Today's talk

- About the Center for the Built Environment (CBE)
- Tour of the Occupant Indoor Environmental Quality (IEQ) Satisfaction Survey
- Recent analysis and findings
  - Acoustics
  - Thermal comfort and air quality
  - LEED IEQ
- Case studies
- Examples of POE studies using the survey
- Update on LEED and surveys
- Wrap-up & discussion
Center for the Built Environment (CBE)

Our Mission: To improve the design, operation, and environmental quality of buildings by providing timely, unbiased information on building technologies and design techniques

CBE Industry Partners

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California Energy Commission
Charles M. Salter Associates
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Flack + Kurtz
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Pacific Gas & Electric Co.
Price Industries
RTKL
Skidmore Owings and Merrill
Stantec
Steelcase

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  • CTG Energetics
  • Guttmann & Blaevot
  • Southland Industries
  • Swinerton Builders
Trane
U.S. Department of Energy (DOE)*
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CBE research programs

- Indoor Environmental Quality
- Envelope and Facade Systems
- HVAC Systems
- Controls and Information Technology

CBE feedback loop

- Finding ways to “take the pulse” of buildings in operation
- Helping industry to make better buildings
Post occupancy evaluation (POE) process

- POEs rarely done by design teams
- POEs may include:
  - Surveys of building occupants
  - Observations and/or interviews with building users
  - Performance in terms of energy and/or water consumption
  - Physical measurements (temperature, humidity, acoustical, lighting, daylighting)
- When to do a POE
  - Part of commissioning plan – 6 months
  - Post commissioning – at least 12 months
### Occupant IEQ survey

- Standardized methodology for studying building performance from occupants’ point of view
- Provide feedback to building designers, owners, and operators
- Helps us understand how buildings perform in practice
- Web format is inexpensive, fast, allows for branching questionos, automatic reporting, data mining
- Results can be used for:
  - Diagnostics
  - Benchmarking

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### Survey history

- ASHRAE Thermal Comfort Studies
- Johnson Controls
  - Tablet-based survey
  - LAN-based survey
- First Web-based Survey
  - Research projects evaluating effectiveness of various building attributes
- U.S. General Services Administration
  - Developed current core survey, and special-purpose modules
Usability testing

- UCB Survey Research Center
  - Focus groups
  - Cognitive interviewing
- Assessed
  - Comprehension of survey wording
  - Scale size and aesthetics
  - Survey length
- Core survey now highly standardized for accurate benchmarking

Survey implementation

Survey notification via email

Occupants respond to web-based survey

Data sent to SQL server database

Results reported online
LEED Post-Occupancy Evaluation: Taking Responsibility for the Occupants

Survey welcome page

Objective information
Typical survey page

Drill-down questions

Satisfaction Scale

Next survey topic

Branched to a follow-up page with probing questions regarding nature of dissatisfaction
LEED Post-Occupancy Evaluation:
Taking Responsibility for the Occupants

November 1-2, 2006

Typical follow-up page

Core survey

Background
Location
Office Layout
Office Furnishings
Thermal Comfort
Air Quality
Lighting
Acoustics
Clean/Maint
General Comments
LEED Post-Occupancy Evaluation: Taking Responsibility for the Occupants

Custom modules

- Background
- Location
- Office Layout
- Office Furnishings
- Thermal Comfort
- Air Quality
- Lighting
- Acoustics
- Clean/Maint.
- Wayfinding
- Commute
- Restrooms
- Safety/Security
- etc…
- General Comments

Custom modules

- Accessibility
- Building and Grounds
- Maintenance Service
- Commute
- Conference and Training Rooms
- Court Work
- Daylighting
- Laboratories
- Office Support Equipment
- Operable Windows
- Raised Floor and Floor Diffusers
- Restrooms
- Safety and Security
- Wayfinding
Automated reporting

Diagnostic problems
Survey database growth

To date: 290+ buildings, nearly 39,000+ respondents

Collecting building characteristics

Excerpt from building profile form
Survey data mining tool

IEQ satisfaction trends

Average Scores by Category

- General Satisfaction-Building: 0.98
- General Satisfaction-Workspace: 0.90
- Office Layout: 0.95
- Office Furnishings: 0.91
- Thermal Comfort: 0.06
- Air Quality: 0.34
- Lighting: 0.11
- Acoustic Quality: 0.10
- Cleanliness and Maintenance: 0.97

N=37525

Source: CBE survey database as of April 15, 2006
Acoustics analysis

- Studied satisfaction with acoustics in office environments
- Acoustical satisfaction lowest category
- Analyzed data from
  - 142 buildings
  - 23,450 occupants

Sound privacy vs. noise level

<table>
<thead>
<tr>
<th>Survey Category</th>
<th>Mean Satisfaction Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ofc Layout</td>
<td>0.2</td>
</tr>
<tr>
<td>Ofc Furn</td>
<td>0.8</td>
</tr>
<tr>
<td>Therm</td>
<td>1.0</td>
</tr>
<tr>
<td>Air Q</td>
<td>1.2</td>
</tr>
<tr>
<td>Light</td>
<td>1.4</td>
</tr>
<tr>
<td>Acoust</td>
<td>1.6</td>
</tr>
<tr>
<td>Clean</td>
<td>1.8</td>
</tr>
<tr>
<td>Gen Wspce</td>
<td>2.0</td>
</tr>
<tr>
<td>Gen Bldg</td>
<td>2.2</td>
</tr>
<tr>
<td>CBE Bldgs (N=4096)</td>
<td>2.4</td>
</tr>
</tbody>
</table>

_Largest 15 CBE Bldgs (N=4096)_

_Noise Level_

_Sound Privacy_
LEED Post-Occupancy Evaluation:
Taking Responsibility for the Occupants

Acoustic average satisfaction score

- Average satisfaction score for acoustic quality impact on productivity:
  - Private office: 0.54
  - Shared office: -0.54
  - High partition cubicle: 0.59
  - Low partition cubicle: -1.87
  - Open Office: -0.84

Acoustic quality impact on productivity

Overall, does the acoustic quality in your workspace enhance or interfere with your ability to get your job done?

- Enhances
- Neutral
- Interferes

- Private office:
  - Enhance: 30%
  - Neutral: 70%
  - Interferes: 0%

- Shared office:
  - Enhance: 40%
  - Neutral: 60%
  - Interferes: 0%

- High partition cubicle:
  - Enhance: 50%
  - Neutral: 50%
  - Interferes: 0%

- Low partition cubicle:
  - Enhance: 40%
  - Neutral: 60%
  - Interferes: 0%

- Open office:
  - Enhance: 40%
  - Neutral: 60%
  - Interferes: 0%
Top sources of dissatisfaction

Of those expressing dissatisfaction with acoustics...

<table>
<thead>
<tr>
<th>Rank</th>
<th>Source of dissatisfaction</th>
<th>Private office</th>
<th>Shared office</th>
<th>Cubicles with high partitions</th>
<th>Cubicles with low partitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>People talking on the phone</td>
<td>21%</td>
<td>50%</td>
<td>70%</td>
<td>83%</td>
</tr>
<tr>
<td>2</td>
<td>People overhearing private conversations</td>
<td>25%</td>
<td>40%</td>
<td>65%</td>
<td>71%</td>
</tr>
<tr>
<td>3</td>
<td>People talking in surrounding offices</td>
<td>15%</td>
<td>21%</td>
<td>45%</td>
<td>54%</td>
</tr>
<tr>
<td>4</td>
<td>People talking in the corridor</td>
<td>6%</td>
<td>12%</td>
<td>25%</td>
<td>27%</td>
</tr>
<tr>
<td>5</td>
<td>Telephones ringing</td>
<td>2.5%</td>
<td>8%</td>
<td>23%</td>
<td>31%</td>
</tr>
<tr>
<td>6</td>
<td>Office equipment</td>
<td>4%</td>
<td>5%</td>
<td>13%</td>
<td>14%</td>
</tr>
</tbody>
</table>

Key findings

- Over 50% of occupants in cubicles think acoustics interfere with their ability to get their job done
- Acoustic satisfaction will not be improved much by making cubicles higher
- Occupants in open office more satisfied with acoustics than occupants in cubicles
- Of the 9 core survey categories, acoustics causes the greatest dissatisfaction
Potential solutions

- Acoustical consideration during design, using consultants or “Speech Privacy Predictor” (SPP)
- Focus on improving conditions for cube-dwellers
  - Sound masking, improved sound absorption
  - Lower telephone ringing volume, visual ring
  - Provide varied workspace options

Thermal comfort and air quality analysis

- Studied satisfaction with thermal comfort, air quality, compared to existing standards
- Analyzed data from
  - 215 buildings
  - 34,169 occupants
Thermal comfort & air quality standards

- Standards define acceptable indoor environment:
  “Conditions in which more than 80% of people do not express dissatisfaction”
  - ASHRAE Standard 55-2004 (Thermal comfort)
  - ASHRAE Standard 62.1-2004 (Air quality)
- And others even more restrictive! (90% threshold)

Thermal satisfaction: 2nd lowest category

“How satisfied are you with the temperature in your workspace?”

Overall: 42% of respondents dissatisfied
Distribution of thermal satisfaction

11% of buildings meet acceptability standard

Percent satisfied: Top 4 points (≥0) on 7-point satisfaction scale

Sources of thermal discomfort

Source of dissatisfaction with temperature in CBE survey database (one-person/one-vote) (total number of complaints = 32,806)

- My area is hotter/colder than other area: 14%
- Thermostat is inaccessible: 11%
- Thermostat is adjusted by other people: 13%
- Air movement too low: 9%
- Heating/cooling system does not respond: 7%
- Drafts from vents: 6%
- Air movement too high: 5%
- Incoming sun: 5%
- Other: 5%
- Humidity too high (damp): 4%
- Hot/cold surrounding surfaces (floor, ceiling): 3%
- Humidity too low (dry): 3%
- Drafts from windows: 3%
- Heat from office equipment: 3%
- Air coming out of vents too hot/cold: 3%
- Clothing policy is not flexible: 2%
- Other: 1%
- Heating/cooling capacity is insufficient: 1%
LEED Post-Occupancy Evaluation:  
Taking Responsibility for the Occupants

November 1-2, 2006

Thermal controls & satisfaction

- Personal control over environmental conditions has a positive impact on occupant satisfaction

- Personal devices that compensate for building conditions can indicate dissatisfaction

<table>
<thead>
<tr>
<th>% satisfied*</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>All occupants</td>
<td>58%</td>
</tr>
<tr>
<td>No thermostat</td>
<td>56%</td>
</tr>
<tr>
<td>Thermostat</td>
<td>76%</td>
</tr>
<tr>
<td><strong>Difference</strong></td>
<td><strong>20%</strong></td>
</tr>
<tr>
<td>No operable window</td>
<td>57%</td>
</tr>
<tr>
<td>Operable window</td>
<td>67%</td>
</tr>
<tr>
<td><strong>Difference</strong></td>
<td><strong>10%</strong></td>
</tr>
<tr>
<td>No portable heater</td>
<td>59%</td>
</tr>
<tr>
<td>Portable heater</td>
<td>44%</td>
</tr>
<tr>
<td><strong>Difference</strong></td>
<td><strong>-15%</strong></td>
</tr>
<tr>
<td>No portable fan</td>
<td>60%</td>
</tr>
<tr>
<td>Portable fan</td>
<td>51%</td>
</tr>
<tr>
<td><strong>Difference</strong></td>
<td><strong>-9%</strong></td>
</tr>
</tbody>
</table>

* (> =0 on the –3 to +3 satisfaction scale)  (p<0.01)

Air quality satisfaction: 3rd lowest category

“How satisfied are you with the air quality in your workspace (i.e. stuffy/stale air, cleanliness, odors)?”

Overall: 32% of respondents dissatisfied

Among those who were dissatisfied with their air quality, major complaints were (in order):

- Air is stuffy/stale 74%
- Air is not clean 67%
- Air is smelling bad 51%
LEED Post-Occupancy Evaluation: Taking Responsibility for the Occupants

Distribution of air quality satisfaction

- 26% of buildings meet acceptability standard

LEED IEQ analysis

- Compared occupant satisfaction in 21 green or LEED-certified buildings with 160 non-green buildings
- Analyzed data from
  - 181 buildings
  - 33,285 occupants
What is “Green” Design?

Design and construction practices that significantly reduce or eliminate the negative impact of buildings on the environment and occupants in five broad areas:

- Sustainable site planning
- Safeguarding water and water efficiency
- Energy efficiency and renewable energy
- Conservation of materials and resources
- Indoor environmental quality

Source: Introduction to USGBC and LEED Green Rating System, 3/18/2004

Research opportunity: LEED IEQ analysis

- Do LEED-rated / green buildings in fact have better indoor environmental quality?
LEED-rated / green buildings in database

15 LEED-rated and 6 self-nominated buildings
160 other buildings in CBE database

<table>
<thead>
<tr>
<th>Type</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>NC 2 platinum</td>
<td>1</td>
</tr>
<tr>
<td>NC 2 gold</td>
<td>2</td>
</tr>
<tr>
<td>NC 2 silver</td>
<td>3</td>
</tr>
<tr>
<td>NC 2.1</td>
<td>2</td>
</tr>
<tr>
<td>NC 2 certified</td>
<td>1</td>
</tr>
<tr>
<td>NC 1 platinum</td>
<td>2</td>
</tr>
<tr>
<td>EB pilot</td>
<td>1</td>
</tr>
<tr>
<td>CI pilot</td>
<td>3</td>
</tr>
</tbody>
</table>

NC=New Construction; EB=Existing Buildings; CI=Commercial Interiors

Self-nominated green buildings

- 6 buildings identified by building design team or owner:
  - 2 received national AIA Top 10 Green Building Awards
  - 2 received *Environmental Design & Construction* awards
  - 1 received Savings by Design award
  - 1 received local awards

Carnegie Center for Global Ecology
National Wildlife Federation
World Resources Institute
### Categories in LEED – NC 2.1 & EB 2.0

<table>
<thead>
<tr>
<th>Category</th>
<th>LEED - NC</th>
<th>LEED - EB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainable Sites</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Water Efficiency</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Energy &amp; Atmosphere</td>
<td>17</td>
<td>23</td>
</tr>
<tr>
<td>Materials &amp; Resources</td>
<td>13</td>
<td>16</td>
</tr>
<tr>
<td>Indoor Environmental Quality</td>
<td>15</td>
<td>22</td>
</tr>
<tr>
<td>Innovation &amp; Design Process</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>69</strong></td>
<td><strong>85</strong></td>
</tr>
<tr>
<td><strong>% of IEQ credit points</strong></td>
<td><strong>22%</strong></td>
<td><strong>26%</strong></td>
</tr>
</tbody>
</table>

### Mapping survey categories to LEED

<table>
<thead>
<tr>
<th>Survey Satisfaction categories</th>
<th>LEED IEQ credit categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office Layout</td>
<td>Dental comfort</td>
</tr>
<tr>
<td>Office Furnishing</td>
<td>Air Quality</td>
</tr>
<tr>
<td>Thermal Comfort</td>
<td>Daylight &amp; views</td>
</tr>
<tr>
<td>Air Quality</td>
<td>Controllability of systems</td>
</tr>
<tr>
<td>Lighting</td>
<td></td>
</tr>
<tr>
<td>Acoustics</td>
<td></td>
</tr>
<tr>
<td>Cleaning &amp; Maint.</td>
<td></td>
</tr>
<tr>
<td>Gen. Bldg &amp; Workspace</td>
<td></td>
</tr>
</tbody>
</table>
IEQ in LEED-rated/green buildings paper

### Average Scores by Category

- **General Satisfaction: Building**: 0.94
- **General Satisfaction: Workspace**: 0.84
- **Office Layout**: 0.86
- **Office Furnishings**: 0.84
- **Thermal Comfort**: -0.16
- **Air Quality**: 0.22
- **Lighting**: 1.12
- **Acoustics**: -0.19
- **Cleanliness and Maintenance**: 0.92

Source: CBE survey database as of September 27, 2005

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### Percentile charts overview

- **Median**: 1.07
- **161 buildings**
- **Un-weighted average**: 1 bldg. = 1 vote
- **Approx. 28,000 occupant responses**
- **Average response rate 49%**

Median entire database

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Center for the Built Environment (CBE)
Building overall: satisfaction

Overall Satisfaction - Building
LEED-rated/green (n=21) Compared to CBE Database (n=160)

Mean Satisfaction Score
Percentile Rank

-3 0 3
0% 25% 50% 75% 100%

Median of rest of database
Median of LEED-rated/green buildings

Database building LEED-rated building Green building

Thermal Comfort: satisfaction

Overall Satisfaction - Thermal Comfort
LEED-rated/green (n=21) Compared to CBE Database (n=160)

Mean Satisfaction Score
Percentile Rank

-3 0 3
0% 25% 50% 75% 100%

Median of rest of database
Median of LEED-rated/green

Database building LEED-rated building Green building
Air Quality: satisfaction

Overall Satisfaction - Air Quality
LEED-rated/green (n=21) Compared to CBE Database (n=160)

<table>
<thead>
<tr>
<th>Percentile Rank</th>
<th>Database building</th>
<th>LEED-rated building</th>
<th>Green building</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>1.14</td>
<td>0.21</td>
<td>-3</td>
</tr>
<tr>
<td>25%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Lighting: satisfaction

Overall Satisfaction - Lighting
LEED-rated/green (n=21) Compared to CBE Database (n=160)

<table>
<thead>
<tr>
<th>Percentile Rank</th>
<th>Database building</th>
<th>LEED-rated building</th>
<th>Green building</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>1.12</td>
<td>1.08</td>
<td>-3</td>
</tr>
<tr>
<td>25%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Lighting complaints**

Average lighting complaints in LEED-rated/green buildings (n=21) and the rest of CBE database (n=160)

- **Not enough daylight**
- **Reflections in the computer screen**
- **Too dark**
- **Too bright**
- **No task lighting**
- **Too much electric lighting**
- **Electric lighting is an undesirable color**
- **Shadows on the workspace**
- **Electric lighting flickers**
- **Other**
- **Too much daylight**
- **No control over sunlight/daylight**

[Bar chart showing lighting complaints]

**Lighting dissatisfaction comments**

**Building A**
- “task lights don’t work”
- “…the only light is above the light shelf, I had to bring in my own lamp.”

**Building B**
- “Too bright in some places, too dark in others, and not enough task lighting…”
- “The light sensors need to be adjusted… to come on sooner.”
- “Task light mounted on wrong side of workstation.”

**Building C**
- “The lighting in my cube was woefully inadequate from day one. The task lighting does not shine where I do my reading and writing. Another light…lights the space behind my computer monitor and over my telephone…”
Lighting controls

Average lighting controls in LEED-rated/green buildings (n=21) and the rest of CBE database (n=160)

- Desk (task) light
- Light switch
- Window blinds or shades
- None of the above
- Other
- Light dimmer

<table>
<thead>
<tr>
<th>Lighting control</th>
<th>Database building</th>
<th>LEED-rated/green building</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% Light dimmer</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>20% Light switch</td>
<td>10%</td>
<td>20%</td>
</tr>
<tr>
<td>40% Window blinds or shades</td>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td>60% None of the above</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>80% Desk (task) light</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>100% Other</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Sustainable design strategies – Lighting

- Common strategies include
  - Provide lower levels of ambient electric lighting
  - Rely more on daylight to conserve energy and enhance IEQ
- Can result in
  - Thermal discomfort
  - Glare/reflections
  - Workspace too dark/bright
- Lessons learned
  - Provide effective controls to occupants such as task lighting, blinds and shades
  - Commission automated systems such as occupancy/daylight sensors and shading systems
LEED Post-Occupancy Evaluation: Taking Responsibility for the Occupants

Acoustics: satisfaction

Overall Satisfaction - Acoustics
LEED-rated/green (n=21) Compared to CBE Database (n=160)

Median of rest of database
Median of LEED-rated/green buildings

Mean Satisfaction Score
Percentile Rank

-0.20
-0.27

0% 25% 50% 75% 100%
Percentile Rank

Database building LEED-rated building Green building

Acoustic complaints

Average acoustic complaints in LEED-rated/green buildings (n=21) and the rest of CBE database (n=160)

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

Database building LEED-rated/green building

- People talking in neighboring areas
- People overhearing my private conversations
- People talking on the phone
- Telephones ringing
- Office equipment noise
- Mechanical (heating, cooling and ventilation systems) noise
- Outdoor traffic noise
- Office lighting noise
- Other:
  - People in corridor
  - Excessive echoing of voices or other sounds

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

Database building LEED-rated/green building

- Office equipment noise
- People overhearing my private conversations
- Excessive echoing of voices or other sounds
- Office lighting noise
Office type

Average distribution of office types in LEED-rated/green buildings (n=21) and the rest of CBE database (n=160)

- Cubicles with low partitions (lower than 5 feet high)
- Cubicles with high partitions (about 5 or more feet high)
- Enclosed office, private
- Workspace in open office with no partitions (just desks)
- Enclosed office, shared with other people
- Cubicles with partitions of different heights

Acoustics dissatisfaction comments

**Building A** (96% open office, n=703)
- “Desks too close…everyone can hear everything. Even a tiny sneeze.”
- “You can hear noises emanating 20 to 25 feet away. There is no sound deadening effect from the cubicle walls and the floor always sounds like a herd of elephants is doing a ballet.”

**Building B** (97% open office, n=173)
- “…obnoxious neighbors who think they are the only ones on the block.”
- “No one can ever hear my radio even though I think it’s turned up loud.”
- “…I’m a loud talker and I’m sure I disturb other people…”
Conclusions: LEED IEQ analysis

- LEED-rated / green buildings had significantly higher satisfaction scores in:
  - building overall
  - indoor air quality
  - thermal comfort
- LEED-rated / green buildings did not have higher scores in:
  - lighting
  - acoustics
- No clear relationship found between LEED credit points and occupant satisfaction with IEQ
- LEED rating by itself does not guarantee better IEQ

Case studies

![Graph showing overall satisfaction - building LEED & GREEN (n=20) compared to CBE Database (n=161). The graph includes case studies such as Carnegie Center, Chesapeake Bay Foundation, Johnson Diversey, and Non-green bldg. The graph compares mean satisfaction scores with percentile rank.](image)
Case study: Chesapeake Bay Foundation

- First LEED-certified Platinum (version 1.0), completed in 2001
- 5 of 7 possible IEQ points (36 of 52 total possible points)
- Numerous sustainable features
- DOE-sponsored field study conducted by Judith Heerwagen, used extended version of occupant survey, interviews and observations


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### Average Scores by Category

<table>
<thead>
<tr>
<th>Category</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Satisfaction: Building</td>
<td>2.36</td>
</tr>
<tr>
<td>General Satisfaction: Workspace</td>
<td>1.97</td>
</tr>
<tr>
<td>Office Layout</td>
<td>1.39</td>
</tr>
<tr>
<td>Office Furnishings</td>
<td>2.22</td>
</tr>
<tr>
<td>Thermal Comfort</td>
<td>0.6</td>
</tr>
<tr>
<td>Air Quality</td>
<td>2.09</td>
</tr>
<tr>
<td>Lighting</td>
<td>1.76</td>
</tr>
<tr>
<td>Acoustic Quality</td>
<td>0.06</td>
</tr>
<tr>
<td>Cleanliness and Maintenance</td>
<td>1.5</td>
</tr>
</tbody>
</table>

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Center for the Built Environment (CBE)
Case study: Carnegie Center for Global Ecology

- Stanford campus, Palo Alto, CA
- Clients understood green building priorities, did not rely on LEED
- Selected design team with extensive green building experience
- Designed to beat California energy code by 57%
- IEQ features include daylighting, radiant heating and cooling, natural ventilation with operable windows

Case study: Carnegie Center for Global Ecology

- High marks overall
- Acoustical score puts building in top quartile
- 83% in open office, no partitions
Case study: JohnsonDiversey

- Survey client: JohnsonDiversey
- 2 buildings surveyed
  - One LEED-EB certified
  - The other not LEED certified
- Core survey plus washrooms and security modules

JohnsonDiversey Headquarters – LEED-EB pilot (gold)

JohnsonDiversey survey results

Certified building performed significantly better than the non-certified building in nearly every category

![Average Scores by Category](chart.png)

- Non LEED certified building
- LEED certified building
JohnsonDiversey survey results, cont’d

Operational applications resulting from the study

- Certified building
  - Continue IAQ and other management programs
- Non-certified building
  - Instituted new cleaning and lighting programs to align with LEED standard
  - Plans improvements to HVAC, lighting and acoustics
- Both buildings
  - Numerous "low hanging fruit" fixes
  - Comments a rich source of information

POE Applications: HOK

- HOK Process
  1. CBE occupant satisfaction survey
  2. Energy evaluation
  3. Interviews
- Customized survey questions
  - Solar control
  - Automated lighting controls
  - Occupancy sensors
  - Building recycling program
- 9 buildings included
POE Applications: HOK

- Summary of POEs identified:
  - Workplace
  - Conservation of resources
  - Placemaking & values
  - What’s working
  - Room for improvement

*Summary of POEs identified:*
- Workplace
- Conservation of resources
- Placemaking & values
- What’s working
- Room for improvement

*What’s working:*
- Conservation of resources
- Placemaking & values
- What’s working
- Room for improvement

*Room for improvement:*
- Workplace
- Conservation of resources
- Placemaking & values
- What’s working
- Room for improvement

*Occupant comments:*
- "There’s not a day that goes by that I take these working conditions for granted..."
- "I feel like a rat in a cage,... Otherwise everything’s fine. Thank you for asking my opinion."

*Source: Sandra Mendler, AIA, HOK*

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- What’s working
- Room for improvement

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*Source: Sandra Mendler, AIA, HOK*
HOK POE outcomes

- Disseminated findings in guidebook
- Presentations to AIA membership, *Green building confessions*
- Motivate industry to conduct POEs
  - Assist design of future projects
  - Fosters closer relationship with clients
  - Raise awareness of need to focus on issues like daylighting
  - Study anticipated vs. actual energy use
  - Show importance of building commissioning

Southwestern B.C. study

- Detailed studies of five green buildings in SW British Columbia
- Led by Greater Vancouver Regional District, Green Buildings BC, and Stantec (Keen)
- Completed Nov. 2004
- Project led to the development of building performance evaluation (BPE) protocol now in development with Stantec and the EcoSmart Foundation
LEED Post-Occupancy Evaluation:
Taking Responsibility for the Occupants

Southwestern B.C. study

LEED – NC 2.2 updates thermal comfort credits

Previous version LEED – NC 2.1
- Credit 7.1 (Comply w/ ASHRAE 55-1992)
- Credit 7.2 (Permanent monitoring system)

New version LEED – NC 2.2 (November 2005)
- Credit 7.1 (Comply w/ ASHRAE 55-2004)
- Credit 7.2 (Verification)
IEQ Credit 7.2 Thermal Comfort: Verification

“Agree to implement a thermal comfort survey of building occupants within a period of six to 18 months after occupancy.

This survey should collect anonymous responses about thermal comfort in the building including an assessment of overall satisfaction with thermal performance and identification of thermal comfort-related problems.

Agree to develop a plan for corrective action if the survey results indicate that more than 20% of occupants are dissatisfied…”

Additional resources

- CBE Publications Page: http://www.cbe.berkeley.edu/research/publications.htm
- Environmental Building News, Volume 12, Number 9, September 2003
  (available free from BuildingGreen.com)
Questions/discussion

David Lehrer
lehrer@berkeley.edu

Survey demo
http://www.cbesurvey.org

Center for the Built Environment
http://www.cbe.berkeley.edu

Survey researcher wanted!
http://www.cbe.berkeley.edu/jobs