Center for Building Performance and Diagnostics (CBPD)

Carnegie Mellon University, Volker Hartkopf, Director, 412.268.2350, hartkopf@cmu.edu

Center website: http://www.arc.cmu.edu/cbpd/index.html

The Robert L. Preger Intelligent Workplace (IW)

The Preger Intelligent Workplace (IW) is a living laboratory designed and engineered by the Center for Building Performance and Diagnostics (CBPD) in close cooperation with architects and engineers and the Advanced Buildings Systems Integration Consortium. The IW has functioned as a living (frequently adapted and updated to incorporate new materials, components, and systems) and lived-in laboratory that is occupied by CBPE faculty, staff and students. The IW pioneered the focus on hands-on integrated research involving robust innovative systems for multiple performance goals. It has partnered with over 50 industries to develop advanced integrated approaches to lighting, mechanical, structure, and interior systems.

The IW has pioneered the concept of integrating horizontal load bearing structure, mechanical ducting, cabling for power, communication and controls, and floor-based infrastructures to support ongoing spatial dynamics. This facility and work has resulted in unprecedented levels of user accessibility, organizational flexibility, and technological adaptability, while eliminating the concept of obsolescence and material waste. The IW testbed has led to the development of Air Conditioning, Heating and Refrigeration Institute publications and has influenced innovative buildings internationally and across the US.

The IW living laboratory also demonstrates the advantages of and opportunities for hybrid conditioning. Hybrid conditioning integrates daylighting with artificial lighting, natural ventilation with mechanical con-

ditioning, passive and active heating and cooling strategies; all of which maximizes indoor environmental quality at the lowest energy cost with minimal material resource use. The energy value of hybrid conditioning represents over 50% of heating, cooling and lighting energy use in buildings. The capabilities of the lab has resulted in a series of ongoing research projects with industry from Gartner facades to Zumtobel lighting, to PPG glass and Alcoa aluminum, to Steelcase furniture, to Armstrong ceilings, Carrier mechanical systems and Johnson Controls. The most recent collaboration involves a ARRA Recovery Act project led by Siemens controls dedicated to profiling control systems to achieve 40% energy savings in existing buildings.

> **Economic Impact:** The economic impact of this innovation in building systems and systems integration for performance is multi-dimensional – impacting energy and operational costs, system reliability, product market share and quality of the indoor environments for building occupants. Owens Corning quantified the benefits of floor based infrastructures and flexible interiors introduced in its Toledo, Ohio headquarters as over 300,000 USD per year in. In separate CBPD efforts focused on building enclosure and mechanical system innovations, the Beijing energy efficient office building of the Ministry of Science and Technology recorded a 60 percent reduced peak cooling load due to the design and engineering involvement of the Center. The impacts of this "living laboratory" at is world-wide. The IW led to the Adaptable Workplace Laboratory at GSA Headquarters, the Laboratory for the Design of Cognition at Electricite de France, and the Building Energy Research Center at Tsinghua University. It created the impetuous for comparable labs at the University of British Columbia, Syracuse University and Purdue University. The R&D that occur in these labs fosters the development of advanced technologies and integrated systems and educates students and professionals to ensure the more rapid introduction of architectural building innovations in the marketplace.

For more information, contact Volker Hartkopf, 412.268.2350, hartkopf@cmu.edu.

National Environmental Assessment Toolkit (NEAT™)

The National Environmental Assessment Toolkit (NEAT™) combines portable instrumentation with questionnaires and expert walkthrough to create robust baseline assessments of thermal, visual, acoustic, and air quality in the workplace. Development of NEAT continues with direct support from the General Services Administration and corporate and industry partners for the before and after field evaluation of cutting edge buildings and federal facilities nationwide. Most post occupancy evaluation (POE) is subjective only, with facility manager and user satisfaction questionnaires attempting to capture the perceived quality of the building. NEAT studies combine on-line and on-site user satisfaction questionnaires with objective measures of indoor environmental quality through substantial on-site measurements as well as capturing the technical attributes of building systems (TABS) to ensure that conclusions are linked to system design decisions. The CBPD team has developed robust data collection techniques, GIS based data records, and innovative data analysis tools from scatter plots to environmental "EKG for buildings" that can be linked to the quality of building systems and facilities use and management. The NEAT field studies are central to informing critical investments for improving indoor environmental quality, for building the business case for high performance buildings by linking facility management costs, health, and productivity to indoor environmental quality.

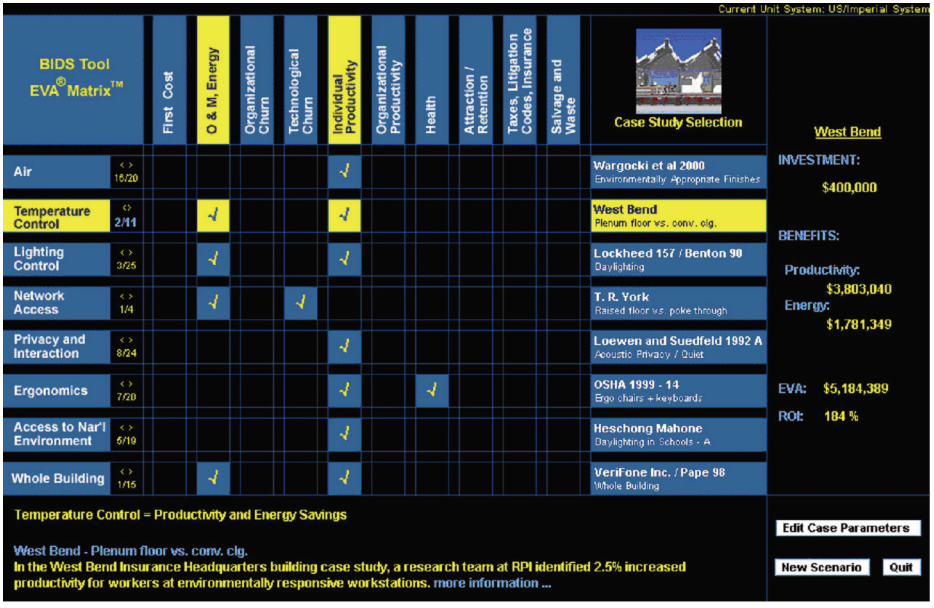
Economic Impact: For the General Services Administration, the National Environmental Assessment Toolkit (NEAT) has been used to evaluate the environmental quality of federal workplaces, the technical attributes of the building systems, and employee satisfaction with the quality of the work environment. Informing renovation programs, specifications and change management, the NEAT studies also contribute to before and after records of improvements in environmental conditions and user satisfaction that are critical to justifications for investment in the quality of the built environment. Compelling quantitative and qualitative results have led utilities and corporate building owners to undertake NEAT studies of their existing facilities in preparation for renovation or new building construction. The value of investing in quality work environments can be measured in energy savings with 50% average reductions, decreased adverse human health outcomes from asthma to headaches to eyestrain seeing 20% average reductions, to productivity and performance improvements ranging from 2 to 20%.

For more information, contact Azizan Aziz, 412.268.6882, azizan@cmu.edu.

Building Investment Decision Support Tool (BIDS™)

Building operations (heating, cooling, lighting and ventilation) consume almost 40% of the U.S. primary energy, and 67% of electricity the nation's electricity. The EPA estimates that sick building syndrome (SBS) costs the US economy in excess of 60 billion USD per year. On top of all this, building waste is the largest contribution to landfill.

BIDS™ is a case-based cost-benefit analysis tool to support investments in advanced and innovative building systems that improve environmental quality, health and productivity in buildings. The tool provides life-cycle and return on investment based frameworks that take into account energy conservation, productivity, human health, and organizational effectiveness results of best practices. Through industry and federal support, the CBPD continues to identify laboratory and field case studies demonstrating the relationship of high performance components, flexible infrastructures and systems integration to the range of over 400 cost-benefit or productivity indices. The tool also relates quality indoor environments to major capital cost and benefit considerations, including productivity, health, and operations costs, with baseline data sets to support life cycle decision-making. Through extensive national and international lecturing and the robust web based tool, leading decision makers are more able to incorporate more efficient high performance HVAC systems and controls into their designs. The CBPD has established the technical and economic feasibility, as well as environmental and social desirability to create win-win solutions that promote investments in building quality that simultaneously improve energy efficiency.



Economic Impact: The importance of capturing the true cost of ownership and striving for long life cycles has never been higher. The McKenzie 2009 report "Unlocking Energy Efficiency in the

> US Economy" identifies buildings as THE most cost effective investment for reducing our national carbon footprint, with the smallest investments yielding the highest reductions, in comparison to new energy sources, industry or transportation investments. The built environment is a key factor for human health, with an average of $5000 per worker per year spent by organizations for individual insurance to cover health care. The CBPD has identified close to a $1000 per year that is directly tied to the quality of the indoor environment, including respiratory, musculoskeletal, headaches and other chronic health concerns. Materials, component and systems choices, as well as building operations, can significantly reduce these health conditions by 10-80%, while also reducing absenteeism and improving worker performance.

The Building Investment Decision Support (BIDS) clearly identifies the relationship between building performance, occupant satisfaction health and organizational productivity. The return on investment can be significant, at times reaching 100% in buildings that have lives of more than 30 years. Smart investments are critical to improved indoor environmental quality and to achieving the 50% energy savings that can be attained in the existing building market, as well as the 80% savings that is possible in new buildings. All three CBPD efforts – the Intelligent Workplace (IW), the National Environmental Assessment Toolkit (NEAT) and the Building Investment Decision Support Tool (BIDS) are dedicated to this low carbon future.

For more information, contact Vivian Loftness, 412.268.2350 loftness@cmu.edu