2018 Commissioning Cost/Benefit Study Findings

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What is Cx? (New Construction, “NCCx”)

Example issues uncovered by NCCx

- Piping design interferes with shut-off valve handle
- Interior lighting shines directly on photosensor, interfering with daylighting controls
- Pathways for conditioned air to escape

NCCx Process

- Pre-Design Phase
- Design Phase
- Construction Phase
- Occupancy and Operations Phase

Source: California Commissioning Collaborative
What is Cx? (Existing Buildings, “EBCx”)

Example issues uncovered by EBCx

Interior lighting is often found to be on during unoccupied periods

Data analysis can uncover problems with economizer dampers

EBCx Process

Planning Phase
Investigation Phase
Implementation Phase
Hand-Off Phase

Source: California Commissioning Collaborative
Prior Cx Cost Benefit Studies


Key Research Questions for 2018 Study

• Are key project metrics different compared to 2009? (savings, costs, payback)
• How do project results vary by region, building type, building size?
• How do EBCx costs/savings compare between utility-funded projects and non-utility projects?
• Have finding/measure types changed over time?
• Is there evidence that EBCx/NCCx has become commoditized? (e.g. broader deployment, more consistent scope/results, less savings per project but remaining cost-effective, etc.)
• Has EBCx/NCCx shifted significantly beyond its historical focus on HVAC (lighting, particularly, but also envelope, refrigeration, etc.)
• Has there been a shift in market drivers for Cx (i.e. what are the main reasons Cx is performed?)
• Has the emergence of analytics-based approaches (ongoing Cx, MBCx using EMIS) changed the savings or cost-benefit for EBCx?
Acknowledgements

• Study funding
  – U.S. Department of Energy

• 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
STUDY COMPOSITION
Study Square Footage (cumulative)

- 2004: 30,398,751
- 2009: 99,224,809
- 2018: 373,384,656
Number of Buildings in Study (cumulative)

- 2004: 224
- 2009: 643
- 2018: 1,482
Geographical Distribution: EBCx

Geographical Distribution, Percent of Total Buildings, 2018 (EBCx)

Top 4 states in 2009
- California: 42%
- Texas: 25%
- Colorado: 17%
- Minnesota: 5%

States and Percentages:
- CA: 8.1%
- CO: 1.4%
- IL: 60.6%
- BC: 21.1%
- WA: 10.2%
- OR: 6.6%
- NY: 4.9%
- MA: 3.1%
- VA: 3.0%
- AZ: 2.9%
- UT: 2.2%
- DC: 1.3%
- MO: 1.2%
- WI: 1.0%
- AL: 1.1%
- CT: 0.8%
- MN: 0.7%
- NJ: 0.6%
Market Sector Distribution: EBCx

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

- Office, 117,760,364
- Hospital (Inpatient), 51,129,968
- Higher Education, 32,109,966
- Other, 13,132,301
- Lodging, 9,612,945
- Retail, 6,639,553
- K-12 School, 5,331,891
- Warehouse, 4,146,000
- Industrial, 3,262,...

Top 4 categories in 2009
- Office 44%
- Higher Ed 13%
- Lodging 11%
- Hospital (Inpatient) 8%
Project Size Distribution: EBCx

EBCx Project Size Distribution (n=684)

Number of Buildings in Size Range

Median 175,591

Project size (thousands sq.ft.)

Min 4,988
Median 175,591
Mean 359,609
Max 3,021,067
Geographical Distribution: NCCx

Geographical Distribution, Percent of Total Buildings (NCCx)

Top 3 states in 2009
Missouri 20%
Washington 19%
Oregon 16%
Market Sector Distribution: NCCx

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

Office, 14,924,243
Hospital (Inpatient), 2,377,503
Higher Education, 1,509,583
K-12 School, 1,612,305
Warehouse, 507,000
Industrial, 734,048

Top 3 categories in 2009
- Public Order/Safety 26%
- Laboratory 22%
- Office 10%

Legend:
- Office
- Hospital (Inpatient)
- Higher Education
- Lodging
- Retail
- K-12 School
- Warehouse
- Industrial
- Lab
- Public Assembly
- Hospital (Outpatient)
NCCx sample composition

Market Segment Breakdown (Projects with Cost Data)

For NCCx data the 2018 dataset has significantly different distribution across market segments.
Project Size Distribution: NCCx

NCCx Project Size Distribution (n=71)

Number of Buildings in Dataset

Project Size (Thousand sq.ft.)

- Median: 115,908
- Min: 2,700
- Max: 3,500,000
- Mean: 232,409
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=604)

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>25th</td>
<td>3%</td>
</tr>
<tr>
<td>Median</td>
<td>6%</td>
</tr>
<tr>
<td>75th</td>
<td>10%</td>
</tr>
</tbody>
</table>
EBCx Percent Savings by Market Segment

- 90th Percentile
- 75th Percentile
- Median
- 25th Percentile
- 10th Percentile

Box/whisker chart interpretation

(EBCx Percent Savings by Building Type (Source Energy) n=604)
EBCx Percent Savings by Market Segment

Apparent wide variation between market segments, though sample size is very small for 7 categories.

Sample Size

<table>
<thead>
<tr>
<th>Market Segment</th>
<th>Sample Size</th>
</tr>
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<tbody>
<tr>
<td>Higher Ed.</td>
<td>112</td>
</tr>
<tr>
<td>Hospital (Inpatient)</td>
<td>115</td>
</tr>
<tr>
<td>Retail</td>
<td>30</td>
</tr>
<tr>
<td>Office</td>
<td>194</td>
</tr>
<tr>
<td>Industrial</td>
<td>10</td>
</tr>
<tr>
<td>Other</td>
<td>42</td>
</tr>
<tr>
<td>Data Center</td>
<td>15</td>
</tr>
<tr>
<td>K-12 School</td>
<td>42</td>
</tr>
<tr>
<td>Lodging</td>
<td>17</td>
</tr>
<tr>
<td>Warehouse</td>
<td>6</td>
</tr>
<tr>
<td>Religious Worship</td>
<td>6</td>
</tr>
<tr>
<td>Food Service</td>
<td>6</td>
</tr>
<tr>
<td>Lab</td>
<td>1</td>
</tr>
<tr>
<td>Public Assembly</td>
<td>2</td>
</tr>
<tr>
<td>Public Order &amp; Safety</td>
<td>2</td>
</tr>
<tr>
<td>Hospital (Outpatient)</td>
<td>4</td>
</tr>
</tbody>
</table>

Total Sample Size: 604
EBCx Percent Savings by Market Segment

EBCx Percent Savings by Building Type (Source Energy) (n=604)

Sample Size

<table>
<thead>
<tr>
<th>Segment</th>
<th>Sample Size</th>
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<tr>
<td>HE</td>
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<tr>
<td>HI</td>
<td>Hospital (Inpatient)</td>
</tr>
<tr>
<td>R</td>
<td>Retail</td>
</tr>
<tr>
<td>O</td>
<td>Office</td>
</tr>
<tr>
<td>I</td>
<td>Industrial</td>
</tr>
<tr>
<td>OTH</td>
<td>Other</td>
</tr>
<tr>
<td>DC</td>
<td>Data Center</td>
</tr>
<tr>
<td>K12</td>
<td>K-12 School</td>
</tr>
<tr>
<td>LOD</td>
<td>Lodging</td>
</tr>
</tbody>
</table>

Removed market segments with sample size of 6 or less.

Median values range from 3%-10%
EBCx Percent Savings by Building Size

Not a strong correlation between building size and EBCx percent savings.

Majority of data points are for buildings <500,000 sq.ft., so worth a closer look …
EBCx Percent Savings by Building Size

Zooming in to buildings <500,000 sq.ft., still no strong correlation between EBCx percent savings and building size.
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 by Project Type (whole Building Source MMBTu)

<table>
<thead>
<tr>
<th>Project Type</th>
<th>Median</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility_1</td>
<td>5%</td>
<td>411</td>
</tr>
<tr>
<td>Utility_2</td>
<td>7%</td>
<td>156</td>
</tr>
<tr>
<td>Utility_MBCx</td>
<td>8%</td>
<td>17</td>
</tr>
<tr>
<td>Other_EBCx</td>
<td>19%</td>
<td>13</td>
</tr>
</tbody>
</table>

Overall study median 6%
EBCx Percent Savings: 2018

EBCx Percent Savings by Project Type (whole Building Source MMBTu)

Two Sample Kolmogorov–Smirnov test suggests that each category represents different distributions, with one possible exception: Utility_2 and Utility_MBCx (P value 0.9921)

<table>
<thead>
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<th>Category</th>
<th>Median</th>
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</table>

Note: relatively small sample size for MBCx and Other

Median 6%
EBCx Percent Savings: 2009

EBCx Percent Savings by Program Type (2009 data) (n=162)

2009 median for Utility_EBCx is similar to 2018 data (5% and 7%).

Wider variation between median values for different project types in 2009 data set, and very wide distribution for “Other” category projects.

<table>
<thead>
<tr>
<th>Project Type</th>
<th>Median</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility_EBCx</td>
<td>4%</td>
<td>47</td>
</tr>
<tr>
<td>Utility_MBCx</td>
<td>11%</td>
<td>21</td>
</tr>
<tr>
<td>Other_EBCx</td>
<td>12%</td>
<td>54</td>
</tr>
<tr>
<td>Other_MBCx</td>
<td>18%</td>
<td>40</td>
</tr>
</tbody>
</table>

Median 10%
EBCx Simple Payback

EBCx Simple Payback (Years) (n=356)

25th Percentile 1.3 years
Median 2.2 years
25th Percentile 4.2 years
No apparent relationship between project cost and simple payback, but worth zooming in a little closer…

EBCx Simple Payback

* Data in 2018 study normalized to 2017 dollars
Looking only at projects costing <$200,000, there is still a high degree of scatter.
EBCx Simple Payback by Project Type

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

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

- Utility_1 had lower median percent savings (5%) than Utility_2 (7%) but has a shorter payback time.
- Non-Utility had very low median payback, and Utility_MBCx similar to Utility_2 (these categories had relatively small sample size).

Utility_1: 1.3 years
Utility_2: 3.9 years
Non-Utility: 0.6 years
Utility_MBCx: 4.0 years
EBCx Simple Payback by Market Segment

EBCx Simple Payback (years) by Building Type (n=356)

K12 School: 39
Hospital (Inpatient): 100
Higher Ed.: 111
Public Assembly: 3
Other: 20
Lab: 3
Office: 48
Religious Worship: 2
Warehouse: 4
Lodging: 12
Data Center: 3
Public Order & Safety: 2
Retail: 2
Hospital (Outpatient): 3
Industrial: 4

Total: 356
EBCx Simple Payback by Market Segment

EBCx Simple Payback (years) by Building Type (n=356)

- K12: K-12 School (n=39)
- HI: Hospital (Inpatient) (n=100)
- HE: Higher Ed. (n=111)
- OTH: Other (n=20)
- O: Office (n=48)
- LOD: Lodging (n=12)

Removed market segments with sample size of 4 or less.
EBCx Simple Payback by Market Segment

Interpretation of this chart is challenging, as variation may be more due to project type than market segment. For example, K-12 schools were mostly from Utility_2 and Office projects were mostly from Utility_1.
NCCX COSTS
New Construction Commissioning Cost
($2017/sq.ft.) (n=67)

- 25th Percentile: 2018 - $0.40, 2009 - $0.60
- Median: 2018 - $0.82, 2009 - $1.16
- 75th Percentile: 2018 - $1.35, 2009 - $2.14
- Mean: 2018 - $1.06, 2009 - $1.94

Box plot showing the distribution of New Construction Commissioning Cost ($2017/sq.ft.) with quartiles and outliers.
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.
Data suggests some level of relationship between building size and cost; some smaller buildings see costs >$1.50 while larger buildings do not. However, many smaller buildings see lower costs: other factors are in play beyond building size.
Looking at 2009 vs. 2018 data sets, neither shows a strong relationship between building size and NCCx cost.
NCCx Cost per sq.ft., by Year (not adjusted for inflation)

There is no clear trend for NCCx cost based on year of implementation.
NCCx Cost vs. Project Size

New Construction Commissioning Cost ($2017/sq.ft.) vs. Project Size (sq.ft.)

Higher Ed

Hospital (Inpatient)

Office

K-12 School
NCCx Cost vs. Project Size

When broken down by market segment, correlation between building size and NCCx cost is still not clear (small sample size)

- **Higher Ed**
- **Hospital (Inpatient)**
- **Office**
- **K-12 School**
NCCx Cost by Building Type

New Construction Commissioning Cost ($2017/sq.ft.)

Reviewed NCCx costs by market segment, but datasets too small to draw firm conclusions

<table>
<thead>
<tr>
<th>Building Type</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>1</td>
</tr>
<tr>
<td>HE</td>
<td>15</td>
</tr>
<tr>
<td>O</td>
<td>20</td>
</tr>
<tr>
<td>HI</td>
<td>8</td>
</tr>
<tr>
<td>K12</td>
<td>15</td>
</tr>
<tr>
<td>PA</td>
<td>1</td>
</tr>
<tr>
<td>I</td>
<td>3</td>
</tr>
<tr>
<td>L</td>
<td>2</td>
</tr>
<tr>
<td>LOD</td>
<td>1</td>
</tr>
<tr>
<td>W</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>67</td>
</tr>
</tbody>
</table>

46
NCCx Cost as Percent of Construction

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

- 25th Percentile: 0.14%
- Median: 0.25%
- 75th Percentile: 0.46%
NCCx Cost as Percent of Construction

New Construction Commissioning Cost as a Percentage of Overall Construction Cost

NCCx costs as a percent of overall construction cost are less than half compared to 2009 data set.
2018 data shows clearer relationship between construction cost and commissioning cost percentage (higher construction cost related to lower percentage). 2009 appears more scattered.
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

- Obtain energy savings
- Ensure system performance
- Ensure or improve thermal comfort
- Ensure adequate indoor air quality
- Qualify for rebate, financing, or other services
- Train/increase awareness of operators or occupants
- Participation in utility program
- Comply with LEED or other rating system
- Comply with organizational mandate/policy
- Extended equipment life
- Increase occupant productivity
- Comply with existing buildings ordinance
- Research/demonstration/pilot
- Reduce liability
- Other

Out of 32 projects where owners’ reasons for implementing EBCx were reported, 100% noted that energy savings was a reason …

… whereas only 3% noted that reducing liability was a reason.
Reasons for Implementing EBCx: 2009 vs. 2018

Top 4 reasons for implementing EBCx were the same in 2009 and 2018:

- Obtain energy savings
- Ensure system performance
- Ensure or improve thermal comfort
- Ensure adequate indoor air quality

Other reasons include:
- Qualify for rebate, financing, or other services
- Train/increase awareness of operators or occupants
- Participation in utility program
- Comply with LEED or other rating system
- Comply with organizational mandate/policy
- Extended equipment life
- Increase occupant productivity
- Comply with existing buildings ordinance
- Research/demonstration/pilot
- Reduce liability
- Other

Fraction of reporting projects with reason (EBCx), 2009 vs. 2018
Some notable differences between 2009 and 2018

- Comply with LEED or other rating system
- Comply with organizational mandate/policy
- Extended equipment life
- Increase occupant productivity
- Comply with existing buildings ordinance
- Research/demonstration/pilot
- Reduce liability
- Other

Reasons for Implementing EBCx: 2009 vs. 2018
Reasons for implementing NCCx

In contrast to EBCx, saving energy is not as commonly cited as a reason for performing NCCx.
Reasons for implementing NCCx

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

- Ensure system performance
- LEED or other rating system
- Smoother process and turnover
- Ensure or improve thermal comfort
- Training and awareness (operators/occupants)
- Comply with organizational mandate/policy
- Ensure adequate indoor air quality
- Extended equipment life
- Obtain energy savings
- Increase occupant productivity
- Reduce liability
- Qualify for rebate, financing, or other services
- Participation in utility program
- Research/demonstration/pilot
- Existing buildings ordinance
- Other

Many notable differences between 2009 and 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

<table>
<thead>
<tr>
<th>Activities</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop design intent documents</td>
<td>80%</td>
</tr>
<tr>
<td>Write specifications</td>
<td>70%</td>
</tr>
<tr>
<td>Develop commissioning plan</td>
<td>60%</td>
</tr>
<tr>
<td>Design review</td>
<td>50%</td>
</tr>
<tr>
<td>Develop sequences of operation</td>
<td>40%</td>
</tr>
<tr>
<td>Review submittals</td>
<td>30%</td>
</tr>
<tr>
<td>Construction observation</td>
<td>20%</td>
</tr>
<tr>
<td>Verification checks/prefunctional testing</td>
<td>10%</td>
</tr>
<tr>
<td>Functional testing; use of diagnostic tools</td>
<td>0%</td>
</tr>
<tr>
<td>Significantly involved in issue resolution</td>
<td>0%</td>
</tr>
<tr>
<td>Oversee training</td>
<td>0%</td>
</tr>
<tr>
<td>Review O&amp;M manuals</td>
<td>0%</td>
</tr>
<tr>
<td>Systems manual/recommissioning manual</td>
<td>0%</td>
</tr>
<tr>
<td>Trend analysis, modeling, or benchmarking</td>
<td>0%</td>
</tr>
<tr>
<td>Evaluate energy cost savings</td>
<td>0%</td>
</tr>
<tr>
<td>Final report</td>
<td>0%</td>
</tr>
<tr>
<td>Ongoing Cx / services after occupancy</td>
<td>0%</td>
</tr>
</tbody>
</table>

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

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<tr>
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</tr>
</tbody>
</table>

- NCCx: New Construction Commissioning x
- Scope of Work
NCCx Scope of Work

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

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<th>Activity</th>
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<tr>
<td>Develop design intent documents</td>
<td>&gt; 80%</td>
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<tr>
<td>Write specifications</td>
<td>&gt; 80%</td>
</tr>
<tr>
<td>Develop commission plan</td>
<td>&gt; 80%</td>
</tr>
<tr>
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<tr>
<td>Trend analysis, modeling, or benchmarking</td>
<td>&gt; 80%</td>
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<tr>
<td>Evaluate energy cost savings</td>
<td>&lt; 20%</td>
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<tr>
<td>Final report</td>
<td>&gt; 80%</td>
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<tr>
<td>Ongoing Cx / services after occupancy</td>
<td>&gt; 80%</td>
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</table>
Activities included in New Construction Commissioning Scope (n=62)

- Develop design intent documents
- Write specifications
- Develop commissioning plan
- Design review
- Develop sequences of operation
- Review submittals
- Construction observation
- Verification checks/prefunctional testing
- Functional testing; use of diagnostic tools
- Significantly involved in issue resolution
- Oversee training
- Review O&M manuals
- Systems manual/recommissioning manual
- Trend analysis, modeling, or benchmarking
- Evaluate energy cost savings
- Final report
- Ongoing Cx / services after occupancy

NCCx scope rarely calls for energy savings: A key reason why it is challenging to obtain data on NCCx energy savings
### Non-Energy Benefits of NCCx

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

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<tr>
<th>CATEGORY</th>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
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<tr>
<td><strong>FIRST COST SAVINGS</strong></td>
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<td>On schedule, problems detected/corrected earlier</td>
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<td>Occupied on schedule</td>
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<td>System design improved, right-size equipment</td>
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<td>Improve team coordination</td>
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<td>Occupied sooner, reduced call-backs / TAB costs</td>
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<td>Fewer change orders; warranty claims</td>
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<td>Other or unspecified first-cost</td>
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<td><strong>ONGOING (RECURRING) IMPROVEMENTS</strong></td>
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<td>Thermal Comfort</td>
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<td>Maintenance</td>
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<td>Improved O&amp;M</td>
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<td>Training; education</td>
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<td>Equipment Life</td>
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<td>Tenant retention; turnover</td>
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<td>Productivity/Safety</td>
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<td>Other (or combination of above)</td>
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10 high-value non-energy benefits reported on over two thirds of projects, impacting construction project first costs and ongoing benefits.
EBCx Measures Implemented

• A total of 3,695 installed EBCx measures were reported, across 503 projects: 7.3 measures per projects
• Top 5 measure types account for 95% of the reported measures
• Detailed data on measures not available for NCCx

Utility Program EBCx Measure Types (n = 3,695 measures, 503 projects)
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

5. EBCx Measures
   a. Top 5 measure types (out of 9) account for 95% of all EBCx measures
   b. Top measures focused on control improvements not mechanical repairs
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
Key Contacts

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Jessica Granderson, jgranderson@lbl.gov