centerline

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

Summer 2011

CLEANTECH
in the building sector

Director's Note

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Dear Industry Partners,

Our feature article in this edition of *Centerline* focuses on the cleantech revolution, and describes how research by organizations such as CBE can support the development of new green building products. We share insights from innovators such as CBE researcher Charlie Huizenga, whose wireless lighting prototype led to the founding of cleantech startup Adura Technologies.

We include updates on several ongoing and new research projects, and also articles describing three new projects designed by CBE partner firms. These projects represent creative directions in sustainable design, and we are excited to share with you the strategies and valuable lessons learned from these projects. We are also pleased to introduce our newest industry partner firm, REHAU, an international provider of polymer solutions for construction, automotive and industry; we look forward to their leadership and insight regarding our research on radiant systems and other energy-efficient technologies.

Finally, we update you with recent news about our research staff, including new faculty and staff hires who are already making positive contributions to our work. I hope you are having an enjoyable summer, and on behalf of our faculty, staff and students, wish to thank you for your support and participation.

Sincerely,
Edward Arens

Clean Technology Innovation in the Building Sector

by David Lehrer

Anyone who has recently visited a green-building product expo, such as USGBC's annual Greenbuild event, will know that the range of innovative green building products has exploded in recent years. Multiple factors drive this growth, including manufacturers expanding their product lines, companies pursuing new market opportunities, and venture capital firms and private investors seeking profits by backing new products, technologies, and companies.

Industry watchers say that venture capital investment in clean energy technologies has proceeded at a rapid rate over the last decade, with growth rates reminiscent of previous investment expansions such as those seen in computer hardware and internet advances. According to a recent report by Clean Edge, a research firm focused on clean energy markets, the percentage of total U.S. venture capital invested in clean technology companies grew from less than one percent in 2000 to over 23 percent in 2010. Revenues for many clean energy technologies also grew steadily during this time — the global market for solar photovoltaics (PVs) grew from $2.5 billion in 2000 to over $71 billion in 2010, an annual growth rate of close to 40 percent. The Clean Edge report predicts that we will see this expansion continue, and estimates that the combined market for wind, PVs, and biofuel technologies will grow by over 80 percent in the current decade, from $188 billion in 2010, to $349 billion by 2020.

Clean /greentech innovation in commercial buildings

While no index for green building investment exists, a recent report by Greenbiz Group Inc. notes that LEED floor area construction represented over 20 percent of all new construction for 2010. For some companies, LEED-registered projects represent a much larger share. Phil Williams, Vice President of Webcor Consulting Group, and CBE's Partner Chair, explains: "LEED has become the base standard of quality for us, and now over 95 percent of Webcor's projects are LEED projects." Phil believes that keeping up with the latest clean/green tech developments is an important aspect of his work. "At Webcor our makeup is to be innovative, and we need to make our projects 'future ready,' to allow buildings to integrate these new improvements." For example, as PVs are expected to become more efficient and less costly, Webcor advises clients to provide sufficient infrastructure (e.g., conduit paths and space for electrical equipment) so that if they are not ready to invest today, building owners can more economically add PV arrays when the technology becomes more financially attractive. Phil has been involved in the cleantech sector since 2008, after he was invited to speak at a cleantech forum. With his experience with construction processes and supply chain issues, he was approached by venture capital firms and product manufacturers to provide insight on potential green building products and investments. He currently serves on the advisory boards for the venture capital firm Navitas Capital, that invests in energy efficiency and green building technologies, as well as startup greentech firms such as Soladigm and Serious Energy. In addition, Phil is frequently consulted by other clean/greentech VC firms including Nth Power and Kleiner Perkins Caufield & Byers.

Cleantech venture capital may be a powerful driver for new green building product development. The building sector, however, poses unique challenges for both investors and product developers.

Phil makes a distinction between "greentech" which he uses to describe building products, and "cleantech" to describe renewable energy technologies such as wind, PV, and biofuels. He points out that the growth rates for renewables is not necessarily matched in energy-efficient building technologies, especially since the economic downturn of recent years, and a number of challenges can hinder the adoption of new technologies. "Buildings are a lot more complicated than people think, and although owners may benefit from these new products, architects and engineers are the ones who specify them. Using new and innovative products increase risk and time in the design process." Phil notes that for new products to be successful, they have to be geared for use existing buildings, since new construction only represents about one to two percent of the total square footage of the commercial building stock annually.

Charlie Huizenga, chief scientist and co-founder of Adura.

Financing cleantech products

Before a new product will be considered by investors, the product team must clear a number of hurdles. Charlie Huizenga, a research specialist with CBE and also chief scientist and co-founder of Adura Technologies, understands firsthand the challenges of securing investment dollars. While his development and testing of a new wireless lighting control concept proceeded relatively quickly, he discovered that securing investments and commercializing the product was more challenging than he expected. He says that the technology of a potential product is not necessarily the top consideration for potential investors. "The first thing they want to know is whether the management team has the experience of leading a company from the start-up phase to a successful financial exit for investors." The next consideration is whether the business model is scalable, "investors are not interested in organic growth of 20 or even 50 percent each year, they want to be able to grow the company by a factor of 100 in a few years." Other top considerations are the attractiveness of the financials (i.e., will the product make money) and the level of protection a product has from potential imitators.

Like many start-ups, the key ideas that led to the founding of Adura Technologies had humble beginnings, in this case in CBE's building science laboratory. Beginning in 2004, Charlie devised a concept for a wireless lighting control system that would take advantage of new technology innovations that had been developed by faculty and students at UC Berkeley. Self-configuring,"ubiquitous sensor networks" that used low-power

radio technologies, using miniature "motes," provided a framework for low-cost wireless networks that could be valuable in numerous applications and industries. With a modest grant of $20,000 from CBE's membership consortium, Charlie and one graduate student produced the first prototypes and tested them in four workstations in CBE's office space. A short video was produced to show the simplicity of the installation, which takes only minutes to complete. When the work was first presented to CBE's consortium members, the response was highly positive, in fact several members offered the use of their offices for pilot installations.

The concept was soon advanced with a $75,000 grant from the California Energy Commission PIER program, which funded a larger pilot that resulted in a 65 percent savings in lighting energy. The system also captured the interest of two MBA students from the UC Berkeley Haas School of Business, Zach Gentry and Josh Mooney, who used the concept as their final business plan project.

The two Haas graduates soon became business partners with Charlie and founded Adura Technologies. The firm went on to gain numerous accolades, including a $100,000 award from the Cleantech Open in 2006. In 2008 Adura secured its first equity financing from VantagePoint Capital Partners and Claremont Creek Ventures. The initial $5 million investment allowed the firm to expand, and to hire senior managers and staff with experience in developing and marketing technology-based products. The financing also allowed Adura to extend its product line and roll out an enterprise software solution scalable to large facilities and campuses. Many of the company's completed installations have demonstrated energy savings of over 50 percent, and up to 70 percent during demand response events, compared to a system with no control capability. This proven energy saving potential helped the firm to raise an additional $12 million from its investors, which now include NGEN Partners.

The company has completed installations in over two-million square feet of commercial building floor space and is planning several large installations in the near future. Upcoming deployments span a variety of building applications for customers such as CSU Long Beach, the City of Pleasanton Public Library, and the historic Hills Plaza Building in San Francisco. Charlie explains that the Adura team is continuing to refine its product lines, and that continuing to reduce the price of the products is an ongoing concern. To streamline production and reduce costs, the product development team includes manufacturing experts who understand the complex issues of designing, sourcing, and assembling electronic devices.

CBE Research Specialist Hui Zhang tests comfort controls during a recent demonstration of Tempronics' chair prototype.

New workplace comfort concept to be tested

Adura's success shows how seed funding and input from CBE's consortium members can be leveraged by larger funding sources, and grow to have significant impacts on the building industry at large. We will soon have an opportunity to support another innovative product concept,

one that is closely related to our ongoing research on thermal comfort with personalized environmental control (PEC) devices such as fans, footwarmers, and heated or cooled keyboards. Tempronics, a firm based in Tucson, Arizona, is developing new products utilizing solid-state thermoelectric chips that offer a number of advantages over mechanical refrigeration. One of the concepts being pursued by Tempronics is an office chair that would allow users to control the temperature of their chair, providing the user with either cooling or heating as desired. The company exhibited a prototype of its chair at Neocon this past June and received enthusiastic feedback from those who tried it.

Tarek Makansi, founder and CEO of Tempronics, recently contacted CBE at the suggestion of Phil Williams, who has acted as an informal advisor for Nth Power, a San Francisco-based VC firm that is backing Tempronics. Tarek has been involved in the development of the chair and other products using thermoelectric chips, and is seeking business partners to manufacture and market products that incorporate their technology. He thinks that the chair represents a paradigm shift in terms of how people think about personal comfort and control in an office environment. "Temperature is one of the most common complaints for building operators. If a worker is comfortable in their chair, it may be fine for the air temperature to be warmer or cooler. There is nothing like this in the marketplace today, and it could provide enormous value for saving energy in space heating and cooling, as research by CBE has already shown."

CBE and Tempronics are developing plans for testing the chair prototype using human subjects in CBE's thermal test chamber. The objective of the study will be to identify the level of comfort provided by the chair in comparison to a conventional chair, its ability to keep people comfortable over a range of temperatures, and its energy consumption under varying test conditions. Research Specialist Hui Zhang says that CBE's research team is very interested in this product concept, as CBE has done extensive research on the ability of PEC devices to provide building occupants with improved comfort and control. "Our research shows that these personal control devices can keep people comfortable over a wide range of temperatures. By allowing indoor temperatures to vary more on a daily or seasonal basis we can really reduce HVAC energy use." (CBE's simulations show that HVAC energy use can be reduced by 7-15 percent for each degree of increased thermostat "dead band.") In the case of the Tempronics chair, Tarek Makansi notes anecdotally that people have been comfortable in the cooled chair even when temperatures were above 80 °F.

The system by Architectural Applications integrates a translucent, selectively permeable membrane within the glazing cavity. Image: Architectural Applications.

Former CBE partner launches cleantech venture

Another commercial building product now in development will use membranes to reduce humidity and provide comfort in humid climates where air conditioning use is intensive. John Breshears, an architect and engineer who was previously with CBE partner firm ZGF Architects, launched his company last year based on a concept that he developed while working as a research fellow with Arup during the mid '90s. Although the term biomimicry had not yet become commonplace, John looked at fields such as biology and medicine to come up with concepts that could be applied to energy in buildings. He found inspiration in natural membranes such as those in plants, fish gills, and the

human lung that efficiently control the passage of gasses and liquids. He designed a system to incorporate a membrane into a building envelope that can reduce humidity at ambient air pressures.

After John's Arup fellowship ended, his product idea went dormant, but with the recent interest in cleantech, the concept is moving closer to reality. "Back then no one knew what to do with this, but now the time appears to be right," he says. John received funding from ARPA-E, a program sponsored by the U.S. Department of Energy to promote energy research, technology transfer, and industrial innovation. The one-year grant is supporting proof-of-concept research being conducted in collaboration with the Building Technologies Department at LBNL, and Membrane Technology & Research Inc. of Menlo Park, California. The team has already developed the membrane and a bench-scale prototype that is now being tested.

In the pursuit of funding and business partners, John has come up against many challenges. "Venture capital investors typically look for returns in 5-8 years. The product cycles and scaling rates in the buildings sector are not well matched to those expectations. If I could get a design team to specify my product today, it might be three years before it would appear on the building and another 3-5 years beyond that for a second generation of customers to adopt it The construction industry is inherently slow to change in many ways." In spite of these challenges, John has found his role as a cleantech entrepreneur to be highly rewarding. "It's been a bit of a roller coaster ride, but it has been a very stimulating and educational year, and I am constantly exposed to new ideas and ways of thinking," he says.

Future directions for commercial building cleantech

Developments from the cleantech sector continue to provide technology and business news. In 2010 the Obama administration announced plans to hire more scientific reviewers to reduce the time needed for new patent reviews from two years to two months, in hopes of accepting up to 3000 clean energy applications in 2011. A recent Brookings Institute study notes that the "clean economy employs more workers than the fossil fuel industry," and that on average, cleantech jobs provide higher pay than other sectors.

While analysts such as Clean Edge predict continuing growth of cleantech investment and markets, building industry insiders such as Phil Williams cite specific areas where innovation is most needed. "For me, the number one priority is improving the envelope, number two is adding wireless technology for HVAC, plug loads, and lighting. This can save money by not having to remove ceiling tiles during retrofits. But how we power these wireless devices is also important, so I like to say 'wireless and batteryless.'" Phil would advise potential product developers to consider how nature solves problems, and to consider the longevity of buildings when making design decisions. "These buildings are going to last a long time, so the design and construction which can take about four years will have impacts for 20 to 200 years. Taking ideas from nature, and using biomimicry are good ideas. In terms of cleantech, you could say that Mother Nature has a good business case."

Links and References

Clean Energy Trends 2011, Clean Edge
http://www.cleanedge.com/reports/pdf/Trends2011.pdf

Sizing the Clean Economy: A National and Regional Green Jobs Assessment
http://www.brookings.edu/reports/2011/0713_clean_economy.aspx

CBE Personal Environmental Control Research
http://www.cbe.berkeley.edu/research/pec.htm

Adura Technologies
http://www.aduratech.com

Tempronics
http://www.tempronics.com

Project Updates

New Software Will Improve Access to Occupant IEQ Survey Data

The CBE Indoor Environmental Quality (IEQ) Survey has been a core part of CBE's research for over ten years, and it allows our researchers — as well as designers, owners and managers — to collect and analyze valuable feedback from building occupants. The software tools currently used to run surveys and to view results were initially developed in the late '90s, with support from the U.S. General Services Administration that used the survey to evaluate the management of hundreds of its properties. Since then the use of the survey has grown, and has been adapted for studying schools, labs, multi-unit residential buildings, and healthcare facilities. With over 600 buildings included, the survey database now provides a rich data set for understanding workplace occupant comfort and satisfaction trends.

In order to keep up with the growing use of the survey, CBE is now working to upgrade the software that underlies the project. Research Specialist John Goins, who manages the survey research, says that the goal of the software upgrades is to provide better tools for the growing number of researchers and professionals using the survey and its database. "We also want to make it available to newcomers to the IEQ world, for example, people using it for LEED points and the new PMP standard."

The survey team is exploring new survey visualizations with tools such as Tableau.

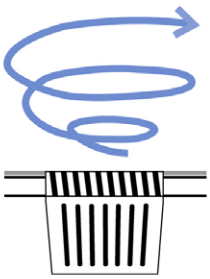
(PMP refers to ASHRAE's new Performance Measurement Protocol, which specifies the use of surveys as a primary measurement tool.) In planning for the software upgrade, John first created a detailed list of software requirements, describing the features users would find most valuable. The list outlines the features of the current version, those to be included in the forthcoming version, and also the "nice to have" features for future releases. To support the software development, CBE hired Ken Craft, a recent graduate in computer science from Cal State East Bay, and Fareshteh Farhangi, a local computer programming consultant.

The team is working on a prototype of the new reporting tool interface, which will merge the features of the current "building scorecard" that shows single building results, with an interface that will allow users to do more complex analysis, for example, being able to filter the set of baseline buildings used for comparison. The reporting tool will include many information displays now in the current version, including percentile ranking displays ("s-curves" in CBE survey jargon), summary graphs, and histograms. The new version will also include advanced features such as box-charts and a dashboard-style screen to give users an overview of a survey results at a glance. The project team plans to release a prototype of the reporting tool this fall to industry partners for beta testing and feedback.

New Resources for UFAD Design and Compliance

This spring we released an online version of CBE's cooling load design tool. This simplified, practical design tool is useful for determining cooling load and design airflow requirements for underfloor air distribution (UFAD) systems. We encourage you to try the tool which is available at:
http://www.cbe.berkeley.edu/research/ufad_designtool-download.htm

To improve CBE's UFAD "toolkit," CBE's research team is currently developing a new software tool that will simplify energy studies for UFAD buildings. This tool will allow users to quickly explore the impact of certain design options without actually having to use EnergyPlus/UFAD software. The group is conducting a parametric study, running hundreds of EnergyPlus simulations to compile a database of simulation results. The team will create an interface that will allow users to query the database using a range of parameters such as building size, aspect ratio, window-wall ratio, and UFAD system configuration (including five options for the plenum design). We expect to release a demo version by the end of the year.



Revised UFAD Design Guide

The Design Guide on Underfloor Air Distribution (UFAD) Systems, originally published by ASHRAE in 2003, has been undergoing a revision that reflects recent advances in UFAD. In the eight years since the guide was released, new tools have been developed, many UFAD buildings have been evaluated, and our collective understanding of these systems has increased. CBE Research Specialist Fred Bauman, the author of the original guide, is participating on the ASHRAE committee that is working on the revision. Research Specialist Tom Webster and Assistant Prof. Stefano Schiavon are contributing new sections and chapters.

The project committee assembled its first draft of the revised guide at ASHRAE's annual conference in Montreal this past June. Committee members, who are volunteering their time to contribute to this effort, include several CBE partners including Bill Reynolds of Tate Access Floor, James Thompson of Haworth, Julian Rimmer of Price Industries, David Marciniak of the U.S. General Services Administration, and others. The draft, now under review, includes new and revised chapters on all aspects of UFAD design and operation, and results from years of CBE research. The revised guide is expected to be completed in summer of 2012. If you are interested in seeing the draft, contact Fred Bauman at: fbauman@berkeley.edu.

New Title-24 Compliance Method Proposed

Showing compliance with California's Title 24 energy code may get easier for design professionals working on UFAD systems. Researchers at CBE have proposed new procedures that would allow engineers and energy professionals to use EQuest to show Title 24 compliance for designs with UFAD systems.

Currently the only energy simulation tool that can reliably model UFAD buildings is EnergyPlus (CBE research provided the UFAD module for EnergyPlus in 2006.) However, only a relatively small number of firms use EnergyPlus on a regular basis, and it is not currently approved for Title 24 compliance calculations. To bridge this gap, CBE ran a large number of EnergyPlus simulations for UFAD and conventional overhead buildings, creating a set of adjustment factors for estimating UFAD performance from the output of eQUEST and EnergyPro DOE-2 programs. This recent work, funded by the California Energy Commission PIER program, was completed this spring. We anticipate that a new UFAD compliance method will be adopted in the 2013 revision to the Title 24 standards as an alternative compliance method (ACM), unless EnergyPlus is approved in the interim. For additional information please email Tom Webster at: twebster@berkeley.edu.

Comprehensive Case Studies Document Building Performance and Operations

CBE researchers have completed two reports that summarize the results of detailed field studies of commercial building design and operations. Both reports will be particularly useful to designers of green office buildings and members of organizations that own and/or operate office buildings.

In collaboration with CBE partner HOK, we completed a case study of the LEED Gold-certified CalSTRS' headquarters building in West Sacramento, California. This report addresses issues commonly observed in green building design and operations; and the recommendations it includes suggest ways to enhance the design process, improve operations efficiency and increase occupant satisfaction. Findings were developed from surveys and interviews of building occupants, building operators, owners' representatives and facilities staff. The report includes conclusions about use of the BMS, occupant controls, drought-tolerant landscaping, speech privacy and thermal comfort.

The CalSTRS report is online at: **http://cbe.berkeley.edu/research/pdf_files/calstrs-final-2011.pdf**

For our in-depth study of the LEED Platinum-certified Kresge Foundation headquarters in Troy, Michigan, we examined performance in 20 areas, including financial, energy, IEQ and potable and stormwater use. Most building performance evaluations only describe whether a building meets certain criteria. In contrast, this report describes the performance of the Kresge Foundation complex in relation to industry-standard design and operations performance criteria while examining the appropriateness of these criteria for this and similar high-performance buildings.

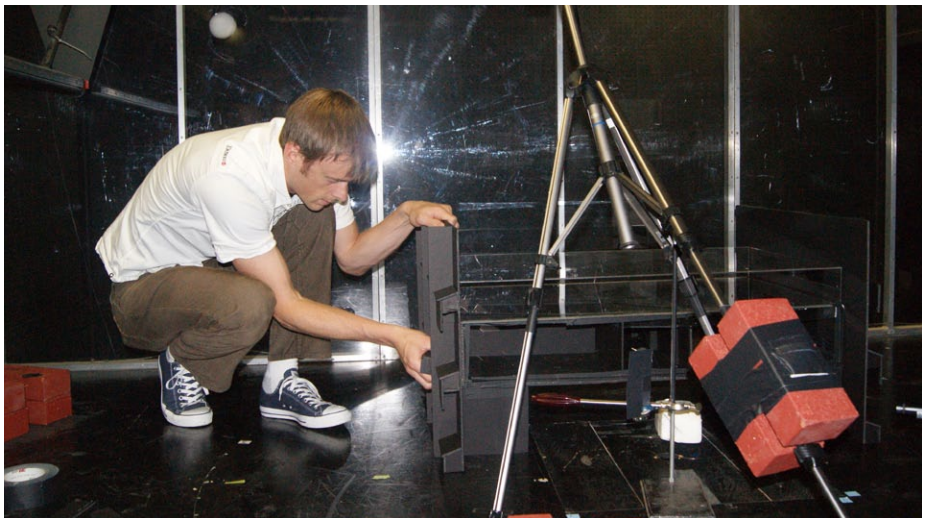
The Kresge final report is available at: **http://escholarship.org/uc/item/30h937bh**

Interior view of the CalSTRS headquarters. Image: Scott McDonald. Architecture: HOK.

CBE's Kresge Foundation evaluation included building, IEQ, and landscape factors. Image: Kresge Foundation.

Collaborations with LBNL Support Low-Energy Projects

Faculty and researchers from CBE began work this spring on research led by Lawrence Berkeley National Laboratory (LBNL) in support of the U.S. DOE's Commercial Building Partnerships (CBP). This program brings together experts from national labs and the private-sector to explore energy-saving strategies in building retrofits and new construction. The program will create living laboratories for commercial building research, and will demonstrate innovative energy-saving concepts.



Nathan Brown of Loisos + Ubbelohde configures models in CBE's wind tunnel facility. Image: George Loisos.

One of the current projects involves the renovation of Kuykendall Hall, at the University of Hawaii, Manoa in Honolulu. The campus undertook the renovation to improve comfort and interior conditions, and to strive towards net-zero energy usage. The campus also hoped to remove the existing air conditioning and to rely only on natural ventilation and fans for space cooling. To support these goals, the CBP team conducted a number of energy and comfort studies. Last April, Fred Bauman and Gail Brager drafted thermal comfort guidelines for Kuykendall Hall that could be applied to other buildings on campus, looking at three options for space conditioning: (1) rely solely on natural ventilation with fans; (2) use mixed-mode strategies; and (3) use mechanical conditioning only. The guidance is largely based on the adaptive comfort criteria, adopted into ASHRAE Standard 55 in 2004, which was based on research conducted at CBE and other institutions.

Based on these recommendations, the design for Kuykendall Hall is expected to rely primarily on natural ventilation, using an efficient cooling system for select spaces with large internal loads. Several members of the Kuykendall Hall team recently used CBE's wind tunnel facility to evaluate the project's natural ventilation strategy in greater detail. Staff from Loisos + Ubbelohde, Ben Woo Architects, and students and staff from the UH School of Architecture's Environmental Lab spent several days conducting wind tunnel tests to study the design of the facade. The wind tunnel studies included flow visualization, velocity measurements, and pressure measurements. These physical tests provided information that was used to update computational models.

Our group is now working with LBNL to document the benefits and knowledge learned from this project, which can be applied to other projects. Our colleagues at LBNL call this project a "game changer," and one that can be a replicable model for the university, for the state, and the region.

More information on DOE's Commercial Building Partnership is available at:
http://www1.eere.energy.gov/buildings/commercial_initiative/building_partnerships.html

People

CBE Staff Make Leaps Forward (Passi Avanti!)

We are happy to announce some exciting transitions and new hires this summer. This fall, **Stefano Schiavon** will join the faculty as an assistant professor of architecture/sustainability, energy and environment. Stefano worked with CBE previously as a postdoctoral scholar and then as a researcher, during which time he made valuable contributions to our work, developing new areas of research, and authoring numerous papers and a book on residential ventilation systems (published in Italy). This spring Stefano received offers for faculty positions from several prestigious universities including Harvard, UC Berkeley, and the Polytechnic University of Turin. Happily he accepted Berkeley's offer and will continue to contribute to CBE's work beginning this fall. Prior to joining CBE, Stefano received a PhD in building physics/energy engineering, and a master's degree in mechanical engineering from the University of Padua, Italy. He also conducted studies at Tsinghua University, China, and at the Technical University of Denmark. Stafano recently returned to Berkeley with his wife Lilliana and son Mattia.

Also from the University of Padua, **Wilmer Pasut** joined CBE in July as a postdoctoral researcher. Wilmer previously worked with CBE while he completed his PhD studies at Padua in building physics. His dissertation was based on his work here, and included the results of field studies and simulations on the effectiveness of using flexible fabric ducts in underfloor supply plenums. Wilmer will initially lead CBE's laboratory study on incorporating fans into commercial ceilings, in collaboration with CBE partners from Armstrong. Wilmer is recently married, and he and his wife Francesca relocated to Berkeley this summer.

Another familiar face around Wurster Hall, **Marc Fountain** joined CBE this summer as a research specialist to support our field and laboratory studies. Marc previously worked with the UCB building science team during his years as a PhD student, contributing to over 20 peer-reviewed technical papers, and receiving the prestigious ASHRAE Nevins award in 1995. He later received an MBA from San Francisco State University, and took a fruitful detour into dot-com-land and the business world. Marc returned to building science in 2005 as a project manager and consultant at PG&E's Pacific Energy Center, and also as a scientist leading studies on lighting and visual performance. Marc is a master technician, and is currently updating CBE's thermal comfort cart and wind tunnel instrumentation. In his free time Marc applies his mechanical expertise to scuba diving and sailing.

Stefano Schiavon

Wilmer Pasut

Marc Fountain

Finally, Research Specialist **Hui Zhang** has taken over as chair of the research subcommittee for ASHRAE Technical Committee 2.1 on Physiology and Human Environment. Hui says that one of her goals in this role will be to support research that may have immediate impacts and improve practice in industry. She also plans to coordinate with the ongoing efforts for improving and updating the comfort Standard 55, led by CBE Partner Gwelen Paliaga of Taylor Engineering (chair of SSPC 55), and to contribute to the next revision of the ASHRAE Handbook of Fundamentals.

Partner News

Building Technology Firm REHAU Joins CBE

This past April, CBE's consortium was broadened with the addition of REHAU, an international provider of polymer-based solutions for construction, automotive and industry, with over 15,000 employees at more than 170 locations. Mike Dietrich, business team manager, building technology at REHAU, explains that REHAU's integrated approach to building technology fits well with CBE's research. "When considering building science issues such as energy and comfort, we look at these holistically, and view the systems we provide simply as components of a larger picture."

REHAU has been successful in mainstreaming systems like radiant heating, and is continually identifying opportunities to introduce the latest renewable energy and energy efficient building technologies. The company has a unique advantage in being able to provide a number of integrated building technologies — including geothermal, radiant heating and cooling, ground-air heat exchange, and high-performance windows and doors — that contribute to an elevated level of building efficiency. Mike hopes that REHAU's collaborative efforts with CBE will help to advance this effort even more rapidly.

Ryan Westlund, a radiant heating and cooling specialist at REHAU's North American headquarters, was impressed with the scope of CBE's research presented at recent advisory board conferences. "Although we initially engaged with CBE expecting an engineering collaboration, it was CBE's extensive work on thermal comfort with the inclusion of physiology and psychology that impressed us. My thinking has evolved to not only consider the holistic design of a building with respect to the interaction of systems, but also in how individuals perceive their environment."

REHAU radiant technology operates at the Milwaukee Art Museum. Image: R. Diesterheft.

As a global company, REHAU supports innovation through technology transfer among regions, with global conferences attended by managers, and exchanges for technical staff. REHAU develops new solutions at its main research center in Erlangen, Germany, and collaborates with university research organizations globally. Ryan was recently stationed in Germany for three months, learning the nuances of engineering radiant cooling systems, embedded with colleagues who've worked with these systems for more than 20 years. While in Germany, he was involved in the design of some of the world's largest radiant cooling projects, including one for Infosys in India (with CBE partners Perkins+Will and Integral Group) and also the 1.75M ft^2 GreenSpaces project near Delhi (also with Perkins+Will).

REHAU's global technology transfer capabilities can be seen in numerous projects in North America as well. As one recent example, pre-insulated PEX energy transfer pipe and an electrically fused fitting system were employed as part of a $50 million, 10-acre project to create an Asian tropics complex at the Denver Zoo. Mike Dietrich notes that "REHAU was able to supply these new products through its international network, and also to apply the technical knowledge our North American staff has gained in cross-training with European counterparts." As CBE's research on radiant systems and other related building technologies grows, we look forward to the experience and insights that our new partners from REHAU can provide.

For more information about CBE's newest partner visit: **http://na.rehau.com/**

Rendering of PeaceHealth Peace Island Medical Center. Architecture/Images: Mahlum.

The Living Building Challenge: A Higher Standard for Sustainability?

Although LEED has been effective for driving the building industry towards sustainable practices, for some practitioners and clients LEED is not sufficiently rigorous. For those in the green building vanguard, the Living Building Challenge represents a higher measure of sustainability. Launched in 2006 by the Cascadia Green Building Council, the LBC is comprised of seven categories, called "petals" (site, water, energy, health, materials, equity and beauty), all of which include mandatory imperatives. Among other things, these demanding requirements include net-zero performance for energy and water, and a "red list" of prohibited materials, requirements that few buildings have been able to meet.

CBE Partner Mahlum recently applied the LBC as a framework for the design of the PeaceHealth Peace Island Medical Center, a hospital on San Juan Island, in Puget Sound northwest of Seattle, that serves the rural island population. Erik Goodfriend, principal in charge of the project, explains that a number of factors were responsible for the adoption of the LBC for this project. Both the client and the local community wanted the project to be at the forefront of sustainable design. In addition, energy and water are genuinely limited resources on the island. These factors, combined with a design team eager to apply the LBC, made the medical center project a useful test case for the new standard.

Following the LBC framework, the design team worked towards a net-zero energy goal. Project manager Rachel Jenner explains that the team developed a decentralized approach to space conditioning and ventilation, tailoring the mechanical systems selected for individual departments to the specific clinical program needs and hours of operation. To keep energy demands down, natural ventilation was maximized throughout the facility. A hybrid system, including a ground source heat pump, provides heating and occasional cooling and uses both

forced air and radiant systems, tuned to the needs of each department. Waste heat is captured and reused for space heating. As Rachel explains, "though almost unheard of in other facilities, the patient spaces here rely on natural ventilation and radiant heating, with added cooling only when needed. In sensitive areas, such as the surgery department — which may be used only a few hours each week — a dedicated air handler is provided." Medical equipment was also selected with a goal of reducing loads. The design team expects the annual energy use to be below 100 kBtu/ft^2, a 63 percent reduction from the average hospital in the Pacific Northwest of 270 kBtu/ft^2. On-site energy generation was rejected due to the duration of payback, making the goal of net-zero energy unattainable. However the intent of this *petal* will largely be met, as the local utility provides 84 percent of its power through renewable sources, primarily hydroelectric.

The project team also designed a water system very close to a net-zero loop, using rainwater harvesting, grey-water reuse, and an on-site sewage treatment system — a solution that offered both lower first costs and life-cycle costs than extending the town sewer to the site. However, local officials insisted on extending the town's sewer to the site, making the cost of an on-site system unaffordable. Despite this setback, the net-zero design strategy proves such a system is both viable and cost effective.

The project team learned valuable lessons by applying the LBC to the project. Erik Goodfriend notes that while LEED sometimes amounts to "chasing points," the LBC gets to the "heart of sustainability, driving down the use of energy, water, and toxic building materials." He describes the LBC as virtually impossible to meet at this time, however, it is effectively raising the bar for green design, and advancing the market for green products by forcing manufacturers to consider reducing toxic materials in product offerings. In the Pacific Northwest region sustainability is a widespread goal, and staff at Mahlum will consider using the LBC again for opportunities where the client, community, and project team share the values and commitment required to seek a higher standard for sustainability.

For additional information on the PeaceHealth Peace Island Medical Center visit:

http://www.peaceislandmedicalcenter.org/

http://www.djc.com/news/co/12030530.html

LPA's Expansions Showcase Creative Reuse, Energy Efficiency and Comfort

by Rochelle Coles and Erik Ring

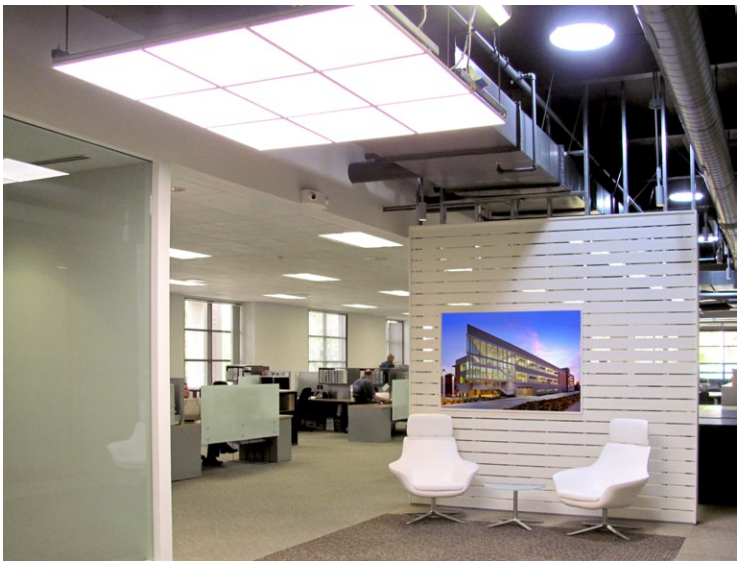
2011 has been a year of expansion for CBE Partner LPA, Inc. The multi-disciplinary design firm opened a new office in San Diego and added approximately 50 percent more space in its Irvine office. LPA is using both projects to explore opportunities for increased energy efficiency, occupant comfort, and team collaboration.

The 5000 square-foot LPA San Diego office, which opened in March 2011, is located within the historic Wonder Bread Building, a former commercial bakery constructed in 1898. The two-story space is dominated by two 20-foot diameter skylights, with floor openings below and two-foot high concrete pedestals that once supported grain silos.

LPA took a "do-less" approach to the fit out of the San Diego office, leaving the structure and brick walls exposed while refinishing existing wood flooring. The landlord provided upgraded information technology, electrical service and new HVAC systems. LPA converted the raised concrete silo platforms to open "collaboration pods" suitable for team and client meetings. Other LPA improvements consisted of furniture systems and demountable storage systems that can be reconfigured as the needs of the office expand and change.

The second floor of the converted space includes a sliding glass door and operable windows. On most days LPA staff take advantage of natural ventilation and San Diego's mild climate to keep the office comfortable. For periods when this is not

In LPA's San Diego office former grain silo platforms have been repurposed as "collaboration pods." Images: LPA, Inc.



Skylights take advantage of former grain silo openings in LPA's San Diego office, above. LED lighting and Solatubes in open plan space in Irvine office, right.

feasible, LPA installed energy-efficient single-zone VAV rooftop heat pump units that include variable speed compressors, variable speed fans and air-side economizer cycle. Occupants have the ability turn on the HVAC units and adjust setpoints as needed.

Lighting systems in the office consist of LED lamps installed into a pre-existing track lighting system along with 10-watt LED task lights at the open work stations. Overall lighting power density in the space is less than 0.5 W/ft^2.

The dramatic skylights, however, have already proved a challenge for occupants' visual comfort, thermal comfort, and productivity. LPA has developed a shade structure made from used boat sails that will be mounted above the skylights, tempering the glare and heat gain on sunny days.

This past June, LPA also expanded its Irvine office, adding approximately 15,000 square feet, and also tubular skylights and operable windows to the second-floor space. The operable windows are interlocked with the building controls — putting perimeter VAV zones into "unoccupied" mode on the frequent days when occupants open windows. Lighting in the open plan office is fully dimmable and addressable with a mix of LED and T8 fluorescent fixtures controlled based on occupancy and daylight responsive sensors. Automated interior window shades on the southeast and southwest elevations provide glare control based on a programmed schedule. LPA's commissioning and tweaking of the lighting, HVAC and shade controls is an on-going process, optimizing the building controls for user comfort and energy efficiency.

Both offices are open plan configurations with low partitions, with a mix of formal and informal meeting spaces designed around promoting effective communication and collaboration. LPA also provided a variety of methods for staff to adjust and control their thermal and visual comfort conditions. The firm is currently pursuing LEED-CI Platinum certification for both projects.

LPA has already used CBE's occupant IEQ survey to identify aspects of the firm's existing office space that could be improved for the new offices. LPA intends to use the occupant survey later in the year in the new office spaces to get a sense of what is working — and what might be improved — and to apply these lessons learned to the firm's projects.

The San Francisco Mint: Preserving the Past, Sustaining the Future

by Sean Gallivan and Paul Woolford

The San Francisco Mint stands vacant. This national historic landmark, built in 1874, survived the great earthquake and fire of 1906 and earned a central place in San Francisco's history. Though closed to the public in the '30s, it will soon begin its second life as the city's new visitor center and history museum. The design team led by HOK, with engineers from Arup's San Francisco office, designed a careful yet comprehensive revitalization of the old Mint, transforming the space into an important civic space for the community.

The designers are striving to make the project an exemplar of sustainable design, using many of the features of the original architecture to their advantage. For example, the thick limestone walls provide thermal mass. Narrow floor plates and a large, central courtyard allow natural light into most spaces. Operable windows allow for natural ventilation. Now, through a series of carefully designed interventions, the project team hopes that the revitalized building will achieve carbon neutrality. Paul Woolford, Design Director of HOK's San Francisco office, led the design team. "The most rewarding aspect of the project," Paul said, "was taking an unused and underappreciated relic and transforming it into an environmentally innovative landmark."

The proposed glass canopy over the central courtyard is vented to provide natural ventilation. Images/Architecture: HOK.

One of the most noticeable changes to the building is the addition of a graceful glass canopy covering the historic courtyard. The canopy, like many design decisions the team made, serves multiple functions. It protects the limestone walls from further deterioration and creates a new year-round public space below. It also serves as the key element in a passive ventilation system, which works by allowing warm air to rise and escape through the canopy, drawing outside air in through open windows and surrounding galleries. The feature also maintains the original purpose of bringing daylight into the building's interior.

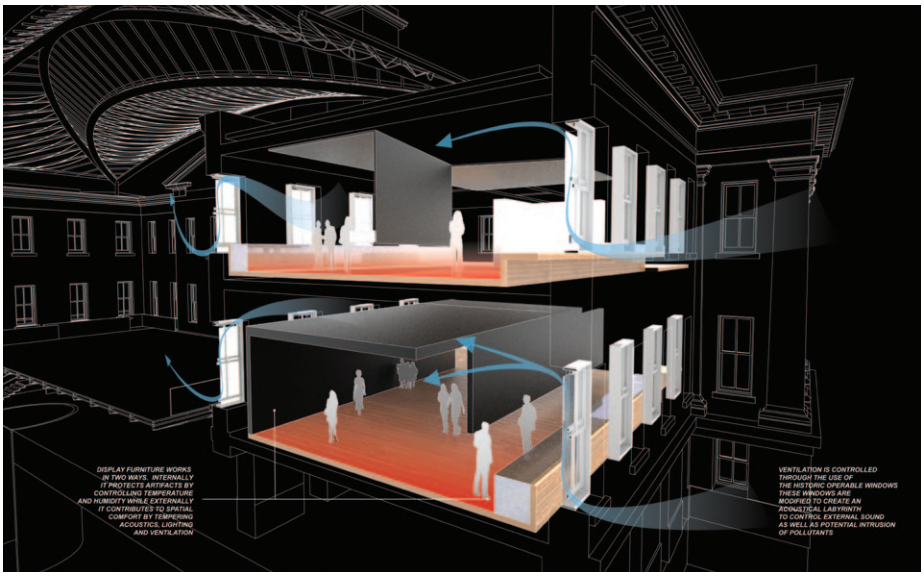
Rainwater and condensation from fog collected by the canopy will also irrigate new rooftop gardens. These gardens provide thermal mass to the roof to better insulate the building and reduce energy loads. The gardens also create a new public green space, where visitors can learn of the site's original upland and wetland ecology. Excess water from the rooftop gardens and gray water from the restrooms irrigate the building's landscaping, which is also comprised of plants native to the San Francisco Bay ecosystem. These were chosen for their ability to both manage stormwater and tolerate extended periods of drought.

All of these features are examples of the Mint's holistic approach to sustainability, where design elements work interdependently to lower energy demands, minimize potable water use, and reduce operational carbon emissions.

The programmatic requirements of designing a working museum and visitor center inside a national historic landmark led the design team to an

early breakthrough: they began to think of the building as a site. Project designer Sean Gallivan describes this epiphany: "We realized the Mint was not a building to be refurbished or altered to accept a new program, but rather a site. As a site, the Mint could be thought of a series of microclimates versus a single homogenous interior. This allowed for huge efficiencies in how we cooled, heated and ventilated the building."

The new interiors were conceived to perform as "furniture" within the historical shell. New materials were designed to allow for future flexibility and efficient operations. The program also opened new public spaces throughout the building, including the gold and silver counting rooms of the Mint's production era. The design allows the building to become more porous and open to the surrounding community, enhancing its image as an icon of the city. San Francisco's local sustainability issues are, at the same time, pressing global concerns — water scarcity, loss of biodiversity, and climate change. As a key historic landmark and museum, as well as the primary visitor's center for San Francisco, the Mint has the potential to have broad influence and to act as a catalyst for sustainability.



The rooftop garden is designed as a public space with educational information about the site's original ecology, top. Diagram showing natural ventilation strategy, below.

centerline
summer 2011

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