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Energy to the Edge

U.S. Army Rapid Equipping Force

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14. ABSTRACT
Operational Energy is critical in sustaining troops and executing operations. The Army Rapid Equipping Force initiated the âEnergy to the Edgeâ project to provide contractor support in Afghanistan where fuel resupply was hazardous. Contracted personnel acted as Operational Energy Advisors. The team traveled to over fifty sites and completed thirty-nine assessments that included recommendations to improve safety, incorporate non-material/ material changes and implement hybrid energy solutions. The REF leveraged existing government and commercial-off- the-shelf (COTS) technologies integrated with legacy military equipment. Documenting these findings is critical to provide a body of information for developing future energy efficient systems, warfighter doctrine, training and combat operations. The greatest impact of Operational Energy is that it is not just about saving energy, but reducing maintenance requirements and improving system operational reliability. Soldiers once tasked with transporting fuel and refueling and maintaining generators, are now freed up for other tasks. Energy to the Edge (E2E) became more than saving fuel, it became a force multiplier.

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Abstract:

In the Central Command area of responsibility (AOR), enemy forces exploited extended logistics lines of communication to small and remote bases. The U.S. Army Rapid Equipping Force (REF) was tasked to provide immediate contractor support at these locations to improve tactical electrical power grid efficiencies and increase energy security to critical systems. The REF leveraged existing government and commercial-off-the-shelf (COTS) technologies with an experienced contractor work force to deploy to remote sites. Work priority was based on command needs at austere base camps where logistical resupply was hazardous and costly. The REF effort focused on providing Commanders greater combat power at these small sites; enabling greater operational availability of key platforms and force protection devices; and giving Commanders greater logistics agility via reduced fuel consumption. The greatest impact of Operational Energy is that **it is not about saving energy**. As changes were implemented that reduced fuel and maintenance requirements and system reliability was improved, the care and feeding of these systems became less. Soldiers once tasked with transporting fuel, adding fuel to generators, and maintaining generators were now freed up for other tasks. E2E became more than saving fuel, **it became a force multiplier**.

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1.0 Executive Summary

1.1 Overview

In the Central Command area of responsibility (AOR), enemy forces exploited extended logistics lines of communication to small and remote bases. The U.S. Army Rapid Equipping Force (REF) was tasked to provide immediate contractor support at these locations to improve tactical electrical power grid efficiencies and increase energy security to critical systems. The REF leveraged existing government and commercial-off-the-shelf technologies along with an experienced contractor work force to deploy to remote sites. Work priority was based on command needs at austere base camps where logistical resupply was hazardous and costly. The REF effort focused on providing Commanders greater combat power at these small sites; enabling greater operational availability of key platforms and force protection devices; and giving Commanders greater logistics agility via reduced fuel consumption.

Command response to this initiative was overwhelmingly positive and demand for REF material and contractor assets continues to increase even as military operations are reducing. Many of these same principals can be applied to other AORs. Moreover, continued synchronization to implement energy efficient changes across all facets of the Army will enable an enduring requirement in the Army 2020 formations.


AFG and U.S. flags at Panjwai site.

1.2 Background

The U.S. Military deploys troops to remote and austere locations to perform a wide variety of missions. Forward Operating Bases (FOBs), Combat Outposts (COPs), Joint Combat Outposts (JCOPs), Village Stability Platforms (VSPs), Village Stability Sustainment Activities (VSSA) and Observation Posts (OPs) are locations where troops live, train, plan and launch operation. While the U.S. is currently drawing down forces in Afghanistan, electrical power will remain imperative to operations, especially in the face of power surety and security needs. Regardless of location, energy security will always be important to military operations.

In 2012 the REF initiated the Energy to the Edge (E2E) program and contracted civilian personnel to act as Operational Energy (OE) Advisors to enable more efficient and secure tactical electric power at very remote combat outposts throughout Afghanistan.

In 2012 the REF initiated the Energy to the Edge (E2E) program and contracted civilian personnel to act as Operational Energy (OE) Advisors to enable more efficient and secure tactical electric power at very remote combat outposts throughout Afghanistan. The focus was on "the Edge"- those FOBs, COPs, JCOPs, VSPs, VSSAs and OPs on the far reaches of operations. These locations are constrained due to difficult logistics re-supply efforts that often require air delivery. The OE team visited over fifty locations throughout Afghanistan and completed assessments to evaluate and install improvements to power capabilities. These site assessments included: material and nonmaterial recommendations to right-size tactical electric grids; operator training to maintain the grids; and insertion of energy storage and/or renewables to further reduce fuel consumption. The net effect was not just greatly reduced fuel, but also greater energy security and reduced manpower. Energy effectiveness is a force multiplier. Personnel that once refueled generators and moved fuel are now freed up for other tasks.

1.3 Findings

This report documents the E2E project including the findings, solutions and lessons learned from the OE Advisors as they traveled in Afghanistan and reviewed fifty-seven (57) locations in 2012 until early 2014. The OE team completed thirty-nine (39) reports which document both material and non-material improvements that were recommended and in most cases, implemented. Key points of the findings are summarized below:

1. Implement systems to distribute power and network generators. The biggest impact to achieving energy efficiency came from non-material solutions - consolidating loads on generators and removing unnecessary generators.

2. Implement hybrid solutions that focus on the 3-10 kilowatt (kW) range. Hybrid Systems (Solar/Wind/Batteries) are most effective at the "Edge" where fuel is the most difficult to resupply and power demand is lower than at a larger base.

   a. Systems such as security, force protection, communication and back-up for weapon systems benefited the most from the addition of hybrid systems.

   b. Systems are fielded with generators that are sized for peak loads and hybrid systems were extremely effective in addressing those situations.

3. Implement solutions to allow current generators to operate at peak efficiency. Battery Storage is critical to leveling loads and ultimately providing the most efficient power systems.

4. Implement solutions to reduce energy demand. Demand reduction must be built into future systems ranging from insulated structures and efficient heating and cooling to providing incentives to contractors to reduce fuel.

5. Improve doctrine to ensure military units deploy with their required equipment. This combined with constant changes at sites created an abundance of commercial generators.

   a. These "white generators" were often oversized and had no parts or warranties and soldiers were not trained to provide maintenance.

6. Instill an energy culture. Training and education on energy would increase understanding and improve efficiencies from the ranks of enlisted to general officer.

1.4 Recommendations

The lessons learned from the E2E project will remain relevant and independent of the theater, the enemy, and the location. U.S. Forces will continue to travel great distances that will expose the supply line and enemy forces will use the logistical tail as a way to deny forces freedom to maneuver by targeting fuel convoys. Regardless of location and mission, the U.S. Military will continue to require additional capabilities, efficiencies and improvements to achieve energy effectiveness. Many technological advances require an increased energy component. Items such as persistent surveillance cameras, counter-mortar systems, thermal sights, computer servers, improved communications, and other equipment all require electricity to provide essential mission support. Whether new equipment is geared for lethality, survivability, or harsh operating environments, the energy demand will continue to increase, and so will the need to resupply. Fuel movement is not only costly in terms of dollars, but it is resource-intensive, vulnerable to disruption, and exposes the warfighter to tremendous risk. The OE Advisors found that material and non-material solutions can be applied to find better ways to achieve energy effectiveness that will reduce the logistical tail needed to support full spectrum operations. Augmenting deployed units with OE Advisors, provides the focus needed to manage and oversee the power needs to improve energy efficiency.

In addition to deploying OE Advisors, the following changes across the Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, Facilities (DOTMLPF) spectrum are recommended across the Army to ensure energy efficiency and security are added into future operations:

Doctrine – Integrate OE concepts into the six Army functional concepts to drive doctrine and publication changes regarding the Army 2020.

Organization – Require pre-deployment planning to include the employment of the appropriate soldiers such as military occupational specialty (MOS)[1] 120A (construction engineer technician), 12P (electronics technician) and 91D (power generation equipment repair) MOS as well as contractor augmentation where needed to enable and maintain the most efficient tactical electrical power distribution networks at operating locations.

Training - Add power management and energy efficiency concepts to the Army generator mechanic, 91D, skill set to include more power distribution, efficient energy operations and the possibility of future hybrid systems, and include that training in pre-deployment training. Professional military education certification for engineers in the 12P and 120A MOS should include basics of solar and energy efficiency.

Materiel - Enable the transition of REF procured COTS/Government-off-the-shelf (GOTS) technologies that provide enduring capability into program of records (PORs). Consider more focus on smart power distribution and hybrid solutions. Integrate performance based contracting mechanisms so that prime contractors are rewarded for providing more efficient structures, electrical grids, and reduced water and fuel consuming platforms.

Leadership and Education - Promote energy management in the mindset *every Soldier is an energy steward and not just a consumer.* Reiterate in all Army educational venues and forums (Professional Military Education (PME),

1 Website: http://army.com/info/mos/all

MOS training, leadership development opportunities, etc.) that OE enables greater lethality, increased operational availability and agile logistics.

Personnel - Consider more efficient utilization of existing power related assets (MOS 91D, 12P and 120A) to establish efficient and reliable tactical electrical distribution instead of additional duties that reduce their availability for power support.

Facilities - Contingency Basing facilities need to comply with the intent of the Contingency Basing Directive 3000.10[2] to ensure efficient base camps. Leverage compliance driven and installation focused energy and water reduction investments at home station by ensuring these investments may also be applicable to facilitating "energy steward training" at locations outside the U.S.

1.5 Conclusion

Deliberate acquisition programs have been initiated across the Army to incorporate many of the concepts implemented by the E2E project. For example, the Program Manager for Mobile Electric Power (PM MEP) is developing the Mobile Electric Hybrid Power System (MEHPS), a 3kW and 10kW hybrid solution similar to the commercial material solutions installed by the REF OE Advisors. This system, however, will not be in in soldiers hands before 2018, over 4 years from now. This reinforces the need and importance of the efforts of the REF and the OE Advisors to provide quick relevant solutions to the warfighter that can be applied today.

Even while efforts drawdown in the AOR, Conventional and Special Operations Forces (SOF) continue to request OE Advisors assistance to enable tactical electric power energy security and efficiency. This is especially critical during Phase IV (Stabilize) and Phase V (Enable Civil Authority) operations where reduced force strength requires even more demand for the capabilities that result from OE Advisors' recommendations and actions.

One of the greatest impacts of Operational Energy is that **it is not about saving energy**. As changes were implemented that reduced fuel and maintenance requirements and system reliability was improved, the care and feeding of these systems became less. Soldiers once tasked with transporting fuel, adding fuel to generators, and maintaining generators were now freed up for other tasks. E2E became more than saving fuel, **it is a force multiplier**.

[2] Website: http://www.dtic.mil/whs/directives/corres/pdf/300010p.pdf

2.0 Purpose

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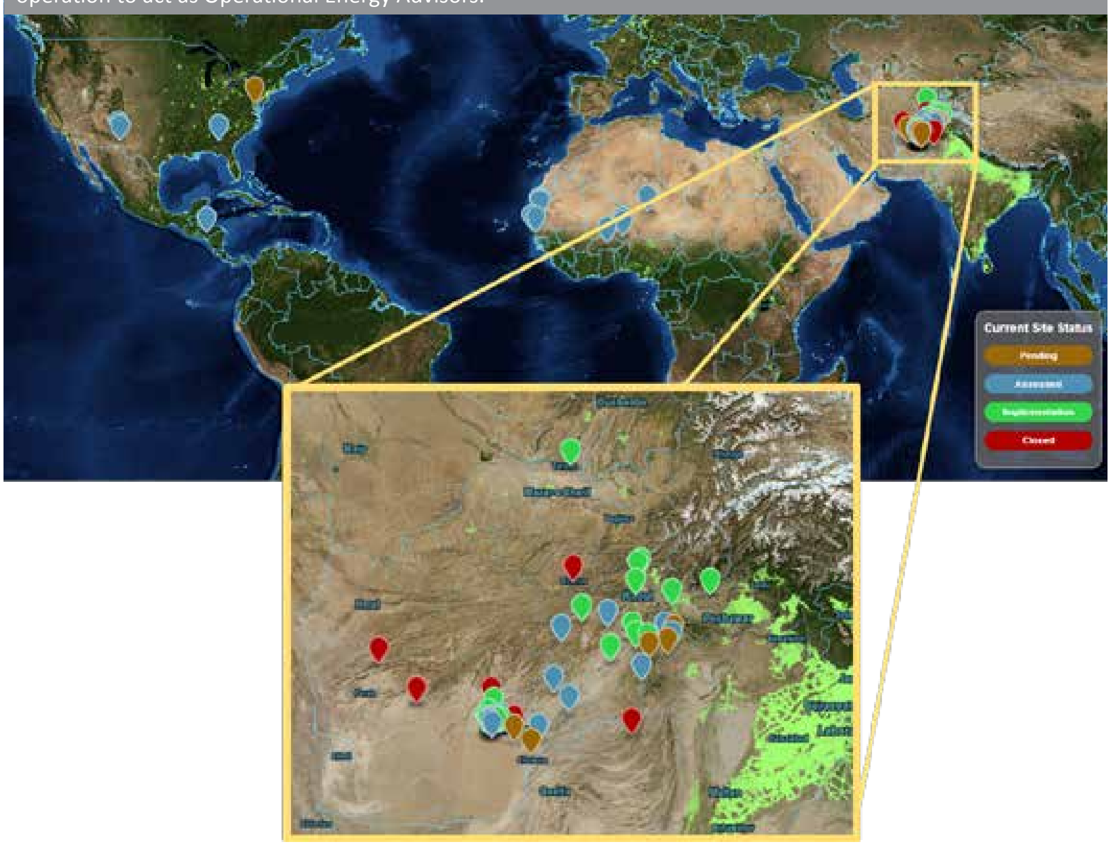
Reliable and consistent energy is required for combat effectiveness. New equipment and systems such as communications and force protection systems have increased the energy demands for the soldier, especially at COPs and VSPs, where troops operate far from larger bases. In addition, the challenges of moving fuel and the need for sustained presence increases the need for energy efficiency.

T-Series solar panels installed at Bagram Airfield.

In order to meet these objectives, the REF contracted Barbaricum, LLC to provide knowledgeable personnel to deploy to the Afghanistan theater of operation to act as OE Advisors. The OE Advisors deployed to COPs, JCOPs VSSA, VSPs and OPs to make changes to the power grids, improve generator efficiency and where appropriate, install hybrid energy systems. This resulted in increased equipment operational readiness and increased soldier availability for counterinsurgency and stability operations.

REF contracted Barbaricum, LLC to provide knowledgeable personnel to deploy to the Afghanistan theater of operation to act as Operational Energy Advisors.

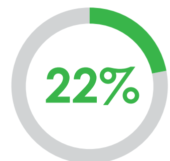


3.0 Background

3.1 Define the Problem

Since 2001, the U.S. Military has been engaged in enduring and expeditionary conflicts in both Iraq and Afghanistan. These extended insurgencies in remote and austere locations exposed the continuing difficulty in moving fuel and the increased demand for power to operate military equipment. Generators make up 22% of the Army's total energy consumption.[3] Moving this fuel to the front line is difficult and expensive – in monetary terms and in lives. Fuel movement is not only costly in terms of dollars, but it is resource-intensive, vulnerable to disruption, and exposes the warfighter to tremendous risk. The casualty factor for fuel resupplies in Afghanistan is almost one casualty for every 24 fuel resupply convoys in 2007.[4]

Generators made up 22% of the Army's total energy consumption.



Besides the cost of energy, access to continuous supplies has been questionable. In 2010, Pakistan temporary closed the main fuel resupply route for 10 days causing disruptions. A similar incident in November of 2011 caused Pakistan to close the Torkham Gate and Chaman border crossings, the main U.S. supply lines into landlocked Afghanistan from the seaport of Karachi. By the end of 2010, the Defense Logistics Agency Energy (DLA-Energy) was moving 40 million gallons of fuel per month into Afghanistan.[5] While operations draw down in Afghanistan, fuel demand will reduce but the resource intensive operations to move that fuel, will continue. More efficient and secure tactical electric power grids at very remote combat outposts throughout Afghanistan where energy security and logistics re-supply efforts are constrained will remain critical.


Soldiers installed solar panels at military installations located in Afghanistan.

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3 Defense Science Board Task Force on DoD Energy Strategy More Fight Less Fuel, February 2008.

4 Army Environmental Policy Institute, Sustain the Mission Project: Casualty Factors for Fuel and Water Resupply Convoys Final Technical Report, September 2009, www.aepi.army.mil.

5 Deputy Secretary of Defense, Energy for the Warfighter: Operational Energy Strategy, May 2011.

The Department of Defense (DoD) has continued to place command emphasis on energy security. The Secretary of the Army, the Honorable John McHugh, recently released his top priorities for 2014 that included "develop effective energy solutions".

3.2 Historical Aspect

The REF was established in 2003 by combining functions across several Army staff elements with the purpose of accelerating material solutions and technology insertion to support warfighter requirements. The REF investigates current and emerging government and commercial technologies to provide rapid solutions for urgent combat requirements. The REF was one of the first organizations to understand the impact of fuel in the battlespace and used spray foam insulation on structures to reduce demand in Iraq and Kuwait in 2007. Around the same time, the REF initiated the Power Surety Task Force (PSTF), a group that investigated energy concepts, including executing the Net Zero Plus Joint Capability Technology Demonstration (JCTD) sponsored by the U.S. Central Command. The Net Zero Plus JCTD demonstrated several technologies to reduce fuel. One of the technologies was a 1 megawatt microgrid that was deployed to Afghanistan in 2011 and proved the concepts of power management in a deployed environment.[6]

40,000,000 Gallons

By the end of 2010, the Defense Logistics Agency Energy (DLA-Energy) was moving 40 million gallons of fuel per month into Afghanistan.

Congress also recognized the need for senior oversight and dictated the establishment of the Director for Operational Energy Plans and Programs in the Defense Authorization Act of 2009 (this position was renamed in 2012 to the Office of the Assistant Secretary of Defense for Operational Energy Plans and Programs (ASD(OEPP)). This position was created to strengthen the energy security of U.S. military operations. The mission of the office is to help the military services and combatant commands improve capabilities, cut costs, and lower operational and strategic vulnerabilities and risks through better energy innovation, accounting, planning, and management.[7]

[6] Army Materiel Systems Analysis Activity, "Afghanistan Microgrid Project (AMP) One Megawatt Microgrid," Technical Report No. TR-2012-02, February 2012.

[7] 10 U.S.C 139b Director of Operational Energy Plans and Programs.


Refueling operation at Panjwai site.

In 2011, a project was jointly organized by the ASD(OEPP) and the REF to access energy use at various locations in Afghanistan. The team included stakeholders from Research, Development and Engineering Command's Field Assistance in Science and Technology-Center (RFAST-C), Communications Electronics Research, Development, and Engineering Center (CERDEC), United States Forces Afghanistan (USFOR-A) Operational Energy Division, Program Manager Mobile Electric Power (PM MEP) and Combined Joint Special Operations Task Force Afghanistan (CJSOTF-A). Analysts traveled to several locations in the theater of operations and produced three extensive reports.[8] [9] [10] These reports were the basis for continued REF energy efforts and provided the following insight into next steps to affect reductions in fuel use in Afghanistan:

1. Deploy an implementation team with the appropriate knowledge, skills, and abilities to audit and make energy saving corrections at COPs.
2. Focus on demand reduction and improving power distribution at COPs.
3. Acquire effective material solutions that allow for a reduction in the logistical effort.
4. Train personnel with critical energy efficiency skills and provide reach back support.

These recommendations provided the framework for the REF to establish the E2E program. As a result, in 2012, REF E2E was initiated to reduce energy requirements in the Afghanistan battlespace at the most remote sites. Power generation for COPs, JCOPs, VSPs, VSSAs and OPs, is where fuel is difficult and risky to deliver, and thus, the focus of the E2E program.

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[8] Survivability & Vulnerability Assessments For U.S. Army Rapid Equipping Force (REF), OSD Energy Office, and USFOR-A Energy Division, Energy Survivability & Vulnerability Project, SURVIAC Technical Area Task 10-25, Delivery Order 371 (Contract No. SPO700-03-D-1380), December 2011.

[9] Analysis of Alternatives (AoA) For U.S. Army Rapid Equipping Force (REF), OSD Energy Office, and USFOR-A Energy Division Energy Survivability & Vulnerability Project, SURVIAC Technical Area Task 10-25, Delivery Order 371 (Contract No. SPO700-03-D-1380), December 2011.

[10] Analytical Report on New/Emerging Technologies For U.S. Army Rapid Equipping Force (REF), OSD Energy Office, and USFOR-A Energy Division Energy Survivability & Vulnerability Project, SURVIAC Technical Area Task 10-25, Delivery Order 371 (Contract No. SPO700-03-D-1380), December 2011.

The E2E project emphasis is on both material and non-material solutions that can be applied seamlessly at the tactical edge of COPS, VSPs and OPs. The primary objectives of the E2E initiative is to: 1) provide Commanders at the tactical edge increased operational flexibility by reducing reliance on resupply operations; 2) provide suitable, sustainable and reliable power to meet the demand of mission critical systems.[11]

3.3 Approach

The REF initiated the E2E project to reduce operational energy requirements specifically in the Afghanistan battlespace. The backbone of the E2E project is the experienced personnel that understand power as well as how to operate in the wartime environment. These persons are referred to as OE Advisors. The REF deployed OE Advisors to Afghanistan to evaluate various sites to assess the in-theater operational energy situation. The embed expertise analyzed strategic, operational, and tactical deployment of both materiel and non-materiel energy solutions, and provided recommendations on how to decrease energy, reduce risk, and increase operational availability of soldiers and systems.

The efforts of the OE Advisors are guided by specific Combat Commander regionally focused requirements that leverage rapid acquisition efforts to enable immediate corrections in tactical electrical deficiencies. The OE Advisors directly support Combat Commanders on the ground with reach back through REF Operations while maintaining situational awareness through USFOR-A staff. Based on this guidance, the OE Advisor traveled to the requested site and completed an analysis that included identification of the current baseline situation. This analysis documented the number of personnel, power usage, power generated, generator use and layout, equipment powered and any other issues noted. From this assessment, the OE Advisor evaluated strategic, operational, and tactical deployment of both materiel and non-materiel energy solutions and provided recommendations to improve generator efficiency, reduce fuel, correct safety concerns and/or employ hybrid and renewable systems. In the case of hybrid and renewable systems, the team determined the feasibility and effectiveness of the hybrid installations. In most cases, non-material improvements were made immediately but in the case of installing hybrid and renewable solutions, considerable coordination was needed to schedule deliveries and installations.

[11] Senior Executive Council brief, January 2012.

In some cases, the status of the sites changed rapidly often closing or expanding in short order, requiring repeated assessments and resulting in changing solution alternatives. Solutions were material or non-material and were implemented immediately, or required additional supplies and equipment. In cases where equipment was needed such as cables to combine generator loads or integration of a hybrid system, the request was made back to the REF forward team. A REF Ten Liner (10L) is the document which addressed the material requirements.


Solar Stik installed at Gambari site.

The REF 10L is the basic equipment starting point for the unit to communicate a capability gap to teams forward at Bagram Airfield (BAF) and Kandahar Airfield (KAF) and can be submitted from anyone starting at the squad leader level. The 10L consists of ten (10) line similar to the Operational Needs Statement (ONS) requesting information on the problem, objectives and potential solutions. Once the 10L is completed and the REF Director approves the requirement it becomes an Army G3 (Operations) requirement and carries the same weight as other requests from the Afghanistan staff. The 10L becomes classified once completed and must be sent through classified networks. Once the REF approves, funds and contracts for the item, the REF team will coordinate the shipment through military or commercial means. Once a unit is equipped with a capability, contracted support, repairs, and/or spares is provided or until a PM or other POR provides for continuation in theater.

As of January 2014, the E2E team traveled to fifty-seven (57) sites and completed thirty-nine (39) reports. The focus of the OE Advisors changed as the U.S. mission in Afghanistan changed. Earlier assessments in 2012 looked at the entire base and recommended changes to the power grid and added hybrid systems where applicable. More recently in 2013 as the U.S. military downsized and the security environment became more critical, efforts concentrated on implementing immediate solutions to weapon system platforms and force protection systems. **Appendix A provides a list of all the sites visited, date of the visit, and what was accomplished at each site.**

4.0 Understanding Operational Energy

4.1 Understanding Power and Energy

To understand the power needs of the combat units, a quick definition is needed. Power is the maximum used or the maximum generation that can be provided. Units are in kWs. Energy is the instantaneous power multiplied by time for each hour measured in kilowatt-hours (kWh). Electrical needs must be addressed as both power and energy requirements. Power is the demand (kW) needed instantaneously to supply the load. Energy is the usage or power consumed (kWh) over time by the load.[12]


Two (2) 15kW generators at Khenjakak site.

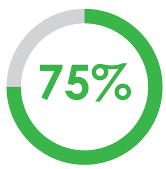
Electrical power encompasses the entire spectrum of power generation and distribution that supports military operations. This spectrum covers tactical power, prime power, and commercial power. Tactical power supports units engaged in combat operations and relies on military tactical generators (TQGs) in power ranges from 5 to 200kW and does not need transformers. These generators are part of the military units table of organization and equipment (MTOE) and should deploy with the unit. Prime Power is power produced by non-tactical generators larger than 200kW. Prime power assets are employed at intermediate staging bases or larger base camps in forward areas as they require significant site prep to install switchgear, transformers and cabling. This power is provided on an as needed basis to support military operations as directed by the theater Army or Joint Task Force (JTF) Commander. Commercial power is the generation systems that are nonstandard systems available from the commercial or local marketplace with output capacity from a few kilowatts to several thousand megawatts.[13] Some COPs use only military tactical quiet generators (TQGs) while others use “white generators” - commercial generators purchased on the local economy.

Energy is further delineated between what is needed for installations and what is needed for tactical needs to support military operations. In addition to mandating the position of ASD (OEPP), 10 U.S.C. Section 138c defines OE as the “energy required for training, moving and sustaining military forces and weapons platforms

[12] CERL Report 2010.

[13] Field Manual FM 3-34.480 Engineer Prime Power, April 2007.

Approximately 75% of the energy consumed in 2009 was considered operational.



for military operations." Approximately 75% of the energy consumed in 2009 was considered operational under this definition.[14] Installation-based sites encompass the remaining 25% and have different and mandated legislative requirements.

Additionally, DoD released Directive 3000.10 on January 10, 2013 to assign policy and responsibilities for contingency basing outside the United States. This directive provides common standards for planning, designing and constructing bases and directs operational energy efficiency.[15]

4.2 Understanding the Site

Military bases are integral to supporting military operations and have a wide range of sizes and missions. In Afghanistan there are large bases such as BAF and KAF that are primary sites for soldier and equipment movement. These sites can have 25,000 or more people. Smaller size bases are camps such as Camp Leatherneck have approximately 10,000 people and are also major hubs for logistics. The next smaller base type is a FOB. FOBs typically have a brigade or a battalion size element plus support personnel and enablers, totaling between 2,000-3,000 personnel. Most of these sites are supported by the Logistics Civil Augmentation Program (LOGCAP). Some sites have airstrips that can support a C-17 Globemaster aircraft to support large resupply operations. Almost all FOBS are serviced by Prime Power with power requirements in the megawatts (MW). This level of installation typically has battalion or brigade command and control elements. FOBs typically have many hard structures, B-huts, large aerostats, maintenance bays and large dining facilities.

As troops deploy to outer areas and within the populace, a smaller footprint is desired and units establish COPs, VSPs, JCOPs, VSSAs and OPs. COPs, JCOPs, VSPs, and OPs are primary locations to execute combat operations. These sites are normally established far from larger bases and normally have much smaller populations and far less power requirements. They are smaller and typically support a company sized element plus enablers—around 200-300 personnel—but

[14] Ibid, DoD Directive 3000.10.

[15] Department of Defense Directive, Contingency Basing Outside the United States, Number 3000.10, January 10, 2013.

could be as small as fifty (50) personnel. They depend on logistical support from a FOB, and the threat of attack is considerably higher.

The power requirements for various sites are based on the size and mission of that site. It is also important to note that each FOB and COP is entirely different and there is no standardization between them. They each have different equipment, physical size, power demand, number of personnel, mission sets, layout, and level of support. There are two established power systems at FOBs: FOBs that are on an established power grid and FOBs using spot generators as their primary source of power. Critical facilities are defined as headquarters, dining facilities, communications and medical facilities. These critical facilities usually have spot generators even if there is a power grid as a back-up. Smaller sites such as COPs, VSPs, and OPs are not on established power grids and utilize a mix of commercial and military TQGs. Many of the sites must relocate on short notice due to mission requirements and will increase/decrease in size due to mission needs. Mission, equipment and personnel all impact the power requirements for each site.

COPs made up the majority of the sites visited by the E2E team. Power generating assets ranged from 658kW at COP Khenjakak to 1585kW at COP Xio Haq. In many cases the generators powering each of the sites were operating at 30% load or less. The average load recorded at these COPS was 219kW, with the smallest at COP Giro of 41kW and the largest recorded load of 400kW at Xio Haq.

Remote COP site.

VSP and VSSA are usually manned at 50 or less personnel and have considerable lower power demands – mostly for force protection systems. These sites normally did not have excess generating capacity in the number of generators but often had only one large generator providing the entire load without any back-up system. These sites, such as VSP Lam, benefited from the installation of hybrid systems to power force protection systems. One or two OPs usually overlook a COP and provide security and early warning in case of attack. Supporting every COP there is at least one OP. OPs are typically manned by a squad-size (twelve (12) personnel) or team-size (six (6) personnel) element, and support COPs by providing early warning and covering fire. The OPs that our team observed had power demand requirements between 5kW and 30kW.

COPs often have Afghan National Army (ANA) or Afghan National Police (ANP) living within their perimeter, but they also could have State Department Provincial Reconstruction Teams (PRT), contractor security, Pakistan military forces, LOGCAP personnel, Other Government Agencies (OGA), and Special Operations Forces (SOF). Shinwar was an Other Defense Activity (ODA) that required power independent of the ANA grid for security reasons. The E2E team installed a transfer switch and developed a power plan that a third party contractor installed.

Power surety, meaning ensuring backup power and continuous power at all times was another issue that was corrected by the OE Advisors. There were circumstances where COPS were without critical power due to generator problems and many did not have back-up generators or switching material to allow seamless transfer to other generators even if they were available. COP Tagab was assessed on May 15, 2013, and reported black-outs. Because the previous COP site had belonged to allied forces, and the generator was removed when those forces left, the unit was left without power for several days. VSP Walen Rabat had only one generator, which often went down, forcing the unit to go black at times. Equipment was installed at COP Takh Tek Pol and COP Edgerton to allow the use of back-up power. The OE Advisors provided equipment and installation to correct these issues.

4.3 Understanding the Roles and Responsibilities of OE Advisors

In Afghanistan, the shortage of uniformed energy informed personnel resulted in the utilization of contracted OE Advisors to provide the necessary technical expertise to both assess and implement power solutions at austere sites. The OE Advisors recommended changes to the power grid and integrated additional hybrid solutions to improve efficiencies thus reducing fuel demand and increasing availability of equipment. The OE Advisors possessed the knowledge and had access to REF distribution networks and Continental United States (CONUS) based logistics support to resource this effort.

REF initially deployed four (4) OE Advisors but quickly found that electricians were vital to making improvements on the numerous small outposts where power grids were in disarray or non-existent. Two (2) electricians were added to the deployment team to enable greater capability.

The U.S. Army Training and Doctrine Command Army Capabilities Integration Center (TRADOC/ARCIC) released a report in July 2013 that investigated the impact of both military and contractor OE Advisors. This report documented the positive results of both the REF deployed OE Advisors and the military operational energy advisor assigned to the 173rd Airborne Brigade Combat Team and recommended "the Army continue to provide OE Advisors while establishing enduring solutions to the Brigade Combat Team (BCT) capability gap in planning and designing power generation and distribution for their outposts."[16]

The OE Advisor understands both non-material and material improvements that can be implemented. The impact the REF OE Advisors made ranged from re-wiring the power grid to save power and improve safety to installing and training soldiers on E2E equipment. There are efforts underway to make the OE advisor part of a military position.


OE Advisor trains soldiers at Mushan site.

Power and generator management training is currently under revision at TRADOC. This report reiterates the need to prioritize that effort based on observations in Afghanistan from 2011 to present. The average COP Mayor has not been properly trained on establishment of an efficient and secure tactical electrical power grid. Moreover, the most valuable engineer MOS Prime Power Production Specialists (21P) that are capable and trained on power distribution, are not organic to most units and were not available to travel to remote operating bases and village stability platforms. These capable soldiers did serve great value at larger base camps where brigade staffs resided. The Generator Mechanics (91D) remain the most common asset a small unit can leverage to ensure a safe and reliable and efficient electrical grid is established. Currently these assets are not fully trained but an aggressive TRADOC effort should alleviate that in Army 2020 formations.

[16] Energy to the Edge Theater Assessment Report, U.S. Army Training and Doctrine Command/Army Capabilities Integration Center (ARCIC), July 31, 2013.

5.0 Implementing Operational Energy

5.1 Non-Material Fixes

The E2E team found the most significant way to reduce energy was to consolidate loads on generators. This allowed removing unnecessary generators that were operating with low or close to no power load. In most cases, the team found the load on generators at 20-30%, well below the 80% recommended operating window.[17] The OE Advisors did not try to reduce demand by turning off soldier equipment, but instead changed the power layout, which was transparent to the user. Assessment of the sites was based on measured electrical loads and observation of available power. The sites were often improved by combining loads and taking generators off-line. In some cases, maintenance plans were developed to reduce maintenance on the generators. VSSA Delaram is an example of successful non-material improvements that saved 318 gallons of fuel a day by removing six (6) generators.


60kW generator with PDISE distribution.

Key Improvements:

1. **Right Sizing - Matched power generation to meet the power load by reconfiguring generators.** Generators are added to support individual systems that are sized to meet peak loads. Additionally, new units to the battlespace often bring their own power generation resulting in an abundance of power generation or large generators supporting unmatched loads. As a result, the generators are underutilized and will break down or have increased maintenance issues. This is often called "wet-stacking" a condition which occurs in engines when fuel is not completely burned. Many generators needed to be replaced due to underutilization. For example, at Sperwan Ghar, a commercial Marapco MP 450kW generator was providing only 61kW at peak demand.

2. **Power Distribution - Maximized the on-site spot generation by combining loads (or circuits/ lines) from one generator to another.** Power distribution equipment such as military varients Power Distribution Illumination System Electrical (PDISE) and MEP-DIS-R and

[17] "Operation Dynamo—power forward," www.army.mil, March 21, 2013.

commercial junction boxes were often on site but were not installed. By developing a power plant and incorporating power distribution, generators could be combined. This resulted in increasing the efficiency of one generator and using the other "underutilized" generator as a backup for the tactical operations center (TOC) or communication needs. Many sites were not equipped with backup generators which are critical. If a generator fails, all powered devices such as communications and camera systems are disabled.

3. **Training - Provided soldiers with a better understanding of site power requirements.** Training included understanding loads, power requirements, right sizing of generators, as well as set-up and operation of hybrid systems. At each site, the delegated soldier is "the power guy" tasked with generator operations/maintenance. Once trained, this solider could advise the command on possible issues or make recommended changes.

5.2 Material Fixes

The E2E team utilized material fixes that involved adding hybrid systems to augment a generator or provide stand-alone power. Because many systems are deployed with generators sized for peak loads, the generator is underutilized the vast majority of the time. Hybrid power systems are able to meet this peak demand and provide a constant load without wasting fuel. Hybrid systems tend to show the most promise because of redundant capability and can support larger power demands. Hybrid energy systems provide both primary and backup power, thus enabling power surety for critical assets.

The REF purchased several hybrid systems to install in theater. The next table shows the equipment and installation location. (Note: this table includes equipment that was moved from one site to another when a base closed and is not to provide system totals.) **Appendix B includes information on the Hybrid Power Systems installed by the E2E team.**

Moored REAP.

Equipment and Installation Location

Location	Solar Stik 360	Solar Stik 400	SS Patrol Pack	H-Series	T-Series (10kW)	T-Series (5kW)	FORGE 440	FORGE 510	WASP	Sundial
BAF-FSR location				powering FSR site						
BAF-TALS site North		power landing system								
BAF-TALS Site South		power landing system								
BAF-TF Dragon		power systems in TOC	power computer stack							
BAF-TF Falcon	power comms/ computer stack									
BAF-Weather Station North						power weather station				
BAF-Weather Station Mid		power weather station								
BAF-Weather Station South		power weather station			power weather station					
Camp Clark			power warm VSP site						power critical Coms	
Chapman		power REAP								
Deleram	power RAID			power GyroCam						power SEAHUTs
Fortress	power RAID						vehicle power			
Gambari		power REAP	power REAP video							
Giro	power RAID						vehicle power			

Location	Solar Stik 360	Solar Stik 400	SS Patrol Pack	H-Series	T-Series (10kW)	T-Series (5kW)	FORGE 440	FORGE 510	WASP	Sundial
Harrington Gate (Hairitan)			power camera system							
Heredia										power (2) TOC Bldgs
Jaghato	power radar system									
Justice	power RAID						vehicle power			
Khogyani		power RAID								
Lam	power RAID		charge vehicle batteries	power aid station			power guard site			
Leatherneck	power HIMARS									
Mazar-e-sharif- SOTF-E			power ITV and camera							power AID station
Maiwand	power RAID									
Mushan				power fire direction center						
NKC Kabal		power REAP								
Pasab	power RAID									
Snake Pit				power coms						
Tapagurhan - SOTF-E										power TOC
Thomas	power RAID									
Walton				power motar pit/ TOC						

5.3 Example Sites

As stated before, no two FOBs, COPs, JCOPs, VSPs, and VSSAs were alike. Every site was different depending on the mission, personnel, and equipment. And almost every site was constantly changing as some bases closed and some added personnel. There were several sites where the OE Advisor made tremendous impacts and some of these sites are outlined below. (Note: Appendix A contains a list of sites visited and the changes that were or were not implemented.)

SITE: VSSA Delaram

Problem: Excess power generation.

SOF soldier lays generator cable at VSSA Delaram.

Background: The E2E team first visited VSSA Delaram in October 2012. This was a small site of 105 personnel and a power load of 207kW. There were 13 generators that could generate 1400kW and were running anywhere from 875kW to 1000kW on a typical day. Fuel was delivered to this site by contractor trucks. Once delivered, an internal fuel trunk operated by SOF soldiers delivered fuel to 8 sites within the VSSA per day.

Solution: This site is an example of a site that benefited from both material and non-material changes. The E2E team developed a power plan to eliminate six generators. In refueling time alone, workload was reduced by 30 hours per week. This was done by installing one 400 AMP breaker panel and cables, which enabled the use of a single generator to power all loads. A maintenance plan was developed that reduced the maintenance team from 10 to 2 personnel. This site also benefited from hybrid/alternative energy systems. The Sundial solar panel system was added to power a training site with a TOC at the outskirts of the VSSA. The E2E team also recommended adding a Solar Stik 360 to power the RAID system and an H-Series to power the main Entry Control Point (ECP) with a small radar system.

SITE: COP Justice

Problem: Excess power generation and minimal energy security.

COP Justice.

Background: The E2E team assessed COP Justice in August 2012. COP Justice was powered by the ANA power grid, which left the U.S. forces in need of energy independence. There was 1270kW of power generating for a load of 180kW.

Solution: This site is an example of excess power generation, energy security needs and the use of hybrid systems. Changes were recommended to reduce the number of generators and E2E equipment was installed. The Solar Stik 360 was installed to power RAID towers and the FORGE 440 provided power to charge vehicle batteries.

SITE: ODA Shinwar

Problem: Improve energy security.

Power distribution terminal at ODA Shinwar.

Background: Shinwar was a location that was occupied by three distinct functional groups. These groups were U.S. Army, ANA, and SOF soldiers. The power grid had a main prime power plant consisting of two 500kW generators that powered most of the site and several groups of smaller generators (100-250kW) that augmented the main power grid where necessary. The Army unit was scheduled to leave and turn over their piece of the FOB to the ANA. The SOF unit that was staying at Shinwar would be provided power from the ANA controlled and serviced power generators. The SOF unit requested that E2E personnel provide power security and independence from the AFG power grid. This was presented as a power surety requirement. Additionally, the SOF unit requested additional power surety for ISR/Force protection platforms to augment power reliability.


Improper electical wiring at ODA Shinwar.

Solution: This site is an example of power surety. The solution was to install two 60kW TQG's to provide independent power for the SOF unit. First, the E2E team isolated the SOF power requirements to a different distribution panel. Next, the E2E team connected the two 60kW generators and an external bulk fuel tank. The two generators and fuel tank were located inside the SOF controlled area to allow exclusive control of a dedicated power source. The ability to draw power from the ANA controlled prime generators remained if that connection was desired. This provided the SOF unit with Power Surety.

SITE: Weather Station at Bagram Airport

Problem: Power needed at active airfield.


Weather station located at Bagram Airfield.

Background: The air stations are not able to be serviced because of close proximity to an active airfield. Fueling a system that consists only of a generator is not possible because regular servicing of these locations would hinder aircraft movement. A solution was needed to power the Tactical Automatic Landing System (TALS).

Solution: This site is an example that required a solution that would burn as little fuel as possible to limit the movement to and around the sites. These stations are required for the enhanced safety of all aircraft using the BAF Airfield in all weather conditions and required a hybrid system for power generation. The South Field received T-Series for the Primary Sensor Group, Mid Field received a Solar Stik 400 and the North Field received an T-Series with 5kW.

SITE: FOB Gambari

Problem: REAP system lost power.

Background: REAP is a critical aerostat that experienced frequent power outages and surges that destroyed tethers and cameras. The system was not operational 2 to 3 days every week due to these problems.


E2E Contractor trains solider to use SS Patrol Packs.

Solution: This site is an example of critical equipment powered by hybrid systems. In September 2013, the E2E team added hybrid power to provide primary power to the REAP platform. The Solar Stik 400 was installed to provide reliable and continuous power. Without the clean power from the Solar Stik 400, the system would not fly. A Solar Stik patrol pack was added to act as the uninterrupted power supply (UPS) for video data during power loss. Before this installation, critical real time video from the REAP would be lost every time the power would go out. Now the video feed continues regardless of power outages.


REAP installation at FOB Gambari.

SITE: Camp Clark

Problem: Fuel limitations for solider missions.

Background: The E2E team traveled to Camp Clark in October 2013 to understand the 4/101st mission. The security environment required the unit is to occupy the VSP only during the day. The unit wanted alternative energy systems to power critical systems while occupying the site. Carrying fuel was not an option.


SS Patrol Packs at Camp Clark site.

Solution: This site is an example of an installation of alternative energy systems that were installed because additional fuel was not an option. The E2E team installed two (2) SS Patrol Packs and WASP systems. The patrol pack provides power for computers, radios and critical infrastructure. The WASP system provides emergency power with BA-2590 batteries and the ability to recharge batteries through solar panels.

SITE: Maiwand


3kW Hybrid Energy System, Solar Stik 360

Problem: Improve operational availability of force protection system.

Background: Force Protection systems such as the RAID are often the only visual presence the warfighter may have of the area. In the case of Maiwand, the site was surrounded by walls and the elevated camera system was the main ISR asset and was required to be operational at all times. Power was provided by a 100kWTQG which was sized to peak load to power other assets as well as the RAID and required constant refueling.

Solution: Installed a SS 360 with a 3 kW TQG to power the RAID tower which enabled the system to operate from the solar charged battery system, and to operate independent of the 100kW TQG. In addition to reducing the amount of refueling needed, this allowed the system to continue to function even if the TQG went down.

6.0 Major Concepts

6.1 Demand Reduction

What E2E team experienced:

The E2E team found a typical base is a mix of buildings and tents at most sites visited, with very little commonality. Sites had poor to no insulation, which only contributed to the high demand of Environmental Controls Equipment (ECUs). Most ECUs were commercial systems purchased on the open market.

What the E2E team accomplished:

While the E2E team did not install specific demand reduction items, the REF demonstrated energy efficient structures in Lite Camps at the Network Integration Evaluation (NIE) 13.2 and at the Army Expeditionary Warrior Experiments (AEWE). These Lite Camps received positive feedback from soldier use[18] and the REF will be deploying these base camps to sites around the world.

How to make these changes Army-wide:

Structures serve the purpose of providing space for the elements such as TOCs, dining and shower facilities, medical, fuel storage and life support operations. The power demand often has more to do with the structure itself then the equipment inside. For example, tents require the ECUs to work harder than if heating/cooling a rigid wall structure. Demand reduction can be implemented by adding insulation or other known construction guidelines. Items such as radiant barriers, tent quilts, solar flies and rigid insulation can improve energy efficiency or more efficient ECUs can be installed to reduce demand further.

6.2 Distribution

What E2E team experienced:

At most sites visited by the E2E team, there was no grid and no distribution network. There were some sections or several applications tied to one generator, but most sites were not wired

Breaker box at Talukan.

[18] U.S. Army Evaluation Center, "Army Expeditionary Warrior Experiment (AEWE) Spiral H Final Report," August 2013.

for distribution. Numerous generators ran at partial load to provide spot power to a specific platform. The generator loads at almost all sites were significantly operating under capacity, and the power distribution was not installed to allow for increased work loads on the generators. Distribution capability was further complicated by the existence of a few engineer or 91D assets being integrated into the force package, almost none were deployed to sites away from the primary FOBs.

What the E2E team accomplished:

REF efforts prioritized efficient grid emplacement via legacy Army systems like MEP-DIS-R, PDISE, affiliated cabling or commercially available panels, breakers and rugged wiring. The immediate result was better loading on generators which improved efficiency. The net result was less soldiers needed to maintain the generators and greater combat power for the small unit. Additionally, site fuel consumption decreased because generators were arrayed in a manner to maximize outputs. This resulted in increased longevity of the generators and provided greater energy security and operational availability.

How to make these changes Army-wide:

Focusing immediate efforts on installing electrical distribution, smart controllers and demand reduction systems will make the quickest impact. Creating distribution is the first step, and can be done using traditional panels, breakers and wire, and more importantly, it can be accomplished using equipment that is in the current military inventory. For example, at the tactical level there is equipment such as distribution boxes, MEP-DIS-R, and PDISE. Military distribution equipment is not the only way to create distributed power. Commercial panels, breakers and wire can also create an efficient and effective grid. Although there are cons to using commercial equipment, it does provide the essential components to optimize current military generators and may be necessary for later smart grid technologies.

The distribution effort validates changes underway in the 91D curriculum to expand distribution instruction. More distribution assets like PDISE and common cabling must be included in future procurements. Smart controls on generators to enable easy and reliable grid connectivity must be incorporated in all acquisition procurement efforts and these lessons track to the requirements discussed in the 2011 Tactical Electrical Power Capability Production Document.

6.3 Hybrid Power

What E2E team experienced:

The E2E traveled to many sites and found that not all sites would benefit from hybrid power solutions. Many hybrid solutions did not provide a sufficient amount of power to meet the total energy demands of a FOB, COP and most OPs. Hybrid systems provided the most benefit when integrated to a military TQG to reduce the amount of time a generator operated and enabled the backup power supply in the event a system did not have enough power. The hybrid systems had the best applications powering security systems such as RAID and the REAP aerostat.

What the E2E team accomplished:

The E2E team has considerable knowledge in installing hybrid power systems from 3kW (Solar Stik 360) and Zero Base 5kW T-series to the larger 18kW Sundial. Each system had benefits as well as limitations. The size of the solar panel systems required to meet energy demands requires very specific applications for hybrid technologies. The Sundial installed at Heredia was able to power the TOC and other buildings. The Solar Stik models operated successfully at many sites and powered smaller demands such as the RAID. Power density is a key driver in the effectiveness of specific technologies. **Appendix C includes summary charts of successful hybrid systems on the battlefield.**


Zero Base 5kW T-Series powering the North Weather Station on Bagram Airfield.

How to make these changes Army-wide:

The Army has initiated the MEHPS program that will provide hybrid systems as a POR beginning in 2018. These systems will augment military generators to use less fuel. However, many systems which use individual power generation would benefit from hybrid systems. Force protection systems should consider hybrid systems as part of the system design and deployment. As a result of the E2E efforts, aerostats are now being procured with hybrid power systems.

7.0 Impact on Operational Energy

7.0 Impact on Operational Energy


Solar panels installed at FOB.

OE has grown to a much broader and significant effort appropriately led by the Army's headquarter and staff elements. This broader approach to OE includes more substantive efforts with deliberate acquisition communities and science and technology elements resulting in a greater net effect in addressing deficiencies in tactical electric power distribution, reduced fuel consumption, more efficient space conditioning and in some cases reduced bulk water logistics. Part of this impact is reflecting these changes in training and doctrine.

7.1 TRADOC/COCOM

Priority of effort must be training of critical MOS and further instilment of an energy informed mindset in all soldier training and education efforts. Additionally the Army community should synchronize efforts resulting from the capability integration of cutting edge technologies. TRADOC experiments, RDECOM technology demonstrations and base camp integration efforts at Fort Leonard Wood, AEWE and NIE as well as exercises at National Training Centers should provide opportunities to assess the value of OE Teams and/or OE Advisors (91D, 12P, 120A) and material solutions in providing Commanders greater capability.


Solar panels at FOB being used to charge the batteries in a military vehicle.

7.2 Outreach

The REF understands that innovation often occurs outside DoD channels and has cultivated relationships with universities and other government agencies to continue to renew and rethink the OE landscape. The E2E team has been a critical piece in outreach efforts as the OE Advisors participated in discussing the challenges from their theater experience and perspective. By collaborating with industry and other government agencies, the REF understands the issues and solutions of OE. The REF sponsored several "NetZero at the Tactical Edge" workshops as follows:


Solar panels installed at FOB.

- **Arizona State University, February 13-14, 2012** – Senior DoD leadership participated in the workshop to articulate operational and tactical NetZero challenges through the use of operational vignettes. This provided an opportunity for industry to share current and future energy capabilities as well as present the obstacles in providing solutions to the DoD. The workshop brought together commercial, academic and government entities interested in developing and testing solutions related to green energy and sustainability for small FOBS.
- **Bechtel Conference Center (Stanford), September 26, 2012** – DoD announced key investments in the FY2013 budget request totaling $1.6 billion in OE initiatives. This workshop provided updates on current NetZero needs and challenges to present and discuss innovative solutions for energy integration. Together with industry, academia and the military, the workshop promoted awareness of the interdependencies between energy security and tactical operational effectiveness.
- **MIT Energy Conference, 28 February - 3 March, 2013 -** The best minds in academia gathered to discuss problems and potential solutions regarding energy on a global scale. Attendees participated in brainstorming sessions discussing a wide range of topics ranging from natural gas capture to islanding power in austere locations. The

E2E team introduced waste to energy for expeditionary and industrial settings as a topic to further explore. Participation of the REF E2E team brought the voice of the warfighter to enrich this forum on energy for help in developing viable solution in the future.

- **NREL, June 4-6, 2013 -** The REF E2E team explored a different approach to problem solving by organizing a workshop with IDEO – the company that is a leader in innovative solutions. In addition to IDEO training, the group had informative briefings from Col (R) Newell, past REF Commander, and Col (R) Charette, past and first USMC Expeditionary Energy Office (E2O) Commander. Both provided insights on what they would have done differently and where to focus future OE efforts.

Fuel truck filling canisters at FOB.

8.0 Operational Energy Changes to DOTMLPF

8.1 Doctrine

Doctrine should be updated to ensure the MTOE correctly reflects equipment that deploys with the units. In addition, field and technical manuals should be updated to account for current conditions. Planning for generator load management, power management, storage, and distribution should be incorporated into field manuals (FM) and technical manuals (TM), such as FM 5-424 Theater of Operations Electrical Systems and TM 5-811-1 Electrical Power Supply and Distribution.

8.2 Organization

Force enablers are part of the initial force package that arrives in the region but are often constrained in higher staff elements. Moreover, staffs need to understand how these elements are integrated into existing organizational structures. The lack of knowledge of power and energy capabilities is a direct result of the lack of unit training at National Training sites where tactical electric power grids and other sustainment drivers are assumed away for the sake of training focus or cost. Units that previously deployed understand the value of 91Ds and are more likely to include such elements.

OE Advisor trains soldiers to use a patrol pack.

8.3 Training

Broadening the Army generator mechanic, 91D skill set, to include more power distribution and understanding energy efficiency concepts is recommended. This will ensure Brigade Combat Teams (BCTs) have a safety net in leveraging Army or Service provided power generation. This would also allow integrating safer and more reliable distribution assets that might include COTS energy storage devices like simple batteries as well as solar or wind or other energy harvesting technologies that work in various regions.

PME certification for engineers in the 12P and 120A MOS should include basics of solar and alternative energy principles. These are mostly civilian certifications that can be folded into promotion benefit related training options the individual soldier can select based on Army goals.

New Equipment Training (NET) will always be a reality, whether provided by contractors or a government entity such as PM, REF, Force Provider, etc. The capacity to support and move assets to support training must be included in planning.

The best training possible is user level unit training during training cycle at home station. This training should include basic generator employment and maintenance procedures clearly defined in existing TQG manuals. Combat units often believe tactical power is a soldier level issue and will arrive in the AOR not understanding the link between base camp or vehicle platform and energy security when moving to dismounted operations. This seamless mindset of energy management can be promoted by helping to embody the mindset that every soldier is an energy steward versus a consumer.

8.4 Materiel

Solar panels installed at FOB.

The responsibility of the Joint program office, PM MEP, is to integrate more efficient small, medium and large tactical power sources such as new generators to augment existing TQGs. The REF, through rapid acquisition and the applied R&D stakeholders have enabled further evaluations of COTS/GOTS technologies on power generation platforms, efficient structures, water re-use equipment and other technologies at the soldier, vehicle platform and basing levels. Improving the mechanisms between the REF rapid acquisition initiatives and the PM level PORs will enable faster material upgrades.

Performance based contracting is one key enabler at base camps. Future force deployments will continue to require the establishment of logistics hubs and enduring semi fixed base camps whether squad, platoon, company, battalion, brigade or larger in size. LOGCAP and other contractor support will most likely be required to augment force strength caps in place for future military operations. Performance based contracting mechanisms can be integrated up front so contractors are rewarded for providing efficient structures, electrical grids, water re-use sites, etc.

8.5 Leadership and Education

Combat Commanders learned that tactical electric power, fuel and water logistics limits their reach, flexibility and ultimate combat power. Reducing the time an operator spends on generator maintenance and refueling will increase combat power. This is especially crucial at the small unit level at austere base camps because of reduced manpower. Practicing at home station the energy steward mindset required to ensure each bullet fired, each MRE consumed and each electron produced by a generator is used wisely. Energy steward education is starting within TRADOC but “train like we fight and fight like we train” will teach young troops that they must operate and excel in and off the grid.

OE advisor training soldiers to use solar panels at FOB.

8.6 Personnel

More efficient utilization of existing assets such as Army MOS 91D, 12P and 120A could be accomplished by adding duties for understanding and implementing energy efficiencies. Additionally, ensure these personnel are included during the initial deployments to properly set up and plan the power needs before deployments. In addition, the use of contractors, such as those deployed as OE Advisors, augment this capability.

8.7 Facilities

Leverage compliance mandated energy and water reduction investments at home station in CONUS by ensuring these investments may also be applicable to facilitating “energy steward training” for leaders and soldiers. Secondly, ensure LOGCAP structures and bases use efficient structures and technologies to enable demand reduction when moving to semi fixed nodes. Use performance based contracting to ensure contractors are rewarded for delivering less fuel or water.

9.0 Conclusions

9.0 Conclusions

1. **Continue to explore hybrid technologies.** Hybrid systems show the greatest potential for near term impact. While the E2E team was very successful in applying hybrid power system, future conflicts in different environments may not have the same result. Many of the solutions for renewables are being designed for the current threat and an open environment. That will not always be the case as arctic and triple canopy jungle may be future battlegrounds. An emphasis on other varieties of energy sources is critical.

2. **Focus future power systems to be automated with open architecture with the ability to control generators, parallel multiple sources, prioritize loads, and balance loads.** Smart grids are based on complex algorithms and controls. These controls are the basis for designing more efficient power grids and reducing some of the additional tasks of the warfighter.

3. **Reduce power demand.** None of the REF procured systems focused on demand reduction. Supply side is important, but demand reduction can be more cost effective and achieve similar results.

4. **Increase power density.** Power demand will not decrease, so in order to reduce weight, power density must be addressed. There have been recent advances in battery chemistry and thermal power management in the commercial arena. These advances need to be adapted for military application.

5. **Plan for energy efficiency in procurement.** Account energy and energy tracking into contracts. Focus on long term lifecycle costing when planning enduring operations.

6. **Incorporate power management into training facilities.** The National Training Center, Joint Maneuver Training Center, and the Joint Readiness Training Center need to incorporate power into training. Using OE issues in the training scenarios will better prepare warfighters with the skills to properly manage energy resources.

Mountain terrain in Afghanistan.

Appendix A:
Table of Sites

	Name	Survey Date	Actions	Equipment At The Site	Effects	Report
1	Baraki-Barak (BBK)	1/28/2013	Electrical/wiring issues including grounding and bonding issues.	Non- E2E equipment needed to correct safety issues.	Improved safety.	
2	BAF	Various Feb-August 2013	H-Series installed and operating FSR site.	H-Series w/10kW.	Implemented hybrid system to reduce fuel.	
3	BAF -TALS	12/6/2013	Power Tactical Landing System (TALS).	Two (2) SS 400 to power North and South sites	SS 400 used to power landing system at BAF airport	
4	BAF - TF Falcon	8/5/2013	Powering critical systems.	SS 400	SS 400 powering secure communications with aircraft and secure internet at the rotary PAX terminal	
5	BAF-TF Dragon	8/10/2013	Powering critical system in TOC.	SS 400 and SS Patrol Pack	Provided power surety and continued system operation.	
6	BAF-Weather Station (North, Mid and South Field)	8/6/2013	Difficult to provide power to this location because it would impact aircraft movement.	T-Series with 10kW ,two (2) SS 400 and H-Series with 5kW	Systems needed to enhance safety of aircraft movement.	
7	Belembai, ODA	8/17/2012	Initial assessment, pending E2E fixes.	Non-material fixes - removed excess power generation.	Fuel savings from removing generator. Decision made in August 2013 to not install E2E equipment due to OPTEMPO.	
8	Black	5/1/2013	Combined loads to reduce fuel.	Recommended transfer switch to combine loads but site was a DynCorp site at KAF.	Reduced fuel by 43 gallons per day.	
9	Boris	7/28/2012	Initial assessment, recommended no E2E fixes at this time.	FLUOR at this site, but will discussed with 1/101 for advice. Safety issues with exposed wires, excess power generation.	No changes made.	
10	Bowri Tana	7/23/2012	Initial assessment, recommended no E2E fixes, but Prime Power should rewire site.	Reevaluate for E2E fixes, After discussion with 3/101 taking over.	No changes made.	
11	Clark	10/3/2014	Solution needed for Warm VSP site.	Provided SS Patrol Pack and two (2) WASP to unit.	Provided power where generators are not an option.	

	Name	Survey Date	Actions	Equipment At The Site	Effects	Report
12	Chapman	1/17/2014	Sent SS 400 used at NKC Kabul to this site.	Installed SS 400.	Power REAP.	
13	Daman DC	10/28/2012	Non-material fixes made to combine generators.	Non-material fixes - removed excess power generation.	Saved 58 gallons per day.	
14	Delaram	10/2/2012	Non-material fixes made but additional fixes need E2E equipment.	Recommend adding one Sundial, one Solar Stik 360, and one H-series.	"Soft fixes implemented. Removed generators for a savings of 318 gallons per day."	
15	Delaram II	12/5/2012	Made improvements to power grid and water.	Requested parts to consolidate generators.	Moved equipment from Deleram to Deleram II.	
16	Edgerton	8/29/2012	Initial assessment, pending E2E fixes.	Required switches and additional generators. Will re-evaluate with electrician.	No changes completed due to closing.	
17	Fortress	4/18/2012	Initial assessment, pending E2E fixes.	Recommended SS to power RAID and a Forge for vehicle power.	No changes implemented.	
18	Gambari	3/28/2012 and 7/26/2013 and 10/4/2013	Site is maintained by FLUOR. Excess power but E2E systems needed.	SS 400 and Patrol Pack.	SS 400 installed for the REAP Aug 19, 2013. SS Patrol installed to power video feed for the REAP installed in Oct 2013.	
19	Giro	5/11/2012	E2E equipment installed and generators taken off line.	1-Forge, 5-SPACES, 1–Solar Stik 360, 1- Sky Case, 1- Sky Pak, H-series	Saved 107 gal/day with material and non-materiel solutions.	
20	Hairitan (Herrington Gate)	9/9/2012	E2E fixes installed Oct 2012 but SS Compact is not a good fit. Waiting for SS 400 installation.	Two (2) Solar Stik compacts.	Power cameras with SS Compact but SS 400 recommended.	
21	Heredia	10/2/2012	Provided power surety for TOC.	Sundial.	Sundial primary power for the two TOC buildings. Removed 16kW and saved 57 gal/day.	
22	Jaghato	8/2/2012	Pending E2E fixes.	SS 360 (173^{rd} assigned system).	SS 360 installed to power radar.	
23	Justice	8/11/2012	Initial assessment, E2E fixes installed Nov 2012.	1 – Solar Stik 360, 1- Sky Case (staying), 1 – FORGE	Installed Solar Stik to operate RAID tower and SPACES for soldier power. Improved reliability of cameras.	

	Name	Survey Date	Actions	Equipment At The Site	Effects	Report
24	Khenjakak	8/28/2012	Initial assessment, E2E soft fixes.	Non-material fixes - removed excess power generation.	Combined two 60 K loads onto one 60 K to remove one 60kW and save 43 gallons per day. Added safety fixes.	
25	Khogyani	9/4/2013	Powered RAID tower.	SS 400	Installed SS 400 to power RAID.	
26	Lakaray	9/11/2012	Powered RAID tower.	Recommended Solar Stik 360.	Install cancelled due to base closure.	
27	Lam	4/8/2012	Reassessment, E2E fixes installed Oct 2012.	1-H Series, 1-Forge, 1-Solar Stik 360, 1- Solar Stik Compact, 2-Sky Pack, 5 Spaces installed	Reduced fuel, added E2E equipment. Saved 107 gal/day	
28	Leatherneck	Various Feb-August 2013	Improved power surety.	SS 360	Installed SS 360 to power HIMARS and TOC critical communications.	
29	Lightning/Camp Destroyer	Various Sept-2013	Force Protection issues.	Recommended E2E systems.	No changes made.	
30	Maiwand	8/16/2013	Provided power surety for camera system.	SS 360	Installed SS 360 to power RAID tower.	
31	Mazar-e-sharif (SOTF-E)	8/12/2013	Provided power pack for ITV and camera. Sundial powered AID station.	SS Patrol Pack, Sundial.	Provided and installed generator for Sundial. SS Patrol Pack for radio frequency in-transit visibility(ITV) that feed data to the computer and central server.	
32	Moscall (Muskal)	2/14/2013	Excess power generation - pulled generators offline.	Non-material corrections implemented.	Removed 150kW and 10kW offline to save 404 gallons per day.	
33	Mether Lam	4/4/2013	Generator problems reviewed.	Repair Generators - ordered parts.		
34	Mushan	8/11/2012	Initial assessment, E2E fixes installed Oct 2012.	H-Series	H-Series to FDC. Pulled 10kW, added Power Surety (backup power to TOC) and saved 55 gals/day.	
35	NKC-Kabul	10/8/2013	Improved power surety.	Installed SS 400.	Powered REAP with SS 400.	
36	Panjwai	8/21/2012	Initial assessment, recommended no E2E fixes.	No changes.	Recommended improvements for refueling.	

	Name	Survey Date	Actions	Equipment At The Site	Effects	Report
37	Panjwai, OGA	8/23/2012	Initial assessment, pending possible E2E fixes.	Non-material corrections.	Recommended improvements for refueling.	
38	Pasab	6/28/2013	Improved camera system reliability.	SS 360 and T-Series.	Provided power surety for RAID.	
39	Penich	8/18/2012	Initial assessment, recommended no E2E fixes at this time but will re-evaluate.	No changes.	No changes recommended.	
40	Rushmore	7/24/2013	Numerous power issues identified.	No changes.	SS 360 needed to power RAID cameras. Power surety needed for TOC.	
41	Sabari	7/24/2012	Initial assessment (see equipment at site).	Re-evaluated for E2E fixes, after discussion with 3/101 taking over.		
42	SB Port (101st)	11/6/2013	Equipment recommended to power RFID reader and transmitter.	SS Patrol Pack.	Improved power surety.	
43	Shank (Tower Yard)	12/29/2013 to 1/29/2013	Towers wired to British standards because they will transition to the ANSF.	Recommended installing SS 360 for RAID towers.	SS 360 installed but missing UPS batteries.	
44	Shinkai/Sweeny	10/23/2012	Assessed excess power generation.	All power generators and maintenance is contracted out to DynCorp LOGCAP IV.	No changes recommended but excessive power generation.	
45	Shinwar	5/3/2013	Recommended SS 400 and provided power layout.	Developed a power plan and another contractor will install.	Recommended SS 400 installation but not yet installed.	
46	Snake Pit (KAF)	3/30/2013	10kW generator is powering communications. Recommended H-Series.	H-Series.	H-Series added to replace 10kW TQG.	
47	Sperwan Ghar	10/31/2012	Initial assessment completed and recommended return assessment.	Non-material fixes completed to combine generator load to remove excess power.	Generators added by unit and fuel consumption went up after unit replace 220kW generator with 450kW.	

	Name	Survey Date	Actions	Equipment At The Site	Effects	Report
48	Tagab	5/15/2013	Former ally site experienced black outs.	Recommended back-up generator and transfer switch and E2E equipment.	No changes due to site closing.	
49	Takh Tek Pol/CP2	9/23/2012	Power instability.	Recommended changes to improve power surety.	Parts not installed due to FOB closing.	
50	Talukan	8/15/2012	Initial assessment, pending E2E fixes.	Evaluating E2E fixes to charge batteries for mini gun.	Implemented safety issues. Stable, using USA Power but no solution available to power min gun.	
51	Tapagurhan-SOTF-E	10/3/2013	Initial assessment.	Sundial	Sundial provided power to TOC.	
52	Thomas	10/2/2012	E2E fixes installed.	SS 360	SS 360 needed to power GBOSS if integrated properly and replace wet stacking problems.	
53	Torkham	8/27/2012	Initial assessment, pending E2E fixes at OP.	FLUOR site but would benefit from sending Solar Stik compact.	No changes made.	
54	Walen Rabit	2/16/2013	Safety issues identified and back-up power needed.	Recommended power generation plan and changes.	ISI contracted to implement E2E plan but OE Advisor corrected safety issues.	
55	Walton	3/18/2013	Installed H-Series for power surety.	H-Series	H-Series added to replace 10kW TQG.	
56	Xio Haq (Ziohok)	8/17/2012	Excess power generation.	Non-material fixes to combine gen load to remove excess power.	Although E2E equipment would have benefited site, only non-material fixes were added saving 171 gal/day. ISI contracted in March 2013 to install E2E plan.	
57	Zerok	8/3/2012	Initial assessment recommended no E2E fixes at this time.	FLUOR fully engaged at this site and making changes.	No changes recommended.	

Legend:

Clickable link for additional site information.

Appendix B: Hybrid Power Systems

- Soldier Power Hybrid System WASP
- Hybrid Energy System Patrol Pak
- Hybrid Power System FORGE 440
- Hybrid Power System FORGE 510
- 3kW Hybrid Energy System Solar Stik 360
- 5kW Hybrid Energy System Solar Stik 400
- 5kW/10kW Hybrid Energy System T-Series 910 Model

Soldier Power Hybrid System WASP

Description:

The WASP provides the warfighter with a complete power system that is designed for both wearable (networked onto the Soldier's person) and spot-power applications such as command and control.

In a networked (wearable) application, it eliminates the need for the warfighter to carry spare batteries and multiple battery types. All of the battery-operated devices on the soldier are consolidated onto one network supported by a single "primary" 2590 battery.

Components:

- X-90 Power Manager
- BB 2590 Battery
- (1) pouch
- (2) 62w Solar Panel (CIGS)
- Optional accessories are selected in accordance with specific applications

Soldier Power Hybrid System, WASP

Specifications:

- Includes 2590 lithium battery
- "Opportunity Charger" allows power to be scavenged from multiple sources:
- 100-240VAC
- Solar
- 24VDC NATO
- Vehicle
- Scavenging from other (disposable) batteries commonly found in the field
- Interchangeable with the soldiers equipment
- Supports loads up to 120 watts
- Weighs less than 2 lbs. (including battery)

Hybrid Energy System Patrol Pak

Description:

- High-Efficiency power model - Power transfers in and out of the batteries only as necessary to keep the appliance loads operating.
- Open Architecture allows multiple sources of power generation which can simultaneously support/charge the battery and ensure uninterrupted power.
- Portable, Modular System – Capabilities can be scaled, added or removed according to the specific mission requirements.
- Intuitive operation with "Plug & Play" setup.

Components:

- 1 – Mil-Series 24VDC Power Pak 1000
- 1 – Mil-Series 24VDC Expander Pak
- 4 – 90W Amorphous Silicone Solar Panels
- 1 - PRO-Verter 2400
- 1 – Set of cables

Hybrid Energy System, Patrol Pak

Specifications:

- Three-case solution
- PRO-Verter 2400 provides up to 2400 Watts of power at 120VAC/60Hz
- 360W flexible solar power generation
- 2kW-h energy storage (batteries)
- Field serviceable
- Area: 10-200 Sq ft

Hybrid Power System FORGE 440

Description:

Forward Operating Renewable Generator (FORGE): ruggedized mobile and transportable Hybrid Power System manages solar/battery power to provide uninterrupted power to replace or augment fossil fuel generators.

- Batteries charge from various sources (AC, DC & Solar).
- Reduces daily fuel consumption to power a generator and overall generators in a COP/VSP/JCOP.
- Powers AC and DC items using 120V AC, 12 or 24V DC, USB, or NATO slave outlets.
- Replaces 3 kW TQG for many applications.
- Compatible with 1-3 kW generators (1kW and 2kW flex fuel and 3kW).

Components:

- 1 - AC module
- 1 - DC module
- 1 - Battery module with (2) lithium ferrous phosphate
- 3 - Solar panel modules (6 solar panels)
- 1 - Cable box with cables

Hybrid Power System, FORGE 440

Specifications:

- Rated Power: 2.4 kW
- Surge Power: 4.8 KVA
- Weight: DC module 124 lbs, AC module 128 lbs and battery module 208 lbs
- DC module: 5, 12, and 24 VDC outlets and NATO slave
- AC module: 120 V, 60 Hz (20 A)
- Battery module: (2) 3.9 kWh lithium ferrous phosphate batteries
- Solar module: (6) 258 watt panels

Hybrid Power System FORGE 510

Description:

Forward Operating Renewable Generator (FORGE): ruggedized mobile and transportable Hybrid Power System manages solar/battery power to provide uninterrupted power to replace or augment fossil fuel generators.

- Batteries charge from various sources (AC, DC & Solar).
- Reduces daily fuel consumption to power a generator and overall generators in a COP/VSP/JCOP.
- Powers AC and DC items using split phase 240 VAC, 12 or 24 VDC, USB, or NATO slave outlets.
- Replaces 3 kW TQG for many applications.
- Compatible with 2-5 kW generators.

Components:

- 1 - AC module
- 1 - DC module
- 1 - Battery module with (2) lithium ferrous phosphate
- 3 - Solar panel modules (6 solar panels)
- 1 - Cable box with cables

Specifications:

- Rated Power: 3.6 kW, 20 Amps
- Surge Power: 4.8 KVA
- Weight: DC module 124 lbs, AC module 192 lbs, and battery module 208 lbs
- DC module: 5 and 12 VDC outlets, NATO slave
- AC module: 120/240 VAC, 60 Hz
- Battery module: (2) 3.9 kWh lithium ferrous phosphate batteries
- Solar Module: (6) 260 W

Hybrid Power System, FORGE 510

3kW Hybrid Energy System Solar Stik 360

Description:

- Hybrid Energy System that uses batteries as the main source of power in a closed loop circuit.
- High-Efficiency power model - Power transfers in and out of the batteries only as necessary to keep the appliance loads operating.
- Open Architecture allows multiple sources of power generation which can simultaneously support/charge the battery and ensure uninterrupted power.
- Portable, Modular System – Capabilities can be added or removed according to the specific mission requirements.

Components:

- 3 – 360w arrays
- 1 – DC Power Hub
- 10 – Expander Paks (24VDC batteries)
- 1 – PRO-Verter APM 3000 AGS
- 1 – Power Distribution Module (PDM)
- 1 - Set of cables
- 1 – MEP-831A 3kW TQG modified with auto start kit

3kW Hybrid Energy System at FOB Pasab, Solar Stik 360

Specifications:

- PRO-Verter 3000 provides up to 3000 Watts (Generator) of power at 120VAC/60Hz and 24VDC (Inverter 1800w)
- Power Hub (processes up to 300A from all DC sources including vehicles, wind, fuel cell and solar)
- PDM provides USB, 12VDC CLA, and 24VDC
- Automatically controls TQG, start-stop & load levels
- 1.08kW solar power generation
- 10kW-h energy storage (batteries)
- Doubles the continuous hours for one fuel load of a 3kW generator from 10 hours to 20 hours
- Field serviceable
- Area: 300-500 sq ft footprint

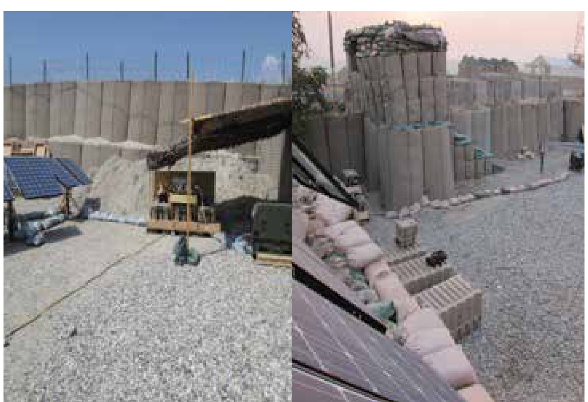
5kW Hybrid Energy System Solar Stik 400

Description:

- Hybrid Energy System that uses batteries as the main source of power in a closed loop circuit.
- High-Efficiency power model - Power transfers in and out of the batteries only as necessary to keep the appliance loads operating.
- Open Architecture allows multiple sources of power generation which can simultaneously support/charge the battery and ensure uninterrupted power.
- Portable, Modular System – Capabilities can be added or removed according to the specific mission requirements.

Components:

- 3 – 400w arrays
- 1 – DC Power Hub
- 12 – Expander Paks (24VDC batteries)
- 1 – PRO-Verter APM 5000 AGS
- 1 – Power Distribution Module (PDM) Plus
- 1 - Set of cables
- 1 – MEP-831A 3kW TQG modified with auto start kit



5kW Hybrid Energy System, Solar Stik 400

Specifications:

- PRO-Verter provides up to 4,800 watts of power available in multiple forms, including 120VAC/60Hz and 24VDC
- Power Hub (processes up to 300A from all DC sources including vehicles, wind, fuel cell, solar)
- PDM provides USB, 12VDC CLA, 24VDC, and 120VAC output
- Automatically controls TQG, start-stop and load levels
- 1.2kW solar power generation
- 12kW-h energy storage (batteries)
- Doubles the continuous hours for one fuel load of a 3kW generator from 10 hours to 20 hours
- Field serviceable
- Area: 300-500 sq ft footprint

5kW/10kW Hybrid Energy System T-Series 910 Model

Description:

T-Series hybrid power systems eliminate or significantly reduce generator fuel consumption and running time. The hybrid system uses multiple power sources to provide operational continuity, extend the fuel supply, and operate silently.

- Integrated with 5kW or 10kW TQG.
- Connect multiple units using NATO slave to increase battery size and power generation.
- Up to 3,000 watts of solar power using integrated or mobile arrays.
- Onboard event logging and storage. Configured for remote monitoring and management.
- In-field switching between single phase or three phase power.

Components:

- 1 - T-Series trailer
- 1 – 5kW or 10kW Generator with auto start
- 1- Set of cables (Gen, Solar & Battery)
- 12 – Lead acid batteries (6 strings of 2)
- 3 - Solar module cases (6 x 258w solar panels)

5kW/10kW Hybrid Energy System, T-Series 910 Model

Specifications:

- Max rated power: 5kW system – 4800w 10kW system – 10kW using 3 phase power
- 1.5kW Solar power generation (up to 3kW)
- Weight: 3820 lbs
- DC Service: 5, 12, and 24 VDC
- DC Outlets: 5V USB-A, 12 V SA, and NATO slave
- AC Service: Single-phase 120/240 VAC, 60 Hz or Three-phase 120/208/240 VAC, 60 Hz
- AC Outlets: (2) 120/240 VAC (20 Amp)
- 28 kWh energy storage (VRLA)

Appendix C: Hybrid Power Systems On the Battlefield

- Support to Weather Station
- Support to Aircraft Landing
- Support to Aerostats
- Support to RAID, Khogyani
- Support to RAID, Pasab

Support to Weather Station

Tactical Problem:

Weather stations are required for the enhanced safety of all aircraft using the airfield in all weather conditions. These stations are unable to be serviced due to the close proximity of an active airfield. Fueling a system that consist only of a generator is not possible because regular servicing of these locations would hinder aircraft movement and reduce the number of missions.

Weather stations powered by a 10kW Hybrid Solution.

Implementation:

OE Advisors installed a 3kW, 5kW and 10kW hybrid power solutions providing tailored reliable power to the weather stations. The systems included a TQG with auto start, solar panels for renewable capability and battery storage.

Weather station powered by a 5kW Hybrid Solution.

Feedback:

"This power provided by the REF will solve a near impossible and costly power production situation for 3 weather stations for Joint Forces aircraft flying into [the airfield]... The system will also provide redundancy for this mission critical weather system that would have been unavailable before."

- 455 AEW Executive Officer

Support to Aircraft Landing

Tactical Problem:
Tactical Aircraft Landing Systems (TALS) are required for the safe landing of weaponized UAVs. Due to the close proximity of active runways, servicing and refueling of traditional power generation puts potentially dangerous limitation on an imperative system. Without these landing systems operational, aircraft are unable to fly.

Implementation:
OE Advisors installed a 3kW hybrid power solution providing reliable power requiring minimal sustainment and maintenance to the TALS. The systems included a TQG with auto start, solar panels for renewable capability and battery storage.

Feedback:
These systems have been operating on 90% solar harvested power with very little generator run time. This solution has made a reliable hands-off power source requiring minimal sustainment. The unit has been very satisfied with the operational performance of the TALS with the hybrid power solution.


Aircraft Landing System.


3kW Hybrid Power Solution.


3kW Hybrid Power Solution.

Support to Aerostats

Tactical Problem:
The current power generation system is not compatible with the REAP aerostat system. The system experiences frequent power outages and surges that burned up two tethers and a camera. This resulted in a reduced operational rate for the REAP which degraded the COPs force protection posture and increased vulnerability. Prior to the OE Advisors assessment, the REAP was down approximately 2-3 days a week due to power related issues.


REAP Aerostat System.

Implementation:
OE Advisors installed a 3kW hybrid solution providing clean reliable power to the REAP. The system included a TQG with auto start, solar panels for renewable capability, and battery storage. Operators were trained on installation and preventative maintenance techniques.


3kW Hybrid Power Solution.

Feedback:
In the 4 months since the installation of the Hybrid System onto the REAP it has had zero power issues. On average the 3kW generator is only operated about 1.5 hours a day. The REAP is not only a ISR platform but a deterrent which the enemy has come to fear. With no power issues the system only needs to come down for routine maintenance and weather.


3kW Hybrid Power Solution.

Support to RAID, Khogyani

Tactical Problem:
SOF units in an austere location were using 850-1000 gallons of fuel a day just between two locations. Every gallon consumed had to be delivered by helicopter. The logistics required to manage fuel and service the generators placed a severe strain on the valuable time and resources of the special operators.


3kW Hybrid Solution.

Implementation:
OE Advisors installed a 3kW hybrid power solution providing reliable, efficient power to an important ISR Platform which reduced both fuel and soldier man hours required of sustainment in an austere environment. The system included a TQG with auto start, solar panels for renewable capability, and battery storage.


RAID Camera System.

Feedback:
The unit was very impressed that in just 3 hours of meeting with the team leadership and surveying the power situation on the ground REF OE Advisors had devised a 4-step plan that showed the unit how to cut their fuel consumption by 60%. **This reduction would result in at least 4 fewer helicopter resupply missions per week** to the location.

Support to RAID, Pasab

Tactical Problem:

The primary source of power generation was a 5kW TQG that was running 24/7 requiring a soldier to add ten (10) gallons of fuel to the holding drum daily. Additionally, the lack of redundant power production and storage capability increased risk to the outpost during system failure or required maintenance down time. Maintenance was scheduled every 3 weeks due to the operating hours (500).


RAID Camera System.


3kW Hybrid Solution.

Implementation:

OE Advisors installed a 3kW hybrid power solution providing reliable, efficient power to an important ISR Platform which reduced both fuel and soldier man hours required of sustainment in an austere environment. The system included a TQG with auto start, solar panels for renewable capability, and battery storage.

Feedback:

	Fuel (9 month)	Maint. Time
Before	2,520 gal	13 hrs
Realized	864 gal	2 hrs
Savings	1,656 gal	11 hrs

Acronyms & Additional Site Information

Acronyms

10L	10 Liner
AEWE	Army Expeditionary Warrior Experiments
AMSAA	Army Material Systems Analysis Activity
ANA	Afghan National Army
ANP	Afghan National Police
AOR	Area of Responsibility
ARCIC	Army Capabilities Integration Center
ASD	Assistant Secretary of Defense
BAF	Bagram Airfield
BCT	Brigade Combat Team
CERDEC	US Army Communications Electronic Research Development and Engineering Center
CJSOTF-A	Combined Joint Special Operations Task Force Afghanistan
CONUS	Continental United States
COP	Combat Outpost
COTS	Commercial-Off-the-Shelf
DLA-E	Defense Logistics Agency - Energy
DOTMLPF	Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, Facilities
DoD	Department of Defense
E2E	Energy to the Edge
E2O	Expeditionary Energy Office
ECP	Entry Control Point
ECU	Environmental Control Unit
FM	Field Manuals
FOB	Forward Operating Base
FORGE	Forward Operating Renewable Generator
GOTS	Government-Off-the-Shelf
JCOP	Joint Combat Outpost
JCTD	Joint Capability Technology Demonstration
JTF	Joint Task Force
KAF	Kandahar Airfield
kW	Kilowatt
kWh	Kilowatt-hour
LOGCAP	Logistics Civilian Augmentation Program
MEHPS	Mobile Electric Hybrid Power System

MEP-DIS-R	Mobile Electric Power Distribution Replacement
MOS	Military Occupational Specialty
MRE	Meal Ready to Eat
MTOE	Military Units Table of Organization and Equipment
MW	Megawatts
NET	New Equipment Training
NIE	Network Integration Evaluation
OE	Operational Energy
OEPP	Operational Energy Plans and Programs
ODA	Other Defense Activity
OGA	Other Government Agencies
OP	Observation Post
ONS	Operational Needs Statement
OSD	Office of Secretary of Defense
PDISE	Power Distribution Illumination System Electrical
PME	Professional Military Education
PM MEP	Program Manager Mobile Electric Power
POR	Program of Record
PRT	Provincial Reconstructive Team
PSTF	Power Surety Task Force
RDECOM	Research, Development, Engineering Command
REF	Rapid Equipping Force
RFAST-C	Research, Development and Engineering Command's Field Assistance in Science and Technology Center
SOF	Special Operations Forces
TALS	Tactical Automatic Landing System
TRADOC	U.S. Army Training and Doctrine Command
TOC	Tactical Operations Center
TM	Technical Manual
TQG	Tactical Quite Generator
USFOR-A	United States Forces – Afghanistan
UPS	Uninterrupted Power Supply
VSP	Village Stability Platform
VSSA	Village Stability Sustainment Activities

Additional Site Information

Baraki-Barak (BBK)	https://s3.amazonaws.com/ref.barbaricum.com/BarakiBarakReport.pdf
Belembai, ODA	https://s3.amazonaws.com/ref.barbaricum.com/BelembaiResurvey.pdf
Black	https://s3.amazonaws.com/ref.barbaricum.com/CampBlackReport.pdf
Boris	https://s3.amazonaws.com/ref.barbaricum.com/COPBorisReport.pdf
Bowri Tana	https://s3.amazonaws.com/ref.barbaricum.com/BowriTanaPP.pdf
Chapman	https://s3.amazonaws.com/ref.barbaricum.com/FOBChapmanPP.pdf
Daman DC	https://s3.amazonaws.com/ref.barbaricum.com/COPDamanDCReport.pdf
Delaram II	https://s3.amazonaws.com/ref.barbaricum.com/Delaram2Report.pdf
Edgerton	https://s3.amazonaws.com/ref.barbaricum.com/COPEdgertonReport.pdf
Fortress	https://s3.amazonaws.com/ref.barbaricum.com/COPFortressReport.pdf
Gambari	https://s3.amazonaws.com/ref.barbaricum.com /FOBGambariReport.pdf
Giro	https://s3.amazonaws.com/ref.barbaricum.com/COPGiroReport.pdf
Hairitan	https://s3.amazonaws.com/ref.barbaricum.com/JCOPHairintanReport.pdf
Justice	https://s3.amazonaws.com/ref.barbaricum.com/COPJusticeReport.pdf
Khenjakak	https://s3.amazonaws.com/ref.barbaricum.com/COPKhenjakakReport.pdf
Lakaray	https://s3.amazonaws.com/ref.barbaricum.com/COPLakarayReport.pdf
Maiwand	https://s3.amazonaws.com/ref.barbaricum.com/DSSPMaiwandReport.pdf
Moscall	https://s3.amazonaws.com/ref.barbaricum.com/FOBMoscallReport.pdf
Mether Lam	https://s3.amazonaws.com/ref.barbaricum.com/VSPLAMReport.pdf
Mushan	https://s3.amazonaws.com/ref.barbaricum.com/COPMushanReport.pdf
Panjwai	https://s3.amazonaws.com/ref.barbaricum.com/VSSAPanjwaiReport.pdf
Panjwai, OGA	https://s3.amazonaws.com/ref.barbaricum.com/COPPanjwaiDistrictHQReport.pdf
Pasab	https://s3.amazonaws.com/ref.barbaricum.com/FOBPasab.pdf
Penich	https://s3.amazonaws.com/ref.barbaricum.com/COPPenichReport.pdf
Rushmore	https://s3.amazonaws.com/ref.barbaricum.com/FOBRushmorePP.pdf
Sabari	https://s3.amazonaws.com/ref.barbaricum.com/JCOPSabariPP.pdf
Shank (Tower Yard)	https://s3.amazonaws.com/ref.barbaricum.com/FOBShankTowerYardReport.pdf https://s3.amazonaws.com/ref.barbaricum.com/FOBShankReport.pdf
Shinkai/Sweeny	https://s3.amazonaws.com/ref.barbaricum.com/COPSweeneyShinkaiReport.pdf
Shinwar	https://s3.amazonaws.com/ref.barbaricum.com/ShinwarReport.pdf
Snake Pit (KAF)	https://s3.amazonaws.com/ref.barbaricum.com/SnakePit120thReport.pdf
Sperwan Ghar	https://s3.amazonaws.com/ref.barbaricum.com /COPSperwanGharReport.pdf
Tagab	https://s3.amazonaws.com/ref.barbaricum.com/COPTagabReport.pdf
Takh Tek Pol/CP2	https://s3.amazonaws.com/ref.barbaricum.com/COPTakhTekPolReport.pdf

Talukan	https://s3.amazonaws.com/ref.barbaricum.com/VSPTalukanReport.pdf
Torkham	https://s3.amazonaws.com/ref.barbaricum.com/COPTorkhamReport.pdf
Walen Rabit	https://s3.amazonaws.com/ref.barbaricum.com/VSPWalenRabatReport.pdf
Xio Haq (Zihock)	https://s3.amazonaws.com/ref.barbaricum.com/COPZiohokReport.pdf
Zerok	https://s3.amazonaws.com/ref.barbaricum.com/COPZerokReport.pdf

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