

# Costs and Benefits of Commissioning New and Existing Commercial Buildings

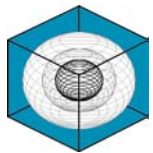
*Building a Sustainable Campus Community*  
*U.C. Santa Cruz, June 21, 2005*



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# Commissioning (Cx) is *Quality Assurance*

*(Green Buildings are not exempt from Murphy's Law)*

- Articulating/verifying design intent
- Construction observation; warranty enforcement  
--> Controlling first cost
- Identifying broken, disabled, or malfunctioning systems
- Optimizing performance (comfort, reliability, safety, energy)
- Training operators
- Enhancing safety and risk management

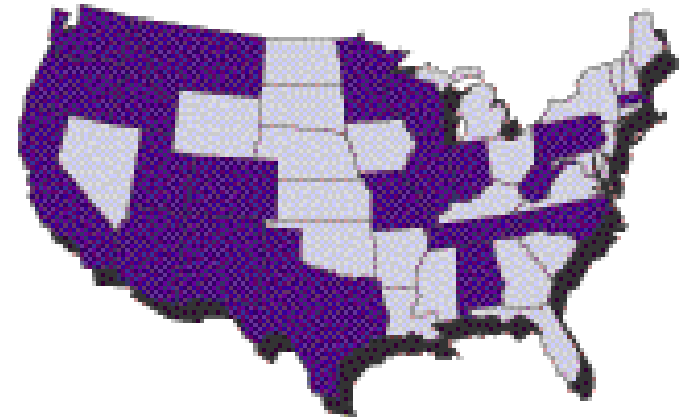
# Project Objective and Methods

- **Objective:** Evaluate costs and benefits of Cx, understand energy savings opportunities from correcting design & operational problems
- **Methods:**
  - Gather data (real buildings)
  - Focus on energy; consider non-energy impacts (+/-)
  - Separate treatment of new and existing buildings
  - Standardize information (definitions, normalized energy prices, inflation). Has significant effect on results; allows inter-comparisons
  - Perform statistical and correlation analyses

>> *About 200 fields of data collected* <<

# Resulting Sample Characteristics

- 224 buildings (175 projects), of which 150 are existing buildings and 74 are new construction
  - 19+ commissioning providers
  - Largest sample yet compiled
- Diversity of building types (heavy on public buildings)
- 30.4 million square feet across 21 states
  - Existing buildings: median 151,000 ft<sup>2</sup>
  - New construction: median 69,500 ft<sup>2</sup>
- \$17 million investment in commissioning
- Projects span two decades, but most done in the 1990s

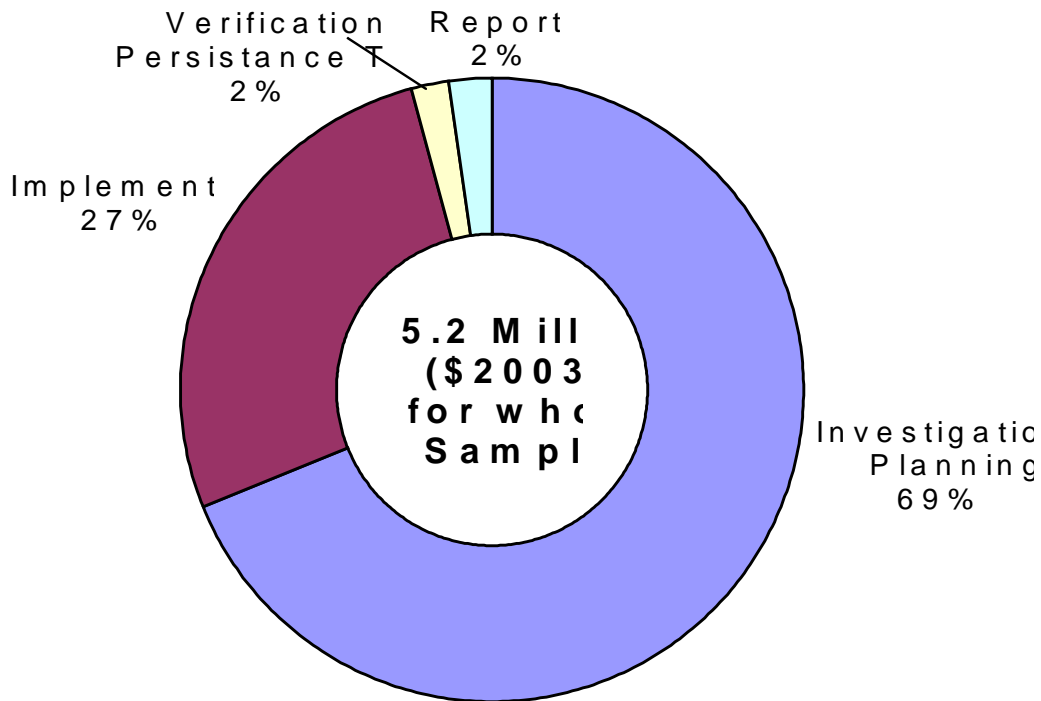


# Top-level Findings (all values are medians)

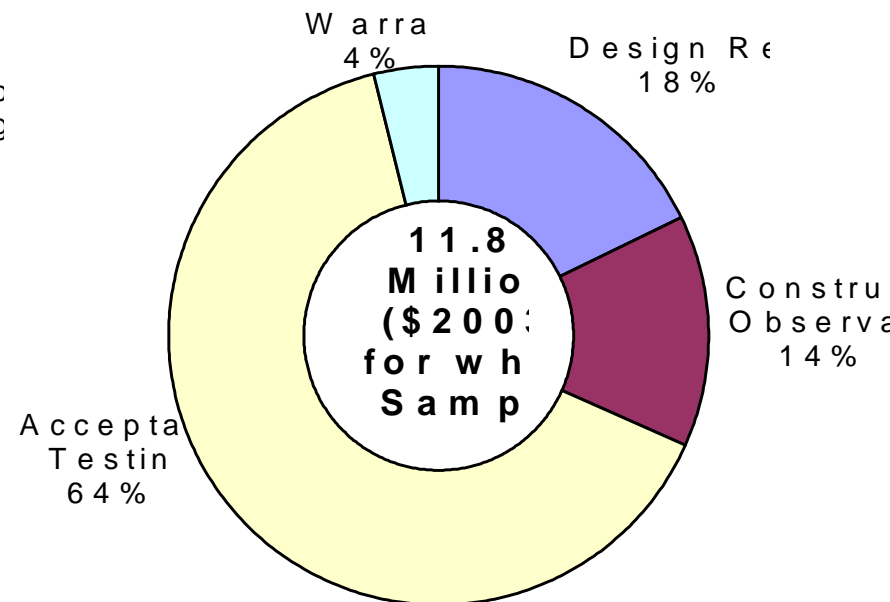
- Existing Buildings
  - Cost: \$0.27/ft<sup>2</sup> • NEBs: \$0.18/ft<sup>2</sup>
  - Deficiencies: 3500 (11 per building)
  - Whole-building energy savings: 15%
  - Payback time: 8 months
- New Construction
  - Cost: \$1.00/ft<sup>2</sup> • NEBs: \$1.24/ft<sup>2</sup>
  - Deficiencies: 3300 (28 per building)
  - Payback time: 4.8 years
- Cost-effective over range of energy intensities building types, sizes, and locations
- Most successful: energy-intensive buildings
- Cost-effective outcomes harder in small buildings

# Cost Allocation

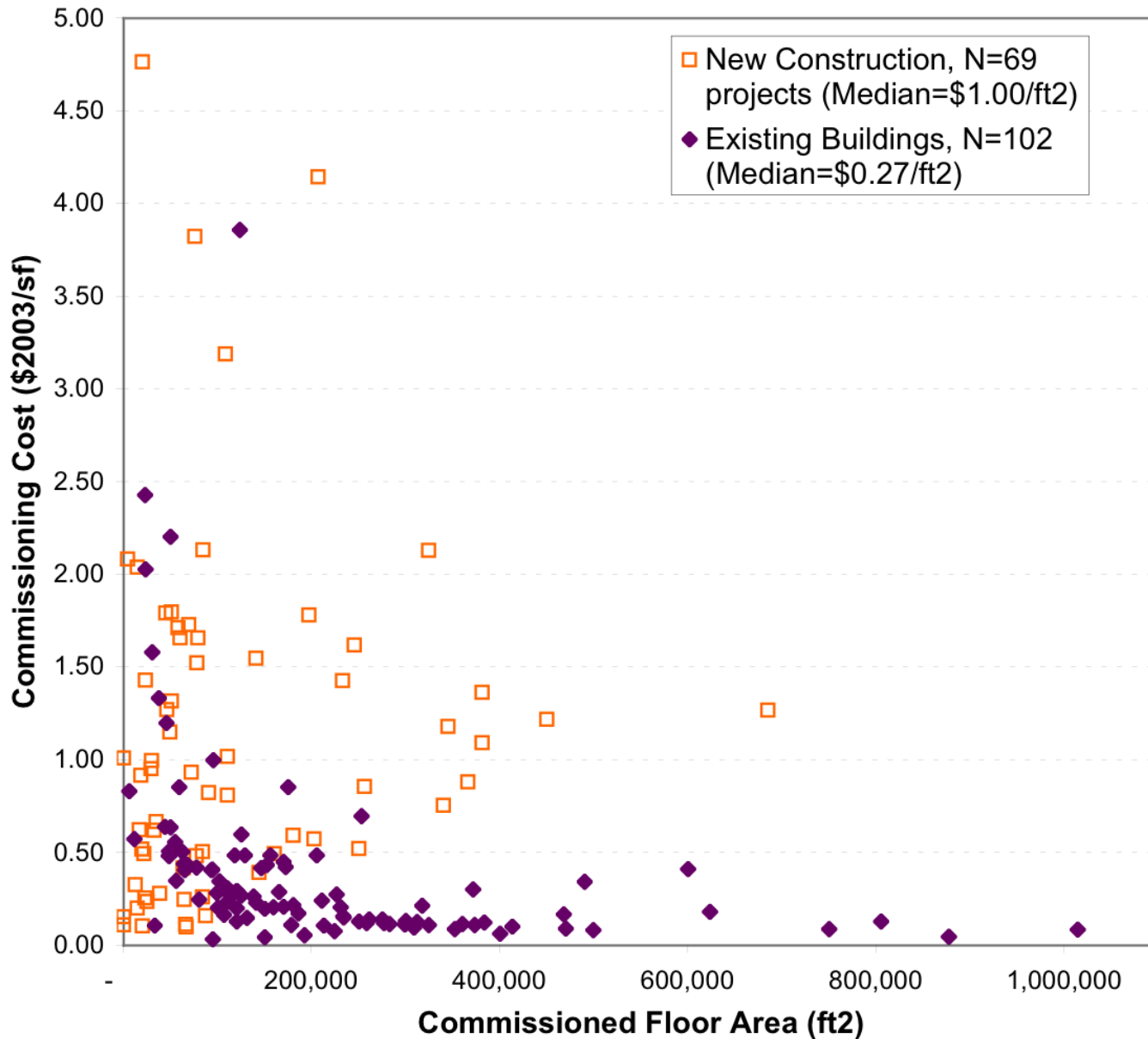
## Existing Buildings (N=55)



## New Construction (N=5)

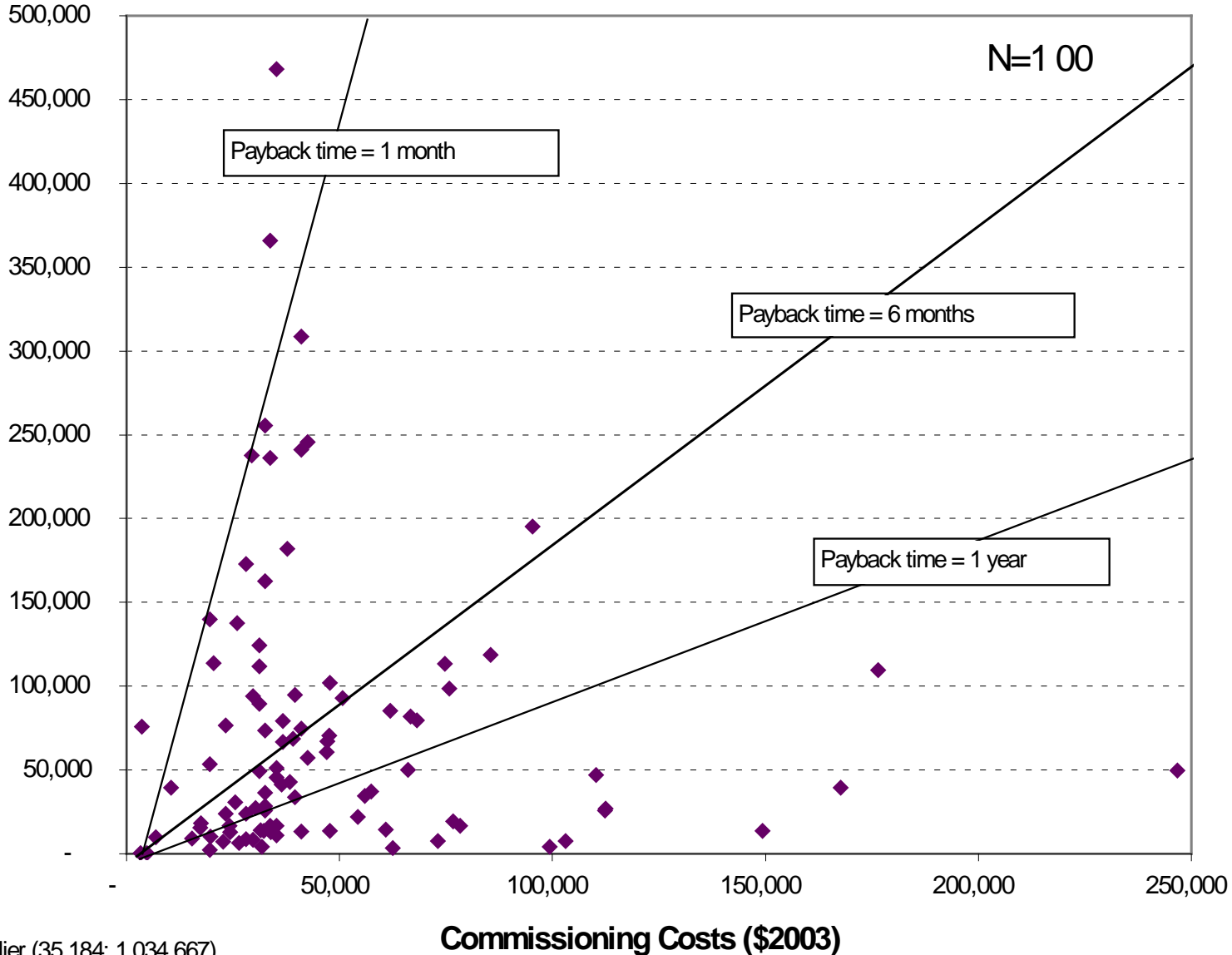


# Normalized Costs



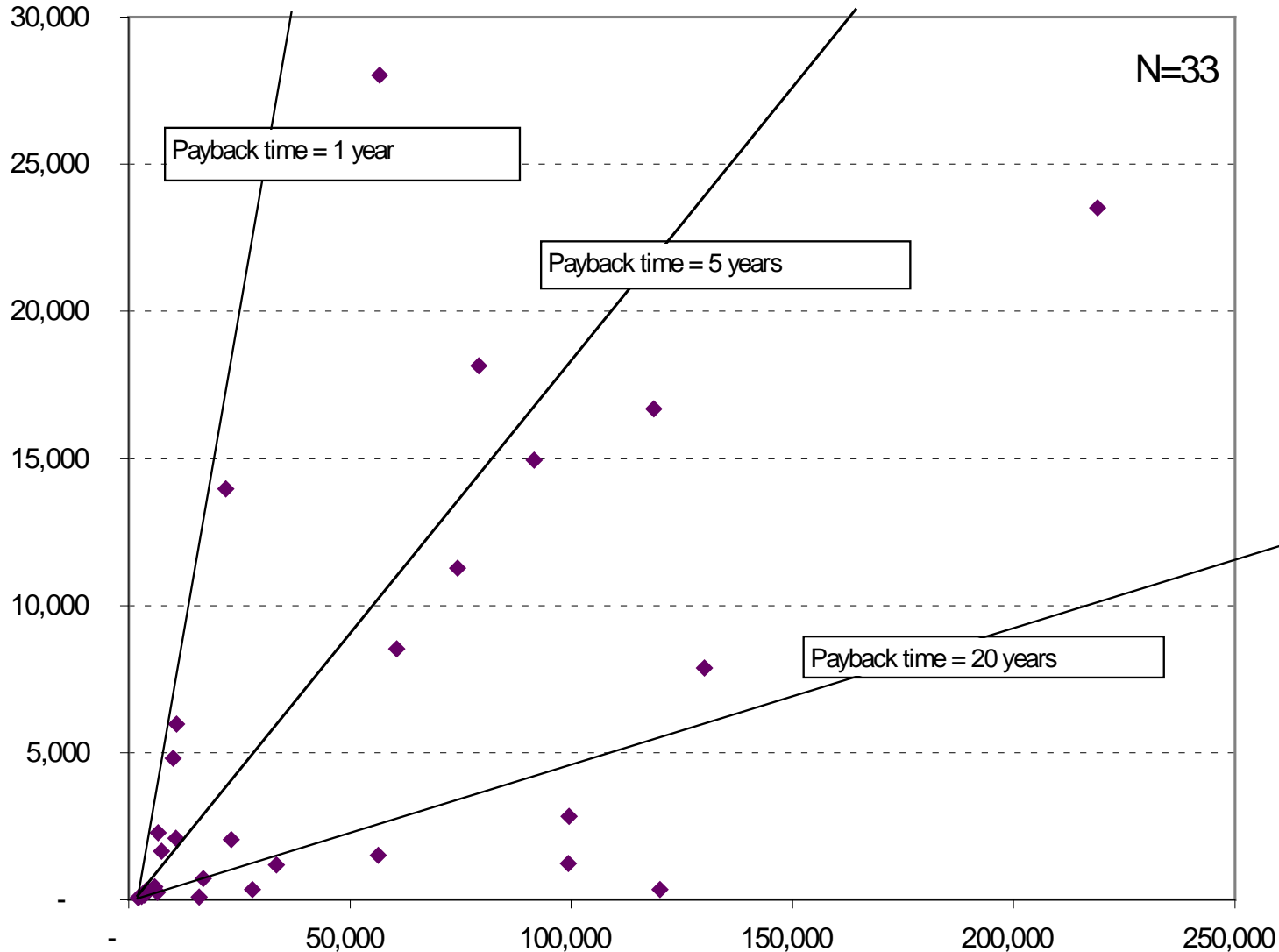
# Payback Times: Existing Buildings

Median Payback Time = 0.7 years



# Payback Times: New Construction

Median Payback Time = 4.8 years

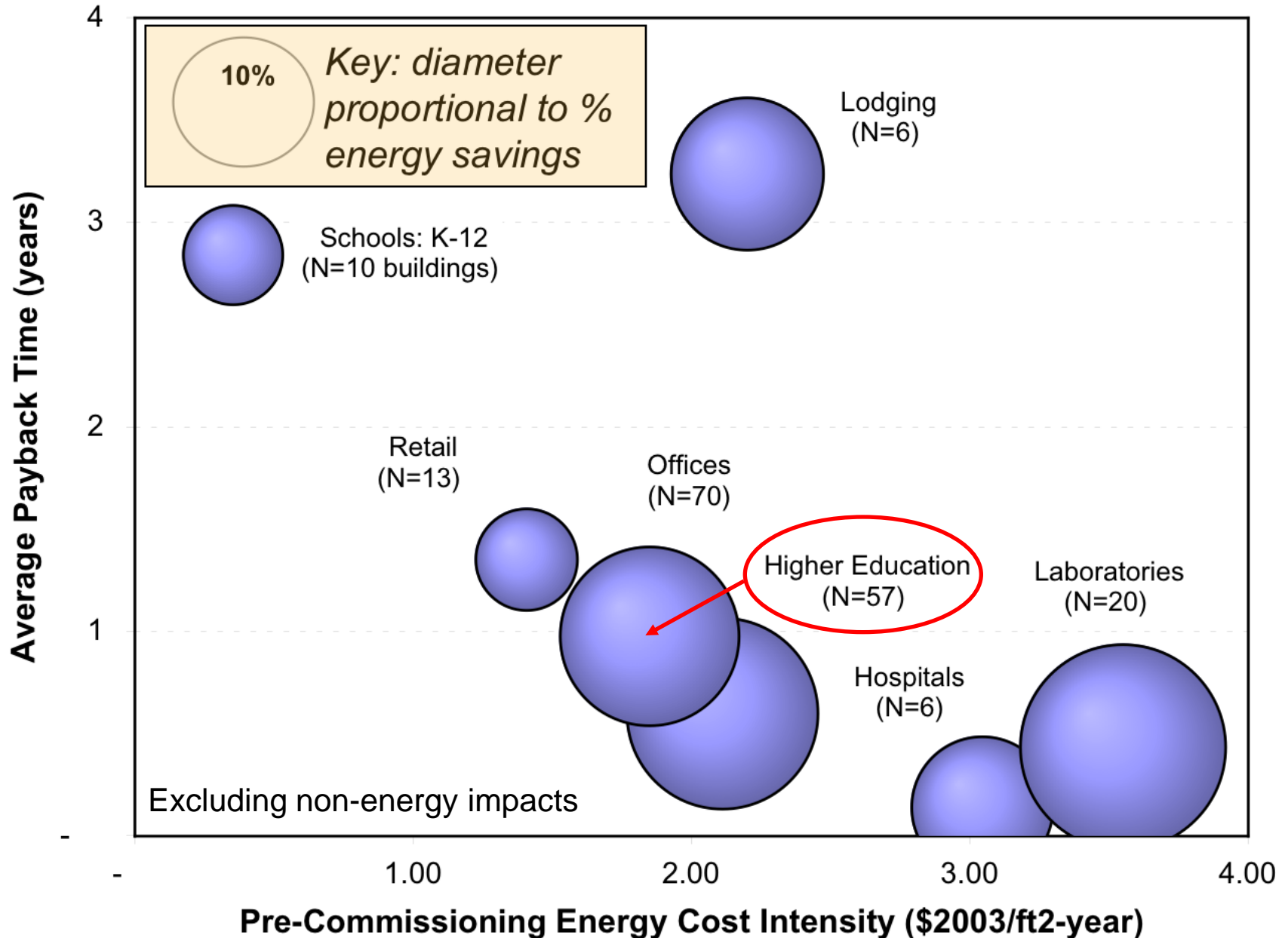


*Payback times not always attractive (if NEBs excluded)*

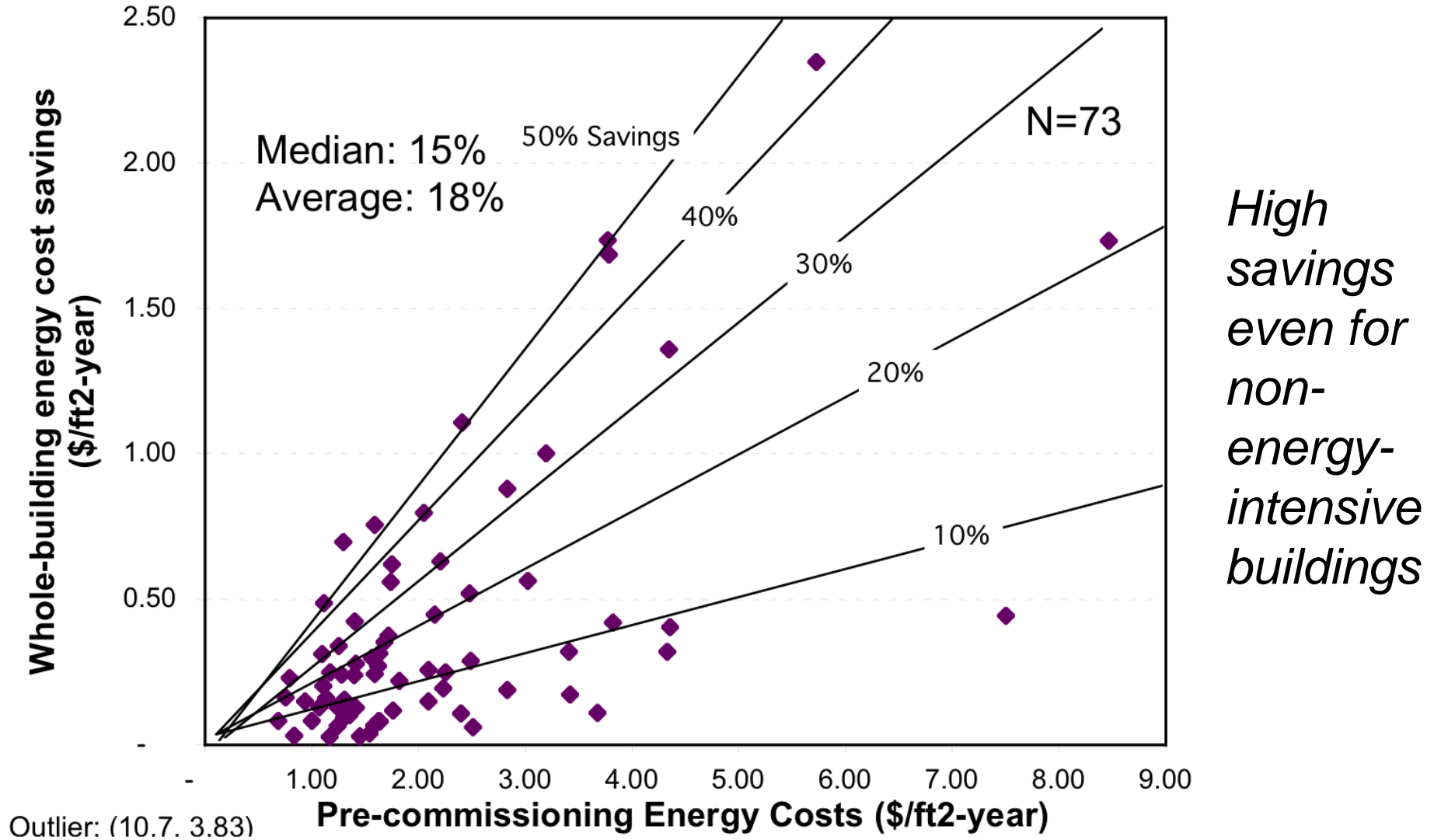
Outliers: (390,575;165,130), (661,752; 149,513), (1,126,000; 306,344)

**Commissioning Costs (\$2003)**

# Results Vary by Building Type

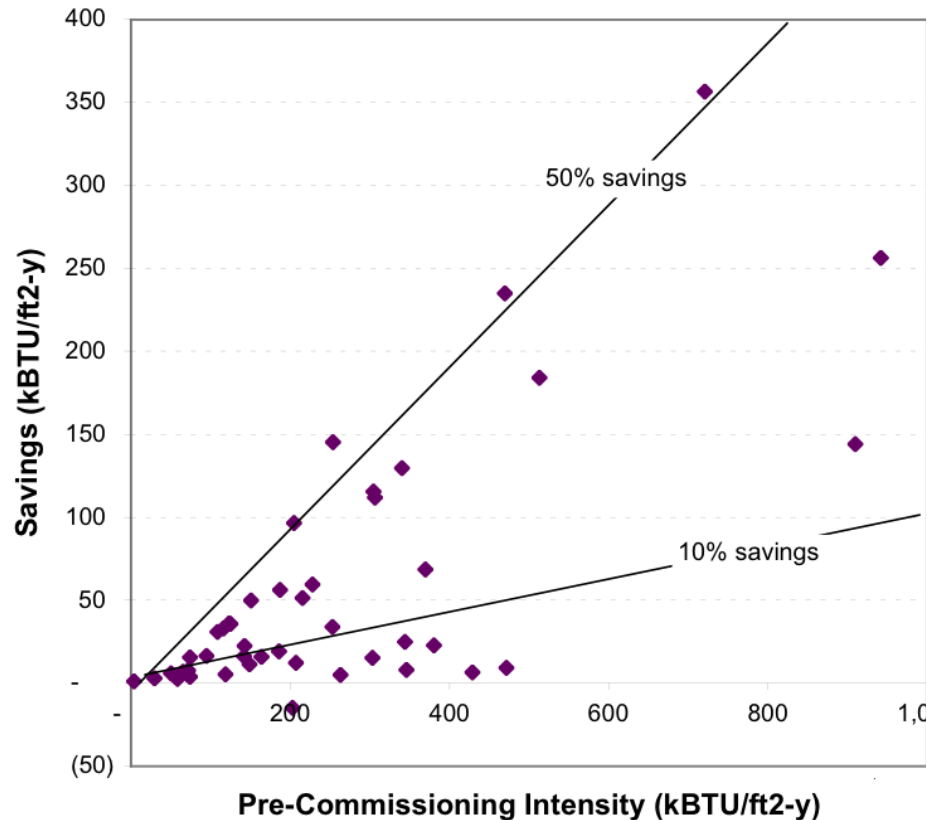


# Up to 50% Whole-Building Energy Savings

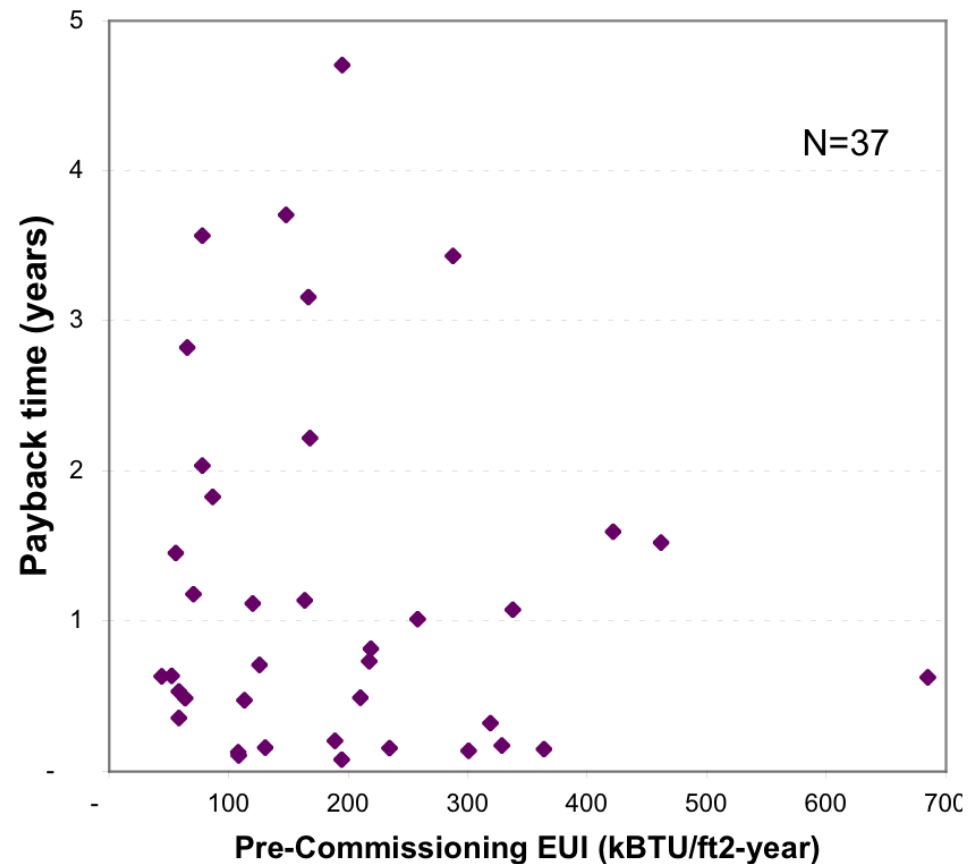


# Energy Savings & Payback Times Independent of Pre-Cx Energy Intensities

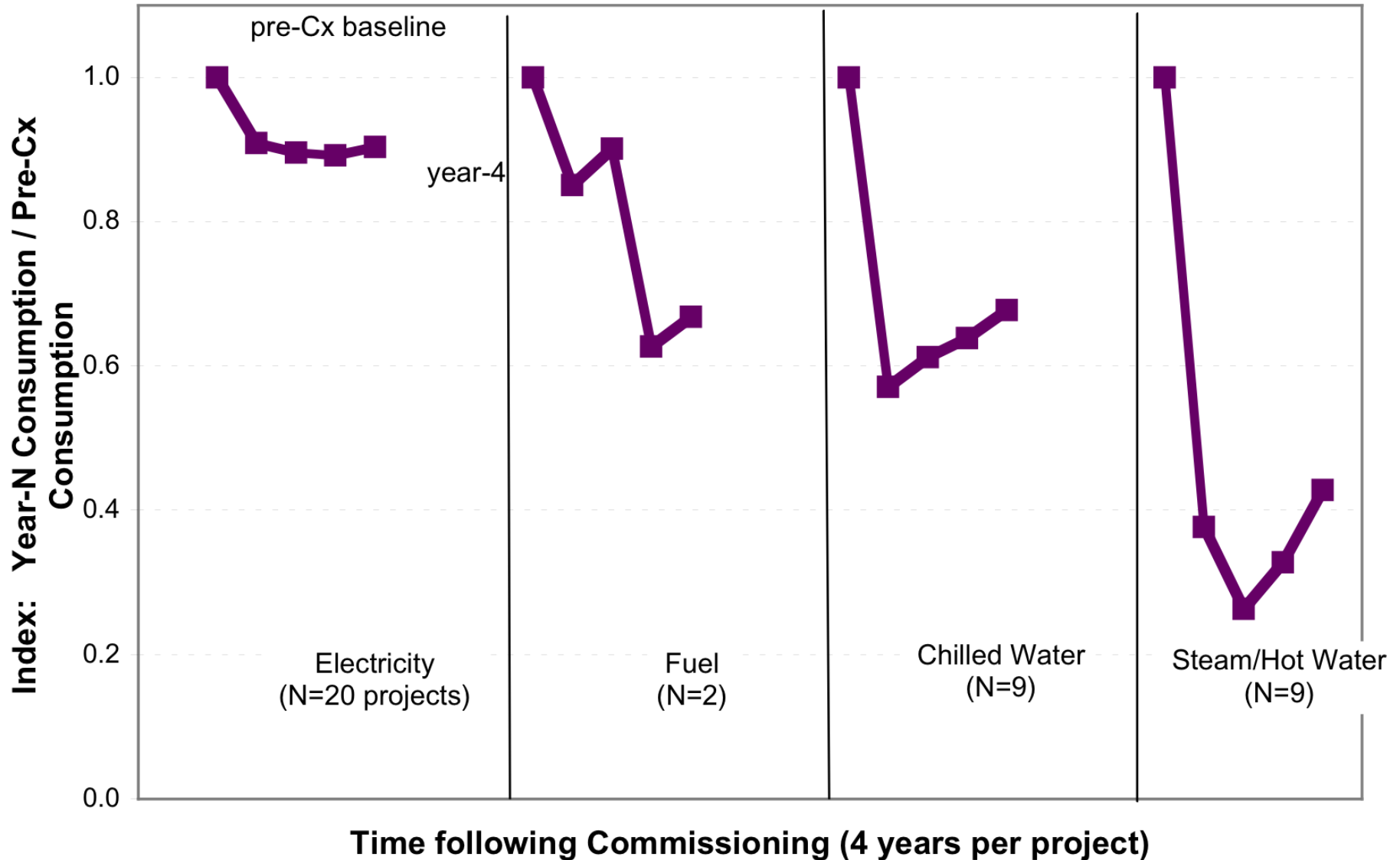
**Total Energy Savings vs. Pre-Commissioning Intensities (Existing Buildings)**



**Payback Time vs. Pre-Retro-Commissioning EUI (Existing Buildings)**

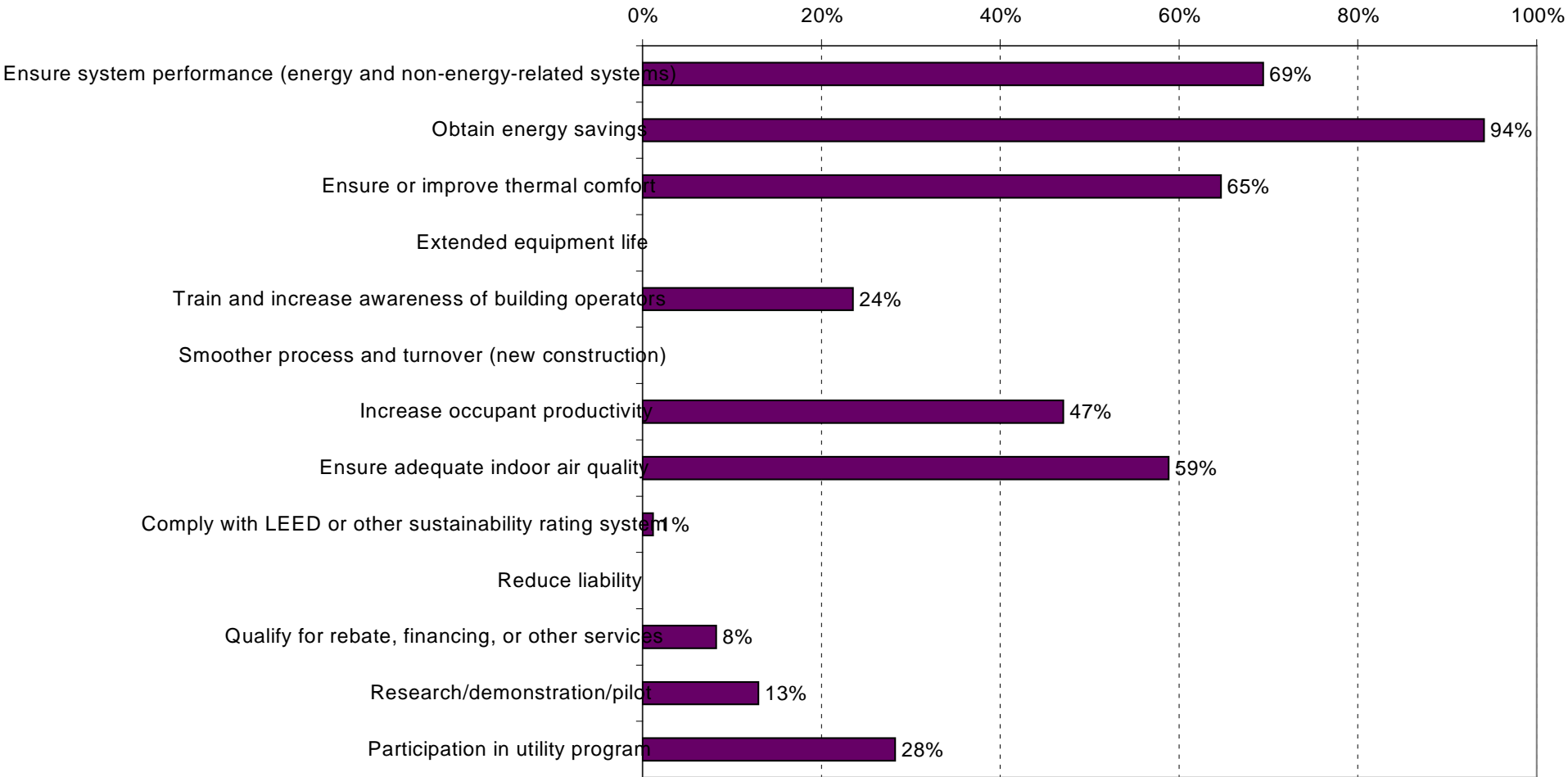


# Emergence & Persistence of Energy Savings



# Drivers: Existing Buildings

**Reasons for Existing Buildings Commissioning (N=)**  
Percent of projects reporting

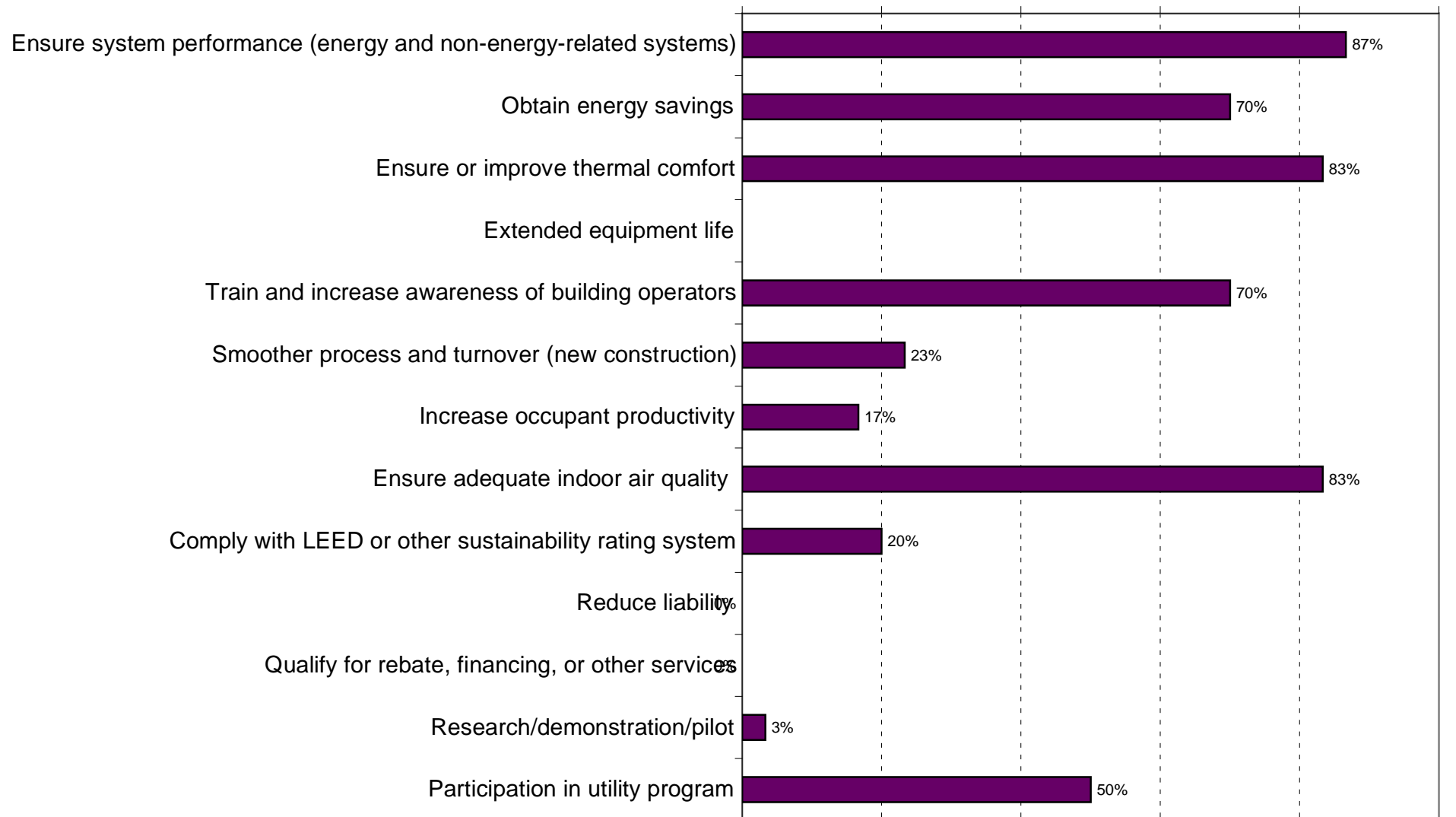


# Drivers: New Construction

## Reasons for New-Construction Commissioning (N=30)

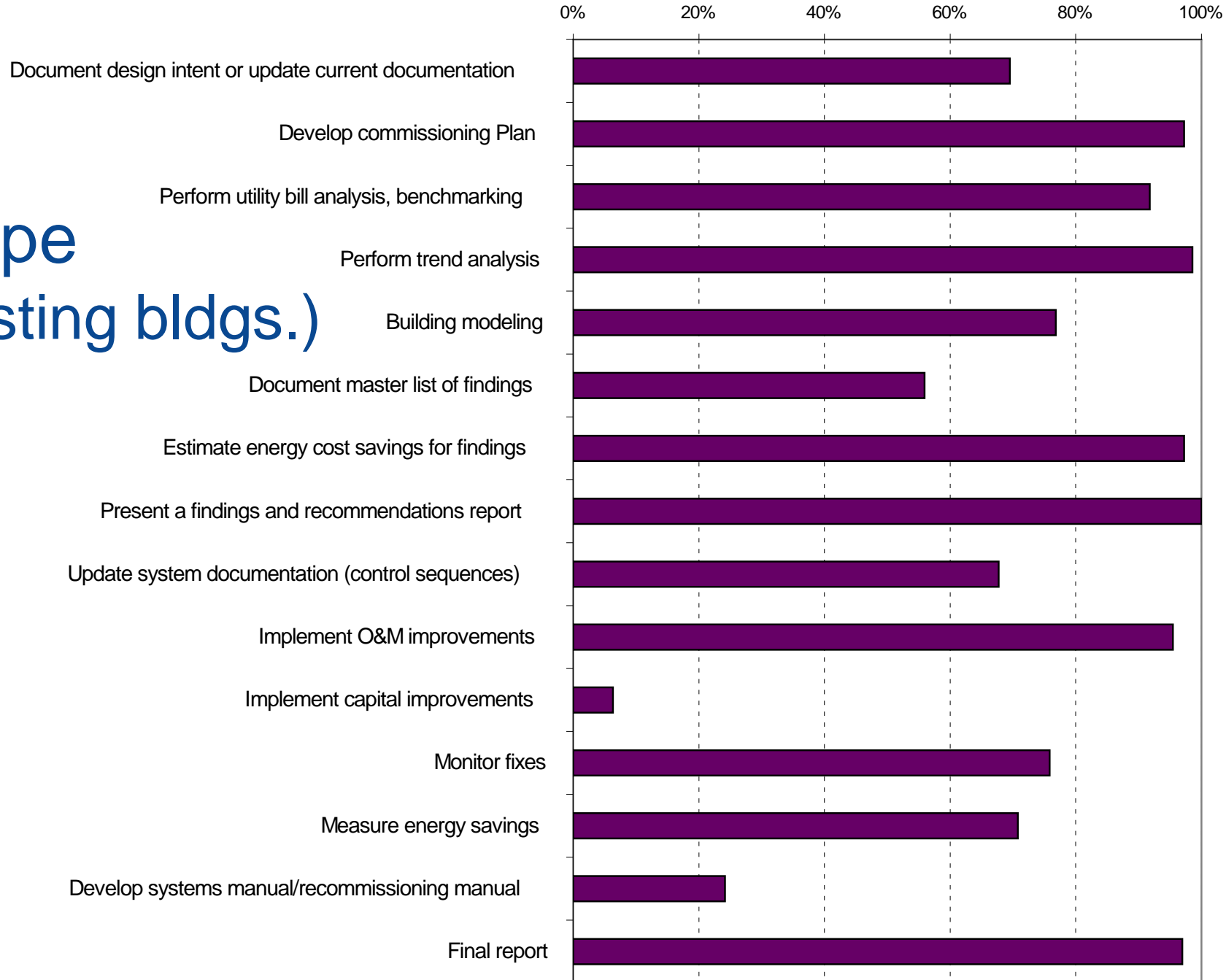
Percent of projects reporting

0% 20% 40% 60% 80% 100%

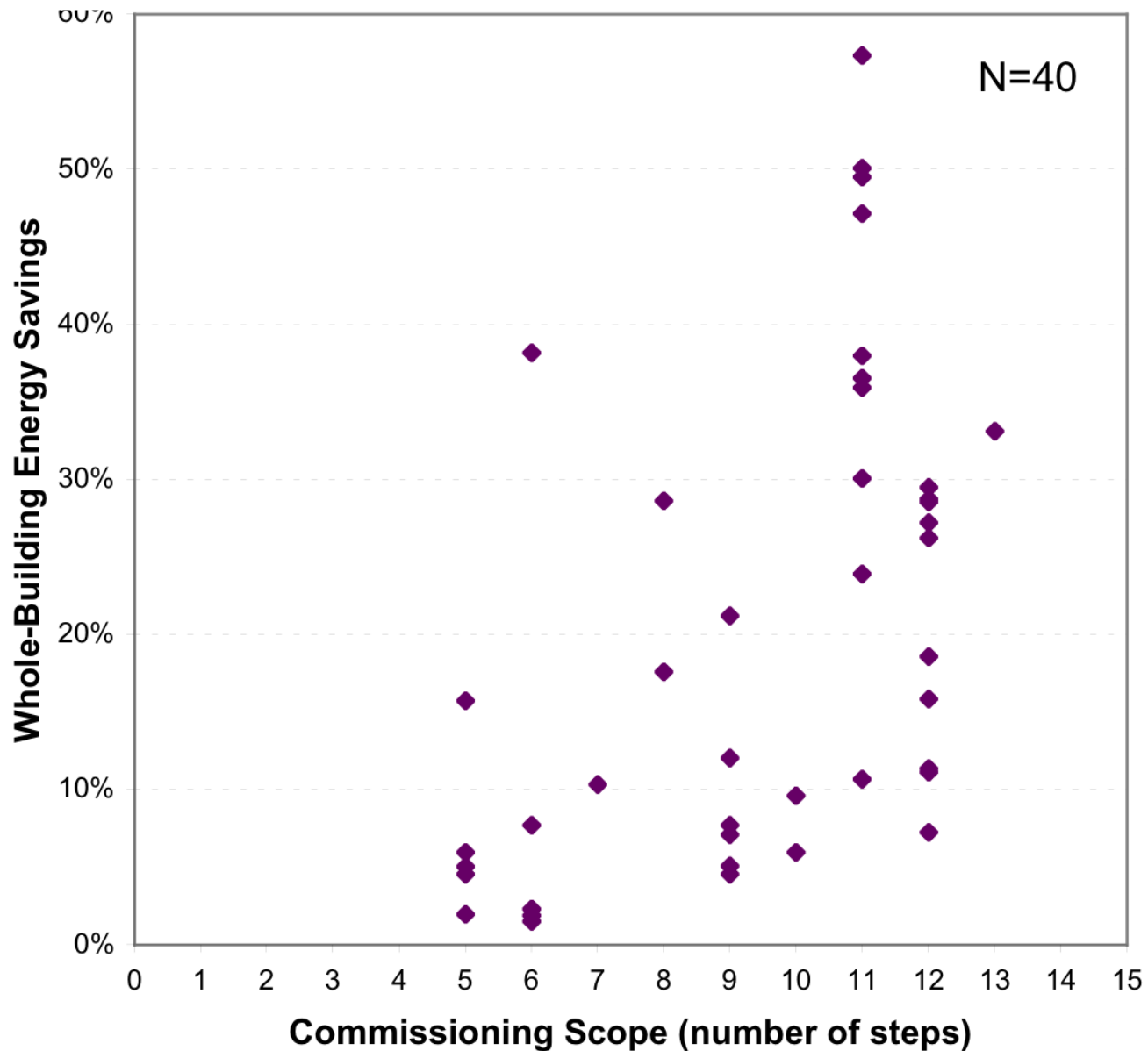


# Scope (Existing bldgs.)

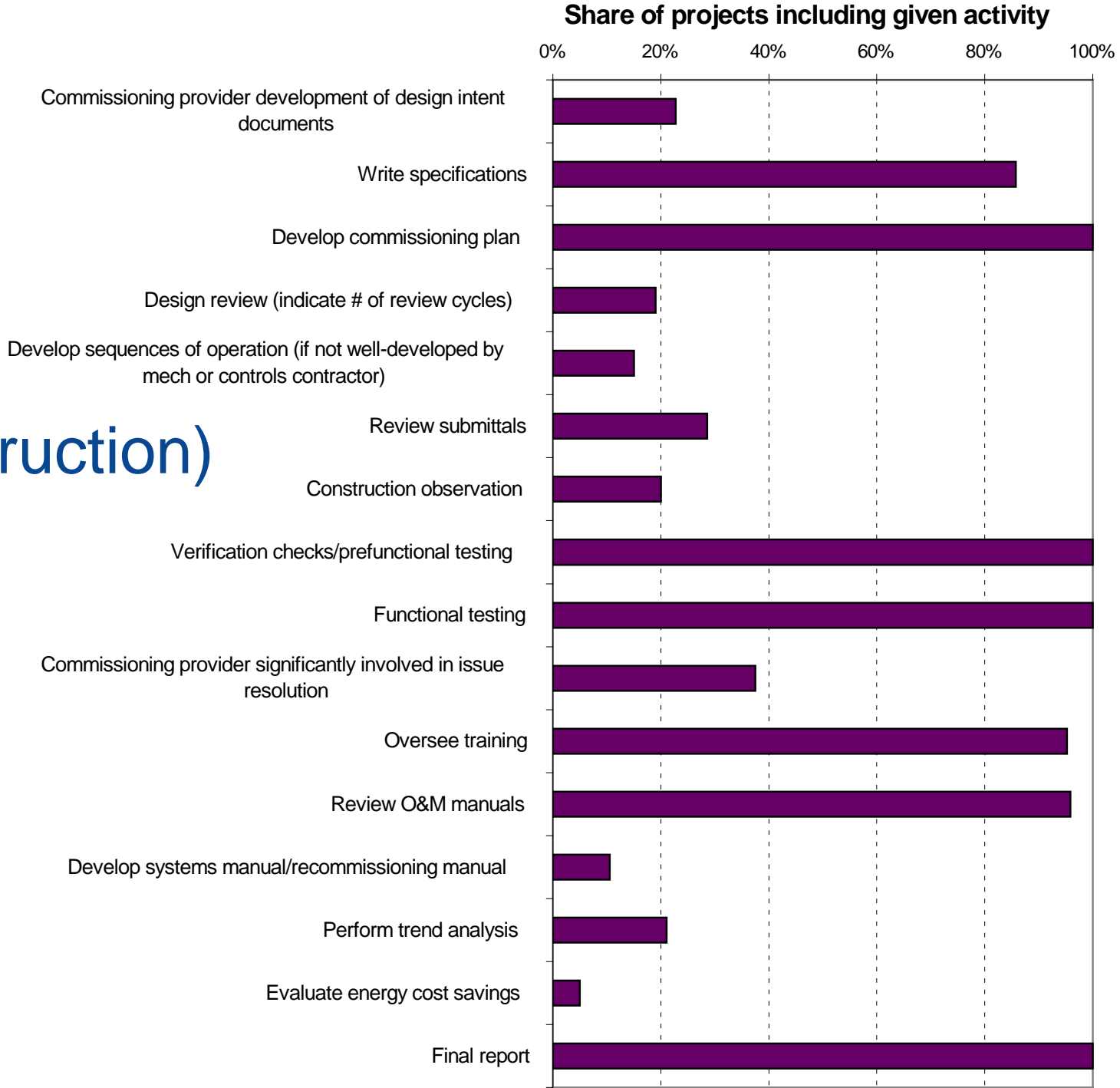
Share of projects including given activity



# Savings Scale with Commissioning Scope

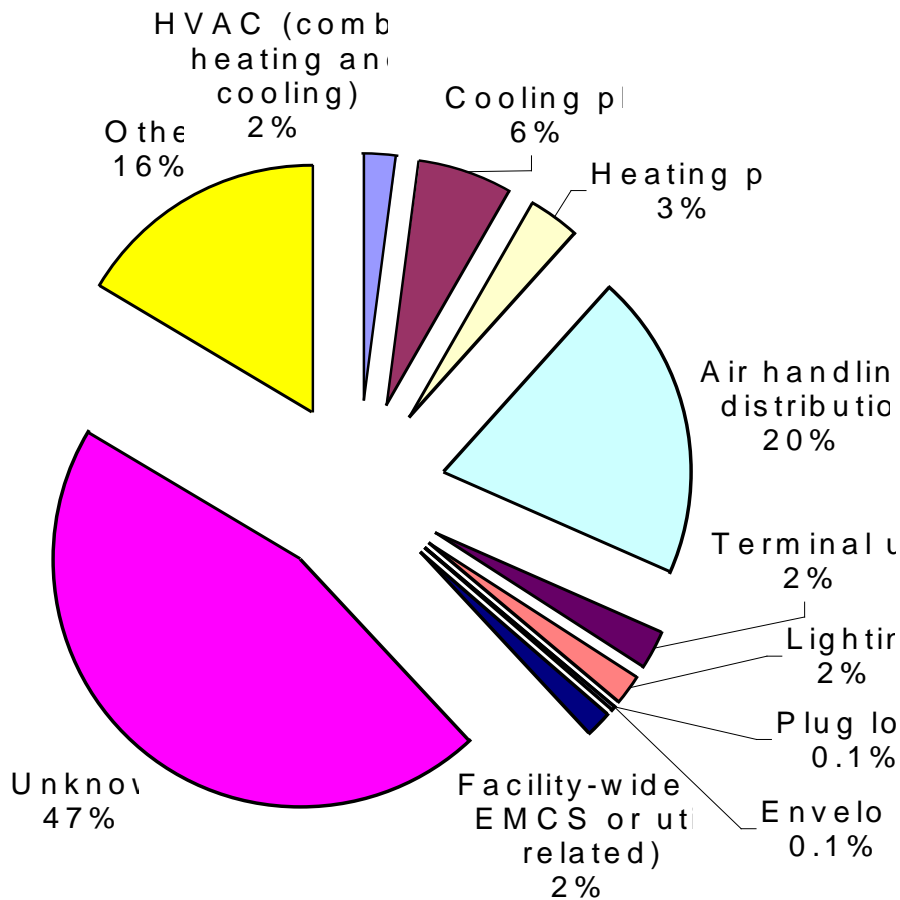


# Scope (New construction)

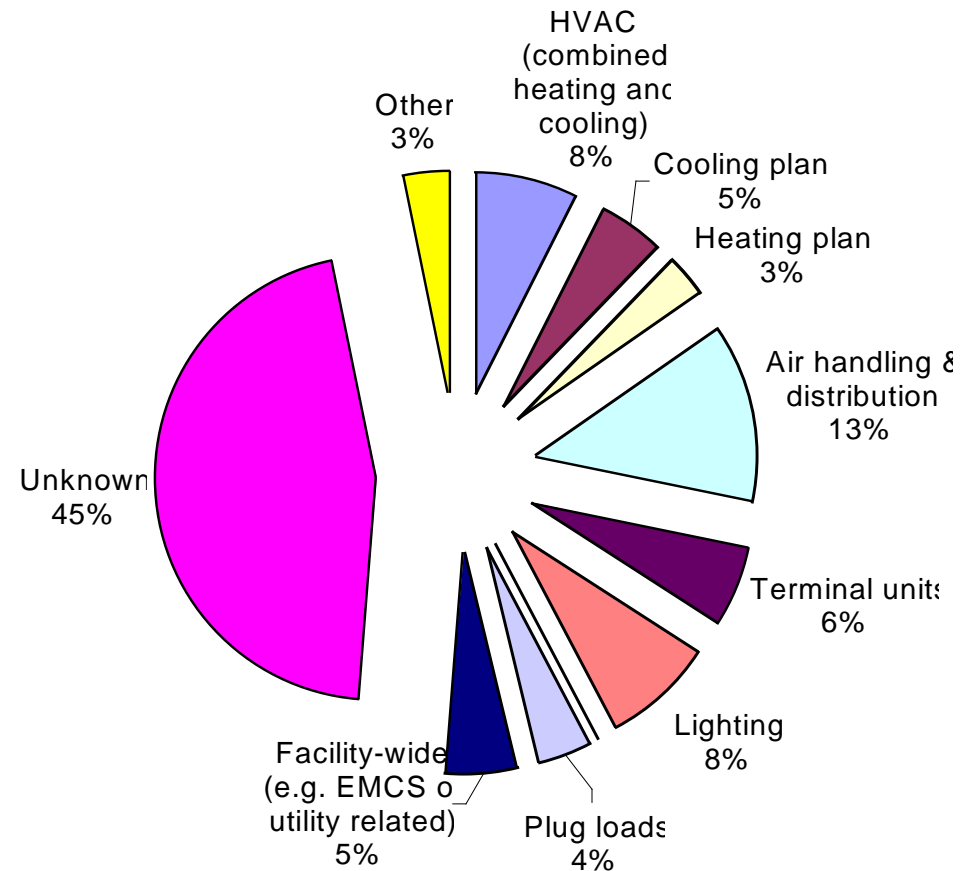


# Deficiencies by Building System

**Number of Deficiencies Identified by Building System (Existing Buildings, N = 3,500)**



**Number of Deficiencies Identified by Building System (New Construction, N = 3,305)**



# Measures Matrix

*Pairing of deficiencies (rows) and corrective measures (columns)*

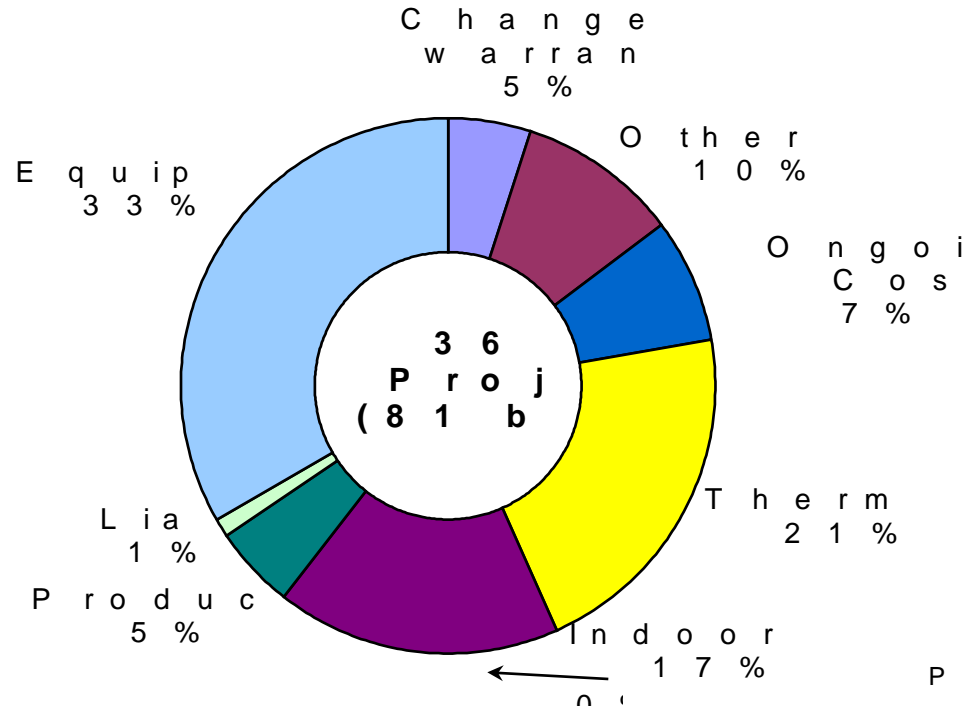
*69 projects;  
702 measures*

		Design, Installation, Retrofit, Replacement				Operations & Control									Maintenance					Deficiency unmatched to specific measure	Total
		D1	D2	D3	D4	OC1 Implement advanced reset	OC2 Start/Stop (environmentally determined)	OC3 Scheduling (occupancy determined)	OC4 Modify setpoint	OC5 Equipment staging	OC6 Modify sequence of operations	OC7 Loop tuning	OC8 Behavior modification/manual changes to operations	OC9 Other	M1 Calibration	M2 Mechanical fix	M3 Heat transfer maintenance	M4 Filtration maintenance	M5 Other		
<b>Deficiencies</b>		D1	D2	D3	D4	OC1	OC2	OC3	OC4	OC5	OC6	OC7	OC8	OC9	M1	M2	M3	M4	M5		
HVAC (combined heating and cooling)	V	0	2	8	1	1	1	5	3	1	5	0	0	2	5	7	1	5	2	12	61
Cooling plant	C	4	11	19	0	26	5	4	10	4	27	3	12	2	4	10	1	0	0	13	155
Heating plant	H	4	0	5	0	15	7	1	4	0	7	1	5	1	4	7	1	0	0	18	80
Air handling & distribution	A	15	9	19	3	80	9	21	25	4	24	12	14	6	40	27	3	4	2	40	357
Terminal units	T	1	3	2	1	4	0	3	14	0	4	1	2	1	7	10	0	0	0	8	61
Lighting	L	3	1	17	1	1	2	4	0	0	0	0	5	0	2	1	0	0	0	1	38
Envelope	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plug loads	P	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Facility-wide (e.g. EMCS or utility related)	F	2	3	2	0	1	0	7	0	0	1	1	7	2	2	2	1	0	0	3	34
Other	O	0	0	2	0	0	0	0	2	0	1	0	1	0	0	3	0	0	1	12	22
<b>Deficiency unmatched to specific measure</b>		10	9	7	0	2	2	1	29	2	7	2	4	1	12	10	0	0	0		809
<b>Total</b>		39	38	81	6	130	26	46	87	11	76	20	51	15	76	77	7	9	5	800	

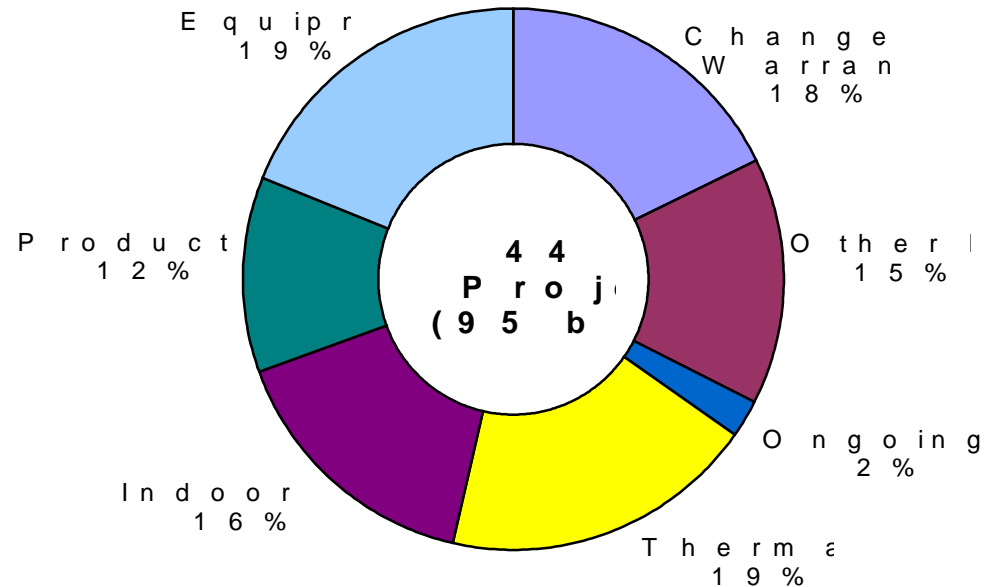
# Observed Non-Energy Impacts

## Existing Buildings (N=55)

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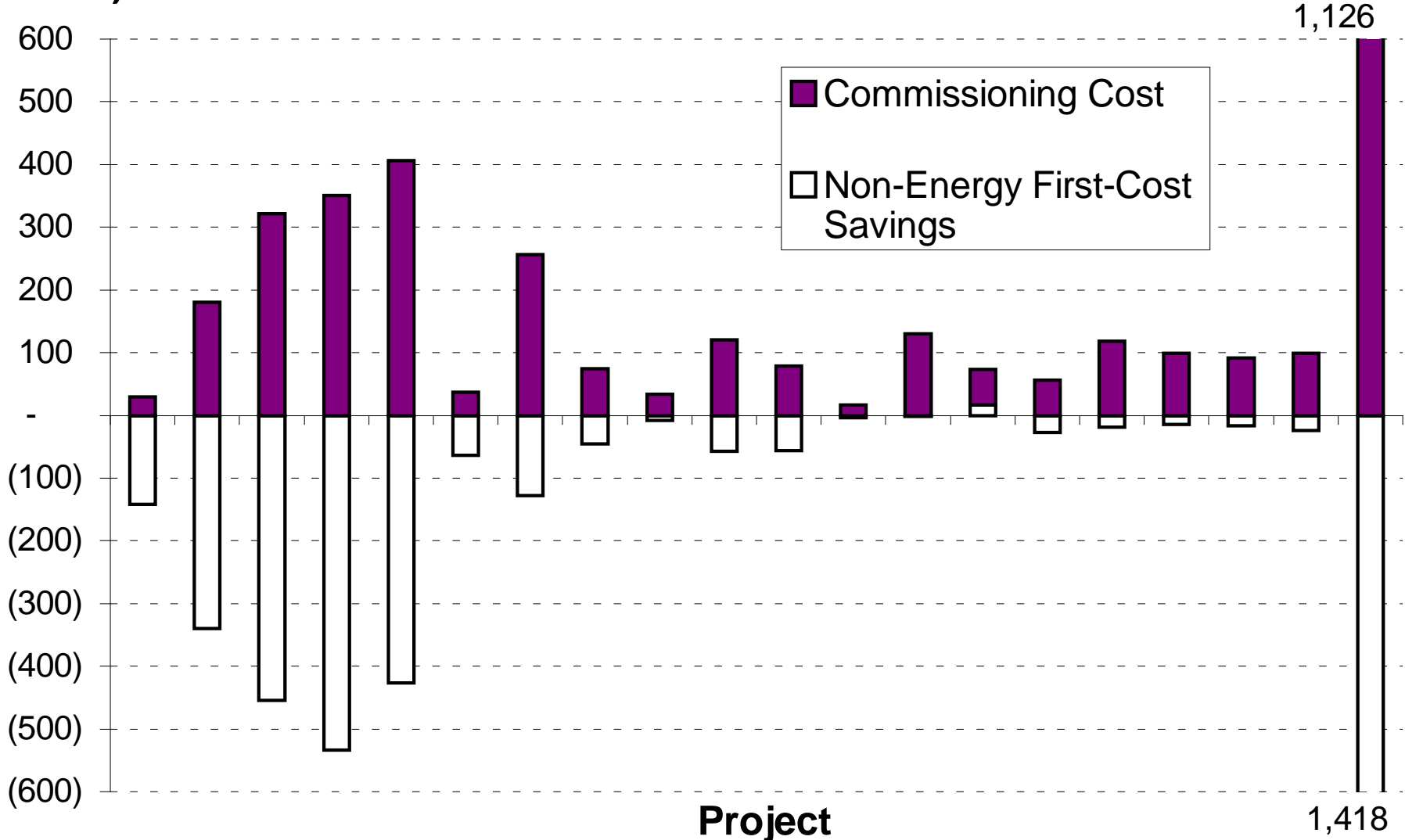
## New Construction (N=5)



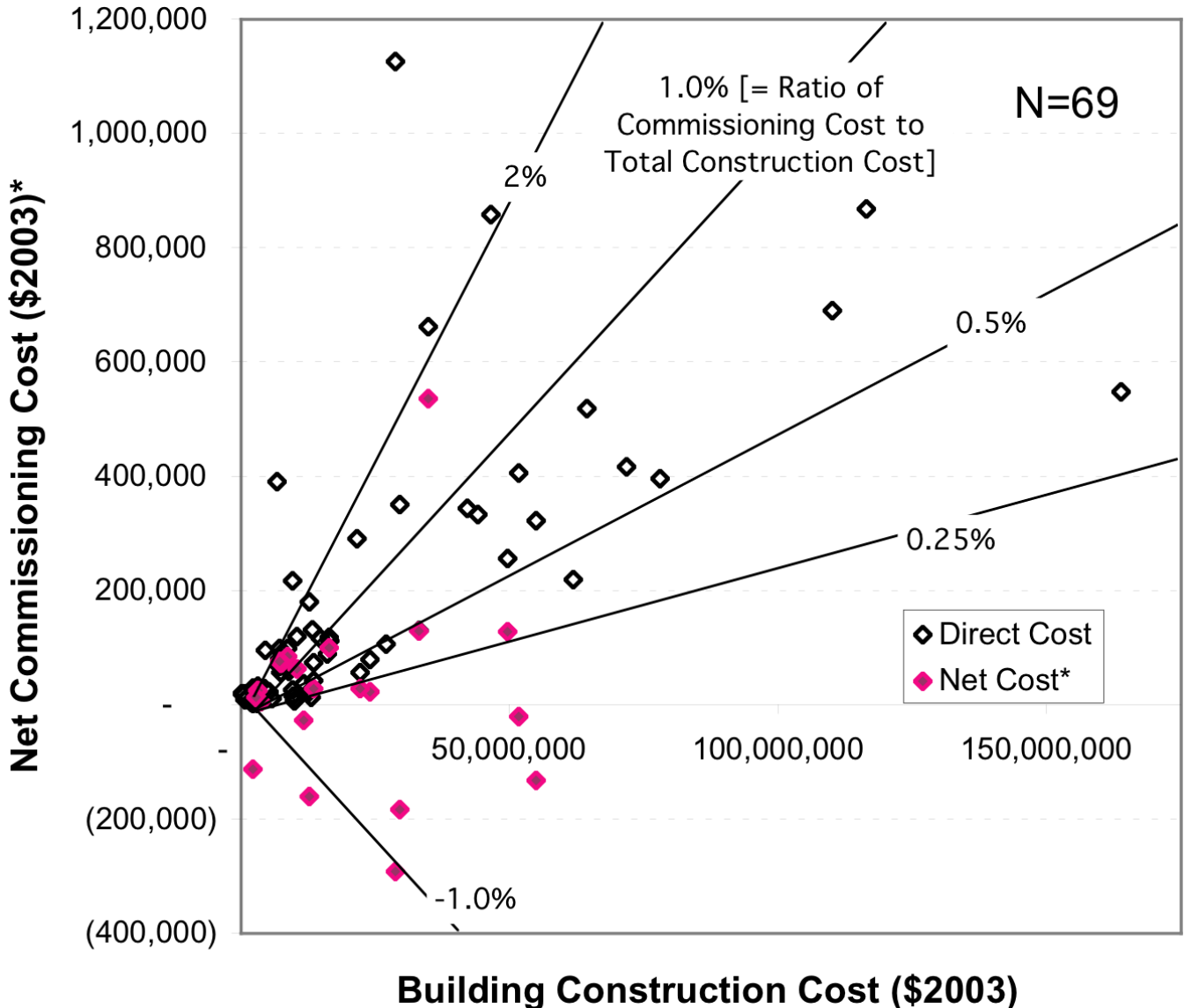
# Value of Non-Energy Benefits Often Offsets Entire Cost of Commissioning

\$2003  
(1000s)

20 projects



# New Construction: Costs range from -1% to 2%+ of total construction cost



*Inclusion of non-energy benefits (e.g. equipment downsizing, reduced callbacks, ... significantly reduces costs*

# National Potential; National Need

- **National potential:**
  - Assuming median savings of 15%
  - \$18 billion annual energy savings potential (US-wide) -- *plus* non-energy benefits
- **National need:**
  - Without commissioning, many energy-efficiency projects, programs, and policies will often fall short of their goals

# Recommendations

- Cx is needed, and is a good investment, with significant energy savings and other benefits
- No energy management program is complete without commissioning (in-house or out-sourced)
- Invest in commissioning and institutionalize the process > track outcomes > refine process
- Develop “Green Building Commissioning”

*Participate in our Research:*

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Lawrence Berkeley National Laboratory

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<http://eetd.lbl.gov/emills/PUBS/Cx-Costs-Benefits.html>

# Existing Buildings vs. New Construction

- **Existing buildings**
  - larger
  - greater normalized energy savings
  - more cost-effective (excluding NEBs)
- **New construction**
  - less comprehensive
  - normalized costs higher
  - larger non-energy benefits
  - NEBs are a more important motivation for embarking on commissioning, and can go farther in offsetting the cost of commissioning
  - more deficiencies found