TECHNOLOGY

LEADING BY EXAMPLE: USING INFORMATION AND COMMUNICATION TECHNOLOGIES TO ACHIEVE FEDERAL SUSTAINABILITY GOALS

CENTER FOR CLIMATE
AND ENERGY SOLUTIONS

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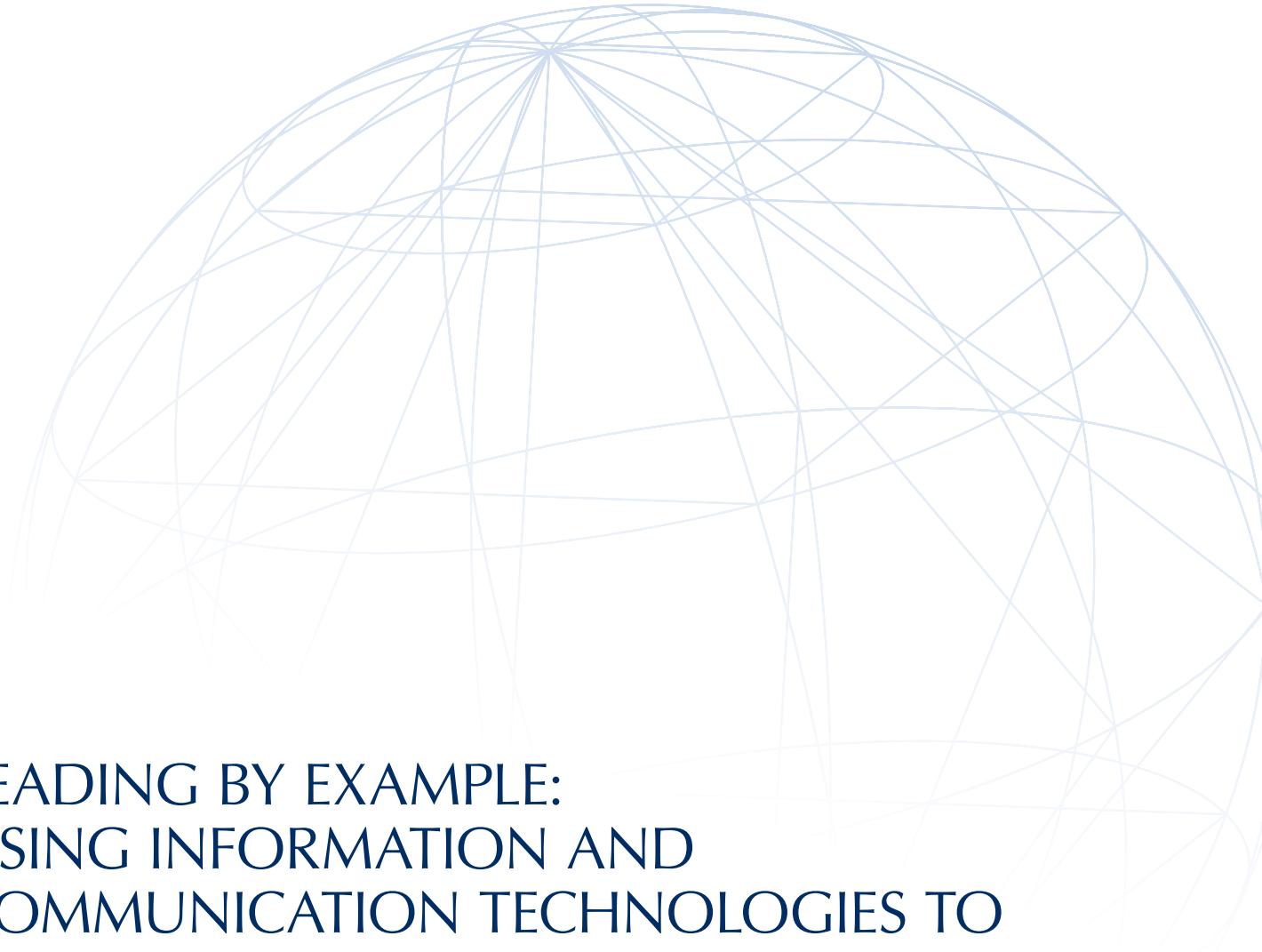
September 2012



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EXECUTIVE SUMMARY

As the nation's largest landlord, fleet operator, and purchaser of goods and services, the federal government has the opportunity, if not the responsibility, to lead by example in moving our country in a more sustainable direction.

Recent initiatives across the federal government have demonstrated that the expanded use of information and communications technologies (ICT) can spur significant reductions in energy consumption and greenhouse gases, while at the same time achieve substantial cost savings and improve productivity. Recent technological developments have created new energy saving opportunities in the areas of smart buildings, smart transportation, and travel substitution. Additional opportunities exist related to mobility and collaboration tools.

Led by the General Services Administration (GSA) and the Department of Defense (DoD), these government-wide efforts are changing the way federal departments and agencies operate. They represent the intersection of two critically important forces driving agency behavior today. Increasingly stringent budget constraints are pushing agencies to take a hard look at ways they can reduce costs and enhance efficiencies.[1] At the same time, new Executive Orders[2] and Congressional actions[3] are mandating that agencies alter their practices to become more sustainable. These two forces have come together to create new opportunities for the government to change in important ways that produce multiple benefits for individual agencies and for the public they serve.

The eight case studies presented in this report highlight how the federal government is using ICT solutions to achieve these multiple objectives. The case studies are:

- *GSA's Prototype Alternative Workspace: Redesigning the Federal Workplace for the 21st Century*
- *Sustainability Base: Channeling NASA's Expertise to Create a High-Performance Building Here on Earth*
- *Defense Connect Online: Advancing Sustainability through Enhanced Collaboration and Communication Tools*
- *Shift to the Cloud: Achieving Efficiency through Cloud Computing and Data Center Consolidation*
- *Fleet Management at the Smithsonian: Using New Tools to Advance Sustainability and Efficiency*
- *Testing New Building Technologies at DoD and GSA: Advancing Energy-Saving Innovations*
- *Energy Savings at Sector San Juan: The Coast Guard's Innovative Shift to Clean Energy in Puerto Rico*
- *GSA's Print Management Initiatives: Cutting Costs and Saving Energy Through Smarter Printing*

A recent report used the term "intelligent efficiency" to describe the use of ICT solutions to reduce energy consumption.[4] Several studies have estimated that these technologies, if widely implemented, have the potential to reduce energy consumption across the U.S. economy by 12 to 22 percent.[5]

Because of its size and scale, the federal government has an important role to play in advancing ICT solutions like those described in this report. Success in this role will come from demonstrating that these technologies not only reduce energy use, but that they do so in ways that are cost-effective, that advance sustainability objectives, and that improve productivity.

LESSONS LEARNED

While each case study tells its own story, several cross-cutting "lessons learned" have emerged from this research:

- Signficant opportunities exist across a range of areas (e.g., fleets, buildings, information technology systems, training and travel) to move toward a more sustainable government, while at the same time reducing costs and enhancing productivity.
- Setting near-term goals for specific, measureable targets (e.g., cutting specific costs, goals for energy or greenhouse gas reductions) coupled with aggressive tracking of progress helps ensure meaningful action.

- Federal facilities and expertise offer unique opportunities to advance sustainability objectives.
- The availability of financing is critical to advancing sustainability efforts. The expanded use of performance contracting offers one potential way to address this constraint.
- Harnessing recent advances in ICT solutions open up new opportunities for agencies to become more sustainable, cut costs and enhance their productivity.

Table 1 summarizes the case studies presented in this report.

TABLE 1: Summary of Case Studies

PROJECT	SUSTAINABILITY OBJECTIVES	TECHNOLOGIES EMPLOYED	BENEFITS	TRANSFERABILITY
GSA's Prototype Alternative Workspace: Redesigning the Federal Workplace for the 21st Century	Energy Information and Security Act (EISA 2007) includes a goal of reducing energy intensity of federal buildings by 30% by 2015. Executive Order (EO) 13514 (2009) mandates that agencies establish greenhouse gas emission targets. Presidential Memorandum (2010) calls for enhanced utilization of federal properties.	Shift from private workspace to reserved workspace based on daily needs (e.g., meeting room, workbenches, quiet rooms). Mobility tools including smart phones, laptops, etc. provided to staff. Online office space reservation system used to reserve space.	Twice the workers in same amount of space. Supports enhanced worker collaboration. Supports enhanced use of telework. 45% energy savings and reduction in greenhouse gas emissions $632,000 rent savings per year with a 2-year return on investment.	As agencies look to reduce real estate, reconfigure existing space and build out new space, GSA pilot provides an example of more cost-effective and sustainable space.
Sustainability Base: Channeling NASA's Expertise to Create a High-Performance Building Here on Earth	Energy Policy Act of 2005 (EPAct) sets a goal of 7.5 percent of renewables for federal electricity use by 2013. EISA 2007 includes a goal of reducing energy intensity of federal buildings by 30% by 2015. EO 13514 mandates that all new buildings beginning in 2020 are designed to achieve zero-net energy.	Utilizes geothermal system for heating and cooling. Incorporates solar PV and advanced fuel cell to supply electricity. Includes gray water recycling system.	Sustainability Base is being used as a living lab to develop integrated intelligent building control system. Building capable of producing more electricity than it consumes. Reduce potable water consumption by 90% through gray water recycling and other measures.	Advanced building design and control systems serve as testing ground for meeting net-zero energy and other sustainability goals for new federal buildings.

PROJECT	SUSTAINABILITY OBJECTIVES	TECHNOLOGIES EMPLOYED	BENEFITS	TRANSFERABILITY
Defense Connect Online: Advancing Sustainability through Enhanced Collaboration and Communication Tools	EO 13514 calls for reductions of carbon emissions from travel and training. Telework Enhancement Act (2010) seeks to expand use of telework. EO 13589 (2011) requires agencies to cut costs by 20% across five areas including travel.	Defense Connect Online (DCO) is a set of collaboration and communication tools employed across DoD and with outside parties. User-friendly system allows DCO to be used on a wide range of equipment and bandwidth. Can be used for video-conferencing, instant messaging, e-training, etc.	Energy and cost savings by reducing business travel and costs of training. Key element of DoD's continuity of operations plan. More than 700,000 users, expected to grow to 2.5 million in 4 years.	The federal government increasingly is relying on new online communications and collaboration tools to reduce travel and training costs.
Shift to the Cloud: Achieving Efficiency through Cloud Computing and Data Center Consolidation	EO 13514 mandates federal agencies to cut GHG emissions. OMB directive (2010) calls on agencies to reduce number of data centers. OMB directive (2010) to agencies calls for a "cloud first" policy.	"Cloud first" policy calls for treating computing resources as a service that can be rapidly procured and financed through operating expenditures. GSA is the first agency to migrate to a cloud-based email and collaboration service.	GSA is expected to reduce email operation costs by 50% over the next 5 years, saving $15.2 million annually. GSA has reduced its email service energy use by 85-88%. GSA cut CO_2 emissions by 85% by migrating to email cloud services.	In August 2012, GSA awarded 20 blanket purchase agreements allowing federal agencies to procure cloud-based email solutions from 17 different companies.
Fleet Management at the Smithsonian: Using New Tools to Advance Sustainability and Efficiency	EO 13514 mandates an annual 2% cut in petroleum use. Presidential Memorandum (2011) on Federal Fleet Performance mandates optimizing fleet inventory.	Fleet management information system (FMIS) tracks vehicle use, gas consumption, maintenance, etc. Telematics system tracks vehicle use, driver safety, idle times, etc.	Reduced reporting costs, enhanced maintenance and improved driver safety. 18% cut in number of light-duty fleet vehicles. 44% cut in petroleum use due to information systems and other actions (alternative-fueled vehicles).	FMIS has wide applicability; GSA has moved to expand FMIS use across the federal fleet. Telematics could be widely used to enhance agency efforts to optimize fleet size and utilization and enhance safety.

PROJECT	SUSTAINABILITY OBJECTIVES	TECHNOLOGIES EMPLOYED	BENEFITS	TRANSFERABILITY
Testing New Building Technologies at DoD and GSA: Advancing Energy-Saving Innovations	EPAct sets a goal of 7.5% of renewables for federal electricity use by 2013. EISA 2007 established goal of 30% reduction in energy intensity. EO 13514 mandates federal agencies to cut greenhouse gas emissions.	Innovative energy-saving technologies are being tested at federal facilities in many applications including: smart grids; energy storage; advanced building controls; renewables; plug load management, etc.	New technologies can contribute to mission-critical goals of increased energy security and cutting energy costs. Use of federal facilities as test bed helps bridge the "technology valley of death" that stands in the way of commercialization. Energy and cost-saving technologies can help agencies meet both budgetary and sustainability goals.	Technologies are selected for testing based in part on their potential for enhancing energy security and substantially reducing energy consumption.
Energy Savings at Sector San Juan: The Coast Guard's Innovative Shift to Clean Energy in Puerto Rico	EPAct and EISA 2007 require increased use of renewables and reduced energy intensity in federal buildings. EO 13514 sets goals for reducing greenhouse gas emissions. Presidential Memorandum (2011) expands use of performance-based contracting for energy savings.	Installation of 3 MW of solar PV. Installation of energy efficiency technologies, including building energy controls and variable refrigerant volume air conditioning units.	Use of PV reduces reliance on grid, enhancing energy security. Buildings were substantially upgraded through renovations associated with project. Reduced energy consumption and GHG emissions by 53% Private financing provided 75% of total project costs.	Project demonstrated feasibility of combining public-private financing for energy retrofits and renewables. Project also demonstrated ability to support more extensive renovations under Energy Savings Performance Contract (ESPC) financing.

PROJECT	SUSTAINABILITY OBJECTIVES	TECHNOLOGIES EMPLOYED	BENEFITS	TRANSFERABILITY
GSA's Print Management Initiatives: Cutting Costs and Saving Energy Through Smarter Printing	EO 13514 calls for reduction in duplex printing. EO 13589 mandates a cut of 20% by federal agencies across five areas including printing.	Managed Print Services replaces personal printers with networked multifunctional printers. Use of default settings for duplex, black and white, and draft quality printing. Use of Federal Strategic Sourcing Initiative (FSSI) to reduce purchase costs and encourage most environmentally sustainable devices	Reductions in energy use and GHG emissions associated with reduced printing. Use of more energy-efficient equipment. Potential savings from cutting federal printing costs in half, from $2 billion to $1 billion annually.	Use of FSSI provides procurement vehicle for all federal agencies. PrintWise behavioral change campaign provides agencies with seven simple steps in 90 days to reduce print costs.

NOTES

1 Executive Order no. 13589, "Promoting Efficient Spending," Code of Federal Regulations, title 3, sec. 13589 (2011), http://www.gpo.gov/fdsys/pkg/CFR-2012-title3-vol1/xml/CFR-2012-title3-vol1-eo13589.xml.

2 U.S. National Archives and Records Administration, "Executive Order 13514--Federal Leadership in Environmental, Energy, and Economic Performance," Federal Register 74, no. 52117 (October 2009), http://www.gpo.gov/fdsys/pkg/FR-2009-10-08/html/E9-24518.htm.

3 U.S. Office of Personnel Management, Status of Telework in the Federal Government (Washington, DC: U.S. Office of Personnel Management, 2011), http://www.telework.gov/Reports_and_Studies/Annual_Reports/2010teleworkreport.pdf.

4 Neal Elliot, Maggie Molina, and Dan Trombley, *A Defining Framework for Intelligent Efficiency, Research Report* (Washington, DC: American Council for an Energy-Efficient Economy, 2012), http://aceee.org/research-report/e125.

5 Ibid.

I. GSA'S PROTOTYPE ALTERNATIVE WORKSPACE: REDESIGNING THE FEDERAL WORKPLACE FOR THE 21ST CENTURY*

OVERVIEW

Given rapid advances in office technology, today's workplace needs to be designed to meet the changing nature and needs of today's workforce. Through its Prototype Alternative Workspace, the U.S. General Services Administration (GSA) has designed and is testing a flexible office layout that fully embraces the latest mobility and collaboration tools. In addition to creating a workplace design that enhances worker satisfaction and productivity, this pilot project advances sustainability goals by reducing the amount of office space required, and facilitating increased telework. This results in cutting energy use by 45 percent with a corresponding reduction in carbon dioxide emissions. As one of the nation's largest landlords, GSA is leading by example in creating the office environment of the 21st century.

GSA'S MODERNIZATION PUSH

The General Services Administration is one of the nation's largest landlords. It is the owner or lessor of more than 9,600 buildings nationwide, encompassing 370 million square feet and housing about 1.1 million federal employees. As one of the federal government's principal property owners and facilities managers, it plays a major role in shaping the office environment of the federal workforce and faces a growing set of challenges and opportunities.

Over a quarter of GSA's owned buildings are listed in or eligible for the National Register of Historic Places; approximately half of its buildings are more than 50 years old. GSA's own headquarters building, located just a few blocks from the White House, provides an example of the challenges facing the agency, as well as the federal government as a whole. The headquarters is a historic property badly in need of modernization, with outdated systems and workspaces. Long corridors, closed doors, and high-walled cubicles act to limit the penetration of natural sunlight and isolate workers from each other. In addition, because of the increase in the size of its staff, GSA has outgrown its headquarters and now has headquarters personnel occupying buildings in four different locations across Washington, D.C., and in suburban Virginia.

Modernizing GSA's headquarters and other federal buildings is about much more than putting a fresh face on the physical plant. No longer tied to a desk, many of today's workers are taking advantage of the flexibility offered by the current generation of mobility tools that have replaced desktop computers and landline phones of the past. To realize their full productivity, federal employees must have the tools to enable mobile work, to bring a full range of resources with them when visiting clients, and to collaborate with colleagues both physically and virtually using chat, document sharing and video conferencing on computers and mobile devices. In effect, they need the tools to be able to perform their work wherever they are, be it in the office or a remote location.

This case study focuses on GSA's innovative approach to the design and testing of a more flexible workspace for its headquarters building. The Prototype Alternative Workspace serves both as a model for GSA's own modernization plans and as a living experiment serving up lessons for other federal agencies seeking new designs to enhance space utilization and worker productivity.

SUSTAINABILITY AND COST-SAVING CHALLENGES

GSA's status as one of the nation's largest landlords comes with a growing set of challenges. Faced with ever-tightening federal budgets, the number-one challenge facing the organization and its leaders is to reduce the costs to the federal government of owning and operating real estate. But GSA faces a host of additional pressures, including: reducing the energy and environmental impact of federal buildings; upgrading facilities to make better use of new technologies; meeting congressional mandates to increase telework; and creating work environments that facilitate collaboration and enhance productivity.

Tightening Budgets

Real estate is a significant cost for federal agencies. In a fiscal environment where government is reducing spending, agencies are actively seeking ways to better utilize their buildings and cut operating costs. In June 2010, President Obama signed a memorandum, *Disposing of Unneeded Federal Real Estate*, aimed at cutting waste in federal real estate holdings.[1] It established a goal, for non-defense agencies, of saving $3 billion by FY2012 by disposing of surplus properties, improving utilization and occupancy rates of existing properties, pursuing consolidation opportunities, and reducing operating costs through enhanced energy and water efficiency. As of February 2012, GSA had achieved savings of more than $300 million toward its goal of $450 million through better utilization and disposal of properties.[2]

New Environmental and Sustainability Goals

Federal buildings have long been the focus of legislative and regulatory mandates designed to minimize energy use and environmental impacts. For example, the Energy Independence and Security Act (EISA) of 2007 mandates that federal buildings achieve a 30-percent reduction in energy intensity by 2015 compared to a 2003 baseline level. EISA also requires that new federal buildings meet performance standards aimed at reducing fossil fuel-generated energy consumption by 65 percent by 2015 and achieving net-zero fossil fuel-generated energy consumption by 2030.[3]

The greening of the federal government has been a bipartisan effort through several administrations aimed at making federal facilities a showcase of leading environmental design and operations. These efforts date at least as far back as President Jimmy Carter, who had solar panels installed on the roof of the White House. President George H.W. Bush, President Bill Clinton and President George W. Bush all signed Executive Orders and directives mandating energy reductions across the federal government.

The most recent presidential action on this front took the form of Executive Order 13514, signed by President Obama in October 2009.[4] Titled *Federal Leadership in Environmental, Energy and Economic Performance,* it requires agencies to prepare and implement a Strategic Sustainability Performance Plan. Required elements of the plan include: data on the agency's greenhouse gas emissions; and details about its plans for reducing energy intensity in federal buildings and increasing the agency's use of renewable energy. The Executive Order also reinforces the EISA requirement that all new federal buildings that enter the planning process from 2020 onward must be designed to achieve zero-net energy by 2030.

Changing Role of Technology

Advances in information and communications technology have created new opportunities to provide increased flexibility for federal workers. These technology changes have fundamentally altered the relationship between employees, their offices and their work. For example:

- Cloud computing allows workers to access their emails and files from any location;
- Smart phones and cell phones are ubiquitous, and phone calls can be automatically routed seamlessly to multiple devices regardless of location;
- Multimedia teleconferencing and video conferencing allow direct interaction without the time and money spent on traveling to a common location;
- Document-sharing software allows select groups to work simultaneously or through a shared arrangement on the same document; and
- E-training has increasingly shifted learning online at far lower costs and with reduced travel time.

The key to a successful enterprise lies in how these tools are integrated into the workplace to enhance worker productivity, reduce costs, advance sustainability goals, and improve worker satisfaction. As explained below, GSA's Prototype Alternative Workspace seeks to fully incorporate these and other tools into the design of the workspace itself.

One way in which the increasing availability of technology has changed how the federal government gets things done is through a new emphasis on telework. The federal government has actively promoted telework for its employees for over a decade, starting with legislation in 2000 that established the government's first telework goals. Among the reasons for Washington's enthusiastic embrace of telework is the fact that the nation's capital ranks number one, even ahead of Los Angeles, for rush-hour traffic.[5] However, despite years of effort, only about 11 percent of eligible federal employees participate to some degree in a telework program.[6]

The availability of new technology tools, including cloud-based solutions that facilitate telework, could prove to be a game changer. These tools remove some of the critical obstacles to successful telework by providing the ability to readily access emails and files, work on shared documents, and interact using chat and teleconferencing tools in a cost-effective manner. In 2010, Congress made one more attempt to spur increased telework through passage of the Telework Enhancement Act.[7] It makes all federal workers eligible to telework unless their agencies affirmatively deem them ineligible. In addition, the law requires all agencies to set telework goals and to monitor and report on progress toward meeting their goals.

Given the increased availability of technology that enables workers to perform more effectively from alternative workplaces, the federal government's new emphasis on promoting telework could lead to major changes. The challenge for GSA and other agencies is to develop an integrated approach that marries technology, workplace design, and worker flexibility in a way that maximizes the benefits of increased telework.

Changing Workplace Requirements

From the groundbreaking discoveries at Bell Labs in the mid-1900s to today's innovations from Google, it is clear that organizations that encourage collaboration among workers can achieve major breakthroughs. Yet federal office space has largely evolved toward private offices for senior officials and high-walled cubicles for everyone else. If the federal government wants to reap the rewards of a higher level of collaboration among workers, then it needs to rethink the prevailing federal office space design.

Promoting more collaboration among employees was one of the primary motivations for GSA as it set out to redesign its headquarters. Given that most employees now will have a choice of working remotely or coming into the office, a major challenge for GSA is to design space that workers want to use and that provides benefits and advantages that they could not realize if they were working at home.

THE PROTOTYPE ALTERNATIVE WORKSPACE

"Work is what you do, not where you do it." President Obama used these words to describe the need for flexible workplaces in a March 2010 address at the White House Forum on Workplace Flexibility.[8] The President's statement frequently comes up in discussions within GSA because it captures the philosophy behind the Prototype Alternative Workspace: federal employees should be fully capable of working from any location using today's mobility tools.

FIGURE 1: Collaboration in Action

Source: Gavin Bloch, "GSA Headquarters 7th Floor Workplace Prototype" (Presentation, March 13, 2012).

GSA developed the Prototype Alternative Workspace as a small part of the renovation of its headquarters building. The effort was founded on six goals that GSA is using to evaluate its success:

- Create a place where people want to come to work;
- Provide a professional workplace;
- Encourage and support collaboration;
- Improve productivity;
- Produce energy savings; and
- Improve the utilization of real estate.

A hallmark of GSA's approach was that the project sought to advance multiple objectives that, if implemented successfully, would produce a range of benefits. Employees would have greater flexibility in where they worked and, when in the office, a range of workspaces available to meet their specific needs. The project also promised to enhance agency productivity through increased collaboration while reducing costs through better space utilization and energy savings.

Space Utilization

One of the first steps GSA took as it considered the design of its new workspace was to examine closely how

TABLE 1: Utilization of Pilot Project Office Space, GSA Headquarters: Feb-May 2011

DAYS	MON.	TUES.	WED.	THURS.	TOTAL
	34%	54%	49%	44%	45%
AM	33%	56%	51%	42%	45%
PM	34%	52%	46%	46%	44%

Note that data for Fridays was not included because as a transitional period workers on this day each week were required to find space elsewhere in the building or to work at home.

Source: Gavin Bloch, "GSA Headquarters 7th Floor Workplace Prototype" (Presentation, March 13, 2012).

existing facilities were being used. This very basic step—simply documenting current space utilization in the soon-to-be-renovated suite of offices—proved invaluable. Over a period of several months, GSA did a twice-daily survey of the extent to which offices and cubicles were in use. The point of the survey wasn't to track where workers were spending their time. Rather, the goal was to determine the percentage of time people were using existing office spaces and the percentage of time they were not, due to conferences, telework, sick leave, travel, training, etc. **Table 1** presents data showing that space utilization never exceeded 56 percent during this period and that average usage was around 45 percent.

Redesigning the Space

The idea of redesigning office space so that nobody has a personally assigned space would likely be a tough sell for any organization. While some workers might embrace the flexibility and the "work-anywhere" ethos, others might resist because they want their own private offices and personalized workspace, or because they prefer the social interaction that they are used to in an environment where you see the same people from day to day. Some managers might push back based on the belief that they cannot effectively fulfill their supervisory duties unless they can directly see and interact with their staff.

But what if you could make the case that an alternative, nontraditional arrangement would do a better job of meeting employees' needs and enhancing their workplace experience?

This is what GSA set out to do in the course of designing its Prototype Alternative Workspace. Through an extensive process of employee engagement, GSA staff responsible for designing and implementing the new space identified key requirements and ways in which they could be met. Because employees wanted to be able to continue to work in close proximity to their colleagues, the new design incorporated "team neighborhoods" for each division. To allow employees to keep personal belongings and important files at the office, the new space featured private lockers. Last but not least, the design included private rooms with phones so that people could still have the privacy they sometimes required.

Above all, the redesigned workspace aimed to foster increased collaboration and provide a range of workspace options to meet the specific needs of employees. The new space included a range of features to enhance collaboration:

- Soft seating in open areas for informal interaction;
- Team tables for impromptu meetings;
- Large and small conference rooms for team and other meetings;
- Lounge and kitchen facilities for gathering at meals and coffee breaks,
- Informal seating on outside balconies; and
- Small private rooms for occasions when privacy is required.

To provide a range of workspace options specific to different needs, the redesign included the following "activity-based" work settings:

- "Touchdown" work stations for short stays;
- Quiet rooms for intense work requiring silence;
- Bench-like workstations accommodating multiple users;
- Private rooms for phone calls; and
- Conference rooms for meetings.

With all staff equipped with laptop computers and mobile devices, the design allows employees to transition easily between different spaces during the course of a day in the Wi-Fi-enabled space. A reservation system allows employees to reserve ahead of time the particular type of workspace they require on a particular time or day. The system also allows employees to quickly go online to locate other employees when they are in the office.

The Business Case for the Prototype Alternative Workplace

Simply putting more people into less space would be an easy way to save money on real estate, but doing so would likely result in reduced productivity, declining worker retention and higher recruitment costs. GSA's design for the Prototype Alternative Workspace is based on the recognition that existing workspaces were utilized less than 50 percent of the time. By redesigning how space is used, GSA set out to show that substantial savings, and other benefits, can be achieved while enhancing the critical objective of increasing collaboration among staff.

The business case for this transformation is demonstrated in **Table 2**.

GSA's Prototype Alternative Workspace now houses 170 full-time employees in space that had been occupied by 73 full-time employees. The design results in over a 50-percent reduction in usable square feet per person. But with higher utilization rates, the actual space available to each worker on site is only slightly lower than before the redesign. The estimated cost of the redesigned space and furnishings was less than $1 million. The implied annual rent savings in reduced real estate costs by consolidating more workers into less space is $632,000 ($42 per square foot). GSA estimates that the revamped space will pay for itself in less than two years. By better utilizing the office space at its headquarters building, GSA should be able to move toward consolidating staff in this single building, resulting in substantial savings as GSA reduces its need for leased space at satellite offices.

ENERGY AND GREENHOUSE GAS REDUCTIONS

Improved space utilization also results in substantial savings in energy consumption and reduced carbon dioxide emissions. Because the space devoted to this project in the GSA headquarters is not separately metered, changes in energy use can only be estimated. Any calculation of the full energy implications of the alternative workspace would take into consideration a range of impacts including: the reduced energy consumption from cutting in half the amount of square feet utilized by the same number of workers; the increase in energy consumption for the higher density of usage for the redesigned space; the reduced energy consumed by teleworkers not commuting to the office; and increased energy use by these workers at their alternative work sites (e.g., plug loads and heating or cooling their homes).

GSA undertook a partial calculation of these energy savings and associated carbon dioxide emissions. Using data from the U.S. Energy Information Administration's Commercial Building Energy Consumption Survey, GSA estimated the energy usage for the 29,000 square feet of space before the redesign and the 14,000 square feet after renovations were complete. The projected energy use after the renovation was adjusted upward by roughly 10 percent to reflect increased energy consumption likely to

TABLE 2: Metrics for Office Space Utilization and Costs

COMBINED RELOCATED OFFICES	BEFORE REDESIGN	AFTER REDESIGN	PERCENT REDUCTION
Usable Square Feet	29,120	14,065	52%
Full Time Employees (FTE)	170	170	0%
Work Stations	170	103	39%
Usable S.F. Per FTE	171	83	52%
Rent Per Square Foot			$42
Reduction in Sq. Ft.			15,055
Implied Annual Rent Savings			$632,310
Approx Project Cost			Less than $1M
Pay Back			Less than 2 Years

Source: Gavin Bloch, "GSA Headquarters 7th Floor Workplace Prototype" (Presentation, March 13, 2012).

FIGURE 2: Prototype Alternative Work Areas

Source: Gavin Bloch, "GSA Headquarters 7th Floor Workplace Prototype" (Presentation, March 13, 2012).

occur in the redesigned space from the increased density of occupancy and plug-load demands.

Using EPA's eGrid estimates of the electricity generation mix for the surrounding region, GSA calculated reductions in carbon dioxide emissions resulting from the reduced energy use. GSA's analysis estimated that the redesigned space would reduce emissions from 516 tons of carbon dioxide annually to 286 tons per year, a reduction of 45 percent.

This calculation assumes that occupants of this space telework three days a week. It does not include changes in energy use from reduced commuting, nor does it reflect increased home energy consumption associated with increased telework. Due to a lack of data, it also doesn't account for the likely increase in telework that would occur after the space redesign.

Keys to Implementation

Changing offices and space allocations can be a highly contentious issue within any organization. If done poorly, the adverse impact on staff morale, productivity and retention could be significant. However, with careful planning and a change management process that encourages input from affected employees and adequate training to support the transition, employers can minimize potential negative consequences.

While the core elements of increased telework and flexible, shared workspace were not negotiable, GSA actively encouraged and solicited employee input on all other matters, with the result that employees played a vital role in helping to determine how the space would be redesigned.

The GSA team engaged affected staff and unions, established a Space Advisory Committee (composed of non-supervisory employees, union representatives and the GSA project team), regularly updated employees and solicited their input. In addition, the affected offices initiated key elements of the plan incrementally, encouraging increased telework and desk sharing prior to the actual move. This allowed staff to become more comfortable with these changes and to provide feedback on ways to improve their implementation.

Training was another key aspect of this transition. Managers needed to adapt to new ways to carry out their supervisory responsibilities. They needed to be comfortable using new tools to collaborate with their staff. Staff also needed training to support their use of the mobility tools now available to them and to help them find the most effective ways to engage in collaborative work in the newly designed workspace. Staff also participated in developing space-use protocols to define expected behaviors in specific settings.

To help support mobile work and telework, GSA made the following tools available to staff so they could work from anywhere: laptops for all staff; easy access to email and files now available through the cloud; a wireless LAN onsite; "softphones" that allow employees to use their computers to make calls (a significant hardware and service cost saving); and Google collaboration cloud services for document sharing and messaging.

Last but not least, senior management commitment was critical to the success of the new workspace. The GSA administrator and other senior leaders "walked the talk" by agreeing to give up their private offices.

Initial Survey Feedback

In a survey conducted three months after move-in to the headquarters pilot space, employees expressed positive opinions about the new work environment. Asked whether the workspace adequately supports their personal productivity, 78 percent answered positively by ranking the space a 3 or above (on a scale of 1-strongly disagree to 5-strongly agree) (see **Figure 3**).

GSA views the Prototype Alternative Workspace as a living laboratory for innovative workplaces and plans to continue to change the design with the goal of further enhancing its effectiveness. In addition, GSA is using the

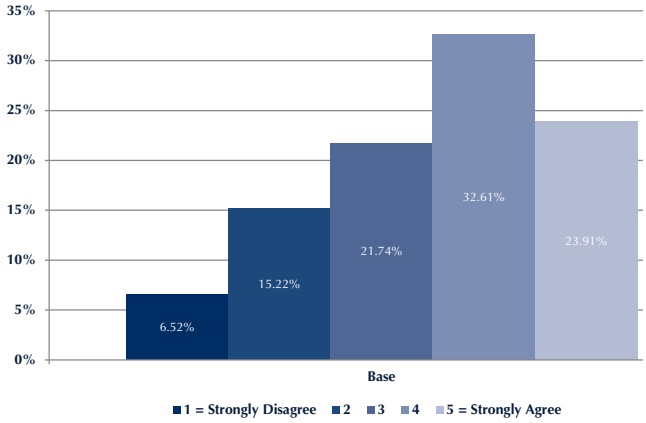
workspace as a showcase for client agencies exploring options for the design of workspaces in their buildings. In the six months since the launch of the new space, GSA has created other pilot projects and dozens of agencies have come to see the workplace prototype. A number of agencies have moved forward in adopting various elements of its design. For example, the new headquarters building of the National Labor Relations Board, which was inspired in part by GSA's pilot, achieves a 35-percent improvement in space utilization over current facilities through reductions in the number of private offices and increased desk sharing.

BARRIERS AND CHALLENGES TO ADAPTION OF FLEXIBLE WORKSPACE

GSA's Prototype Alternative Workplace provides agencies with a concrete example of some of the approaches they might consider in addressing their own future workplace requirements. In considering the GSA approach and the extent to which it might meet their needs, agencies have to consider a number of potential barriers. First, a change in office design of this magnitude requires a cultural change that must be fully embraced by senior management, along with buy-in from staff and unions throughout the organization. While the GSA experiment has shown the value of thoughtful engagement and consultations in building support for changes like this, it can be a challenging and lengthy process to get everyone on board.

Another barrier involves identifying and procuring the funds to finance a shift to a more flexible workspace. Even though these types of projects can save money over time, they require agencies to pay for up-front costs at a time of increasingly constrained government budgets. Current federal budgeting practices, with their focus on today's costs rather than tomorrow's savings, make it difficult to justify spending funds on energy-saving investments even when they will more than pay for themselves in a relatively short time period. In addition, agencies have little incentive to invest in energy-saving measures in instances where GSA owns their buildings and pays the utility bills.

FIGURE 3: Initial Survey Results of Employee Satisfaction



Source: Gavin Bloch, "GSA Headquarters 7th Floor Workplace Prototype" (Presentation, March 13, 2012).

NEXT STEPS/TRANSFERABILITY

GSA intends to continue to refine the concept and design of the Prototype Alternative Workplace and to develop additional alternative approaches to supporting increased workplace collaboration. GSA's goal is to provide agencies with a range of options to consider, recognizing that there is no single approach that will work in all situations across the federal government.

In addition, GSA is in the process of building out the first half of its headquarters modernization and intends to incorporate aspects of the Prototype Alternative Workplace in the final redesign of its own building.

NOTES

* The Center for Climate and Energy Solutions wants to express our appreciation to several GSA employees for contributing their insights and collaborating on the joint preparation of this case study, including Gavin Bloch, Brian Gilligan, Robert Obenreder, and Bart Bush.

1 U.S. National Archives and Records Administration, "Memorandum on Disposing of Unneeded Federal Real Estate," Daily Compilation of Presidential Documents, 2010 DCPD No. 00483 (June 10, 2010), http://www.gpo.gov/fdsys/pkg/DCPD-201000483/html/DCPD-201000483.htm.

2 *One Year Later: Effectively Utilizing Assets*. 112th Congress. 2012. (Statement of Robert Peck, Commissioner, Public Buildings Service for the GSA). Testimony available at: http://www.gsa.gov/portal/content/124223

3 "Energy Independence & Security Act," U.S. Department of Energy, last modified September 24, 2010, http://www1.eere.energy.gov/femp/regulations/eisa.html.

4 U.S. National Archives and Records Administration, "Executive Order 13514--Federal Leadership in Environmental, Energy, and Economic Performance," Federal Register 74, no. 52117 (October 2009), http://www.gpo.gov/fdsys/pkg/FR-2009-10-08/html/E9-24518.htm.

5 David Schrank et al., *2011 Urban Mobility Report and Appendices* (College Station, TX: University Transportation Center for Mobility, Texas Transportation Institute, Texas A&M University System, 2011), http://mobility.tamu.edu/ums.

6 U.S. Office of Personnel Management, *Status of Telework in the Federal Government* (Washington, DC: U.S. Office of Personnel Management, 2011), http://www.telework.gov/Reports_and_Studies/Annual_Reports/2010teleworkreport.pdf.

7 Telework Enhancement Act of 2010, Pub. L. No. 111-292, http://www.gpo.gov/fdsys/pkg/PLAW-111publ292/html/PLAW-111publ292.htm.

8 U.S. National Archives and Records Administration, "Remarks at the Closing Session of the Workplace Flexibility Forum," Daily Compilation of Presidential Documents, 2010 DCPD No. 00217 (March 31, 2010), http://www.gpo.gov/fdsys/pkg/DCPD-201000217/html/DCPD-201000217.htm.

II. SUSTAINABILITY BASE: CHANNELING NASA'S EXPERTISE TO CREATE A HIGH-PERFORMANCE BUILDING HERE ON EARTH*

OVERVIEW

Drawing on the same "can-do" spirit that sent men to the moon and unmanned rovers to Mars, NASA has channeled its technical expertise into the design of an innovative new building for its employees at the Ames Research Center in Northern California. Called "Sustainability Base," the building is designed to surpass the LEED Platinum sustainable design certification. Sustainability Base pushes the envelope on environmentally driven design, serving both as functioning office space and as a living laboratory for continuous advancements in intelligent building energy systems. It is one of the federal government's greenest buildings and is designed to produce more electricity than it consumes. Sustainability Base occupies a unique place within the federal government's efforts to lead by example in developing and occupying environmentally advanced buildings.

HUMBLE BEGINNINGS

One of 10 NASA centers throughout the country, the focus of work at Ames Research Center began with research on the aerodynamics of propellers dating back to before World War II. In addition to its continued focus on advanced aeronautics, over the years Ames has developed new areas of expertise including earth sciences, astrobiology, bioengineering, space- and aeronautics-related information technology, and others. Ames is located at Moffett Field in the heart of Silicon Valley, California.

The origins of Sustainability Base can be traced to 2007, when NASA started a "Renovation by Replacement" initiative providing financial support to its centers to replace antiquated buildings and reduce energy intensity by reducing the square footage of facilities. After Ames was selected to receive funding, the center's leadership proposed a fairly traditional design for its replacement facility. Ames Associate Director Dr. Steve Zornetzer had a different vision. He pictured a building that would reflect NASA's technological expertise and its leadership in imagining the future. Under his proposal, NASA would apply the expertise developed in creating livable conditions for spacecraft and astronauts to break new ground with an environmentally sustainable building at Ames. As Zornetzer states, "It was inconceivable to me that in the 21st century, in the heart of Silicon Valley, NASA would be building a building that could have been built 25 years ago. NASA had to build the highest-performing building in the federal government, embed NASA technology inside, and make a statement to the public that NASA was giving back to the people of planet Earth what it had developed for advanced aerospace applications."

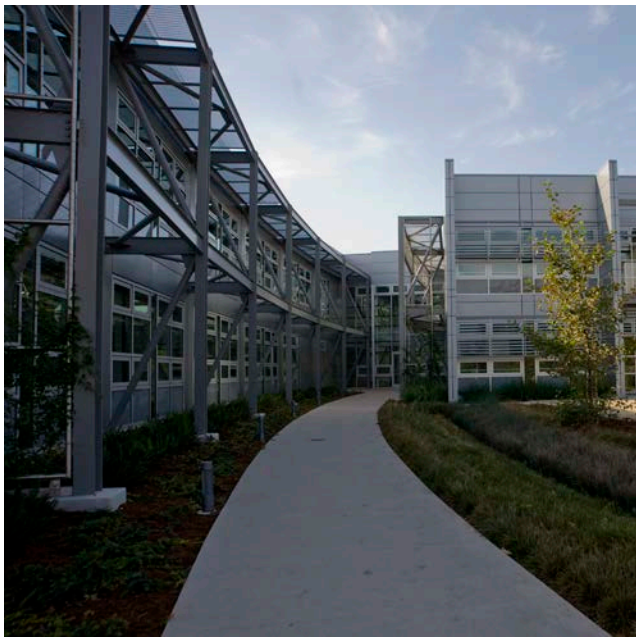
The one important catch was that the redesigned building could not cost more than the originally proposed project.

SUSTAINABILITY CHALLENGES[1]

The challenges faced by NASA for its facilities at home involve meeting a growing set of sustainability mandates. Executive Order 13514 requires that all new federal buildings beginning in 2020 be designed to achieve zero net energy.[2] Congressional energy acts have set a goal of using renewables to achieve 7.5 percent of renewable energy by 2013 (Energy Policy Act of 2005)[3] and to reduce energy intensity by 30 percent by 2015 (Energy Independence and Security Act 2007).[4]

Over the decades since it was established in 1958, NASA has repeatedly faced the need to create self-sustaining systems to operate reliably in the harsh environments of space and on extraterrestrial surfaces. As a result, the agency has developed considerable expertise in managing complex systems based on extensive monitoring of dynamic, vital conditions (including energy generation and demand) and maintenance of key systems. No matter the task at hand—safely sustaining an astronaut floating tethered in space, establishing the International Space Station for long-term residence 200 miles above Earth, or powering a rover exploring the hostile surface of Mars—NASA has successfully met the challenges of building instruments and habitats capable

FIGURE 1: Groundlevel View of Sustainability Base



Source: "NASA - Digital Press Kit - NASA Ames Sustainability Base," NASA/ Eric James, last accessed August 28, 2012, http://www.nasa.gov/centers/ames/events/2012/sustainability-base-presskit.html.

of advancing its vision to "reach for new heights and reveal the unknown."

It was that same spirit and commitment to technological advancement that NASA's leadership brought to the design and implementation of Sustainability Base.[5]

The plan for the building centered on four key elements:

- Make maximum use of the existing physical environment through "native to place" design;
- Employ advanced technologies (including renewable energy generation and recycling/reuse) to minimize energy and water consumption and maximize resource efficiencies;
- Install advanced monitoring and adaptive operational systems to achieve sustained building system performance over time; and
- Create a living laboratory for research into advancing sustainability goals.

These elements were fully integrated at the earliest stages of the building's design and construction. The building's core design elements included a complex radial geometry, an innovative steel-frame exoskeleton, and numerous eco-friendly features, such as geothermal wells, natural ventilation, high-performance wastewater treatment, and photovoltaics on the roof. Faced with a tight timeline due to budgetary constraints and the challenges inherent in the building's unique geometry and exoskeleton, the architects and contractors chose to utilize design tools that allowed fast and effective communications among all involved. The design team relied on a Building Information Modeling (BIM) process based on Autodesk Sustainability Solutions, which was integrated with other modeling tools. This facilitated communication across teams and aided in making design decisions in a timely and accurate manner.[6]

For example, in order to maximize the use of natural daylight, the architect modeled local geophysical conditions, including the path of the sun across the sky throughout the seasons of the year. Using Ecotect Analysis software, the building was designed to allow for maximum penetration of sunlight into workspaces. The team also utilized information from the Revit Architecture model, used in the design of the structure, to better understand the cost impacts of its design decisions, particularly the floor-to-ceiling heights and integration of daylight into the design. The extensive use of virtual design tools allowed the project team to complete the drawings and design in nine months, roughly half the time originally estimated for this critical stage of the project.

The resulting $26 million, 50,000-square-foot, two-story building houses 220 office workers, including scientists, managers, mission support personnel, and financial specialists. The extensive floor-to-ceiling windows and open spaces fully embrace the natural daylight. With reduced demand for artificial illumination and the application of high-efficiency radiant heating/cooling systems, the building site produces more electricity than it uses. And it is well on its way to reducing potable water consumption by up to 90 percent compared to a traditional building of the same size. Sustainability Base is not only energy efficient, but resource efficient as well.

NATIVE-TO-PLACE DESIGN

A critical starting point in the design of a resource-efficient building is to make maximum use of the existing environment in ways that minimize energy requirements. Up to 50 percent of the energy savings in a building can be achieved through native-to-place design. In the design of Sustainability Base, the positioning of the building

itself, the use of natural light and air, and key features of the building's design all were developed with the goal of reducing energy needs and maximizing natural light and ventilation, while enhancing the comfort of its occupants.

Sustainability Base is located on the San Francisco Peninsula in Silicon Valley, where the semi-arid, Mediterranean-like climate results in temperate days most of the year. The key challenge for the building's designers was keeping the building comfortable in an area generally characterized by a temperate climate but also subject to an occasional hot summer day.

In pursuing native-to-place design solutions, Sustainability Base takes these climatic factors into consideration. The positioning of the building with a narrow western face maximizes shading and limits solar heating during the long summer days. To further reduce heat load and late afternoon glare in the summer, the sides most exposed to the sun have horizontal aluminum grills on the exterior that act to deflect sun exposure away from the interior of the building.

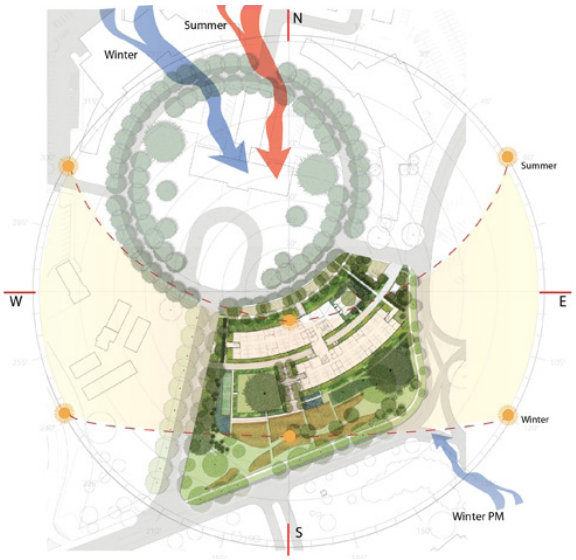
In addition, the base of the building is narrower than comparable buildings. This made it easier to design the building without interior columns, allowing for freer penetration of natural light and circulation of air. The floor-to-ceiling banks of windows are double-paned and argon-filled, with Solarban 70XL glaze permitting sunlight penetration while minimizing heat load and glare.

Windows accessible to the occupants on each floor can be manually opened and closed. Other windows throughout the building are operated automatically depending on external weather conditions. For example, the automated windows are set to open when the outside temperature reaches 70°F. With increased natural ventilation from the open windows, the rooftop air handling system automatically shuts off until outside temperatures rise above 83°F, when the windows close.

Window shades are also operated automatically to reduce solar heat loads. A series of three radiometers on the roof provide data to the software program that incorporates programmed solar tracking to determine when the shades should be open or closed.

To take advantage of the cool nighttime temperatures, which are typically 20°F lower than daytime readings year-round, rooftop air handlers perform nighttime air flushing. Some of this refreshed cool air is then retained in underfloor plenums and circulated into the building during the day for ventilation.

FIGURE 2: Sustainability Base Through the Seasons



Source: "NASA Sustainability Base," William McDonough + Partners, last accessed August 28, 2012, http://www.mcdonoughpartners.com/projects/view/nasa_sustainability_base.

The building's design further embraces the temperate climate by offering wireless access surrounding the building and landscaped outdoor work areas for employees. To minimize water use, the landscaping relies extensively on drought-tolerant, native plants with low water requirements. The landscaping also utilizes bioswales (gently sloped vegetation) in its design, maximizing the retention of rainwater. Additional irrigation is provided with water remediated from nearby groundwater contamination sites, further reducing the requirement for use of primary potable water sources.

ADVANCED ENERGY TECHNOLOGIES

To achieve its goal of producing more electricity than it consumes, Sustainability Base relies extensively on a range of advanced clean energy technologies that reduce its demand for electricity from the grid. Among the cornerstone technologies is a geothermal system providing radiant heating and cooling. Using an extensive network of more than 100 interconnected wells drilled to an average depth of 140 feet, the system circulates water through a closed-loop piping system in the ground. The system draws on the thermal inertia at this depth and maintains the recirculated water at 57°F regardless of outdoor temperatures.

On-site heat exchangers modify the temperature of the circulating water, either increasing or decreasing it to warm or cool the building. Instead of traditional temperature-controlled forced-air circulation, Sustainability Base is cooled through radiant ceiling chilling panels and warmed through wall-mounted radiators. Occupants of the building have noted the absence of the noise and drafts associated with forced-air systems and have observed that the indoor air feels more refreshing and less dry. NASA estimates that the combined system of geothermal wells, water pumps and heat exchangers is designed to be up to 70 percent more energy efficient than traditional methods used in commercial buildings.

For on-site electricity generation, Sustainability Base relies on energy from solar photovoltaic (PV) panels and an emerging fuel cell technology. The solar PV installation includes 432 SunPower E-19 panels that have an estimated conversion efficiency of 19 percent and that can produce 87 kilowatts (kW) of electricity at peak generation. At maximum output, the electricity produced from these solar panels should exceed the building's instantaneous demand. Averaged over the year, the electricity from the solar panels should generate up to 30 percent of the facility's total needs.

Sustainability Base also utilizes a state-of-the-art fuel cell that converts natural gas into electricity through a chemical reaction rather than traditional combustion. This device, the Bloom Energy Server ES-5700 (aka BloomBox) from Bloom Energy, is rated to produce 200 kW (max.) of electricity. The fuel cell can achieve up to 55-percent efficiency and reduce greenhouse gas emissions by 40 percent compared to conventional combustion. The BloomBox installed at Sustainability Base is the first installation of the second-generation model of this emerging technology.

The PV installation was financed using a Utility Energy Service Contract (UESC) with Pacific Gas and Electric. Under this agreement, the utility provided the upfront capital required for the purchase and installation of the solar panels. NASA will repay the initial capital cost over time, based on prorated utility charges that it would have paid without the UESC-provided improvements. When the investment is paid in full, the improvements and subsequent energy savings remain with NASA.

When electricity production exceeds Sustainability Base's demand, both the solar panels and BloomBox move the excess electricity to the grid, and this net contribution is metered.

Sustainability Base also reduces energy consumption through technologies aimed at lowering the electricity usage of its occupants' plug-in equipment. Plug-load demand represents approximately 30 percent of total building electricity use. The building includes such energy efficiency technologies as LED lights, laptops (where possible) that use less power than desktops, and some plug-load monitoring to automate power savings. Several technologies related to plug-load management are being analyzed in pilot studies in Sustainability Base. Early results from simple "rule-based" automation of power-up/power-off strategies indicate that they can achieve savings of 30-50 percent for identified devices.

WATER REDUCTION TECHNOLOGIES

Drawing on technology developed for space travel, Sustainability Base utilizes a grey-water recycling system. It consists of a water purification system that was initially developed for use on the International Space Station and that uses both forward- and reverse-osmosis. The recycled grey water replaces potable water for flushing toilets and urinals. The system installed at Sustainability Base will serve as a scaled-up, long-term test before it is deployed in future extraterrestrial applications. To facilitate reusing wastewater, the building was designed with a dual piping system that allows for segregation of grey water and potable water. These technologies combine with low-flow fixtures to keep water requirements to a minimum; potable water consumption is reduced on the order of 60 percent. Additional reductions in water requirements are achieved through drought-tolerant plants and landscaping that captures rainwater while reducing runoff. Together, these measures were designed with the goal of reducing potable water requirements by up to 90 percent compared to a conventional building design.

OPERATIONAL PARAMETERS

Optimal design and innovative energy-saving technologies are the cornerstones of all high-performance buildings, but by themselves are not sufficient to ensure that the buildings can actually achieve energy-saving goals. Studies have shown that initial energy savings are diminished over time as buildings age and building performance systems deteriorate.

Integrated building control systems are designed to monitor the performance of key systems and to ensure optimal set points and proper operations and maintenance. These systems have become standard in modern

buildings and typically focus on the performance and upkeep of the lighting and heating/cooling/ventilation systems.

Sustainability Base currently uses a state-of-the-art building control system, but over time NASA aims to develop a more integrated, adaptive system. This Integrated Intelligent Building Control System would take extensive real-time measurements of light, humidity and temperature, and combine these with online weather predictions and the calendars of occupants. It would also integrate the automation algorithms of existing building system elements (lighting, shades, windows). The operation of windows and shades, for example, would interact and mutually inform alterations to cooling and heating controls to provide for maximum comfort at minimum energy consumption. Data mining and fault-checking rules would be incorporated into the system for early identification of operational instabilities and maintenance requirements.

NASA intends to work with its own experts and with outside partners from industry and universities in developing this intelligent system over time.

LIVING LABORATORY

Continued efforts to develop the Integrated Intelligent Building Control System are one example of how Sustainability Base serves as a living laboratory for research and testing of advanced systems. NASA Ames Research Center is reaching out to public- and private-sector researchers interested in advancing sustainability goals and utilizing aspects of this building as a test bed. For example:

- NASA is working under an interagency agreement to conduct joint research with DOE's Lawrence Berkeley National Laboratory's Energy Efficient Building Systems Regional Innovation Cluster.
- A partnership with a private company, Integrated Building Solutions, produced the energy dashboard that greets visitors to the facility, displaying real-time energy generation and demand and other real-time data.
- Sustainability Base is experimenting with plug load management instruments from Enmetric Systems, with the company also providing consultation on the project.
- Partnership agreements have recently been concluded with Autodesk and Verdigris Technologies, for projects investigating Building Information Modeling for high-performance facilities and plug-load management, respectively.

Additional partnerships are under development and reflect a key feature of NASA Ames' mindset and history: its focus on entrepreneurship and advancing forward-looking technological solutions.

BARRIERS AND CHALLENGES FACED BY SUSTAINABILITY BASE

The lessons learned from NASA's experience with this building underscore the important role that technological advances can play in meeting the growing challenges of becoming a more sustainable society. NASA's experience with this building also provides additional examples of the practical applications from the technologies NASA has developed for its mission to explore outer space.

Pushing the design envelope for a high-performance building has not been without its problems. Just as NASA has occasionally encountered challenges in space, so has Sustainability Base faced start-up issues on Earth. The initial shakedown period has required significant interaction with, and fine-tuning of, the hydronic heating/cooling system to optimize function and flush out finely milled installation debris. During installation of the geothermal field, the installers unexpectedly discovered artesian wells at the depth initially planned for the drilling locations, necessitating a revision to shallower depths and more holes to compensate.

Setting aside start-up issues, the building is meeting its goals of providing more quality office space in a more sustainable manner for the employees at Ames. Most importantly, there is a genuine continued commitment to using the building and NASA's technological expertise to look outside the box to find solutions for advancing sustainability. If innovations developed for Sustainability Base find their way into widely disseminated products and practices, then this cutting-edge habitat will truly have made an impact far beyond its Earth-based footprint.

NEXT STEPS/TRANSFERABILITY

By bringing the skills and creativity it has applied to the challenges of exploring space, advancing aeronautics, and studying Earth systems to the design of its newest office building, NASA has once again demonstrated its willingness to be a leader in developing problem-solving technologies. Sustainability Base stands out as an example of a high-performance federal building that breaks new ground in utilizing advanced energy-saving technologies and ”native-to-place” design. As a living laboratory for further advancing sustainability objectives, this building is expected to continue to be a model for other buildings and a source for innovative solutions to improving the way we design, build and occupy buildings.

NOTES

* The Center for Climate and Energy Solutions wants to express our appreciation to several NASA Ames employees who contributed their insights during the preparation of this case study, including Rosalind Grymes and Krisstina Wilmoth, and Aniruddha Deodhar from Autodesk.

1 "NASA Sustainability Base," NASA, last accessed August 28, 2012, http://www.nasa.gov/externalflash/sustainability-base. Much of the following information was drawn from this website.

2 U.S. National Archives and Records Administration, "Executive Order 13514--Federal Leadership in Environmental, Energy, and Economic Performance," Federal Register 74, no. 52117 (October 2009), http://www.gpo.gov/fdsys/pkg/FR-2009-10-08/html/E9-24518.htm.

3 Energy Policy Act of 2005, Pub. L. No. 109-58, http://www.gpo.gov/fdsys/pkg/PLAW-109publ58/html/PLAW-109publ58.htm.

4 Energy Independence and Security Act 2007, Pub. L. No. 110-140, http://www.gpo.gov/fdsys/pkg/PLAW-110publ140/html/PLAW-110publ140.htm.

5 NASA Ames selected William McDonough + Partners (WM+P) as design architect and AECOM as architect of record for the project. Swinerton Builders served as general contractors.

6 "NASA Sustainability Base," Autodesk, Inc., last modified July 28, 2010, http://usa.autodesk.com/adsk/servlet/pc/item?siteID=123112&id=16881672.

III. DEFENSE CONNECT ONLINE: ADVANCING SUSTAINABILITY THROUGH ENHANCED COLLABORATION AND COMMUNICATION TOOLS*

OVERVIEW

Effective collaboration and communication tools can enhance the way an organization functions both internally and with outside entities. For the U.S. Department of Defense, Defense Connect Online (DCO) is a user-friendly, easily accessible platform for communicating and collaborating that provides a potential model for other public- and private-sector institutions. The number of registered users of this tool has increased by 700 percent to over 700,000 users in just four years. Among the many benefits of DCO: it contributes to DoD's efforts to lead by example in meeting its sustainability goals by reducing the need for travel for meetings and training.

CONNECTING A SPRAWLING OPERATION

The Internet and the rise of new Web technologies have fundamentally reshaped how information is generated and shared, and how people communicate. Increasingly, individuals connect and collaborate without regard to traditional technical, locational or organizational boundaries. These technological changes have empowered the Department of Defense (DoD) to expect more from the communication systems that enable its personnel to perform their functions.

DoD oversees the largest and most technologically advanced military force in the world—operating in every time zone, climate, and geography. U.S. military forces deploy globally on a wide range of missions, including conventional warfare, nation building, counterterrorism, special operations, humanitarian operations, and disaster relief. Given the scope and scale of the department and its operations, improving communication and collaboration both internally and externally is a substantial challenge. At the heart of the challenge: connecting users throughout the world—on land, at sea or in the air—using a wide range of equipment that is accessible through varying degrees of bandwidth connections. Adding to the challenge is the fact that DoD's mission requires that it operate separate systems for classified and unclassified communications.

The responsibility for addressing this challenge on DoD's behalf goes to the Defense Information Systems Agency (DISA). DISA's charge: to identify and deploy interoperable information systems that meet the highest standards for security, availability, and quality.

This case study focuses on DISA's Defense Connect Online (DCO) service, which provides a suite of Web-based tools that allow users to collaborate virtually anytime from anywhere. Current DCO capabilities include a Web portal, Web conferencing (DCO Connect powered by Adobe Connect), instant messaging, persistent (i.e., "always there") chat rooms, and offline recording. DCO has evolved from a planning and collaboration tool into a mission-critical function connecting DoD's global operations. It has enhanced collaboration among users on classified and unclassified networks, as well as users both within and outside the department.

MEETING SUSTAINABILITY AND COST-SAVING CHALLENGES

While DoD's primary objective in developing DCO was to enhance collaboration and engagement, the system also has proven to be a powerful and versatile tool for achieving other department-wide goals, including reductions in energy use and greenhouse gas emissions. The following are a few of the benefits that DCO has delivered since its launch in 2007:

- **Enhanced progress toward environmental and sustainability goals:** Recognizing the environmental benefits of virtual communication, Executive Order 13514: *Federal Leadership in Environmental, Energy and Economic Performance* requires agencies to implement "accommodations for transit, travel, training, and conferences that actively reduce carbon emissions associated with commuting and travel by agency staff."[1] DoD

plans to reduce GHG emissions associated with work-related air travel by 7 percent by 2020, in part through the use of DCO.[2]

- **Stronger Continuity of Operations (COOP):** Web-based communication tools such as DCO take advantage of the decentralized nature of the Internet to ensure that agencies' primary missions and functions can continue to be performed during a wide range of emergencies. These can include natural disasters, accidents, and technological or attacked-related emergencies.
- **Increased use of telework:** DoD recently issued a new telework policy requiring management to "make every effort to overcome artificial barriers" to working offsite. The new policy was prompted by the Telework Enhancement Act of 2010. DCO should help to expand the use of teleworking at DoD and allow the agency to achieve greater flexibility in managing its workforce.[3]
- **Cost savings:** Executive Order 13589, *Promoting Efficient Spending*, was issued in November 2011 requiring agencies to cut expenses by 20 percent across five areas including official travel.[4] The Office of Management and Budget (OMB) issued a memorandum in May 2012 instituting a 30-percent reduction in agency travel expenses compared to 2010.[5] Agencies have been asked to "devise strategic alternatives to Government travel, including local or technological alternatives, such as teleconferencing and video conferencing."[6] DoD has implemented this measure in part by requiring that employees seeking permission to travel must certify that the business objective cannot be met through teleconferencing and other activities supported and enabled by DCO.

FIGURE 1: DCO Used for Face-to-Face Meetings

Source: Mike Murtha, "Connect and the U.S. DoD: Defense Connect Online" (Presentation, Washington, DC, June 21, 2012

DCO IN DETAIL

With 3.1 million military personnel operating around the world under various conditions, the Department of Defense is the largest employer in the United States. The scale of DoD's operations presents substantial challenges when it comes to promoting communication and collaboration within the department. Before the implementation of Defense Connect Online, DoD relied on a variety of often-disconnected information systems. The lack of interoperability limited communications and interfered with efficient operations. The concept behind DCO was to implement one DoD-wide system that would effectively meet diverse needs while enhancing collaboration and engagement within DoD and between DoD and other entities.

DCO capabilities

DCO is an enterprise service that enables text, audio, and video collaboration for both classified and unclassified networks among DoD, individual services, and outside parties. The service is available at no expense to the organizations that use it. As a Web-based solution, DCO combines web conferencing services and chat and presence awareness (i.e., knowing whether someone else is available). These web-based communication tools allow organizations to:

- Have users in multiple locations collaborate and interact virtually;
- Strengthen operational effectiveness by improving collaboration;
- Allow dispersed groups of users to participate in organization-wide meetings;
- Provide content-rich meetings that allow for real-time collaboration; and
- Provide continual training through online courses and e-learning.

DCO Implementation

The key to success for any enterprise solution—such as DCO—is how these technologies are integrated into the

work environment to enhance and expand productivity and reduce costs.

DCO was in use by several users and organizations within DoD before its general availability in November 2007. Strategic Command (STRATCOM), one of DoD's nine Combatant Commands, was the operational sponsor who wanted it to serve as a new collaboration tool to improve planning and communications across its global operations.

A pre-release version was tested twice over a five-month period; DCO went live in April 2008. As users overwhelmingly migrated to DCO, the reach of the system expanded across other Combatant Commands, as well as the Joint Chiefs of Staff in the Pentagon, and DCO quickly morphed into a partnership across all DoD commands and agencies.

Building on its early success, in February 2009 DoD designated DCO as the Department's "collaborative enterprise" tool with the goal of eliminating duplication of information technology systems.[7]

Today, DCO is the mandated collaboration system used across DoD. Anyone within DoD wanting to employ an alternative system must make the case based on a compelling operational need or a clear business rationale that the proposed alternative would be superior for their particular needs.

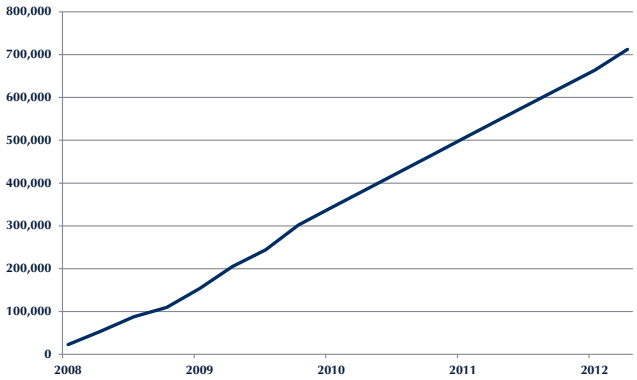
As **Figure 2** demonstrates, DCO has rapidly become a popular tool with more than 700,000 registered users.

While earlier DoD communication and collaboration systems required downloading and installing software that might or might not have worked on specific machines, DCO was novel in its use of Web-based technologies. In many respects, DCO's rapid adoption within DoD was driven primarily by its ready and widespread availability and its ease of use as a Web-based application.

DCO is capable of running on nearly every computer regardless of operating system and browser, without the user having to download or install any additional software. Because it relies on widely used Web-based technologies—Adobe Flash is available on almost every computer—DCO avoids many of the problems experienced by users of past DoD systems. In addition, DCO is also accessible on most mobile devices as a standalone application.

In addition, DISA uses the Voice over Internet Protocol (VOIP) feature in DCO to conduct communications among more than two parties. DCO can be used in a wide range of settings, from small meetings between two participants all the way up to larger meetings with thousands of participants.

FIGURE 2: DCO Usage Growth



Source: Mike Murtha, "Connect and the U.S. DoD: Defense Connect Online" (Presentation, Washington, DC, June 21, 2012).

In order to meet Continuity of Operations requirements, the Defense Enterprise Computing Centers in Texas and Ohio provide hosting services for the DCO system. Hosting DCO via two geographically disparate locations provides redundancy of service, ensuring mission-critical communications and operations can continue with minimal disruption and downtime for the system's users.

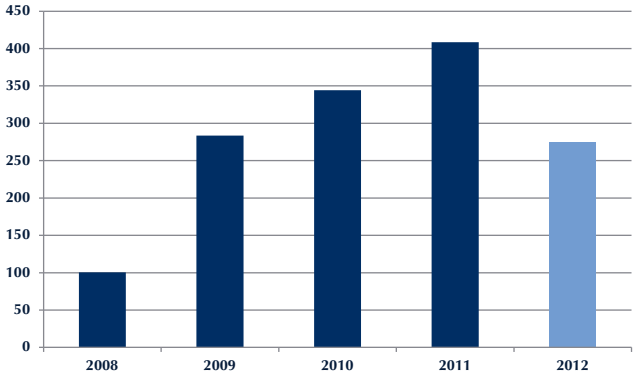
THE BENEFITS OF USING DCO

DCO is projected to grow at a rapid clip in the next four years, from its current roster of 700,000 registered users to 2.5 million users. Most importantly, DCO users are making extensive use of the systems features. DCO's usage numbers are already substantial: more than 1 million chat messages a week; about 410 million minutes of web conferencing in 2011; and 315,000 web conference sessions a month (see **Figure 3**).

DCO's popularity stems from a broad range of features and capabilities, such as:

- It works in low-bandwidth areas, making it an ideal solution for almost any location or scenario.
- Application and desktop sharing of content in real-time enhances the interactivity of a live training session or team meeting.
- Video conferencing fosters a more collaborative work environment by increasing face-to-face interaction with globally dispersed team members.

FIGURE 3: DCO Million Minutes Web Conferencing



Note that figures are for fiscal years. Figures for 2012 are for the first half of 2012.

Source: Mike Murtha, email conversation with author, September 7, 2012.

- Users can record online meetings, presentations or chat sessions for later playback.
- Whiteboard and annotation features help users coordinate and analyze visual data.
- Users can access DCO across different hardware and software platforms, including popular mobile devices.

DCO has been particularly valuable in supporting communications and collaborative work for those employees at bases that have been relocated under the Base Realignment and Closure Commission (BRAC). These tools also have been widely used when extreme weather or local circumstances have required that employees work from home or other remote locations.

The examples in **Box 1** highlight the importance of DCO as a collaborative tool, while also providing evidence of how the system makes DoD operations more cost-effective and energy-efficient. In response to government-wide mandates to become more sustainable through reduced energy use and greenhouse gas emissions, DCO has been used in the following ways:

- To organize agency town hall meetings for participants across the globe, thereby reducing travel and associated energy use and emissions;
- To facilitate and enable telework, especially for those assigned to temporary duty, and for those whose bases were closed or moved as part of the BRAC process; and
- To reduce travel associated with face-to-face meetings, conferences and training by providing a virtual, face-to-face platform for these activities.

These are just a few of the ways in which DCO has allowed DoD to reduce costs, cut energy consumption and limit greenhouse gas emissions. DISA has estimated that the costs of operating DCO "in-house" are up to one-half of what DoD would have to pay if the services were provided by an outside vendor. The department has not, however, undertaken any analysis of the cost or energy savings associated with reduced travel, improved training, and enhanced collaboration. As government budgets come under continued pressure, it would be useful for DoD to analyze the energy (and other) savings and emission reductions associated with the use of these tools.

Well before DCO was chosen for use across DoD, the Army's 172nd Stryker Brigade used a communication and collaboration system that was the forerunner to DCO. A 2004 analysis found that using this system saved a minimum of $500,000 in annual travel expenses for the 4,000-employee organization. This unit was split between two locations—Fort Wainwright (Fairbanks, Alaska) and Fort Richardson (Anchorage, Alaska)—and separated by 350 miles of Alaska wilderness. Typically the unit's leadership would fly weekly between both locations for important meetings and events. In addition, some of personnel were able to save money from simple things such as not driving a few miles for a meeting every week.[8]

BARRIERS AND CHALLENGES OF DCO

The growth and success of DCO since its inception should not disguise the enormous barriers and challenges associated with implementing a one-size-fits-all system for an organization with more than 3 million personnel stationed across the world.

The most obvious challenges were the technical barriers of implementing DCO. DoD, much like the Internet, relies on multiple layers of network and IT administrators across the world. Each of these groups has its own, sometimes very different hardware and software systems. Bringing together these diverse elements into a single system was a challenge. Each entity had to recognize that the benefits of an enterprise-wide system would more than offset the loss of control that would result from its widespread adoption.

Continued coordination among groups using DCO is also critical. IT administrators across different networks must continue to work together to ensure compatibil-

ity and usability—for example, by ensuring that one network isn't inadvertently blocking DCO from another network.

Finally, DCO is based on a shared hosting model. Five entities within DISA and two private companies—Carahsoft and Adobe Systems—are charged with hosting and supporting DCO. With multiple hosting partners, it becomes important to clearly define roles and responsibilities, and work towards shared hosting goals.

NEXT STEPS/TRANSFERABILITY

As communication needs and tools continue to change at a rapid pace, the systems and tools that DoD and other government agencies employ will also evolve. But one constant is that users will need to continue to collaborate via multiple means, and this creates a clear niche for DCO as an enterprise platform that allows agencies to increase operational efficiency. DISA expects DCO adoption to nearly quadruple to 2.5 million users over the next four years. The system's growth will result in part from upgrades to the communications platform that incorporates such enhancements as computer-telephone integration and video teleconferencing capability.

The main goal of enhanced communications and collaboration will always be to make an organization more efficient and effective. From a sustainability perspective, an important side benefit from the use of these tools is reduced travel costs with associated cuts in energy consumption and greenhouse gas emissions. While few face the same challenges experienced by DoD, a variety of government agencies are moving toward greater use of enhanced communication and collaboration tools. DCO represents a useful model and an effective tool for other agencies to consider.

BOX 1: Examples of DCO in Action

DCO has proven to be a flexible collaboration tool in a wide range of environments. Its suite of applications has greatly improved DoD's operational efficiency in a number of key instances, such as:

- **Web-based education and training through DCO enables those separated by geographic distance, or those unable to attend due to other conflicts, to participate in online workshops and sessions.** For example, starting in 2010 the Fleet and Family Support Centers throughout the Naval District in Washington, DC, used the system to host a variety of online workshops, such a "Saving and Managing Your Income," for all service members and their families.[9]
- **DCO supported the planning and coordination of the 2009 Presidential Inauguration**. Its use enabled information-sharing and coordination across the military branches and DoD agencies, as well as with numerous state, local, and federal interagency partners responsible for operations at this event. The use of DCO provided real-time shared situation awareness, enabling each organization to succeed in its assigned mission.[10]
- **DCO has been used as a first step in getting mental health care services delivered remotely to soldiers and families** who might not have received it otherwise because of stigma or their geographic location.[11]
- **DCO has allowed the Naval Tactical Command Support System (NTCSS) to remotely provide IT help desk support**. DCO enables NTCSS to provide technical support to deployed and shore-based commands, such as installations, submarines, ships, and combatant command units. Use of DCO has reduced the time it takes to resolve trouble tickets for submarines from a period of days to less than a day.[12]
- **DCO has been used to support disaster relief and humanitarian assistance.** The 2010 Haiti earthquake devastated much of that country, including most of its telecommunications infrastructure, but left some Internet connectivity. The limited bandwidth connection was sufficient to coordinate disaster relief efforts through DCO. The coordinated efforts enabled by DCO not only saved lives but maximized relief and rescue efforts. For example, the collaborative nature of DCO allowed for multiple sessions that organized information by audience, mission, and geography. This allowed military units, nonprofit organizations, and multilateral organizations to accomplish critical tasks such as: briefing relief workers prior to arrival; coordinating aid and medevac flights; and providing daily status reports.[13]
- **DCO is a command-and-control tool for military personnel** to better coordinate tactical battle planning and tracking by facilitating sharing of real-time data among ground, satellite and airplanes.[14]

NOTES

* The Center for Climate and Energy Solutions wants to express our appreciation to several DCO personnel who contributed their insights during the preparation of this case study, including Mike Murtha, Ashley Keating, Giap Ngo, and Karl Kurz.

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IV. SHIFT TO THE CLOUD: ACHIEVING EFFICIENCY THROUGH CLOUD COMPUTING AND DATA CENTER CONSOLIDATION*

OVERVIEW

The federal government is the world's largest consumer of information technology (IT), spending approximately $80 billion annually on more than 10,000 systems.[1] Recent policies aimed at reducing the number of government data centers by 40 percent and migrating IT services to "the cloud" have the potential to produce billions of dollars in savings for federal agencies while advancing sustainability goals. This case study provides an overview of how federal agencies are leading by example in consolidating data centers and embracing cloud-computing solutions. As the first agency to shift its email services to the cloud, the U.S. General Services Administration (GSA) has cut email related energy consumption by 85 percent.

SUSTAINABILITY AND COST REDUCTION CHALLENGES: REFORMING FEDERAL IT

Federal IT infrastructure has been expanding rapidly in recent years. The number of federal data centers grew dramatically from 432 in 1998 to 2,095 in 2010. From Fiscal Year (FY) 2001 to FY 2009, federal IT spending grew at a compound annual rate of nearly 7 percent, with the growth leveling off in recent years.[2] Due to the rapidly changing nature of technology, the government's IT infrastructure has been expanding in a largely ad hoc manner. Today's infrastructure fails to achieve many of the security, reliability, and energy and cost-saving efficiencies that the federal government could realize through a smarter IT system.

Past federal efforts to reduce the environmental impact of IT have largely focused on electronic stewardship (i.e., limiting the life-cycle impact of electronics from manufacturing and procurement to disposal, recycling and/or reuse). More recent initiatives have taken a higher-level approach to achieving greater efficiencies. For example, as part of the President's FY 2013 budget, Steven VanRoekel, federal Chief Information Officer, emphasized maximizing the return on federal IT investments by reducing duplicative systems and applications, consolidating data centers, and shifting to the cloud.[3]

These priorities are at the heart of two significant efforts initiated by the federal government in 2010. The first was the February 2010 launch of the Federal Data Center Consolidation Initiative (FDCCI) by the Office of Management and Budget (OMB). The overall goal of FDCCI is to reduce the number of government data centers through the following actions:[4]

- Promoting the use of "Green IT" by reducing the overall energy and real estate footprint of government data centers;
- Reducing the cost of data center hardware, software, and operations;
- Increasing overall IT security within government;
- Improving IT service delivery; and
- Shifting IT investments to more efficient computing platforms and technologies.

A broader initiative was announced in December 2010 when OMB issued its *25-Point Implementation Plan to Reform Federal Information Technology Management*.[5] This plan seeks to fundamentally reshape how the federal government utilizes information technology by improving operational efficiency and more effectively managing large-scale IT programs. Building on the FDCCI, one of the goals of the 25-point plan is to reduce the number of data centers by at least 800 by 2015.[6]

The 25-point plan also called for a government-wide shift to cloud computing through a "cloud first" policy. "Cloud first" requires agencies to implement cloud-based solutions (i.e., shifting computer networks from stand-alone, on-site infrastructure to networked, on-demand services) whenever a secure, reliable and cost-effective cloud option exists.[7] The plan also requires agencies to identify three "must-move" IT services within three months (by March 2011), and to move all three services to the cloud within 18 months (by June 2012).

FIGURE 1: A Typical Data Center

Source: "Connecting Big Data in the Data Center," Intel Corporation, last modified October 31, 2011, http://communities.intel.com/community/datastack/blog/2011/10/31/connecting-big-data-in-the-data-center.

To further support this shift to the cloud, in February 2011 the federal Chief Information Officer issued the *Federal Cloud Computing Strategy*.[8] This document fleshes out the "cloud first" policy by emphasizing the benefits and trade-offs of cloud computing, providing a decision framework for agencies, and identifying federal government activities, roles, and responsibilities in the cloud computing realm.

These initiatives were launched in part as a response to Executive Order 13514: *Federal Leadership in Environmental, Energy and Economic Performance*, which calls for "implementing best management practices for energy-efficient management of servers and federal data centers."[9]

OPPORTUNITIES FOR COST AND ENERGY SAVINGS

Both the data center consolidation effort and the 25-point plan have the potential to dramatically revamp the federal IT infrastructure and deliver substantial benefits to agencies. It's estimated that the federal government could save $150 billion to $200 billion over the next decade, primarily through data center and server consolidation.[10] Data center infrastructure now is responsible for about 30 cents of every dollar spent on federal IT. By embracing data center consolidation and the 25-point plan, the federal government is on track to close at least 40 percent of its data centers by the end of 2015.

OMB has estimated $20 billion of the federal government's IT spending could be a potential target for migration to cloud computing solutions.[11] A shift to cloud computing by itself could reduce data center infrastructure expenditures by 30 percent.[12]

Data Center Consolidation

In 2010, the interagency Federal Data Center Consolidation Initiative identified 2,100 large data centers across the government. The initiative set out a plan for reducing the number of federal data centers by at least 800 by the end of FY 2015. So far, agencies have closed 250 data centers and plan to close a total of 479 by the end of FY 2012.[13] In March 2012, FDCCI expanded its definition of a data center to include data centers of any size; this bumped the total number of centers from 2,100 to 3,133. The plan now is to shut down at least 40 percent of these centers, with at least 1,200 closed by the end of FY 2015.[14]

Adopting server and data center consolidation best practices can deliver billions of dollars in potential cost savings for the federal government. The FDCCI estimates these activities could save the federal government $3 billion by 2015 due to reduced hardware and software costs, cuts in real estate requirements, and energy savings.[15] In a recent review of the status of the government's consolidation efforts, the U.S. Government Accountability Office (GAO) found that 19 agencies reported over $2.4 billion in projected cost savings and an additional $820 million in cost avoidance expected by 2015.[16]

Data center consolidation is about more than just having agencies identify systems that are candidates for consolidation and then migrating them to other existing federal IT infrastructure. Bigger changes are involved as federal agencies will need to deal with the shift from dedicated, in-house computing resources to a shared-service, multi-tenant environment.[17] Systems could be shared within or across agencies, or they could be migrated to the cloud.

In many respects, the challenges of consolidating data centers and migrating to cloud computing solutions are inherently linked. According to OMB, "Cloud computing can accelerate data center consolidation efforts by reducing the number of applications hosted within government-owned data centers."[18]

Cloud Computing: Shift to the Cloud

Cloud computing is a model for making computing resources (e.g., networks, servers, storage, applications and services) more readily available over the Internet.[19]

TABLE 1: Cloud Benefits: Efficiency, Agility, Innovation

	CURRENT ENVIRONMENT	BENEFITS OF THE CLOUD
Efficiency	Low asset utilization (typical server utilization: 27%) Fragmented demand and duplicative systems Difficult to manage	Improves asset utilization Promotes aggregated demand and accelerated system consolidation (e.g., FDCCI) Facilitates improved productivity in application development, application management, network, and end-user
Agility	Years required to build data centers for new services Months required to increase capacity of existing services	Can be purchased "as-a-service" from trusted cloud providers Enables near-instantaneous increases and reductions in capacity Is more responsive to urgent agency needs
Innovation	Burdened by asset management De-coupled from private sector innovation engines Risk-averse culture	Shifts focus from asset ownership to service management Taps into private-sector innovation Encourages entrepreneurial culture Is better linked to emerging technologies (e.g., device)

Vivek Kundra, Federal Cloud Computing Strategy (Washington, DC: U.S. Office of Management and Budget, 2011), http://www.cio.gov/documents/federal-cloud-computing-strategy.pdf.

Cloud computing can greatly improve operating efficiency in federal IT environments by reducing duplicative and fragmented systems, increasing data center efficiency and utilization rates, and lowering operating costs. From a sustainability perspective, a shift to the cloud allows for significant savings from reduced energy use and associated reductions in greenhouse gas emissions.

Through its "cloud first" policy, OMB sought to harness the benefits of cloud computing by requiring agencies to evaluate cloud-computing options before making any new IT investments. This policy has fundamentally changed the business model of how federal agencies procure IT infrastructure. Instead of treating computing resources as locally hosted assets financed through capital expenditures, cloud computing treats computer resources as a service that is delivered over a network and financed through operating expenditures.

Table 1 compares current IT infrastructure with the potential benefits for agencies associated with shifting to the cloud. It identifies a number of key benefits related to increased efficiency and agility while also creating the conditions for enhanced innovation over time.

By leveraging a shared infrastructure and economies of scale, cloud-computing services deliver such benefits as: improved asset utilization; aggregated demand; accelerated data center consolidation; easier management of resources (e.g., through pay-as-you-go models); increased flexibility; faster deployment of IT services; and decreased time spent on IT operations and maintenance.[20]

Based on early efforts to implement the 25-point plan, federal agencies had already eliminated 50 legacy systems and shifted 40 services to the cloud (with 79 more services planned for transition) as of June 2012.[21] Email is one of the first systems that the federal government has focused on migrating to cloud computing services. Forrester Research estimates that email migration could

save the federal government $1 million annually per 7,500 users.[22]

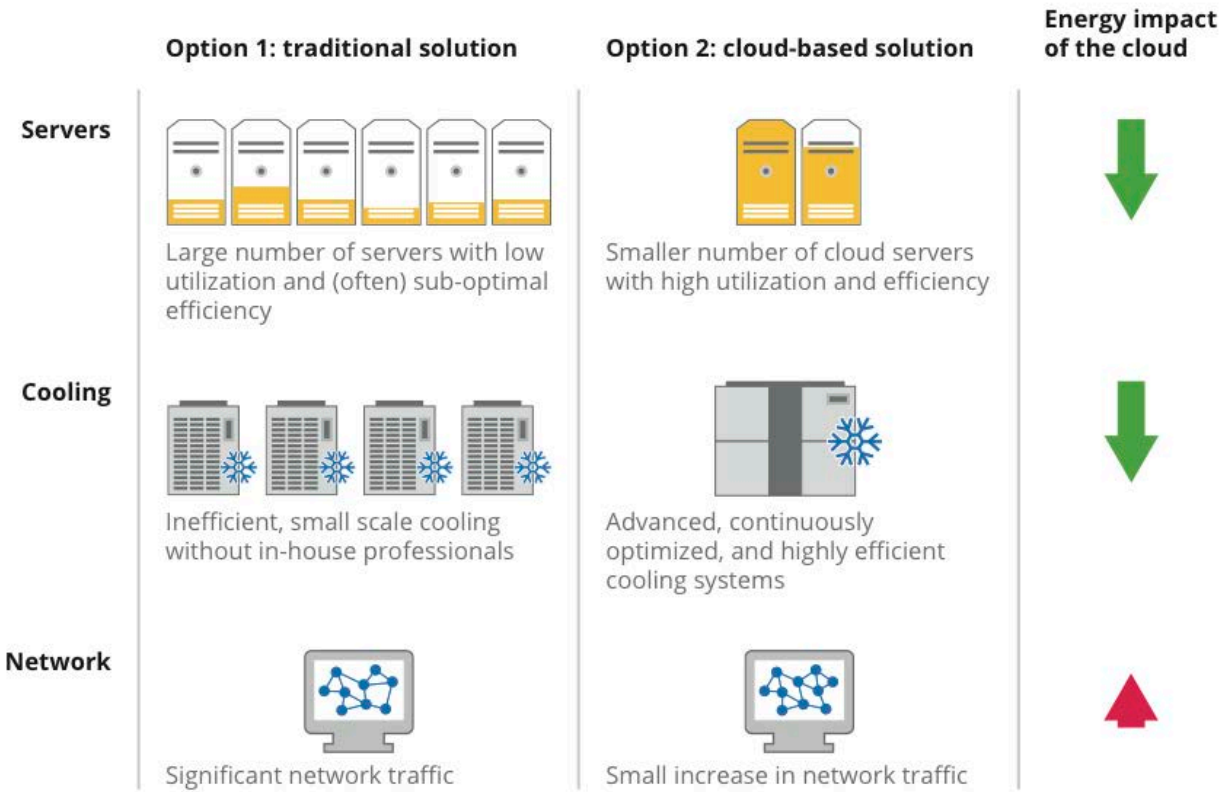
To date, 14 agencies have indicated that they will move their email and collaboration services to the cloud. One of these agencies is GSA, which has led the way in the federal government's embrace of cloud computing.

GSA: LEADING THE WAY IN FEDERAL CLOUD COMPUTING

In June 2011, GSA became the first federal agency to migrate to a cloud-based email and collaboration service.[23] Within the federal government, GSA helps manage and support basic functions (e.g., office space and transportation) for federal agencies. It also manages federal procurement of products and services, and develops cost-minimizing and management policies for use across the government. GSA has a history of being a leader in federal IT innovation. In the 1990s, it pioneered introducing the federal workforce to the Internet. GSA's early efforts to migrate to the cloud continue that tradition.

Responding to the "cloud first" policy under the 25-point plan, in December 2012 GSA chose to migrate its 17,000 email users from a locally hosted email system to a cloud-based email and collaboration service provided by Google. Before the shift, GSA hosted a traditional email system made up of 324 servers in 14 data centers it operated across the United States. GSA's email service was considered dated because it didn't include features such as integrated messaging and collaboration tools. In addition, the system was not fully compatible with GSA's telework efforts.[24] Email archiving was implemented inconsistently, was difficult to use, and did not meet e-discovery requirements. The storage associated with backing up email was costly to manage, and the servers running GSA's email system were older, underutilized, and redundant.

FIGURE 2: Why is Cloud Computing More Efficient?



Source: Google Apps: Energy Efficiency in the Cloud (Menlo Park: CA: Google Inc., 2012), http://static.googleusercontent.com/external_content/untrusted_dlcp/www.google.com/en/us/green/pdf/google-apps.pdf.

TABLE 2: Net Energy Savings, GSA Hosted Environment vs. GSA After Migration

	GSA LOCALLY HOSTED EMAIL SYSTEM	GSA HOSTED SERVERS AFTER CLOUD MIGRATION	SAVINGS FROM SWITCH
Users	16,742	17,671	-
Total number of servers operated by GSA for email and collaboration	324	61	82%
Total direct power of GSA servers (kW)	163	22	87%
Annual GSA server energy consumption per user, direct and indirect (kWh/user)	175	20	89%
Additional cloud-based Google and network energy consumption (kWh/user)	-	1-5	2-3% increase
Total energy required (kWh/user)	175	21-25	85-88%
Annual GSA server energy costs ($)	$307,400	$22,400	93%
Annual carbon emissions from server energy (metric tonnes of CO_2)	1860	290	85%

Source: Google Apps: Energy Efficiency in the Cloud (Menlo Park: CA: Google Inc., 2012), http://static.googleusercontent.com/external_content/untrusted_dlcp/www.google.com/en/us/green/pdf/google-apps.pdf.

As shown in **Figure 2**, a cloud-based email and collaboration service offers many benefits over a traditional system such as those hosted and managed by federal agencies. As the figure shows, a traditional system typically relies on a large number of poorly utilized servers, each of which requires inefficient, in-house cooling systems. The main advantage of cloud computing is that it enables IT services to be better utilized, achieving greater economies of scale in both computer hardware utilization and efficiency of cooling systems. While a significant reduction in energy consumption occurs in both of these areas, a marginal increase in energy use results from the increase in network traffic. From sustainability and energy cost perspectives, the overall reductions in energy use far outweigh any increases.

Table 2 provides an overview comparing utilization and energy consumption figures of GSA's hosted email server and cloud-based service.

Federal servers are typically underutilized by one-third.[25] This is a problem because servers draw nearly the same amount of energy regardless of how busy they are, resulting in wasteful energy consumption for operating and cooling. Adding to the problem is the fact that for every dollar GSA spent on direct energy costs related to operating a server, about 60 cents was spent on energy for the air conditioning and ventilation system used to cool the servers. The total energy cost to run GSA's traditional email system was estimated to be $307,400 a year.

By migrating to the cloud, **Table 2** shows that GSA achieved significant energy savings and reduced its environmental impact. Following the migration, GSA has kept 61 servers (down from 324) to provide auxiliary email infrastructure services (e.g., mobile device support). As a result, GSA now will spend only $22,400 a year on server energy costs, a 93 percent reduction from before the shift to the cloud.

Table 2 also highlights the savings per user that GSA has achieved by shifting the agency's email to Google's cloud-based email and collaboration service. The total energy required to run GSA's email system went from 175 kWh per user to 21-25 kWh per user. The overwhelming majority of the post-migration energy consumption—about 20 kWh per user—is from GSA's auxiliary email servers. Google's estimates an incremental energy consumption of 1-5 kWh per user on their end and from increased network energy usage.[26] The net effect is an 85-88 percent reduction in per capital energy use.

This shift to the cloud also resulted in a cut in CO_2

emissions by 85 percent, from 1,860 metric tonnes to 290 metric tonnes. As more email infrastructure services are migrated to cloud computing solutions, the number of GSA-hosted servers is expected to decline even more, further reducing energy costs and CO_2 emissions.

GSA expects that using the cloud-based system will reduce email operation costs by 50 percent over the next five years and save more than $15.2 million.[27] In addition to the energy savings, the shift to the cloud will decrease in the number of costly data centers requiring hardware, software licenses, maintenance and contractor support.[28]

BARRIERS AND CHALLENGES

The data center consolidation initiative and the 25-point plan provide a roadmap and goals for achieving operational efficiency, in part through the "cloud first" policy. While the federal government has made considerable progress, it also has encountered many bumps along the road to successfully implementing this strategy—and the bumps are likely to continue.

Among the early bumps in the road was an incomplete inventory of data centers. As part of the FDCCI, 24 agencies were required to submit inventories of their data centers and plans for consolidation. In the first year, 17 agencies did not provide full information about their data center power usage.[29] The problem was that most federal data centers do not have metering capabilities to measure power usage. Agencies have been working towards installing such capabilities at federally owned data centers, but are less likely to obtain power usage information at leased facilities. Without power usage information, it's difficult to perform a full analysis of the costs and benefits of consolidating centers.

Similarly, the shift to cloud computing can pose its own challenges. Cloud computing represents a paradigm shift in how federal agencies use and purchase computing resources. The shift in computing resources can be a challenge for IT departments that are accustomed to purchasing and operating assets through the capital expenditure portion of their budgets. Departments will now need to think of IT as a commoditized computing resource purchased as a service through the operating expenditure portion of their budgets.

Last but not least, cybersecurity has been cited as the largest barrier in the way of broader adoption of cloud computing. In December 2011, OMB established the Federal Risk Authorization and Management Program (FedRAMP) to address this challenge. FedRAMP is a government-wide program that provides a standardized approach to security for cloud computing solutions. FedRAMP also includes a pre-screened list of cloud computing service providers. FedRAMP uses a "do once, use many times" framework that will reduce IT security cost, time, and staff required to conduct redundant agency security assessments.

NEXT STEPS/TRANSFERABILITY

Federal agencies are working towards consolidating their data centers and implementing the 25-point plan to reform their IT infrastructure. Based on its early success, OMB has expanded the scope of the FDCCI to include data centers of any size, and agencies are now on track to shut down at least 1,200 data centers of the 3,133 identified centers by the end of FY 2015. In addition, OMB is helping to speed the adoption of cloud computing by addressing cybersecurity concerns through FedRAMP.

GSA intends to take additional steps to facilitate the transition to cloud computing solutions by other federal agencies. It is developing standardized procurements for cloud services for all agencies to use. In October 2010, GSA awarded a cloud-based Infrastructure as a Service (IAAS) blanket purchase agreement to 12 vendors to provide agencies with cloud storage, virtual machines, and web hosting services to support a continued expansion of the federal government's IT capabilities into cloud computing environments.

In August 2012, GSA awarded "email-as-a-service" blanket purchase agreements to 17 vendors that will be offering five different cloud-based email solutions to federal agencies,[30] creating an easier option for federal agencies to migrate hundreds of thousands of email accounts.

As a result of these efforts, the federal government is on track to substantially upgrade its IT infrastructure while cost-effectively advancing sustainability goals in the years ahead.

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* The Center for Climate and Energy Solutions wants to express our appreciation to Derrick Rogers from GSA and Michael Terrell from Google for their assistance during the preparation of this case study.

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V. FLEET MANAGEMENT AT THE SMITHSONIAN: USING NEW TOOLS TO ADVANCE SUSTAINABILITY AND EFFICIENCY*

OVERVIEW

The Smithsonian Institution operates a widely diverse fleet of 1,500 vehicles to support its operations in more than 80 countries around the world. Through the use of a fleet management information system and telematics (which combines GPS tracking and information networking), the Smithsonian has been able to reduce the number of light-duty vehicles in its fleet by 18 percent. These measures, along with other actions such as a shift to alternative-fueled vehicles and biofuels, have reduced petroleum consumption by the Smithsonian fleet by 44 percent since 2005.[1] The Smithsonian has been leading by example in a government-wide effort to advance sustainability goals through improving the way it manages and utilizes its fleet.

A DRAMATIC TURN TO SMARTER FLEET MANAGEMENT

Established in 1846 by Congress with the mission of supporting the "increase and diffusion of knowledge," the Smithsonian Institution is the world's largest museum and research complex.[2] It includes 19 museums, nine research centers, and the National Zoological Park. The Smithsonian has permanent locations in eight states and in Washington D.C. and Panama, and is active in more than 80 countries across the world.

The Smithsonian has a somewhat unique place in the federal family of departments and agencies. Because it is directly funded by Congress, but also receives substantial funding from outside sources, it is considered a "quasi-federal" entity. Nevertheless, the federal government expects the Smithsonian to meet the same energy, efficiency, and sustainability requirements as all other federal agencies. In addition, the Smithsonian faces the same pressures as other government agencies when it comes to increasingly constrained budgets.

With a small and highly diverse vehicle fleet, the Smithsonian has dramatically altered how it manages its transportation needs and has quickly moved to the forefront of strategic fleet management within the federal government. Two key elements of this shift are the use of an enterprise-wide fleet management information system (FMIS) and the Smithsonian's use of vehicle telematics (more below). By using innovative new tools to modernize the way it collects and monitors a wide range of fleet data, the Smithsonian has substantially improved the way it operates and maintains its motor vehicle pool.

This case study focuses on the Smithsonian's use of the FMIS and telematics to accomplish the following goals: reducing the administrative burden of reporting requirements; right-sizing its fleet; enhancing maintenance; streamlining direct capital and staffing expenditures; reducing fuel consumption and fuel expenditures; and meeting energy and environmental goals. The Smithsonian's experience serves as a model for other agencies seeking to better utilize and operate their fleets.

SUSTAINABILITY AND COST-SAVING CHALLENGES

With increased pressure to reduce costs, cut energy use and limit greenhouse gas emissions, federal agencies increasingly are taking a fresh look at ways they can better manage their fleets. While the Smithsonian manages its vehicle fleet on its own, most federal agencies have turned to the U.S. General Services Administration[3] to supply and maintain their fleets.

Federal fleets are subject to several legislative and regulatory mandates to minimize their energy use and environmental impacts. For example, the Energy Independence and Security Act of 2007 (EISA) requires federal agencies to reduce annual petroleum consumption by 20 percent by 2015 from a 2005 baseline.[4]

As one of his first major environmental initiatives, President Obama issued Executive Order 13514 on October 5, 2009. Titled *Federal Leadership in Environmental, Energy and Economic Performance*, it requires agencies to prepare and implement a Strategic Sustainability Performance Plan, report on agency greenhouse gas emissions, and set a percentage reduction target for these emis-

FIGURE 1: Types of Smithsonian Fleet Vehicles

Source: Thi Dao, "Using Data as a Tool: How the Smithsonian's FMIS Helped Streamline Operations," Government Fleet, November 2011.

sions.[5] The Executive Order also requires that agencies reduce consumption of petroleum products by 2 percent annually through 2020 compared to a 2005 baseline. In addition, it mandates that agencies use low greenhouse gas-emitting vehicles and that they optimize the number of vehicles in their fleets.

The Obama Administration followed up this Executive Order with more detailed guidance specific to federal fleets. On May 24, 2011, the Administration issued a Presidential Memorandum titled *Federal Fleet Performance*.[6] It requires agencies to utilize a new tool from GSA—the vehicle allocation methodology (VAM)—to determine "the optimum inventory with emphasis placed on eliminating unnecessary or non-essential vehicles from an agency's fleet inventory and ensuring lifecycle cost-effectiveness of maintaining such inventory." Based on their use of the VAM, agencies are required to post targets for their optimal fleet inventory on their websites and to develop and implement a plan to meet these targets by the end of 2015. The memorandum also requires that by 2016, all new light-duty vehicles leased or purchased by agencies must be alternative-fueled vehicles.

CHANGING ROLE OF TECHNOLOGY

A range of new technologies provide federal agencies and other organizations with powerful new information and communication technology (ICT) tools to enhance fleet productivity. These technologies have the potential to fundamentally change how federal agencies operate and manage their vehicle fleets. ICT-enabled solutions can allow agencies to:

- Reduce administrative time and costs associated with data entry and reporting, which frees up staff to work on other projects;
- Reduce the number of vehicles and deliveries between facilities by optimizing routing;
- Automatically track and schedule preventive maintenance so vehicles can be repaired before problems escalate;
- Gather information on driver behavior that can be used to promote more fuel-efficient driving and alert managers to safety concerns; and
- Collect detailed data about vehicle use and maintenance, allowing agencies to right-size their fleets.

The Smithsonian fully integrated these tools into a newly created fleet management department to better manage its vehicles.

An essential first step in streamlining fleet management and operations is the adoption of a fleet management information system (FMIS). A FMIS provides a comprehensive inventory of all fleet and equipment assets. The system also assists in the development of vehicle replacement plans; tracking and control of fuel use, costs, and vehicle utilization; production of fleet acquisition budget plans; and preparation of a range of other standard fleet management analyses. The Smithsonian's FMIS replaced a manual system that had developed in an ad hoc manner over time. The prior system did not allow the Smithsonian to fully monitor fuel consumption, nor did it provide real-time information to inform operational decisions.

Telematics are an additional tool that can enhance tracking and management of vehicle fleets. Capitalizing on the increased availability and reduced costs of various wireless technologies, including GPS, telematics can be used to monitor location, operator performance, and engine diagnostics for each vehicle in the fleet. Among the key features of these technologies is that they can connect to a vehicle's engine computer and send vehicle fault code notifications via email to a centralized location. This allows the fleet management team to take action before a problem escalates and helps limit unscheduled maintenance. Telematics also allow fleet managers to ensure that their vehicles are being operated in a safe and efficient manner (e.g., by tracking vehicle speed and location).

THE SMITHSONIAN'S FLEET MANAGEMENT EFFORTS

The Smithsonian operates a wide range of facilities, including museums, zoos, animal research and educational centers, and more traditional office space. The fleet required to support this sprawling operation is equally diverse and includes approximately 1,500 vehicles. Law enforcement vehicles used to ensure safety at Smithsonian facilities make up the majority of the fleet, which also includes vehicles for facility support, shuttle bus service, animal transport, construction and maintenance, and other purposes.

An independent review of the Smithsonian's fleet management practices in 2006 highlighted a number of critical shortcomings, including the lack of central control of fleet operations and an absence of data collection and reporting.[7] The report recommended consolidating the Smithsonian's fleet services into one office, and creating a new position of fleet manager. The Smithsonian began implementing the report's recommendations by hiring its first fleet manager, who then proceeded to consolidate all fleet operations and introduce the use of the FMIS and vehicle telematics.

The Smithsonian's FMIS

The Smithsonian's fleet department motto is, "You can't manage what you don't measure." It's an expression that comes up frequently when discussing the Smithsonian's "Green Fleet" plan, which focuses on alternative fuels, fleet right-sizing, management and maintenance practices, and emission reductions.[8] While no one tool will meet all of an agency's fleet management requirements, the Smithsonian has used its FMIS as an integral component of a broad effort to improve its fleet operations. **Table 1** shows the steps and timeline the Smithsonian used in moving forward with its FMIS over a five-year implementation plan.

The Smithsonian was able to procure and implement the first phase of the FMIS within a six-month window. Deployment of a new information system required a number of interrelated steps, from conducting detailed business process reviews to designing and testing a FMIS user interface to migrating data from stand-alone systems. After the fleet department successfully configured the software to meet the needs of the Smithsonian and performed initial staff training, it launched the first phase in March 2008. The focus of this phase of work was management of vehicle assets, maintenance, and schedules.

TABLE 1: Major FMIS Implementation Milestones

TASK/PRODUCTS	INITIAL PROJECTION	PROJECT STATUS
Requirements review and market analysis	09/2007	Completed
Phase I, Fleet Management	09/2007	Completed
FMIS Production acquisition	09/2007	Completed
System design	01/2008	Completed
Training	02/2008	Completed
Operational (assets, maintenance schedules)	03/2008	Completed
Phase II, Fuel Management	04/2009	Completed
Phase III, Fleet Pool Reservation	03/2010	Ongoing
Expand use of Fleetwave to include telematics	12/2011	Completed
Phase IV, GPS Interface	08/2010	Ongoing
Phase V, Implement Mobile Technology	12/2012	Ongoing
Interface with Facility Center	12/2010	Ongoing

Source: Smithsonian Institution, "Smithsonian Information Technology Plan FY 2012- FY 2016" (Washington, DC: Smithsonian Institution, 2012).

BOX 1: GSA's Telematics Offering

The U.S. General Services Administration (GSA) offers an assortment of vehicle telematics management and tracking solutions for use by federal agencies. Agencies can order telematics monitoring solutions ranging from GPS vehicle tracking to real-time vehicle diagnostics to video recording and instant driver feedback. All vehicle information is transmitted wirelessly either by cellular or satellite communication. Fleet managers within agencies can then access a customized website that displays vehicle tracking and monitoring information.[9]

The launch of the Smithsonian's FMIS meant it now had a state-of-the-art, web-based tool to help it manage more than 1,500 vehicle assets across the world. Each subsequent phase of the work expanded the functionality of the FMIS as follows:

- The second phase allowed the Smithsonian's fleet managers to track fuel usage. It was completed a month ahead of schedule in March 2009. Every vehicle was assigned an individualized federal fleet card, with vehicle fuel transactions loaded into the fleet system on a weekly basis.
- The third phase established an online fleet pool reservation system allowing for increased vehicle utilization and reduced administrative and staff costs.
- The fourth phase expanded the use of vehicle telematics and provides real-time telematics data back to the Smithsonian.
- The fifth and final phase will implement a mobile technology component and interface with the new Smithsonian Facility Center that recently opened in suburban Maryland.

Benefits of Using the FMIS and Telematics

The FMIS is simply a tool that collects detailed data from multiple sources. How this tool is used is what determines whether it can become a powerful force in managing vehicle fleets. For the Smithsonian, the FMIS facilitates the collection and aggregation of data in a central place, making it far easier to meet federal reporting requirements. The Smithsonian's use of its web-based FMIS allows fleet operators across the world to monitor real-time progress toward meeting federal mandates, and to make more informed decisions about managing their fleets. The FMIS also has made the financial cost of operating the Smithsonian's fleet more transparent, and helped identify opportunities to reduce costs. In addition, the phased rollout of the FMIS has benefited the fleet team at the Smithsonian, allowing them adequate time to fully understand the new metrics and to transition to new fleet management practices.

The use of the FMIS and telematics has played a critical role in the Smithsonian's efforts to meet the targets set forth in Executive Order 13514. Using these new tools, the Smithsonian has refined its strategy for right-sizing its fleet, redefined fleet utilization reviews, and incorporated and expanded the use of a basic Vehicle Allocation Methodology (VAM) that is now required of all federal agencies. Using vehicle telematics and data from fuel cards, fleet managers are able to monitor real-time vehicle usage as well as fuel consumption of all Smithsonian vehicles. (see **Box 1**). As a result, they have achieved important benefits in optimizing the size of their fleets and increasing vehicle utilization. These benefits include:

- Reducing the Smithsonian's light-duty vehicle fleet from 600 to 490 vehicles (an 18-percent reduction);[10]
- Optimizing routing and deliveries to achieve a reduction of 12 full-size vehicles;[11]
- Ensuring vehicles are used in a safe manner and for authorized work purposes only;
- Reducing vehicle idle time by 40 percent through vehicle telematics;[12]
- Reducing fleet petroleum consumption by 44 percent (compared to 2005 baseline year) in 2011;[13]
- Reducing unscheduled maintenance by 15 percent through preventive maintenance;[14] and
- Reducing the number of full-time staff needed to manually collect and enter fleet information from three employees to one.[15]

For the Smithsonian, the FMIS and use of telematics has been about more than dollars and cents. It's about having the ability to access a rich dataset that has better enabled the fleet department to increase the efficiency of

its operations. According to the Smithsonian's first fleet manager, "The system has enabled us to make genuine, fact-based decisions and to be able to see where our money is going."[16] As a result, the Smithsonian is now able for the first time to make detailed justifications for its fleet vehicle procurements and department budget. The FMIS has allowed the Smithsonian to produce in-depth fiscal reports at the touch of a button, which not only saves the time and expense involved in data manipulation and manual analysis but also enables more informed, fact-based financial decisions. The time it takes for bi-annual mandatory fleet status reporting alone has been cut from months to days.

While this transformation has produced numerous cross-cutting benefits, the business case for the move to the FMIS and telematics is backed up by several critical measures, such as: reduction in fleet size; reductions in vehicle idle time; savings on maintenance and fuel consumption; and reduction in administrative costs associated with reporting requirements.

The costs of purchasing and implementing the Smithsonian's FMIS were relatively small. The system was funded through its information technology budget and cost about $20,000 for the last two fiscal years.

BARRIERS TO ADAPTION OF FLEET MANAGEMENT TOOLS

The Smithsonian is on the cutting edge of improving fleet performance among federal agencies and provides a concrete case for the benefits of an enhanced fleet management system. While implementing the FMIS can deliver a host of benefits as described above, it is not an easy process. In adopting such a system, agencies could run up against a number of potential barriers and challenges.

For example, integrating vehicle data from multiple locations and across a wide range of vehicle types and ages proved a challenge for the Smithsonian. This problem was compounded by network security concerns. The Smithsonian spent considerable time resolving such issues as how the vehicle data would be sent and how that data could be accessed via the FMIS.

During the implementation stage, the Smithsonian's fleet management team quickly discovered that not all vehicles were equally able to pass along electronically the required vehicle information back to the FMIS. As a result, the fleet team has to be selective in deciding which existing vehicles can have the telematics system installed. In addition, the Smithsonian has added fleet connectivity as a consideration when purchasing new vehicles.

Another potential barrier to the adoption of systems like this is the perceived adequacy of an agency's current vehicle management systems. In 2007, the Smithsonian was faced with a need to significantly revamp how it managed its fleet. This created an excellent opportunity for making substantial changes, including the implementation of the FMIS. Agencies with established fleet management practices may be resistant to adopting new systems that fundamentally reshape everything from how they collect and process data to how they maintain the vehicles in their fleets.

NEXT STEPS/TRANSFERABILITY

The Smithsonian has used its FMIS as a tool to right-size its vehicle fleet, reduce petroleum consumption and greenhouse gas emissions, and improve safety. The Smithsonian intends to continue to expand the functionality of its FMIS to further reduce costs and increase the energy savings and environmental benefits associated with using the system. One project currently in the testing phase is a shared motor pool system in Washington D.C., totaling about 80 vehicles. Vehicles in four pilot motor pools can be reserved online with key boxes at each pool location, accessible through radio frequency identification technology. If successful, this shared motor pool system represents another opportunity to make better use of vehicles and lower costs.

Agencies across the federal government are moving forward in their efforts to meet goals of reducing petroleum consumption, increasing the number of alternative-fueled vehicles, and right-sizing fleets using the vehicle allocation methodology from GSA. The Smithsonian's early efforts in these areas should prove instructive for others.

GSA has taken steps to require agencies to use fleet management information systems, and has established readily available contract mechanisms for their purchase. In order to comply with new requirements for agencies to implement a FMIS, GSA developed a Federal Fleet Management System (FedFMS).[17] The goal of FedFMS is to create, at the lowest cost possible, a standard and reliable government-wide inventory management system for both GSA-leased vehicles and agency-owned vehicles.

The Smithsonian has exceeded the mandate in Executive Order 13514 that federal agencies achieve a 20-percent reduction in petroleum use from a 2005 baseline. The Smithsonian's actual numbers are impressive: a 36-percent reduction in 2009 and a 44-percent reduction in 2011.[18] Using data from its FMIS, the Smithsonian's fleet managers are constantly looking at how to further improve operations, productivity, reliability, fuel economy, and alternative fuel use—proof positive that better measurement and better management go hand in hand.

NOTES

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VI. TESTING NEW BUILDING TECHNOLOGIES AT DOD AND GSA: ADVANCING ENERGY-SAVING INNOVATIONS*

OVERVIEW

Two programs launched recently by the U.S. Department of Defense (DoD) and the U.S. General Services Administration (GSA) use federal facilities to test the real-world performance of promising new energy-saving technologies. These programs will support these agencies in achieving their critical missions, while contributing to transforming energy technologies in buildings across the country. By using federal facilities as test beds for innovation, DoD and GSA are helping to bridge the "technology valley of death" that prevents too many promising technologies from moving to commercialization and are leading by example in our nation's efforts to advance energy security and sustainability goals.

DRIVING INNOVATION IN THE BUILDING SECTOR

As two of the largest property owners and managers in the country, DoD and GSA are on the frontlines of the effort to reduce energy consumption in the U.S. building sector, which is responsible for 40 percent of the nation's total energy use.[1] Given the U.S. government's status as a major player in the sector, it is a key area where federal leadership has the potential to produce substantial energy and cost savings.

This case study focuses on two programs that show how the federal government is using its market clout to drive innovation and transform the marketplace for energy-saving technologies. By using DoD and GSA facilities to demonstrate and validate the costs and effectiveness of emerging energy-saving technologies, these programs provide a critical step toward facilitating commercialization of new products with potentially large benefits for the agencies themselves and the entire nation.

With the goal of supporting DoD's needs for enhanced energy security and reliability at its facilities, its Environmental Security Technology Certification Program's (ESTCP) Installation Energy Test Bed initiative began in 2009 and has supported more than 70 projects since its inception. GSA's Green Proving Ground (GPG) was started in 2010. In its first two years of operations, it has initiated testing of more than 20 energy-saving technologies.

Both programs follow a similar format:

- They use open solicitations or requests for information to identify potential technologies that can be deployed and tested at federal facilities.
- They select emerging technologies that have the greatest potential for delivering energy savings and enhanced energy security and reliability and that can be fully evaluated at federal facilities.
- They include careful documentation of baseline data and detailed monitoring and verification of costs and effectiveness of the technologies.
- They result in project reports that provide credible, detailed information about product performance that is critical to the technology's future success in the marketplace.

The programs differ mainly in the stage of development of the technologies they test. DoD's initiative focuses on technologies that are at a slightly earlier, often pre-commercial stage of development. GSA's program focuses on underutilized existing technologies and new technologies that are just entering commercial markets. The programs cover a wide range of technologies many of which rely on advanced metering, sensors, controls and other "smart" systems enabled by information and communication technologies.

SUSTAINABILITY AND COST REDUCTION CHALLENGES

GSA is mandated by Congress to "provide superior workplaces for federal customer agencies at good economies for the American taxpayer." To fulfill that role, GSA's Public Buildings Service owns or leases more than 9,600 buildings containing 370 million square feet of space.[2] DoD, for its part, operates more than 500 installations around the world with a wide range of facilities. It manages just under 300,000 buildings totaling about 2.3

FIGURE 1: Installation Energy Test Bed

Source: "Installation Energy Test Bed," Strategic Environmental Research and Development Program (SERDP) / Environmental Security Technology Certification Program (ESTCP), last accessed August 28, 2012, http://www.serdp.org/Featured-Initiatives/Installation-Energy.

billion square feet, roughly three times the size of Wal-Mart's facilities.[3] DoD's current energy bill for its buildings is estimated to be just under $4 billion per year.[4]

Reducing energy use associated with operating these facilities would have multiple benefits for these agencies—enhancing energy security, reducing pollution and greenhouse gas emissions, and saving money. In an effort to realize these benefits, both Congress and the White House have set ambitious targets for energy savings in federal buildings, including:

- The Energy Policy Act of 2005 requires a 20-percent reduction (from a 2003 baseline) in energy use in federal buildings by 2015 and the purchase of at least 7.5 percent of electricity from renewables by 2013.[5]
- The Energy Independence and Security Act of 2007 mandates a 30-percent reduction in energy intensity by 2015 (compared to a 2003 baseline) for all existing federal buildings and net zero energy consumption for all new buildings (and major modifications to existing ones) by 2030.[6]
- Executive Order 13514 calls for all new federal buildings, entering the design phase in 2020 or later, to be designed to achieve zero net energy by 2030.[7]
- In December 2011, a Presidential Memorandum called for federal agencies to enter into a minimum of $2 billion in performance-based contracts within 24 months, with the goal of saving energy in federal buildings.[8]

Reaching these targets will be a challenge for federal agencies. Meeting the challenge will require: (1) substantial advances in the market uptake of currently available energy-saving technologies; and (2) the introduction of new and even better energy-saving technologies.

In the product development cycle for new technologies, one of the biggest hurdles is moving from a "bench-scale" model to a deployed and proven commercial product. The chasm facing innovators trying to move a promising idea to a marketable reality is often broadly referred to as the "technology valley of death." Among the causes of this conundrum: few building owners are willing to risk being the test case for an unproven new product; and first users frequently face higher costs than those who wait and adopt a proven technology later on. Yet unless pathways are found to overcome risk aversion and the reluctance to deploy new products, the federal government (and the United States as a whole) will have a very difficult time achieving ambitious energy-saving and security goals.

The DoD and GSA programs described in this case study were developed with the purpose of providing one pathway for demonstrating and validating the in-use performance of innovative energy-saving technologies. If successful, these programs should aid in promoting greater acceptance of a range of new technologies that will substantially reduce energy consumption and enhance energy security in buildings across both the federal and private sectors.

DOD'S ESTCP INSTALLATION ENERGY TEST BED INITIATIVE

As the defender of our nation from external threats, DoD is not in the business of developing energy or any other technologies other than those critical to performing its mission. It was with this clear objective in mind that DoD has played a significant role in developing such landmark technologies as the jet engine, integrated circuits, the Internet and GPS. In each case, DoD advanced its mission as the defender of the country through advancing innovation and technology deployment.

This same mission-critical rationale has lead DoD to seek out ways to reduce energy use associated with the operation of its facilities. DoD's two priorities in this work are: reducing the substantial costs of energy consumption at its vast installations; and enhancing energy

security and reliability. Reducing the $4 billion that the department now pays annually for installation energy costs would free up funds that could be used to strengthen national security. In addition, DoD believes it can ensure more stable and more secure supplies of energy for its operations through the expanded use of on-site renewable energy combined with energy efficiency, advanced microgrid and storage technologies. The overall goal is to dramatically reduce the department's reliance on the existing electrical grid (see **Box 1**).

Recognizing that it could not meet either of these goals with existing technologies, DoD has embarked on a program that uses its facilities as test beds to validate the performance, costs and benefits of innovative energy technologies.

DoD's Environmental Security Technology Certification Program (ESTCP) was started in 1995 with a focus on demonstration and validation documenting the performance of new technologies critical to meeting DoD's environmental challenges. In its early years, the program focused on a wide variety of technologies aimed at remediating contaminated sites at DoD installations, reducing hazardous materials in weapon systems, and enhancing energy and water efficiency.

In 2009, DoD started a new initiative under this program that focused on using its facilities as test beds for innovative energy-saving technologies. The program operates in the same manner as previous activities under ESTCP. It begins with a public solicitation of proposals for energy-saving technologies that could help the department achieve its goals; the proposal process is open to federal agencies, academics, and the private sector. Proposals undergo a thorough independent technical review by experts to determine which emerging or pre-commercial technologies are most likely to advance the energy goals established by DoD.

For those technologies that DoD selects for testing, the initiative covers the critical stages of demonstrating and validating their performance, costs and environmental impacts in actual use at a DoD operating facility. To the extent that these technologies are successful, this information can then be used to transfer lessons learned across DoD and to facilitate more wide-scale procurement and deployment. DoD is a sophisticated first user and an early customer with sizable market demand. Product developers can also use the information produced by the test bed installation to further refine their products (where necessary) and to market them to the private sector.

Table 1 lists the areas of focus for DoD's 2012 installation energy demonstration program.[9]

DoD received more than 575 proposals seeking support for technologies across these areas. Of these, DoD competitively selected 27 new projects for funding totaling approximately $30 million in fiscal year 2012.

Evaluating Success

DoD's leadership in supporting emerging energy-saving technologies could be an important factor in transforming markets for these innovations. In some cases, information produced during the evaluation phase has already triggered improvements in product design. In other cases, the economic and performance information from the test bed installation has proved a critical fac-

BOX 1: Secretary Panetta Addresses DoD's Energy Challenges[9]

In a recent speech, U.S. Secretary of Defense Leon Panetta described DoD's commitment to energy innovation. "We are working to be a leader and an innovator in environmental stewardship, energy efficiency, and energy security." He identified two principal challenges facing DoD in this work: rising energy costs and threats to energy security. "We now face a budget shortfall exceeding $3 billion because of higher than expected fuel costs last year. I have more than a deep interest in more sustainable and efficient energy options."

The Secretary continued: "I have a deep interest in working to try to ensure from a security perspective that we take measures that will help facilitate and maintain power in the event of an interruption of the commercial grid that could be caused, for example, by a cyberattack."

TABLE 1: Installation Energy Test Bed Priorities for 2012

TECHNOLOGY	OBJECTIVE
Smart microgrids and energy storage	Increase energy security
Advanced building component technologies	Cut energy consumption
Advanced building energy management and control technologies	Cut energy consumption
Tools and processes for energy-related design, assessment and decision-making	Cut energy consumption
Renewable energy technologies	Increase energy security

Source: "Department of Defense announces new installation energy technology demonstrations for FY 2012," Strategic Environmental Research and Development Program (SERDP) / Environmental Security Technology Certification Program (ESTCP), last modified November 18, 2011, http://www.serdp-estcp.org/News-and-Events/News-Announcements/Program-News/Department-of-Defense-announces-new-installation-energy-technology-demonstrations-for-FY-2012.

tor in successful commercialization to both federal and private-sector purchasers.

But given that the program has only been up and running for a few years, it is simply too early to make any sweeping judgments about its success. Only over time will it be possible to determine whether this program has had a material impact in spurring the successful introduction of energy-saving technologies. However, the promise of the program is clear: if DoD's success in other areas of technology deployment holds true, this program could have a substantial payoff for DoD and society at large.

GSA'S GREEN PROVING GROUND (GPG)

As part of its first Strategic Sustainability Performance Plan issued in 2010, the General Services Administration established the following vision: "GSA will eliminate its impact on the natural environment and use its government-wide influence to reduce the environmental impact of the Federal government." Specifically, the plan commits GSA to the goals of reducing greenhouse gas emissions by 28 percent and achieving a 30-percent reliance on renewable energy by 2020.[10]

The Green Proving Ground (GPG) program is one of several initiatives adopted by GSA over the past several years aimed at advancing these ambitious goals. GSA

BOX 2: Sample Projects Supported by DoD's Installation Energy Demonstrations[11]

Automated Demand Response for Energy Sustainability tests an approach being developed by Honeywell to achieve better balance in the supply and demand of electricity. The approach is being tested at Fort Irwin, California. This project will demonstrate an Open Automated Demand Response communications and control technology. As part of the installation's Energy Management System, the new technology will adjust the operation of the building and other electric loads in response to ancillary service commands and demand response signals.

Rapid Energy Modeling Workflow Demonstration Project is an energy-saving tool developed by Autodesk that will be tested in cooperation with the Army Corps of Engineers. The tool is designed to quickly, accurately and cost effectively predict annual energy consumption for individual buildings. This project will demonstrate the effectiveness of this tool and validate its suitability for broader DoD implementation.

Grid Interactive Renewable Energy Generation System with Battery Storage Integration Capable of Hybrid Microgrid Operation has been developed by Satcon Technology Corporation and will be tested at Fort Detrick, Maryland. This project will demonstrate a hybrid electricity generation system that integrates DC-connected bulk energy storage with solar photovoltaic (PV) power sources. The objective: to mitigate the inherent intermittency of the electricity produced by PVs. The leveled AC power output will enhance installation energy security, reduce dependence on grid-supplied power, and reduce overall energy costs.

launched the program in 2010 with the straightforward objective of using its facilities to test and document the performance of innovative and underutilized sustainable building technologies and practices. The program began with an overall assessment conducted for GSA by the U.S. Department of Energy's (DOE) Pacific Northwest National Lab. The purpose of the assessment was to look at those aspects of building energy consumption where technological advances could make a substantial difference for GSA in terms of reducing energy use in federal buildings. Based on this analysis, GSA established a number of priority areas focused on the building envelope, heating, ventilation and air conditioning (HVAC), lighting, on-site power generation, and water use.

GSA issued a request for information to its regional offices to propose funded projects at existing facilities that would serve as test cases for the GPG program. The request identified the following broad categories as areas of interest:

"(Projects) that optimize energy performance; protect and conserve water; enhance indoor air quality; reduce waste and environmental impact of materials; reduce greenhouse gas emissions associated with building operations; or promote integrated design."[12]

The initial batch of proposals consisted of 147 submissions. These were evaluated by GSA staff, with DOE's Pacific Northwest National Lab conducting a third-party expert review. The criteria for evaluation were:

- Degree to which the technology or practice is innovative or underutilized;
- Potential to be widely deployed;
- Ability to provide practical data needed to measure results and/or outcomes;
- Ability to establish quality baselines in a timely manner;
- Probability of success commensurate with projected risk;
- Wide deployment likely to be life-cycle cost effective; and
- Availability on the market.[13]

The 16 selected projects for 2011 are shown in **Table 2**. They were evenly divided between innovative new technologies and existing underutilized technologies.

TABLE 2: Green Proving Ground Projects Selected for 2011

INNOVATIVE TECHNOLOGIES	UNDERUTILIZED TECHNOLOGIES
Variable speed chiller plant	Commercial ground source heat pump
Chilled beams	Condensing boilers
On-site renewable energy guidance	High R-value windows
PV with integrated solar thermal	Integrated daylighting systems
Smart windows	Workstation specific lighting
Variable refrigerant flow	Magnetic bearing compressor
Wireless mesh sensor network	Non-chemical water treatment
Plug load reduction	Thin film photovoltaic

Source: Kevin Powell, "A River of Energy Solutions: Green Proving Ground" (Presentation, GovEnergy – Cincinnati, Ohio, August 8, 2011), http://www.govenergy.com/Files/1Presentations/Building%20Technologies/Session6_KPowell.pdf.

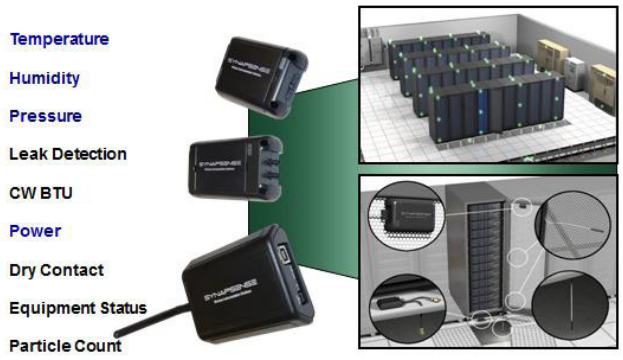
One project focused on a non-chemical water treatment technology, while the remaining 15 dealt with various aspects of reducing energy consumption or expanding the use of renewables.

Once the selected technologies are installed at federal facilities, they undergo an extensive measurement and verification process focused on the following factors:

- Performance claims;
- End-user acceptance;
- Maintainability; and
- Return on investment.

The Green Proving Ground technologies are not separately funded but are included as part of ongoing GSA projects. The result: added costs are not substantial and are focused primarily on evaluation activities. GSA has established working agreements with DOE labs to undertake these evaluations.

FIGURE 2: Wireless Environmental Sensors



Source: "SynapSense," IIS Group, LLC, last accessed August 28, 2012, http://www.optimumpower.com/monitoring-solutions/synapsense.

First Completed Project—Wireless Mesh Sensor Network

Green Proving Ground issued its first completed project report in March 2012.[14] The report evaluated the use of a wireless sensor network installed at a U.S. Department of Agriculture (USDA) data center. Because data centers are large consumers of energy, the federal government has undertaken a major initiative to reduce the number of its centers and cut their energy consumption.[15] The facility operators in the USDA project tested the use of wireless sensors to monitor temperature and airflow conditions in the facility. Based on these readings, they were able to change the use of existing equipment to achieve energy savings, better airflow management and cooling efficiency.

Figure 3 shows the energy consumption changes at the data center before and after installation of the wireless sensor technology. During the period of evaluation, USDA reduced the facility's cooling load by 48 percent. As a result, the data center cut its total energy consumption by 17 percent and cut greenhouse gas emissions by 542 tons of carbon dioxide annually. The energy savings were estimated at $30,000 per year and the payback period for the system was calculated to be 3.4 years.[16]

Examples of Other GPG Technologies

The following are two examples of other technologies that Green Proving Ground is testing:

- A **plug load reduction** technology at six federal sites tracks the amount of energy consumed by workspace electronics including computers, task lights and printers. The system provides direct feedback to building occupants through electronic dashboards that show how an individual's behavior contributes to overall building energy use. Plug loads are estimated to account for 15 to 35 percent of total building energy consumption. DOE's National Renewable Energy Laboratory is responsible for measurement and verification of the test installations. The final report is due in summer 2012.
- **Integrated daylighting systems** offer a means of harvesting maximum daylight to minimize the need for artificial overhead lighting. Through the use of automated dimmable ballasts that adjust to the amount of available daylight, lighting levels in a building can be maintained at the desired level for tenant satisfaction. Past case studies have suggested energy savings of 35 percent may be achieved through the use of dimmable electronic ballasts in perimeter areas. Lawrence Berkeley National Laboratory is performing the measurement and verification of this project and expects to have findings available in September 2012.

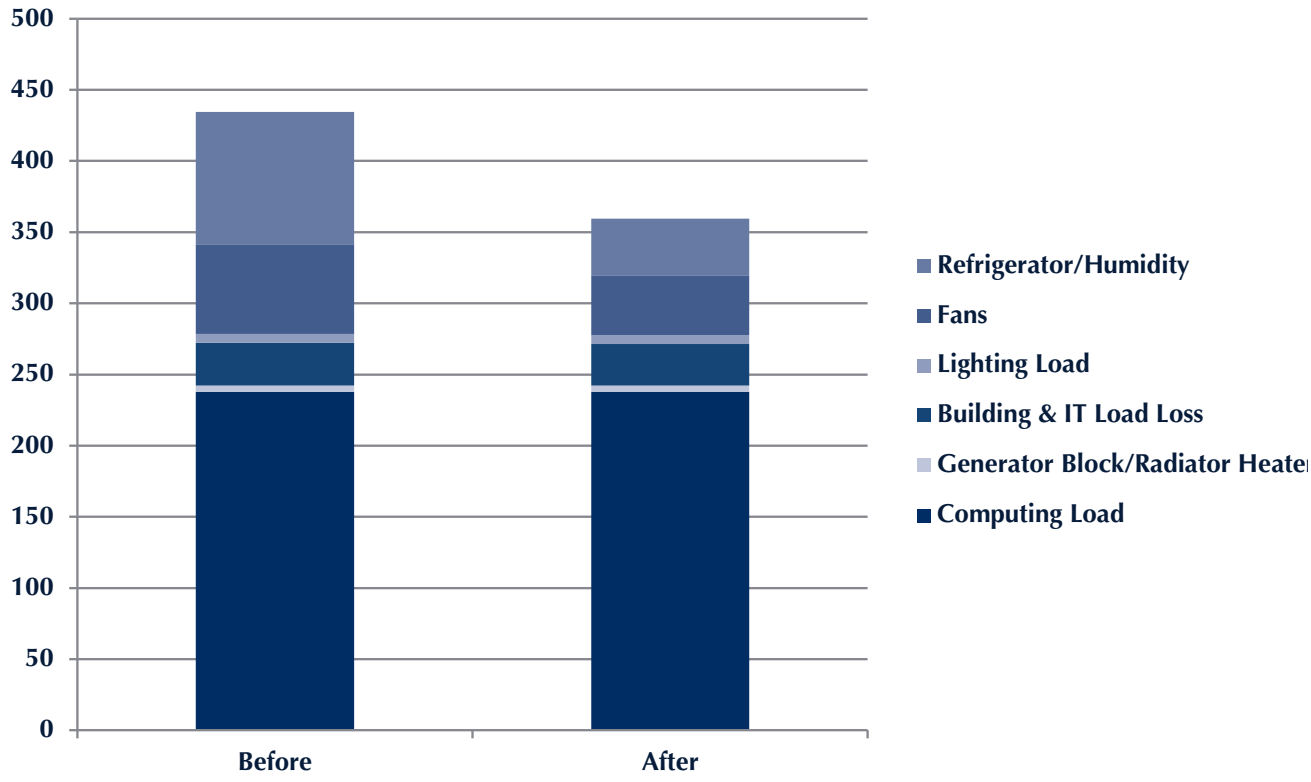
An Evolving Program

In December 2011, GPG issued its second request for information soliciting technologies for testing in 2012. This request was expanded to include proposals from sources outside of GSA (if applicants were willing to pay for the costs of providing the technologies for testing at GSA facilities). Forty-six proposals were submitted from within GSA ranks and 71 came from external parties. Following an evaluation process similar to the one used in 2011, GPG selections are scheduled to be announced some time in the latter half of 2012.

BARRIERS AND CHALLENGES

Serving as a test bed for new technologies is an important but sometimes difficult role to play. It is not uncommon for a promising technology to fail to make the leap from prototype to a proven solution in the field. These test bed programs must carefully balance the potential disruption to an existing federal facility with the potential benefits of demonstrating a new technology. The continued cooperation of facility managers across the federal enterprise is essential if these programs are to continue to find willing test sites for evaluating new

FIGURE 3: Data Center Power Usage Distribution



48 percent cooling load reduction, 17 percent overall data center energy reduction.

Source: U.S. General Services Administration Public Building Service, Wireless Sensor Networks (Washington, DC: U.S. General Services Administration, 2012), http://www.gsa.gov/graphics/pbs/Findings_Wireless_Sensor_Network.pdf.

technologies.

Because they rely on existing buildings and installations, these programs require only a limited amount of federal resources. Nonetheless, financial support is needed to properly conduct independent evaluations of proposals and to document the performance of the technologies. As new programs, both Green Proving Ground and the ESTCP Installation Energy Test Bed initiative may be more vulnerable in times of reduced federal budgets.

NEXT STEPS/TRANSFERABILITY

Over time, it will be critical that both of these programs undertake objective evaluations of their costs and benefits to demonstrate whether or not they are delivering on their promise of advancing mission-critical needs of these agencies to reduce energy costs and enhance energy security and reliability. In addition, DoD and GSA will need to focus on wide dissemination of the evaluations of the technologies both within their organizations and to outside parties.

It is also important to note that DoD and GSA represent substantial markets for these products on their own. DoD intends to make market performance information widely available to its facilities managers, and GSA plans to work with vendors of technologies that prove successful to help them get on its purchasing schedules. Having a place on the GSA schedule makes it easier for technologies to be purchased by federal agencies, and can be used as a selling point in marketing efforts to the private sector.

NOTES

* The Center for Climate and Energy Solutions expresses its appreciation to James Galvin (DoD) and Kevin Powell (GSA) for their input during the development of this case study.

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VII. ENERGY SAVINGS AT SECTOR SAN JUAN: THE COAST GUARD'S INNOVATIVE SHIFT TO CLEAN ENERGY IN PUERTO RICO*

OVERVIEW

The United States Coast Guard operates 360 aging buildings at installations located across Puerto Rico. In recent years, Coast Guard leaders have been facing the same challenge confronting building owners across the country: rising energy costs and mounting maintenance expenditures. But the Coast Guard recently has taken ambitious steps to address this challenge. Thanks to the use of innovative financing tools that limit direct federal expenditures, the Coast Guard was able in 2010 to substantially upgrade its facilities and install new lighting and energy controls, as well as three megawatts of solar photovoltaic power. These actions reduced the Coast Guard's consumption of fossil fuels by 53 percent while enhancing the energy security of its Puerto Rico operations. This case study tells the story of an agency leading by example in maximizing the use of innovative financing to cut its energy consumption and costs and advance its sustainability goals.

ADDRESSING SECTOR SAN JUAN'S ENERGY AND MAINTENANCE CHALLENGES

The Coast Guard's shore-based operations in Puerto Rico—referred to as Sector San Juan—are responsible for all Coast Guard missions in the eastern Caribbean. This includes enforcement of laws and regulations on maritime borders, protection of natural resources, and saving those in peril. Now part of the Department of Homeland Security, the Coast Guard's motto, *semper paratus* (Latin for *always ready*), aptly describes its core mission, but also captures how it tackled its need to reduce energy costs.

Sustainability and Cost-Saving Challenges

Recent legislative and executive mandates are driving federal agencies, including the Coast Guard, to reduce overall energy consumption and dependence on fossil fuels. For example:

- The Energy Policy Act of 2005 requires that at least 7.5 percent of federal agency electricity come from renewable sources beginning in 2013.[1]
- The Energy Independence and Security Act (EISA) of 2007 requires federal buildings to achieve a 30-percent reduction in energy intensity by 2015, compared to 2003 baseline levels.[2]
- Executive Order 13514 ("Federal Leadership in Environmental, Energy, and Economic Performance") requires agencies to reduce energy intensity in federal buildings, increase their use of renewable energy, and limit greenhouse gas emissions.[3]

At the same time that it began planning to meet these mandates, the Coast Guard also was determined to address the twin problems of rising energy costs and growing concerns about energy reliability. These problems are particularly pronounced in Puerto Rico, which imports almost all of its energy. As a result, the U.S. territory is dependent on costly oil-based fuels as its primary energy source. With soaring oil prices and the high transportation costs associated with shipping oil to the island, electricity is expensive.

When the Coast Guard's project began, power from the grid in Puerto Rico cost 23 cents/ kilowatt-hour (kWh). Since then, electricity costs have increased further by 15 percent. These costs are more than double the average cost of electricity in the United States (9.99 cents/kWh).[4] The cost of energy in Puerto Rico is a major concern for the Coast Guard; some of its largest energy-consuming facilities are located there. These sites account for 6 percent of the Coast Guard's overall facility energy costs.

For Sector San Juan, the path forward was clear: it needed to implement more efficient energy technologies and install renewable energy generation. By embracing energy conservation measures, the Coast Guard would not only meet its federal energy and environmental mandates, but also significantly reduce energy-related

costs. As Daniel Gore, program manager of the U.S. Coast Guard Energy Program, has pointed out, "It is no secret that energy costs are steadily growing while federal budgets are continually shrinking, so it is imperative that agencies identify creative solutions for difficult obstacles."[5]

Other Driving Factors

While sustainability mandates and energy costs were the principal drivers for this project, high maintenance costs also were an important consideration. For example, the high temperatures and extreme weather of the Caribbean are notorious for their harmful effects on building roofing systems. In part, because of budgetary constraints that limited its ability to undertake extensive operations and maintenance work on its facilities, the Coast Guard faced a 10-year backlog to repair and replace roofs in Puerto Rico. Conditions had deteriorated to such an extent that Coast Guard personnel located at Air Station Borinquen received a 25-percent premium for their overseas housing allowance because these facilities were deemed "inadequate."

By combining energy efficiency solutions with badly needed roof repairs, the Coast Guard was able to lower the overall cost of the project and improve quality of life for its personnel stationed in Puerto Rico.

PARTNERING WITH THE PRIVATE SECTOR

Energy savings performance contracts (ESPCs) are a congressionally authorized tool that allows federal agencies to partner with an energy service company to implement energy-saving measures. The building and equipment upgrades are paid for by the company and is compensated by a portion of the energy cost savings realized over an agreed-upon period of time. At the beginning stage of the project, the energy service company conducts a

FIGURE 1: Different Types of Coast Guard Facilities in Puerto Rico

Source: Jesse Maestas, "Striving toward Net Zero using the ESPC Contract Vehicle" (presentation, Joint Engineer Training Conference & Expo (JETC), St. Louis, Missouri, May 24, 2012).

comprehensive energy audit of the federal facility and identifies cost-effective measures that save energy. In consultation with the federal agency, the company then designs and constructs a project that meets the agency's needs and arranges the necessary funding. The company guarantees the improvements will generate energy savings sufficient to pay for the project over the contract period, which is usually up to 25 years. If the dollar savings are not achieved in a given year, the company covers the difference. After the contract ends, all additional cost savings continue to accrue to the agency.

ESPCs provide an important financing tool to implement energy efficiency savings with minimal risk to federal agencies. Against the backdrop of tight budgets and growing energy costs, a December 2011 Presidential Memorandum called for federal agencies to increase their use of energy saving performance contracts to $2 billion for fiscal year 2011-12.[6]

Federal agencies have worked with energy service companies to implement nearly 300 ESPC projects since 1998. This has resulted in savings totaling $7 billion and cumulative energy reductions exceeding 335 trillion BTU.[7] The Coast Guard had implemented nearly a dozen ESPCs prior to the Puerto Rico project.[8] However, the ESPC in Puerto Rico stands out for its scope and its inclusion of renewable energy. To date, this is the largest Coast Guard ESPC project as measured by cost savings.

Projects funded through ESPCs are typically focused on readily achievable energy efficiency measures—retrofitting HVAC systems, upgrading lighting, and installing better insulation. These measures are typically straightforward and result in a reliable, near-term payback. In early 2010, the Coast Guard initially considered an ESPC in Puerto Rico that required a $3.7 million capital investment focused on conventional energy-efficiency technologies that would pay for themselves in 10 years.

After selecting an energy service company—Schneider Electric—the Coast Guard expanded the project to include a much more extensive retrofit to reduce energy use through a broader range of energy conservation measures. These included the installation of a solar photovoltaic (PV) system to generate clean energy, and a range of related improvements to address major operations and maintenance issues (such as window improvements, water conservation, and roof replacement).

The comprehensive project covered the Coast Guard facilities in Puerto Rico:

- **Sector San Juan Headquarters:** 18 facility buildings, including office buildings, an exchange, and recreation center.
- **Rio Bayamon Housing:** 5 facility buildings and 153 housing units.
- **Air Station Borinquen:** 13 facility buildings and 175 housing units.

These three installations cover nearly 360 buildings and housing units, totaling 964,000 gross square feet of space. A preliminary analysis projected that the Coast Guard could avoid the purchase of about 9.3 million kWh of electricity annually by implementing energy conservation measures and installing renewable energy systems at an estimated cost of nearly $50 million in capital improvements.[9] To address time constraints related to the availability of financing, the project was divided into two phases. The first phase, installing solar PVs and replacing roofs, was awarded within six months and completed within a year. More than 600,000 square feet of cool roofs were installed to replace existing uninsulated and leaking roofs. Through these measures alone, the buildings experienced a 5-degree temperature drop, saving the Coast Guard nearly $250,000 annually in energy costs. The newly installed roofs also allowed for the installation of nearly 3 megawatts of solar PV, generating over 4 million kWh annually of clean electricity and saving the Coast Guard nearly $1 million a year in energy costs.

The second phase implemented the rest of the energy efficiency project, and took several more months and was completed in May 2012. This phase included the following energy control measures:

- **Building Automation System Optimization:** Outdated building controls were upgraded to full digital control and optimized to maximize energy savings.
- **HVAC efficiency:** Variable Refrigerant Flow/Volume (VRF/V) cooling units were installed for better temperature and humidity control as well as set control points.
- **Lighting retrofits and controls:** Occupancy sensors and photocell sensors were installed to control lighting fixture runtime based on occupancy or daylight.

- **Building envelope improvements:** Over 600,000 square feet of "cool roofs" were installed to replace existing un-insulated and leaking roofs. Solar window film was used to reduce building solar heat gain.
- **Water conservation:** Low flow plumbing fixtures were installed to significantly reduce water use at the facilities

INNOVATIVE FINANCING OF SOLAR ENERGY

The Coast Guard project in Puerto Rico has embraced many innovations. One of the most notable is its first-ever use of a Renewable Energy Service Agreement (RESA) embedded within an ESPC. An RESA is a financing method based on third-party ownership of renewable energy assets. This tool is sometimes used to allow the third party to take advantage of various tax incentives and renewable energy credits that the federal government itself would not receive.

The Coast Guard's Puerto Rico project was structured to allow for a third party entity to hold ownership of the solar PV systems; this meant that the third party could benefit from $6.3 million in tax incentives (Sec. 1603) from the expenditures on the PV system. This tax benefit covered approximately one-third of the costs of the PV installation. Under the terms of the agreement, the Coast Guard will purchase solar energy generated from the system at a fixed rate (with an escalation clause over time), with the cost coming in well below what the Coast Guard was previously paying for electricity. Typically, an RESA runs for 10 years, but by embedding it within an ESPC, the Coast Guard was able to lengthen the contract duration to 23 years and make it more cost-effective for all parties to implement this clean-energy solution.

This innovative financing approach allowed the Coast Guard to purchase clean energy without having to directly finance and maintain the PV systems. By agreeing to a fixed-price contract, the Coast Guard is insulated from the price volatility of buying electricity from the grid. In addition, the PV installations allow Coast Guard operations in Puerto Rico to generate a sizable portion of its electricity requirements on site. This protects them against service interruptions from a sometimes unreliable electricity grid.

PROJECTED ENERGY SAVINGS

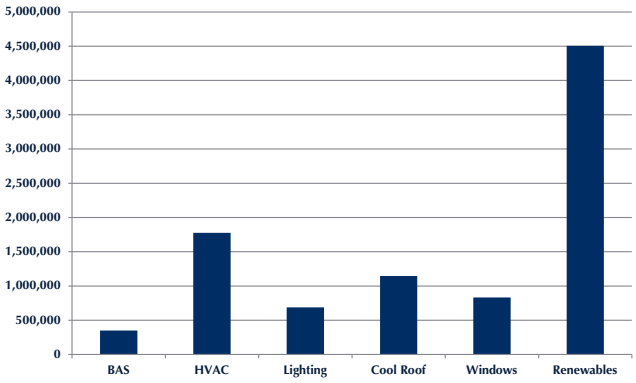
The energy-saving measures and the use of renewables associated with this project required a $50 million capital investment. However, the Coast Guard was only directly responsible for $13.8 million of this total, or roughly 28 percent. The resulting energy savings have allowed the Coast Guard to redirect $1 million of its annual energy expenditures from oil-based fuels to solar power, and to save an additional $1.1 million from reduced energy consumption thanks to the energy efficiency measures.

The energy conservation measures within the ESPC are projected to reduce energy consumption by nearly 9.3 million kWh. As seen in **Figure 3**, roughly half of these savings are a result of energy efficiency technolo-

FIGURE 2: Aerial View of Installed PVs

Source: Jesse Maestas, "Striving toward Net Zero using the ESPC Contract Vehicle" (presentation, Joint Engineer Training Conference & Expo (JETC), St. Louis, Missouri, May 24, 2012).

FIGURE 3: Projected Annual Energy Savings by ECM



Source: Kevin Vaughn, United States Coast Guard Embarks on Milestone Energy Savings Project with Schneider Electric (Austin, TX: Schneider Electric, 2011).

gies, with the remaining half resulting from the installation of renewable energy.

These energy solutions are projected to have a significant impact in reducing overall energy use across all of the Coast Guard's sites in Puerto Rico. As seen in **Figure 4**, the ESPC is projected to produce an annual energy savings of 53 percent. Energy saved through energy efficiency measures account for 28 percent, and energy replaced by solar power makes up the rest. This equates to roughly $2.2 million in annual savings from reduced energy expenditures. These dollar savings are guaranteed under the ESPC. If in a given year the energy dollar savings are not achieved, the energy service company will reimburse the Coast Guard for the difference.

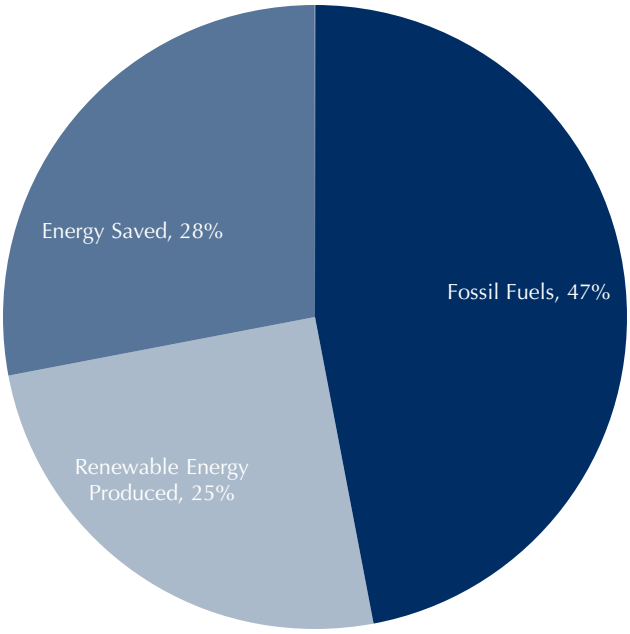
ADDITIONAL PROJECT BENEFITS

In addition to the cost and energy savings outlined above, the use of an energy savings performance contract to pay for energy efficiency and renewable energy technologies has produced other significant benefits for the Coast Guard:

- Support for the Coast Guard's efforts to comply with legislative and executive mandates to increase the use of renewable energy, improve energy efficiency, and reduce greenhouse gas emissions;
- Electricity price stability through the use of an RESA to finance nearly 3 megawatts of solar PV;
- Increased reliability and energy security through on-site generation;
- Reduced operations and maintenance burden due to the roof replacements under the ESPC; and
- Improved quality of life through better-maintained shelter for Coast Guard personnel based in Puerto Rico.

The ESPC has greatly improved the Coast Guard's energy security for its installation in Puerto Rico. In addition to the obvious risk of outages from hurricanes sweeping through the Caribbean, some Coast Guard facilities are in isolated parts of the island with unreliable connections to the grid. The Coast Guard had previously purchased all its electricity from the local Puerto Rico utility. These purchases are projected to be cut in half as a result of the PV installations and efficiency measures. For example, Air Station Borinquen is now producing nearly 85 percent of the energy it consumes via solar panels. This facility is located on the end of the electricity grid, and was particularly dependent on backup generators whenever there were disruptions caused by extreme weather.

FIGURE 4: Projected Post-Project Energy Use



Source: Kevin Vaughn, United States Coast Guard Embarks on Milestone Energy Savings Project with Schneider Electric (Austin, TX: Schneider Electric, 2011).

The project also dramatically improved housing conditions for Coast Guard personnel stationed in Puerto Rico. Roofing was the largest operations and maintenance item for San Juan and Air Station Borinquen locations. Because it has resolved the roof problems at the housing facilities at Air Station Borinquen, the Coast Guard recently was able to remove the "inadequate" designation and ended the premium it had been paying for housing. This not only allows the Coast Guard to save money, but also greatly improves the quality of life and morale of the personnel and their families based there.

BARRIERS AND CHALLENGES

Predictably, several challenges arose as the Coast Guard was negotiating the largest ESPC in its history. The first had to do with the issue of timing. It is not unusual for a major federal project to face time constraints. These often are the result of a narrow window when federal dollars become available and must be spent. In the case

of the Coast Guard project in Puerto Rico, there was concern that the Treasury grants needed to help finance the solar PV installations were set to expire in a relatively short period of time. To meet this deadline, the Coast Guard divided the project into the two phases described above, with the PV installation included in phase one.

Challenging weather conditions added to the concerns about meeting tight time deadlines. The contractor needed to replace roofs and install PV panels during a time of the year when it rains just about every day. Through trial and error, the contractor built a framework over the roof that provided cover to each of the affected buildings before work began.

In addition, the hurricane season lasts for several months in Puerto Rico and threatened timely completion of the project. During construction, two hurricanes came close enough to the island to require that severe storm precautions be taken.

There were also unforeseen, but not unusual, challenges associated with working on older buildings. During the development phase of the project, for example, the energy service company learned that asbestos existed in over half of the housing units and buildings, which required close coordination between the roof replacement team and a team established to abate the hazardous materials.

NEXT STEPS/TRANSFERABILITY

As demonstrated in this case study, innovative financing tools are available and can be used to achieve multiple benefits including: reductions in energy consumption, increased energy security through on-site production of clean energy, and upgrades to aging facilities.

Given the dual challenges of higher energy costs and increasingly constrained federal budgets, the use of ESPCs and RESAs as financing tools is only likely to grow across the federal government. The recent Presidential Memorandum committing the federal government to $2 billion in performance-based contracts in federal building energy efficiency is just one recent example of this trend.

The expanded scope of the Coast Guard project to involve more extensive retrofits and renewable energy could well serve as a model for other federal agencies implementing energy-saving projects in the future. The Coast Guard intends to build on the success of its Sector San Juan project. It will continue to lead by example by pursuing options for using ESPCs to move closer to net zero energy consumption at its facilities both in Puerto Rico and throughout the country.

NOTES

* The Center for Climate and Energy Solutions wants to express our appreciation to several Coast Guard employees who assisted in the preparation and review of this case study, including Daniel Gore, Jesse Maestas; and Schneider Electric's Kevin Vaughn.

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2 "Federal Energy Management Program: Energy Independence & Security Act," U.S. Energy Information Administration, last modified September 24, 2010, http://www1.eere.energy.gov/femp/regulations/eisa.html.

3 U.S. National Archives and Records Administration, "Executive Order 13514--Federal Leadership in Environmental, Energy, and Economic Performance," Federal Register 74, no. 52117 (October 2009), http://www.gpo.gov/fdsys/pkg/FR-2009-10-08/html/E9-24518.htm.

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VIII. GSA'S PRINT MANAGEMENT INITIATIVES: CUTTING COSTS AND SAVING ENERGY THROUGH SMARTER PRINTING*

OVERVIEW

Federal agencies spend up a $2 billion per year on printing and associated expenses. It is therefore not surprising that Washington is looking at printing as an area where it can reduce costs. The U.S. General Services Administration (GSA) has initiated efforts to transform how the federal government purchases and manages printing. It is estimated that these efforts could cut printing-related costs almost in half, while reducing energy consumption, putting a lid on paper purchases, and substantially lowering the number of printers used by the federal workforce. These efforts represent an important step toward the ultimate goal of a paperless government. This case study examines GSA's effort to lead by example in the drive to reduce printing-related energy costs while advancing sustainability goals.

THINKING DIFFERENTLY ABOUT PRINTING

Printing and copying documents[1] are tasks that are largely taken for granted as a common and necessary part of the everyday workplace. As long as the printer prints, and the toner and paper don't run out, few employees give much thought to how much they print, how much it costs, and how much energy is involved.

The most extensive review of federal printing practices was conducted in 2009.[2] This survey of federal employees found:

- On average, federal employees printed 7,200 pages per year;
- Employees estimated that they threw away 35 percent of what they printed that same day;
- Nine percent of agencies had policies in place requiring the use of two-sided (duplex) printing as the default option; and
- Twenty percent of agencies had restrictions on the use of color printing.

As one respondent volunteered, "Printing at work is made very easy, so I tend to print without thinking about it."[3]

The management of printing equipment and practices within a federal agency has typically been handled by the agency's information technology (IT) staff. Among the defining features of print management across the federal government: decentralized purchasing and a near total absence of any efforts to achieve efficiency or limit costs.

As a result, federal agencies now spend an estimated $2 billion annually on printing. These costs include the purchase of new equipment, maintenance and supplies (e.g., toner and paper) required by the existing fleet, the energy required to power this equipment, and costs associated with disposing of unneeded or obsolete equipment.

GSA recently launched two initiatives aimed at driving down these costs. These initiatives include a new procurement effort to leverage the purchasing power of the federal government to reduce equipment costs. As a complement to this effort, GSA's PrintWise[4] campaign seeks to bring about behavioral change within agencies with the goal of fully capturing the potential benefits from an enhanced print management program. While both of these efforts are in their early stages, initial results reported by some agencies suggest that by "printing smarter," they can achieve substantial cost savings and environmental benefits.

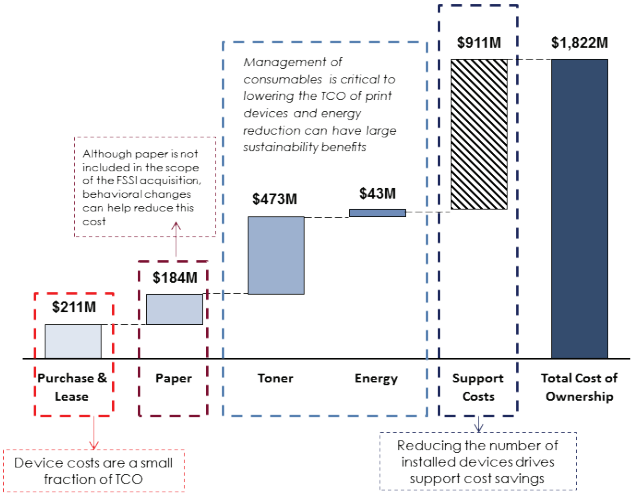
SUSTAINABILITY AND COST REDUCTION CHALLENGES: FEDERAL DIRECTIVES FOR MORE EFFICIENT PRINTING

Two recent federal directives have helped focus attention on agency efforts to bring down the costs of printing and reduce its environmental impact. Executive Order 13514: *Federal Leadership in Environmental, Energy and Economic Performance,* issued in October 2009, covers a broad range

FIGURE 1: Using Multifunctional Printer

Source: "Federal Strategic Sourcing Initiative (FSSI)," U.S. General Services Administration

FIGURE 2: Estimated Printer / Copier / Multifunctional Device Total Cost of Ownership for FY 2011



Source: "Federal Strategic Sourcing Initiative (FSSI)."

of sustainability issues that impact agencies. Specific to printing, it calls on agencies to reduce paper use through duplex printing and to purchase paper with at least 30-percent postconsumer fiber. The executive order also calls for the purchase of printers and other products meeting ENERGY STAR and Electronic Product Environmental Assessment Tool (EPEAT) certifications.[5]

More recently, the President signed another Executive Order (EO 13589: *Promoting Efficient Spending*), in November 2011. EO 13589 calls for a 20-percent reduction in spending by Fiscal Year (FY) 2013 across five areas of federal spending, including printing. It also specifically calls on agencies to limit the printing of hard-copy documents and to use the Federal Strategic Sourcing Initiative (described below) to reduce the costs of acquiring printing equipment.[6]

OPPORTUNITIES FOR COST AND ENERGY SAVINGS

Figure 2 shows GSA's estimates of the total cost of ownership for providing printer services across the federal government. As the figure shows, equipment costs are a relatively small share (around 11 percent) of total costs. The greatest costs (around 50 percent of the total) go to support servicing and maintaining the fleet of equipment. Toner and paper are also sizable expenses—at 36 percent. Energy costs for print operations were estimated to be about $43 million annually.

Developing a clear understanding of the total cost of ownership for this equipment was a critical first step in shaping a program to better manage federal printing. With the cost information in hand, the federal government was able to identify a range of opportunities for reducing those costs, such as:

- The government could drive down support costs by reducing the number and diversity of devices and by automating servicing notifications and supply outages.
- It could reduce paper and toner costs through duplex printing and limiting the use of color printing.
- Using GSA's purchasing power to negotiate reduced costs for new devices and to encourage the purchase of the most energy-efficient products would reduce both equipment and energy costs.

GSA'S STRATEGY TO REDUCE PRINTING COSTS

Working with representatives from 24 federal agencies, GSA initiated a comprehensive print management strategy that includes two major initiatives. First, GSA set out to leverage federal purchasing power to drive down the costs of equipment through a Federal Strategic Sourcing Initiative (FSSI) for print management devices and support. Second, GSA created the "PrintWise" awareness campaign to engage agencies in activities that encourage federal employees to make better printing decisions.

Federal Strategic Sourcing Initiative for Print Devices

Federal agencies are not required to purchase equipment using GSA contract vehicles, but the existence of a blanket purchase agreement (BPA) encourages agencies to go this route. From an agency's perspective, the use of a BPA streamlines the administrative process and ensures that it is getting a low price based on large-quantity purchases. Dan Gordon, former administrator with the Office of Federal Procurement Policy, captured the advantage of centralized purchasing for printers. "For too long the government purchased as if it were hundreds of medium-sized businesses, rather than the world's largest purchaser," Gordon said.[7]

A major milestone in this effort was reached in September 2011, when GSA awarded 11 firms BPA acquisition vehicles. Two firms received contract awards to supply agencies with fleet assessments. These contracts provide agencies with the ability to work with a technical vendor to document their baseline printing costs and needs. The fleet assessment also includes an analysis of approaches the agency can take to optimize its print services and includes vendor-neutral device recommendations based on the agency's workflow and business needs.

In addition, GSA awarded BPAs to nine contractors to assist agencies in the procurement of printing devices, including both multifunctional devices and network printers. While reducing total cost of ownership was a critical factor in the contract awards, the selection process also included a number of important sustainability measures:

- All devices must be ENERGY STAR compliant;
- Maintenance agreements must achieve a 95-percent uptime rating while using 100-percent recycled and 50-percent post-consumer content paper;
- Devices are required to default to duplex printing;
- Devices are required to incorporate the most advanced sustainability technologies; and
- Sustainable consumable supplies must be available including solid-state toner, remanufactured toner cartridges, and poly-resin color toner.

For agencies seeking to maximize their sustainability objectives, the BPA includes one option under which all devices are ENERGY STAR compliant, automatically track energy usage, accept 100-percent recycled and 50-percent post-consumer content paper, and come with factory-installed default duplex printing to minimize paper usage.

The goal of the FSSI purchasing initiative is to dramatically reduce the average costs of printing across the federal government. Current estimates are that for all federal printing, the average cost per page is 6.7 cents. **Figure 3** shows the substantial reductions that are being sought under the GSA initiative.

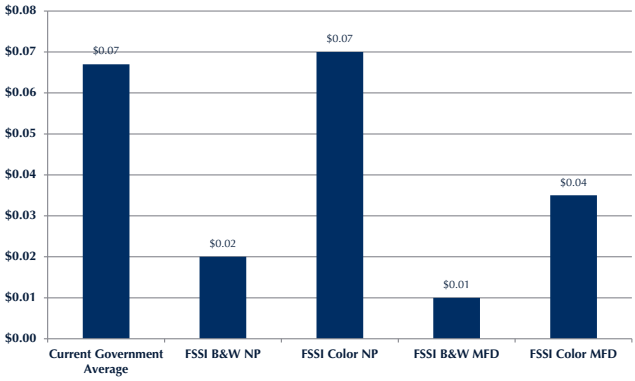
In addition to managing the existing BPAs, GSA is seeking to go beyond new devices and is developing a BPA for agencies to help them better manage and support their existing devices.

TABLE 1: Seven Steps to Lower Printing Costs Within 90 Days

SEVEN STEPS	ESTIMATED ANNUAL GOVERNMENT-WIDE SAVINGS
1. Set default to duplex printing	$61 million
2. Set default to black-and-white or grayscale printing	$171 million
3. Set default to draft quality printing	$30 million
4. Use toner-efficient fonts (Times New Roman, Garamond, Century Gothic)	$30 million
5. Power down devices on weekends; additional savings possible if devices turned off for weekends.	$30 million
6. Reduce the number of personal printers to a minimum	$6 million
7. Cease the purchase of personal printers	$10 million

Source: U.S. General Services Administration, GSA PrintWise Campaign, Seven Steps to Lower Printing Costs within 90 Days (Washington, DC: U.S. General Services Administration, 2012), http://interact.gsa.gov/sites/default/files/seven_steps_to_lowering_print_costs_within_90_days_guide_vjune2012.pdf.

FIGURE 3: Average FSSI Cost Per Page: Network printers (NP) and Multifunctional Devices (MFD)



Source: "Federal Strategic Sourcing Initiative (FSSI)."

PrintWise Education and Awareness Campaign

Recognizing that the availability of BPAs for improved devices alone will not automatically lead to more efficient printing, GSA took the unprecedented step of adding a change management element to its overall strategy. It created the PrintWise campaign aimed at addressing the behavioral component of print decisions.[8] This initiative works with interested agencies to develop an action plan to implement best practices among their employees. PrintWise will also work to showcase successful efforts by agencies and document and communicate the savings they achieve.

A cornerstone of this effort is a strategy called "Seven Steps to Lowering Costs Within 90 Days." It lays out a series of concrete actions for agencies that will deliver substantial near-term benefits. Among the simple steps that agencies are urged to take is setting default controls on printers to: double-sided (rather than single-sided); black and white (as opposed to color); and draft quality (as opposed to high quality). **Table 1** describes the seven steps and the projected savings of over $330 million that they can help federal agencies achieve.

BARRIERS AND CHALLENGES

Until recently, print management didn't get a lot of attention across the federal government. But now it's seen as an issue that, if properly addressed, can produce substantial cost savings. In addition, there is increased awareness that these savings can be achieved without affecting the ability of federal workers to meet their workplace printing needs, and that printing smarter also helps the government achieve its sustainability goals.

BOX 1: How Two Agencies Are Beginning to Cut Printing Costs

Department of Commerce: The Commerce Department began with a review of its current printing practices. The key finding: Commerce printed 250 million pages during the previous year on its networked printers. Almost all were printed single-sided and a quarter were printed in color. The review also found that a significant number of employees had personal desktop printers and that the department relied on more than 350 contracts and 400 vendors for its printing support.

With the goal of cutting 20 percent from the $4.7 million the agency spent annually on printing, the Commerce Department instituted a new campaign. In its first year, this campaign has: increased double-sided printing from 11 to 53 percent; increased black-and-white printing from 75 to 88 percent; and decreased the number of pages printed by 27 percent. Commerce has also moved to substantially reduce the number of desktop printers and will be shifting its purchasing of new devices to the BPAs established by GSA.[9]

Federal Aviation Administration (FAA): The FAA reviewed its print services and found that inefficiencies were unnecessarily costing the agency substantial resources. FAA found that its fleet of printers was aging, that far too many employees relied on costly personal printers, and that there was an abundance of abandoned print jobs. With the goal of providing "the right printer with the right capacity and features in the right location," FAA has gone about revamping the location and number of devices available to its employees, reducing the number of personal printers, and enhancing remote maintenance processes. It has also worked to communicate the benefits of these actions to help bring about the cultural change required to fully realize potential savings. Across all of its facilities, FAA has estimated potential savings of almost $2.5 million in reduced toner and paper costs alone.[10]

To make this transition successful, senior management in agencies must target printing as an area that merits increased attention, and that means assigning clear responsibility for managing the required changes. The GSA's PrintWise campaign recognizes these requirements and requests that any agency seeking to join the effort begin by sending a commitment letter from its deputy secretary and appointing a "print management champion."

Like many programs that can achieve cost and energy savings, better print management may require agencies to invest some money in the near term in order to achieve far greater longer-term savings. With increasingly constrained budgets, agencies may have a difficult time funding the initial fleet assessments that would help them fully understand their current printing situation and the cost-saving opportunities available to them. Agencies may be able to overcome this obstacle by shifting from owning to leasing devices, or by outsourcing print management services entirely to a strategic partner.

NEXT STEPS/TRANSFERABILITY

GSA's leading-by-example efforts on the issue of print management should provide a strong foundation for government-wide action to enhance the efficiency and improve the sustainability of federal government printing systems. As more agencies successfully implement these programs and share their experiences with other agencies, it is likely that the federal government will go a long way to achieving an estimated $1 billion in savings, in addition to substantial environmental benefits. **Box 1** describes how two agencies are beginning to cut printer costs. GSA has recognized the importance of keeping the focus on this effort and is committed to continuous improvement as a cornerstone of its print management activities.

The focus of GSA's work to date is on optimizing the existing system rather than enlisting agencies in a broader effort to achieve the goal of a "paperless government." As technology advances and makes electronic files more accessible and as behaviors change, the vision of paperless government should move closer to reality.

NOTES

* The Center for Climate and Energy Solutions would like to express its appreciation to Mark Storay, Meredith Parker, and Marny Burke of the U.S. General Services Administration for their input into this case study.

1 This case study focuses only on activities related to printing, faxing and copying undertaken directly by agency employees. It does not include publishing federal documents. This is typically handled separately by the Government Printing Office.

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The case studies presented in this report highlight the federal government's use of ICT solutions to cut costs, improve efficiency, and advance sustainability goals. The Center for Climate and Energy Solutions (C2ES) is an independent non-profit, non-partisan organization promoting strong policy and action to address the twin challenges of energy and climate change. Launched in November 2011, C2ES is the successor to the Pew Center on Global Climate Change, long recognized in the United States and abroad as an influential and pragmatic voice on climate issues.

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