ARMY TECHNOLOGY

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A publication of science and technology news from the U.S. Army Research, Development and Engineering Command

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POWER & ENERGY

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INTERVIEW WITH

THE HONORABLE KATHERINE HAMMACK

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ACRONYM GUIDE

RDECOM	Research, Development and Engineering Command
AMC	U.S. Army Materiel Command
AMRDEC	Aviation and Missile Research, Development and Engineering Center
APG	Aberdeen Proving Ground
ARDEC	U.S. Army Armament Research, Development and Engineering Center
ARL	Army Research Laboratory
ASA(ALT)	Assistant Secretary of the Army for Acquisition, Logistics and Technology
ASA(IEE)	Assistant Secretary of the Army for Installations, Energy and Environment
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CERDEC	Communications-Electronics Research, Development and Engineering Center
CP&I	CERDEC's Command, Power and Integration Directorate
ECBC	Edgewood Chemical Biological Center
EITF	Energy Initiative Task Force
EIO	Energy Informed Operations
GEMS	Gains in the Education of Mathematics and Science
MPDS	Mobile Power Distribution System
NSRDEC	Natick Soldier Research, Development and Engineering Center
PEO Soldier	Program Executive Office Soldier
PM MEP	Program Manager Mobile Electric Power
REPPS	Rucksack Enhanced Portable Power System
SWIPES	Soldier Wearable Integrated Power Equipment System
TARDEC	Tank Automotive Research, Development and Engineering Center
TGER	Tactical Garbage to Energy Refinery
TRADOC	Training and Doctrine Command
USCYBERCOM	U.S. Cyber Command
VTO	Department of Energy Vehicle Technologies Office

It was amazing to see how many of our industry partners are actively engaged in bringing products to market to meet Army needs for power and energy during the recent Association of the United States Army exhibition in Washington.

We are especially proud of our partnership with many of these companies, as well as in academia, to research, develop and engineer solutions in the field of power and energy.

Our Soldiers rely on power and energy for operating, vehicles, communicating, firing weapons, and more. It's almost inconceivable that America's Army would maintain its decisive edge without the power and energy required by today's technology. Looking to the future, it appears our reliance on power and energy will only grow.

Many innovative technologies are being proposed as potential solutions, but the real answer lies in enabling a mix of these technologies for an adaptable solution that will reduce the use of fuel on the battlefield. It's critical for our scientists and engineers to continue pushing toward more efficient and effective power and energy solutions.

The good news is—It is achievable. I'm proud of our accomplishments.

Thanks to CERDEC-led efforts in Energy Informed Operations, RDECOM is making power and energy technologies smarter on the battlefield to address the challenges of fuel consumption, waste, and resupply.

Our role is to inform the Army of what's possible in terms of tactical power solutions in terms of the limitations and the risk and reward tradeoff for each solution. In doing so, we define the space between the state of the art and the art of the possible. We enable a family of technologies with an adaptable infrastructure that intelligently generates, manages, and distributes power.

Our work in intelligent power management, energy harvesting, and hybrid and renewable power sources will ultimately reduce fuel usage, shrink the power grid footprint, and improve generator efficiency and reliability.

We hope to enable our forces to go longer and stronger, to be lighter and more agile, and to adapt as the mission changes. In short, they will be able to effectively execute the mission at every phase.

At TARDEC, we have teams working on new energy-efficient vehicle designs, powertrains, and fuel cells. Through these engineering initiatives we look to transition advanced technology to our current vehicle fleet and enhance the mobility and versatility of our future fleet.

The availability of energy is a major concern on today's battlefield. The Department of Defense is moving to reduce fuel consumption on the battlefield to reduce the cost of fuel resupply. These costs are realized financially as well as through the cost of Soldiers' lives.

AMRDEC is finding ways to employ lighter-weight armor systems in aircraft while maintaining or increasing the ability to withstand advanced ground fire. Advances in new composites allow us to integrate new lighter-weight ballistic protection systems.

At NSRDEC, we partner with PEO Soldier to develop solutions to benefit the individual. As we lighten the load, we are also looking at new solutions for powering our forward operating bases.

In addition, ARL and CERDEC are also collaborating with NSRDEC, MIT-Lincoln Laboratories, Maneuver Support Center of Excellence, and tactical electrical experts to develop new safety standards for future tactical microgrids. Soldier safety is paramount as we move forward to provide innovative solutions.

We are always searching for innovative power solutions to support our Soldiers, and we will continue to embrace out-of-the box thinkers who will ultimately usher in a new era of technology. Ultimately, the Army depends on us to work with our partners to develop power and energy technology breakthroughs. Our success will not only empower Soldiers, but we will transition these technologies to empower America and the world.

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Power & Energy Vision for the Future

INTERVIEW WITH THE HONORABLE KATHERINE HAMMACK, ASSISTANT SECRETARY OF THE ARMY FOR INSTALLATIONS, ENERGY AND ENVIRONMENT

Katherine Hammack, Assistant Secretary of the Army for Installations, Energy and Environment, was appointed by President Obama in June 2010. She serves as the primary advisor to the Secretary of the Army and Chief of Staff of the Army on all Army matters related to installation policy, oversight and coordination of energy security and management.

ARMY TECHNOLOGY: The Army has ambitious energy goals. Knowing what you know about energy research and development, how optimistic are you about meeting these goals?

Hammack: I'm optimistic for several reasons. The goals are ambitious, but I believe we will achieve our goals through continued research, development, new initiatives and partnerships.

To put it into perspective, the Services are committed to generating 1 gigawatt of renewable energy, on our installations, by 2025. The Army's share of this goal is equivalent to the electricity needed to power over 750,000 U.S. homes. The Army alone manages almost 1 billion square feet of building space. We have over 100,000 homes on our bases being utilized by 2.2 million Soldiers, Families and civilians. We drive thousands of government vehicles. Our installations and posts around the world are basically equivalent to 152 small cities.

With this amount of people and infrastructure, we have the distinction of being the largest facility energy consumer in the federal government, at a cost of $1.3 billion in FY12. We spent another $3.5 billion in FY12 on liquid fuel to support our overseas contingency operations.

On one front, the Army established Energy Initiatives Task Force to plan and execute large-scale renewable energy projects greater than 10 megawatts on Army installations. The EITF leverages private-sector financing and expertise to gain access to up-front capital investments in return for a long-term power purchase agreement.

To support the EITF, the U.S. Army Corps of Engineers initiated the first of its kind, Multiple Award Task Order Contract, or MATOC, to identify a pre-approved list of project developers in four technology areas: geothermal, solar, wind and biomass. The total contract ceiling across all four technologies is $7 billion, and allows for maximum flexibility for use by other military services and federal agencies. The MATOC is one of the contract vehicles and procurement options that will help the Army in its efforts to plan and execute a cost-effective portfolio of renewable energy projects.

We have moved forward on seven projects. These projects represent more than 175 megawatts of power, which is almost 20 percent of the Army's goal. We are planning groundbreaking and construction to start on many of these projects in 2014. We also have a pipeline of 4GW of potential projects that we are currently assessing or validating.

In addition to renewable energy, improving our energy security requires us to improve our energy efficiency. We are leveraging our limited budget dollars with private sector funding through energy savings performance contracts, utilities energy services contracts, and utilities privatization to obtain energy savings and efficiencies. Our energy saving performance contracting program enables private industry to implement energy savings technologies on Army bases—and we pay them back out of the energy savings—when those savings are realized.

The Army has the most robust energy savings performance contract program in the federal government.

On another front, we need to appropriately manage our resources and our consumption. This is a challenge that the Army has been addressing through technologies, policies and programs, such as the Net Zero Initiative, which has been the cornerstone of Army energy security and sustainability efforts since 2011.

Through the principles of integrated design, the Net Zero strategy strives to bring the overall consumption of energy, water and waste on our installations down to an effective rate of zero.

With the help of the U.S. Army Research, Development and Engineering Command, we are looking to reduce fuel consumption by 25 percent, water resupply needs by 75 percent and waste generation by 50 percent. Our Net Zero efforts focus on water and waste because it takes energy to pump, treat, distribute, collect and dispose of water resources, and it takes energy to transport and properly dispose of waste.

We'll leverage the lessons learned from our pilot Net Zero installations, because the Army is expanding the Net Zero challenge to all permanent installations and forward operating bases. In the coming years, our collective challenge will be to adopt and embed these types of best practices into all that the Army does.

Katherine Hammack (far right), assistant secretary of the Army for Installations, Energy and Environment, talks with Robert Berlin, a TARDEC mechanical engineer, Nov. 14, 2013, at the Pentagon Courtyard.

ARMY TECHNOLOGY: How will operational energy technology solutions protect our Soldiers?

Hammack: One of the best ways we can help protect our Soldiers is to ensure they have the power and energy they need to complete their operational missions. Without power and energy they stand still, unable to move their vehicles and they are silent, unable to use their radios to communicate.

On the battlefield, the Army is partnering with the other Services to ease the aggregate burden of powering the tactical edge, while still providing the amount of power and resources required by Soldiers. Fuel and water comprise 70 to 80 percent of ground resupply convoys by weight and represent significant risks to our mission and our Soldiers.

As we reduce energy consumption, we reduce the supply lines, convoys and the number of Solders being diverted from their primary missions to maintain generators, load and deliver fuel.

ARMY TECHNOLOGY: How critical are RDECOM researchers and scientists to meeting Army energy goals?

Hammack: Research and development is essential not only to meeting Army energy goals, but for keeping us Army Strong at home and while deployed. Energy is a foundational enabler for all military capabilities. Sufficient and efficient use of energy provides America's Soldiers with the ability to be flexible, mobile and enduring.

I've had the opportunity to see first-hand three RDECOM organizations: the Tank Automotive Research, Development and Engineering Center; Communications-Electronics Research, Development and Engineering Center; and Natick Soldier Research, Development and Engineering Center. They are making tremendous progress in base camp logistics and sustainability at Fort Devens, Mass. The Fuel Efficient Ground Vehicle Demonstrators are helping us advance ground-vehicle fuel efficiencies. The Natick center is developing power sources for Soldiers that are lighter, smaller and cost-effective.

RDECOM's efforts are important because flexibility and agility is essential. We have to be ready for any environment, anywhere in the world, austere conditions without wall-sockets or filling stations. New technologies are being tested at home and in combat theaters will increase mission agility through better power management and more flexible power sourcing.

We have been able to establish tactical micro grids, new and more efficient generators, and on-site renewable power at our combat outposts and FOBs. These achievements are largely due to the type of testing and evaluation that takes place at the Base Camp Integration Lab in Fort Devens.

We have lightened the dismounted Soldier's energy load by giving Soldiers the capability to manage energy status, resources and performance. We have significantly reduced our energy footprint and provided flexibility and resiliency by developing alternative and adaptable capabilities. We have reduced the weight of the batteries a Soldier has to carry into the field. Not long ago, a Soldier would have to carry 14 pounds of batteries for a 72- hour load. Today, aided by alternative and adaptable capabilities, they need only 9.7 pounds of batteries.

We are moving in the right direction.

ARMY TECHNOLOGY: Do you have any additional words of encouragement for our Army scientists and researchers?

Hammack: As we continue to partner with research and development, industry, academia, government and our communities, we will find the means and technology to overcome our challenges, be they financial, technical or social.

Let there be no doubt, Army researchers and scientists have already had a significant impact on our reducing our energy footprint.

Together, we will continue to work hard to build financial and technical partnerships with third-parties and defense communities. We will find solutions we can apply to the battlefield as well as across our installation enterprise. Together we will remain "Army Strong" despite the challenges facing us. ■

Read biography: http://www.asaie.army.mil/Public/IE/bios/

Bob Wood, an electrical engineer with the U.S. Army Research Laboratory, recently received configurable test equipment that can handle multiple energy loads and sources. The set up is the first step toward testing novel ways to streamline energy management in Army operations. (U.S. Army photo by Doug LaFon)

The Future of Army Power and Energy

Innovations in operational energy deliver future capabilities

BY JOYCE BRAYBOY, ARL PUBLIC AFFAIRS

Army scientists continue to explore far-reaching technology solutions that provide efficient and effective operational energy. ARL researchers forecast energy solutions into the future with a portfolio of basic and applied science.

The laboratory focuses on technology research that will enable lightweight compact power sources and high-power density components designed to significantly reduce the Army's logistics burden. The goal is to enhance future capabilities such as survivability and lethality.

ARMY SCIENTISTS SCOUT ENERGY SOLUTIONS FOR THE BATTLEFIELD

The Army science and technology community is pursuing novel technology aspects of the Army's Operational Energy Strategy. What if scientists and engineers could scavenge energy for warfighters, like bottom feeders scavenge in the ocean?

Energy Scavenging is just one way ARL experts are getting more from existing resources, said Dr. Edward Shaffer, who is the Energy and Power Division chief at the lab. Energy harvesting is critical to realize "net zero" energy use, a key element of the Army's Operational Energy Strategy.

There are a number of technology areas enabling operational energy, such as energy storage, alternative energy sources, high-density power converters and micro grids that the lab is pursuing.

Department of Defense operational energy is an emerging area being shaped. It is what is required to train, move, and sustain forces, weapons, and equipment for military operations. It accounted for 75 percent of all energy used by DoD in 2009, according to the DoD energy website.

"We want to develop technologies to enable future energy networks for the warfighter," Shaffer said. "The challenge is to develop something that could be valuable to Soldiers 15 to 20 years from now—based on what we know today."

A past history of success in areas like electrochemistry is "informing the way forward for other technologies," he said.

"In the recent past, ARL electrochemists discovered a way to increase the duration of high-energy batteries with an electrolyte additive. Now, other teams are thinking about high-efficiency, miniature power supplies that could give small, unmanned systems bursts of power "on-demand," Shaffer said. "Technology is ever changing."

Basic research will help the Army to be better in the next conflict, said John Carroll, RDECOM action officer for the Power and Energy Technology Focus Team. "The fuel challenge won't go away. We have to fix it."

Shaffer originated the concept of Smart Battlefield Energy on-Demand, or SmartBED.

"SmartBED is one way we think Soldiers would be able to link up to the power they need. It will ultimately bring complex pieces together—generator, solar systems and energy storage—in a flexible, resilient way into an energy network," said Carroll, who retired from the Navy as a nuclear propulsion engineer before coming to ARL.

"The essence of SmartBED is being able to get energy seamlessly when and where it is needed, but yet not wasting it," Shaffer said. "Currently, we waste energy and it limits availability because often a single power source is tied directly to a single load.

"We want Soldiers to plug into the energy they need to keep their sources, batteries and devices topped off, yet drawing energy only as needed," Shaffer said. "SmartBED is designed to improve energy capacity for Soldiers while they are at base camp or otherwise on the move."

Shaffer has a wide view of the energy needs across Army, DoD and interagency efforts through his participation in forums that explore complimentary ways of addressing energy and power technology gaps. Shaffer has led the DoD Energy and Power Community of Interest and been a part of the Interagency Advanced Power Group that includes agencies like the Department of Energy and NASA.

These communities of scientists, engineers, subject matter experts, technologists and program managers have a common interest in promoting innovative energy and power solutions for the nation.

"One of the good things is to be able to see the flow of technology and communicate at each level," Carroll said. "We come together as a science and technology community and see what investments are necessary to better get Program Executive Offices and Program Managers the operational energy tools they need when they need it."

The Army acknowledges energy and power challenges to its operational energy concept and strategy, beyond technological improvement—there are cultural, policy and procedural concerns that leaders are addressing.

There are ongoing research initiatives within the Army to explore alternatives and technology improvements in order to offset long-standing issues, like delivering large amounts of JP8 to the front lines, Carroll said.

The good news is that within and beyond the Army there are partners that are finding solutions and pushing technologies ahead together more smartly, he said.

At ARL, the future is a seamless energy architecture that begins with concepts like SmartBED, Long-lived Power and Fuel-Reforming for better energy convergence.

ARMY LAB ENGINEERS WANT 'SMART ENERGY' FOR WARFIGHTERS

Troops in a tactical environment have unique challenges with efficient energy use that are uncommon to the rest of the fighting forces.

A Soldier standing guard at an outpost, or forward operating base, should not have to think about energy—a distraction from the strategy and Soldier protection.

In an April 10, 2013, panel discussion in Washington, Katherine Hammack, the Army's assistant secretary for Installations, Energy and Environment, said that "energy is mission critical. It is vulnerability. It is a risk."

The effective use of energy increases mission capabilities, she said.

This challenge of efficient operational energy in remote, combat areas in part belongs to scientists and engineers at ARL, who are a part of the team that manages SmartBED.

"The real goal is more efficient use of energy at small operating posts," said Bruce Geil, power conditioning branch chief who oversees the SmartBED project. "We want to streamline the way we go about managing the energy, which is all over the map right now."

Geil's team started with the question of, "How do we give a plug-and-play simplicity to that Soldier who's tasked to put the microgrid together in the heat of battle?"

That single question birthed the SmartBED program, which along with other programs is giving engineers an idea of how the energy is used, and how it can be distributed simply and efficiently.

Part of the SmartBED effort is a highly configurable test bed that can handle multiple loads and sources; emulating battlefield conditions. The technology should get researchers as close as they can get to a real-world scenario while staying in a laboratory, said Bob Wood, an electrical engineer on the project.

"Theater is not the place to test microgrid equipment," said Wood, who has deployed to Afghanistan and Iraq. "The last thing you want is for a Soldier on the front lines to have an experimental piece of hardware that may or may not work."

The test bed allows you to prove whether equipment is ready for field testing. What is unique about SmartBED is the ability to configure it in ways to fit Soldiers' needs at outposts.

One goal of this research is to take steps toward developing a power distribution system that could make automated decisions about when to shut off less critical loads to keep as much of the critical capability as possible, Geil said. A further goal of the program is to provide the Army chain of command critical information such as "how long will the generator function before maintenance problems occur."

Dr. Sarah S. Bedair, an ARL electronics engineer, adjusts the settings on ink-jet printer used to deposit nanomaterials onto the surfaces of micro-devices. These devices would be used in high-power-density power supplies. The lab is pursuing energy solutions in areas like energy storage, alternative energy sources, high-density power converters and micro grids. (U.S. Army photo by Doug LaFon)

John Russo, who uses 3D printing to fabricate the Long-Lived Power battery casings, works with Dr. Marc Litz, both of the Power and Energy Division at ARL, to measure output voltage on space-grade photovoltaic cells before bonding tritium capsule to a photovoltaic wafer. (U.S. Army photo by Doug LaFon)

"It gives the commander the capability to plan ahead," he said. "We have intelligent systems out there now, but the challenge is that those systems rely heavily on human decision-making. If things change, and a person is not there to program the energy grid, there will be problems."

ARL researches cognitive networks and the use of this technology in power conversion and distribution for the future is one of many places that "smart systems" have value for the Army, he said.

This technology would be a key part of a power "router" that directs power from multiple sources to critical and non-critical loads. The system will prioritize power loads based on what is plugged in. At the lab, "our job is to push beyond the current capability and step up that ability by looking at controls and cognitive applications," Geil said.

Geil envisions a system with cognitive algorithms to make decisions with minimal human guidance. Systems that can maintain operations of the most critical requirements such as critical communications and medical operations in the absence of guidance—but that can be easily overridden by system operators—people.

Engineers like Wood recognize it's one thing to make something work in the sterile lab environment, but "it's a much different environment in places like Afghanistan."

Organizations like CERDEC, take fundamental concepts closer to transition and have near-term programs such as the hybrid intelligent power (HI Power) program that increases efficiency by sharing loads on generators, he said.

"We develop and refine a concept, and then ARL works with other RDECOM centers to refine and materialize intelligent energy solutions," Wood said. "There are many trials before technology like this gets to the Soldier. SmartBED is designed to one day speed that process along."

'LONG-LIVED POWER' COULD EXTEND LIFE FOR BATTLEFIELD SENSORS

"Long-Lived Power" sounds like it could be an energy revolution, a revolutionary of sorts within the family of far-reaching energy solutions for the battlefield—because it uses radioisotopes.

It is a power source that supports low power for years—100 microwatts of average power—according to its developers.

ARL scientists are testing tritium, a radioisotope that is produced in nuclear reactors, to power sensors. This alternative energy source could give sensors—the eyes and ears of warfighters—a battlefield energy source capable of lasting a 13-year half-life. Half-life is the measure of time it takes for the material to fall to half of its value.

"Other available isotopes last 100 years," said Dr. Marc Litz, of the Power and Energy Division, who conceptualized the idea.

The laboratory is addressing the Army's issue of weight and duration of usefulness among the limitations of chemical batteries.

"Chemical batteries are vastly available, but the small capacity means leaving a trail of batteries on the battlefield. In contrast, isotope batteries are a 'deep well,' but the 'pipe' is kept small—or in other words, the batteries give off a trickle charge but for many years," Litz said.

"A trickle charge is useful when an Army squad needs awareness of activities happening in an isolated area," Litz continued. "One way to keep them from the potential danger is sensing the acoustic and electromagnetic vibrations using a monitor that communicates the data back to a safer location. The isotope power source allows the sensors to operate with a power switch from kilometers away for extended periods of time. Isotopes store more energy in this way, or greater energy density, than chemical materials."

"The team of researchers have designed and fabricated power source prototypes that house the tritium and other ingredients to charge the multi-functioning sensors in a battery format that Soldiers are comfortable using in the field," Litz said. "One of the challenges of the research is to make sensors work at a low enough power level to make long-lived power a safe, practical and easy to handle resource."

"Decaying isotopes are a concern," said Dimos Katsis, who designs the energy-harvesting circuits with Athena Energy as part of Litz's team. "The isotopes emit radiation in an amount comparable to that in local medical X-rays

"Radioactive elements like kryptonite, a fictional material that appeared to weaken the 'Man of Steel,' have given isotopes a bad name," Katsis said. "But the trace levels of tritium that you would find in a theater exit sign or glow stick are just enough to power Army sensors that can detect acoustics and electromagnetic signals for more than 10 years."

In order to use small amounts of tritium, which would be safe for any Soldier, reduced power output is necessary.

"It puts bounds on how much power we are willing to get out of the device," Katsis explained. "This power source would never be used for something like a high-powered laser system."

Another challenge the team has faced was housing the tritium in material that makes it safe and easily transportable.

"People are surprised to find the materials in the power source are less toxic than something like ibuprofen," Katsis said.

"The team has been working on sensors for about three years, and it is still likely years before long-lived power is useful to industry," Litz stated. "We want to make the long-lived power devices smaller and even more efficient. Solutions like long-lived power are examples of 'high-risk, high-reward' basic science that is one of the laboratory focus areas."

CONCLUSION

Army scientists and engineers are expanding their search for operational energy solutions for the battlefield. Smart Battlefield Energy on-Demand and Long-Lived Power have the potential to change how Soldiers approach power and energy in the future. ■

Energy Informed Operations

The U.S. Army is staying in command of demand

BY MARNIE DE JONG, CERDEC COMMAND, POWER AND INTEGRATION

Increased capabilities for the Soldier have caused energy demands on the battlefield to increase. Fuel and battery use at forward operating bases, specifically patrol bases and combat outposts at the "tip of the spear," has been problematic. The power and energy community has been working to keep up with that demand, creating smaller, lighter, energy-dense power sources that are more efficient and will allow Soldiers to go longer between resupply. However, the increase in demand has been far outpacing supply. There is more that needs to be considered in order to achieve a solution; instead of focusing efforts into producing better power supplies, a serious examination need to be done on how best to manage and reduce demand.

Engineers at CERDEC's Command, Power and Integration Directorate are attacking the problem on all fronts, but we believe that the key is through better power management. That's why we're working to enable an energy-informed environment at the tactical edge where systems interoperate intelligently.

All the parts of the power system play an important role, but historically not much attention has been paid to power management for the battlefield. CP&I's new Energy Informed Operations program enables two key management components which aid in a more effective use of available power: the ability to closely match energy supply with energy demands and the ability to prioritize loads. The first point allows power systems to operate more efficiently thereby reducing the amount of fuel needed while the second makes the best use of the available energy in order to assure the mission can be completed before running out of power.

Generator systems typically run inefficiently because trained personnel are limited. These inefficiencies lead to a significant amount of wasted fuel and a higher incidence of generator failures. Generator "right-sizing" and the use of microgrid type distribution systems can help alleviate some of the fuel use problems. These solutions have seen little use due to difficulties of implementing them into forward operations.

CP&I is developing applications and algorithms that will make power generation and management systems intelligent—capable of monitoring and communicating power data and developing creative ways to deal with unintelligent loads. This is the key to implementing intelligent tactical microgrids. CP&I is demonstrating this capability for tactical operations by leveraging work previously accomplished under its Hybrid Intelligent Power program with the addition of this advanced communications and controls piece to support contingency base power.

However, this power management concept can be applied across the tactical battle space. The idea is for power systems to automatically interoperate and share usage data, moving seamlessly from the tactical operations center to the vehicle and ultimately to those worn by the Soldier.

Let's take batteries for example. They are used to power almost every piece of equipment a Soldier carries. While batteries have made incremental improvements over the years, they still suffer from short runtimes and must be swapped out frequently. Take the current rifleman radio: the desire is to allow the Soldier 72 hours of dismounted operation without resupply; however at the current power consumption rates, currently fielded batteries would last less than 10 hours. Current CP&I battery development is looking to extend that window of use to 24 hours with the far term goal of reaching 60 hours by the year 2020. But even with those advances, it's not enough to keep up with the demand.

One answer to this complex issue, we believe, is SIMPLE: as in the Soldier Interface to Manage Power of Local Equipment. This EIO effort places a hub on the Soldier which is used to manage the power of the Soldier equipment as well as collect data on the power systems and develop an interface to display that data on the end user device. As this effort progresses, the individual Soldier data will be rolled-up to and available at the squad and platoon levels and will be used to determine how to more effectively utilize power across the formation.

The CP&I team is working to achieve power-aware development, where power consumption is taken into consideration early in the development cycle and alternative low-power methods to achieve the same goal are considered. Power consumption information plays a critical role in accomplishing an energy-informed architecture. Knowing the power draw of a load allows units to more closely matching power generation to usage, which leads to efficiency. It can also assist in predicting the power needed for a mission or time between resupply.

Obtaining applicable information on the demand side of the power equation, however, is problematic since the power draw of equipment is rarely, if ever, constant due to daily and seasonal fluctuations. Furthermore, the conditions and the duty cycles seen in the field are not necessarily analogous to the ones developed by stateside experimentation. Ideally, all the loads will also be intelligent, capable of sensing, storing and communicating their peak and average power draw. This is a substantially larger challenge due to the

Architecture for the Soldier Interface to Manage Power of Local Equipment. In this configuration, a mobile application provides critical, mission-relevant energy information to the Soldier via the EUD.

vast amounts of equipment used by the Army fielded through various offices and will take some time.

In the near term, some of the larger power consumers on the battlefield like Environmental Control Units are being considered. CP&I is not only working on managing their use, but additionally CP&I's work on the ICE, or Innovative Cooling Equipment, Program sponsored by the Operational Energy Capability Improvement Fund out of the Operational Energy Plans and Programs office is looking to improve the efficiency of ECUs so that they need less power to operate. Implementation of these improved cooling systems will lead to significant fuel reductions on the battlefield. The EIO program is working to incorporate a common standard communications interface to the ECU's which would allow them to operate in intelligent tactical microgrids.

These efforts work in concert to significantly reduce energy use in the battlefield. This reduces costs to the Army, reduces the amount of fuel conveys on the roads, and allows the Soldier to spend more time focused on his mission rather than worrying if he will run out of power.

CP&I is strategically postured to add value in the power management space for the Army as its core competencies of power, mission command and integration provide the personnel and skill sets needed to attack problems where those capabilities merge.

Additionally we seek to partner with others in the Department of Defense to help us complete our goals. Through the OECIF sponsored efforts for the Tactical Microgrids Consortium and Energy Efficient Outpost Modeling Consortium, CP&I is partnered with CERL and Office of Naval Research respectively as well as with numerous other DoD and Department of Energy organizations through those efforts, including the PM customer base.

To succeed in achieving the seamless intelligent operations the EIO program is looking for, there will need to be consensus among government organizations on how these systems are supposed to operate and interface. Interoperability of systems is a critical component of the Energy Informed Operations which makes these strategic partnerships essential to a successful program.

At the end of the day, it will be everyone working together, whether it's intelligent power systems with information sharing, or coordination of efforts in government agencies, that will really make an impact on solving the power problem on the battlefield. ■

About the author: Marnie de Jong is the REDUCE Research Project Manager for CERDEC's Command, Power and Integration Directorate. She holds a bachelor's degree in Electrical Engineering from the University of Delaware, a Master's degree in Electrical Engineering from the Pennsylvania State University and an MBA from University of Maryland. She is Level 3 certified in SPRDE career field.

Fuel Reformation

Army fuel reformation looks to increase efficiency, save lives

BY ALLISON BARROW, CERDEC PUBLIC AFFAIRS, WITH ADDITIONAL REPORTING BY JOYCE BRAYBOY, ARL PUBLIC AFFAIRS

Fuel is the second largest transported item in the field next to water. As a result, fuel truck convoys that deliver fuel are vulnerable to enemy attacks, which have resulted in loss of money, time and lives.

To combat this problem, RDECOM scientists and engineers are working to lessen the reliance on fuel truck convoys by reducing the amount of military fuel, called Jet Propellant 8, or JP-8, the Army needs in theater and improving the efficiency of its use.

One way they are doing this is through reforming JP-8 so that it can be used in efficient portable energy systems, like fuel cells and other novel power sources, which primarily operate on hydrogen or other cleaner fuels.

"The goal is to take the logistic fuel that's already all over the battlefield, that's there and available to the Soldiers, and convert it to something that can be used in smaller and renewable systems," said Steve Slane, RDECOM's communications-electronics center, or CERDEC, Command, Power and Integration Directorate, Power Generation and Alternative Energy Branch chief.

Engineers and scientists from CERDEC, along with ARL and TARDEC are working to reform JP-8 and integrate it into systems so it can be converted seamlessly and locally.

"Fuel reforming is one of those leap-ahead technologies that could allow JP-8 to be transformed into valuable fuels that can be used and generated on the battlefield forward. So instead of shipping propane and methanol and kerosene and gasoline, why not reform JP-8 locally to power those systems?" said Slane.

The process of reforming fuel entails high-temperature catalytic reactions that covert a liquid fuel, in this case JP-8, into a lighter, gaseous fuel.

This comes with two main challenges due to the sulfur contained within JP-8 and its complex composition, said Dr. Terry DuBois, subject matter expert in fuel reforming and combustion in CERDEC CP&I's Power Division.

First, sulfur can deactivate catalysts, which means it can limit the life or poison catalysts during the reforming process and make it inoperable. Second, sulfur can accelerate carbon formation, where solid carbon particles form in the reactor, clog the flow of the reactor or deactivate catalysts and cause it to fail, said DuBois.

"Those are two big challenges for us in reforming; how do we transform JP-8 to a hydrogen rich stream and deal with the two mechanisms for killing the reactor?" said DuBois.

This fuel transformation effort is a main focus for CERDEC, TARDEC and ARL.

The challenge is developing a practical fuel reformation process for better energy conversion that would have to be portable, quick and easy to use, said Dr. Zachary Dunbar, an ARL fuel cell team member.

Dr. Dat Tran, ARL fuel cell team lead, has tested at least 300 different combinations of materials during the last four years while he has been investigating fuel reforming with the team, he said.

"JP-8 is a complicated and dirty fuel. The sulfur is a huge problem because it can hurt the fuel cells," Tran said. "Sulfur has many different compounds that behave differently. The compounds in sulfur make it hard to find an agreeable material."

While ARL conducts the basic research of fuel reforming, CERDEC integrates the basic research into a system and evaluates it, while also performing further research and development of fuel reforming materials.

"Both of the efforts that we have ongoing are focused on addressing desulfurization of JP-8, and ARL is pursuing complimentary R&D on unique materials for sulfur absorption. In addition, ARL is looking at membranes that can selectively separate hydrogen from the gaseous reformed fuel stream so that you have a pure hydrogen stream," said DuBois.

"CERDEC's in-house program is looking at catalytic materials. So we have ongoing research work evaluating different catalytic materials and how well they stand up to chemical compounds found in JP-8. We are also evaluating sulfur absorbent materials and processes on a long-term basis," said DuBois.

TARDEC also works in fuel reforming by integrating it into fuel cell power systems.

"The main applications are combat and tactical vehicle auxiliary power units, silent propulsion for unmanned ground systems and extending the silent range of electric vehicles for scout or reconnaissance missions," said Kevin Centeck, TARDEC Non-primary Power Systems team lead.

"TARDEC is also investigating the requirements for a fuel reformation system to be integrated with a commercial automotive fuel cell stack, which could help reduce cost and increase reliability of fuel cell power systems," said Centeck.

CERDEC, ARL and TARDEC collaborate on their fuel reforming efforts for the Army through Fuel Cell Test and Integration Working Groups with other Defense Department partners through quarterly program and design reviews.

CERDEC is taking fuel reforming one step further by working to integrate its efforts into its Energy Informed Operations, or EIO, initiative, which aims to make power systems "smart" by enabling "smarter" monitoring on the systems as well as integrating them into a smart tactical micro grid.

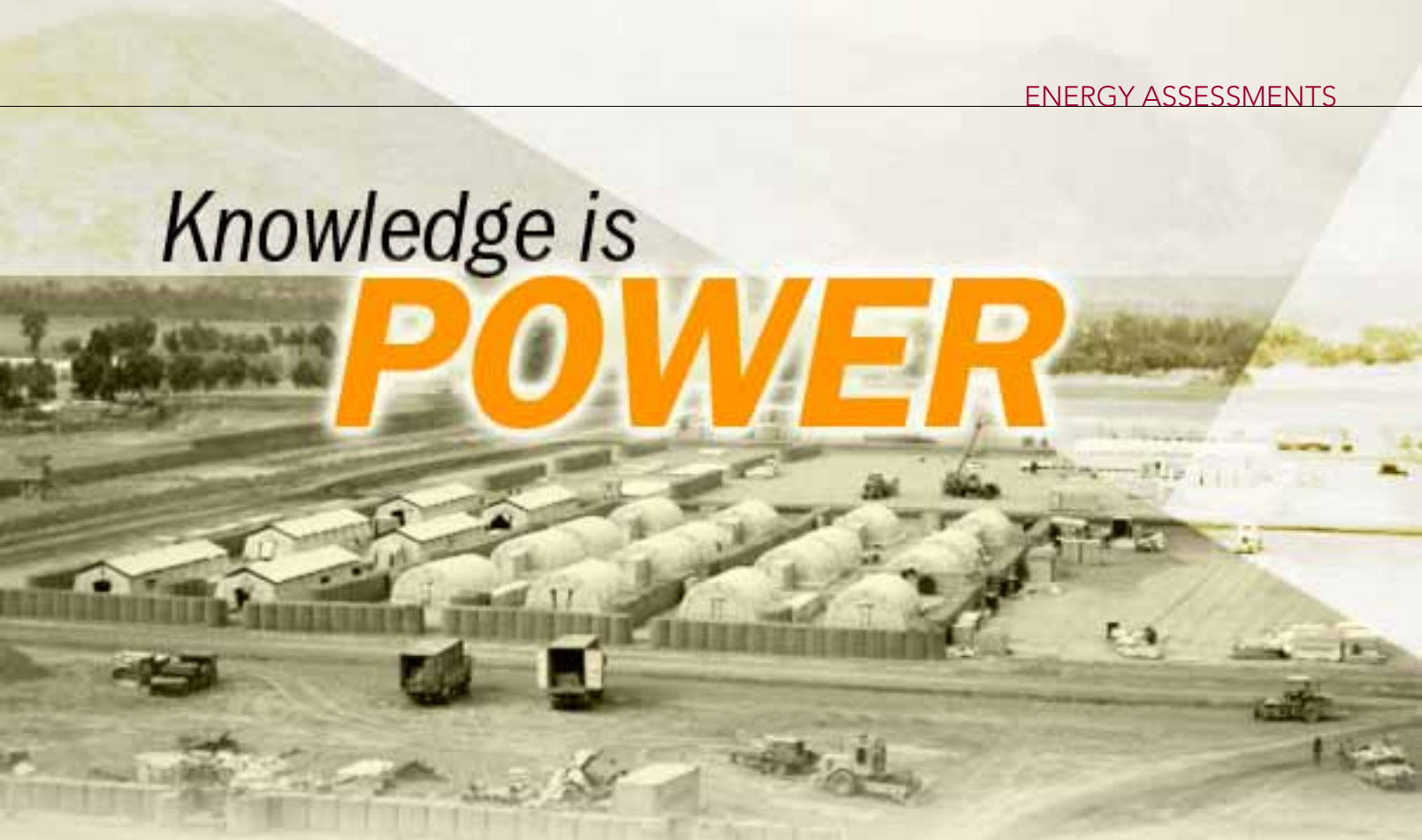
This smart technology will enable and inform Soldiers with data such as, "How much fuel do I have left? When are the fuel trucks coming next? What's my energy status?" said Slane.

"The efficiencies gained by using grid data to control power and inform operations will increase availability and reliability of power while reducing the burden of fuel logistics, storage and cost," said Slane. "CERDEC CP&I is uniquely qualified to cover all this because we have our mechanical engineers who are working fuel reformation and combustion but we also have engineers within the mission command community here working on intelligent micro-grids through EIO."

RDECOM will continue to work to address the challenges with fuel reforming and integrating it into a full power system that can then be transitioned to the field.

"Reducing the amount of fuel is really a goal of what this organization is about," said Slane. "Fuel reforming is one of the key technology areas that will enable us to reduce fuel on the battlefield, reduce the amount of truck convoys, the amount of storage needed and the cost of operating in austere environments." ■

Knowledge is POWER



Since 2012, CERDEC CP&I has supported PM MEP forward power assessment teams in rebuilding 31 command outposts and 35 village stability platforms in theater. As a result of CERDEC team efforts with PM Mobile Electric Power, COPs and VSPs are using more energy efficient generator sets, which has resulted in a 21 percent lower fuel consumption across the fleet. Units are able to log energy/fuel consumption, track maintenance frequency, and note trends.

Assessments enable commanders to optimize energy, operational effectiveness

BY EDRIC THOMPSON, CERDEC PUBLIC AFFAIRS AND TARA A. CLEMENTS, U.S. ARMY ACQUISITION SUPPORT CENTER PUBLIC AFFAIRS

When it comes to power and energy, the Army research and development community continually seeks to develop solutions to increase performance, reduce consumption, increase efficiency and ensure power availability. However, the benefits of innovation cannot be leveraged to its fullest potential if the power grid is not set up properly, which may lead to redundancies, waste, and safety issues. Unfortunately, in theater, this is the case more often than not.

In August 2012, CERDEC electrical engineers Noel Pleta and Jennifer Whitmore deployed to Afghanistan in support of Project Manager Mobile Electric Power where they served as power assessment engineers on a team responsible for assessing and improving the energy stability of forward-deployed units throughout Afghanistan. What they found were conditions so poor that they had to overhaul several combat outposts and village stability platforms just to lay a sound power and energy foundation before implementing the new operational energy plans.

"Many of the COPs were on their last leg of generator power causing them to shut down their sustainment of life support systems and focus on the tactical support systems. We found that backup power for tactical operation centers wasn't consistent. If the TOC goes down, the mission is compromised as well as the Soldiers' safety, and that's priority. That's why it's so important to do it right the first time," said Pleta.

The assessments—which included a detailed layout of the area, the state of current power sources and power consumption rates—allowed them to tailor optimized power grid plans, design new distribution systems, replace legacy systems with more efficient equipment, fix electrical issues that posed safety concerns and implement energy improvement plans that supported quality of life measures such as dining facilities and latrines.

Over the past 13 years, the CERDEC Command, Power & Integration Directorate has used its, in-house government expertise in support of Project Manager Mobile Electric Power to perform approximately 100 power assessments, CONUS and OCONUS, for the Army, Navy and Marines. This work has supported tactical operation centers, combat outposts, village stability platforms, combat support hospitals, C4ISR platforms/technologies and other entities of the military that require power.

During this time, CERDEC CP&I has developed a unique set of assessment capabilities and methodologies that not only inform commanders, but help them to design, build and implement optimized tactical power grids.

"Successful missions require us to consider energy from planning through execution. Power assessments enable commanders to improve operational effectiveness by understanding how to optimize power requirements," said Edward Plichta, Power Division chief for CERDEC CP&I.

"Knowing how much energy Soldiers need is important, but we also need to know where the redundancies and unnecessary drains exist. We need to view energy requirements as a commodity and focus more on decreasing demand in addition to the efforts to increase supply," Plichta said.

Power assessments begin with a detailed data collection process that includes a site survey of all the equipment. CERDEC CP&I works closely with PMs and units to gather requirements—such as power distribution systems, layouts, wiring diagrams and existing and projected equipment/assets—and combines these with manufacturer data to help determine their power profile. This aids in producing solutions with right-sized generator sets and

optimized environmental controls, which are particularly important as environmental control units consume 60 to 70 percent of all energy used at a COP or FOB. The analysis is used to generate a database that can be referenced and adjusted going forward.

AutoDise, a planning tool jointly developed by CERDEC CP&I and PM MEP, enables commanders to plan more efficient grids by allowing them to generate virtual before-and-after layouts of COPs, VSPs and FOBs. The user enters relevant data—such as the number of tents, servers, and anything that uses power—and the software projects the overall power/fuel consumption per hour.

"It can also determine power distribution configurations, the cables that would be required for wiring and whether units are utilizing the existing generator set properly," Pleta said. "We're training instructors at Fort Lee so they can teach soldiers/generator mechanics on how to use this unique capability in theater. Meanwhile, we're beta testing Version 7.0 now and hope to release the upgrades next year."

CERDEC CP&I engineers then generate and implement an optimized solution set that includes the AutoDise layouts, equipment lists and fielding plans—all of which can be adjusted as needed. Everything from before/after configurations to the types of equipment on site is documented and rolled up into a report that is given to the unit, providing the commander a full record of system layouts should he choose to the duplicate system.

But a power assessment is more than just a method to estimate the power consumption of tactical operations centers, platforms and systems; it's a capability that uniquely positions the R&D community to help the Soldier, Pleta said.

"Power assessments allow engineers first-hand experience to see how equipment is used in the field versus how folks in the lab think it is going to be used. They also provide a more accurate load profile that helps in projecting fuel savings and other theoretical calculations. We feed this documentation back into the R&D process so we can chronicle efficiencies, gauge fuel savings and determine the size or type of grid needed," Pleta said.

Since 2012, CERDEC CP&I has supported PM MEP forward power assessment teams in rebuilding 31 command outposts and 35 village stability platforms in theater. As a result of CERDEC team efforts with PM Mobile Electric Power, COPs and VSPs are using more energy efficient generator sets, which has resulted in a 21 percent lower fuel consumption across the fleet. Units are able to log energy/fuel consumption, track maintenance frequency, and note trends.

"The smaller bases in theater sometimes have poorly managed power sources and improper or unsafe electrical distribution. The equipment modifications resulting from CERDEC-supported assessments have led to significant savings in acquisition and operational savings during this period. In one example, a COP that was totally dependent on aerial resupply saved 93 gallons of fuel per day; this is equivalent to 42 airdrops of 800 gallons each. CERDEC personnel were critical to the successful completion of this PM MEP effort," said Christopher Bolton, chief for PM MEP's Technical Management Division.

CERDEC CP&I plans to continue this critical support and provide immediate in-theater solutions as well as continued PM support in this area.

CP&I engineers have also extended power assessments to the Soldier in order to collect information regarding the actual individual and squad requirements during a mission. Utilizing these data points as a performance baseline, CP&I engineers will look to identify redundancies and areas where consumption can be reduced.

"We're uniquely qualified to examine the suite of C4ISR devices that the Soldier requires, and we see a gap where we can provide value added by conducting power assessment to validate those requirements," said Jonathan Novoa, power management thrust lead for the CERDEC CP&I Power Sources branch.

As with the small base power grids, the Soldier power assessments will be used to develop novel solutions to lessen the overall Soldiers burden.

"We're looking for ways to manage and decrease the power draw of that equipment through intelligent load management and enhanced situational awareness. We want to enable our Soldiers to make energy informed decisions on the battlefield so they can manage the availability and consumption of energy on their person just like they currently do with food and ammunition," Novoa said.

Power assessments generate vital information that will enable continuous improvement.

"You just don't get the same experience behind a desk. With each deployment, we increase knowledge regarding the latest challenges facing FOBs, TOCs, COPs and VSPs," Pleta said. "It provides new perspective on the systems' lifecycle, how the Soldiers use the equipment and the frequency or infrequency with which they perform maintenance. It allows us to accurately 'size' the power generation equipment and design more efficient power distribution systems, which result in lower costs and reduced fuel resupply. But most important, it allows us to customize user-friendly solutions that will improve safety, reliability and quality of life for the Soldier." ■

INTEGRATED POWER SOURCE

Next-gen, multifunctional Soldier power sources fueled by changing how the Soldier uses and views power assets

BY AMANDA ROMINIECKI, CERDEC PUBLIC AFFAIRS

CERDEC engineers are addressing the Army's small unit power demands by providing the dismounted Soldier with lightweight, integrated solutions that will increase his power, extend his mission time and enable him to harvest and manage power.

When U.S. Soldiers first arrived in Afghanistan over a decade ago, they were carrying 3-pound, brick-shaped batteries originally designed for battery boxes and non-portable devices. Multiply that 3-pound battery by the number of devices they had, plus a couple spares for each, and a Soldier was typically carrying upwards of 20 pounds in batteries alone.

Engineers at CERDEC's Command, Power and Integration directorate recognized that problem and began work to lighten the Soldier's load through more efficient power sources. Fewer batteries meant a Soldier could carry something more crucial to survival like additional food, water or ammunition. Fewer batteries also meant shedding pounds from the already over-loaded weight Soldiers carried on a mission.

"The battery, at that point, had not been designed or optimized for wearable applications. As we adapted more toward wearable electronics, we had to come up with a design [for a battery] that allowed us to support what the Soldier was wearing," explained Chris Hurley, an electronics engineer who leads CERDEC's battery development team.

CERDEC CP&I engineers, who have developed Soldier power solutions for the Army for more than three decades, met the small unit's demand for an integrated power source through the Soldier Wearable Integrated Power Equipment System, known as SWIPES, and the conformal battery.

SWIPES, recognized as one of the Army's Greatest Inventions of 2010, integrated the charging of electronics carried by the Soldier into the tactical vest; each device has a specific pocket with an associated power cord, connecting it to one central power source, simplifying the process of powering electronics and drastically reducing the number of batteries a Soldier had to carry.

"SWIPES allowed a Soldier to focus on the mission, rather than how often he needed to swap batteries and remembering which battery went with which device. It lightened both the physical and mental load on the Soldier," said Mike Brundage, CERDEC CP&I Power Sources branch chief. "And logistically, to the Army as a whole, it meant less money spent on disposable batteries, less waste, and fewer convoys bringing in supplies—which were often targets for attack."

The current conformal battery, at just over 2 pounds and lasting up to 24 hours, serves as the main power source for PEO Soldier's Nett Warrior, a handheld situational awareness system. Initially developed by CERDEC in 2008, the conformal battery provides a flatter, flexible alternative to the traditional brick-shaped battery by conforming to the Soldier's body and top charging any Soldier-wearable electronics.

CERDEC engineers are continuously working to extend the life of the conformal battery in order to last the duration of a small unit's typical 72-hour mission. Since 2008, there have been four updates to the battery, each improving on its size, weight and power capacity.

The success of both SWIPES and the conformal battery changed how a dismounted Soldier and the small unit carried power during a mission and has fueled subsequent Soldier power development efforts within the Army.

"We have the conformal battery now, and moving forward, as always, we try to take the power sources that we have and make them smaller, lighter, more energy-dense and more powerful," Hurley said.

For the next generation conformal battery, Hurley and other engineers at CERDEC are also looking to integrate ballistic protection for the Soldier into the battery. Currently, the battery is designed to be worn in front of the Soldier's ballistic plate and must be disposed of if it is punctured.

"It would provide ballistic protection to a certain level and also function as the Soldier's main power source," Hurley said. "The goal is to have the battery function at 80 or 90 percent if punctured—you don't want the battery to be struck and you lose your entire power source—while still adhering to Soldier protective requirements."

Providing ballistic protection through the conformal battery makes the device multifunctional, reducing the need for two separate pieces of equipment and thus the overall weight and number of devices a Soldier must carry.

"As SWIPES tied all the Soldier-borne equipment to one power source, we're looking to do something similar where instead of cables and wires, we'd do it wirelessly, eliminating the bulk of power cables and further reducing the load on the Soldier," Hurley said.

Current wireless power charging and transfer technologies are not nearly efficient enough for Soldier use, but with research and development in this area, there is evidence that significant improvements are possible. In lab tests, researchers find only 40-70 percent efficiency of wireless power transfer, Hurley said.

"If we can develop our power sources to have greater energy, it might help compensate with the inefficiencies of wireless power transfer, but until we see wireless power efficiency up near 80-90 percent, we won't see it in a Soldier configuration."

Hurley noted the most near-term application of wireless power, in the form of vehicle to Soldier power. As a Soldier sits in a vehicle, wireless charging components integrated into a seat would top-charge the conformal battery or other central power source in the Soldier's vest. Other wireless charging possibilities include a table or closet that would charge the tactical vest while not in use.

Even with these applications, however, CERDEC engineers note limitations like the physical alignment of the battery and charging device, which plays a significant role in energy transfer. Any misalignment can result in energy loss and inefficient charging, Hurley said.

E-textile technology is another viable power transfer option, reducing the Soldier's load and the complexity of Soldier systems, but without the power loss tied to wireless charging. E-textiles are fabrics with electronic components seamlessly embedded within the textile.

"If we don't ever get to a wireless construct for Soldier power, we could make the vest itself out of e-textiles. The wires are basically the size of the thread you're weaving the vest out of," Brundage said. "At the end of the day, it makes it a lighter weight piece of equipment just by the fact that you don't have the additional weight of power cables. You can just substitute thread in the vest for an e-textile."

The limiting factor for any potential Soldier power source is often the ability to provide enough power for a small unit's typical three or four day mission without the need for resupply. Novel power technologies, including energy harvesting and Soldier-borne solar power are currently being researched in order to meet that mission requirement.

Soldiers spend a lot of time and energy walking, and through energy harvesting that energy could be converted into real, usable power to fuel electronics.

Energy harvesting technologies use small kinetic devices that oscillate back and forth when a Soldier moves to produce small amounts of energy that can trickle-charge the Soldier's main power source and extend the life of electronic devices during a mission, Hurley said.

"One device we're looking at is a backpack. If you incorporate the energy harvesting technology into the rucksack design, you don't increase the weight you're carrying and you've created a multi-functional device. Its carrying your load and generating energy for you," Brundage said.

Research is also looking at ways to incorporate wearable solar panels into the Soldier uniform, whether it is on top of the Soldier's helmet, on the rucksack or in another location. The solar panels would also trickle charge the Soldier's main power source.

Adding energy harvesting devices or solar panels to the Soldier system conceivably means adding more power cords for the Soldier to wear or carry. E-textiles, used in conjunction with these technologies, can eliminate the need for additional power cords. If the uniform itself can act as the energy transfer mechanism between the harvesting devices and the conformal battery, it would provide the Soldier with a greater power supply without increasing the load they carry, Brundage said.

While increasing a Soldier's power supply has always been a focus for Army researchers at CERDEC, there has been a shift toward providing Soldiers with the means to effectively manage their power supply. Engineers believe integrating power management capabilities into future power sources, including the conformal battery, will help small units operate more efficiently, Hurley said.

Currently, Soldiers use a separate device called the Soldier Power Manager, developed in partnership with another RDECOM lab, NSRDEC, which serves as a hub for powering devices and informing Soldiers of remaining battery life and the state of charge.

"Power management plays a huge role in the Soldier being able to efficiently use the power sources that are available to him," said Hurley. Integrating power management into the conformal battery would not only diminish wasted energy, but also reduce the equipment the Soldier carries, he said.

"The user can prioritize how he uses his energy. He's got so many different devices that are drawing different levels of power and depending on what his mission is, he may or may not need all those devices to run in full power mode," said Brundage.

A Soldier will be able to display important energy information on his tactical smartphone through a special app, toggle on and off which devices are the most power-hungry and which are critical to the current mission, and send power usage data to the squad leader. Both the individual Soldier and the squad leader can better manage power usage on the battlefield through this manner.

Platoon leaders can use power management data to improve situational awareness on the battlefield. By tracking how much power each squadron has and determining whether certain tasks need to be diverted to a squadron with more power supply they can improve mission effectiveness and ensure Soldiers can complete missions safely.

The smartphone power app, using the Soldier Power Manager device, has been demonstrated most recently as part of the Army's Mission Command TECD program. Integrating the Soldier Power Manager device into the conformal battery as a single, multi-functional piece of equipment is the next step in the natural progression of power management, Hurley said.

The shift of focus from solely providing the Soldier with a greater power supply to both providing more efficient power and allowing the Soldier to strategically manage the power supply has changed the course of power development at CERDEC. Improvements to both sides are critical to meet Soldier power and energy demands.

As the Army transitions to a faster, more mobile fighting force, the number of wearable devices including smartphones, GPS devices, radios and other electronics carried by the Soldier continues to grow—and so does the Soldier's demand for tactical power technologies.

"We can provide the Soldier with all the power in the world, but if he doesn't have the tools to manage it effectively, power will be wasted," Hurley said. "Our focus at CERDEC CP&I has always been to lighten the Soldier's load, reduce the complexity of what he's carrying and give him the ability to accomplish the mission in all scenarios—but now, more than ever, that includes being able to manage the power supply we give them and that will be critical as we move into the future." ■

Bringing Solutions Together

A power and energy interview with John S. Willison

John S. Willison is director for CERDEC's Command, Power and Integration Directorate, where he is responsible for planning and executing the Army's science and technology investments in Mission Command, Power Generation and Quick Reaction and Prototyping technology. Willison was appointed to the Senior Executive Service in August 2011.

ARMY TECHNOLOGY: Tell us about your organization, the Command Power and Integration Directorate.

Willison: Our organization is part of RDECOM's Communications-Electronics Research, Development, and Engineering Center. Our mission is to research, develop and provide engineering support in the areas of Mission Command, Position/Navigation/Timing, Power and C4ISR platform integration.

What is unique about CP&I is the diverse set of core competencies inherent to one organization. I believe this strategically positions us to work across domains on integrating projects to leverage our unique disciplines.

Power and energy is a great example of this. On its own, our power and energy efforts transition state-of-the-art technologies to our PEO partners and work novel leap-ahead capabilities. But when power and energy efforts are coupled with our mission command, prototyping and integration efforts, CP&I is able to work towards complete, integrated products that provide additional capabilities to the Army. Our mission across these areas is to improve current capabilities while helping to shape the future.

ARMY TECHNOLOGY: You talk about the idea of Mission Command and Power and Energy coming together—why is that important?

Willison: The base of science and technology expertise is in a number of diverse core competencies. We could easily work those areas separately and make advancements individually, which we do to an extent. However, to realize the true potential of the impact this organization can make, we have shifted much of our emphasis to working on problems and solutions which pull from multiple core competencies.

The goal is to offer big ideas and solutions to big problems, and we are uniquely postured to do so. One of those areas is Energy Informed Operations. It involves developing advanced solutions which will allow commanders to have situational awareness expanded by insight into available power resources and status and to enable commanders to make even more informed decisions. To do this, we have teamed our Power engineers with our Mission Command engineers and pulsed from their expertise in smart grids, soldier power management, artificial intelligence, and mission command application development. While our expertise is in different core competencies; our value to the Army is in working at the intersection of those competencies.

ARMY TECHNOLOGY: What are the Priority S&T investments CP&I is currently making in the Power and Energy area?

Willison: Historically, our S&T investments in Power have been almost completely focused on 'power supply': that is advancing generator technology, batteries, fuel cells, renewables, etc. in order to increase the supply of available power to our Soldiers.

Over the years, we have developed impressive technical advancements that have had a positive operational impact and received wide acclaim, like the conformal battery. The challenge is that even with those advances, power demand continues to significantly outpace supply. So we are shifting a significant portion of our S&T investment to addressing the demand side—areas like power management, smart grids, energy efficient electronics design, etc., in order to ensure the power supply is used effectively.

ARMY TECHNOLOGY: What power and energy test and development can you support in your facilities at APG?

Willison: Our Power facility at APG is approximately 100,000 square feet, about two-thirds of which is state-of the-art labs and test chambers. We have a dry room and labs for pursuing advanced battery chemistries, a fuel reformation lab, a high bay chamber for prototyping

and testing renewable energy capabilities, a battery test facility, and environmental test chambers, to name a few.

We have some of the best Power labs in the Army and DoD. We employ a unique mix of Army personnel—including chemical, mechanical, electrical, materials science, computer scientists and engineers—allowing for component research and development as well as system engineering to be performed in a collaborative and productive environment.

We really have a significant Army core competency in the area of Power and Energy with extensive in-house expertise and technical knowledge across broad power disciplines and unique in-house facilities capable of performing component to system level engineering design, development, and prototyping from batteries to generators. We like to say we can work Watts to Kilo-Watts.

Part of our role within the Power and Energy S&T community is to be a smart, honest broker who completely understands the Army's unique requirements for technology.

ARMY TECHNOLOGY: What do you foresee as the most difficult hurdle for the Army (in terms of P&E) going forward?

Willison: Power and Energy is an enabler for all the operational capabilities required by our Soldiers. The commercial marketplace is driving much of the advancements made in power supply technology. That said, the Army must maintain some investment in power supply technology to address unique requirements such as mobility, extreme operational temperatures and conditions, etc.

The significant challenge is in managing and meeting demand. At some point, the entire C4ISR Army community needs to recognize and collectively address the very real limitations of power and energy technology and start to consider power as a key performance parameter on other technical development programs. Otherwise, demand for power will continue to grow and outpace capabilities. Power is like network bandwidth in that way. No matter how much is available, we will find ways to consume it in support of maintaining an operational advantage.

ARMY TECHNOLOGY: What do you see as future Army 2020 P&E Capabilities?

Willison: Technically, the Army will continue to leverage commercial advancements in power. Operationally, the goal is to have a more agile, adaptable, and secure Army. This holds for power as well. We continue to emphasize advancements that will increase agility and adaptability—such as energy harvesting, wireless power transfer, and intelligent power systems.

We are researching and developing technologies that will enable the Soldier to efficiently transmit/transfer power from source to load without using electrical contacts or wires. While there is significant technical work to be done in this high risk/high payoff area, wireless transmission of power and data is a future Army 2020 capability that will enable better situational awareness, while dramatically lightening the Soldier load by reducing, and potentially eliminating, power cables and spare batteries.

Energy harvesting technologies provide interoperable power solutions that maximize mission effectiveness and reduce the physical burden on the Soldier. By exploiting the energy a Soldier creates while moving across the battlefield, energy harvesting can allow mission length to be flexible and independent of the amount of power storage that is available; energy harvesting enables power at any location with minimized resupply and on-the-move battery charging.

We are also developing intelligent power management systems that would prioritize and utilize power resources according to mission needs; this, in turn, would provide commanders, providing them with the information and flexibility to complete the mission in a resource-constrained environment. Basically, we want to maximize available mobile power while effectively and intelligently managing the use of that power.

ARMY TECHNOLOGY: What capabilities does your Energy Informed Operations project provide?

Willison: The Energy Informed Operations Project or EIO is CP&I's main project to develop an intelligent power management system. The primary product is a set of open power and data standards that will enable the development of power management systems for Soldiers, dismounted and mounted, and command posts. As we pursue those standards, we are prototyping soldier power manager components, smart grids, and mission command applications that will demonstrate the value of EIO.

ARMY TECHNOLOGY: Where do you get your Power and Energy requirements?

Willison: We work closely with various TRADOC Centers in order to address identified operational gaps while helping to shape the requirements for future capabilities. We also work closely with PEOs and PMs to help prioritize our efforts and to ensure that there is a transition for those products being developed in support of advancing current capabilities.

Our primary customers are Project Manager Mobile Electric Power, and Project Manager Soldier Warrior. We focus our current more mature technology development on collaborative efforts with our PM customers while working leap ahead concepts that are in line with TRADOC future capabilities and the long-term Operational Energy strategy.

ARMY TECHNOLOGY: Can you talk about some of your recent Power and Energy transitions/fielding success stories?

Willison: Many of our current efforts have the potential to be real 'game changers', such as the development of an advanced conformal battery primary power source, a soldier power manager capable of pulling power from multiple sources while collecting actionable-data on power demand, and a towable renewable power trailer capable of extending the available power supply at remote outposts.

In 2011, our Soldier Wearable Integrated Power Equipment System—SWIPES—which integrates a set of capabilities for the dismounted solider—was selected as an 'Army's Top 10 Greatest Invention.' We have also fielded hundreds of flexible, manpackable solar panels that have been used in Theater. The Rucksack Enhanced Portable Power System, or REPPS, is a rucksack kit which utilizes a foldable, solar panel and connectors to convert energy from the sun into power for recharging batteries or to directly power radios, laptops, surveillance cameras and reconnaissance devices. The REPPS was also recognized as a recipient of the 'Army's Top 10 Greatest Invention.' We never lose sight that our primary mission is to improve the capability of our Soldiers.

Deployable TGER

The Army converts garbage into energy and reduces carbon footprint

BY ECBC COMMUNICATIONS

When Typhoon Haiyan devastated the Philippines a few weeks ago, it left an unrecognizable landscape filled with debris in its wake. The death toll from the strongest typhoon on record has now risen above 5,000, Philippine officials announced last week. Those that remain are now trying to survive in a country with insurmountable waste and disconnected from power sources. A new power and energy technology developed by ECBC could potentially find use in humanitarian efforts, providing relief aid to those in need.

The Tactical Garbage to Energy Refinery, known as TGER, is a deployable bio refinery prototype system tactically designed to convert field waste into immediate usable energy. The prototype was originally developed for military applications at forward operating bases and has undergone two intensive rounds of 90-day testing under austere conditions at Camp Victory in Baghdad in 2008 and the Edgewood Area of the Aberdeen Proving Ground, Md. in 2012. The system can support a 550-person unit that averages about 2,500 pounds of waste per day, converting roughly 80 percent of that waste into synthetic gas that produces energy at a rate of 500 BTUs (British Thermal Unit) per cubic foot gas. The synthetic gas allows the generators to run on roughly 75 percent power, which reduces the amount of diesel fuel from five gallons per hour down to one. Additionally, TGER reduces the volume of waste in a 30 to one ratio, turning 30 cubic yards of trash into one cubic yard of environmentally friendly, benign ash.

"TGER is an energy machine that happens to get rid of waste," said Dr. James Valdes, a senior technologist for biotechnology at ECBC. "It is not a trash disposal that happens to make a little energy. There's a big distinction and it depends on your mission."

For disaster relief efforts, the TGER prototype could be scaled up to accommodate large waste, low-energy kinds of situations where there is a concentration of people needing to get rid of garbage, generate power for lights and keep food refrigerated. Countries in the Pacific are challenged by long stretches of space between various distances, making the logistics difficult for supply chains. The TGER technology could be used to promote energy independence in times of need.

TGER has two generations of prototypes and is currently seeking funding for a TGER 3.0 model that would be automated for a turnkey operation. Right now, there is a touch screen control panel that tells operators that status of various components the gasifier subsystem, including temperature, oxygen content, fermentation, diesel use, and energy production. It currently requires one engineering technician and one operator to run the machine, but according to Valdes, the hope is to manufacture a product that can be fired up and continuously fed.

"The major lesson we learned from the field trials in the TGER 2.0 prototype, was that the steam reforming gasifier was so efficient in converting waste into synthetic gas that voids began to form in the space," said Valdes. "As waste is being turned into gas, the volume of it gets smaller and smaller, creating voids that reduce heat transfer and energy efficiency. To fix that, a TGER 3.0 prototype would include a variable auger that moves through the tube as waste is being reduced in size, eliminating voids from forming."

With a zero carbon footprint, the improved TGER 2.0 prototype reduces the volume of waste in a 30 to one ratio. According to ECBC scientist James Valdes, 30 cubic yards of trash could be reduced to one cubic yard of ash. (U.S. Army photo)

The TGER technology is revolutionizing the way the Army innovates solutions for power and energy. Another invention is the Mobile Power Distribution System (MPDS), a transportable power distribution technology used for various types of work that require electrical power for use in a field or outdoor space, such as construction or environmental remediation sites. Jeff Gonce, field maintenance branch chief for ECBC's Chemical Biological Application and Business Reduction Business Unit, developed the technology and received a U.S. patent for the technology April 23, 2013.

The MPDS is a rapidly deployable system that uses commercial off-the-shelf electrical supplies configured to support complex site set-up and mobilizations by providing power distribution to multiple items. Gonce developed the system after recognizing the need to have a transportable power solution that could be deployed to multiple sites and reduce the amount of time it took to generate power to all necessary pieces of equipment at a given project site. The MPDS can operate in remote locations using two generators to power the system. In the event of a power failure, the technology is capable of automatically switching to the backup generator in less than one minute. Once primary power is restored, the MPDS switches back to its original input source.

Before the MPDS, the method for distributing power at project sites was cumbersome, involving the construction of temporary structures using hard wires, panel boxes, circuit breakers and disconnects to adapt private power sources to equipment. Upon project completion, the system would be disassembled, rendering many components unusable. The MPDS enables recycling of equipment, saving on cost and resources. The technology is currently available in two configurations: trailer-mounted and skid-mounted. Now, customers can operate on clean, reliable energy without the complexity of a traditional site set-up.

SHELTER TESTS

NSRDEC deploys energy-efficient tents for testing

BY ALEXANDRA FORAN, NSRDEC PUBLIC AFFAIRS

Wherever Soldiers go, shelters must go, too. These shelter systems not only protect and provide comfort; they also must be as energy efficient as possible.

Every time a base camp needs fuel delivered, that camp and its warfighters are exposed to vulnerabilities.

That's why a group of shelters were sent to the Southwest Asia Area of Responsibility to be tested by both the Army and Air Force recently as part of the "Advanced, Energy-Efficient Shelter Systems for Contingency Basing and Other Applications" program.

"It's not until you actually put it in an operational environment where you can really have a good assessment of what will work and what won't work for the Army," said Amy Klopotoski, NSRDEC contingency basing science and technology lead.

Most of the shelters being tested are 20 feet wide by 32 feet long, and are equipped with various energy-saving technologies that must adapt to the environments warfighters face: median temperatures ranging from minus 25 to 120 degrees Fahrenheit in all sorts of weather.

Tent fabrics have to be durable, mildew resistant, flame resistant, and capable of blackout, which is why "you have multiple layers with multiple different functions in these textiles," Klopotoski said.

Advanced materials such as additional reflective layers, "basically aluminized film," were added onto pre-existing shelter fabrics. Low-emissivity coatings are another product being tested, specifically for durability. This coating will also reflect the sun's energy away from the shelter, she said.

Engineers outfitted all the tents with advanced thermal insulation, also developed by NSRDEC, which they designed to reduce the power required to heat and cool the shelters without increasing weight and bulk.

Every tent also had integrated solar shades that reduce solar load and the build-up of heat within the tents, without increasing the shelter's footprint.

"The NSRDEC provided many technologies utilized in the tests," Klopotoski said. "The reduction in energy demand will be achieved through a combination of technologies."

The joint Army and Air Force team hopes to reduce that demand by at least 50 percent through the use of solar shades, photovoltaics, advanced materials and coatings.

Besides energy reduction, there will also be less weight and extra equipment warfighters would need to support sustainable living.

"Currently, we field each 640-foot-square shelter with one five-ton (portable environmental control unit), where with these shelters, we have two 640-foot-square shelters being cooled with one five-ton ECU," Klopotoski said.

This reduction eliminates 2,200 pounds and 4,160-square-feet of equipment, as well as reducing up to 40 kilowatts of energy consumption on a 150-man camp.

One shelter is even outfitted with photovoltaic modules, balance of systems electronics to make the power generated usable, and battery backup for storage and future use that was developed through NSRDEC projects.

"The photovoltaics generate power for lights and subsidiary equipment, which reduces the need for diesel-fueled generators," Klopotoski said.

Reducing the need for diesel fuel cuts down on energy consumption, cost and the need for refueling, which will mean fewer Soldiers transporting fuel on the roads.

Previous similar tests could only be run if NSRDEC personnel physically came to the site every 30 days to download data; now that data can be accessed remotely in real time.

"The data collection equipment measures the temperatures at all of the different layers of the shelters, including outside of the solar shade, in-between the solar shade and tent, the tent surface, and internal temperatures, as well as airflow inside the tent," Klopotoski said. "We are also measuring the fuel being consumed and the power usage of all of the equipment."

This intensive testing will be completed in November. Following this testing will be tests at a cold-weather location to collect the same type of data in a minus 25 degree Fahrenheit environment.

The results of this data will assist both the Army and Air Force as they seek to provide warfighters with the best technological advances possible. ■

A group of shelters were sent to the Southwest Asia Area of Responsibility to be tested by both the Army and Air Force recently as part of the "Advanced, Energy-Efficient Shelter Systems for Contingency Basing and Other Applications" program. Tents were outfitted with advanced materials and other technology. (U.S. Army photo)

Science for the ENVIRONMEN

Army looks at energy reduction measures at Base Camp Integration Lab

BY NSRDEC PUBLIC AFFAIRS

Reducing energy consumption at Army base camps of the future is the goal of many Army research teams.

NSRDEC scientists and researchers are working to measure electricity and water usage and find ways to make Army base camps of the future more energy efficient.

At a data collection event at the Base Camp Integration Lab, known as BCIL, at Fort Devens, Mass., NSRDEC engineers are partnering with Soldiers and civilians at Product Manager Force Sustainment Systems.

The teams measured the amount of electricity and water used in an expeditionary base camp, such as those being used in Afghanistan today. The BCIL is composed of two instrumented 150-man base camps set up side-by-side. One camp establishes the base line data with standard issue equipment, while the other camp utilizes the latest innovations in energy-saving developments such as solar shades and water reclamation systems.

The purpose of the event was to "collect data from the system to lead the authentication process," which supports future modeling and simulation, said Dr. David Darkow, NSRDEC researcher. He added it was critical not to have a negative "impact on Soldier readiness or quality of life" in the effort to become more environmentally friendly and reduce the logistics burden at Army base camps.

The 542nd Quartermaster Company (Force Provider), which occupied the BCIL for their annual training, supported the data collection. The unit is the Army's only force provider company, which is responsible for the types of systems found in expeditionary base camps.

Engineers from other RDECOM centers also participated in the data collection. CERDEC supported many of the power and energy innovations and TARDEC focused on water reclamation technology.

Also on site were engineers from the U.S. Army Construction Engineering Research Laboratory; and the Maneuver Support Center of Excellence at Fort Leonard Wood, Mo.

"The event was designed to use available technology to make the data collection predominantly automatic with technical and environmental data coming from instrumented systems," said Bill Harris, the Experimentation, Demonstration, and Validation Team Field Lead for the Sustainability and Logistics-Basing Technology-enabled Capability Demonstration team. "It enabled better input for the modeling and simulation programs that will ultimately be used to forecast demands for power, water and fuel as well as predict waste generated."

The team hopes to reduce the need for fuel resupply by 25 percent, the need for water resupply by 75 percent and decrease waste by 50 percent while maintaining quality of life. The focus of the effort is on the smaller bases, from 50-person patrol bases to 1,000-person small forward operating bases.

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1. *A close-up of an electricity monitoring device used for data collection at the Base Camp Integration Lab.*
2. *The complex data collection and storage station in a shelter at the Base Camp Integration Lab.*
3. *Soldiers from the 542nd Quartermaster Company (Force Provider) install a solar shade on a shelter at the Base Camp Integration Lab during the data collection event.*

All of these efforts will reduce the logistics burden, make the camps more environmentally friendly and save Soldiers' lives by taking more supply vehicles off the road and reducing the need for ground logistical convoys.

The Power of Sharing

Transferring power from vehicles to a mobile grid allows bases to store all the electricity they need, and even sell the reserves to regulate costs

BY JERRY ALIOTTA, TARDEC PUBLIC AFFAIRS

The DoD is testing the capability of electric cars, when not being driven, as a power source for electricity to civilian homes and military installations. The aim is to regulate the vehicles' power usage carefully and return unused power in the vehicles to the public grid. For the Pentagon, that means revenue, earned from the plug-in electric vehicle's stored energy. For the nation, it means a more stabilized power grid and less dependence on petroleum.

Jointly funded, the DoD Vehicle-to-Grid project, known as V2G, is a collaboration between: TARDEC; Office of the Assistant Secretary of the Air Force for Installation, Environment and Logistics; and the Air Force Research Laboratory. TARDEC is the technical lead for this program, SAF/IE is the executive lead, and AFRL is the acquisition lead. Separately funded initiatives through the OSD and the Naval Facilities Engineering Command provide additional critical support to DoD's overall efforts in the area of V2G and battery development.

As the technical lead, TARDEC is responsible for preparing the statement of work and PEV specifications, vehicle charging stations, review infrastructure design, evaluation of PEVs, testing and data analysis.

"This effort includes development and training on the algorithm for the vehicle controller to perform cyber secure vehicle-to-grid services such as power management, peak power shaving and frequency regulations," stated TARDEC's PEV Lead Engineer Shukri Kazbour. To get the initiative in gear at Los Angeles Air Force Base, the Air Force is replacing 43 gas- and diesel-powered vehicles with electric versions and building charging stations that allow the electric vehicles to send energy back to the grid. Vehicles and charging stations have already begun testing and delivery, while the remainder will be ordered and put in place over the next several months. Once the project is fully functional, TARDEC will gather data and gauge the program's effectiveness.

By January 2015, this project aims to lease, modify and install approximately 100-150 non-tactical plug-in electric vehicles including facilities' infrastructure at up to five additional DoD installations: China Lake Naval Air Base, Calif.; Fort Hood, Texas; McGuire Dix Lakehurst, N.J.; Andrews Joint Base, Md.; and U.S. Marine Corps Base, Hawaii.

A TWO-PHASED PROGRAM

The DoD V2G Project will be executed in two phases. Once the 100-150 existing conventional (gasoline or diesel) vehicles are replaced with new plug-in electric vehicles, the PEVs will be capable of supporting mobility missions and providing cyber-secure grid services when they are not being driven. During Phase One, data will be collected to validate a cost-justified non-tactical vehicle electrification path.

If results are positive, Phase Two calls for expanding the program with additional PEVs at other DoD installations across the country.

"Demonstration results will help quantify the capabilities of a PEV V2G fleet to enhance energy security as a backup power source for installation power requirements, satisfy vehicle mission requirements, and participate in the ancillary services market to improve the life-cycle cost for the PEV," Kazbour said. "Lessons learned from the execution of this program will assist the DoD and other agencies with understanding operational implications of fleet electrification and determining the value of V2G operations."

Military benefits include the capability in theater to stabilize the power micro-grid on a forward operating base and/or a weak host nation grid. A dedicated grid also allows high-speed communications between vehicles and FOBs enabling vehicle fault maintenance, diagnostics and prognostics, as well as reduced time to deploy and remotely operate installed radar and weapon systems on vehicles.

V2G SAVINGS AND IMPACTS

V2G business-case and return-on-investment studies have shown that huge savings can be generated. According to Special Assistant to

the SAF/IE Dr. Camron Gorguinpour: "Proper management of the unused stored power in the plug-in electric vehicle can generate revenue as much as $7,300 a year from plugging the vehicle in the power grid when it's not in use."

Army Assistant Secretary for Installations, Energy and Environment Katherine Hammack said some DoD projections show the revenue from utility companies for the returned power could potentially offset the vehicles' costs. The vehicles include passenger cars, trucks and buses, ranging from $30,000 to $100,000 in purchase cost. "It could mean we get the vehicles at no cost, which—if we are able—would change the industry and would certainly help the American public," Hammack concluded.

PROPOSED IMPLEMENTATION

Each installation will receive various types of fully electric and Plug-in Hybrid Electric Vehicles, known as PHEVs, to meet its transportation's mission needs. Vehicle selection is based on mission requirements and driving profile, such as distance, type of terrain and usage.

For the PEV to meet or exceed the performance of conventional vehicles and generate revenue from its stored energy when not in use, Kazbour offered several suggestions to ensure program success:

The fleet manager must document accurate vehicle usage in the fleet management system and provide the necessary training to vehicle operators, who are reminded to plug their vehicles in to the building power system/Electric Vehicle Supply Equipment when not in use.

All vehicles must be fully charged during off-peak hours (usually charging is controlled and managed by the battery management system) and ready to be used for local transportation and/or participating in V2G services.

It is imperative that all V2G-associated software and hardware—such as the fleet management system, aggregators, controller server and Ethernet/Internet communications—be fully functional and well maintained.

ESTIMATING POTENTIAL SAVINGS

When comparing a typical class 6 conventional truck to an electric truck, an estimated $7,300 in annual revenue could be generated by plugging the PEV into the power grid when not in use, saving approximately $8,770 a year in net effect. In some cases, the revenue could be much higher if the PEVs are used to manage the installation demand charge through a process called peak shaving, which involves discharging PEV batteries to the grid when the installation crosses certain thresholds for electrical consumption. In other words, if the system can produce 1,000 kW of power at the right time, the monthly savings on the installation's electric bill could be $10,000 to $40,000. This cost avoidance can then be used to offset the price difference between purchasing a PEV versus a conventional Class 6 truck, as well as from reduced fuel consumption.

Based on Army data and studies compiled from 2009 (the most recent year available), the net impact from leveraging this technology and integrating it into tactical vehicles can lead to 20-percent reduction in fuel consumption and logistic support required by current fleets.

"For the deployed warfighter that means 8,000 fewer fuel convoys, resulting in 100 fewer casualties and less logistics burden," said TARDEC Ground Vehicle Power and Mobility (GVPM) Advanced Propulsion Team Leader Dean McGrew. "This translates to $1 billion in annual fuel savings.

The Plug-In Electric Vehicle and Vehicle-to-Grid Initiative is a joint collaboration between Army and Air Force researchers. (U.S. Army photo)

In addition, the PEV V2G initiative is meeting other government mandates, including reducing greenhouse gas emissions and providing a cleaner environment."

HOW THE PEV GENERATES REVENUE

Kazbour explained that for a PEV to generate revenue, the customer/installation has to undergo the bidding process by responding to the utility-encrypted signal to participate in V2G activities. The utility signal will be received and processed by the grid controller, which is in continuous communication with the master aggregator that contains the real-time data for all PEVs. Based on this information, the grid controller determines whether the PEV's stored energy can meet the utility request to participate in the V2G activities. There are two major steps the PEV and V2G system must follow to support V2G services:

First, each PEV is plugged into the charging station to do the "handshaking" via the J1772 Combo connector to identify itself as a registered vehicle and report its stored energy profile and availability for V2G services. All EVSEs furnish their vehicle's status to the aggregator, which is connected to the grid controller server via TCP/IP over an ethernet switch through a firewall to the grid controller server and the utility company.

Second, the Grid Controller Server is in continuous communication with the aggregator and the utility company through the grid operator router to participate in grid services by discharging its stored energy upon receiving the encrypted signal from the utility company/Independent System Operator to perform peak power sharing or frequency regulations. ■

Efficiency Collaboration

TARDEC-DoE collaborate on fuel efficiency for broad results

In 2010, the Department of Energy and the Department of Defense recognized how interdepartmental collaboration on technology development may benefit the United States on a broad scale.

The DoE Vehicle Technologies Office and DoD's representative agency, TARDEC, were assigned lead roles and began a collaborative journey in 2011.

Since then, both organizations have identified areas that promise to reduce energy consumption within the public and military sectors.

"We are still spending almost $1 billion every day just for the petroleum we consume," DoE-VTO Director Patrick Davis said. "This is an economic issue. This is an energy security issue, and it translates to a national security issue. It's also about environmental stewardship."

The scope and scale of technologies of the 21st Century Truck Partnership, known as 21CTP, align well with military ground vehicles. TARDEC researchers are especially looking at tactical trucks, some of which are based on commercial truck platforms.

TARDEC hosted the 21CTP Fall Meeting Nov 6-7 at Detroit Arsenal, Mich., where officials briefed original equipment manufacturers and suppliers about warfighter capability and functionality needed for future tactical trucks.

Leaders also presented a TARDEC 30-Year strategy overview.

The meeting laid the foundation for future project collaboration to close technology gaps and overcome barriers, which will result in more fuel-efficient commercial and military ground vehicles.

Conference attendees identified many potential mutual interest areas.

"The next step is to work those through the respective stakeholder groups to identify where there are strong matches and implement a next-steps plan," said TARDEC National Automotive Center senior engineer Scott Schramm.

Engines and lightweight materials for vehicles are examples of mutual technical interest areas explored by the group.

"It's incumbent upon us in the science and technology community to work with industry to mature and transition the advanced technologies this community has developed," said TARDEC Director Dr. Paul Rogers during his opening remarks. "It's a testimony to the success of the DoE's relationship with industry, and as much as we can replicate that and 'steal' from it, I am here to do that."

Collaboration establishes communication paths enabling awareness of ongoing activities within the organizations and the broader technical communities in which they engage.

During the meeting, guests toured the TARDEC Ground Systems Power & Energy Laboratory, known as GSPEL, and learned that the facility is available for purchased service testing.

Potential benefits include: revenue generation, joint learning and experience/expertise exchange between industry and government subject matter experts. Working together, the organizations have the potential to accomplish more, faster than any single organization working alone.

VTO and TARDEC are also targeting respective joint-value engagement in lightweight structures and energy storage and batteries. The AVPTA Lightweight Vehicle Structures project trade-off study recommended material substitution for the U.S. Marine Corps Light Armored Vehicle turret that could save significant weight. A prototype lightweight turret may be demonstrated as early as next year. Possibly as important as the results, working on these programs enabled the organizations to refine their methods of collaborating and combining resources, Davis said.

"Collaboration like this requires common goals, equally willing partners and a great deal of trust," Davis said. "We have the common goals—we both are intently interested in the development of advanced vehicle technologies to achieve our respective missions—and we both are intently interested in leveraging resources and capabilities. For me, one of the most satisfying aspects of the partnership is the way we have been able to set aside whatever differences we have to truly work together, pooling resources to achieve success."

Examples include:

- **VTO Annual Merit Review**: advanced energy projects funded by DoE are reviewed for technical accomplishment and future direction. TARDEC SMEs sit on AMR review panels where they interact with peers throughout government and industry, thereby sharing and gaining insight.
- **Small Business Incubator Program**: an area for potential future VTO/TARDEC engagement, the VTO is launching a program aimed at next-generation technologies and approaches supporting commercially viable transportation solutions and promoting small businesses and suppliers.

Davis applauded TARDEC's efforts to develop its 30-Year Strategy and noted that the DoE has its own long-range plan.

"If you really don't think in terms of 20 to 30 years [out], then you're missing it," he said.

In DoE's case, leaders seek to close the gap between petroleum consumption in the United States and domestic production.

"That gap was increasing. We started

showing the gap chart 20 years ago, and I still show that chart sometimes in my presentations. We've had a little turnaround over the last few years, but that gap is nonetheless still there."

The Army's primary logistics burden is shipping fuel and water to forward-deployed operational forces in war zones. By joining in programs that examine how to make heavy-duty commercial trucks more fuel efficient, the Army can transfer those technologies, first, to its work vehicles on U.S. bases and installations, and after further reliability testing and performance demonstrations, to its tactical and combat vehicle fleets.

"These semi-annual 21st CTP on-site meetings are excellent opportunities for host organizations to interact with an important national transportation sector," Davis said. "I was pleased that TARDEC could host the Fall Meeting and provide their military perspective to the heavy-vehicle industry."

TARDEC's Rogers said the Army can define its challenges, but it needs industry partners, such as the transportation industry representatives attending the 21CTP conference, to help deliver the solutions.

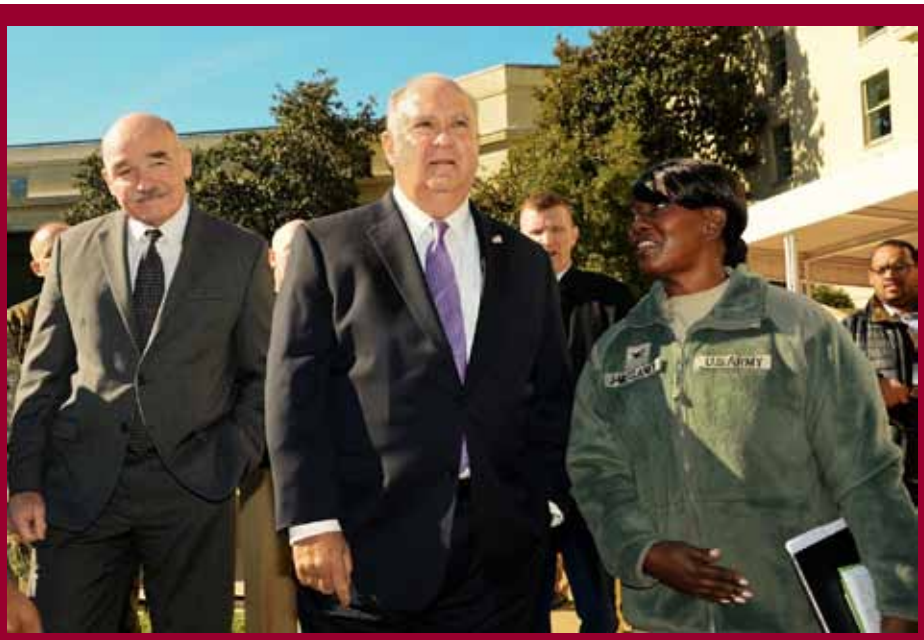
"The laboratory is an important place for us to get together and have this dialogue, and we are taking full advantage of it," Rogers said. "It's our responsibility to define the military problems and share with you where we think military procurement and capability are going over time. That was the purpose of diving so deep and putting so much energy into our 30-Year Strategy—to share that information with industry over the coming months."

"The better we articulate our challenges and the better we articulate where we're going over time, the more we enable industry to bring us solutions—affordable, timely solutions—that benefit our warfighters," Rogers said. ■

The Ground Systems Power and Energy Laboratory at Detroit Arsenal in Warren, Mich., opened April 11, 2012. The GSPEL is a 30,000-square-foot facility featuring eight state-of-the-art power and mobility laboratories. (U.S. Army photos)

Insight on Army Operational Energy

Interview with Col. Shelia Faye J-McClaney, chief of Operational Energy for the U.S. Army G-4



Col. Shelia Faye J-McClaney, chief of Operational Energy for the U.S. Army G-4, speaks to Under Secretary of the Army Joseph W. Westphal and other officials during a Nov. 14, 2013, energy showcase event at the Pentagon Courtyard. (U.S. Army photo by Conrad Johnson)

ARMY TECHNOLOGY: How is your organization helping the Army meet its energy goals?

Faye: The goal of Army Power and Energy is to increase operational effectiveness and reduce risk for the warfighter, as well as to increase efficiency and reduce costs.

In September 2012, the Chief of Staff, Army Gen. Raymond T. Odierno assigned responsibility for operational energy on the Army Staff to the Deputy Chief of Staff for Logistics, G-4 Lt. Gen. Raymond V. Mason, in support of Assistant Secretary of the Army for Installations, Energy and Environment the Honorable Katherine Hammack. The G-4 Operational Energy and Contingency Basing Office is working with organizations across the Army—Soldiers and leaders—as well as with our partner in the other services, to achieve energy informed operations.

ARMY TECHNOLOGY: How do you see technology helping the Army meet its goals? What key enabling technologies do you think will get us there?

Faye: Operational energy enables extended range and endurance, flexibility and resilience, enhanced mobility and freedom of action.

It enhances combat capability and reduces the challenges, risks and costs associated with delivering fuel to remote and austere combat outposts, forward operation bases and village stability platforms.

We are making battery loads lighter and fielding more efficient technologies.

Key enabling technologies include: the Integrated Soldier Power/Data System; next generation generators; insulated shelters; microgrids; alternative energy systems; the Improved Engine Turbine Program for Black Hawk and Apache; and the Abrams auxiliary power unit.

ARMY TECHNOLOGY: Many say our culture needs to change. What do you think?

Faye: The Secretary of the Army John M. McHugh named "Developing Effective Energy Solutions" as one of his top ten priorities. In support of this, the Army continues to work to embed an energy informed culture across the Total Army Force through doctrine, operations, materiel solutions, training, leadership and communication, to ensure we are making the best use of energy.

Across the Army, we are training the force on the new technologies, so all Soldiers have confidence that the technologies will perform as intended and increase operational effectiveness.

In addition, a pilot initiative in select Initial Military Training at Fort Lee ties personal energy habits to operational energy practices which will continue throughout the Soldier's careers.

ARMY TECHNOLOGY: What words of encouragement do you have for the Army research and development community?

Faye: We encourage the Army research and development community to continue with its outstanding work and will work to ensure the Army is leveraging all that the Research, Development and Engineering Command has to offer in terms of operational energy. ■

Energy Showcase

RDECOM demonstrates advances at an Army power and energy event at the Pentagon

BY DAN LAFONTAINE, RDECOM PUBLIC AFFAIRS

The U.S. Army showcased how its research and engineering centers are enabling advances in operational energy for Soldiers Nov. 14 at the Pentagon.

RDECOM subject matter experts discussed their work in technologies that included Soldier-borne electronics, ground-vehicle fuel efficiency and sustainable base camps.

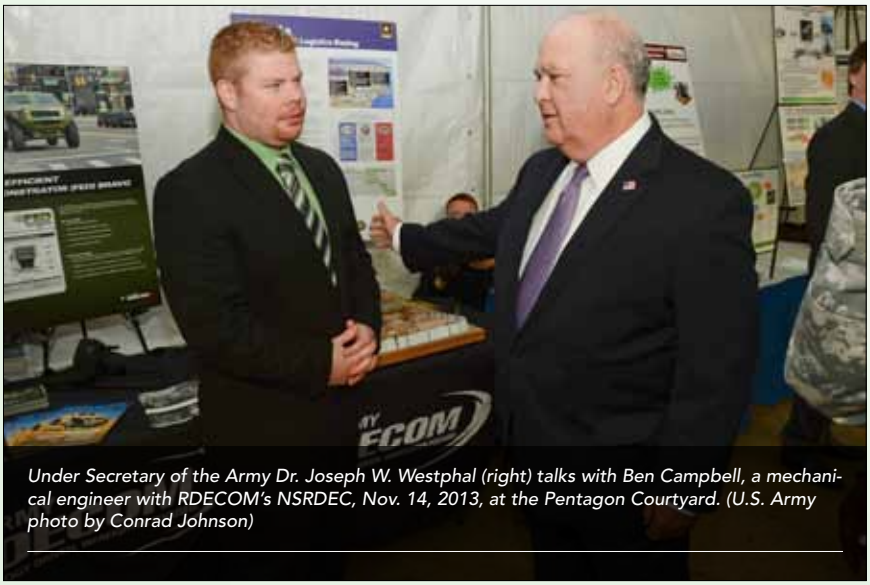
Dan Rusin, staff engineer for power and energy at RDECOM headquarters, said the command's scientists and engineers provide the underpinnings for most of the hardware on display by the Army's PEO Soldier and Rapid Equipping Force at the Pentagon.

"No one effort is going to solve any power and energy problem. It's going to be collective of many, many efforts," Rusin said. "RDECOM technology went into two-thirds of what you see here today."

"RDECOM is doing research and making the connections. In power and energy, there are a lot of connections with the commercial world. How do we as military engineers fit commercial technologies that are often installed by licensed electricians and make it simple and safe for a sergeant or field commander to use?"

Three RDECOM organizations—TARDEC, CERDEC and NSRDEC—discussed power and energy efforts with Pentagon military and civilian workers throughout the day.

Senior Army leaders who visited RDECOM's exhibits included Under Secretary of the Army Dr. Joseph W. Westphal; Sgt. Maj. of the Army Raymond F. Chandler III; Katherine Hammack, assistant secretary of the Army for Installations, Energy and Environment; and RDECOM Director Dale A. Ormond.



Under Secretary of the Army Dr. Joseph W. Westphal (right) talks with Ben Campbell, a mechanical engineer with RDECOM's NSRDEC, Nov. 14, 2013, at the Pentagon Courtyard. (U.S. Army photo by Conrad Johnson)

LOGISTICS AND SUSTAINABILITY FOR BASE CAMPS

Ben Campbell, an NSRDEC mechanical engineer, is the lead systems engineer for Technology Enabled Capability Demonstration 4a that addresses logistics and sustainability for base camps.

RDECOM will be conducting a physical demonstration of technologies next year at a Fort Devens, Mass., integrated base camp lab.

"We're working with the other RDECs for technologies that help us meet our goals of reducing energy use and waste at base camps," Campbell said. "We're looking to reduce fuel consumption by 25 percent, water resupply needs by 75 percent and waste generation by 50 percent. We'll be doing a side-by-side comparison of the baseline base camp and our integrated solutions set base camp to understand

how these technologies are helping us meet our operational energy reduction goals."

The technologies being tested include waste-to-energy conversion, reducing energy consumption from generators, solar panels, and water re-use. The demonstration at Fort Devens will allow engineers to complement the modeling and simulation tools already in use, Campbell said.

"When we have new a technology effort coming in, we can put those technical parameters and metrics into a modeling tool to then understand the impacts of the technology in a base camp. We'll be conducting the physical demonstration to calibrate that tool and get operationally relevant data to refine it," he said.

ADVANCES IN GROUND-VEHICLE FUEL EFFICIENCY

TARDEC mechanical engineer Robert Berlin discussed the Fuel Efficient Ground Vehicle Demonstrator Alpha and Bravo.

Army engineers integrated technologies to demonstrate state-of-the-art fuel-efficient vehicle design. Key features of the FED Bravo include an integrated starter generator, prismatic lithium-ion advanced battery, lightweight carbon-fiber body panels and low-rolling-resistance tires.

"The FED program highlights a lot of different areas that we work in, including fuels, lubrications, lightweight structures, and powertrain development and testing," Berlin said. "We have our hands in developing the entire ground system suite. It's a highlight of everything that TARDEC does."

Berlin said the trucks' technologies are complete, and the next step is to work with the Army's program managers to incorporate those advancements into existing and future ground systems.

CERDEC employees Mary Hendrickson, Ed Plichta and Jonathan Novoa display their technologies in the Pentagon Courtyard Nov. 14, 2013. (U.S. Army photo by Conrad Johnson)

Product Manager Force Sustainment Systems displays an airbeam tent in the Pentagon Courtyard Nov. 14, 2013. (U.S. Army photo by Conrad Johnson)

ENERGY-INFORMED OPERATIONS

CERDEC is focusing on power management and how the Army can reduce the power consumption of the systems that a Soldier carries, said Ed Plichta, chief of the Power Division within CERDEC's Command, Power and Integration Directorate.

Plichta's team is looking to develop technology that identifies which of a Soldier's power consumers are drawing the largest load and provide that additional information to the Soldier. This could help Soldiers extend their mission times by allowing them to actively monitor their devices.

"For many years, most of the focus has been on developing power sources for the Soldier that are lighter, smaller, cost-effective," Plichta said. "We've achieved many milestones in bringing down the weight of what the Soldier is carrying, specifically in batteries. We've introduced renewable-energy capabilities so you can re-charge those batteries in the field.

"Energy-informed operations is an aspect of power management so the Soldier will know through applications on his handheld devices what the status of energy is. Squad leaders and company commanders will be able to get that information through the network so they can better ascertain what the energy status is among the small units."

MAKING CONNECTIONS

RDECOM is also integral to developing the software and platforms to ensure that power systems connect with each other and work together, Rusin said. Without these essential connections, the technology will be a hindrance to a Soldier in combat.

"We're trying to make not just technology and hardware, but make decision-making software to inform the commander and Soldiers on how to better use energy," Rusin said. "There is a combination between the technology that you can see and the technology that you cannot see.

"Many of the decision-making algorithms are invisible to the external community. It's important to connect the hardware in a way that people can use it."

ARMY ENGINEERS EDUCATIONAL OUTREACH

CERDEC engineers bring 'Power, Energy and Cyber' to students

BY ALLISON BARROW, CERDEC PUBLIC AFFAIRS

Army engineers provide high school students a look into the science-related career paths available to them through advanced classroom instruction and hands-on experiments each summer as part of an expanded Gains in the Education of Mathematics and Science program, known as GEMS.

CERDEC engineers, with the assistance of local high school teachers and college students, led "Power and Energy" and "Network and Cyber" curricula last summer to rising 11th and 12th grade students from all over the East Coast.

"GEMS provides students with an outstanding bridge between what we think of as gateway programs such as the CERDEC Summer Camp, and the more rigorous academic or lab experiences they will encounter as they continue their scholastic careers," said Erica Bertoli, CERDEC Educational Outreach Program lead.

The CERDEC-led course was part of a larger Aberdeen Proving Ground GEMS program made possible through the collaboration of the Research, Development and Engineering Command's Army Research Laboratory, the Communications-Electronics Command, the U.S. Army Medical Research Institute of Chemical Defense, the Army Test and Evaluation Command, the Army Materiel Systems Analysis Activity and CERDEC, hosted at the new Aberdeen Proving Ground STEM and Education Outreach Center. In it, students learned about various technologies and science-related occupations, as well as the work the Army is doing in those areas. They conducted in-class experiments to compliment the lessons.

The curriculum for the "Power and Energy" week was put together by engineers from the CERDEC Command, Power and Integration Directorate, Power Division, with a focus on renewable energy and kinetic energy.

"All these renewable energies are fairly new and it takes years to investigate and research to develop better, more reliable systems and these young kids are the future. That's why I'm participating, to help keep them motivated and keep them up to speed," said Cao Chung, CERDEC CP&I chemical engineer.

Students learned how to build a homemade battery and designed their own models for an alternative energy system.

"My passion is both automobiles, especially cars, and alternative energy," said Kevin Duda, a 12th-grade student from Pennsylvania. "In the future I want to go into designing cars that are both powerful and fuel efficient. I know a lot about cars, but not a lot about fuel efficiency and energy like that, so I wanted to come to a program that would offer me the intellectual ability to learn about alternative energy."

During the "Network and Cyber" week students learned about the intricacies of how networks operate, cybersecurity and digital forensics.

Local math and science teachers supported the program by adding the traditional classroom learning-environment, said Bertoli. They provided lesson recaps and asked questions to the students to help them understand complex subject matter.

"It's good to interact with kids outside of the traditional classroom," said Diane Sumutka, Joppatowne High School science teacher and Science Department chair. "It gave me an idea on different ways to structure classroom activities and different ways to approach material. It also gives the kids exposure to experts, and if nothing else, it allows us as classroom teachers to make connections in the workforce so that if I have a question about a topic that I'm not sure on I now have seven or eight subject experts that I could email."

"Being a math teacher, I wanted to get a look at the scientific aspect of it and learn myself a little bit more about the science portion of it," said Melissa Dorn, C. Milton Wright High School mathematics teacher and Harford Community College adjunct in mathematics. "Working with some really great kids in a non-traditional classroom setting was appealing to me."

College science majors served as "near peers" for the students throughout the week to guide them through activities and provide advice on higher education.

"GEMS is exciting because we were able to provide students not only a hands on program with strong academic requirements, but also because the students work with a combination of professional teachers, college students and Aberdeen Proving Ground engineers and scientists," said Bertoli. "Through this we are able to present many sides of [science, technology, engineering and math] and allow students a unique opportunity to interact on various levels in one program and to make the connection between classroom work and real-life application."

The GEMS program also allows students to see the various job opportunities and specialty areas available to them within the science and math fields, said Bertoli.

"I like everything, so this is also helping me figure out what I'm most comfortable with and what I like the most," said Katherine L. Allison, an 11th-grade student from Maryland, who participated in the GEMS program the past three summers. "I really like knowing what people actually do here. They aren't just telling us random science stuff. This is what actually goes on. Because I think I might want a career here someday, so it's really neat to actually talk to the people who really work here and get the real experience." ■

Army Chief of Staff Sees 'Bright Future' for Natick

Army Chief of Staff Gen. Raymond T. Odierno visited Natick Soldier Systems Center in mid-November to tour its facilities and learn more about the research and development done to keep Soldiers safe and provide them with a better quality of life during deployments.

Odierno learned about female body armor and body armor design enhancements, human systems performance, Soldier power, multi-functional fibers, vision protection, and the operational energy savings that the Army will realize from work done at Natick.

"What they do here is an incredibly important mission to the Army, as they continue to work what I consider to be our center of gravity, which is helping our Soldiers do their job," Odierno said. "That's something that will never change. The Army is about Soldiers. It's about their ability to perform and conduct their mission.

"This lab is focused on how they can do that better, how they can do it with less load, how they can do it in an expeditionary manner," he continued. "And everything that they do here adds to that. So it's a very, very important place in the Army, and the work they do here is critical for our future."

Odierno pointed out that Natick civilians and contractors persevered despite the recent furloughs and government shutdown.

"I wanted to personally thank them for their tremendous dedication to their mission, their dedication to our Army, and the dedication that they bring to their job every, single day," Odierno said. "They are a critical part of the Army. They are a critical part of the joint force, because much of the work they do here not only impacts the Army, but the other services, as well."

Army Chief of Staff Gen. Raymond T. Odierno learns about female body armor from Annette LaFleur, team leader of the Design, Pattern and Prototype Team at NSRDEC, during a Nov. 15, 2013, visit to Natick Soldier Systems Center, Mass. (U.S. Army photo by David Kamm)

ARL Analysts Win 2013 Army Acquisition Excellence Award

Members of the Stryker Double-V Hull Army Test and Evaluation Integrated Product Team, including two ARL employees, won the 2013 Army Acquisition Excellence Award in the category Equipping and Sustaining Our Soldiers' Systems.

The Army Acquisition Excellence Awards recognize an Army acquisition workforce individual or team, from senior management to newly hired interns, whose performance and contributions set them apart from their peers. The awards directly reflect the outstanding achievements in support of the Soldier and the Army's business transformation efforts.

Richard zum Brunnen, an operations research analyst in ARL's Survivability/Lethality Analysis Directorate, served as ARL's representative to the U.S. Army Test and Evaluation Center's Stryker ATEC System Team.

David Hendrickson, a manpower and personnel integration analyst from ARL's Human Research and Engineering Directorate, has been working on the Stryker since the first operational test in 2003.

Double-V hull Stryker vehicles began arriving in Afghanistan in the summer of 2011. (U.S. Army photo)

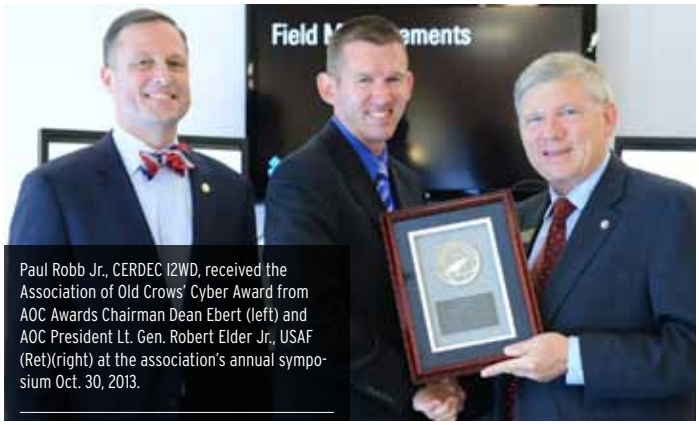
Army Civilian's Cyber Contributions Honored by Electronic Warfare, Information Operations Society

The Association of Old Crows honored a CERDEC computer engineer at the association's 50th International Symposium and Convention in Washington Oct. 30.

Paul Robb Jr., CERDEC, received the AOC's Cyber Award for his contributions to the Army cyber community.

Each year the AOC recognizes individuals and units for their outstanding performance in furthering the aims of the AOC in support of the United States or Allied electronic warfare, information operations and electromagnetic spectrum operations, according to the AOC website.

Robb's AOC recognition stems from his more than 12 years of experience developing and transitioning cyber technologies that have ended in the field for Soldiers to leverage. He currently serves as the Cyber Technology Branch chief in CERDEC's Intelligence and Information Warfare Directorate.



Paul Robb Jr., CERDEC I2WD, received the Association of Old Crows' Cyber Award from AOC Awards Chairman Dean Ebert (left) and AOC President Lt. Gen. Robert Elder Jr., USAF (Ret)(right) at the association's annual symposium Oct. 30, 2013.

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