Toward Net-Zero Energy Installations

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To carry out missions vital to national security, military installations must be self-sustainable after a natural disaster or terrorist act, which means they must generate as much power as they consume. Four strategies can get an installation closer to that goal.

Military energy programs are at a transformational moment. The leadership and funding are in place to address current deficiencies, and the potential is at hand to create the tools and framework for long-term success. Part of that transformation is to establish net-zero energy installations—those that generate as much electricity as they consume—to provide an islanding capability in case of commercial grid failure and power loss.

A move toward net-zero energy has four main strategies: reduce energy consumption and demand, implement sustainable business practices, install renewable energy and other onsite energy generation systems, and develop a smart grid to control and manage onsite generation and installation demand.

Within these strategies are actions that both renew and rebuild, including improvements to operations and maintenance, reducing water, solid waste, and transportation requirements, and managing a variety of energy demands. As the sidebar "Evolving an Action Plan" describes, no single, isolated action can produce a net-zero efficiency, so a necessary first step is to establish a framework for integrating strategies and their components.

Inside Track

- Energy at military installations has become more than just a focus on efficiency and cost reduction; it has become critical to ensure mission viability and national security.
- No single isolated action can produce a net-zero efficiency. Integrating individual solutions is critically important to capture the interactions among building systems and components, operations, and power generation requirements.
- At a minimum, ensuring that the energy efficiency of the existing buildings meets Energy Star certification will provide a high return on investment and deliver energy cost savings.
- Net-zero energy installation concepts are being expanded to incorporate other sustainable operations and have implications for policy, planning, and operations.

Reduce energy consumption and demand

Opportunities for cost-effectively reducing energy consumption and demand vary. Raising awareness to encourage changes in behavior incurs little or no cost; retrofitting lighting or mechanical systems is far more capital intensive. As Table 1 shows, a number of funding mechanisms are available, and facilities will often use multiple mechanisms simultaneously. Alternative financing is also available through both the servicing utilities (utility energy service contract), and the private sector (energy savings performance contract). Partnership opportunities are also available with the private sector, national laboratories, and other organizations to leverage technical resources and best management practices and to share lessons learned. The Federal Energy Management Program, for example, helps federal agencies identify and apply best practices in energy efficiency and reduction.

Implement sustainable business practices

All new building and infrastructure must be designed and constructed with high-energy efficient equipment and be designed to operate as high-performance buildings. To that end, military agencies have adopted a Leadership in Energy and Environmental Design (LEED) certification requirement for all new construction projects. A study by the Department of Energy (DOE) found that high-performance buildings on average use 43 percent less energy than traditionally designed buildings.[1] Installations can use the LEED certification process for existing buildings to improve building efficiency and optimize sustainable operations. The Marine Corps Base at Camp Pendleton, for example, has reduced its energy costs 44 percent, in part by incorporating LEED standards into all its construction projects since 2004.[2]

Energy Star certification provides installations with reliable and predictable return-on-investment opportunities and delivers

energy cost savings. Green buildings also improve workplace performance and employee retention and reduce absenteeism—all of which adds to bottom-line savings.[3]

Lasting behavioral changes at the individual level means that installation personnel understand the impact that their decisions and actions have on resource consumption and costs. Installation leadership can institutionalize a culture of high-performance and sustainable operations by public commitment to resource-efficiency awareness and to the importance—and value—of training all installation personnel.

An installation can address the reduction of energy use associated with transportation through a variety of measures. Procuring high-efficiency electric, or alternatively fueled vehicles; providing bicycles, buses, and ride-sharing programs; and implementing teleconferencing are just a few of the available options. The U.S. Army, for example, has made a commitment to purchase 4,000 non-tactical electric vehicles by 2011 that will be used on Army bases for passenger transport, security patrol, and maintenance and delivery services. By using electric vehicles, the Army will reduce its fossil fuel consumption by 11.5 million gallons over a six-year period.[4]

Many sustainable business practices can be implemented through changes in policy, design criteria, and investing in people. A number of resources can help installations identify, implement, and track progress in meeting target goals for both energy efficiency and greenhouse gas reductions. These include but are not limited to the DOE, the Office of Federal High-Performance Green Buildings, U.S. Green Building Council, and a number of the internal design and sustainability resources within the military such as the Army Corps of Engineers and Naval Facilities Engineering Command. All these resources provide professional services as well as materials to help installations identify opportunities and implement projects.

Evolving an Action Plan

Integrating individual solutions is critical in using the interaction among building systems and components, operations, and power-generation requirements to best advantage. Technological innovations alone—no matter how well integrated—cannot be successful unless personnel are properly trained to analyze information and operate equipment properly.

It is also important to understand and prioritize the reasons for becoming a net-zero energy installation such as energy security, cost reduction, or regulatory requirements. Assessing the vulnerability of mission-critical assets will help determine the installation's risk tolerance and help prioritize investments to improve the resiliency and adaptability of critical systems and assets. These priorities should be captured in an action plan to help manage risks and opportunities, identify funding requirements and alternatives, and establish clear roles and responsibilities for meeting the net-zero energy installation goal.

For example, an installation would first reduce its energy consumption and demand requirements through more efficient energy practices and after implementing high-performance building operations. It would then be in a position to assess its options for meeting installation energy requirements through onsite power generation.

Increase onsite power generation

Alternatives for onsite power generation depend on the installation's available resources, infrastructure, and activities. Typical alternatives start with combining heat and power and end with implementing a portfolio of renewable energy technologies and energy management systems. In fiscal year 2004, for example, Yuma Proving Ground (YPG) built a new energy-efficient demonstration building with funds received through Arizona's[5] renewable energy rebate program. An active Army research, development, and testing installation, YPG has proved to be a fertile testing ground for innovative renewable energy alternatives since 1985. Photovoltaic generation of renewable energy, and ongoing

Table 1. Opportunities, initiatives, and funding for reducing energy consumption and demand.

Opportunity	Initiative or Program	Cost	Funding Mechanism
Turning off lights, material recycling, water conservation, cooling and heating management, ride-sharing, telecommuting, and so on	Awareness raising and training: communicate the impact of individuals on reducing energy and environmental footprints at the installation	Zero to very low	Materials and instructors provided by service headquarters organizations and commands
To create professional energy managers	Training and certification of military personnel in energy management, resource efficiency, and LEED practices	Low	Training provided by service headquarters and commands at various locations across the country
Alternative vehicles	Electric vehicles, installation-wide buses, bicycles	Medium	Energy-efficiency funding from American Recovery and Reinvestment Act of 2009; installation-level operations and maintenance (O&M)
Repair existing heating and cooling systems	Tiger teams-, retro-commissioning	Low to medium	Installation-level O&M
Alternative and renewable energy production	Service-specific enhanced-use lease, power purchase agreements	Medium to high	Energy Conservation Investment Fund, developer funded
Identify opportunities for savings, efficiencies, and reductions	Net-zero energy installation, resource efficiency manager	Low	Department of Energy grants, energy savings performance contract, installation-level O&M
Retrofit lighting and mechanical systems	Energy savings performance contract	Medium to high	Energy savings performance contract, installation-level O&M

Figure 1. A photovoltaic array at Nellis Air Force Base, Nevada. The 15-megawatt array installed in 2007 currently provides 25 percent of the base's energy needs. (Photo courtesy of Nellis Air Force Base.)

applications of new technology have allowed YPG to achieve a 38 percent annual reduction in energy use.[5]

The Air Force expects to achieve similar efficiencies at locations that can take full advantage of photovoltaic technologies, such as the array depicted in Figure 1.

DOE in partnership with the military recently completed a renewable energy resource assessment that culminated in a map showing the type and quality of renewable energy resources available at military installations nationwide. A number of other resources are available through DOE and through national laboratories, and military service branches.[6] The Air Force Civil Engineering Support Agency's Utility Rate Management Team, for example, specializes in supporting the development of renewable energy projects at Air Force installations worldwide.

Funding mechanisms for energy-generation projects include construction funds for building integrated generation systems, such as photovoltaic arrays. Table 2 lists funding mechanisms according to project size. As the sidebar "Greening a Marine Corps Air Station" describes, projects funded through an energy savings performance contract are estimated to save the Marine Corps Air Station Miramar more than $3.5 million annually.

The 15-megawatt photovoltaic system at Nellis Air Force Base uses a power purchase agreement, and a 500-megawatt solar energy project is being solicited under an enhanced-use lease at Fort Irwin. Both these mechanisms exploit private sector financing and its ability to leverage tax incentives and renewable energy and carbon offset credits. These characteristics enable the third-party ownership and operation of extremely large (utility-scale) renewable energy projects on the installation site.

Table 2. Funding for renewable energy projects.

Project Size	Funding Mechanism
Small-scale projects of < 200 kilowatts	Energy Conservation Investment Program
Medium-scale projects from 1 megawatt to 50 megawatts	Energy savings performance contract, utility energy service contracts
Large projects of > 500 megawatts	Enhanced use lease

Greening a Marine Corps Air Station

The Department of the Navy recently selected Marine Corps Air Station (MCAS) Miramar to become a green installation as part of the U.S. Marine Corps Green Initiative and Campaign Plan. Since then, MCAS Miramar has been implementing a number of energy-generation and efficiency measures to become a net-zero energy base:

- purchase of 3 megawatts (MW) of renewable power from an onsite landfill gas project;
- installation of 8 MW of site-wide backup generation;
- installation of 2.5 MW of local cogeneration, which provides power and heat for most of the bachelors' enlisted quarters;
- building a 400 kilowatt integrated photovoltaic roof system;
- boiler replacement and other energy efficiency measures; and
- a site-wide control strategy for managing MCAS Miramar's entire electrical grid.

MCAS Miramar is also implementing water conservation and reuse measures, including converting all irrigation water from potable to recycled and installing dual piping in all new construction. The dual piping will enable the use of recycled water for flushing toilets, cooling tower makeup water, and other applications that do not require potable water.

The station is using a number of alternative contracting mechanisms to implement the projects, including a power purchase agreement for the landfill gas power, an energy savings performance contract for the backup-generation and energy-efficiency improvements, and station operation and maintenance and construction funds. The projects will reduce not only energy consumption and demand, but also energy costs on site. The landfill gas project, for example, will provide over half the station's required energy and potentially save MCAS Miramar more than $750,000 annually.

The projects funded through an energy savings performance contract are estimated to save more than $3.5 million annually. The station's energy manager, Randy Monahan, sees "multiple benefits" to MCAS Miramar's green initiative, including energy security; cost savings; energy control to address emergency situations and demand response opportunities; and most important, "the ability to continue airfield operations without interruption."

The station is also taking the next steps to green its entire operation, including programs to manage its carbon footprint, recycling program, supply chain, natural resources, and transportation assets.

Develop smart power management

One of the most promising techniques for energy management and cost savings is the application of smart grid technologies. The military has only recently started evaluating smart grids as a way to manage power, and the results of smart power management have yet to be fully realized. Nonetheless, smart grid technology has had measurable success in the commercial sector, and military installations can easily adopt it to manage onsite generation resources and effectively, reliably, and safely deliver power to site buildings. In 2009, over 16 percent of all energy

What Is a Smart Grid?

Experts say that the smart grid is analogous to having the Internet drive an electrical system, because the grid provides a nearly instantaneous balance of supply and demand for a particular device. The Department of Energy has identified five core technologies for the smart grid:[1]

Integrated communications will connect components to open architecture for real-time information and control, allowing every part of the grid to both "talk" and "listen." *Sensing and measurement technologies* will support faster and more accurate response, such as remote monitoring, time-of-use pricing, and demand-side management. *Advanced components* will realize the latest research in superconductivity, storage, and power electronics and diagnostics. *Advanced control methods* will monitor essential components, enabling rapid diagnosis and precise solutions appropriate to any event. And finally, *improved interfaces and decision support* will amplify human decision-making, transforming grid operators and managers quite literally into system visionaries.

Of particular benefit to implementers of smart grid technology is that they can add sensing and analytical capabilities to existing energy systems without significant build-out and its associated cost.

Rudimentary smart metering is already enabling consumers to time-shift their power use to take advantage of off-peak rates, with utility-bill savings as high as 20 percent.[1] Smart meters, such as that in Figure A, will be able to measure the consumption of electricity, gas, or water and monitor details in real time, such as kilowatt demand, kilowatt-hours, voltage, and power factor. Smart meters already allow the mapping of charges and credits for electricity consumption and production to the time-varying value of electricity. Such mapping supports short-term interval data recording and two-way communication.

Figure A. Smart meter (left) versus a traditional meter (right). The smart meter comes with a digital readout and enables two-way communication about resource consumption, in this case water. The standard meter can only measure resources consumed and must be read. Photo used with permission from Blue Water Power; http://www.bluewater-power.com/energyservices/Smart-Photos.html.

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used is expected to be in the form of electricity, yet the current average efficiency of the world's legacy electricity grid is around only 33 percent. Smart grid technologies, in contrast, offer 60 percent efficiency.[7]

Smart grid technologies assist in load leveling the electrical grid. With such leveling, a power-generating entity can run cleaner power sources, such as nuclear or hydroelectric longer, reducing the need to generate power using more carbon-emitting technologies and coal plants. By reducing variability in demand, fewer new power plants need to be constructed. For the installation, this means more efficient power generation and management with less need for additional infrastructure. The sidebar "What Is a Smart Grid?" describes the underlying technologies and the overall benefit.

Energy efficiency is inexpensive, easily available, and the most effective approach to lowering energy costs, improving performance, and achieving energy independence for military installations. The evolving energy arena over the past decade has compelled the military to try new technologies that develop mutually reinforcing and supporting projects (portfolio management) and to establish a secure energy web, thereby achieving both resource efficiencies and the overall resiliency of the military's built environment.

Centralized planning and goal setting, a virtue of the military organization, needs to be joined with innovative partnering to apply knowledge and techniques at the local level and with innovative financing by third parties to take advantage of shared interests in power generation and resource efficiency. With this intertwining of planning, partnering, and funding, the dream of net-zero energy can become a reality. ■

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