centerline

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

Winter 2007

Opportunities with Radiant Cooling

Also... People, Partner News, and Project Updates

Director's Note

Contents

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Dear CBE Industry Partner,

I am excited to introduce this first edition of *Centerline*, CBE's first newsletter. This publication is a part of our Outreach and Communications Program that we are developing in order to provide you with relevant information and design guidance based on our research. We will use this publication to advise you of our activities, and to better keep in touch with our membership, research affiliates, and new prospective partners.

Centerline will include feature articles on topics related to our research and industry trends. We will include updates on projects that have reached significant milestones (these were previously distributed to you as "mid-meeting reports" each January and July.) We'll also include profiles and news about staff, alumni, and partners.

We welcome your input on the content and format of *Centerline*, and I especially encourage you to let us know if you have news or ideas for articles that would be beneficial to CBE's membership. I hope you enjoy this and future editions of *Centerline*.

Sincerely,

Edward Arens

Opportunities with Radiant Cooling

CBE's research keeps pace with new building technologies

Many building industry experts believe that radiant cooling systems are in an early adoption phase, similar to that of underfloor air distribution (UFAD) approximately ten years ago. Based on this belief, CBE started its first radiant cooling research in 2005, and published an Internal Report on the subject in April 2006. In this initial scoping study we identified a number of information needs that CBE could address, and we recently received funding from the California Energy Commission to build upon and expand this initial research phase. The project will continue under the direction of Research Specialists Charlie Huizenga, Fred Bauman, and Graduate Student Researcher Timothy Moore, the lead author of the initial scoping study.

There are many examples of radiant cooling in Europe and in Canada, most notably in the Vancouver, B.C. region. However our scoping study found that there remains a need for a "comprehensive assessment of radiant cooling with respect to design strategies, applications, climates, thermal and energy performance, acoustics, financial considerations, and interactions with both building design optimization and other building systems."

Unlike forced air ventilation, which relies on moving large volumes of air to control temperature, radiant cooling uses actively cooled surfaces to absorb excess thermal energy and remove it from a space. As Timothy Moore explains, radiant systems have advantages over traditional forced air HVAC systems. According to Moore, forced air HVAC systems "try to solve too many problems at once. They try to make the air temperature comfortable, provide fresh air, and remove humidity. Implementing radiant cooling lets each of these component problems be solved individually and efficiently." Typically, radiant cooling does not eliminate the use of forced air or other ventilation strategies, it simply allows

Opportunities with Radiant Cooling

the ventilation to work in a way that is much more efficient, and therefore less obtrusive.

There are two types of radiant cooling systems. Slab-integrated systems use plastic tubes installed in concrete floor or ceiling slabs. Panelized systems are similar to common dropped ceilings, but with tubes fitted to modular panels that can double as finish elements in a space. In a few cases these two systems of radiant cooling may be used together. Typically, however, these two approaches to radiant cooling are suitable for different types of situations. For example, slab-integrated systems are excellent at removing solar loads from structural elements such as floor slabs. Conversely, panel systems can help provide faster responses with more unpredictable loads. Panel systems are also especially suited for retrofit applications. A table that describes typical applications of these two systems appears to the right.

Radiant cooling offers several market-friendly advantages. For the renovation of the building at 2020 Milvia Street in Berkeley, the project team first considered radiant cooling during a visit to the Minoru Yasui building in Denver, Colorado. That building, a former 70's-era hotel converted to office space, had one of the same problems of 2020 Milvia—an extremely low floor-to-floor height. Laura Billings of SRM Associates, the project manager for the 2020 project, explains the decision to go with radiant cooling, despite an installation cost that was $200,000 higher than forced-air, "Other options weren't as flexible if you looked at the likelihood of tenant improvements over time."

Because forced-air systems work by moving large volumes of air, the ductwork required takes up large amounts of space, both along walls and overhead. With radiant cooling, engineers can reduce the size of the ductwork, and in some cases significantly increase ceiling heights. In some cases this may make it feasible to adapt, rather than demolish, existing buildings. Higher ceilings allow more light to penetrate spaces, and can create more rentable and flexible spaces that justify higher HVAC installation costs.

Another reason to consider radiant cooling is potential energy savings.

Typical values used in radiant cooling applications offer distinct opportunities.

	Slab-integrated Systems	Panel Systems
Thermal Mass	High	Low
Thermal Inertia	High	Low
Typical Surface Area	Up to 100% of ceiling/floor area	50% to 70% of ceiling area
Cooling Surface Temp	64-75° F (18-24° C)	56-59° F (13-15° C)
Cooling Capacity	24 Btu/hr-ft2	30 Btu/hr-ft2
Cooling-mode ventilation supply air temperature	Just below space temperature	44-55°F
Best Applications	Buildings with high-performance envelopes Moderate climates Use with natural ventilation and/or low-energy cooling or heating sources	Buildings with greater variation in skin loads Buildings with spaces with highly variable internal loads Mixed-mode buildings with zoned or seasonal operation
Condensation Avoidance	Robust design strategies, rather than controls	Dehumidification, sensors, and controls
Additional Opportunities	Use to remove solar loads from structural elements, or to create a "constant-temperature" slab or pre-cooled building Lower cost per unit surface area	Good for retrofit applications, including supplementary space conditioning Some designs integrate acoustical solutions

Adapted from Moore, Bauman, and Huizenga. "Radiant Cooling Research Scoping Study." Center for the Built Environment, Internal Report: April 20, 2006.

Photo: Gilbert Detillieux

The Institute for Computing Information and Cognitive Systems at the University of British Columbia utilized a slab radiant cooling system and achieved LEED Silver certification.

At 2020 Milvia, consulting engineers at Stantec conducted analyses that showed that radiant cooling would use 25% less energy than the forced air alternative—a savings that translated into a projected savings of $25,000 per year at current prices. Given the difference in initial cost, the developer and building owner viewed the additional installation cost as an investment yielding a payback of 12% per year.

This prediction is confirmed in a previous study conducted by Lawrence Berkeley National Laboratory. The LBNL study showed that cooling with radiant panels can reduce overall cooling energy by 30%. These energy savings result from simple physics, moving thermal energy with water and electric pumps takes less than 5% of the electrical energy required to move that same thermal energy with air and electric fans.

While there is clearly potential for energy savings, overall cost is another factor that remains to be sorted out. Preliminary studies suggest that for new construction, radiant cooling may be less expensive than an equivalent forced-air system. One study suggested that radiant cooling allowed for smaller, and therefore less expensive, ducts and equipment. The authors of the study suggest another potential source of savings: smaller ducts may allow for lower ceiling plenums and reduced floor-to-floor height, leading to reduced cost construction materials in general. Studies by Mumma, and by Carpenter and Lay, suggest that in new construction, first costs may be lower than conventional HVAC systems by as much as 55¢ to $2 per square foot.

Another potential benefit of radiant systems is an increased level of comfort for occupants. Preliminary findings from CBE research now underway show that radiant cooling in rooms with relatively warm air temperatures can result in greater comfort than that achieved with uniform conditions. In addition, with a cooled ceiling a higher level of temperature stratification may be allowed, while still providing a occupant comfort. We will release an Internal Report on thermal comfort with radiant systems at our Industry Advisory Board meeting in April.

One of the barriers to wider adoption of radiant cooling is the concern of condensation on actively cooled surfaces. “Engineers are always afraid that it’s going to rain inside” if they specify radiant cooling, says Timothy Moore. However examples of radiant cooling in locations as diverse as Bangkok and South Carolina show that these systems can work even in humid climates. Well-designed applications control humidity through other means, or simply use large

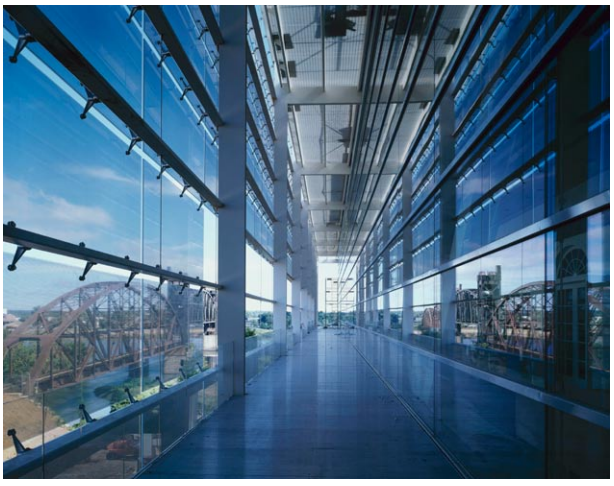


Photo: www.clintonfoundation.org

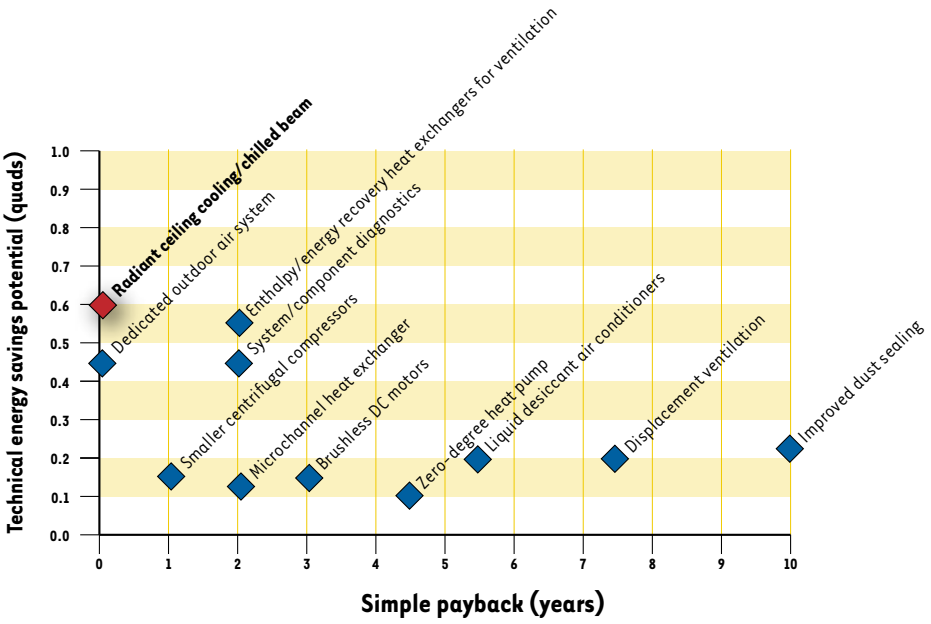
The Clinton Presidential Library includes ten miles of tubing embedded in its concrete floor slabs.

Opportunities with Radiant Cooling

cooled surfaces (and not overly cold temperatures) to avoid condensation. As radiant cooling is used more widely, more needs to be known about these methods to prevent or to deal with condensation.

Another possible barrier is the concern for acoustical implications of radiant systems. Moore points out that the reduction in ambient noise provided by radiant systems can be good or bad in different situations. In spaces where low sound levels are preferred, radiant systems may offer a good acoustical solution. In open offices, designers may need to actively improve acoustics through other means, rather than relying on the ambient HVAC noise levels to mask distracting sounds.

Clearly, there is great potential for radiant cooling systems to be more widely used and better understood. Researchers at CBE are currently focused on identifying and developing tools that will help design professionals design and evaluate HVAC systems that incorporate these systems. In parallel, CBE will also produce guidelines for the application of radiant cooling: what it is capable of handling, where it is especially well-suited, and when it is not an appropriate solution. In the future we also hope to contribute more knowledge about occupant comfort, condensation control, and cost. Just as our UFAD research program has grown over the past ten years to keep pace with the needs of industry, we hope to grow this new research area to provide the design resources needed as the technology becomes more widely adopted. ■



Adapted from Moore, Bauman, and Huizenga. "Radiant Cooling Research Scoping Study." Center for the Built Environment, Internal Report: April 20, 2006. Original source: "Energy Consumption Characteristics of Commercial Building HVAC Systems Volume III: Energy Savings Potential." Roth, et al. DOE, July, 2002

Previous studies sponsored by DOE show radiant cooling's potential for high energy savings with a short simple payback.

People

Our work improves the built environment

New to CBE

John Goins

Research Specialist

We are happy to have John Goins join CBE as the lead researcher in charge of the CBE Occupant IEQ Survey Project. John is most interested with the ways that architecture overlaps with environmental, economic and social justice concerns. He has been a developer of affordable housing and life sciences labs, and has researched the intersection of economics and social development.

John joins us with unique experience, as he worked with the survey project while completing his Master's degree in architecture here at UC Berkeley. He has hit the ground running, and has already started new initiatives with a new building report card, a series of survey-related workshops in collaboration with PG&E, and a study of productivity using CBE survey data.

He also holds a graduate certificate in Real Estate Development from USC. His awards include the Zak Asefa Award in Architecture, Marshall School of Business Development Proposal Award and the Arcus Foundation Award. John was also a member of the winning 2006 Bank of America Low-Income Housing Challenge team, and is a member of the Urban Land Institute.

CBE Alumni Interview

Gwelen Paliaga

Senior Mechanical Designer
Taylor Engineering

What do you like best about your work?

I like the intellectual challenges, that each project is unique, and that I feel like I am doing something to make the world a better place. Also, the people I work with are supportive and interesting, our office is a good environment in that way.

What are some of your biggest challenges?

The complexity of buildings, and the volume of technical information that needs to be understood to engineer high performance buildings, its daunting. Also, keeping up with the uncontrollable deadlines that are the nature of the building design process.

Have you developed strategies to deal with these challenges?

I have had to figure out what's important, and to have a triage mentality. The other strategy is asking my co-workers and supervisors lots of questions.

Are all the projects in your office green?

No, maybe about 50% are green, but we take pride in delivering energy efficiency even when the client is not asking for it. That's our standard design practice.

What drives this percentage?

I think it is mostly because we are interested in any large office or institutional project in Northern California, and they are not all interested in going green.

Does your experience at UC Berkeley, in which you conducted an in-depth study of a naturally ventilated building, play into your professional work?

It definitely does, not every day, but the knowledge that I gained as a graduate student is unique in our office and our profession. For example, with the Orinda City Hall, we designed this as a mixed-mode building, and a lot of what I learned from the CBE study went into that. I don't think our office would have done it without that knowledge. From my research I developed an interest and an unique understanding of comfort and how occupants use buildings.

You worked on CBE research as a graduate student, and now you help direct that research as an Industry Partner. Which side of the table do you prefer?

I much prefer being on this side because I don't have to stand up and give presentations! Actually I miss getting involved in the details of the research.

You maintain a green lifestyle, riding a bike several miles to your office. How do you manage when its raining?

This morning I put on all my rain gear, put my computer in my waterproof rain bag, squinted into the torrential downpour, and got on my bike and rode in. I always carry a second waterproof bag with my work clothes so I don't have to worry about getting wet or dirty while riding.

CBE Alumni Interview

Sahar Abbaszadeh

Project Manger
CTG Energetics

What projects are you working on currently?

I am managing several new construction projects at UC Irvine: a computer sciences building, a biological sciences building, and the expansion of their student center. I am also working on a project called Uptown Oakland, near the Nineteeth Street BART. And I am working on a warehouse retrofit in LA for a non-profit organization.

Which projects in your office are the most exciting?

I am excited about Uptown Oakland, because the developer is really into building sustainably, they have us there because they want us there, not because they have to. We are also working on Heritage Fields—a Lennar Communities project adjacent to the Orange County Great Park project, at the old El Toro Marine Air Station in Irvine. This will be like the Central Park for Orange County covering 1300 acres. It will have features like a wildlife corridor to link previously disconnected open spaces. CTG played a key role in enabling the developer to design sustainably. We may relocate our office to the lifelong learning district. And right now we are planning to use the CBE survey to see how people like our current office, so we can design a better future building to house our office.

As a graduate student, you studied occupants' perceptions of LEED and green buildings. In your professional work, do you advocate for the future occupants of your projects?

I try to do that a lot, and I think the level of awareness on this issue is high. For our LEED projects I put my emphasis on the IEQ section, as this ties to my training at Berkeley. But as my research showed it is not a black-and-white issue. So I tell clients if they do it right, they will have more healthy and comfortable occupants. But if you raise occupants' expectations, provide them with building features they don't fully understand and cannot control, and the features end up not working properly, you can end up with very frustrated occupants!

Have you had to dispel any myths about energy or green buildings?

It goes back to the question of occupant satisfaction, we need to tell clients that just by aiming at building a green building, it will not necessarily make occupants more satisfied. There are so many factors that affect occupant satisfaction in buildings that sometime it's hard to get your arms around it. But hopefully, by putting the issue on the forefront of every design decision we take a best shot at building a more comfortable and healthy building.

Of course there is always the question of the additional cost of green building. The answer is that "it depends." What is the base case for the cost comparison? If you think about green from the very beginning the additional costs should be minimal, what they say about early integration really plays out in practice

Project Updates

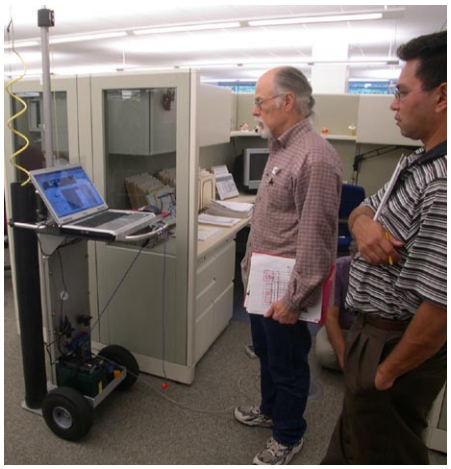
Insights on our latest research

Project: **Underfloor Air Distribution (UFAD) Cost Study**

In September 2006 we submitted to GSA our first-cost analysis report, "Underfloor Air Distribution (UFAD) Cost Study: Analysis of First-Cost Tradeoffs in UFAD Systems." This report identifies some of the major factors that affect the cost differences between traditional overhead and UFAD systems. We also have continued our development of life-cycle cost (LCC) issues and are close to completing three of our four modeling elements— maintenance and repair, churn, and accelerated depreciation. We were recently presented with an opportunity to improve on our plan for the energy model for LCC utility expenses. We are working with the developer of a new version of eQuest that includes a simplified UFAD model. The LCC model and related studies are slated to be completed by July 2007.

Project: **Underfloor Air Distribution (UFAD) Commissioning Cart**

In March 2006, we were contracted by a private client to develop a UFAD commissioning "toolkit" to assist with the commissioning of a noteworthy high-rise office building currently under construction. (The identity of the building will be revealed in our April meeting.) The heart of the toolkit is a mobile measurement cart that can measure and record stratification and other operating parameters via on-board sensors as well as plenum temperature distribution using state-of-the-art wireless mesh networking technology. The toolkit also includes artificial load devices that simulate the thermal plumes from workstations as well as commissioning specifications, and acceptance testing criteria. We delivered a final version of the cart in December 2006, and formal commissioning commenced in February. We have also developed a second cart to support this project and for ongoing UFAD commissioning development work we expect to begin under a CEC contract in June.



Research Specialist Tom Webster and George Anwar of Integrated Motions Inc. conducting final tests the UFAD cart in December of 2006.

Although the cart was designed primarily to address the unique characteristics of UFAD systems we believe that this cart technology represents a new paradigm in system monitoring for commissioning and evaluation for many types of buildings; it should be viewed as a highly flexible measurement platform capable of real-time monitoring and analysis.

Project: **Using Task-Ambient Conditioning Systems to Improve Comfort and Energy Performance**

The goal of this project is to obtain scientific quantification of two approaches that are most promising for task-ambient space conditioning—cooling the head in warm environments, and warming feet and hands in cool environments. By quantifying the effects of these conditions on comfort, we can propose new HVAC system designs and operating strategies. This fundamental human subject research may have a significant influence on peak demand and energy conservation in buildings, and provide specifications for the building control systems. We intend to target our findings to ASHRAE Standard 55 to enable adoption of task-ambient conditioning systems in the building industry.

Since the October CBE meeting we have finalized the development of the test procedures and laboratory setup, and we have begun testing with human subjects. We are planning to conduct 90 tests with 18 subjects. We are using a new series of productivity measures that includes 15 minutes of Sudoku puzzles, 8 minutes of math problems, and a 10-minute typing test. Subjects will repeat these productivity tests under randomly sequenced environmental conditions—no task conditioning, the heated keyboard only, and full task comfort control by the subject. We are very excited to have reached this phase of this project, and we look forward to providing preliminary results in our April meeting with our industry partners.

Graduate Student Researcher Yoon Soo Lee conducts a final test of the task-ambient test configuration.

Project: **Evaluating Thermal Comfort of Radiant Systems**

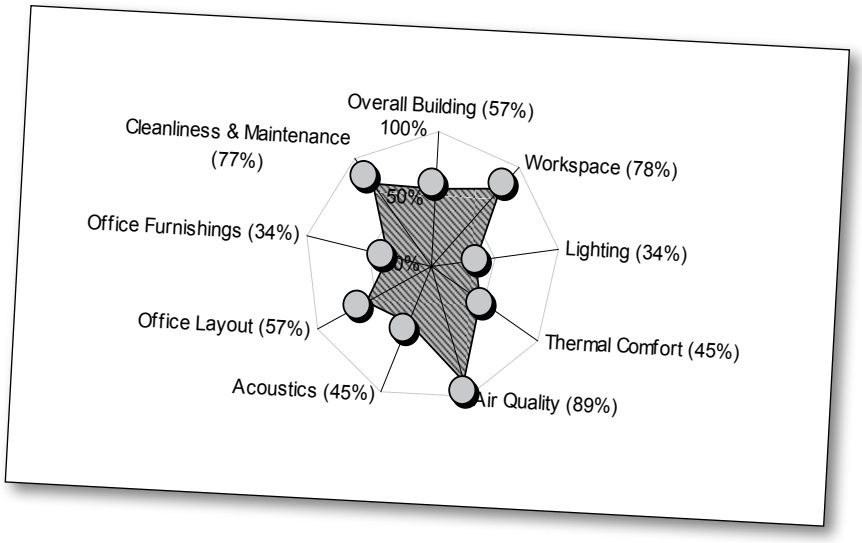
Our objective with this research is to quantify the effects of radiant heating and cooling systems on occupants' comfort, allowing the costs and benefits of the technology to be more comprehensively and fairly evaluated. We will also provide quantitative design guidance for CBE partners designing radiant cooled ceilings.

Initial simulations have shown that with radiant cooled ceilings, a warmer ambient temperature combined with a chilled ceiling can provide better energy efficiency and comfort than a uniform temperature environment. This is due to the typical preference people have for feeling cool around the head and breathing zone.

Our simulations also show that chilled ceilings can provide comfort with air temperatures up to 84° F (29° C). Because of the radiative heat exchange between the ceiling and floor, with a chilled ceiling the floor surface temperature is also likely to be cooler than the room air temperature, and this adds to the likelihood that occupants will be comfortable.

A common design strategy is to integrate two low-energy techniques, radiant cooled ceilings and displacement ventilation, since each provides limited cooling capacity. Displacement systems can cause stratified temperatures that can cause warm head discomfort. Radiant cooled ceilings can substantially improve comfort by providing increased cooling to the head. Our final report on this project will quantify how a radiant cooled ceiling can offset temperature stratification typical of DV systems.

CBE's new building report card will provide a printable, high-level summary of survey results.



Project: **Occupant Indoor Environmental Quality (IEQ) Survey**

Our database is approaching the 500 building mark, and now has responses from over 75,000 users. Recent and upcoming survey implementations include Alameda County GSA; Engen Refinery in Durban, South Africa; San Francisco Federal Building post-occupancy evaluation; and the San Francisco AIA offices.

The Alameda County project is a particularly noteworthy implementation since it will use the core CBE Occupant IEQ survey along with a courtroom module (as developed and implemented for the U.S. GSA.) The survey will have a branching structure so that only people who use the courtroom (judges, court clerks, etc.) will see the courtroom module. CBE will also provide and implement the Operations and Maintenance (O&M) survey, which will be taken by building maintenance staff, in one pre-move building, and in the post-move location. This survey gathers information on building performance from the perspective of operations and maintenance staff.

We are constantly looking for opportunities to make the survey tools easier to use, and the data easier to understand. We have nearly completed the development of the survey setup 'wizard' which will allow users to deploy surveys rapidly. We are also reformatting the survey report based on feedback from our users and collaborators. We expect the new format to include an executive summary of results, details for each IEQ category, and a final comments section. This redesign is an iterative process that needs industry feedback. If you would like to get involved in this effort, please let us know.

We are pleased to welcome John Goins back to the survey team as lead researcher. John worked on the survey project as a graduate student researcher for just over a year. A short profile on John's background appears on page seven.

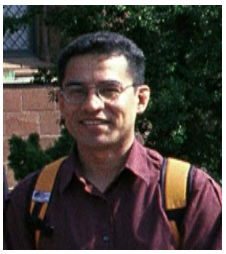
Partner News

News from our industry partners

Clark Bisel
Senior Vice President
Flack + Kurtz

Clark C. Bisel, Senior Vice President with Flack + Kurtz, recently gave his presentation, "The Asian Century: Current Economic Development and Its Impact on Global Energy" to faculty, staff and students at CBE. In his talk, Clark explained how the economic expansion well underway in Asia will have dramatic effects in terms of energy consumption and global environmental outcomes. The impact of China is a primary concern, as its energy use is six times that of Japan, and 3.5 times that of the US, in terms of the energy used per unit of GDP. Coal is the primary fuel source in both India and China, which raises additional fears as its use results in high levels of greenhouse gases and other pollutants.

Clark has given his presentation to diverse groups in the Bay Area, including the AIA and church groups, and is scheduled to present to the Golden Gate ASHRAE Chapter in June. His goal is to raise awareness in the building industry and beyond, and to initiate dialogue about solutions to this potentially dire situation. The presentation is available at http://www.cbe.berkeley.edu/research/pdf_files/CBisel2007_AsianCentury.pdf



Robert Marcial
Director
PG&E Pacific Energy Center

We are happy to announce that Robert Marcial was recently named Director of the PG&E Pacific Energy Center (PEC) in San Francisco. We know Robert well from his time as a graduate student in UC Berkeley's Building Science Program, and all of us at CBE wish him great success in this important new role. Robert will lead the PEC in its role of providing design advice, energy efficiency education, and building diagnostics tools free of charge to professionals in the commercial building industry.

Faculty and staff at UC Berkeley have collaborated with the PEC since its founding in 1991. With California's increasing goals for energy efficiency, such an institution is very important for assisting the State meet those goals. Beyond energy efficiency, the PEC embraces broader issues to improve to the built environment, including programs on water conservation, occupant satisfaction, and climate change. We look forward to collaborating with Robert and PEC staff in the future.

Industry Partners at the Center for the Built Environment

CBE's research is supported and guided by CBE's consortium of industry partners, a diverse group of leaders in the building industry. The Center currently includes the following firms and organizations (as of April 2007):

Armstrong World Industries
Arup*
California Energy Commission
Charles M. Salter Associates
CPP
Engineered Interiors Group (EIG)
Flack + Kurtz
Gensler
Haworth
HOK
Pacific Gas & Electric Company
Price Industries
RTKL Associates
Skidmore, Owings & Merrill LLP
Stantec
Steelcase
Syska Hennessy Group
Tate Access Floors*
Taylor Team:
- Taylor Engineering
- CTG Energetics
- Guttmann & Blaevoet
- Southland Industries
- Swinerton Builders

Trane
U.S. Department of Energy*
U.S. General Services Administration*
Webcor Builders*
York International Corporation

* founding partner

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