

# UC Berkeley

## Indoor Environmental Quality (IEQ)

### **Title**

Learning from experience

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Ask anyone who designs, owns, or manages an office building if they want the occupants of their building to feel comfortable, healthy, and productive, and the answer would of course be 'yes'.

But ask again if they know what the occupants actually feel about the space, and the answer will be quite different.

# LEARNING FROM EXPERIENCE

By Gail Brager

Sadly, very few architects or other members of the design team are likely to know how well their building is working after it is completed and occupied. . .

The facility manager is most likely to have a sense, but often it's only anecdotal. The building owner might eventually have an inkling about occupant sentiment if they see a financial effect because an environment is inadequate. Yet, sadly, very few architects or other members of the design team are likely to know how well their building is working after it is completed and occupied, the fees have been paid, and they are on to another project. Without learning from experience in an objective way, building industry professionals are less likely to make design or economic decisions that will truly enhance the performance and experiential quality of their buildings.

And while this information would be valuable for *any* project, it is particularly essential if one is claiming to have designed or built a green building,

where the quality of the indoor environment is a critical dimension of sustainable design. The only way to back up those claims is to evaluate a building's actual performance, in terms of energy consumption or indoor environmental quality, and compare the performance to design intent.

Without question, it is absolutely crucial to reduce energy consumption in buildings and help avoid the potentially devastating impacts of climate change. But in terms of the building owner's pocketbook, energy costs are still relatively small compared to worker salaries, which represent over 90% of the total operating costs of a commercial building. In addition, the cost of worker recruitment and retention is significant. Thus, from the building or company owner's point of view, perhaps the most persuasive argument for

sustainable design is one that makes the connection between a higher quality indoor environment, and increased comfort, health and productivity of the workers.

So, how does one learn about the quality of the indoor environment? While there are many physical measurements one can take, they need to be interpreted in terms of the impact on occupants. Occupants themselves are a rich yet underutilized source of direct information about how well a building is working, but the challenge is how to collect both the positive and negative feedback in a systematic way. This has been at the core of research underway at UC Berkeley.

**CENTER FOR THE BUILT ENVIRONMENT**

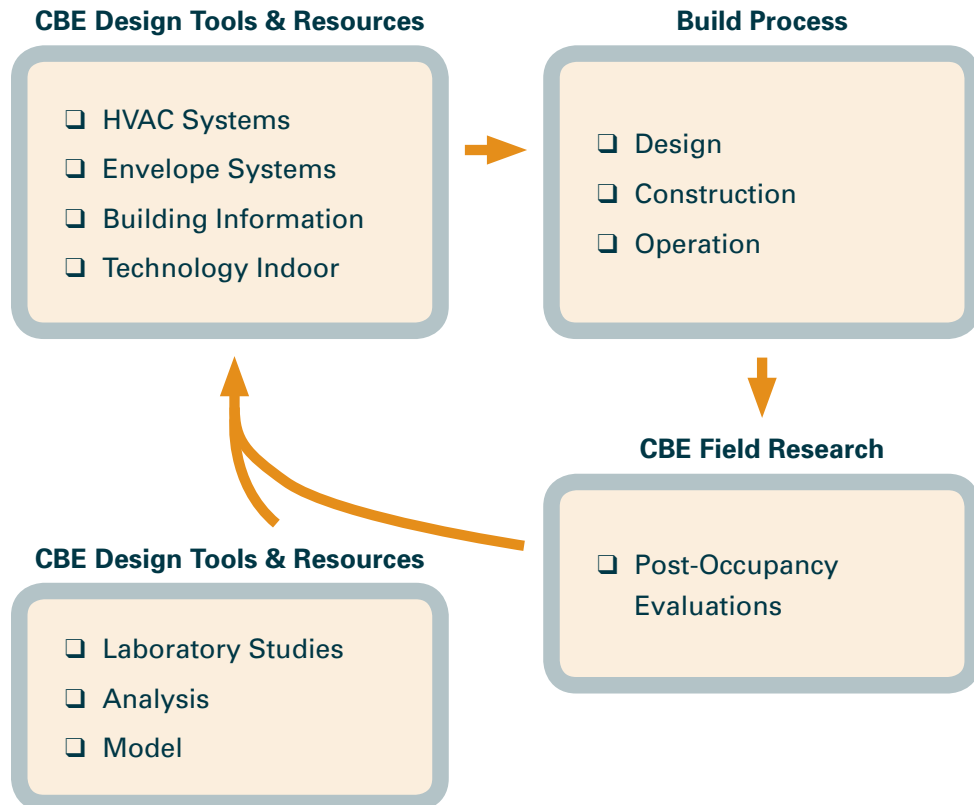
The Center for the Built Environment (CBE) is a collaborative research organization that links faculty, researcher,

and students with a consortium of firms and organizations that share a commitment to improving the performance of commercial buildings. The Center has two broad purposes, represented in a wide range of research projects of relevance to the building industry. First, we develop ways to “take the pulse” of occupied buildings, looking at how people use space, what they like and don’t like, and we link those responses back to physical measurements of indoor environmental quality. Secondly, we study technologies that have the potential to make buildings more environmentally friendly, more healthy and productive to work in, and more economical to operate. These range from envelope and HVAC systems, to controls and information technology. Our industry partners represent architects, engineers, contractors, manufacturers, utilities, building owners, and govern-

ment organizations. Our current CBE Industry Partners are *Armstrong World Industries, Arup, CA Dept. of General Services, CA Energy Commission, Charles M. Salter Associates, CTG Energetics, Flack + Kurtz, Guttman & Blaevonet, HOK, PG&E Pacific Energy Center, Price Industries, RTKL Associates, SOM, Southland Industries, Swinerton Buildings, Stantec, Steelcase, Syska Hennessy Group, Tate Access Floors, Taylor Engineering, Trane, US Dept. of Energy, US General Services Administration, Webcor Buildings, and York International*. For more information about CBE, see [www.cbe.berkeley.edu](http://www.cbe.berkeley.edu).

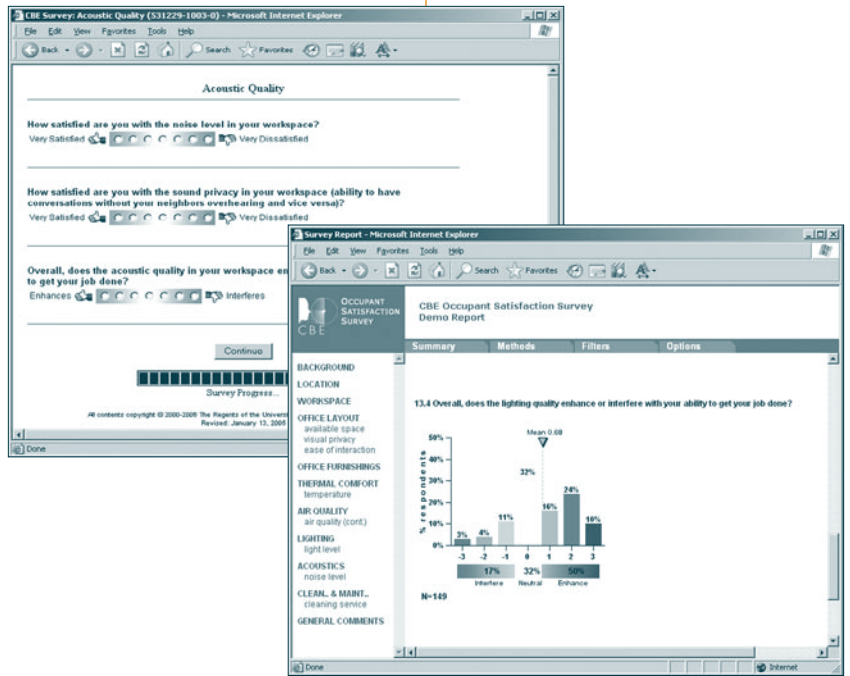
**THE CBE SURVEY**

CBE has developed a web-based indoor environmental quality survey to help designers, building owners and operators, and tenants evaluate how well



their office buildings are working from the occupants' perspective. Advantages of the web-based format are: 1) it is quick and inexpensive to use; 2) it facilitates more focused and detailed feedback (particularly, when the occupant indicates dissatisfaction with a certain area); and 3) survey results can be accessed using an automated, advanced reporting tool that allows users to filter, aggregate, compare, or benchmark their data. The core CBE survey measures occupant satisfaction and self-reported productivity related to nine environmental categories: office layout, office furnishings, thermal comfort, air quality, lighting, acoustics, cleanliness and maintenance, overall satisfaction with the building, and with the workspace. Additional, custom survey modules can be added, which would enable you to gather data about additional topics, depending on available building features or the client's particular issues. Examples of existing modules include accessibility, safety and security, daylighting, and operable windows.

To date, the CBE Survey has been implemented in nearly 300 buildings, with over 41,000 individual responses, making it the largest database of its kind. The survey can be used as a diagnostic tool for individual buildings, to enable designers or building owners to evaluate specific aspects of their building design features and operating strategies, identify problem areas, and help prioritize investments for improvements. Users can do both before and after surveys to evaluate the effectiveness of changes in the design or operational improvements, or before and after a move. The database is also useful for evaluating trends across many buildings. By using a standardized instrument to collect data from a wide variety of office buildings, we are



able to mine the data to look for trends or comparative analysis in the performance of particular design strategies or technologies. By utilizing the full database, clients can also evaluate how their building is doing in comparison to groups of buildings in the same or different categories.

The CBE Survey is being used in a wide variety of contexts, for both pri-

Survey to evaluate tenant satisfaction in up to 100 buildings each summer as part of their facility management assessment program, replacing their previous paper-based survey administered by Gallup. We are also developing and administering new surveys as part of GSA's Workplace 20/20 initiative, which focuses on the interrelationships between people, space, technology,

**To date, the CBE Survey has been implemented in nearly 300 buildings, with over 41,000 individual responses, making it the largest database of its kind.**

vate and institutional clients. In some cases, we are contacted directly by architecture and engineering firms to study their buildings (recent examples include Arup, Chong Partners, EHDD, ELS, Enermodal Engineering, Glumac, HKT, HOK, Keen Engineering, Moseley Architects).

The U.S. General Services Administration (GSA) is using the CBE

knowledge, work process, and organizational effectiveness.

With UC San Francisco, we have developed a new module to evaluate laboratories. We completed several baseline surveys of UCSF facilities, and we will continue to evaluate many of their new lab facilities.

As a one-year promotion, we offered the CBE Survey free for LEED-

certified buildings, to improve our understanding of how green buildings were performing in the field. We have also been contacted independently by architects or building owners who can use the CBE Survey to achieve a LEED-NCv2.2 credit for thermal monitoring.

Internationally, we have collaborated with Indoorium, a Finland-based consulting firm specializing in indoor air quality, lighting, and acoustics, to evaluate 20 buildings and develop multilingual capabilities for the survey.

And here on the UC Berkeley campus, in Cris Benton's Arch 249: Secret Life of Buildings, students surveyed 13 campus buildings and discovered that the deferred maintenance of recent years is keenly felt!

We are currently embarking on new projects to use the CBE Survey to evaluate some of the recent AIA-COTE Top Ten Green Projects, and to survey occupants of the new San Francisco Federal Buildings, both in their current spaces and then after they move later this year.

And finally, we utilize the CBE Survey extensively in our own research projects investigating technologies such as underfloor air distribution, operable windows, demand response technologies, and high performance facades—often combining the survey with detailed indoor physical measurements.

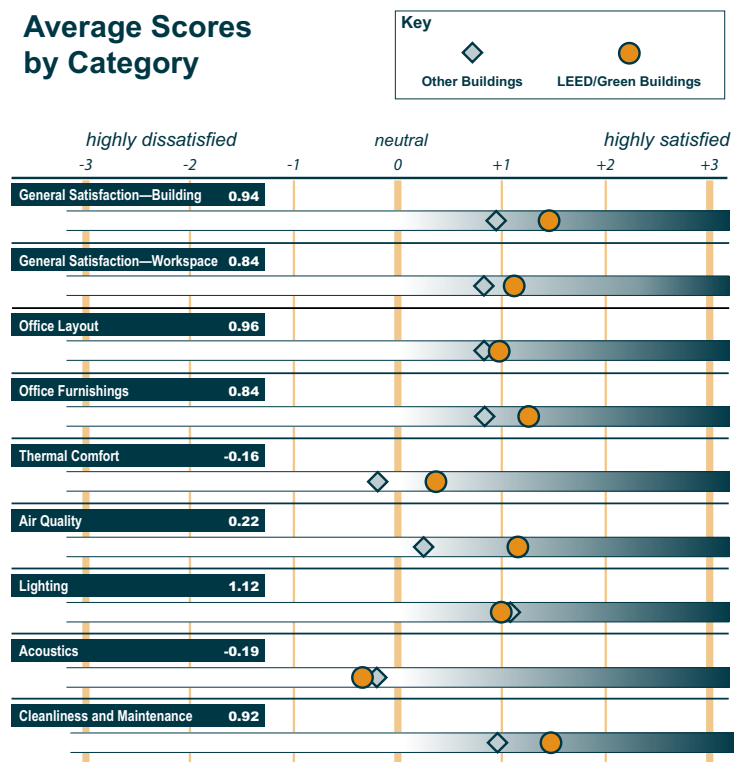
### LESSONS LEARNED

Looking at the entire database, of all the environmental attributes evaluated in the CBE Survey, acoustics consistently receives the lowest ratings, followed by thermal comfort and air quality. The most common sources of dissatisfaction with acoustics relate to sound privacy (people overhearing others' private conversations) and distractions from hearing people's conversations while talking

on the phone or to others in neighboring areas. Much less frequent were complaints about excessively loud sounds, noise from the HVAC system or office equipment, or outdoor noises (even in buildings with operable windows). Not surprisingly, people with private offices are significantly more satisfied with acoustics than those in open plan spaces. However, when we looked at the influence of open plan design, we were surprised to find that the absence of partitions provided higher satisfaction scores than having partitions, yet partition height itself had no discernible effect. This suggests that visual privacy may lead to unrealistic expectations of acoustic privacy. When people have a full view of their co-workers, they are either more courteous at keeping their voices lower, or change their expectations and are therefore not disturbed by the lack of privacy.

ASHRAE publishes standards for both thermal comfort and acceptable air quality in buildings (ASHRAE Standard 55-2004, and 62.1-2004, respectively), both recommending conditions in which 80% of the occupants are satisfied. But when we look at satisfaction scores from our database, we find that buildings are falling far short of these standards. It was disturbing to find that only 11% of the buildings met the intent of the thermal comfort standard, with an overall average of only 59% of the occupants expressing satisfaction with the thermal environment. Thermal dissatisfaction was most commonly related to people feeling that they did not have enough control over their environment, in addition to complaints about air movement being too low. This is particularly interesting given that thermal comfort standards are geared towards limiting air movement, mistakenly

### Average Scores by Category



Average satisfaction scores for green building vs. the overall database, showing that green buildings perform better in thermal comfort and air quality, and Overall satisfaction with the building.



EXAMPLES OF GREEN BUILDINGS THAT PERFORMED WELL IN THE CBE SURVEY.

World Resources Institute  
HOK, Washington, DC.  
Courtesy of HOK

Global Ecology Center  
EHDD, Stanford, CA  
Photo by Paul Sterbentz



Left and right: Chesapeake Bay Foundation,  
Smith Group, Annapolis, MD.  
Center for the Built Environment, UC Berkeley 2007  
Photo by Prakash Patel

believing that drafts are a more common problem.

Responses to air quality were only slightly better, with only 26% of the buildings meeting the intent of the standard, and on average 69% of occupants are satisfied with the air quality. The most common complaints were that the air was stuffy or stale, or smelled badly, with the most frequently identified sources being food, carpet or furniture, or other people.

Not surprisingly, we found that satisfaction with both thermal comfort and air quality increases significantly in buildings that provide people with some means of personal control over their environment, such as thermostats or operable windows. The opposite was true for people with portable heaters and fans, indicating that the presence of these devices may have been a result of inadequate performance of the centralized HVAC system. Given the relative energy intensity of these portable devices, it is clear that providing for personal control should be a thoughtful and integrated part of the overall building design, rather than an afterthought.

We also did a comparative analysis of 21 green buildings, 15 of which were LEED-rated. In comparison to the rest of the database, occupants in these buildings expressed higher rates of satisfaction with thermal comfort and air quality, and with the building overall. Contributing reasons for this include improved ventilation, green materials with reduced off-gassing, solar gain control, operable windows, task-conditioning, and other means of personal control. In contrast, we didn't see any significant improvement in lighting and acoustic quality in the green buildings. With regard to lighting, occupants consistently enjoyed and valued higher levels of daylight and access to views, but there were often problems with glare

(particularly on computer screens), and inadequate electric task lighting or provision of controls over the lighting. High levels of dissatisfaction with acoustics in the green buildings were often attributed to problems with sound privacy and noise distractions, often exacerbated by the high ceilings and open plan layouts that are beneficial for daylighting and natural ventilation. Additional factors influencing the acoustics in these buildings were often harder surfaces associated with minimal use of textiles as a way of avoiding the off-gassing.

### CONCLUSION

Providing workers with a quality indoor environment should be a goal of any building design, but is particularly important for green buildings that claim to be more responsive to supporting occupant comfort, health and productivity. Improving the quality of our buildings critically depends on accountability and learning from experience—what works, what doesn't, and what choices about building design or operation can make the biggest difference. The voices of the occupants are an invaluable component of that assessment. As we move towards embracing high-performance, green buildings as the industry standard (as we must), we must also insist that post-occupancy evaluations be a natural part of that process. In the end, everyone benefits from learning how a building performs in practice. <sup>FW</sup>

### ACKNOWLEDGEMENTS

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tributed to and received financial support from the Survey project.

### FOR MORE INFORMATION:

To see a demo of the CBE Survey and reporting tool, or to find out how to use the CBE Survey in your building, see: <http://www.cbe.berkeley.edu/research/briefs-survey.htm>. Or send us an e-mail at: [cbe-survey@berkeley.edu](mailto:cbe-survey@berkeley.edu)

### FOR MORE DETAILED DISCUSSIONS OF THIS SUBJECT SEE:

Abbaszadeh, S., L. Zagreus, D. Lehrer and C. Huizenga. "Occupant Satisfaction with Indoor Environmental Quality in Green Buildings." *Indoor Air* 2004; 14 (suppl 8) December 2004. 65-74.

Huizenga, C., S. Abbaszadeh, L. Zagreus and E. Arens. "Air Quality and Thermal Comfort in Office Buildings: Results of a Large Indoor Environmental Quality Survey." *Proceedings of Healthy Buildings* 2006, Lisbon, Vol. III, 393-397.

Zagreus, L., C. Huizenga, E. Arens, and D. Lehrer. "Listening to the Occupants: A Web-based Indoor Environmental Quality Survey." *Indoor Air* 2004; 14 (suppl 8) December 2004. 65-74.

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