GSA's Green Proving Ground: Identifying, Testing and Evaluating Innovative Technologies

Preprint

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To be presented at the 2012 World Renewable Energy Forum
Denver, Colorado
May 13-17, 2012

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Conference Paper
NREL/CP-7A40-54599
May 2012

Contract No. DE-AC36-08GO28308

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Cover Photos: (left to right) PIX 16416, PIX 17423, PIX 16560, PIX 17613, PIX 17436, PIX 17721

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WREF 2012: GSA'S GREEN PROVING GROUND: IDENTIFYING, TESTING AND EVALUATING INNOVATIVE TECHNOLOGIES

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ABSTRACT

The federal government's General Services Administration's (GSA) Public Buildings Service (PBS) acquires space on behalf of the federal government through new construction and leasing, and acts as a caretaker for federal properties across the country. PBS owns or leases 9,624 assets and maintains an inventory of more than 370.2 million square feet of workspace, and as such has enormous potential for implementing energy efficient and renewable energy technologies to reduce energy and water use and associated emissions.[1]

The Green Proving Ground (GPG) program utilizes GSA's real estate portfolio to test and evaluate innovative and underutilized sustainable building technologies and practices. Findings are used to support the development of GSA performance specifications and inform decision making within GSA, other federal agencies, and the real estate industry. The program aims to drive innovation in environmental performance in federal buildings and help lead market transformation through deployment of new technologies.

In 2011, the GPG program selected 16 technologies or practices for rigorous testing and evaluation. Evaluations are currently being performed in collaboration with the Department of Energy's National Laboratories, and a steady stream of results will be forthcoming throughout 2012. This paper will provide an overview of the GPG program and its objectives as well as a summary and status update of the 16 technologies selected for enhanced testing and evaluation in 2011. Lastly, it provides a general overview of the 2012 program.

Keywords: building technologies; Green Proving Ground; GSA; innovative; underutilized

1. INTRODUCTION

In 2011, the GSA created the GPG program to test and evaluate innovative and underutilized sustainable building technologies and practices based on their potential to support GSA's programmatic needs and accelerate environmental efficiency in building operations in the context of GSA's Strategic Sustainability Performance Plan and Zero Environmental Footprint vision.[2,3] The goal of the program is to identify effective building technologies and practices which could be broadly deployed to reduce energy costs and environmental impact of GSA site operations through decreased energy and water use and waste creation at GSA sites. Findings from the testing and evaluation of technologies are used to support the development of GSA performance specifications and inform decision making within GSA, other federal agencies, and the real estate industry. The program aims to ultimately drive innovation in environmental performance in federal buildings and help lead market transformation through the deployment of new technologies.

Sixteen technologies were selected in 2011 for testing and evaluation in GSA buildings. These technologies are currently being installed and monitored, and findings on each technology will be published throughout 2012. In 2012 the GPG program is currently in the process of selecting additional technologies for testing and evaluation. These technologies, and the associated GSA locations selected for testing, will be announced in mid-2012. Installation and monitoring will begin in late 2012 or early 2013, with publication of findings occurring in 2013.

2. 2011 GPG PROGRAM OVERVIEW

The GPG program was initiated with a project submittal process for GSA employees. The data call sought funded, underutilized, and innovative technologies or practices for possible inclusion in the GPG program. One hundred forty

seven submittals were received. A review process was conducted which included a third-party review by the Pacific Northwest National Laboratory (PNNL) and internal, GSA staff, reviews. The 2011 review process utilized seven equally weighted criteria to evaluate submitted technologies:

(1.) Degree to which the technology or practice is innovative or underutilized
(2.) Potential to be widely deployed
(3.) Ability to provide practical data needed to measure results and/or outcomes
(4.) Ability to establish quality baselines in a timely manner
(5.) Probability of success commensurate with projected risk
(6.) Wide deployment likely to be life-cycle cost effective
(7.) Availability on the market.

Sixteen projects – consisting of a technology or practice installed at one or more GSA sites – were selected for the GPG 2011 program; these projects received testing and evaluation through enhanced measurement and verification (M&V). The projects were announced on Earth Day (April 22, 2011) by GSA Administrator Johnson and Commissioner Peck. Many of the selected projects are being installed as part of building modernization projects funded by the American Recovery and Reinvestment Act of 2009.

Technical support for each project is provided by Department of Energy (DOE) national laboratory staff from PNNL, National Renewable Energy Laboratory (NREL), Lawrence Berkeley National Laboratory (LBNL), Sandia National Laboratory (SNL), and Oak Ridge National Laboratory (ORNL). This support includes verification of performance claims, end user acceptance, maintainability, and return on investment.

Measurement and verification is currently underway for the 16 projects; M&V will last from 4 to 12 months. National laboratory staff performs enhanced testing, monitoring and evaluation of the selected technologies. Ultimately, the associated savings of evaluated technologies will be calculated and potentially extrapolated to additional building types and locations. The most effective and promising technologies or practices will potentially be used to inform GSA's technology performance specifications and future practices.

2.1 2011 Project Overview

In 2011, 16 projects were selected for testing and evaluation through the GPG program. The projects are investigating forward-leaning and emerging heating, ventilation, and air conditioning (HVAC), lighting, metering, policy, power generation, building envelope, water, and solar water heating systems. A listing of each project is provided below, and a summary of the technologies and status of each project is provided in the next sections:

- Building Envelope
  - High R-Value Windows
  - Smart Windows
- Lighting
  - Occupant Responsive Lighting Solutions
  - Integrated Daylighting Systems
- Metering
  - Plug Load Reduction
- Policy
  - On-Site Renewable Technologies
- Power Generation
  - Photovoltaic (PV)
- HVAC
  - Chilled Beams
  - Condensing Boilers
  - Variable-Speed Chiller Plant Controls
  - Magnetic Bearing Compressor
  - Variable Refrigerant Flow
  - Commercial Ground-Source Heat Pump
  - Wireless Mesh Sensor Network
- Water
  - Non-Chemical Water Treatment
- Solar Water Heating
  - PV with Solar Water Heating

2.1.1 Building Envelope Technologies

High R-Value Windows: High-performance glazing is defined by the DOE as having a heat transfer coefficient (U-value) around 0.2 (R-5). By comparison, ENERGY STAR windows are R-3, while commercial double plane glazing is R-2. High-performance glazing also often includes spectrally selective coatings, which filter out 40% to 70% of the heat normally transmitted through clear glass, while allowing the full amount of light to be transmitted to improve energy performance and occupant comfort. This technology is deployed at one GSA site in Provo, Utah. The testing and evaluation is expected to be complete in fall 2012 with deliverables including guidance, recommended practices, and zonal considerations for a GSA portfolio-wide façade retrofit strategy for high-performance glazing.

- Smart Windows: Smart windows can dynamically change light transmission, transparency, and solar heat gain factor. This project compares two smart window technologies: electrochromic windows, which have varied tinting values between 2% and 60% via electronic controls, and a thermochromic, organic polymer, "window filler" that darkens as surface temperature increases. These are the first federal building installations of this technology. This technology is deployed at one GSA site in Denver, Colorado. The testing and evaluation is expected to be complete summer 2012 with deliverables including guidance, lessons learned, and recommended practices for deployment of smart window technology for energy savings and occupant acceptance.

2.1.2 Lighting Technologies

- Occupant Responsive Lighting Solutions: The most common lighting design for commercial buildings is general overhead lighting, where the lighting fixtures are laid out in a grid pattern to produce relatively uniform illumination throughout the space. In task / ambient lighting, overhead lighting is designed to meet lower general illumination requirements, and supplemental task lighting is provided to meet the needs of the individual occupant and specific tasks to be performed. Using task/ambient lighting design and workstation specific controls to match light to occupant needs, achieving energy savings and improved occupant satisfaction. This technology is deployed at 4 buildings in locations throughout California. The testing and evaluation is expected to be complete in summer 2012 with deliverables including guidance and recommended practices for installing occupant responsive lighting solutions.
- Integrated Daylighting Systems: Integrated daylight harvesting control provides energy savings and enhanced occupant satisfaction in perimeter zones. Digital Addressable Lighting Interface (DALI) enables individual control of fluorescent ballasts using fixture-mounted daylight and occupancy sensors. DALI defines light output for all levels of dimming signals, ensuring consistent dimming performance across multiple dimming ballasts, regardless of type or manufacturer. This technology is deployed at 24 sites in 98 buildings in New Hampshire, Massachusetts, New York, Indiana, Illinois, Ohio, Michigan, Texas, California, Nevada, and Washington, D.C. The testing and evaluation is expected to be complete winter of 2012 with deliverables including guidance and recommended practices for integrated daylighting systems.

2.1.3 2.1.3 Metering Technologies

- Plug Load Energy Reduction: Plug load energy reduction using end-use monitoring and dashboards. This technology consists of an automated energy management system (EMS) that tracks how much energy is consumed for typical work days by workspace electronics such as computers, task lights, and printers. Energy-intelligent outlets monitor plug level power use and interact with the equipment plugged into it to prevent plug-load waste. EMS data is then fed back to occupants through electronic dashboards showing how their individual behavior contributes to overall building energy use and encouraging changes in tenant office routines. This technology is deployed at eight GSA sites in New Jersey, Pennsylvania, West Virginia, and Maryland. The testing and evaluation is expected to be complete in summer 2012 with deliverables including guidance and recommended practices for application of plug load control, occupant facing energy sub metering, and engagement campaigns for preventing plug-load waste.

2.1.4 Policy Practices

- On-Site Renewable Technologies: Best practices for PV procurement and inter-connection agreements. Even though overall, the electric consumption of GSA's buildings with PV arrays exceed the amount of electricity generated by their PV systems, the imbalances between time of generation and time of demand means that a substantial amount of electricity is returned to the utilities. This project will evaluate net metering versus registering a building as a Qualified Facility with the Federal Energy Regulatory Commission (FERC). The intent is to optimize how GSA locates, sizes, and funds future renewable energy systems. This project includes 62 GSA sites which currently have PV installed. It is expected to be complete spring of 2012 with the deliverable being a training that summarizes recommended practices for procurement, installation, and interconnection agreements for on-site PV.

2.1.5 Power Generation Technologies

- Photovoltaic (PV): This project includes approximately 2 MW of high-efficiency solar panels. The panels are installed on a "Solar Lab" where these state-of-the-art high efficiency solar panels and four forward leaning PV technologies will be evaluated to determine which

solar panels work best in a four season climate with frequent cloud cover. Research will be completed by GSA and the Department of Energy's Sandia National Laboratories to determine which solar panels work best in the Midwestern climate. This technology is being deployed at one site in Indiana. The testing and evaluation is expected to be complete summer of 2012 with deliverables including guidance and best practices for optimum PV performance in a four season climate with frequent cloud cover.

2.1.6 HVAC Technologies

- Chilled Beams: Use of active beams as the primary source of conditioning office spaces uses the more efficient thermal transfer rate of water (rather than air as is often typical in office settings) to achieve enhanced energy efficiency. Chilled beams are quiet and are claimed to improve occupant satisfaction with indoor environmental quality. The report will not be written based on a specific site but as an in-depth evaluation of the technology. The analysis is expected to be complete winter of 2012 with deliverables including guidance and recommended practices detailing the cost-effective deployment of chilled beams.
- Condensing Boilers: A condensing boiler extracts additional heat from waste gases by condensing the water vapor to liquid water, thus recovering its latent heat; increasing efficiency and achieving energy savings. This technology is being deployed at one site in Georgia. The testing and evaluation is expected to be complete fall of 2012 with deliverables including guidance, recommended practices, and performance specifications for condensing boilers.
- Variable-Speed Chiller Plant Controls: Hartman LOOP technology optimizes all-variable speed chilled water plants by creating a network-based control strategy that operates the plant as an optimized complete system, rather than as optimized individual component elements (such as the centrifugal chiller, chilled water supply pumps, condenser water supply pumps, and tower fans). This technology is being deployed at one site in Missouri. The testing and evaluation is expected to be complete fall of 2012 with deliverables including guidance and recommended practices detailing the cost-effective application of network-based variable frequency drive (VFD) chiller plant control.
- Magnetic Bearing Compressor: Magnetic bearing compressors are essentially frictionless, and their speed is controlled by a VFD. Eliminating the friction in these compressors greatly increases their efficiency at part-load conditions. These chillers have not seen widespread adoption. The project is being deployed at one site in Arkansas. The testing and evaluation is expected to be complete in fall of 2012 with deliverables including guidance, recommended practices, and zonal consideration for optimizing chiller plant performance using magnetic bearing compressors.
- Variable Refrigerant Flow: Variable refrigerant flow (VRF) systems were invented in Japan more than 20 years ago, but they are new to the American market. VRF uses refrigerant as the cooling/heating medium, and allows one outdoor condensing unit to be connected to multiple indoor evaporators, each individually controllable by its user, while modulating the amount of refrigerant being sent to each evaporator. The report will not be written based on a specific site but as an in-depth evaluation of the technology. The analysis is expected to be complete winter of 2012 with deliverables including guidance and recommended practices for cost-effective deployment of VRF for zone-specific occupant control.
- Commercial Ground-Source Heat Pump: Ground source heat pumps (GSHP) rely on the fact that the Earth (beneath the surface) remains at a relatively constant temperature throughout the year. A GSHP system buries a series of pipes, commonly called a "loop," in the ground near the building to be conditioned. The GSHP circulates a fluid that absorbs heat from, or relinquishes heat to, the surrounding soil, depending on whether the ambient air is colder or warmer than the soil. Effective GSHP designs also integrate a dedicated outdoor air system (DOAS) for ventilation control, where the direct-expansion (DX) coil can be very effective at humidity control. Using a centralized, water GSHP system in retrofit locations will save energy, and water, and reduce greenhouse gas emissions. This technology is being deployed at one site in Washington DC. The testing and evaluation is expected to be complete winter of 2012 with deliverables including guidance, recommended practices, and zonal consideration for commercial GSHP in urban locations.
- Wireless Mesh Sensor Network: A wireless mesh sensor network supports active (real time) monitoring of temperature, humidity, air pressure, and electrical power in multiple locations, enabling continuous improvement in energy management of large enterprise data centers; achieving state-of-the-art power usage effectiveness (PUE) in data centers. This technology is being deployed at one site in Missouri. The testing and evaluation for this technology is complete, and findings are available online.[4]

2.1.7 Water Technologies

- Non-Chemical Water Treatment: Non-chemical water treatment technologies include electric field, magnetic field, electro-magnetic field, ultra-violet (UV), cavitation, and ozone generation devices. They are all designed to replace all or some conventional chemicals used to treat water circulated through chiller condensers and cooling towers to reduce water consumption, energy, and chemical discharge into wastewater systems. This technology is being deployed at nine sites located in California, Colorado, Georgia, and Pennsylvania. The testing and evaluation is expected to be complete fall of 2012 with deliverables including guidance and best practices for cost-effective deployment for non-chemical water treatment across the GSA portfolio.

2.1.8 Solar Water Heating Technologies

- PV with Solar Water Heating: This "turnkey" project combines normal roof mounted photovoltaic panels with thermal heat extractor panels mounted beneath them, thereby collecting both electric and thermal energy from the same footprint. Additionally, reducing the temperature of a PV panel increases its average efficiency and energy delivered, potentially improving the efficiency of the PV modules. This technology is being deployed at one site in Massachusetts. The testing and evaluation is expected to be complete fall of 2012 with deliverables including guidance, recommended practices, and zonal considerations for cost effective deployment of PV with integrated solar water heating across the GSA portfolio.

3. 2012 GPG PROGRAM OVERVIEW

Moving forward, the GPG program plans to evaluate approximately 12-20 technologies per year. The 2012 program is currently underway. In January 2012 an internal and external data call solicited information on innovative building technologies for possible inclusion in the GPG program. The technology categories of interest included:

- Energy management
- On-site energy generation
- HVAC
- Lighting
- Building envelope
- Water use reduction
- Other

The internal data call aimed to attract already-funded innovative building technologies for possible inclusion in the GPG program. Forty-six submittals were received from this internal data call. Also in January, a data call was issued for the vendor community to submit information on innovative building technologies or practices for possible inclusion in the GPG program. Seventy-one submittals were received from this external data call.

These submittals will undergo internal GSA staff reviews as well as a third-party review conducted by NREL. The 2012 review process utilizes five criteria to evaluate submitted technologies:

(1.) Degree to which the technology or practice is innovative
(2.) Cost-effectiveness of technology or practice, including life-cycle benefits, first cost, and annual savings potential
(3.) Risk, relative to magnitude of potential success;
(4.) Potential for the technology to be broadly deployed and result in large, agency-wide cost saving
(5.) Likelihood of GPG project success, including the ability to provide practical data needed to measure results and/or outcomes and the ability to establish quality baselines in a timely manner.

The projects selected for GPG 2012 will be announced in mid-2012.

4. CONCLUSION

The GSA has enormous potential to reduce energy and water use and associated emissions through the implementation of energy efficient and renewable energy technologies; the agency owns or leases 9,624 assets and maintains an inventory of more than 370.2 million square feet of workspace.[5] Through GSA's Strategic Sustainability Performance Plan and Zero Environmental Footprint vision, the agency has shown a leadership role in environmental performance and stewardship.[6,7]

The GPG program supports GSA's progressive environmental goals. It utilizes GSA's real estate portfolio to test and evaluate innovative and underutilized sustainable building technologies and practices. The program generates findings which are used to support the development of GSA performance specifications and inform decision making within GSA, other federal agencies, and the real estate industry. The program aims to drive innovation in environmental performance in federal buildings and help lead market transformation through deployment of new technologies.

5. ACKNOWLEDGMENTS

This work was funded by the GSA and interagency agreement number 11-1833 through a partnership with National Renewable Energy Laboratory under Contract No. DE-AC36-08-GO28308 with the U.S. Department of Energy.

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[1] http://www.gsa.gov/portal/content/104444

[2] http://www.gsa.gov/graphics/admin/GSA_Strategic_Sustainability_Performance_Plan.pdf

[3] http://www.gsa.gov/portal/content/184949

[4] http://www.gsa.gov/portal/content/121031

[5] http://www.gsa.gov/portal/content/104444

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[7] http://www.gsa.gov/portal/content/184949