

Occupant Performance Optimization System

Overview

When we build green buildings, we choose high performance machinery and designs and then monitor them carefully so that they perform optimally. However, if the building occupants practice habits that are not optimal, the full potential of our product and design decisions will never be achieved. Duke is aiming to go beyond building machinery optimization to “occupant performance optimization.” Duke recognizes that perhaps the most important element of the building that needs to be monitored and optimized is occupant building-use habits. In partnership with Lucid Design Group, Pratt School of Engineering students and faculty have designed and are in the process of implementing a comprehensive Occupant Performance Optimization System.

Goals of the Occupant Performance Optimization System

- Direct occupants to modify their behavior in real-time, in response to real-time performance data.
- Provide feedback that reinforces and rewards occupant efforts to optimize building performance through habit transformation.
- Render flows of energy and cycles of matter transparent, accessible, teachable and researchable for a diverse audience that includes technical as well as non-technical building occupants such that further occupant performance optimization strategies can be discovered.

How does the Occupant Performance Optimization System work?

Step 1 Environmental Sensors & Data Acquisition Devices

Automated Building Sensors: When constructing CIEMAS, the Pratt School of Engineering invested heavily in advanced building sensors and controls.

Things that are monitored in real-time through Siemens system are:

- AC
- Steam
- Plug load
- Room Temperature
- Water use

External Sensors: Microclimate data is being collected by a weather station on top of Hudson Hall, directly next door to CIEMAS:

- Wind
- Humidity
- Outdoor temperature
- Rainfall

Manually Collected Data: A number of performance indicators will be collected and entered into the system, including:

- Solid waste (tonnage and % recycled)
- Periodic counts of office and laboratory lights left on overnight
- Results of periodic surveys on transportation modes utilized by building occupants

Step 2 Server

Pratt's Office of Information Technology will host a server which hosts Lucid Design Group's software that will:

- Aggregate data from acquisition devices
- Store and organize data in common database
- Process data to create units of measure intelligible to a wide audience
- Serve updates, instructions and micro-climate data to "screen-bugs"
- Serve updates and instructions to lobby and web display
- Generate graphics for lobby and web display
- Provide downloadable data sets for use by students & faculty in classes

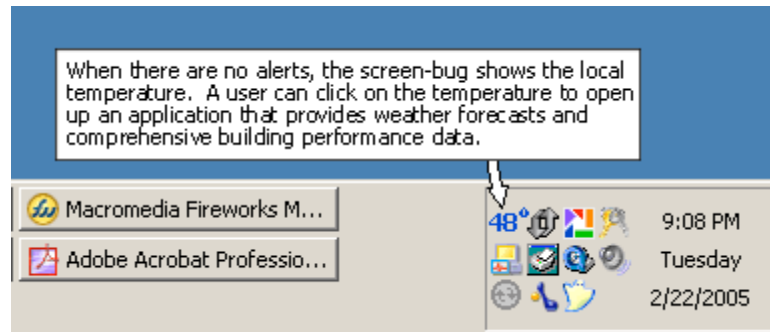
Step 3 Dissemination of Real-time Instructions to Occupants

The core of the Occupant Performance Optimization System is three venues for providing directions and feedback to building occupants.

Screen-bugs:

First, some background on screen-bugs. "Weatherbug" is a wildly popular screen-bug that can be downloaded from weatherbug.com. It is a small executable program that runs in the background on any computer, providing the user with weather information and alerts through a small icon in the system tray. Despite being loaded with advertising, the availability of real-time weather information and alerts has made Weatherbug one of the most downloaded applications on Download.com

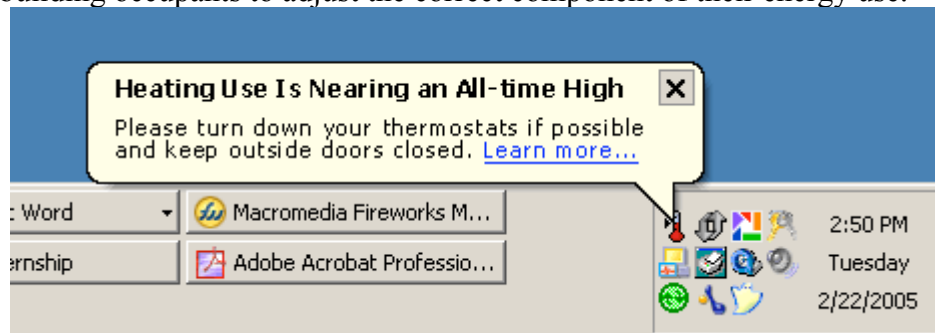
Together with Lucid Design Group, Pratt students and faculty have designed a CIEMAS screen-bug similar to Weatherbug that will provide micro-climate weather data collected by the weather station on Hudson Hall next door to all computer users in the building.



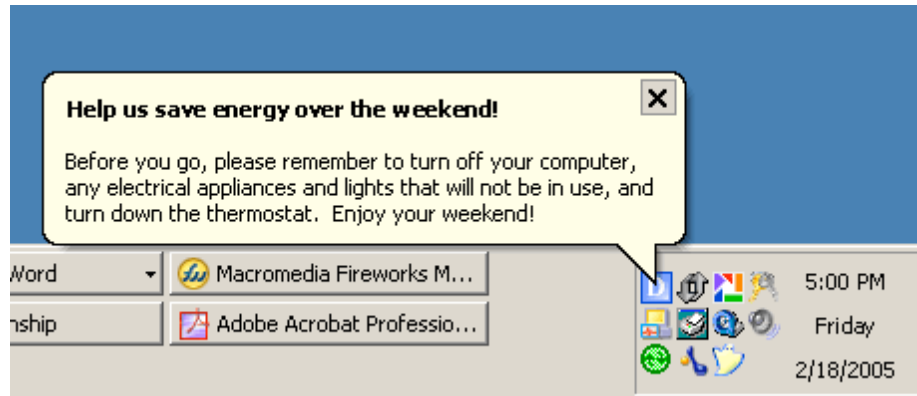
In addition to providing weather data, the screen-bug will present real-time building performance data through a small icon in the system tray. Most importantly, the screen-bug will broadcast “alerts” to all the computers in the building, instructing building occupants when there is a need to modify occupant behavior. For example:

Energy:

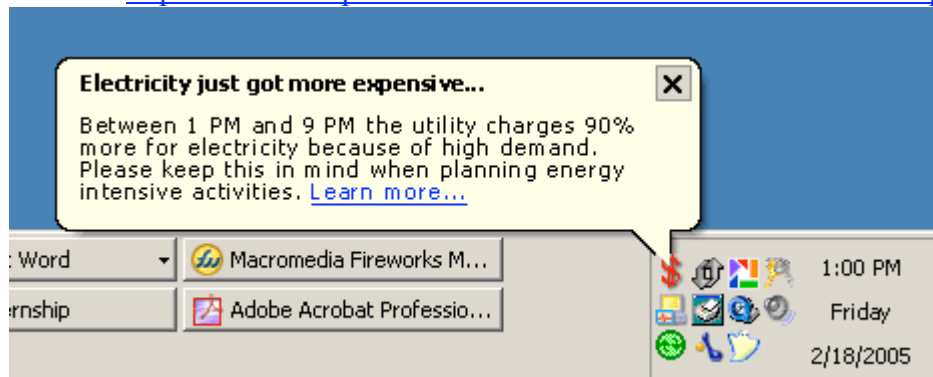
- When energy use is approaching a new high, or an agreed upon threshold, an alert will pop-up in the system tray of everyone’s computers to alert them to the rising energy use. This will be implemented in a total use and break-out fashion, such that a different alert will appear if HVAC energy use is approaching a new peak versus plug-load energy use. This will allow building occupants to adjust the correct component of their energy use.



- As business comes to a close on Friday, an alert will flash in the task bar, reminding occupants to turn down the heat or air conditioning and shut off lights and computers before leaving for the weekend. On Monday, the screen bug will report back to the building occupants how well the building performed in the off-hours and how much occupants contributed to that performance (by reporting average thermostat settings over the weekend and light and plug load usage).



- In order to encourage reasonable thermostat settings, an alert will appear if an unreasonable number of thermostats are set outside of an agreed upon threshold.
- Because Duke pays more for electricity at different hours of the day (“time-of-use”), it is financially advantageous to run high-energy processes outside of the peak hours. It is also environmentally advantageous to remove demand during peak hours so power plants run at a more constant level, thereby achieving higher efficiency. A notice will appear when Duke enters and exits peak charge time periods. Alerts could be set to appear if energy use during peak hours rises above an agreed-upon threshold. Here is Duke’s rate schedule: <http://www.dukepower.com/aboutus/rates/ncrates/ncscheduleopt.pdf>



- Starting fresh each year, the system will count the volume of coal burned to heat and power the building. As the volume of coal burned passes benchmarks such as the volume of a floor in CIEMAS, an alert will pop-up saying something like “The volume of coal burned to heat and power CIEMAS has now passed the volume of the first and second floors of CIEMAS combined.” This will encourage cognizance, but it will hopefully establish a desire to lengthen the time between these kinds of announcements.

Waste:

- As solid waste is hauled away from CIEMAS, Duke Sanitation will weight the volume of both the trash and the recyclables collected. When the diversion rate reaches new highs, screen-bug users will receive a congratulatory message. When the diversion rate falls below an agreed upon threshold, screen-bug users will be alerted to the drop in recycling.

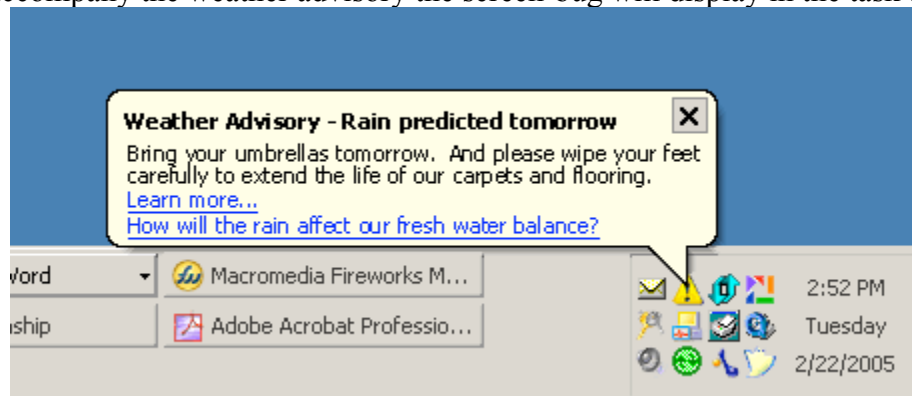
- A similar alert to the coal usage alert may be employed for solid waste, alerting building occupants each time another floor in CIEMAS has been “filled up” with waste produced by the building occupants.

Water:

- While we do not want to encourage people to reduce their hand washing or use of the toilets, we do want people to be cognizant of their water use, particularly as it relates to rainfall. For this reason, an alert might appear when in-building water use has outstripped the volume of rainfall over an agreed upon area of land.

Durability and Care of the Facility:

- When rain or snow is predicted for campus, a reminder to wipe feet carefully upon entry in order to extend the life of the carpet and flooring will accompany the weather advisory the screen-bug will display in the task tray.



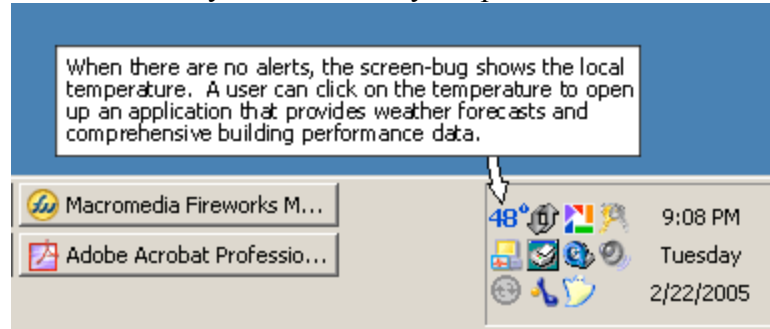
Additional Information:

- In order to provide a full analysis for occupants whose interest is piqued by the screen-bug alerts, the screen-bug will link to additional information and the website.

We are confident that the screen-bug will achieve wide usage for a number of reasons:

1. The screen-bug will be installed on all Pratt-owned computers in CIEMAS. Approximately 800 computers.
2. Weatherbug is widely used on campus despite pop-up advertising and weather data collected at the airport weather station 25 miles away. Our screen bug will be attractive to building occupants because it will provide weather data collected right outside the building and it will contain no advertising. (It may provide Pratt School announcements, which we believe would only augment its usage.) For this reason, we believe building occupants with personal computers will download and use the screen-bug voluntarily. We can track usage and if this does not prove to be the case, we intend to provide incentives for adoption.

3. Lucid Design Group has deployed a similar screen-bug at Oberlin College and found that it was widely and voluntarily adopted.



Website:

While the screen-bug will provide a mechanism for communicating to building occupants when they should modify their behavior, the website will permit building occupants, students and faculty to conduct their own analysis of the building's performance in order to develop new optimization strategies, both operational and behavioral. The professors responsible for designing courses EGR 53, ECE 64 and ECE 141 have commit to using the website and data sets produced by the Lucid Design Group system in their classes.

- 1) EGR 53 - Computational Methods in Engineering

Topics:

- Data modeling and interpolation
- Numerical integration
- Numerical differentiation
- A/D and D/A conversion

- 2) ECE 54 - Signals and Systems

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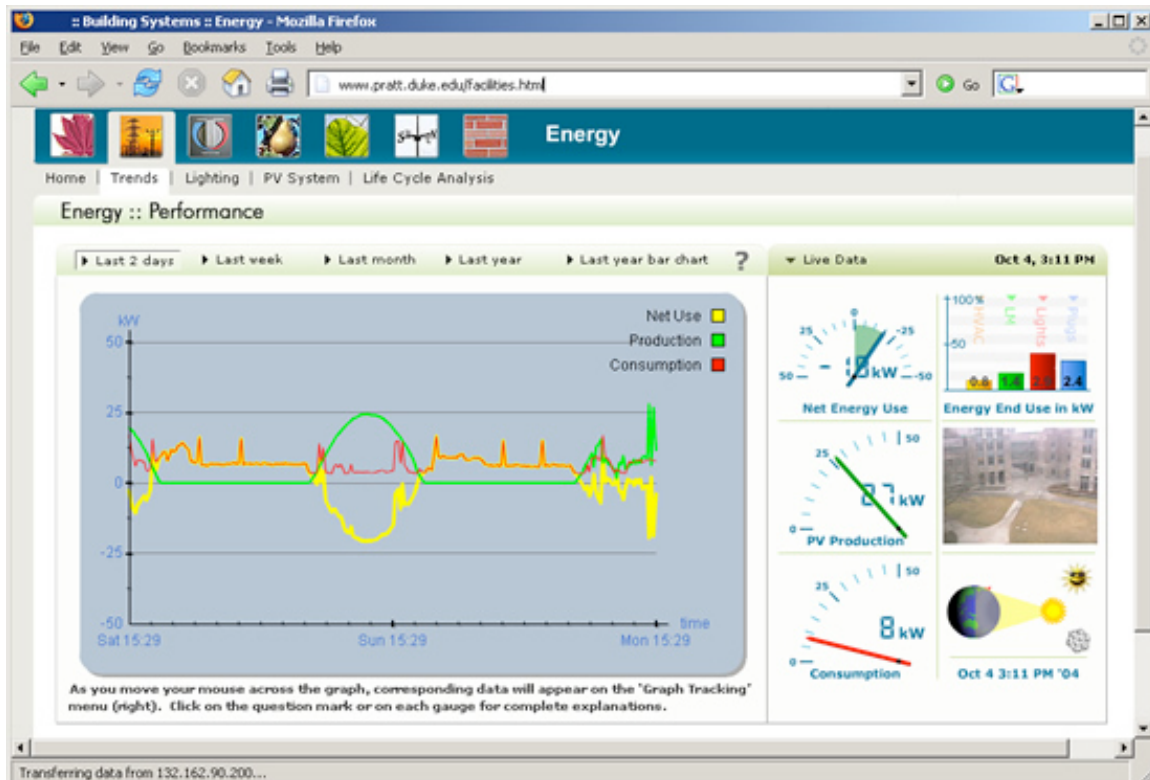
- Linear and linearizable systems
- Transducer and transfer functions
- Introduction to control systems

- 3) ECE 141 - Linear Control Systems

Topics:

- Linear and linearizable systems (part deux)
- Transducer and transfer functions (part deux)
- Open and feedback control systems
- Modeling of electrical, mechanical, and electromechanical systems

The website will contain a series of pages that provide a comprehensive view of the building and environmental performance data. Visitors to the site will be able to chart trends in energy and water use, for example, in order to establish correlations between building occupancy and performance.

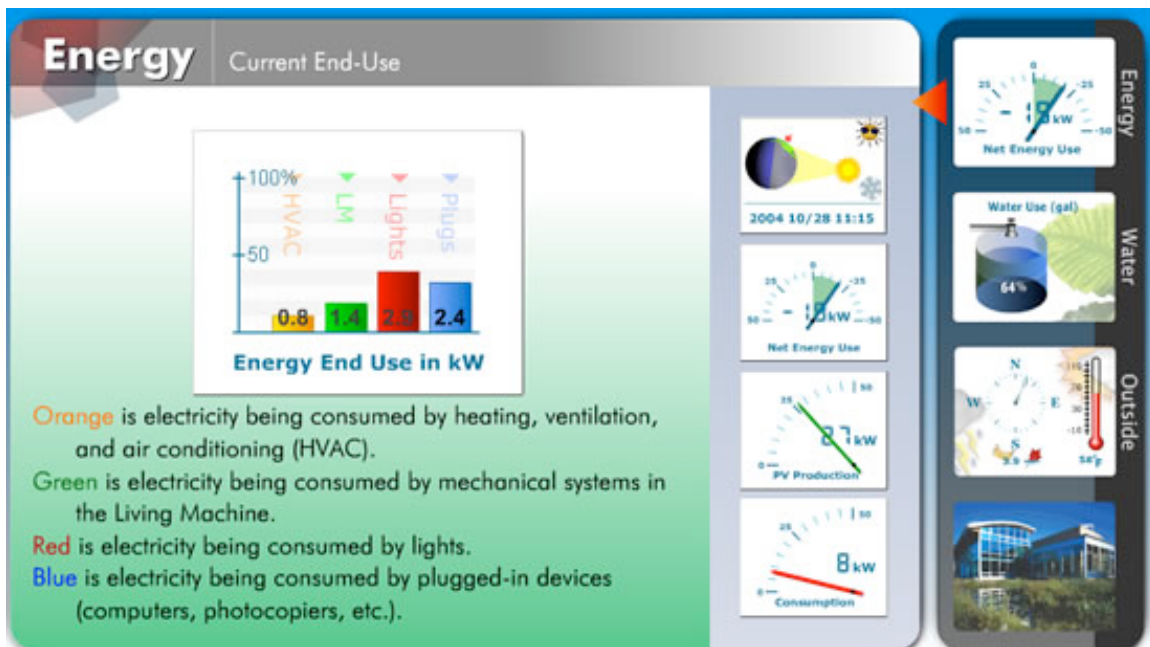
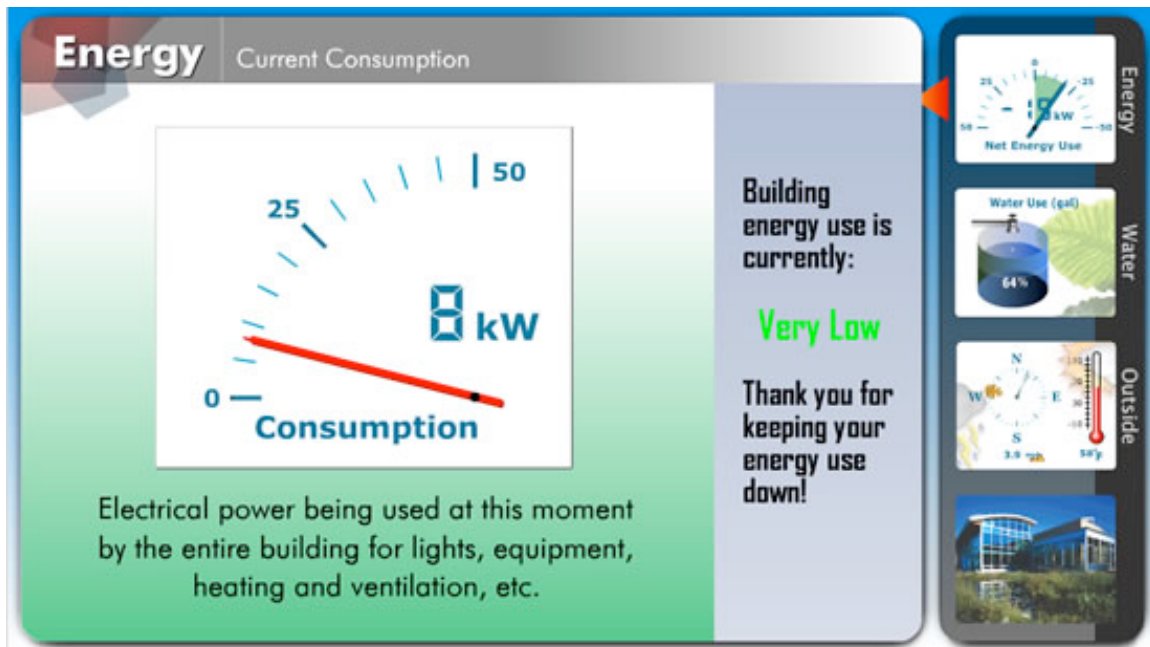


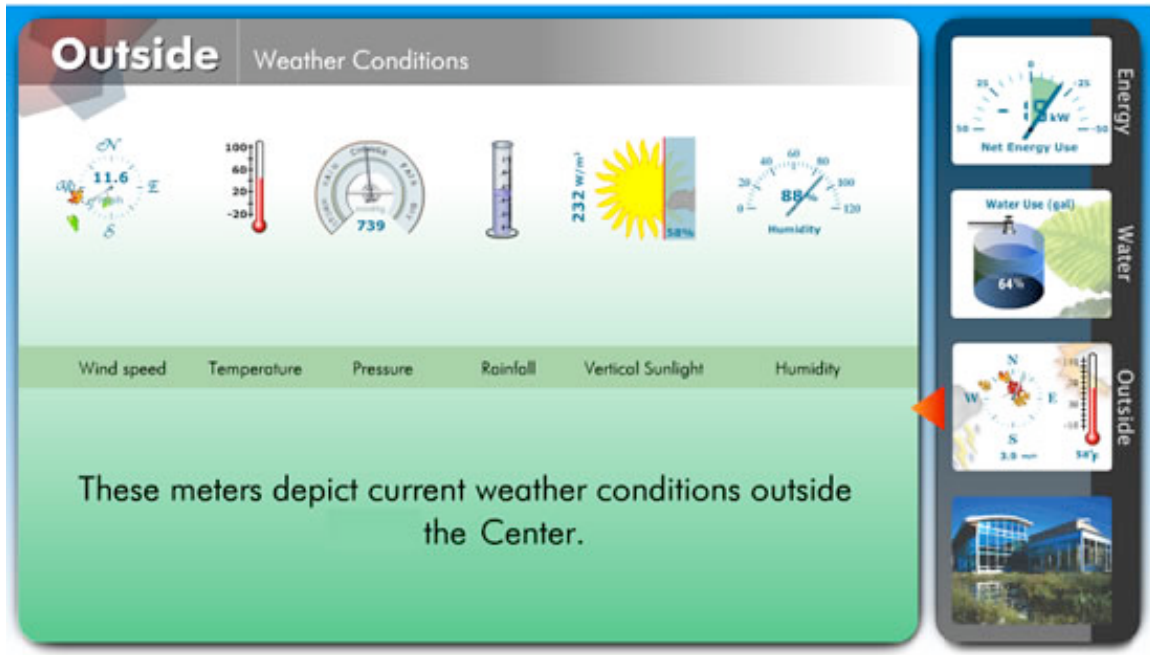
Above is a sample screen shot of what the site will look like. You can see the live data as well as the trend data. A webcam of CIEMAS that is already installed, provides an elapsed view of the building over the time period being charted so visitors to the site can easily correlate outdoor conditions with building performance. (As the Lucid System for Duke is still under construction, this view is based on previous implementations of Lucid's system.)

In addition to the webcam of the building, a webcam will be placed above the on-campus steam plant's coal pile. In time-elapsd compilations, visitors to the site will be able to see the pile diminish and be replenished at varying rates depending on changes in steam consumption that result from building-use patterns and the seasons.

Kiosks:

Because there are many building users (visitors, maintenance, housekeepers) that may not be online, flat screens will be installed in the entrances to the building presenting the real-time performance of the building along with the same alerts and real-time instructions for building occupants that is provided through the screen-bug. The kiosk will rotate through slides with dynamically created content, such as these:





The Feedback Loop

Because both the screen-bug and the website can monitor traffic, we can directly measure the degree to which building occupants are being attentive to the building's performance. Overtime, perhaps as part of classes, we should be able to optimize the system on the basis of what we find engages occupants the most effectively. For example, with the screen-bug, we could make it so certain features and alerts can be turned on or off and then study what percentage and types of users elect each feature.

Going Beyond Measurement & Verification

While the Measurement & Verification credit (EA 5) does address building performance optimization, its requirements focus entirely on *systems* optimization, not *occupant performance* optimization. We believe that treating the occupant population as a feature which can be optimized is a novel approach to augmenting building performance and is worthy of an innovation credit.

Going Beyond Education

In the past, the USGBC has correctly recognized the value of educational displays and tours that share the design features and products used in the construction and operation of green buildings. It should be noted that the education that will result from implementing the Occupant Performance Optimization System described above is a *byproduct*. In other words, the intent of the system is to *further optimize building performance* by directing occupants to change their behavior in real-time, in response to real-time building

performance data. The intent is *not* education, though we recognize and are pleased that the system will likely create a sense that the building is a “living and breathing” entity whose health depends on occupant stewardship. Therefore, we feel the Occupant Performance Optimization System should not be considered as equivalent to the education work USGBC has previously recognized for credit.

Research Opportunity

As CIEMAS is investing quite a lot in developing this system, it would be wasteful not to share our experience. The feedback loop inherent in our system provides excellent opportunities for research. We hope that USGBC will assist us in sharing what we learn about the nexus between building optimization and occupant behavior.

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Screenshots courtesy of: Lucid Designs Software