centerline

Newsletter of the Center for the Built Environment at the University of California, Berkeley

Summer 2012

MEASURING PRODUCTIVITY

Director's Note

Contents

centerline

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Cover illustration by Leigh Wells
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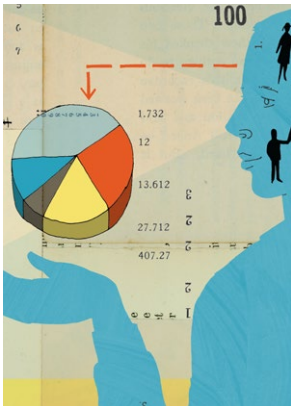
Dear Industry Partners,

Our sensory environments affect our moods, health, social interactions, and ultimately our ability to be productive in our work. In this issue of *Centerline* we describe work done by CBE partners, researchers, and others who have studied how to make the most of our work environments – places where we spend a large part of our waking day. Many research approaches have been applied to questions of work productivity, and we strive to contribute to this work, and to help disseminate valuable work done by others. In writing this edition of *Centerline* we learned about creative work being done by CBE partners who are working to better understand the "holy grail" of workplace productivity. In October we will be hosting a panel on this topic to further advance this discussion; stay tuned for details which we will email to all CBE partners.

This summer our research lab has been humming with a wide range of research activities, including two human subject tests; we report on many of these efforts in the pages that follow. We also introduce our newest partner firm, Affiliated Engineers, Inc., and note the semi-retirement of Tom Webster, who has been one of CBE's core researchers for over a decade. On behalf of all of our team, thank you for your on-going support and interest.

Sincerely,
Edward Arens

The Holy Grail of Measuring Workplace Productivity



In the simplest terms, productivity is an economic measure of the efficiency of production, a ratio of the economic inputs and outputs. Productivity measures can be applied at the macro-economic scale — for example, a nation's gross domestic product per hour worked is a common measure — as well as at the level of an individual worker focused on a single task.

When we consider productivity in the context of the workplace environment, the term has various interpretations and a large number of potential metrics. We may be interested in productivity of an individual worker, a group, or an entire enterprise. Many research approaches have been used for measuring productivity, including field or laboratory studies, and objective measures (hard data) or self-reported (perceived) measures.

Field research that isolates productivity benefits resulting from the physical environment is challenging at best, as objective performance metrics in office environments are rare and often not made available due to a reluctance of companies to release competitive or human resources information. Additionally, many companies have combined sick time and vacation days into a single measure of "paid time off," making absenteeism and sick days less useful as indicators.

Collaboration and productivity

Fundamentally, workplaces need to provide a comfortable environment that is sufficiently free of distractions to allow individuals to concentrate and focus. But as knowledge-intensive organizations rely more and more on creativity and collaboration to succeed, they realize that their success is not based solely on the productivity of individuals. The collective effort of groups, interdepartmental communication, and collaboration is essential. In his book, "How Breakthroughs Happen: The Surprising Truth About How Companies Innovate," author and UC Davis professor Andrew Hargadon describes how breakthroughs are rarely the result of individuals working alone, but result from networks and connections between people, ideas, and objects. He describes how innovative companies use "technology brokering" that result in process improvements through collaboration. By extension, work environments that facilitate networking can contribute to innovation and positive outcomes. A recent article in the *New York Times* describes how spaces that allow for "social breaks" can improve morale and improve bonds between employees. The article note the example of Google's highly successful Gmail product, which was first conceived by a small group in a Google office cafe.

As workplaces have evolved to promote collaboration, companies show great interest in studying interactive workplaces.

As workplaces have evolved to enhance collaboration, companies show great interest in studying the outcomes of interactive workplaces. In its design of the BJC Institute of Health at Washington University, Cannon Design strove to create a workplace that would promote productivity and interdisciplinary collaboration among faculty and researchers. Approximately 700 people were relocated from ten sites to the new LEED Gold certified facility, which was designed with collaboration

Coffee area and team meeting workspaces at the BJC Institute of Health at Washington University. Architecture by Cannon Design. Image: Debbie Frank Photography.

spaces, open stairs, and co-located principal investigators (PIs).

To evaluate the new work environment Cannon implemented surveys before and after the move, with questions focusing on collaboration, productive outputs, comfort, and satisfaction. A total of 223 people participated in the pre-move survey, and 210 responded to the post-move survey. Although results are preliminary at this point, the study shows that in the new space PIs mentored more people, and planned, submitted, and published more manuscripts compared to the previous spaces they occupied. The study also showed that conference rooms, break rooms, and corridors were highly utilized as places to discuss work with colleagues.

David Craig, Director of Workplace Strategy for Cannon Design, explains that survey research is a valuable way to measure productivity in knowledge worker organizations, where there are often few well-defined outputs. He also points out that social science theory correlates "network density" with productive output in many types of organizations, and that it is possible to use survey research to measure linkages between employees as a predictor of company performance. He explains, "the work environment can bring people together, so that knowledge is shared, which can lead to faster time to market, or fewer bugs in software, or whatever the goal is. We can get information about interactions and connections on a time frame that is relevant to design."

Individual vs. collaborative workspace demands

With collaborative work there is an inherent conflict between the needs for concentrated workspace free of distractions, and for interactions that spur collaboration. Indeed one person's interruption is another person's interaction. A study by Barry P. Haynes of Sheffield Hollam University (UK) notes that "interaction was perceived…to have the most positive affect [sic] on productivity, and distraction was perceived to have the most negative." How are designers and managers to respond to this apparent contradiction?

While interruptions may cause a person to feel that he or she is less productive, the interactions with

others may benefit the group effort. In fact, one study suggests that self-reported productivity may not be entirely reliable. Craig cites a study conducted at CSU San Marcos that tested an "electronic brainstorming" system that could be used by groups or individuals. The study found that the group that was forced to interact more intensively (by exchanging files more frequently) clearly outperformed the group that interacted less. However, individuals in the higher interaction group felt that they had more interruptions, and were less able to concentrate. In addition, both interacting groups felt that they did a less thorough job than did the individuals working alone. The forced interaction resulted in a higher level of group achievement; however the individuals felt less satisfied with their individual output.

Part of the solution may be providing distinctly tailored spaces for each type of task, allowing for both individual and collaborative work. Craig was also involved in a before and after survey study conducted for new offices for pharmaceutical company Lilly, which had fewer spaces assigned to individuals and more unassigned spaces that were purposefully designed for diverse functions, including concentrated focus rooms, team workspaces, cafes, and discussion enclaves. The survey found that overall satisfaction increased from 35 to 64 percent, and the number of people that felt that the office was an attractive part of the job increased from 21 to 58 percent.

We may be able to lessen the conflict between individual and group needs by managing expectations and making group performance goals explicit. CBE Research Specialist John Goins suggests that for collaborative work environments, new employee orientations might explain the purpose of open office areas. "They could tell new employees, 'in this workplace you are going to be interrupted, but that is a good thing.'"

Recent research done by CBE and the Technical University of Denmark (DTU) analyzed the data collected in the CBE Occupant IEQ Survey to study the relationships between self-reported productivity and aspects of the work environment. Of the workplace characteristics included in the survey, temperature, noise and air quality were found to be the most important factors related to self-reported productivity. The analysis showed that overall satisfaction with the workspace significantly improved self-reported productivity; however, the impact was fairly small, in the range of a one to four percent productivity improvement for each 15 percent increase in workspace satisfaction.

CBE plans to build on this research going forward, using this rich source of self-reported productivity data for additional studies.

Measuring productivity in schools

The conflict between individual and collaborative work is not only an issue in corporate environments, but also in learning environments of schools. Marcel Harmon, Senior Associate and Applied Anthropologist with M.E. GROUP, has conducted evaluations of many schools to provide feedback on building design approaches, using ethnographic studies such as surveys, focus groups, and interviews. Harmon cites one example in which the benefits from collaborative design features were not obvious, but were discovered through ethnographic study. Teachers at a high school in New Mexico complained about the lack of wall area available due to large glass areas between classrooms and adjoining corridors. However, M.E. GROUP observed a high incidence of interactions between teachers that resulted from the visibility and transparency that the design provided, although teachers did not fully appreciate the benefits from the

In laboratory research a group that was forced to interact more intensively clearly outperformed a group that interacted less.

interactive design elements. As in corporate design, many new schools are designed with both individual classrooms and separate open spaces that can be used for individual grade levels, mixing grades, and group activities.

Harmon points out that studies conducted in schools generally found that factors other than the physical environment may have the greatest impacts on productivity and student success. Demographic, health and family factors may be the most important predictors, with environmental impacts on productivity on average being under 10 percent. However impacts can be greater than 20 to 30 percent for individuals experiencing the worst environmental conditions, or those who have increased sensitivities to environmental factors.

Call center productivity metrics

Call centers with quantifiable metrics offer promise for studying productivity in the field; however, isolating the effects of single factors has proven elusive. Heschong Mahone Group conducted a call center study in 2003, and found that daylighting and views could improve call performance by 6 to 12 percent. A related study by HMG of office workers saw improvements of 10 to 25 percent for tests of mental function and memory recall. In a call center study conducted by MIT's Human Dynamics Laboratory, wearable sensors were used to study the communication patterns of call center employees who worked in teams. By suggesting that team members take coffee breaks together, work performance was greatly improved, and bank management decided to change the break schedules for 25,000 call center employees, forecasting productivity improvements worth $15 million annually from the change.

A call center field study was conducted by CBE to determine whether ventilation rates would impact productivity as measured by the length of time to handle a call, and "wrap up" time required in between calls. The project came up against numerous difficulties; for example, due to a confrontational relationship between company management and an employee labor union, the study had to be modified and CBE's human subject protocol revised. During the test, the company made changes to the phone system technology, complicating the data analysis. Air change rates could not be reduced below minimum standards, due to health and safety concerns, so ventilation could only be adjusted up from the minimum. This may have contributed to the null finding regarding ventilation, however the test did show that higher temperatures and longer shifts did impact productivity negatively.

Laboratory studies

Controlled lab studies avoid the complications of field research, and are effective for studying specific environmental characteristics such as temperature, air quality and lighting, with a high level of control. Productivity lab studies typically include some measurable task, such as proofreading, typing or mathematical tests that simulate a portion of the work typically conducted in the workplace. Subjects' performance is measured by the speed and/or accuracy at which the tasks are completed.

Transparency and collaboration spaces were evaluated at the V. Sue Cleveland High School, Rio Rancho, NM. Image courtesy of M.E. GROUP.

For example, researchers at the Technical University of Denmark conducted a series of lab studies to show the negative impact on productivity resulting from poor indoor air quality and sick building syndrome (SBS). The studies show that lost productivity can be as great as six to nine percent, and suggest that the payback from green building features that improve indoor air quality can be as short at two years.

Researchers at CBE included productivity measures in our testing of an early version of the personal comfort system. The study included

Sudoku puzzles to test logical thinking, math problems to study mental performance, and typing tests to test for dexterity. Although the effects on productivity were not highly conclusive, the study found that for the Sudoku and math tasks, subjects' performance with the personal control systems was increased in many cases. This reinforces other research that shows that personal control of one's workplace environment is highly beneficial.

Adrian Leaman and Bill Bordass of the Usable Buildings Trust describe what they call the "killer variables," broad concerns that contribute most directly to productivity: comfort including personal control, responsiveness to need, ventilation type, workgroup layout, and how design intent is communicated to occupants. (This paper is included as chapter 10 in Clements-Croome; see inset box at right.) As workplace trends evolve, we expect that new research methods will be devised to add to our collective understanding of productivity and workplace effectiveness. Although the incorporation of new technology and collaborative tools will continue to be major drivers of workplace design, attending to these common forward human factors issues are likely to produce positive results.

On October 18, 2012, CBE will host a panel session on workplace productivity as part of the CBE's Industry Advisory Board Conference, which is open to all CBE Industry Partners and invited guests. We will email details to all CBE Partners.

Related Reading

Books & Articles

Creating the Productive Workplace, Second Edition, by Derek Clements-Croome (ed) 2006. Taylor & Francis, London.

How Breakthroughs Happen: The Surprising Truth About How Companies Innovate, by Andrew Hargadon, 2003. Harvard Business School Press, Boston.

Communal Breaks: A Chance to Bond, by P. Korkki, P. *New York Times*, July 14, 2012.

CBE & Collaborating Institution Papers

Zhang, H., et al., 2009. Comfort, perceived air quality, and work performance in a low-power task-ambient conditioning system. www.escholarship.org/uc/item/5j8071wn

Federspiel, C., et al., 2002. Worker performance and ventilation: analyses of individual data for call-center workers. www.cbe.berkeley.edu/research/pdf_files/Federsp2002_indoorair.pdf

Wargocki, P., et al., 2012. Satisfaction and self-estimated performance in relation to indoor environmental parameters and building features. www.escholarship.org/uc/item/451326fk

Research Papers by Others

Miller, N., et al., 2009. Green buildings and productivity. www.costar.com/josre/JournalPdfs/04-Green-Buildings-Productivity.pdf

Haynes, B., 2008. An evaluation of the impact of the office environment on productivity. www.emeraldinsight.com/0263-2772.htm

Wyon, D., 2004. The effects of indoor air quality on performance and productivity. www.onlinelibrary.wiley.com/doi/10.1111/j.1600-0668.2004.00278.x/pdf

Jessup and Connolly, 1993. The effects of interaction frequency on the productivity and satisfaction of automated problem-solving groups. www.interruptions.net/literature/Jessup-HICSS93.pdf

Project Updates

Personal Comfort Demonstration to Test Concept Feasibility

Several field demonstrations starting this summer will evaluate the effectiveness of a new approach to space conditioning that has the potential to improve occupant comfort while at the same time reducing HVAC energy use. The new system, dubbed the "personal comfort system" (PCS), has been in development at CBE for over two years, and will be tested with the support of two new funding awards.

The first field study will take place at UC Berkeley's Doe Library Annex, where approximately 25-40 PCS units will be installed in an office; this project is supported by new funding from the California Institute for Energy and Environment (CIEE). The study will be conducted this summer and through the winter to capture a range of seasonal variation, and will monitor both the resulting comfort and energy outcomes. In addition to providing occupants with the comfort stations, the research team will change thermostat settings so that the dead band (range between heating to cooling set points) is increased from the standard range of approximately 3-4°F, up to 7-10°F. In a location with a mild climate such as Berkeley, such a change can reduce HVAC energy by as much as 40 percent. The research team will poll occupants using "right now surveys" to document occupant comfort under various conditions.

Additional funding from the California Energy Commission PIER Program will allow us to expand this research to an additional three buildings. For this work we are seeking buildings with varying characteristics, including a conventional air conditioned building, one with natural ventilation or mixed mode, and one with a radiant system. The work will begin this summer, and is scheduled to last two and a half years. We are currently seeking buildings in warm climates having conventional and radiant systems, where the set point can be changed according to the research plan. If you know of candidate buildings for this study, please email Zhang Hui at zhanghui@berkeley.edu.

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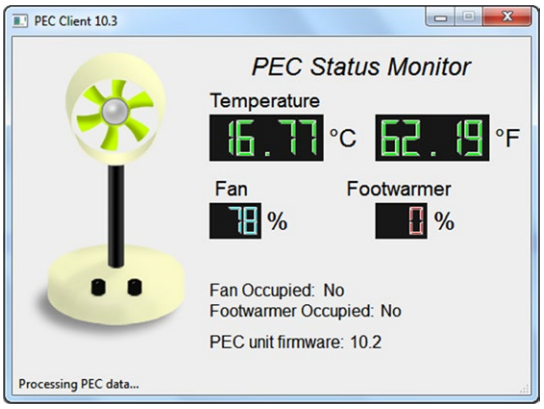
Personal control systems (PCSs) will be installed in the Doe Library Annex on the UC Berkeley campus. Image: Steve McConnell.

Footwarmer and desktop fan installed at the David Brower Center in Berkeley, CA.



The PCS interface shows test subjects details about the indoor environment and the comfort devices.

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The systems to be tested consist of low energy desktop fans (3W max) and energy efficient footwarmers (40W max), both of which have occupancy sensors that reduce the energy use of the devices, and are controlled by dials mounted on the fan base. The fans also include temperature sensors and data collection capabilities, allowing the research team to remotely collect detailed information about the conditions under which the devices are used.

Past CBE research has found thermal comfort to be one of the most problematic areas in office environments. Using occupant survey data collected by CBE, researchers found that 42 percent of occupants were dissatisfied with their thermal comfort, and the ASHRAE standard requiring 80 percent of occupants to be satisfied was only met in 11 percent of the buildings surveyed. However, a study conducted in the late 1990s tested a commercially available personal comfort system, and found that 100 percent of occupants with the system were happy with thermal comfort.

New Research to Highlight Best Practices in Radiant System Design for Near ZNE Buildings

Future phases of CBE's research on radiant systems will highlight successful case studies, and support laboratory and simulation studies. Approved in May at the business meeting of the California Energy Commission's PIER program, the new funding builds on current field study research on advanced integrated systems, such as buildings with hybrid UFAD/radiant systems.

The future phase of work will include detailed case studies of two successful near zero net energy (ZNE) buildings that employ slab integrated radiant systems. Information from these case studies will be shared with CBE partners and the wider public to provide improved guidance on how to optimally design and operate highly energy-efficient buildings using radiant slab systems. CBE will monitor and analyze performance data and conduct an occupant survey in order to highlight best practices and lessons learned from these examples. CBE will work with consortium members and others to identify candidate buildings that have completed commissioning and are known to have a low energy profile.

Radiant heating and cooling installation by REHAU at the YWCA Toronto Elm Centre. Image courtesy of REHAU.

CBE also plans to conduct a series of laboratory experiments, possibly at the new FLEX test chambers at Lawrence Berkeley National Laboratory (LBNL), planned as a series of full-scale test beds that allow for integration of multiple building systems and technologies. The goal of this work will be to provide validation-quality data for comparison with the predictions of energy modeling programs, leading to improved simulation algorithms for radiant systems. All findings from the case studies and laboratory testing will be supplemented with whole-building energy simulations using an updated version of EnergyPlus, allowing a sensitivity analysis of climate and control strategies.

At our April Industry Advisory Board Conference, we announced our search for potential field study sites, and began to identify candidate buildings: low energy buildings with in-slab radiant systems, likely to implement a nighttime pre-cooling strategy, in California or a similar climate. If you know of buildings that may be appropriate for this study, please contact Fred Bauman at fbauman@berkeley.edu.

Human Test Chamber Active with Studies on Comfort Using Fans

CBE researchers have been busy this summer with two comfort studies in our human test chamber. Both tests have the goal of showing how the use of air movement can keep people comfortable under a wide range of temperatures. Allowing the acceptance of a broader range of temperatures can provide significant savings in conventional buildings (up to 7-15% total HVAC energy for every degree Celsius) and enable the adoption of low-energy alternatives to conventional air conditioning.

In July we completed tests to understand how fans can keep people comfortable under warm and humid conditions that may be experienced in many parts of North America, Hawaii, and other regions around the globe. This testing fills an important knowledge gap, as previous tests conducted at CBE proved that elevated air movement improves comfort and perceived air quality at high temperatures, but those tests were conducted at moderate relative humidity (RH) levels (50%). The recent series of tests were conducted at 60% and 80% RH, at temperatures of 78.8°F (26°C), 82.4°F (28°C), and 86°F (30°C). The tests included 16 subjects, dressed in typical light summer clothing, who could adjust floor fan settings to their preference. The results, now being summarized by the research team, shows that people are comfortable under five of the six test conditions, all of which are outside the standard comfort range specified by ASHRAE Standard 55. Only at the highest temperature and humidity test conditions (86°F and 80% RH) did comfort fall off appreciably. Although preliminary, these results provide compelling evidence that occupant-controlled fans can be part of an energy saving approach to space conditioning, and that standard temperature set points may be excessively constrained.

The study is being led by Yongchao Zhai, a visiting scholar and PhD

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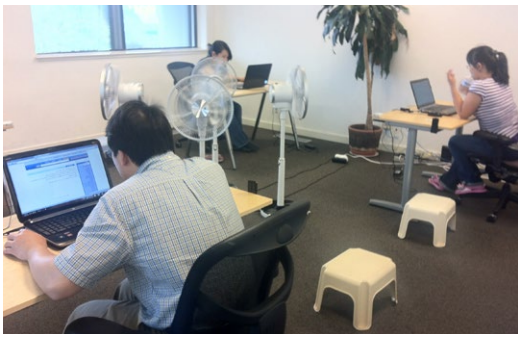
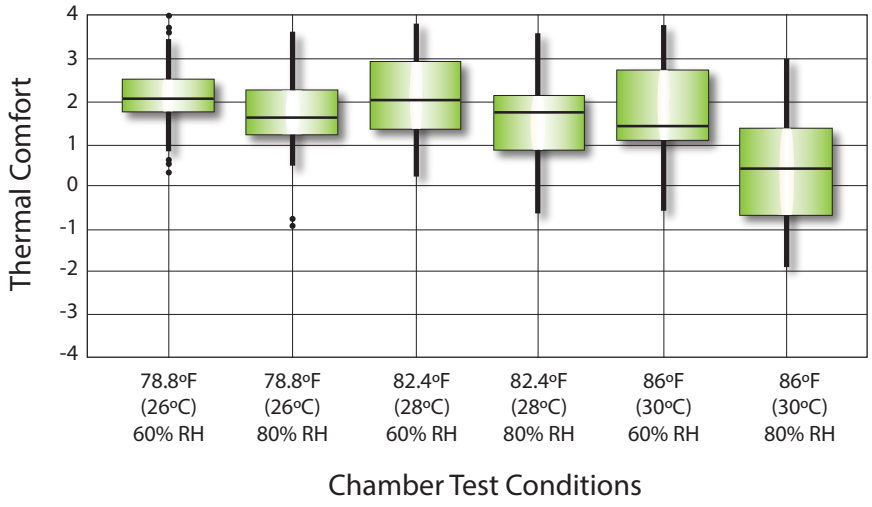
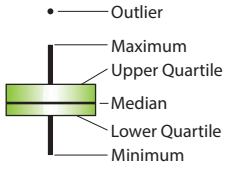


With controllable floor fans, test subjects kept themselves comfortable in hot, humid conditions.



Preliminary results show that people are comfortable under five of the six test conditions, all outside of the standard comfort range. The comfort scale is from "very uncomfortable" (-4) to "very comfortable" (4).



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candidate from the Southern China Institute of Technology. Yongchao points out that the findings may be important to help adoption of higher temperatures in buildings, as set summer cooling points in North America and other countries are often well below the tested "neutral" temperature of 78°F (25.7°C). An example of what can be achieved with new insights into comfort are seen in Japan's successful Cool Biz campaign, that prescribed thermostat settings of 82.4°F (28°C), and was reported to reduce CO_2 emissions by an amount equivalent to that produced by one million households in one month.

The second human comfort test to be conducted this summer will investigate the use of fans integrated into the ceiling of the chamber, with a focus on the effects of oscillating fan movements that can cover wider areas of the space, and may provide benefits due to varying air velocity that occupants experience. The research team has been working with industry partners at Armstrong to develop various design and fan alternatives, and has completed the chamber set up. We will present results from both these studies at CBE's October meeting.

Overhearing the News About CBE's Acoustical Research

Reading the front page of the Sunday *New York Times* last May, CBE staff were happily surprised to see the CBE occupant survey referenced and a quote from Research Specialist John Goins in an article entitled "From Cubicles, Cry for Quiet Pierces Office Buzz". The article quickly led to other media exposure for CBE, including a piece on NPR's Radio Times on WHYY radio from Philadelphia, and in *Building Opportunties Management Magazine*.


The New York Times

Science

From Cubicles, Cry for Quiet Pierces Office Buzz

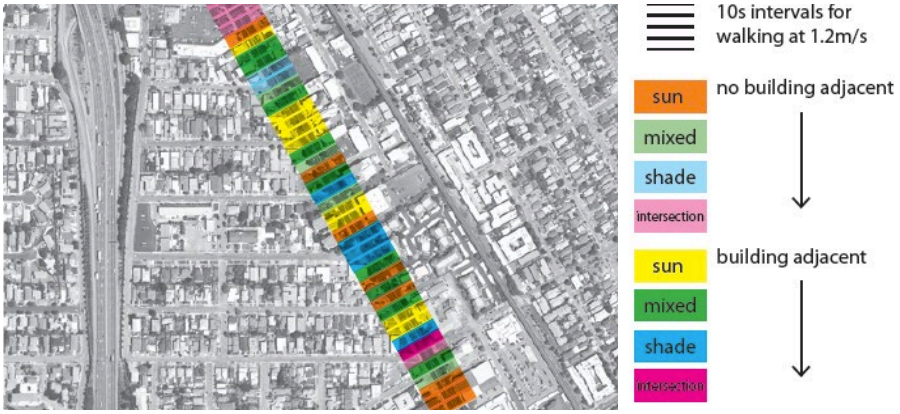
The *Times* article discussed the conflicting needs of collaboration and privacy, an increasingly important issue as open plan offices are being widely adopted, especially among startups and IT firms. (More on this in feature article, page 3). As confirmed in research by CBE and examples cited in the article, acoustics is a highly problematic aspect of open plan offices. The article struck a chord with readers, and generated over 180 reader comments. Many were critical of open office spaces, and cited examples of workplace neighbors with annoying habits such as sharing too much personal information when talking on the phone. One reader describes her neighbors' phone conversations as being "like watching an exhibitionist disrobing at the window."

Acoustical engineer and CBE partner Charles Salter notes that open plan offices, which have been designed to increase collaboration, do not support people that require quiet environments. This topic is explored in the acclaimed book, "Quiet: The Power of Introverts in a World That Can't Stop Talking," by Susan Cain. Salter also points out that many people attempt to mitigate acoustical distractions by putting on headphones (which some managers and designers think is an acceptable solution), but by doing so they are closed to collaboration, as they would be behind a closed door.

John Goins thinks that acoustical problems are exacerbated as people are spending more time in the office, and therefore have high expectations for their workspace. Although many aspects of the workspace are now given more consideration due to LEED checklists, acoustical concerns remain underappreciated by many owners and workplace designers.

Interdisciplinary Collaboration to Create Sustainable City Planning Tools

CBE is collaborating with UC Berkeley's Center for Resource Efficient Communities (CREC) and the i4Energy Center on the development of new digital tools that can be used by public and private planning entities to evaluate impacts of proposed developments on the basis of key sustainability metrics, including transportation, energy, greenhouse gas emissions, and pedestrian comfort. The project is funded by Siemens through its Corporate Research and Technology group, which has locations in Berkeley, CA, and Princeton, NJ. Through its Sustainable Cities Program, Siemens is working to create sustainable technologies for energy efficient buildings, water treatment facilities, transportation infrastructure, and public safety systems.



Researchers with CREC proposed a pedestrian thermal comfort model for use in planning sustainable cities.

Currently, existing tools and models for planning rely on coarse spatial data about existing and projected regional land uses and demographics. Missing from these models entirely are effective analyses of the potential for land use or urban design changes in which walking and bicycling may substitute for short-distance automobile trips in large numbers, or in which mass transit is supported by a land use context that ensures adequate ridership. In addition, cities and regions generally lack even basic inventories of the physical characteristics of their streets. In an age where aerial photography and other digital data sources about the urban environment are easily accessible for virtually the entire United States (and increasingly the world), that is a needless and counterproductive state of affairs.

In the first phase of work, CREC and CBE conducted interviews with planning professionals to identify the spatial data needs that will enable the planning of transportation systems that minimize life-cycle and/or operational energy use and greenhouse gas emissions. The team documented a wide range of available digital resources, including crowdsourced public data, and technology choices that would allow such data to best interface with existing transportation and planning tools. We also advanced the capability of CBE's Advanced Comfort Model to enable outdoor comfort simulators that can interface with new planning tools. Findings from the first year of the project will be summarized this fall, and we are in discussions with Siemens to continue this work in the future.

CREC operates within UC Berkeley's College of Environmental Design, and was launched in 2009 with support from the California Energy Commission, in order to address community-scale resource efficiency. www.crec.berkeley.edu.

The i4Energy Center brings together multi-disciplinary minds to create information technology advances to address our multi-layered energy challenges. www.i4energy.org.

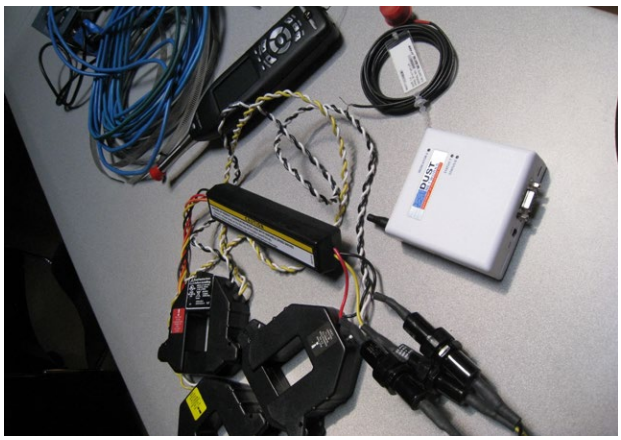
Workshop Launches Testing Phase of Building Measurement Toolkit

In July, CBE held a workshop with partner firms who will conduct field tests of the new performance measurement toolkits being developed by CBE for use in commercial buildings. The toolkits will allow industry professionals — commissioning agents, energy services companies, engineers, and others — to conduct detailed performance measurement audits that fulfill the requirements of the new Performance Measurement Protocol (PMP) that was released in 2012 to promote comprehensive evaluation of buildings, including resource use (energy and water) as well as indoor environmental quality (IEQ) factors such as occupant comfort and satisfaction. The workshop was led by Research Specialist Tom Webster and Graduate Student Researcher David Heinzerling, and was attended by representatives from WSP Flack + Kurtz, Syska Hennessy Group, and QuEST, firms that will conduct the pilot field tests.

CBE's PMP toolkit provides users with a range of sensors and a robust data collection system built on a wireless mesh network, and utilizes cell net internet connection to allow for data collection that is fully independent and can be deployed in most locations. The system also includes connection to many building management systems (BMS), allowing users to supplement wireless data with comprehensive energy and operations data. The data management systems uses an open source protocol called sMAP (Simple Measurement and Actuation Profile) developed by UC Berkeley's Computer Science Division.

At the July workshop CBE staff demonstrated the capabilities of the toolkit and discussed details about the implementation process. The team also has started to identify candidate sites for field testing the prototype toolkits later this summer. Results from the field testing will be published in the form of case studies and will provide valuable information that will be helpful for commercialization of the technology in future projects.

Graduate Student Researcher David Heinzerling demonstrated the toolkit during the recent workshop held by CBE.



The building measurement toolkit includes handheld sensors for sound, power, and other variables.

People & Partners

New CBE Member AEI Applies Integrated Design to Complex Project Types

Madison, Wisconsin-based Affiliated Engineers, Inc. joined CBE in early 2012. The multi-discipline technical consulting, design, and engineering firm has a staff of 600 working out of twelve offices across the country supporting projects around the world, primarily in the healthcare, research science, energy infrastructure, and higher education markets.

Due to the functional complexity of these project types, AEI has deep roots in integrated design. With the increasing complexity that a sustainable approach now brings to even conventional building types – and to long-term capital project considerations – AEI's role is also expanding to broader institutional integration, participating in early planning efforts and providing increased support to building operations.

Throughout their services and markets, AEI is fundamentally committed to rigorous verification of engineered systems, technologies, and strategies. They characterize their new membership in CBE as a natural continuation of that commitment. "Systems monitoring can give us a terrific quantitative window on the performance of the buildings we've worked on," says AEI Sustainability Practice Leader Paul Erickson, LEED AP, "but what CBE membership offers us is the additional perspective of our peers' experience, as well as access to comfort and broader indoor environmental quality data that we can't generate on our own. Such information in conjunction with tools and other research undertaken at CBE allows us to encourage our clients to take the next step, not based on a hunch or a whim, but on rigorous research. We're also excited to contribute our expertise and experience to conversations related to such markets as healthcare and labs, and on technologies such as chilled beams, radiant cooling, and phase change materials."

Among the firm's notable recent projects are the LEED Platinum King Abdullah University of Science and Technology in Saudi Arabia, the Wisconsin Institutes for Discovery (both are *R&D Magazine's* 2011 and 2012 Labs of the Year, respectively), the Ann & Robert H. Lurie Children's Hospital of Chicago, the U.S. Department of Energy's Energy Systems Integration Facility at the National Renewable Energy Laboratory in Colorado, the James B. Hunt Jr. Library at North Carolina State University, and the new Kellogg School of Management at Northwestern University.

When it opened in 2009, the 5 million ft^2 King Abdullah University of Science and Technology represented over half of the LEED Platinum square footage in the world. Image: Sam Fentress Photography.

The Wisconsin Institutes for Discovery building at UW Madison features natural ventilation, a geoexchange system, aggressive heat recovery, and chilled beam technology, and is aiming to use 50% less energy and water than comparable facilities. Image: AEI.

Researcher Tom Webster Shifting Focus to Human Aspects of Sustainability

At our April CBE meeting, Research Specialist Tom Webster announced that he would retire as a full-time staff member and return on a part time basis to support key projects such as CBE's PMP toolkit project (see page 13). Since joining UC Berkeley's Building Science Group in 1997, the year that CBE was launched, Tom has led many of CBE's core research efforts, including CBE's energy simulation studies, field study research at multiple sites across North America, studying emerging HVAC technologies such as UFAD and radiant systems, and more recently, supporting "advanced integrated systems" research focusing on promising system combinations. Tom was also instrumental in the creation of two testing laboratories for UFAD systems research.

Much of this work has been done in collaboration with CBE's industry partners, and Tom feels that these interactions have been a rewarding part of working with CBE. "The dialogue is very helpful, and we always learn things that are eye opening and useful," he says. Tom has mentored numerous graduate students who have worked on complex and challenging technical projects, and he has authored or co-authored over 50 reports, articles and book chapters. He has also been our go-to person for questions about building control systems.

Then and now: Tom Webster and wife Chris Weahunt.

Tom's extensive experience in commercial building energy has been highly valuable for the research team; before joining CBE he did pioneering work in Lawrence Berkeley National Lab's passive solar energy group, developing early versions of whole-building energy software (BLAST), and conducting technical reviews for all DOE solar demonstration projects west of the Mississippi River. He previously worked as the director of the industrial products division for EnergyLine, a Berkeley controls company later purchased by S&C Electric, and he holds three patents.

Going forward, Tom plans to combine personal and professional interests, and his goal is to work towards connecting climate change and sustainability with human behavior, trying to gain insight into and help people understand and adapt to these concerns as our world changes. Tom says that he will be reading through a stack of things that he has collected, and he plans to link up with groups such as the Greater Good Science Center at UC Berkeley, which conducts positive psychology research; UC Berkeley's Energy Resources Group's carbon footprint calculator team, and with the University of Wisconsin Center for Investigating Healthy Minds. Tom says that part of his purpose in this work is to "shift my focus to people-oriented things, rather than technology-focused things."

We expect that when Tom applies his "the devil is in the details" ethos to these new efforts, he will be sure to generate interesting results. Although he will not be leaving CBE completely, this is an appropriate time to thank Tom for his many years of contributions, and we look forward to learning about his new endeavors.

Events

October Workshop: Comparing System Design in Low and Zero Net Energy Buildings

Zero net energy (ZNE) buildings are the wave of the future. In California, commercial buildings will be required to meet ZNE goals by 2030. To achieve this goal, engineers will be called on to carefully design HVAC systems and controls. With a variety of existing HVAC options, how do you select which system will perform best?

Join us at the all-day seminar, "Deep Dive: Comparing and Selecting Low Energy HVAC", on October 17th at the PG&E Pacific Energy Center in San Francisco (sponsored by ASHRAE, and in collaboration with Bay Area consulting firms, the Center for the Built Environment, and PG&E). This seminar will review how to compare HVAC systems in a commercial building, using an occupied building on the UC Davis campus as a case study. They will compare an emerging technology, active chilled beams, to a more "traditional" system, variable air volume (VAV) reheat. Each option will be evaluated on the following criteria: up-front and life cycle costs; energy performance, utility cost, and technical modeling issues; space usage; indoor air quality; qualitative factors; and risk assessment. While other HVAC options exist, the discussion will identify the process of evaluating different systems using these two systems as examples, which in turn can be used when looking at other HVAC options.

Presenters include staff from Guttmann & Blaevoet, Taylor Engineering, SOM, CBE, and a roundtable in which various perspectives are provided, including the owner, architect, general contractor, HVAC contractor, and facility engineer.

Free to attend and open to the public. Registration available soon.

Greenbuild 2012: Visit Our Booth!

San Francisco is hosting Greenbuild 2012, and we are excited to announce that we will have a 10x10 booth on the expo floor. Come visit us at **Booth #4088N** to see demonstrations of our personal comfort system and performance measuring cart. Researchers and graduate students will be on hand to give overviews of our work and answer questions.

Following the conference, there will be numerous local green building tours. One includes the David Brower Center in Berkeley, which features many unique architectural and systems features. Research Specialist Fred Bauman will help lead the tour of the building, which has a hybrid UFAD/radiant system that CBE has been monitoring. The tour will take place on Saturday, November 17, and is part of the Berkeley Walking Tour, HD17.

The Greenbuild conference and expo takes place November 14-16. Learn more and take advantage of early bird pricing (ends Sept. 10) from www.greenbuildexpo.org.

Greenbuild is the world's largest conference and expo dedicated to green building. Thousands of building professionals from all over the world come together for three days of outstanding educational sessions, renowned speakers, a vast exhibition floor, green building tours, special seminars and networking events. In 2012, Greenbuild is bringing technology and sustainability together in the global green movement, and is "going beyond buildings" at Greenbuild 2012.

Industry Partners at the Center for the Built Environment

CBE's research is supported and guided by a consortium of industry partners, a diverse group of building industry leaders who are working to advance standards for the design and operation of commercial buildings through their collaborations with CBE.

The Center's membership includes the following firms and organizations:

- Affiliated Engineers, Inc.
- Armstrong World Industries
- Arup*
- California Energy Commission
- Cannon Design
- Charles M. Salter Associates
- DIALOG
- EHDD Architecture
- HGA Architects and Engineers
- HOK
- Integral Group Membership Team:
  - Integral Group
  - CPP
  - DPR Construction
  - Mahlum Architects
  - Perkins+Will
- Interface Engineering
- KlingStubbins
- LPA Inc.
- M.E. GROUP
- National Security Agency/Central Security Service (NSA/CSS)
- Pacific Gas & Electric Company
- Price Industries
- REHAU
- RTKL Associates
- San Diego Gas & Electric
- Skidmore, Owings & Merrill (SOM)
- Southern California Edison
- Syska Hennessy Group
- Tate Access Floors*
- Taylor Membership Team:
  - Taylor Engineering
  - Cadmus Group
  - Guttmann & Blaevoet
  - Southland Industries
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- Webcor Builders*
- WSP Flack + Kurtz
- ZGF Architects

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