Center for Building Performance and Diagnostics (CBPD)

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Center website: http://www.cmu.edu/architecture/research/cbpd/absic-cbpd.html

The Robert L. Preger Intelligent Workplace (IW)

An exterior view of The Intelligence Workplace with additional inset exterior and interior views. Compared to United States. standard average the IW uses one-fifth of the energy to create optimal air, thermal, visual, and spatial ergonomic qualities with the lowest artificial energy consumption.

The Robert L. Preger Intelligent Workplace (IW) is a living and lived-in 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 (ABSIC). As a living laboratory, the IW is frequently adapted and updated to incorporate new materials, components, and systems. The IW pioneered the focus on hands-on, integrated research involving robust, innovative systems for multiple performance goals. It has partnered with over 50 companies and governmental agencies worldwide to develop energy-effective daylighting, natural ventilation, and passive/active heating and cooling with advanced lighting, mechanical, structural, and interior systems. The work of the CBPD and the ABSIC was awarded the 2013 Alexander Schwarzkopf Prize for Technological Innovation by the Industry-University Cooperative Research Center Association.

In the United States, about 40% of all energy and 70% of all electricity is used for building operations. The capabilities of the IW lab have resulted in a series of ongoing research projects with industry partners, including: Gartner Facades, Zumtobel Lighting, PPG glass, Alcoa Aluminum, Steelcase, Armstrong, Carrier, Lufttechnischegesellschaft (LTG), Mahle GmbH, Johnson Controls, Siemens, and OSIsoft. The most recent IW collaboration involves an American Recovery and Reinvestment Act (ARRA) project led by Siemens Controls that is dedicated to profiling control systems to achieve 40% energy savings in existing buildings.

The IW pioneered the concept of integrating horizontal load bearing structure, mechanical ventilation ducting, cabling for power, communication and controls, and floor-based infrastructures to support ongoing spatial dynamics. The 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 test bed has led to the development of Air Conditioning, Heating and Refrigeration Institute publications and has influenced innovative buildings across the United States and internationally. The concepts pioneered by the IW team improve upon the previous state-of-the-art methods by employing multi-disciplinary, inter-disciplinary and trans-disciplinary decision-making processes, as well as by integrating public/private partnerships into policies, practices, and operations.

The IW living laboratory also demonstrates the advantages of and opportunities for hybrid conditioning., integrating daylighting with artificial lighting, and natural ventilation with mechanical conditioning, passive and active heating and cooling strategies for highest air, visual, and thermal qualities. Compared to United States standard average primary energy (considering the energy demand to generate electricity) and site energy (measured energy use in the buildings), the IW uses one-fifth of the energy to create best air, thermal, visual, and spatial ergonomic qualities for the occupants with the lowest artificial energy consumption. It concurrently combines minimal material resource use with zero waste in production, construction, and internal reconfigurations.

The IW also encouraged the creation of comparable IW labs at the University of British Columbia, Syracuse University, and Purdue University. The R&D that occurs 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. The Building Investment Decision Support (BIDS) tool developed by the CBPD and applied in major, breakthrough projects, has been based on over 450 case studies published nationally and internationally. These case studies identify energy, environment, human health, organizational productivity, learning, and teaching benefits of building performance. Many of these are related to the *10 Strategies for Living, Bio-climatic Facades for Sustainability, Human Health and Performance* posters (developed by the Center for the CBPD with the University of California, Berkeley, Berkeley Lab and supported by industries and governmental agencies). These strategies are: 1) Access to Nature; 2) Daylighting; 3) Natural Ventilation; 4) Heat Loss/Heat Gain Control; 5) Solar Heat and Glare Control; 6) Load Balancing Heat and Power Generation; 7) Passive and Active Solar; 8) Water Management; 9) Enclosure Life; and 10) Systems Integration. The IW continues to have world-wide impacts.

Economic Impact: The economic impacts of this innovation in building systems and systems integration for performance are multi-dimensional - affecting energy and operational costs, system reliability, product market share, and indoor environment quality for building occupants. Building innovations used in the IW, such as energy dashboards (which show consumers how much power they are using), daylighting, and electric lighting integration, have been shown in studies to significantly decrease the amount of energy expended to power buildings. A *Wall Street Journal* article from September 22, 2013 entitled "Energy Dashboards Enter the Office Cubicle," highlights research by both the CPBD and the National Renewable Energy Laboratory (NREL) that addresses the potential for a national reduction in energy consumption through the use of dashboard technology by office workers. Separately, CPBD research on daylighting control indicates "the net impact of daylighting and electric lighting integration is significant energy savings and improved workplace satisfaction." This research also states that other, emerging research "...is revealing that day-lit offices, classrooms, and hospitals measurably contribute to greater health and performance at tasks," thereby directly reducing companies' operating costs, in addition to reducing workers' health costs. By implementing IW floor-based plug-and-play systems in new large office buildings, the average cost per person can be decreased from $450 to as little as $100 per person, resulting in net annual savings of nearly a million dollars. In addition, employees experience improvements in overall health, as measured by the number of sick days taken. This can make it possible for companies to renegotiate health insurance contracts, thereby providing significant savings.

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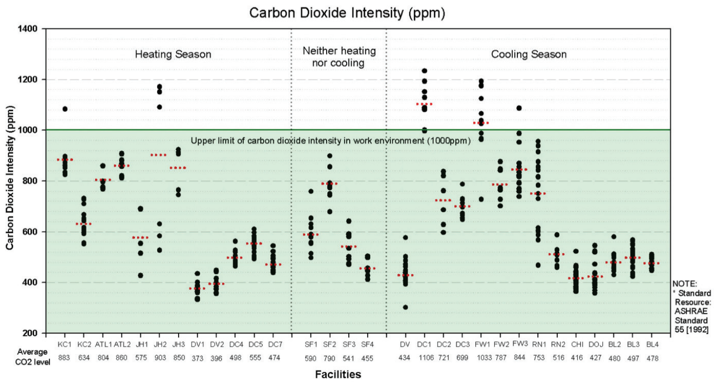
National Environmental Assessment Toolkit (NEAT™)

NEAT portable sensors and datalogger suite

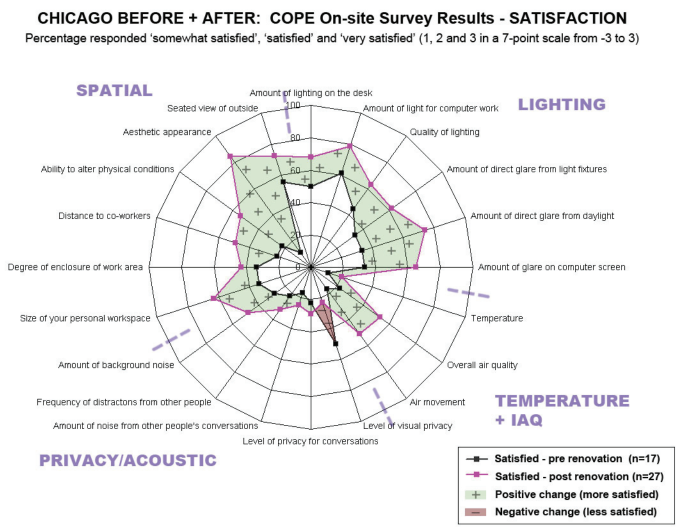
NEAT™ combines portable instrumentation with questionnaires and expert walkthroughs to create robust assessments of workplaces' thermal, visual, acoustic, and air quality. This is the indoor environmental quality (IEQ). Development and refinement of the Toolkit continues with direct support from the General Services Administration and corporate and industry partners. The Toolkit is used nationwide for before and after field evaluations of cutting edge corporate buildings and federal facilities. NEAT studies combine online and on-site user satisfaction questionnaires with objective on-site IEQ instrumentation, as well as with assessments of the technical attributes of building systems (TABS). These ensure that conclusions are linked to system design decisions. In addition to developing robust data collection techniques, the CBPD team has developed innovative data analysis tools ranging from scatter plots to environmental "EKG for buildings" that can be linked to the quality of building systems and facilities. As of now, field data from over 1,000 workstations provide in-depth analyses for achieving better indoor conditions and energy savings.

Most post occupancy evaluation (POE) is subjective only, with facility manager and user satisfaction questionnaires attempting to capture the perceived quality of the building. Results from CBPD field studies are coming to be viewed as central for informing critical investments for improving indoor environmental quality and for building the business case for high performance buildings. This is accomplished via simultaneous linking of facility management costs, health and productivity to indoor environmental quality.

The NEAT field studies support opportunities for energy conservation while meeting IEQ standards. The Toolkit collects data on IEQ, occupant satisfaction, and the physical characteristics of buildings. Cross-sectional analyses of datasets provides recommendations for building owners and managers to reduce energy consumption while enhancing indoor environmental quality and occupant satisfaction.



Spot measurements of CO_2 at multiple facilities



Before and After user survey comparison at one facility

Economic Impact: There is often a significant discrepancy between the designed and the actual total energy use in buildings. The reasons for this discrepancy are generally poorly understood and often have more to do with the role of occupant behavior and building operations than the building design. Field data collection on IEQ, user satisfaction, and the technical attributes of building systems can reveal inefficient building operations and is one of the most important efforts for energy consumption reduction. An analysis of the General Services Administration portfolio data collected using the NEAT Toolkit concluded the following: 1) 4% total energy savings can be attained by raising summer set points; 2) 40% lighting energy savings can result from reducing ambient lighting; and, 3) 25% reductions in lighting energy can be achieved by daylight harvesting. Ongoing work with the Department of Energy will lead to more robust cross-sectional analyses. Findings from these analyses will provide better economic estimates to support the importance of investing in quality built environments.

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