U.S. General Services Administration (GSA)
Office of Federal High-Performance Green Buildings (OFHPGB)

Discussion Paper for Green Building Advisory Committee Meeting
November 12, 2013

Topic: **GSA Green Building Demonstration Projects: Findings & Follow-up**

Background

The Energy Independence and Security Act of 2007 (EISA) directs GSA's Office of Federal High-Performance Green Buildings (OFHPGB) to conduct a green building demonstration project at a Federal green building annually. OFHPGB conducted its first demonstration project at the U.S. Environmental Protection Agency (EPA) headquarters for Region 8 in Denver, CO, and its second demonstration project at the Army's Fort Carson installation in Colorado Springs, CO.

The law's goal for these projects is to improve understanding of how sustainable technologies and approaches can improve building performance. These projects allow us to:

- test green technologies and strategies;
- develop benchmarks and performance metrics;
- identify replicable, scalable best practices;
- integrate findings into the Federal government's policy, guidance, and practice;
- disseminate research results government-wide and beyond;
- identify areas where additional research is needed.

More information, including reports from completed projects, is available at OFHPGB's Building Research webpage: www.gsa.gov/buildingresearch.

Problem

OFHPGB requests the Advisory Committee's input regarding which findings from these two demonstration project deserve the greatest attention and investment in policy and tool development, outreach and implementation across the Federal government, and into the private sector.

Summary of Findings

This summary is divided into two sections:

1) Behavioral research findings of our first two demo projects
2) Building systems research findings of these two projects

Behavioral Research Findings

Overview: Behavior change projects were conducted in both demonstration projects. There is growing awareness of the impact of occupant behavior on building energy and water consumption and the need for strategies to engage occupants in conservation efforts. Our goal was to test the effectiveness of behavioral change strategies and methods on building energy and water use in these projects.

Methods and Results: The energy field experiment in the EPA building (conducted by the National Renewable Energy Lab or NREL) focused on desk top devices that were under the control of the occupants. Three conditions were each tested for a month:

1) automatic shutdown of computers and other devices using a system linked to occupancy sensors;
2) an information campaign that urged participants to reduce their energy use and identified how much energy was consumed by each of the common devices; and
3) a competition between workstation pods (groups of 6 workstations).

Compared to the baseline energy use, the automatic shutdown performed best, but was not cost effective. The competition came in second, but suffered from the fact that the participants could opt out of having their computers shut down by plugging them into a special outlet. The information campaign had no effect on desktop energy use.

Research at Ft Carson (conducted by the Pacific Northwest National Lab (PNNL)) covered five buildings and focused on computer nighttime shutdown and night time temperature setbacks using wall mounted thermostats under the control of occupants. The methods included training the "building energy monitors" (BEMs) to work directly with occupants to implement change and engaging high level leaders to support the effort. Results show high variability across the buildings, although all showed some degree of energy reduction after the energy monitor training. The researchers estimated that the methods, if deployed broadly, could reduce building energy use by about 4%.

Key Lessons Learned.

1. **Behavior change is difficult**. Both projects show that behavior change is difficult – and that patterns of behavior are hard to change. Thus our over-arching finding is that we should seek to devise control and building operating strategies that do not rely on changing behavior, but rather achieve the conditions that we are seeking through creating default conditions (see below) that achieve the goals, allowing user override to ensure comfort and accommodation of individual needs.
2. **Changing default conditions may be a better option in some contexts**. Changing default conditions is usually a more effective method to reduce energy. The EPA building research showed that the automatic shutdown linked to occupancy saved the most energy – even when compared to social competition,

which is often effective. The EPA research also showed that a retrofit of dual flush toilet handles (changing the lower flush to the down flush, the flushing behavior to which occupants are habituated) resulted in lowered water use than the signs in the toilet stalls telling occupants how to use the toilets.

3. **However, behavior change can be a useful approach – but know when and how to use it and whose behavior to change**. This is especially true if methods lead to long term change. Given that much energy behavior is likely to be highly habitual, a focus on creating new habits could have significant benefits. Behavior change may be the best option when there are no funds for technology upgrades. It would also be useful to review new methods that use gaming techniques to increase interest and motivation.

4. **The context matters**. Behavior takes place in a social setting; it is not isolated. It is important to identify how organizational policies, roles, and relationships influence behavior and how these can be used in intervention strategies. Focusing on the role of building energy monitors was a key to changing occupant behavior at Ft. Carson. However, the research also pointed out that the leadership needs to do a more effective job in selecting people for the role and reinforcing it with visible leadership support.

5. **Continue to identify methods that do and don't work**. Better understanding is needed of which change methods work best for which behaviors and contexts.

Building Systems Research Findings

Overview: OFHPGB's first two demo projects conducted research on the impacts and effectiveness of a variety of green building systems and issues.

At the EPA building, these included energy efficient data centers, plug and process loads, dual flush toilets, waterless urinals, underfloor air distribution and green roofs. A total of 14 best practices associated with energy, water use, operations and maintenance were identified from the final report (see Appendix).

A group of facility managers interviewed by OFHPGB identified three topic areas of most interest:

(1) how to identify, evaluate and measure phantom plug and process loads;
(2) building data center energy reduction; and
(3) how to address the problem of dual flush toilets not providing predicted water savings, with traditional US dual flush handles.

OFHPGB's Research into Practice team reviewed the interview results and decided to move forward with content development for building data centers.

At Ft. Carson, research focused on building envelope performance, lighting and daylighting systems, and net zero energy retrofit.

Among the most valuable findings of both projects were:

1. **Lighting and Daylighting:** NREL found that Ft. Carson was achieving 50% lighting savings through daylighting with clerestories and skylights combined with occupancy controls. The research identified opportunities to boost savings to 90% through a task-ambient lighting strategy that starts with a basic ambient design illuminance level of 250-300 lux (25-30 footcandles), zoning spaces based on use and providing opportunities for occupants to "opt-in" for more light. More occupant engagement is recommended, including through the use of vacancy sensors rather than occupancy sensors (i.e., turning lights off, but not on, automatically).
2. **Energy Retrofit Optimization:** NREL piloted the application of a suite of publicly-available tools (SketchUp, OpenStudio, Google Earth) to evaluate and graphically display lifecycle cost effective options for the retrofit of Ft. Carson barracks to office space. Through this approach, NREL created an "optimization curve" of technology options that could be bundled together, starting with the most cost effective bundle to drive energy use down, leading to a "net zero ready" bundle, and then to the bundle that allows the project to reach the net zero energy level. This technique is fully replicable.
3. **Data Center Energy Use Reduction:** The EPA building data center study focuses on recommendations for energy savings, associated costs, and simple payback of the investments. Improvements recommended, with estimated payback periods, included:
   a. Replace, Virtualize and Consolidate IT Equipment (6.3 years)
   b. Optimize Airflow Management (2.0 years)
   c. Replace Uninterrupted Power Supply (UPS) with High Efficiency UPS (5.7 years)
   d. Install New air handling unit (AHU) with Economizer + Evaporative Cooling (1.8 years)
   e. Install Light Switch (0.23 years)

Discussion Questions

1. How would you prioritize these research findings in terms of their value to the Federal government's efforts to green its building portfolio?
2. Which mechanisms would be the most effective to transmit these best practices for government-wide implementation: e.g., develop policies, guidance documents, factsheets, checklists, webinars, etc.?
3. What research questions should future demonstration projects pursue?

Appendix: Key Best Practices Identified from
EPA Building Demonstration Project

Building Energy Use
1. Where to find, evaluate and measure "phantom" plug & process loads such as video screens, copiers/printers, security equipment, hard-wired equipment (alarms, HVAC fans, etc,)
2. Occupant behavioral impacts on energy use: methods for identifying impacts and changing behaviors
3. Data Center energy use reduction
4. IT electronics energy use and electronic stewardship policies for purchase, operation and disposal
5. Policy roles in energy use reduction such as banning desk-top energy burdens (radios, water fountains, individual heaters, etc), operating computers with night time shut-off and daytime janitorial services

Building Water Use
1. Dual flush toilets: what to look for if they are not performing well and flush valve installation issues.
2. Occupant behavior and the up vs. down flush valve handle - retrofitting if the toilets flush the "wrong way"
3. Use and maintenance of waterless urinals
4. Tips and pitfalls in conducting a water audit

Building Operations and Maintenance
1. The Building Engineer as part of an integrated team
2. Continuous commissioning Best Practices and the extended amount of time required for problem solving
3. Successful building operation is not just about energy using equipment – water systems, occupant behavior, janitorial and waste management are also factors
4. The importance of a visual inspection of all the water related systems
5. The creative ways people find to do workarounds - why training occupants on how to use systems the right way is important