# centerline

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

Summer 2014

## The Internet of Things in Commercial Buildings

# Director's Note

## Contents




**centerline**

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Dear Industry Partners,

Although summer is sometimes quiet around campus, for the past few months our offices have been abuzz with activity in the preparation of important funding proposals for the California Energy Commission and the Advanced Research Projects Agency-Energy (ARPA-E). We passed the initial rounds with four projects, submitted three full proposals, and are sub-contractors on three more. While this work has been time consuming, success with one or more of these proposals could advance our research significantly in key areas: research on optimizing radiant systems, and the development of ideas and technologies for providing occupant-centric comfort in buildings with minimal energy use.

Your participation in CBE's consortium is of real value as we compete for funding. Through your letters of support, your collaboration, and through membership funds that can be applied as match funding, our proposals are highly competitive, and we thank you for your generous support.

In this issue of *Centerline* we feature research by CBE and other groups at UC Berkeley that may contribute to the future Internet of Things, improving control and occupant responsiveness in commercial buildings. We also provide updates on our research, we profile the winners of the Livable Buildings Awards, and we introduce five new CBE partners that represent leadership in the building sector. It's been an exciting summer and we hope you enjoy reading about our recent work. Thank you again for your ongoing interest and support.

Sincerely,
Prof. Edward Arens
Director, CBE

# The Internet of Things: Hype or Hope for Commercial Buildings?

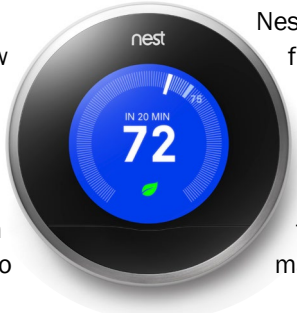
The mainstream and technology media are currently flooded with hopeful predictions surrounding the Internet of Things (IoT), a synthesis of technologies that are beginning to connect and bring intelligence to millions of diverse devices and objects, expanding our ability to monitor, understand, and control the world around us. Tech research firms estimate that as many as 30 billion devices may be connected via the IoT by 2020, translating to $1.9 trillion in economic impacts from reduced cost and productivity gains. The IoT builds on the rapid development of technologies such as wireless networks, cloud computing, embedded computing, and the hardware and software used in tablets and smartphones. The concept of a network of smart devices is not new, as the term "Internet of things" was first used as early as 1999, when the Internet was in its infancy.

Today, IoT promoters point to potential advancements in many sectors including energy, healthcare, infrastructure, and the electric grid. However we hear also about seemingly frivolous applications, such as the digital "onesie" used to monitor infants via smart phones, or the WiFi-connected toothbrush, both of which were demonstrated at the Consumer Electronics Show last January.

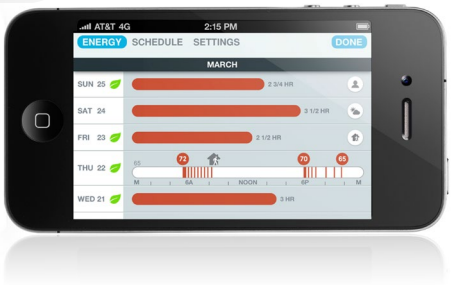
Competition to monetize the IoT in buildings is fierce, as both startups and technology giants such as Google and Cisco work to leverage the possibilities offered by the IoT for collecting consumer data, providing the platforms that will enable the IoT, and providing new products and services, such as Cisco's "Internet of Everything" consulting business.

Industry observers speculate that wireless connectivity may soon be a basic part of all home appliances and electronics, as costs come down and the benefits from network connections increase. Such broad interest in expanding consumer networks reveals a belief in Metcalfe's Law, which posits that the value of a network increases proportionality to the square of the number of users.

With Google's highly publicized $3.2B purchase earlier this year of Nest Labs, the maker of beautifully designed thermostats and networked smoke/$CO_2$ detectors, the search giant and CBE partner is poised to provide a framework for providing new information technology services in the home. Nest recently launched a development program that allows manufacturers to integrate home appliances with data from utilities and other sources. Nest partners to date include Whirlpool, Mercedes-Benz, LIFX (LED lighting), Logitech, and others. More recently, Nest Labs, Samsung and Arm Holdings have launched the "Thread" home network protocol, listing Yale



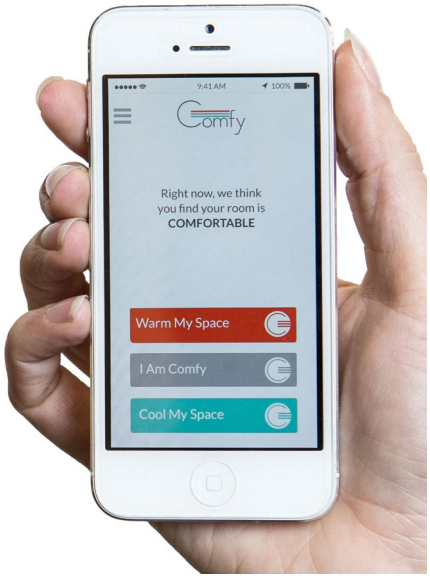

**Competition to monetize the *Internet of Things* is intense, but what do these innovations offer for commercial building stakeholders?**




Compelling design: Nest thermostat and mobile interface. Images: Nest.

Security and CBE partner Big Ass Fans among the supporting partners.

This intensive business activity reveals the interest in dominating home intelligence, however bringing the IoT to commercial buildings may be a more challenging prospect. Residential lighting, HVAC, and appliances are generally stand-alone systems with little or no connectivity or intelligence. However today's commercial buildings — especially medium to large buildings — are already typically equipped with control systems, and with hundreds if not thousands of sensors and actuators, even if these systems are not fully integrated. How can the creation of a widely adopted IoT improve life for commercial building occupants, operators and owners?




Occupant input from mobile applications such as Comfy may become part of the IoT ecosystem in commercial buildings. Image: Building Robotics.


The Jawbone UP wristband, a personal activity tracking device, is designed to work with Nest products via the Nest API. Image: Jawbone.

## Potential commercial building enhancements from IoT innovations

The improved sensing and connectedness promised by the IoT could potentially make buildings more responsive to the needs of users. For example, information could be gathered about occupants' activities and personal preferences — occupancy, location, activities, and personal preferences — which could be used to tailor indoor conditions to suit the occupants, and to reduce unnecessary energy use during unoccupied periods, controlling HVAC, lighting, operable windows, shades and plugged-in devices. Such data could also be useful in optimizing shared resources such as conference and meeting rooms, and managing hotelling, hot desking, and telecommuting, which are becoming more frequently tested and adopted in office environments.

Useful occupant data could be pulled from applications on mobile phones, occupancy sensors, sensors on fans and operable windows, computer and monitor status, and from emerging products, such as CBE's personal comfort chairs, that allow users to choose individual heating or cooling settings. Additional data could be provided by wearable digital devices such as those from Jawbone, Nike and FitBit, and the recently announced Apple watch. Such data could provide a better indication of occupants' needs than the limited information from thermostats that may be poorly located, and that do not reflect important comfort factors such as solar radiation and occupants' activity levels. While some people have reservations about sharing personal data, others are eager to adopt technologies that offer novelty or provide user with benefits. Many people already share personal information through social media websites, including their location through mapping applications and sites such as Foursquare.

Andrew Krioukov, CEO & Co-Founder of Building Robotics, notes that the success of the Nest thermostat shows that people see value in smart building devices, especially when executed with compelling design. "The jury is still out on what the biggest applications of the IoT in commercial buildings will be, but the key ideas are all about energy and comfort." The company has launched Comfy, a software tool that allows people to affect the temperature of their workspaces, regardless of whether they have access to a thermostat. The company was founded

by UC Berkeley graduates from Electrical Engineering and Computer Science (EECS), Building Science, and Architecture, and uses technologies that were first tested on the UC Berkeley campus.

Other companies seeking to benefit from the demand for smarter, interconnected buildings include Enlighted, a provider of lighting and networked energy efficiency systems, and Enmetric Systems, a maker of systems for monitoring and controlling plugged in equipment. Enmetric this spring issued a media release about its installation in the San Francisco office of CBE partner DPR Construction, designed to meet zero-net energy certification.

## Barriers to bringing the IoT inside commercial buildings

However, numerous technical obstacles must be overcome before commercial buildings are ready to embrace the IoT. Today's proprietary building management systems (BMSs) are poorly suited for this task, as they are not easily customized, and they are not *extensible* — they cannot readily be expanded upon to accept new types of sensor data. Unless customizations are made by approved contractors, which generally entails high costs, adding control points may void warranties. CBE Research Specialist Paul Raftery points out that in today's buildings, "each system works on its own network. We need a common network, based on the internet, so we could log on and control and run building apps as easily as we run a Google application." He notes that the lack of standardization in commercial buildings — and that each one is a one-off product— inhibits connectivity between systems.

Although many control systems are compliant with BACnet, a communications protocol created over 25 years ago, this standard is insufficient in many ways. As Andrew Krioukov points out, BACnet was developed before the internet became a standard, and was designed to communicate via a serial port or dial-up modem. It provides only a low-level communications standard, it lacks metadata needed to describe equipment and sensors, and its use varies considerably between vendors. Considering that a single air handling unit may have as many as 30 sensor points (pressure, flow, speed, valve status, etc.) this lack of uniformity is problematic, and is a barrier to the creation of applications that can be deployed at scale with low cost.

**Data and communications standards developed decades ago — but still in use — are insufficient for today's big-data challenges.**

## Building technology development at UC Berkeley

To overcome these barriers to connecting building data, a common data platform with standardized metadata conventions is needed. Several research efforts at UC Berkeley are focused on this goal, and may also improve our ability to effectively monitor and control buildings.

CBE Research Specialists Paul Raftery and Tyler Hoyt are collaborating with other UCB departments in creating new software tools that will better visualize building data and optimize control sequences, and will be tested in several UC Berkeley campus buildings.

For example, as part of CBE's "Changing the Rules" project (*Centerline* Summer 2013), researchers are developing and testing office chairs with battery-powered heating and cooling elements that allow users to control for their own comfort. The data from the chairs will ultimately be used in real time to control HVAC systems, optimizing for comfort and energy savings.

CBE's team is using the open source framework sMAP (Simple Measurement and Actuation Profile) developed by UC Berkeley EECS faculty and students. The sMAP framework provides a common architecture for metadata, time series and other data to be stored and rapidly accessed, allowing for creation of new applications. The system is agnostic regarding where data comes from, it can be from BMSs, BACnet, thermostats, lighting, or weather data sources. Many of the ideas that emerged from the sMAP

development have been adopted by research groups on campus, and by a few local cleantech startups.

In addition to these efforts, colleagues at UC Berkeley's i4 Energy are developing OpenBAS, an open-source building automation system for small and mid-sized buildings that are rarely equipped with BASs to manage HVAC and other systems. Finally, advances in micro-electrical-mechanical systems (MEMS), such as the accelerometers and gyroscopes that enable many smartphone applications, provide new tools that may lead to additional creative solutions. Several companies and innovations based on MEMS research have emerged from research conducted at the UC Berkeley Sensor and Actuator Center (BSAC).

## Trading data for services

In addition to improving services for building users, the IoT may offer societal benefits by reducing the energy use and environmental impacts of building operation. Lindsay Baker, a UC Berkeley PhD student also working with Building Robotics, explains that more granular occupancy data can help buildings to provide lighting and conditioning only when needed, while better serving the needs of people. "We don't know exactly where this is going to go, but many opportunities come to mind, for example in healthcare settings, and to serve people with mobility and other needs. Another example is a smoke detector that could blink lights on and off in case of a fire, to alert people who cannot hear the alarms."

With any data sharing, especially with personal data, issues of security, confidentiality and data reliability come to mind. Most people have little sense of the amount of data mining that is already being done with their personal data. For anyone with a smartphone or tablet with GPS, our wireless providers (and many companies that provide apps) can already track our every move, day and night. But Lindsay Baker thinks that if people are given a useful benefit, they will share data. For example, we readily use Gmail in exchange for allowing the company to mine our email text in order to show us targeted ads. A recently published laboratory study of a social media energy application, conducted at CBE, shows that young adults would be willing to share energy data and goals in a workplace setting.

Some might also ask whether we can reliably control a building based on data from occupants. In some ways this is already being done, but primarily by way of complaints, certainly a poor measure of occupants' overall preferences. We also know that the conventional inputs from building sensors (such as thermostats) are frequently inaccurate, and in spite of the large number of sensor points available in commercial buildings, today's BMS products are poorly suited to store, process, and utilize this data.

With the many developments that are evolving around the IoT in buildings, it is still impossible at this point to predict which innovations will be truly disruptive and have major impacts. However when we consider the current state-of-the-art in commercial building information technologies, a future of optimized and connected buildings looks promising indeed.

## Links

**Wikipedia article on the IoT**
http://en.wikipedia.org/wiki/Internet_of_Things

**More than 30 billion devices will wirelessly connect to the internet of everything in 2020**
https://www.abiresearch.com/press/more-than-30-billion-devices-will-wirelessly-conne

**Cisco's Internet of Everything Value Index**
http://internetofeverything.cisco.com/explore/full#/country/usa

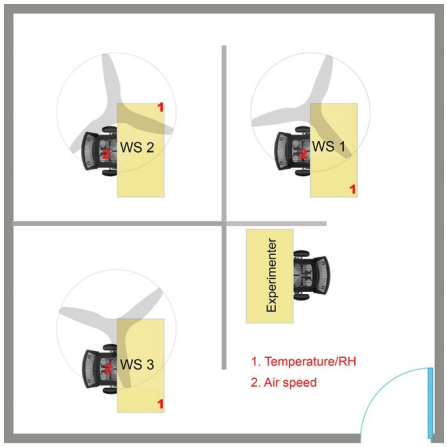
# Research Updates

## SenseME Control Technology Incorporates CBE Comfort Research

This spring CBE industry partner Big Ass Fans unveiled the SenseME control system as a new option for its Haiku line of energy efficient ceiling fans. The system is revolutionary in its ability to modulate fan speeds to provide tailored comfort, and was developed with input from thermal comfort researchers at CBE. While residential ceiling fans are typically controlled manually with wall switches, remotes or pull chains, SenseME is unique in its ability to automatically change the fan speeds based on occupancy, humidity and temperature in order to create highly comfortable conditions. The system also learns from users' preferences, which are highly variable, to further improve comfort.

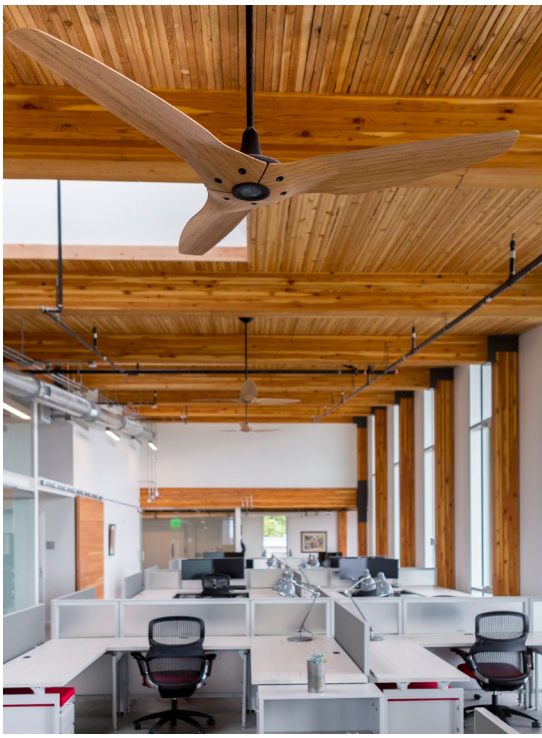
As an example of the benefit of this technology, consider a hot summer night, when a fast-moving fan provides cooling relief. But as rooms cool off, that same fast fan setting can lead to an unwelcome chilly wake up hours later. With intelligent control, the fan is gradually slowed down to maintain comfortable conditions, avoiding the need for manual adjustments as the room temperature changes.

Although thermal conditions in workplaces may not be as variable as those in homes, advanced fan control is likely to be beneficial in both private offices and shared workspaces, especially in low-energy passive buildings with wider temperature swings.




*above:* Diagrams of the fan testing configurations in CBE's environmental test chamber.

*right:* Haiku fans are used prominently at Seattle's Bullitt Center. Image: Big Ass Fans.



The development of SenseME was supported by researchers at CBE who conducted a series of tests in the UC Berkeley human test chamber, working closely with the engineering team at Big Ass Fans. The study was led by Hui Zhang and Yongchao Zhai, two CBE researchers who are recognized experts in thermal comfort. In the test chamber they varied the temperature, humidity level, and fan speeds, while 23 subjects worked on laptops and responded to online questionnaires about thermal sensation, comfort, air movement and perceived air quality. In some cases occupants could change the fan speeds, and in other cases the speed was fixed. Some subjects were also asked to spin a small set of bicycle pedals, to test the effects of increased activity.

Through regression analysis of the test results, the researchers then defined the relationships between

*(continued from page 7)*

these factors that would lead to the most comfortable conditions, taking into account the fact that people have a range of preferences about air movement. CBE's researchers also collaborated with the Big Ass Fans team on the temperature and fan speed logic.

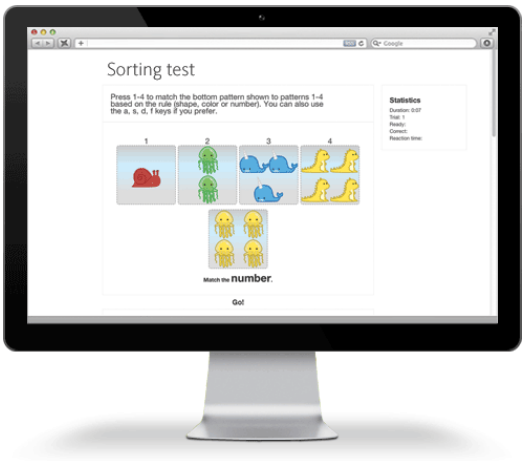
The collaboration between CBE and Big Ass Fans is an example of industry/university partnering, leading to benefits for customers and for the society at large by reducing energy usage and improving comfort for people in their homes and workplaces. The Haiku with SenseME has been featured on CNET, Business Insider, Gigaom, and other media. More information at: http://www.bigassfans.com/senseme/

*Editor's note: A related article in Low-Tech Magazine describes how ceiling fans are much more energy efficient than air conditioning, and how they can reduce peak electrical system loads.*

# New Research Compares Cognitive Functions and Environment

Accurately measuring workplace productivity represents an important but challenging research goal, as we reported in previous editions of *Centerline* (Summer 2012). A new study directed by UC Berkeley Assistant Professor Stefano Schiavon, in collaboration with a Singapore-Berkeley collaborative research center and Stanford University, is using new tools to investigate the impacts of thermal factors on cognitive function.

The project is studying "executive function," a set of cognitive processes that include our ability to manage our time and attention, to plan and organize, and to resist distractions and temptations. The goal is to learn to what degree executive function is affected by air speed, humidity, and temperature, in order to know whether certain energy-saving conditioning strategies are feasible in knowledge work settings. Previous CBE research showed that with personally controlled fans or with heated and cooled chairs, people are quite comfortable at temperatures as high as 86°F, an approach that can save significant energy and reduce peak loads. The previous tests were conducted with subjects who are accustomed to tropical climates, using personally controlled fans, in temperatures from 73°F to 84°F, and with relative humidity of 60 percent.




Sample screen from the Quantified Self cognitive test. Image: Stanford University.

Schiavon is working with Yoni Donner, a PhD student at Stanford who also works on artificial intelligence with Google. He also leads the Quantified Mind project, a "mind hacking" research project looking at the impacts on cognition from drinking coffee, meditation, time-of-day, and even sex. The tests, completed this summer, used survey tools available from Quantified Mind and the Center for the Built Environment, and were supported by SinBerBEST, a collaboration between UC Berkeley, universities and agencies in Singapore, and other academic and corporate partners. The results are expected to be released in spring of 2015.

# Partner News

## New CBE Partners Represent Many Facets of the Commercial Building Sector

We welcomed five new industry partners to CBE's industry consortium this spring. These members represent firms and agencies across the diversity of the building sector, including building materials, technology, architecture, engineering, and commercial building operations. At last April's advisory board conference we enjoyed participation from representatives of these firms, and we look forward to working with them on synergies and future collaborations.

**BASF Corporation** is the world's largest chemical company, and operates in a variety of market segments. With offices around the globe, they employ over 112,000 people, including 17,000 in North America. Their portfolio ranges from chemicals, plastics, performance products, functional solutions and agricultural solutions to oil and gas. BASF's Center for Building Excellence serves as a conduit to the depth and breadth of BASF's innovative technologies, and provides solutions for design and construction challenges. Their team includes building scientists, architects, engineers, and sustainable construction experts. BASF aims to solve challenges in the built environment through sustainable, high-performance solutions. As a provider of raw materials, systems and finish products to the construction industry, BASF delivers economically and ecologically sound solutions that facilitate high-quality construction. Their products aim to increase resource and energy efficiency, and to improve building life expectancy, thus lowering expenditure on maintenance and repairs.

The BASF House at the University of Nottingham showcases energy efficient technologies. Image: BASF.

International firm **BuroHappold Engineering** also joined CBE in April 2014. Over the past 40 years, they have teamed up with leading architects and collaborated with global organizations such as the United Nations, The World Bank, and UNESCO. Focused at the building and city level, they work with their clients to find innovative and sustainable solutions for every project. Their team includes a wide range of engineers, innovative thinkers, economists, and planners, with diverse skill sets. Projects include stadiums, academic buildings, bridges, transportation (including San Francisco's Transbay Terminal, currently under construction), commercial offices, and more. They have been at the forefront of low and zero-energy building design, evident in some of their recently completed projects. They were on the team for the net-zero Morphosis LA Office, the Honorable Mention of the 2013 CBE Livable Buildings Award. Their recently completed Hawaii Prep Academy received LEED Platinum and is the third project to receive "Living" status under the Living Building Challenge. The building's cost-effective passive design demonstrates net-zero energy and water performance and an aesthetically pleasing solution.

Global technology leader **Google** also joined CBE this spring. Their Real Estate and Workplace Services group is responsible for creating and maintaining spaces that encourage high productivity for thousands of Google employees all over the world. When it

*above left:* BuroHappold was on the project team for the Hawaii Preparatory Academy, only the third recipient of *Living* status under the Living Building Challenge. Photo: Matthew Millman.

*above right:* Google aims to create workspaces that put the health and well-being of the users first. Photo: Christophe Wu, Google.

*(New CBE members, continued)*

comes to building office environments, Google applies the same focus as any of their other products: put the user first. From concept through design, construction and building operations, they strive to create workplaces that positively impact the health and well-being of their employees, both now and 30 years from now. They construct healthy workplaces by approaching buildings as living systems, designing for daylight, clean air, and removal of harmful toxins and chemicals.

The **U.S. General Services Administration** was one of CBE's founding members, and recently rejoined CBE after a short hiatus. GSA focuses on creating great work environments, providing workspaces, security, furniture, equipment, supplies, and communications. GSA currently employs 15,000 people and accounts for nearly $65 billion in goods and services contracts. GSA has been a valuable supporter of CBE, and was instrumental in the development of the CBE Occupant Survey beginning over 15 years ago. GSA's Office of Federal High-Performance Green Buildings is conducting research at three recently completed new construction and major modernization projects to: (1) study the impacts of natural daylighting on human health and identify health outcomes linked to light exposure. This could have far reaching impact on sustainable lighting design as a means to achieve energy goals and enhance health and well-being, improve work effectiveness, and reduce long-term health problems; and (2) examine the integrated project delivery (IPD) process and link high performance outcomes with decisions made

*(New CBE members, continued)*

during the design and construction processes. This will be useful as GSA's project teams support future projects, influence improvements to the government procurement process, and offer lessons learned for implementing integrated processes and performance contracting.

Award-winning architecture and planning firm **WRNS Studio** joined CBE in April as part of the Taylor Engineering membership team in April. The 60-person firm, based in San Francisco, creates sustainable places for work, play, health, transit, and civic engagement. Recent projects include multiple buildings at UCSF Mission Bay, Adobe's corporate campus in Utah, expansion of Intuit's Mountain View campus, and the Hayes Valley Playground in San Francisco. They have received over 30 design awards since their founding in 2005, including an AIA COTE Top Ten Green Projects Award, several AIA design awards, and being named *Architect* magazine's top firm of 2013. WRNS Studios' design ethic is informed by sensitivity to place, contextual engagement, technical proficiency, and conservation. Currently, they are utilizing the CBE IEQ Occupant Survey for a large project with the Hawaii Department of Education. They are leading a project team to improve schools across Hawaii to become more sustainable and healthier for the students, teachers, and other faculty.

*top:* The Sacred Heart Schools' Stevens Net Zero Library, in Atherton, CA by WRNS Studio is LEED Platinum and designed to meet three petals for the Living Building Challenge. Photo: Bruce Damonte.

*above:* U.S. GSA's Federal Center South Building 1202 near Seattle, WA, was awarded an AIA Top Ten Green Projects Award in 2012. Architecture: ZGF; Photo: Benjamin Benschneider.

# Livable Buildings 2014

## Two zero-net energy buildings combine excellent occupant satisfaction with high ecological response.


2014 Livable Buildings Award winner: David and Lucile Packard Foundation Headquarters, Los Altos, CA. Photo: Jeremy Bittermann.

We are excited to announce the winners of this year's Livable Buildings Award, two buildings that keep occupants happy and productive, and demonstrate excellence in design and sustainability.

This year's winner, the **David and Lucile Packard Foundation Headquarters**, was envisioned not only as a sustainable building, but the project goals went beyond the building to advance the foundation's overall sustainability as a whole. The integrated design team, including transportation planners, sustainable food experts and the foundation's newly formed sustainable task force, began with an assessment of the organization's overall greenhouse gas impacts. They found that commuting, travel, and building energy use each represented about a third of these emissions. The team then developed strategies to address each sector, and to reduce the entire carbon footprint by 80 percent by 2050. Getting their building to zero-net energy was a key first step, and will reduce total emissions by 35 percent. The building received Net Zero Energy Certification through the International Living Future Institute by meeting net-zero energy use in its first year of operation. It is the largest net-zero energy certified building to date in ILFI's program.

Located in Los Altos, California, the building brings together employees previously in separate buildings. It includes open workstations, some private offices, and a variety of communal and social spaces. The project team, composed of many CBE

partners, including EHDD Architecture, DPR Construction, Integral Group, and Charles M. Salter Associates, used feedback from the CBE occupant survey to go back and modify problems that were brought up (such as glare and daylighting issues) in order to create a building that operates at maximum comfort for its occupants. Award program jurors commended the team for such diligence in remedying occupant issues.

Scott Shell, Principal with EHDD Architecture, says that he and his colleagues are happy to get news of their third Livable Building Award, "It's hard to think of a higher honor than one based on the occupants' personal experience of the building."

The award jury also recognized with an Honorable Mention the **DPR Construction Southwest Headquarters** in Phoenix, Arizona. This net-zero energy project repurposed an existing building, keeping much of the original fabric as part of the sustainable approach. The building exhibits dozens of innovative low energy design ideas, including roll-up doors, ceiling fans, photovoltaic panels, LED lighting, a living green screen, and a "solar chimney" that has high-level operable windows and evaporative cooling towers for passive cooling. Meeting ZNE goals while keeping people comfortable in Phoenix's challenging climate is a noteworthy accomplishment.

We congratulate these winners and all the finalists of this year's award, as very few buildings meet the high qualifications to compete for this award.

CBE would also like to thank the program jurors for their time and consideration of all the submissions: Ed Clark, ZGF; Rick D'Amato, LPA; Paul Erickson, AEI; Don Horn, GSA; Anne Less, Google; and Tony Saracino, BASF. Their expertise and diverse backgrounds were valuable throughout the review process.

This award program is unique in its inclusion of building occupant satisfaction in its selection criteria. To be considered for the award, now in its eighth year, buildings must rank among the top scorers in CBE's Occupant Indoor Environmental Quality Survey, which has been implemented in over 650 buildings around the world. The key categories of the survey, along with resource efficiency and architectural design, are assessed by a panel of jurors.

Honorable Mention: DPR Construction Southwest Headquarters, Phoenix, AZ. Photos courtesy of DPR Construction.

# People

## Research Appointee Yongchao Zhai Brings Expertise on Thermal Comfort and Low-Energy Design

The most recent addition to CBE's research team, Yongchao Zhai, joined our team this spring as a post-doctoral researcher. However, Yongchao is not entirely new to CBE, as he has been a valuable contributor to CBE's work for several years working as a visiting scholar from South China University of Technology (Guangzhou), where he received his doctorate in 2013. He previously earned a Bachelor's degree in Architectural Design from Shandong University in 2006. Yongchao brings a wide set of skills and knowledge to CBE's research, and he has been a key team member for numerous laboratory and field studies focused on thermal comfort, natural ventilation, personal comfort systems, and automotive cabin conditioning. He led studies conducted in CBE's environmental test chamber to evaluate the effectiveness of ceiling and pedestal fans to maintain comfort in warm and humid conditions, building on CBE's efforts to bring energy-conserving personal comfort systems into the mainstream. His dissertation topic was on air movement and comfort in hot and humid climates, for which he also used the environmental test chamber.

Most recently he led the chamber study in collaboration with CBE partner Big Ass Fans that supported the company in the creation of the SenseME control system now available on the Haiku fan (see page 7.)

In addition to his work in building environments, he has also worked on comfort studies in collaboration with automotive manufacturer Hyundai-Kia, and with Faurecia, a global manufacturer of automotive systems.

Going forward with his work at CBE, Yongchao aspires to bring together what he has learned from these studies, adding a human element into the control and operation of buildings. He plans to work towards the development of automated building systems that integrate occupant feedback, along with intelligent control of operable windows and fans, into an integrated system. In addition to his work, Yongchao is also known as the undisputed champion in ping pong among CBE staff.

Post-doctoral researcher Yongchao Zhai.

# Interview

## David Heinzerling

Mechanical Designer, Taylor Engineering

**You are working with one of CBE's industry partners, a leader in HVAC design. What exciting projects are you are working on?**

The biggest one is the expansion for the San Francisco Museum of Modern Art. When I started at Taylor a year and a half ago, it was in final construction documents. I got on the project then, and now I am the main person working on the construction administration.

**That is a lot of responsibility, how are you managing it?**

One of the senior engineers took me under his wing, I worked closely with him for one year, and learned a lot. It has been good to get exposed to such a wide variety of issues all at once, it's a bit overwhelming, but Steve Taylor has been helping and checking all my work. I probably learned more in one year than some would learn in many years. It's a complicated and unusual system, and I do jobsite walks about every other week, and get to crawl around in the existing building.

**Have you had to climb any scary ladders?**

Not yet, I am terrible with heights. Most of what I have seen has been pretty safe, but the roof at MOMA just has a cable around the edge.

**Are you working on other interesting projects?**

Another one is the Marine Lab Biology Building at UC Santa Cruz, at the J.M. Long Marine Laboratory, with EHDD. It's right on the coast, so there is no central cooling, it's done with economizer operation; this is unusual in a lab building.

**Great projects. What else do you enjoy about your work?**

The best thing is getting to learn something new every day, there is so much to absorb. And working on teams with architects and other engineers to solve problems. This is interesting, working on communication and diplomacy.

**Diplomacy is important in a team. I think you would be good at that.**

I think so, some might say I'm too nice to the architects! But I've learned a lot about good team communication, and the importance of communicating design challenges early and often.

**Are there things about the job that are unexpected?**

I was surprised about how much BIM and Revit have infiltrated the market, and the level of detailed coordination done. It's also been a bit overwhelming, in the sheer amount to learn and feel comfortable with. But I would say that in three to five years I will be in a good spot to do a lot of the work in our office comfortably.

David Heinzerling with fiancée Katie Ackerly, UC Berkeley building science/ architecture graduate.

**When you were a graduate student researcher you worked on technically challenging projects at CBE. Has that experience been applicable to your current work?**

Taylor has a project called TOPP, or the theoretical optimum plant performance — we developed models and run scenarios to identify the most optimum control sequences for chilled water plants. I took this project over and improved the code, and now [Taylor Principal] Allan Daly has me writing code so we can do optimization in real time for his startup company, BrightBox Technologies. I am using the same set of programming tools I used for my thesis work at Berkeley, so yes, that experience has been useful.

# Events

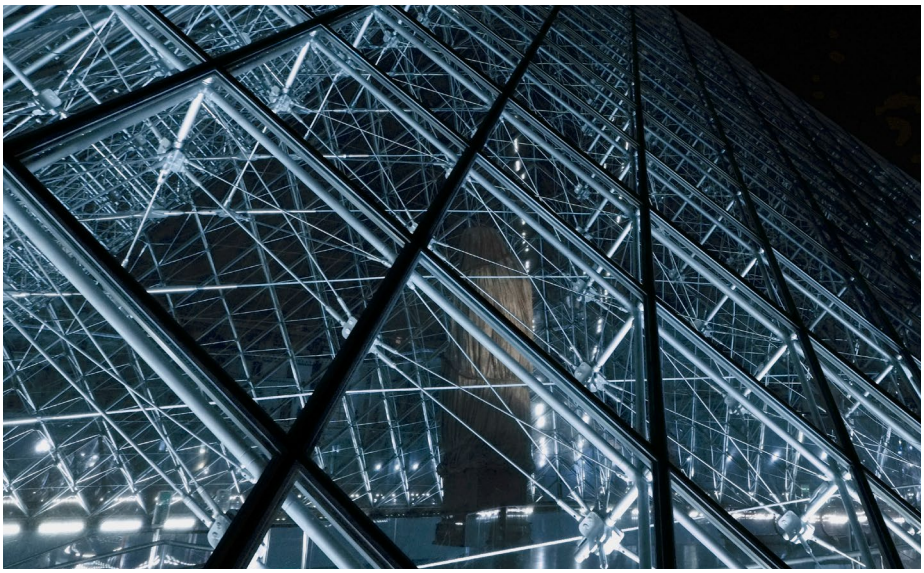
## October Symposium on Glass in Architecture will Consider Aesthetic Goals and Physical Performance

In coordination with CBE's October Industry Advisory Board Conference, CBE is collaborating with the Golden Gate Chapter of ASHRAE and the PG&E Pacific Energy Center to host a symposium that will explore the many benefits of windows including views, daylighting, the potential for natural ventilation and increased economic value.

Expert speakers and panelists will discuss emerging window technologies, techniques for modeling windows in energy simulation programs, how the design of HVAC systems are influenced by windows, how to design windows to maximize the daylighting benefits, and issues related to codes, standards and testing.

The speakers will represent perspectives from architecture, engineering, building science, property management, and others (including many current and past CBE industry partners).

The October 8th event is free and open to the public. Please use the registration links at right for the San



### Glass in Architecture: Balancing Beauty, Light, Air, Comfort and Energy

**October 8, 2014**
**9:00 AM – 4:00 PM**

On site at 851 Howard Street, San Francisco, CA 94103

Also available by live webcast.

Read speakers bios and the detailed schedule in the **online brochure**.

Register for San Francisco class:
**www.pge.com/pec/classes/7088.htm**

Register for the live webcast:
**www.pge.com/pec/classes/7094.htm**

CBE is a participant, partner or is otherwise supporting the following events that may be of interest to CBE members and others:


## Emerging Technologies Summit 2014 Oct. 20-22, San Francisco, CA

The **ET Summit** spans the intersection of energy efficiency and demand response programs, technology, market drivers, customer engagement, policy and implementation for accelerated advancement and adoption of emerging technologies. This year's event includes optional tours at UC Davis, an opening night reception at the LEED Platinum Exploratorium, and unique events such as a "shark tank" session where innovators will present and defend their solutions.


## Well 2014: Oct. 20, New Orleans, LA

**WELL 2014** is the first annual symposium for design, construction, and real estate professionals who want to lead the market and build a movement for wellness real estate – a pioneering concept that marries design and construction with evidence-based technologies to support personal well being and health.

Several speakers have worked with us here at CBE, including Lindsay Baker of Building Robotics, Judith Heerwagen of U.S. GSA, and Whitney Austin Gray, of Cannon Design.


## Greenbuild 2014 Conference and Expo Oct. 22-24, New Orleans, LA

We hope to see many of you at **Greenbuild** this year, please stop by our booth #123 in the non-profit section. Organized by the USGBC, Greenbuild is the premier event for sustainable building.

Prof. Gail Brager will participate in the session on "Experiential Aesthetics: Bridging Research And Practice." Session C08, Wednesday, October 22, 2:00 – 4:00 PM. Co-presenters include Eric Soladay of Integral Group, and Bob Harris of Lake|Flato Architects.


## VERGE SF 2014: Oct. 27-30, 2014

GreenBiz Group's flagship **VERGE San Francisco** conference will convene the world's largest companies, most progressive cities, and brightest innovators to examine the technologies and systems that accelerate sustainability across sectors.

This year's event has an impressive lineup of leaders in energy, sustainability and technology, including Biomimicry Institute Founder Janine Benyus, Chief Scientist of RMI Amory Lovins, and many more.

CBE is a proud partner of VERGE: Save 10% with our discount code VSF14CBE. **Register soon** to take advantage of the Early Bird rate, ending September 20.

# 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 the design and operation of commercial buildings through their collaborations with CBE.

The Center's membership is comprised of the following firms and organizations (including firms joining October 2014):

Affiliated Engineers, Inc.
Armstrong World Industries
Arup*
BASF Corporation
Big Ass Fans
Buro Happold
California Energy Commission
Charles M. Salter Associates
Delos Living LLC
DIALOG
EHDD Architecture
Google, Inc.
HGA Architects and Engineers
Integral Group Membership Team:
- Integral Group
- CPP
- DPR Construction
- P2S Engineering
- Perkins+Will

LPA Inc.
Pacific Gas & Electric Company
Price Industries
REHAU
RTKL Associates
San Diego Gas & Electric
Skidmore, Owings & Merrill (SOM)
Southern California Edison
Stantec
Syska Hennessy Group
Taylor Membership Team:
- Taylor Engineering
- Atelier Ten
- HOK
- Southland Industries
- WRNS Studio

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Webcor Builders*
WSP
Yost Grube Hall Architecture (YGH)
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