Uncle Sam, the Energy Miser

The federal government takes the lead in net-zero building construction.

By Jeffrey Spivak

Far above the Earth, on the International Space Station, technology does some amazing things. Something called "intelligent control" guides the station's flight. "Inductive monitoring" determines if any operation is running abnormally. And "forward osmosis" recycles astronauts' urine into filtered water.

Now NASA is putting such space-age advances to work on Earth for its regular employees — in an office building.

This past December, NASA opened the $24 million Sustainability Base at the Ames Research Center complex near San Jose, California. It's a crescent-shaped pair of buildings topped by solar panels, and it uses intelligent controls to track such things as room schedules and weather forecasts to then adjust a room's temperature and even automatically open and close windows. If the building's power usage happens to spike abnormally, inductive monitoring alerts management immediately — not when the electric bill comes.

And while the 220 scientists and consultants in the building aren't drinking filtered urine, forward osmosis does recycle gray water draining from sinks for use in flushing toilets.

"It's the first time these kinds of technologies have been used in a building on planet Earth," says Steve Zornetzer, the Sustainability Base's project director.

All this is helping the Sustainability Base achieve one ultimate environmental goal — consume zero net energy. That is, to use only as much power as it generates by itself. It's just one example of the federal government's leadership in developing the next frontier of green architecture: net-zero buildings.

"The federal government is developing models of sustainable design that the private sector isn't. They're leading with new technologies and innovations," says Stuart Kaplow, a Maryland-based real estate attorney specializing in sustainable construction.

Joule box

A net-zero building is one that, over the course of a year, produces as much energy as it needs through a combination of technological efficiencies and its own on-site energy generation, such as solar power. When the building's energy usage peaks, it still may
draw extra power from a mainstream electric utility grid. But when on-site energy generation is greater than the building's needs, excess electricity can be exported back to the utility grid. Thus over a year's time, the building consumes a net zero amount of utility-based energy.

Net-zero commercial buildings are a relatively new phenomenon. In the past decade, only one to two dozen such buildings have opened in the U.S., depending on who's counting. Until recently, the structures were typically pretty small — three stories or less and comprising less than 15,000 square feet, according to the U.S. Department of Energy. They include the Magnify Credit Union in Florida, Richardsville Elementary School in Kentucky, the Science House museum in Minnesota, and Sonoma State University's technology center in California.

But the federal government has taken net-zero architecture to a new level by incorporating it in larger commercial buildings. No private-sector net-zero building is larger than 25,000 square feet, according to a compilation of projects by Building Design + Construction magazine. But several new federal buildings are substantially larger.

NASA's Sustainability Base is 50,000 square feet. Also this past December, the Army opened the first net-zero building in Arizona, an 89,000-square-foot middle school for military families at Fort Huachuca. The General Services Administration is currently constructing the first net-zero historic renovation, a 42,000-square-foot former post office in Colorado. And the Department of Energy in 2010 completed what's still the largest net-zero building in the country, the 220,000-square-foot Research Support Facility at the National Renewable Energy Laboratory campus in Colorado.

These federal buildings share many of the same advanced design features, such as rooftop photovoltaic solar installations, geothermal heating, and cooling systems with underground storage wells, plus minimized plug loads that limit the number of electronic devices that plug into walls. The interiors are bright and open, with lots of large windows, low cubical walls, and overall less noise, without the background hum of a furnace or air conditioner blowing through ductwork.

"This is an effort the federal government will be focusing on," says Eleni Reed, AICP, GSA's chief greening officer. "With net zero, we're really pushing the envelope."

Growing phenom


The green building movement has evolved both as an environmental concern and as a competitive advantage. Environmental stewardship often targets the U.S. building stock, which is responsible for almost 40 percent of carbon dioxide emissions, even more than transportation, according to the DOE. Moreover, a number of public and private studies
have found that reducing a building's environmental footprint can increase the property value up to 25 percent and improve the occupancy rate up to 15 percent.

From the beginning, the federal government has been a leader in this movement. The U.S. Green Building Council in 2000 launched its Leadership in Energy and Environmental Design (LEED) rating system, in which building owners try to achieve points for energy efficiency, water conservation, and air quality to receive silver, gold, and platinum certification. That initial year, the U.S. Navy achieved the government's first LEED certification. A few years later, in 2003, GSA, the nation's largest civilian landlord, started designing all its new federal buildings to LEED standards.

"LEED wouldn't be where it is today without the federal government," says Chris Cheatham, a Kansas City-based construction attorney who specializes in green building law.

According to the U.S. Green Building Council's LEED project database, the federal government owns just 11 percent of LEED buildings that list an identifiable owner. But some green building consultants maintain that the federal government's share of green buildings is actually more like 25 percent once federal leased buildings and confidential military facilities are counted.

"The federal government is farther along the curve than other sectors because green is truly integrated into how they do business. They've raised the bar for everyone," says Melissa Gallagher-Rogers, director of the government sector for the U.S. Green Building Council.

The big push

As more buildings go green, it's becoming tougher for a property to stand out from a competitor's. So net zero is considered the next step in green building's architectural evolution and marketability. A few states and private organizations have already hopped on the bandwagon. California's Long-Term Energy Efficiency Strategic Plan set a goal for all new commercial construction to be net-zero energy by 2030. Meanwhile, the Portland, Oregon-based International Living Future Institute, which promotes sustainable strategies, last fall unveiled a voluntary net-zero energy certification program for buildings.

But it's the federal government that's been the most aggressive in mandating net zero energy for its next generation of buildings.

The Energy Independence and Security Act of 2007 set a goal for newly constructed commercial buildings to achieve net-zero energy by 2030. President Obama's Executive Order #13514 in October 2009 went further by mandating that all federal buildings designed after 2020 achieve net-zero energy by 2030.

In addition, the Department of Energy's Net-Zero Energy Commercial Building Initiative
aims to research and market emerging technologies for net-zero buildings, with a goal of converting half of all public and private commercial buildings to net-zero energy by 2040 and the entire stock of U.S. commercial buildings by 2050.

"I can sum up the reason why with one phrase: reducing waste," says Maria Vargas, director of the energy department's Better Buildings Challenge, a series of partnerships with communities and corporations to develop best practices. "If we're not wasting energy, it frees up money to be used somewhere else, plus it reduces greenhouse gas emissions."

Then there's the military. The Army launched a Net Zero Installation Strategy last year in which 17 forts and other installations were chosen as pilots to become net zero in energy, water, or waste by 2020. Secretary of the Navy Ray Mabus has mandated that half of the Navy's bases should achieve net-zero energy by 2020.

The armed services increasingly see net zero as "operationally necessary," in the words of the Army's "Vision for Net Zero," so the services can eventually avoid transporting energy and water to bases and installations, especially those on foreign soils. "We're taking this net-zero imperative to heart," says Robin O'Connell, AICP, director of sustainability and land-use planning for Naval Facilities Engineering Command.

Measuring results

Part of the attraction of net zero is its performance, which has been an issue with green buildings in general. Studies of LEED buildings have consistently found that tenants are more satisfied and employees are more productive. But results on operating performance have been more mixed. A GSA study last year discovered that some of its LEED-certified buildings used more energy and water than a typical U.S. non-green commercial building. GSA concluded: "Design intent does not always translate into real-world performance."

That's where net zero represents a step beyond LEED. While LEED's point system focuses on design and construction materials and strategies before a building opens, net zero is based solely on how a building operates. Net zero can be verifiably measured, so a building either is or it isn't. As Marc L'Italien, an architect designing the new Exploratorium net-zero museum in San Francisco, told an American Institute of Architects panel last year: "This is performance based. You don't get the credential until it measures up."

Another important distinction between net-zero projects and more conventional buildings is the architectural design process. Conventional buildings can be designed as a series of independent pieces, with the exterior skin being one, the heating and ventilation system being another, and so on. Net zero, though, involves an integrated design, where all the pieces work together toward the common goal. For instance, the need to maximize daylighting requires high ceilings, which eliminates space for ductwork, so larger net-zero buildings employ radiant heating and cooling through water pipes under the floors,
which creates a need for geothermal storage, and so on.

With net zero, then, energy drives the architecture.

The energy department's Research Support Facility at the National Renewable Energy Laboratory was designed in the shape of an "H," with two narrow 60-foot-wide wings to maximize sunlight and provide enough roof space for solar panels. Another unusual architectural device was the addition of horizontal metal panels along the south exterior. They're used to capture solar heat, which is then sucked into a labyrinth of crawl spaces under the building, where the warm air is stored for later use.

NASA's Sustainability Base consists of two wings, too, and buildings feature a structural support system called an exoskeleton design that places all the vertical structural steel supports on the exterior, thus leaving the interior free of support columns and allowing more open and consistent air flow. In addition, the buildings face south-southeast to take advantage of the sun's arc across the sky. Computer modeling predicts the buildings won't need artificial lighting the equivalent of 40 days out of the year.

Meanwhile, at Colorado's Wayne N. Aspinall Federal Building — the historic former post office undergoing a renovation to net-zero status — the architectural shape was set in 1918, so the greening process involves more modifications. Inside, drop ceilings are being taken out and insulation is being inserted behind interior walls along the perimeter. Outside, a geothermal system is being installed with 32 underground wells that use the warmth or cold of the ground to heat or cool water, which is then pumped to the building and used to fan warm or chilled air.

"The characteristics of the building itself — like its large windows and original high ceilings — have made it more feasible for net zero," says Jason Sielcken, GSA's project manager.

With so much emphasis in net-zero buildings on saving energy, working in them requires some adjustments.

In the federal government's new net-zero buildings, cubicle walls are 40 inches high instead of 60 inches, to allow more sunlight deeper into the interior, but the lower walls don't protect privacy and they're too low to hold shelves. There are fewer enclosed offices or conference rooms, because walls block sunlight. Personal space heaters aren't allowed, and common-use refrigerators and copying machines are usually limited to one per floor.

"There were people who had to get used to the open spaces," says Paul Torcellini, the principal engineer on the Renewable Energy Lab's Research Support Facility. "People had to learn to be quieter."

NASA's Sustainability Base was still working out some kinks the first weeks that employees were there. For instance, the indoor temperature was chilly in December, but there are no fixed thermostats to adjust. It was a matter of tweaking the radiant system.
"It's different from any other building, where you can call up someone and have the temperature turned up," says Krisstina Wilmoth, assistant director for research collaborations and institutional development for NASA.

Still, all the design innovations seem worthwhile. The Renewable Energy Lab's Research Support Facility uses about 35 kBtu per square foot a year, or one-quarter of the energy used in its former leased building and one-third of the energy used in a typical Denver office building, according to the lab's estimates. For the private sector, one consultant estimated that utility savings for an 80,000-square-foot net-zero building could average $240,000 a year and that savings could be passed on to tenants and provide a marketing advantage.

Yet, achieving net-zero performance does cost more — between five and 25 percent above typical construction costs, according to most estimates. The Research Support Facility, at $55 million, cost about $260 per square foot, only slightly above some other LEED-certified buildings in Colorado, but well above Reed Construction Data's benchmark of $140 per square foot for a typical Denver office tower. The Sustainability Base is estimated to cost six percent more than an office building of similar size.

Net zero does pay off, but it takes time. The return on investment is estimated to be eight to 12 years.

The upward climb

Going forward, net zero is still far from becoming mainstream. Dozens of net-zero commercial buildings are currently in various stages of planning and construction, including the first private-sector ones larger than 25,000 square feet. Yet, some challenges stand in the way of wider adoption.

For one thing, energy modeling done by the Renewable Energy Lab has found net zero is more difficult to achieve in structures four stories and taller because those buildings have higher load levels and insufficient roof area for solar panels. For another thing, the federal government's continued leadership faces fiscal roadblocks. Congress has stymied the Obama administration's sustainability agenda, such as 2011's Better Buildings Initiative, by failing to approve additional grants and incentives. Plus, budget cutting slashed the GSA's usual $1 billion annual construction budget to almost nothing, so there won't be much new construction this year.

Nevertheless, green building experts only see the net-zero momentum accelerating. A DOE study determined that 62 percent of commercial buildings had the potential to achieve net-zero energy use. The study concluded, "These results indicate that the (federal net-zero) goal is not too aggressive and can be achieved for large segments of the commercial sector."

Harvey Bernstein, vice president of industry insights for McGraw-Hill Construction in Washington, D.C., concurs. "The market is moving beyond just a green building and
looking more for performance improvements in energy, water, and air quality," he says. "We have to be realistic: Net zero is still a relatively small number of buildings. But that's ultimately where we want to get."

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Resources

Image: Top — Part of the Ames Research Center complex near San Jose, California. Middle — Ceiling-mounted panels circulate 57-degree water from geothermal wells, regulating temperatures in occupied spaces with low-energy radiant cooling. The building is supported by an exoskeleton, so there are no internal columns to obstruct the flow of fresh air and daylight. The windows are all operable and are automated to flush the building with cool air at night. Photo courtesy of NASA Ames Research Center. Bottom — The 'H' shape of the Research Support Facility at NREL maximizes sunlight penetration to the interior and provides roof space for solar panels. Photo by Dennis Schroeder, NREL.

Sonoma State University Environmental Technology Center: www.sonoma.edu/etc; International Living Future Institute: www.living-future.org.