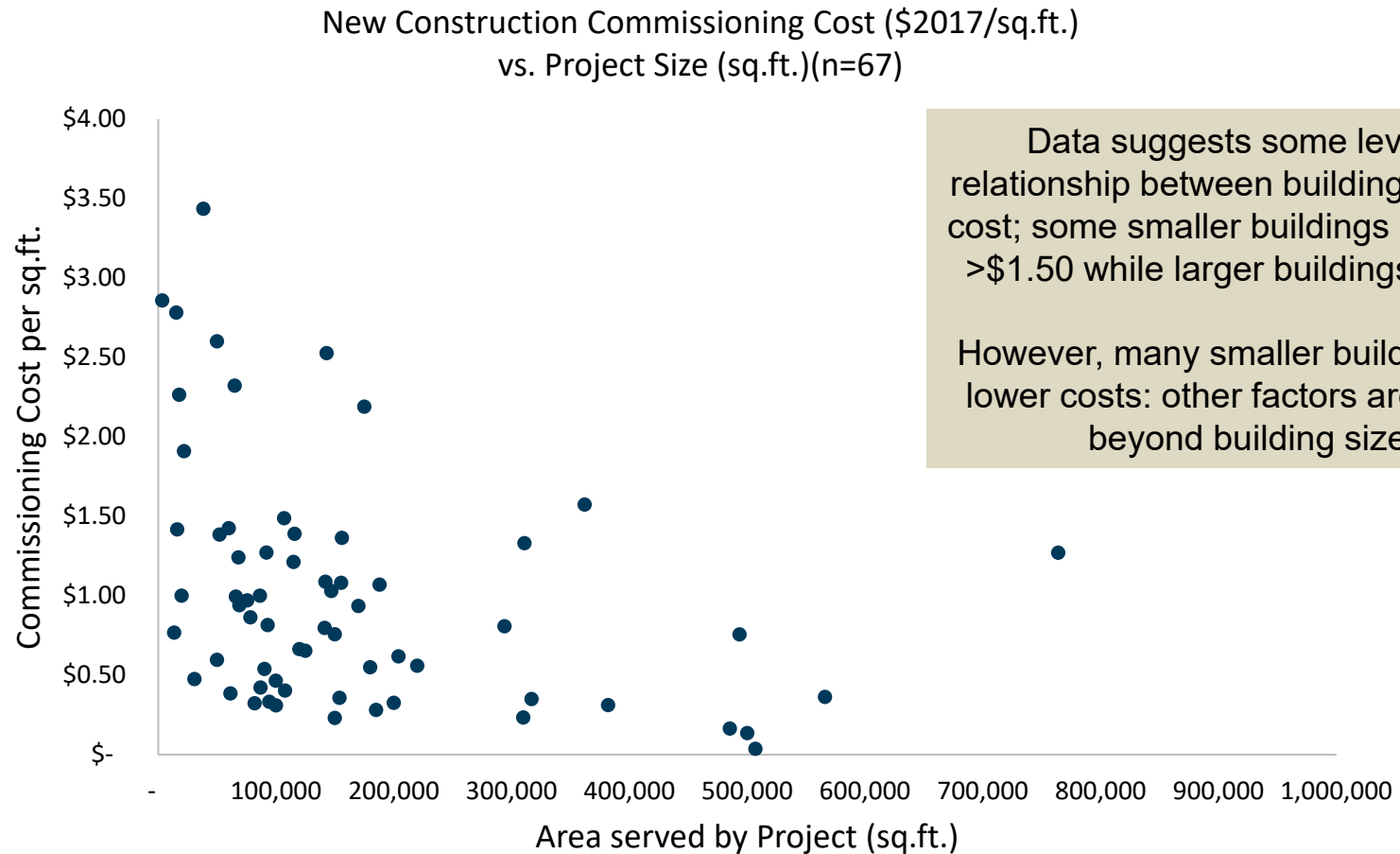


# NCCx Cost per sq.ft., 2009 vs 2018



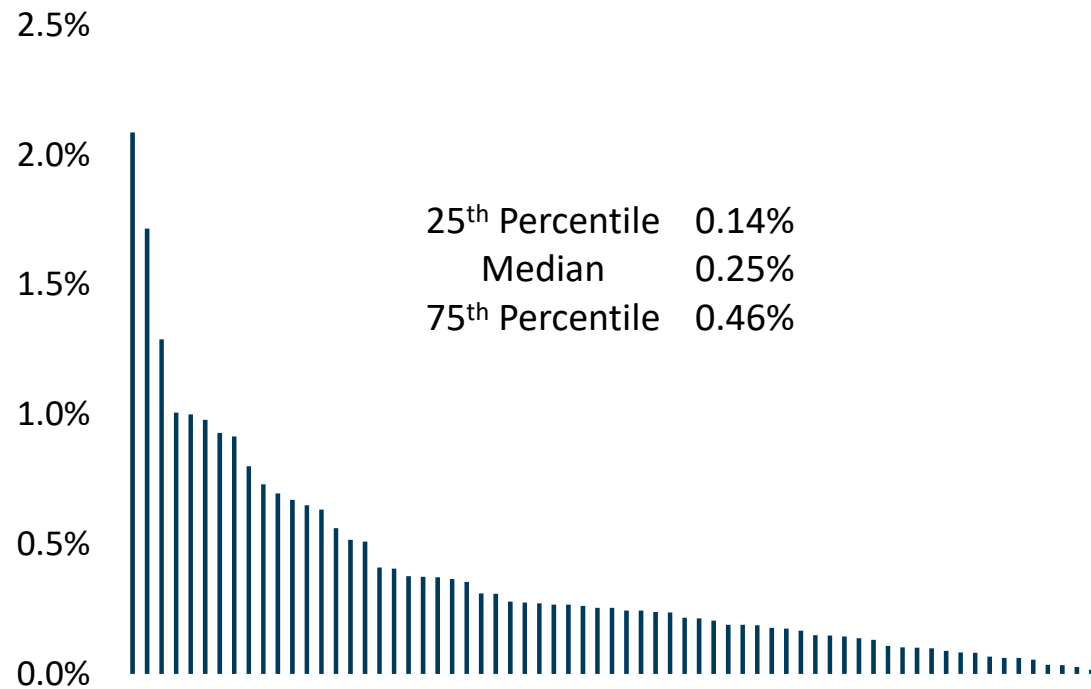
2018 data shows lower cost per sq.ft. than 2009 data set. Need to look deeper to understand if this is a true shift in market costs or possibly due to sample composition

# NCCx Cost vs. Project Size



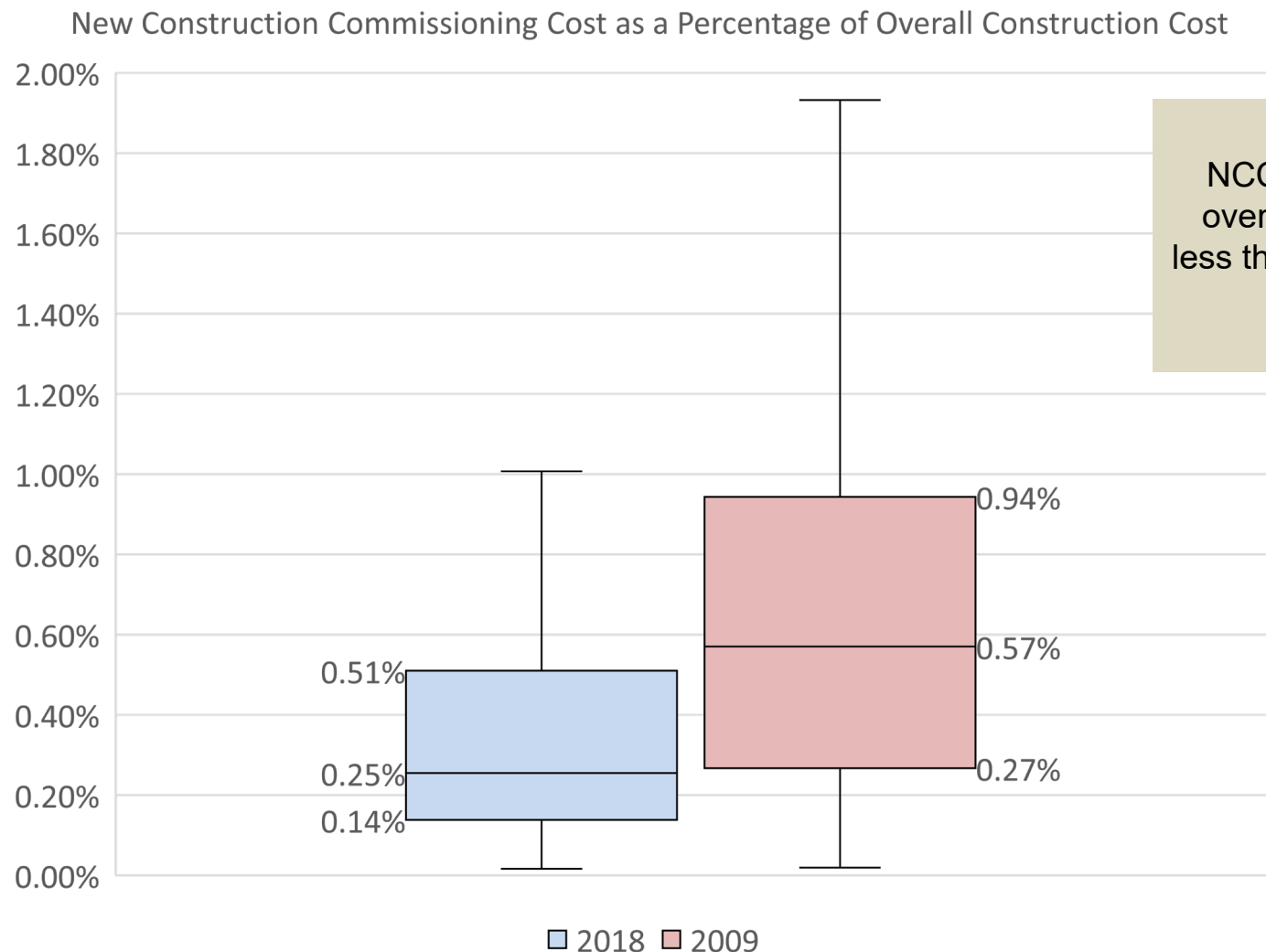
# NCCx Cost as Percent of Construction

New Construction Commissioning Cost as a Percentage of Overall Construction Cost (\$2017)(n=67)



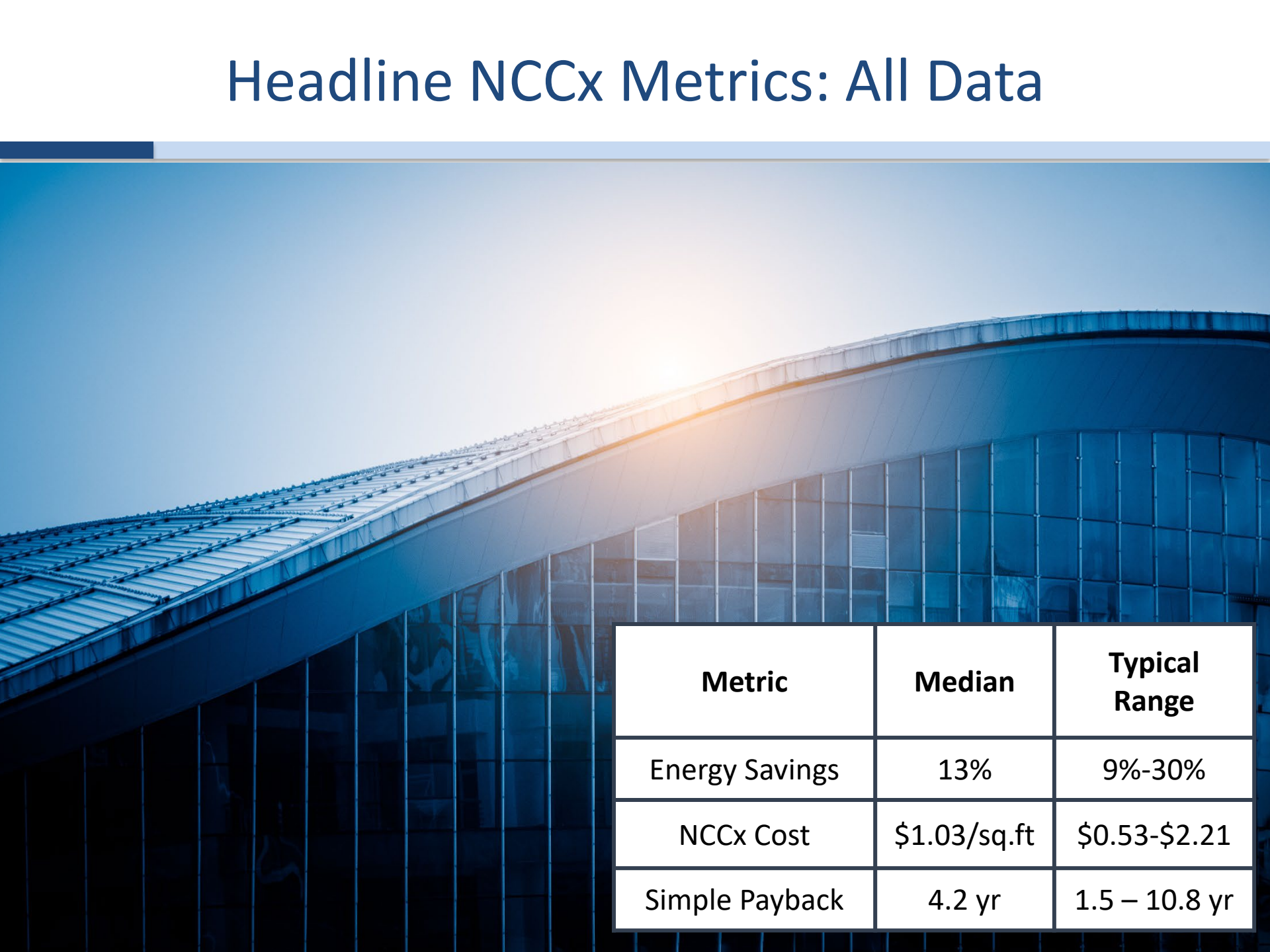


# NCCx Cost as Percent of Construction



NCCx costs as a percent of overall construction cost are less than half compared to 2009 data set

# Headline NCCx Metrics: All Data



Metric	Median	Typical Range
Energy Savings	13%	9%-30%
NCCx Cost	\$1.03/sq.ft	\$0.53-\$2.21
Simple Payback	4.2 yr	1.5 – 10.8 yr

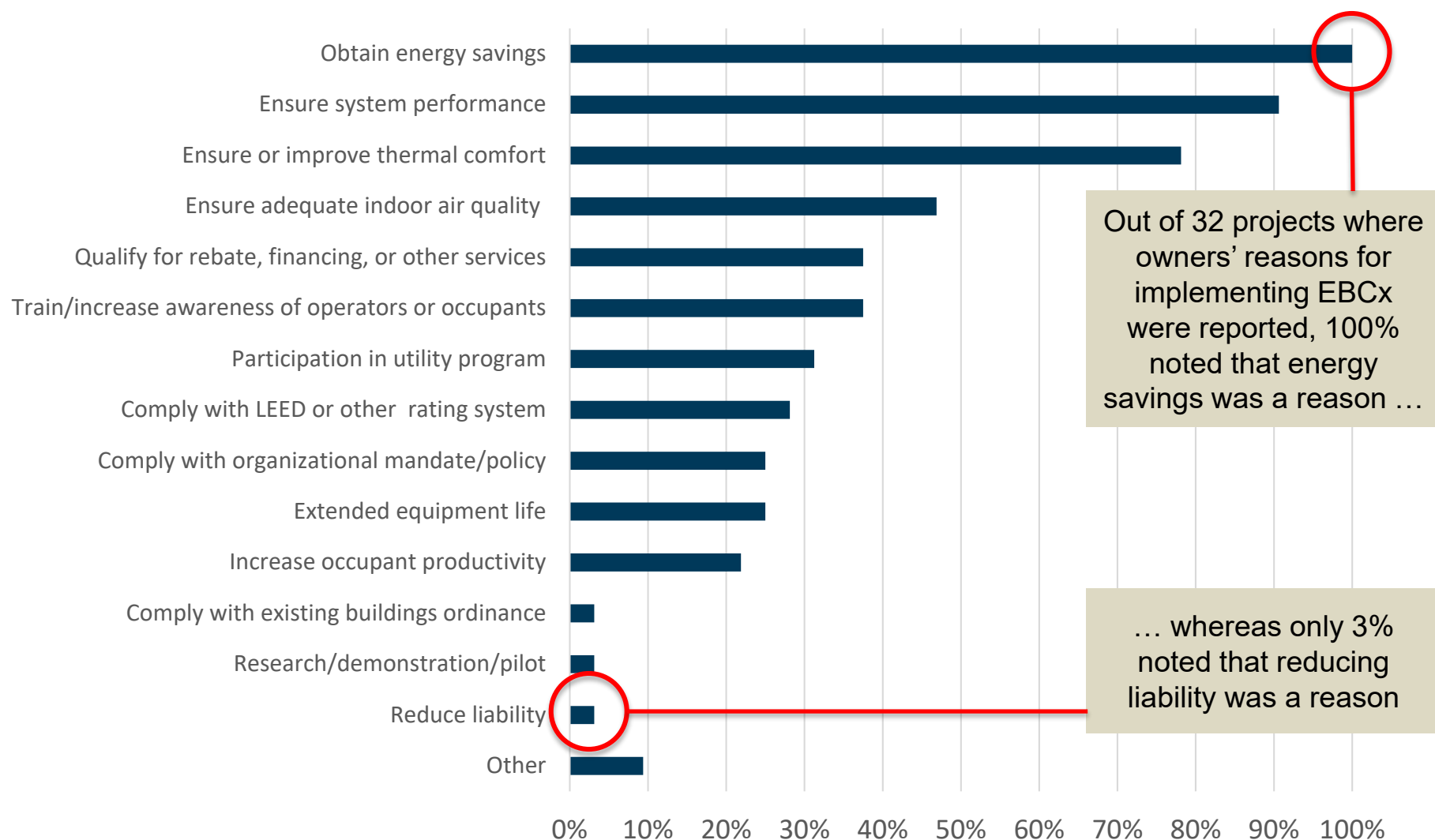
# THE WHAT AND WHY

## Reasons for Implementing Cx

- Data survey included questions relating to owner motivation for implementing Cx
- 15 possible reasons; respondents (Cx Providers) could choose multiple
- Results determined as: percent of projects where reason 'X' was one of owner's motivations

# Reasons for Implementing EBCx

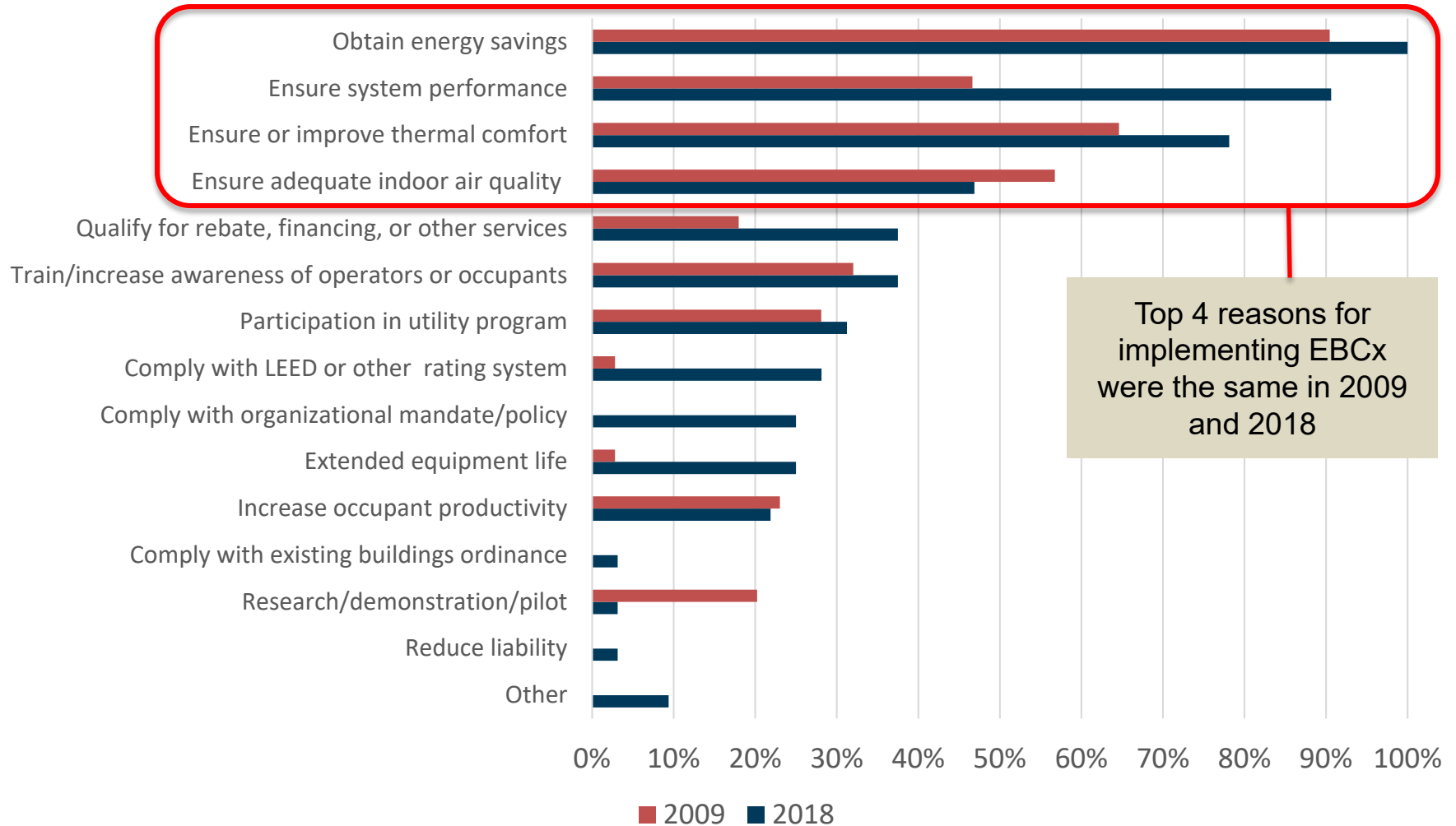
Fraction of reporting projects with reason (EBCx), 2018





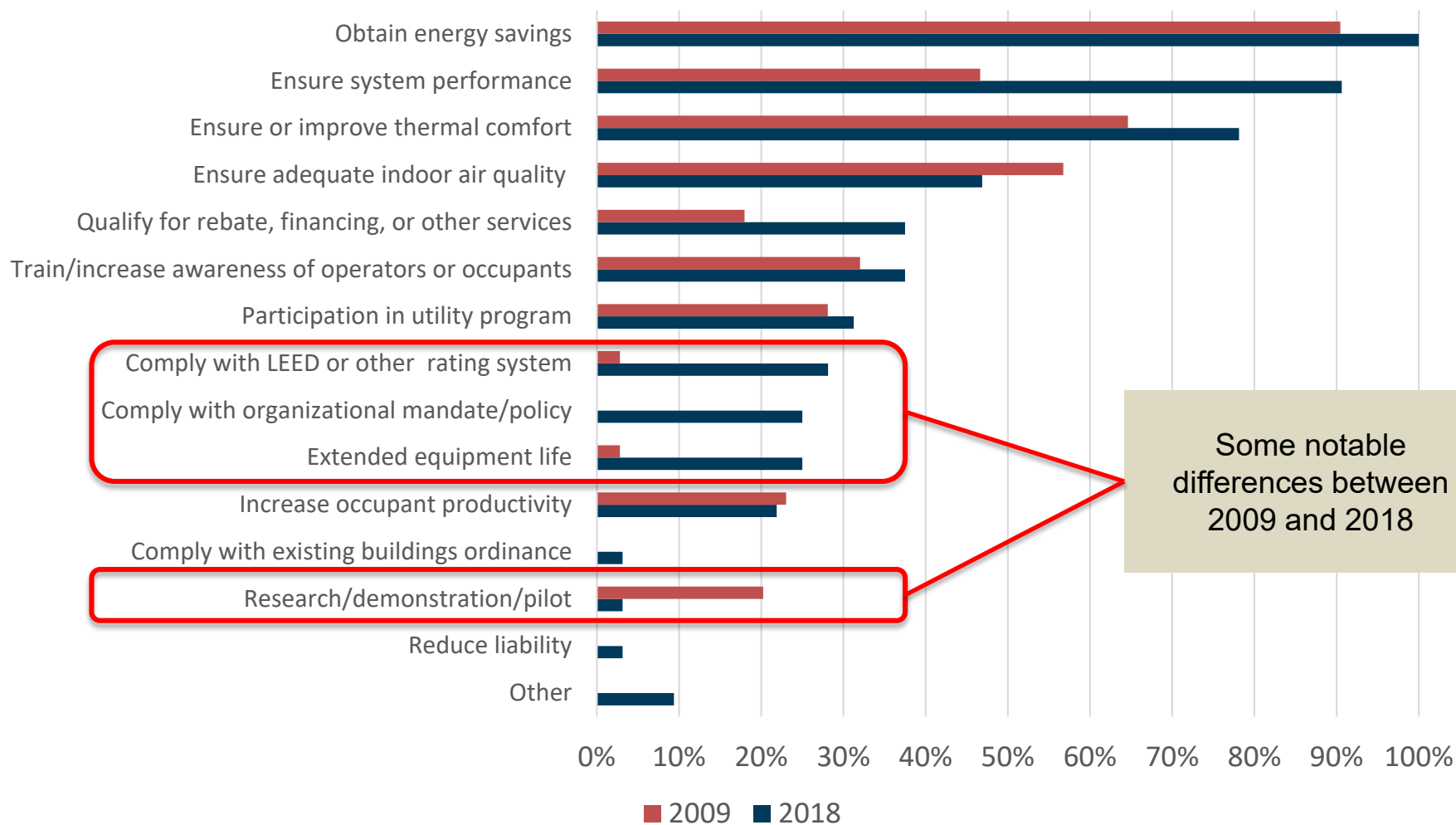
# Reasons for Implementing EBCx: 2009 vs. 2018

Fraction of reporting projects with reason (EBCx), 2009 vs. 2018



# Reasons for Implementing EBCx: 2009 vs. 2018

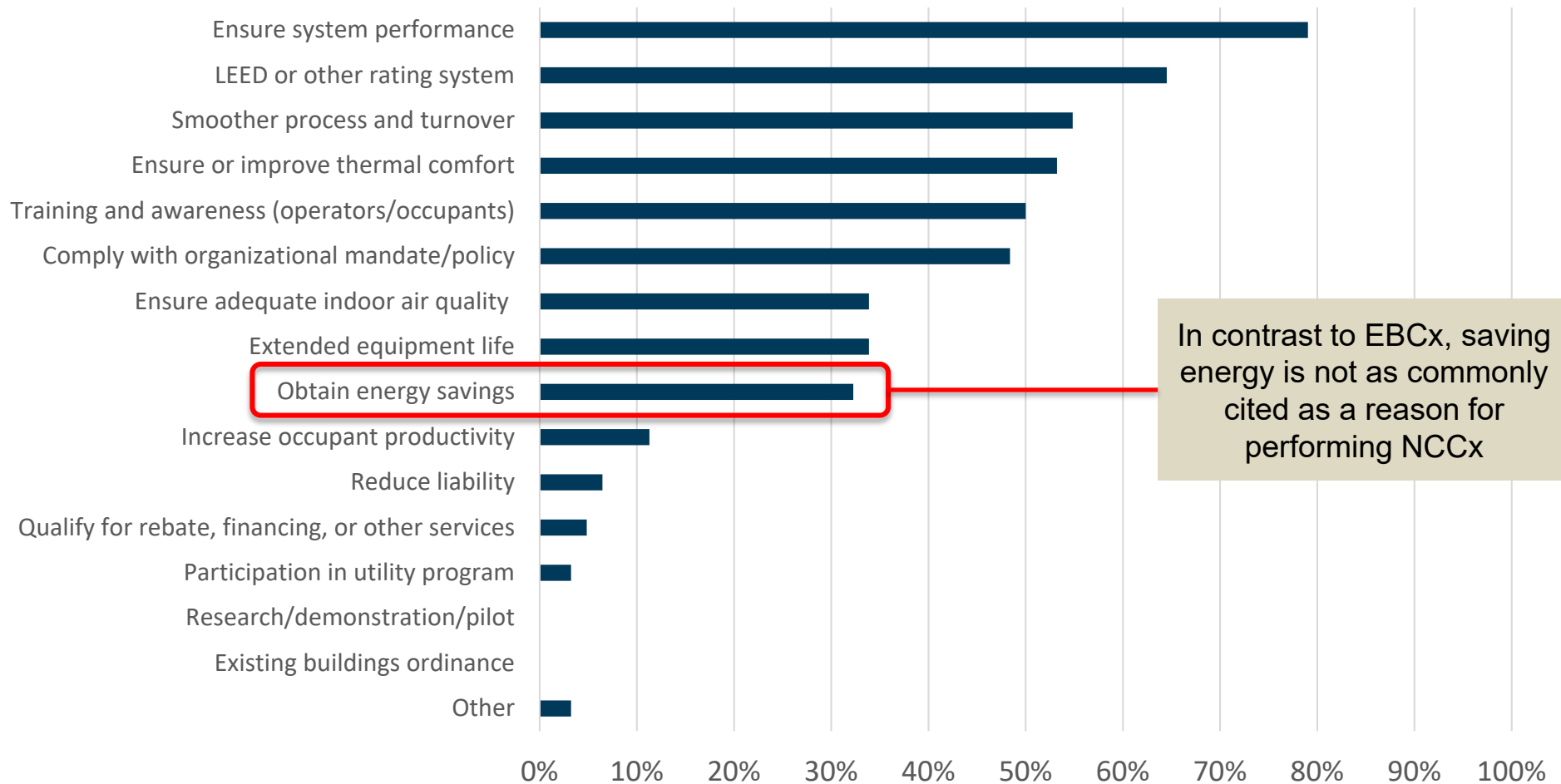
Fraction of reporting projects with reason (EBCx), 2009 vs. 2018





# Reasons for implementing NCCx

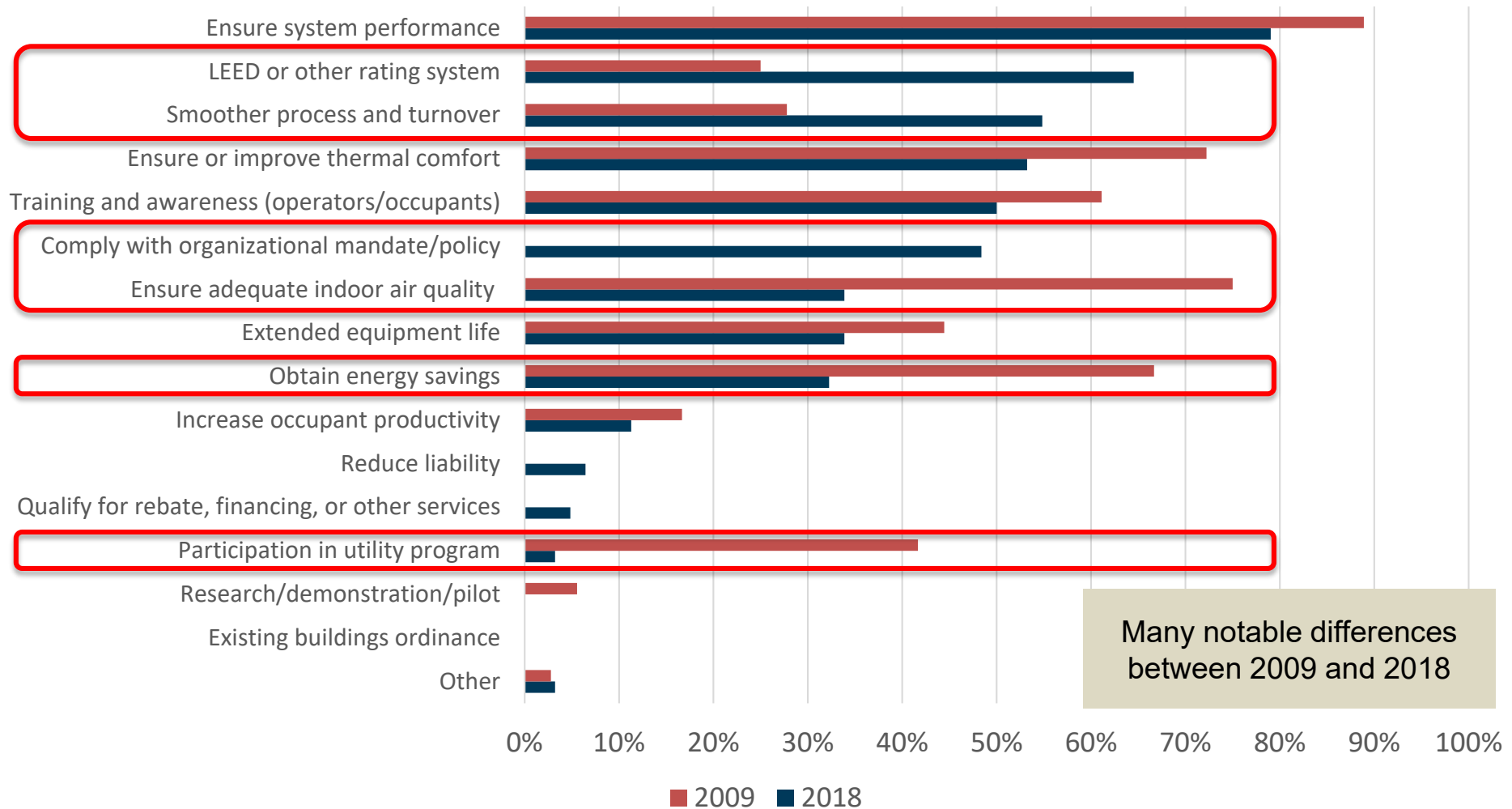
Fraction of reporting projects with reason (New Construction), 2018 (n = 62)





# Reasons for implementing NCCx

Fraction of reporting projects with reason (New Construction), 2009 vs. 2018





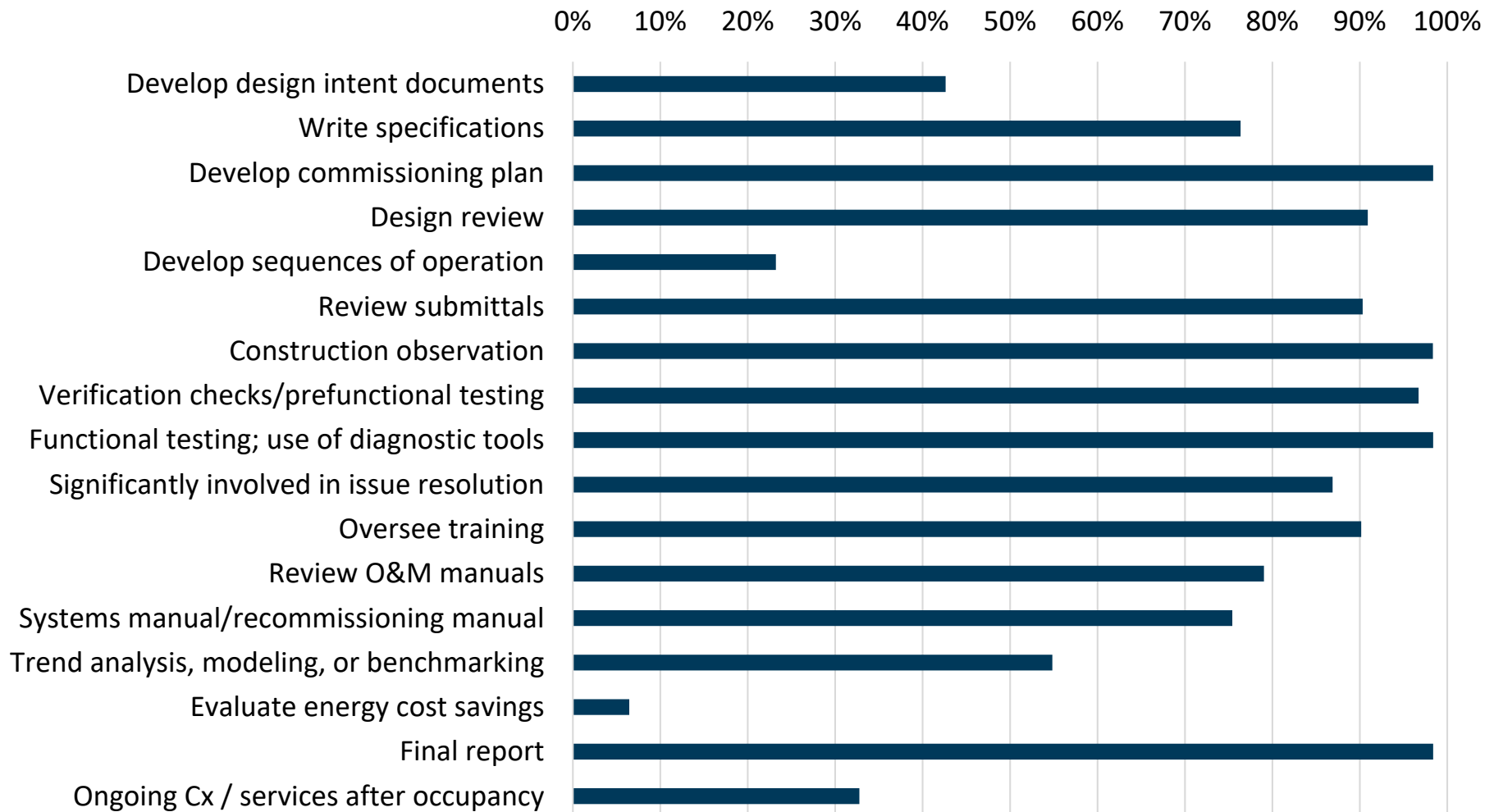
# NCCx Scope of Work

- NCCx best practice calls for Cx Provider involvement from pre-design stage through to occupancy
- Implied linkage between quality of Cx, Cx cost, and the comprehensiveness of Cx scope
- Data survey asked or list of items included in NCCx scope



# NCCx Scope of Work

Activities included in New Construction Commissioning Scope (n=62)



# NCCx Scope of Work

Activities included in New Construction Commissioning Scope (n=62)

> 80%

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

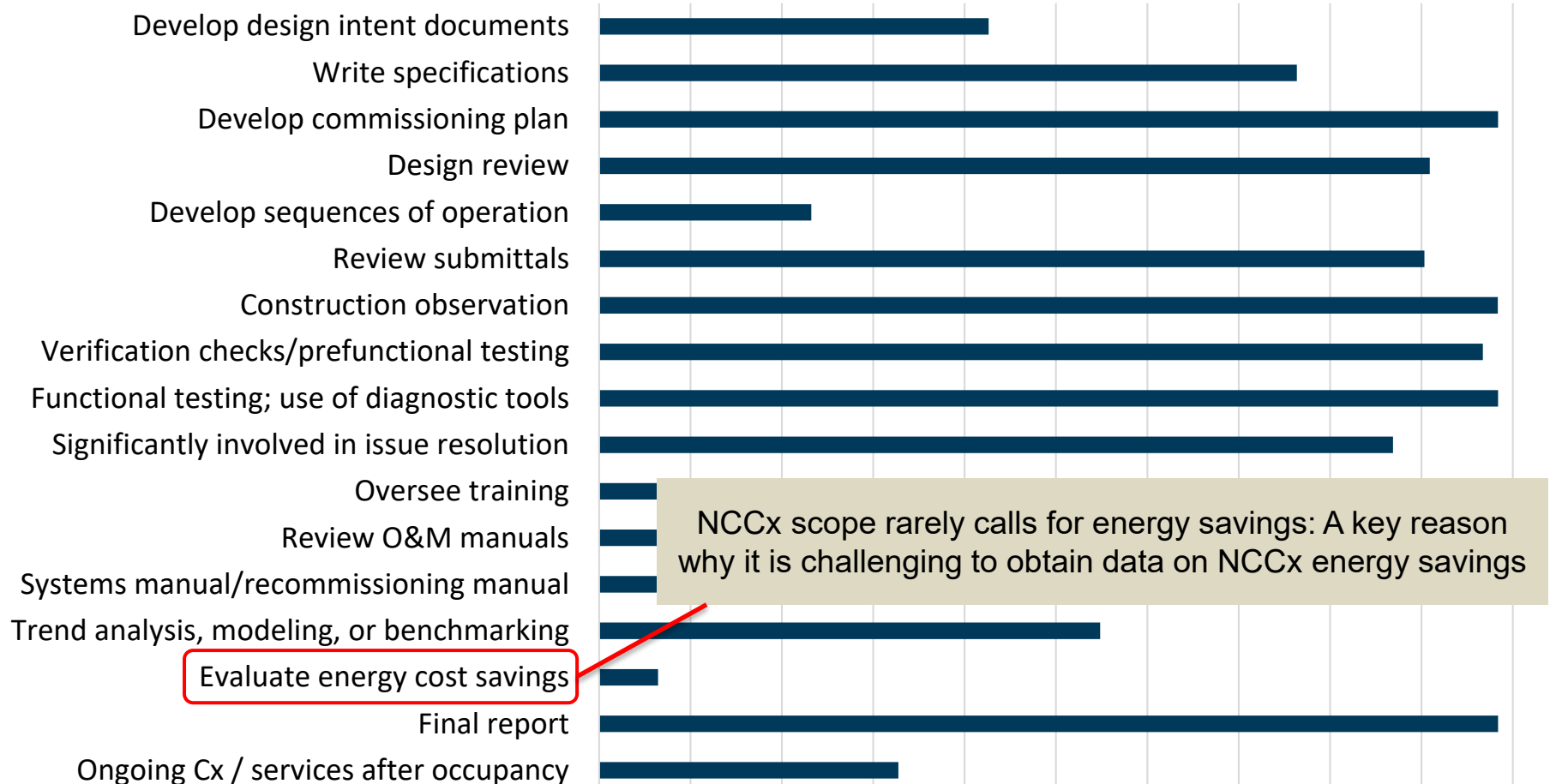




# NCCx Scope of Work

Activities included in New Construction Commissioning Scope (n=62)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%



# Non-Energy Benefits of NCCx

Percent of Projects Reporting Non-energy Benefits (New Construction)(n=39)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

## FIRST COST SAVINGS

On schedule, problems detected/corrected earlier

Occupied on schedule

System design improved, right-size equipment

Improve team coordination

Occupied sooner, reduced call-backs / TAB costs

Fewer change orders; warranty claims

Other or unspecified first-cost

## ONGOING (RECURRING) IMPROVEMENTS

Thermal Comfort

Maintenance

Improved O&M

Training; education

Indoor Air Quality

Equipment Life

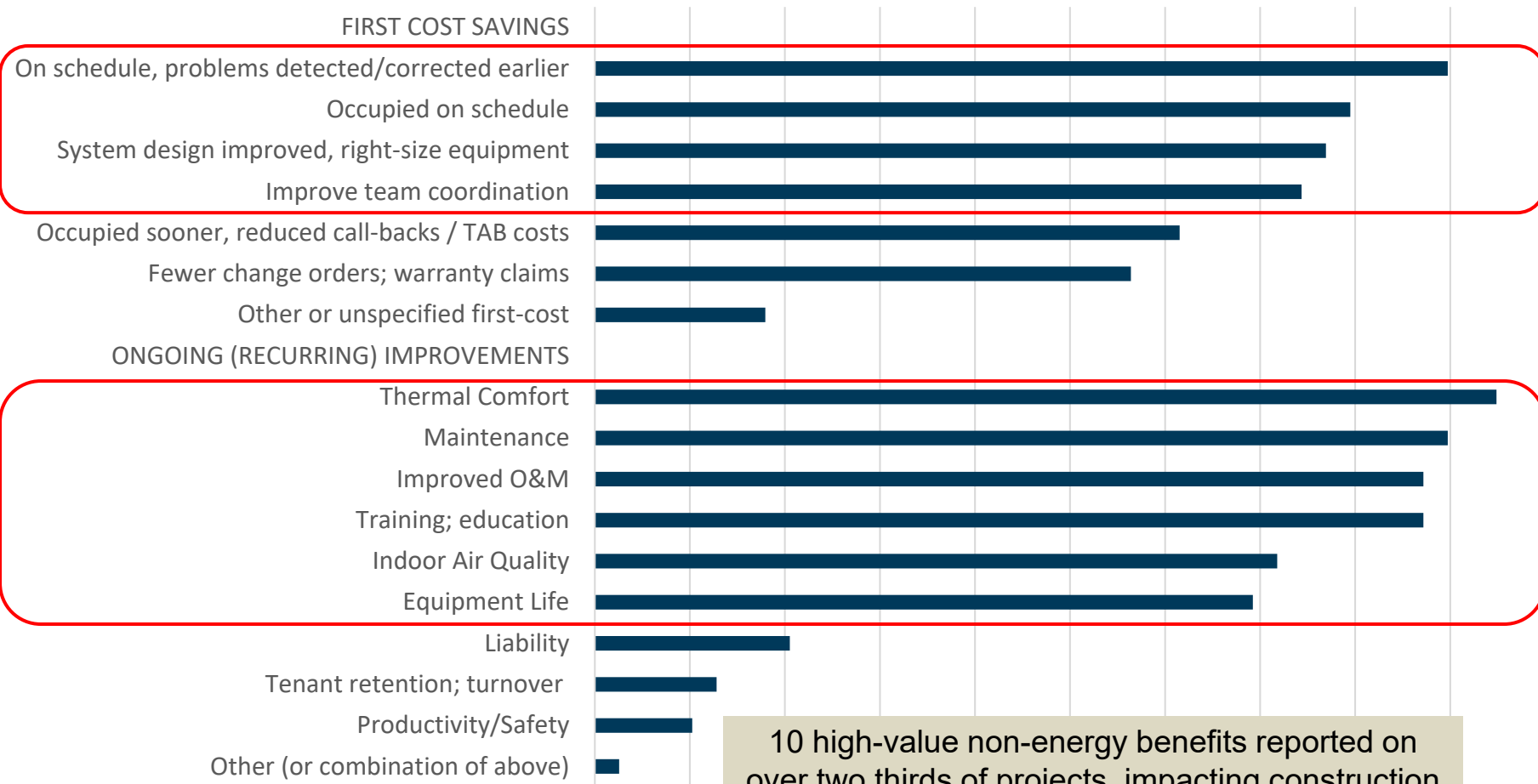
Liability

Tenant retention; turnover

Productivity/Safety

Other (or combination of above)

10 high-value non-energy benefits reported on over two thirds of projects, impacting construction project first costs and ongoing benefits



# Key Findings: EBCx

1. Utility EBCx programs shown to reliably offer cost effective savings in the 3%-10% range, at scale
2. Energy Savings
  - a. Median 6%, typical range 3%-10%
  - b. MBCx or EBCx outside utility programs could hit 10%-20% range (but data is limited)
  - c. 2018 median down from 2009, though looking at project type suggests no major market shift (changes more likely due to sample composition)
3. Simple Payback
  - a. Median 2.2 years. Range generally 1 and 4 years payback
  - b. Median \$0.25 project cost per sq.ft., with a typical range \$0.13-\$0.48
  - c. Projects at lower percent savings can still be highly cost-effective
4. Owners' reasons for implementing EBCx: Top 4 are unchanged from 2009 study

# Key Findings: NCCx

## 1. NCCx Cost

- a. \$0.82 per sq.ft., typical range \$0.40-\$1.35, compared with median \$1.16 in 2009 study
- b. 0.25% of overall construction cost, compared with median 0.57% in 2009 study
- c. Difference in 2018 and 2009 sample composition makes it difficult to conclude true shift in market costs for NCCx, though there is anecdotal evidence costs have reduced
- d. Larger projects tend to have lower cost per sq.ft., and market segment also has an impact on cost

## 2. Savings and Payback: insufficient data for updating 2009 results

- a. Survey responses report that only 6% of projects include scope item to evaluate energy savings

## 3. NCCx Scope of Work

- a. For projects in 2018 dataset, >90% of Cx Providers were involved at the design review stage
- b. Engagement of Cx provider for post-occupancy services is still low

## 4. Non-Energy Benefits

- a. 10 high-value non-energy benefits reported on over two thirds of projects, impacting construction project first costs and ongoing benefits



This concludes The American Institute of Architects  
Continuing Education Systems Course

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