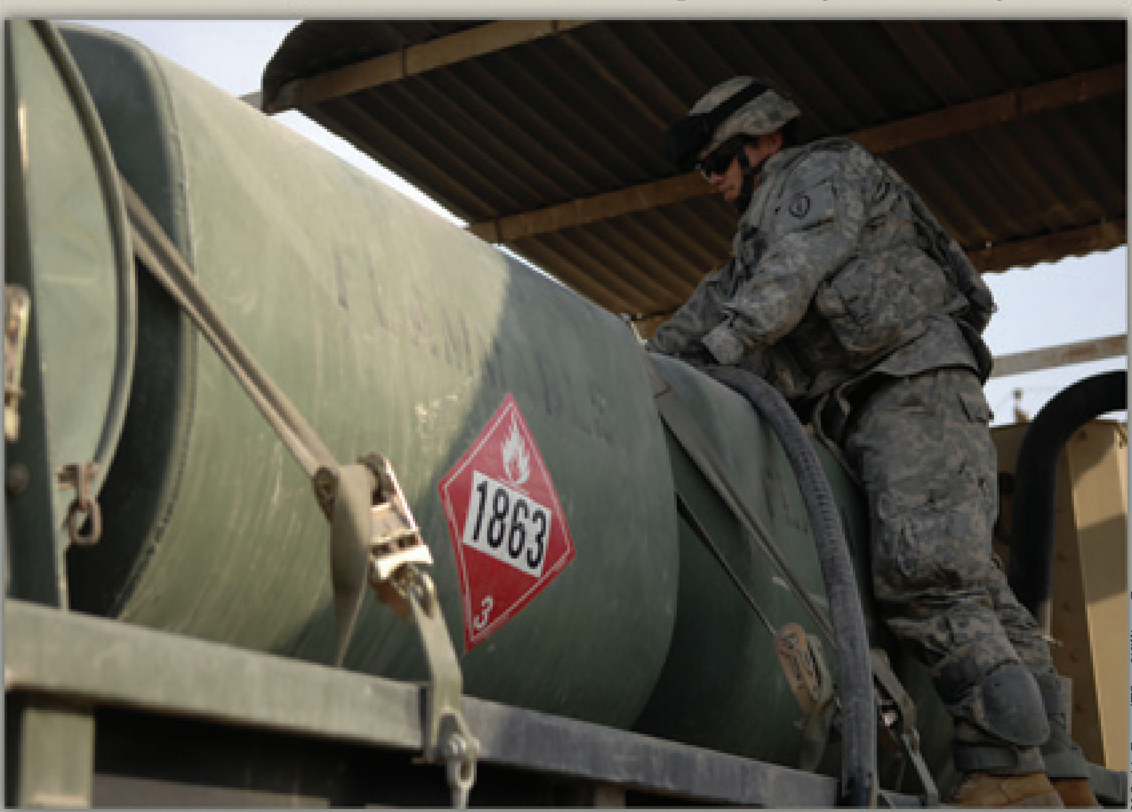
The Army's Operational

By LTG Michael A. Vane
and
COL Paul E. Roege

Over the next two decades, U.S. forces will operate in a geostrategic environment of considerable uncertainty against adversaries who will rely less on conventional force-on-force battles to thwart U.S. actions and more on employing tactics that seek to frustrate U.S. intentions without direct confrontations. Meanwhile, energy will become increasingly important, considering its impact on economic growth, political stability and the conduct of military operations, because the majority of oil production will occur in potentially unstable regions. Even as we pursue alternative energy technologies, fossil fuels will likely remain dominant.

Power and energy grow ever more important to our military capabilities; they enable every system that supports soldier and unit performance, from mobility and weapons systems to surveillance and communications—not to mention simple heating and cooling.



PFC Chris Goldberg, a petroleum supply specialist with 225th Warrior Support Brigade Support Battalion, 2nd Stryker Brigade Combat Team, 25th Infantry Division, transfers diesel fuel from a portable lift system to a fuel tank at Joint Security Station South in Iraq in 2007.

U.S. Air Force/TSgt. William Greer

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Energy Challenge

In recent years, several factors have emerged that further complicate the engineering and logistics challenges associated with power and energy, including asymmetric threats to logistics and infrastructure, increasing competition for the world's oil supplies and concern about global climate change.

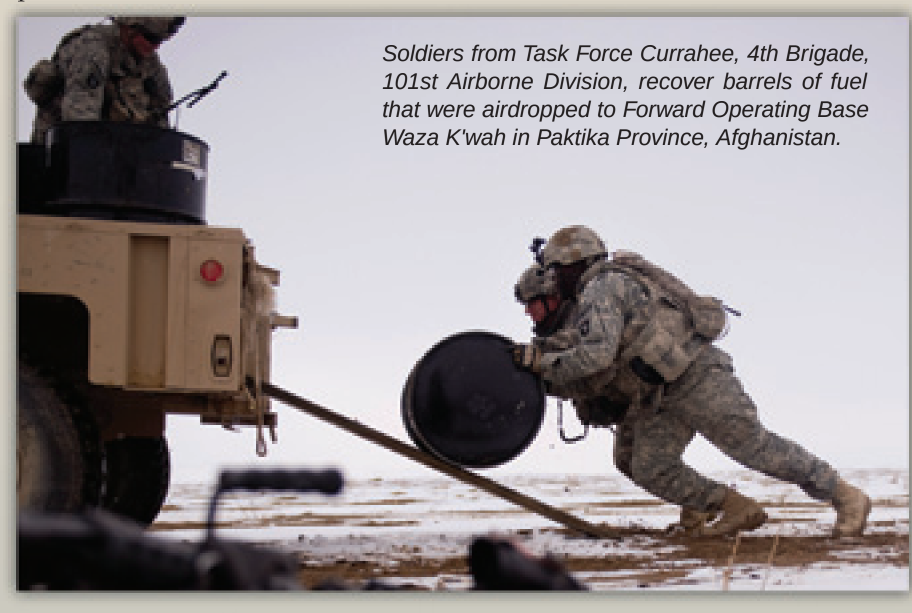
Army operations span a diverse range of tasks and operating environments, from enduring activities and infrastructure under little threat to expeditionary operations and sustained campaigns in hostile zones. The energy needed to sustain these operations is called operational energy.

Operational energy is the energy and associated systems, information, and processes required to train, move, and sustain forces and systems for military operations. It is an important enabler for operations as described in *The Army Capstone Concept* and *The Army Operating Concept*, which emphasize the need for synchronized maneuver and sustainment. Energy is essential to wide-area security, combined arms maneuver, effects, information and understanding, prioritized in concert with the operation. These ideas are consistent with the 2009 Army Energy Security Implementation Strategy and provide the foundation for recommendations made by the 2010 Army *Power and Energy Strategy White Paper*. While the current force relies almost entirely upon petroleum-based fuel to supply its needs, the future force will need alternatives in order to support flexible, resilient operations. Demands are composed of consumption and the use of power and energy in any form, whether to propel platforms, power electronic systems, or provide heating and cooling to sustain soldiers in the field. Infrastructure includes the methods, processes, and systems that produce, distribute, manage, monitor, measure, assess, meter, conserve, prioritize and control energy and power as well as systems and equipment performance.

The Army recently drafted an initial capabilities document (ICD) that outlines energy-related capability requirements. Common goals that pervade the analysis include: improve operational energy management; improve awareness of energy issues that affect operations; increase power-source density and commonality; decrease the size and weight of systems; increase power generation and distribution efficiency and capacity; decrease energy demand; and foster energy innovation.

Operational Energy History

Energy was a critical factor during many of the major battles and campaigns of World War II. We have since become even more dependent on the resource, yet we often take it for granted. Army vehicles consume unprecedented amounts of fuel for mobility and onboard power. Average fuel demand per soldier has increased from about 1 gallon per day in World War II to 15–20 gallons in Operations Iraqi Freedom and Enduring Freedom in 2007, nearly half of which was used to generate electric power. This dependence translates to a vulnerability as fuel and water compose the vast majority of resupply volume, which, in turn, diverts forces and commands attention from the operational tasks at hand.



Soldiers from Task Force Currahee, 4th Brigade, 101st Airborne Division, recover barrels of fuel that were airdropped to Forward Operating Base Waza K'wah in Paktika Province, Afghanistan.

U.S. Army/MSG Adrian Cadiz

Over the past century, modern militaries migrated to petroleum-based energy for its ease of handling and worldwide availability. We now must consider alternatives in order to ensure availability, mitigate price risk and fulfill environmental responsibility.

The Army already has promoted the priority of energy performance and formed various working groups. In 2008, the Army established a governance structure for energy policy, guided by a Senior Energy Council and facilitated by the Deputy Assistant Secretary of the Army for Energy and Partnerships. In February 2009, the council issued an Army Energy Security Implementation Strategy, including five strategic energy security goals: reduce energy consumption, increase energy efficiency across platforms and facilities, increase use of renewable/alternative energy, assure access to sufficient energy supplies, and reduce adverse impacts on the environment.

Airmen with the West Virginia Air National Guard and the 437th Aerial Port Squadron work to load and secure U.S. Army-procured water-drilling equipment at Joint Base Charleston, S.C., in July 2010.

U.S. Air Force/SrA Timothy Taylor

The Army's energy policy and governance structure is currently being merged with sustainability, consistent with concepts presented in the 2010 Quadrennial Defense Review.

Ongoing and emerging initiatives address power and energy objectives ranging from reduced cost and expanded use of renewable sources to lightening soldier load. Energy performance metrics and directives historically have focused on consumption, cost and energy diversity, explicitly exempting operational systems to avoid inappropriate constraints on Army operations. Recent efforts to identify operational energy objectives highlight the need for systems analysis to identify mission-related attributes such as resilience, endurance and flexibility—important not only in an expeditionary environment, but on domestic installations in a "flattening" world.

Army energy initiatives must establish a capability-based approach to energy and power that integrates all doctrine, organization, training, materiel, leadership and education, personnel and facilities aspects and identifies performance parameters based upon analysis of operational concepts. This will require both operational analysis and a comprehensive assessment of baseline energy use and performance, providing the basis for modernization priorities and improvement goals as well as management tools and training.

Operational Energy Grand Challenges

To simplify the enormous task at hand, the Army has taken its operational energy deficiencies and grouped these into three "grand challenges."

First, give soldiers and leaders a means to manage—measure, monitor and control energy status, usage and system performance; prioritize and redistribute resources. This challenge includes building awareness and training, integrating power and energy management into operational planning and execution, and developing interfaces and media that enable energy to be transferred readily among systems for the mission and situation at hand. In summary, establish the ability to manage energy/water resources.

Second, significantly reduce requirements to transport fuel and water in an expeditionary environment. The need is clear, given our experiences in Iraq and Afghanistan. The approach will require a concerted effort involving a combination of efficiency improvements, alternative sources and other technologies. In summary, dramatically reduce energy/water demand.

Third, build resilience and flexibility into force capabilities to continue operating in the face of energy disruption. These disruptions can occur at the national, regional or local levels, and affect bases, platforms and soldiers. Army forces must still prevail, even in the face of disruptions due to enemy action, weather, shifting priorities or energy availability. In summary, build resilience and flexibility to maintain operational effectiveness under changing situations.

Enabling Energy Strategies

To tackle these three operational energy challenges, the Army identified enabling strategies. These include: identifying a single proponent to align concepts, requirements, capabilities, policies, research and acquisition for the energy and power to support Army operations; establishing a holistic model to manage power and energy; analyzing operational concepts to identify operationally relevant metrics for power and energy such as logistics burden (tooth to tail), usage rate, availability, weight and safety; integrating these measures into the concept of operations, design, training and operations; combining and integrating technologies in order to optimize system characteristics that support military requirements; leveraging characteristics of different technologies such as solar heating and thermal batteries; combining functions to reduce cost, weight and complexity; and improving and packaging capabilities to recycle and to utilize local resources. These

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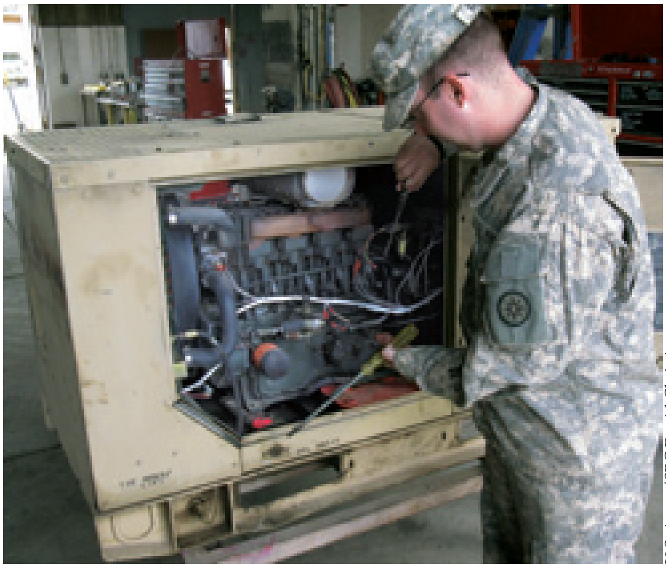
SPC Benjamin Knepp, 298th Support Maintenance Company, 13th Combat Support Sustainment Battalion, 3rd Sustainment Brigade, 103rd Sustainment Command (Expeditionary), checks the oil on a 10-kilowatt generator during a maintenance inspection at Joint Base Balad, Salahuddin Province, Iraq.



U.S. Army/SPC David Christian

measures enhance endurance, reduce the need for logistic fuel, provide resilience and may mitigate tactical signature.

The U.S. Army needs to find alternative energy sources, both for installation and operational energy. This is critically essential, not only to mitigate volatility in energy costs, but simply to promote resilience to disruption of our mission. It is important, however, to consider implementation factors such as cost, simplicity and compatibility within the operational context.

Looking at the big picture and from an operational standpoint, Army fuel usage is a small part of overall DoD usage. In the second quarter of 2010, it was only 12 percent of the DoD total, with the majority used by generators, tactical wheeled vehicles and Army aviation. A savings of 10 percent across the Army will improve DoD fuel requirements by slightly more than 1 percent. There is a more important way to look at the impact of Army fuel efficiencies and its impact on operational effectiveness, however. The idea is that we can transform energy savings into greater combat efficiency by conserving resources to purchase needed capabilities for our soldiers and enhancing force protection.

U.S. Army/SPC Roland Hale

PFC Bryant Shueler, an Army fueler serving in Iraq with the Enhanced Combat Aviation Brigade, 1st Infantry Division, pumps fuel into a Kiowa Warrior helicopter.

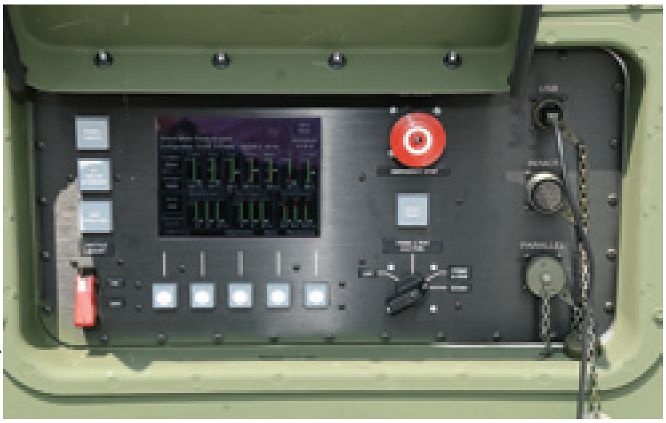
What the Army is Doing

The Army Capabilities Integration Center (ARCIC) initial capabilities document and cost-benefit analysis was a major step in delineating energy attributes and metrics that support the Army's operational capabilities. Taking these insights forward, we will be in a better position to align our material development, science and technology, training and other efforts to provide the greatest operational "bang for the buck." Since January 2009, Army acquisition programs have been required to consider the fully burdened cost of fuel in cost calculations. This ICD can help define additional important attributes such as interoperability and flexibility. We will use this capability-based approach to lay out an operational energy campaign plan that will integrate a number of distinct initiatives, prioritized to provide the greatest operational benefit.

We have formed a team to investigate base-camp requirements and completed the functional solutions analysis, which identifies gaps regarding energy management and efficiencies, capturing them in the Operational Energy ICD.

The Army Deputy Chief of Staff/G-4 sponsored development of a tactical fuel and energy implementation plan, which identifies specific improvement objectives such as awareness, measurement systems and demand reduction. An Army Science Board team is developing recommendations on strengthening the sustainability and resilience of the future force. The Natick Soldier Research Development and Engineering Center's Future Soldier Initiative is continuing with a series of small-unit operations tabletops to improve definition of soldier system design needs, and energy is being introduced into Army war games, such as the Unified Quest series. These are but a few examples from a growing list of Army initiatives directed toward improving operational energy capabilities and performance.

We see some great potential from our early cost-benefit analysis. Our technical community has identified "smart grid" technology as one of the most promising solutions we could deploy to improve operational performance while reducing energy consumption. Smart grid, or microgrid, is an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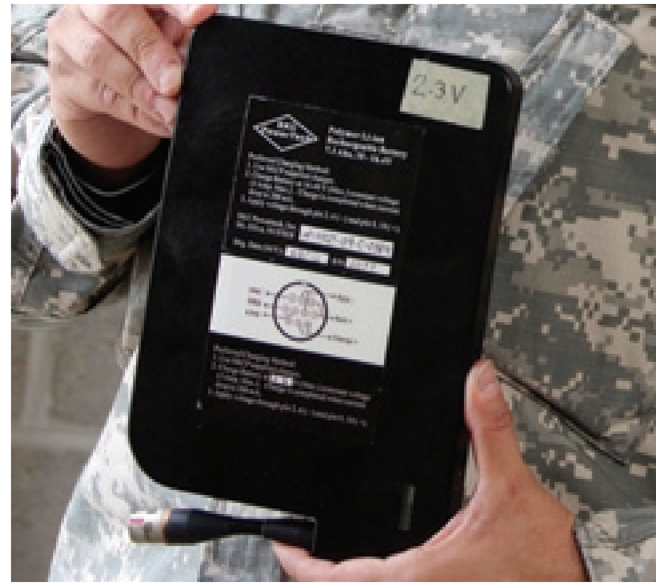


U.S. Army/Michael Allison

Right, the Soldier Conformal Rechargeable battery allows for easier execution of typical ground combat maneuvers. Below, the Advanced Medium Mobile Power Source family of tactical diesel generators uses significantly less fuel than comparable tactical quiet generators.

electric power distribution system incorporating integrated, multiple power sources and loads, efficiently managed by controls, that can interface with other relevant grids. It is also a utility independent, colocated, multisource, multiload system with power distribution and some level of control, which allows energy storage, grid, and microgrid connections, and the application of alternatives and renewables. If we start fielding those technologies now, predictions estimate that we could ultimately save as much as half of the fuel we currently use to produce electricity, or 15–20 percent of our total fuel use in theater—that would have amounted to a $540 million savings on our $2.7 billion fuel bill last year.

We should also look at the human costs and operational effects. Fuel savings of 165 million gallons could translate to 20 percent fewer fuel convoys. At 100,000 gallons/convoy, that would translate to 1,650 fewer convoys and, subsequently, fewer casualties and less exposure of our convoy personnel.

Our recently completed ICD not only lays out our requirements and metrics, but prioritizes and evaluates operational energy solutions. In addition to the traditional dollar-for-dollar approach, which predicted about a 15 percent overall savings from proposed solutions, we want to establish the "operational business case." Approaches predicted to provide the greatest operational payback are incorporating the ability to manage and network energy resources and simplifying the logistics—precisely the intent of smart grid technologies.

The Army has undertaken many materiel initiatives directly associated with the three grand challenges. To establish the ability to manage energy/water resources, the Army has developed the following programs.

- Fuel Manager Defense, an automated fuel accountability and tracking system that will be deployed at the retail level in the Southwest Asia theater during fiscal year (FY) 2011.
- Hi-Power project, a standardized smart grid capability for tactical command posts and similar multigenerator tactical applications. Testing and evaluation is occurring during FY 2010–11, and a procurement decision will be made in FY 2014.
- Rechargeable conformal batteries and soldier power networking devices, which were recently demonstrated during the Nett Soldier Warrior limited user test, can significantly simplify and lighten soldier loads. Twenty-one units will be deployed to Afghanistan in FY 2011 with the Nett Soldier Warrior ensemble.

The Army is reducing demand.

- The Army has deployed improved temporary structures that incorporate insulation to reduce heating, ventilation and air conditioning energy consumption. In advance of more versatile systems, the Army has already deployed an expedient commercial off-the-shelf (COTS) technology using polyurethane foam sprayed on erected tents, with payback periods in months.
- The Army Corps of Engineers is updating the Army Facilities Components System, which prescribes standard Army camp designs from tent-based (initial), temporary and semipermanent structures. Updated standards will address energy efficiency and facilitate the use of locally available materials and construction techniques.
- The Advanced Medium Mobile Power Source family of tactical diesel generators (5-, 10-, 15-, 30- and 60-kilowatt sets) will reduce fuel consumption by more than 20 percent over the comparable tactical quiet generators (TQGs) currently fielded. These sets are also lighter and have a wider operational envelope than the TQGs they will replace. Production is slated for FY 2011, with deployment beginning in FY 2012.
- Water-production capabilities significantly reduce logistics and associated energy demand, including COTS technologies such as the water-well drilling rig, capable of drilling to 2,000 feet; small-unit water purification systems, able to purify 1–2 kilogallons per day; and the expeditionary water packaging system, which can fill up to 700 1-liter plastic bottles of potable water per

hour. Three drill systems, eight purification systems and two packaging systems have been delivered into theater.

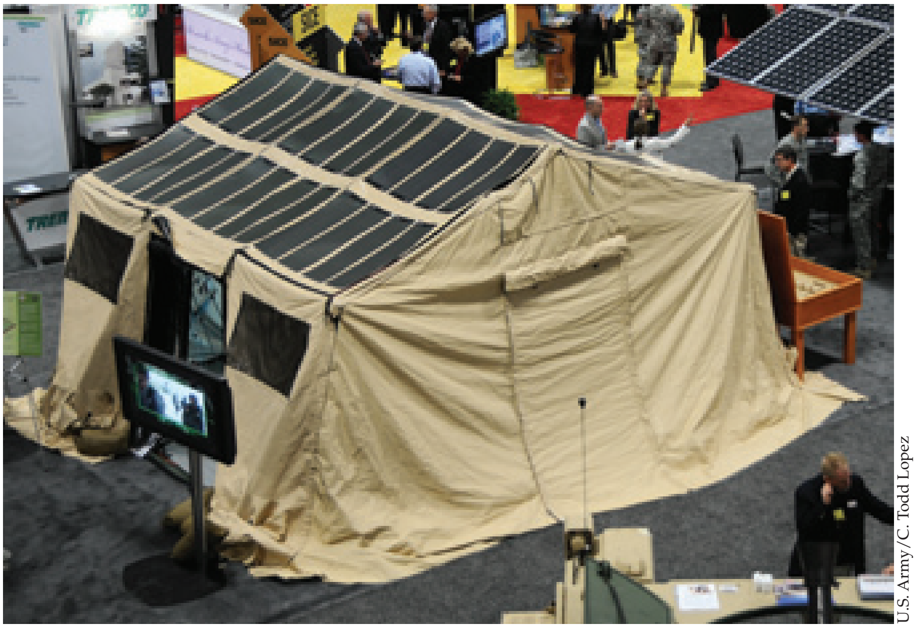
To build resilience and flexibility to maintain operational effectiveness under changing situations, the Army is pursuing the following alternative energy solutions.

- Rucksack Enhanced Portable Power System (REPPS)—a lightweight, portable power system capable of recharging batteries or acting as a continuous power source. Already deployed in small numbers, 10 REPPS systems will be deployed to Afghanistan during FY 2011 as part of the initial Nett Warrior Ensemble.
- Flexible Photovoltiacs in Shelter Integrated and Soldier Portable Applications—a suite of products that are integrated into solar shading material and traditional military shelter items and other foldable formats to power small soldier loads or recharge military batteries in the field via complementary high-efficiency battery chargers.
- Solar Hybrid—a system capable of providing up to 10 kilowatts of power continuously while reducing generator running time by 20 percent. As of February, the project was undergoing U.S. Army Test and Evaluation Command testing and was scheduled for deployment in March. In December 2010, this system deployed for operational assessment with a Skycam Power Upgrade—an extended solar-power solution to operate a wireless surveillance system for combat outpost force protection.
- Reusing Existing Natural Energy Wind and Solar—a combination solar/wind/energy storage system to provide high levels of power in the field for reducing fuel logistics and soldier load.
- Tank Automotive Research, Development and Engineering Center has an ongoing program to evaluate the operation of Army systems on alternative/synthetic hydrocarbon fuels.

What is the expected net result of these initiatives? Efficiencies in operational energy can lead to substantial increases in effectiveness for the warfighter. Energy savings translate not just to less fuel used, but to more boots on the ground available for other tasks, more resources available for the mission and more mobile, resilient forces. For example, in Afghanistan, where fuel is not readily available from the commercial market, some 60 to 70 tankers a day are used to power the mission in the region. Security for supply convoys in theater is estimated to require an average of one combat battalion on a continuing basis. Winter resupply in Afghanistan can take up to 45 days from the source to the end user, with fuel and water composing 70–80 percent of ground resupply volume.

Our energy consumption experience in Iraq is also compelling. The per-soldier demand there was about 16 gallons of fuel per day, and water demand was at least 3 gallons a day. About 50 percent of fuel used was for electricity in forward operating bases, which typically is less than 40 percent efficient, with the overall efficiency of base-camp power systems closer to 10 percent. Just a 10 percent reduction applied to non-brigade combat team soldiers involved in fuel transport and handling could result in as many as 1,500 or more soldiers available for other missions and 234 less vehicles per day, or 85,000 fewer road-miles per year.

The Army must "operationalize" energy. We need a fundamentally "lean" approach, which demands an understanding of operational requirements and systems and how energy supports them. As we organize and equip the force, we must build in energy awareness, control capability and alternative energy sources. This is essential, not only to reduce or mitigate volatility in energy costs, but simply to promote resilience to the disruption of our mission. The Army must establish capabilities and procedures to manage power and energy utilization as an integral aspect of its operations. Moreover, we need to identify those critical performance measures that correspond to operational challenges beyond the historical focus on cost and environmental impacts. Military requirements demand that we consider additional criteria such as power and energy densities, logistics, ease of integration into military applications, safety, security, reliability, availability, flexibility and adaptability. The Army will require multiple solutions integrated through a systems-engineering framework. A systematic approach will enable incremental improvements in power and energy density and efficiency. ★



U.S. Army/C. Todd Lopez

A tent with solar cells and a solar-powered water purifier was just one of tomorrow's energy-saving technologies on display at the 2010 AUSA Annual Meeting and Exposition in Washington, D.C.