Strategy Research Project

The Other Operational Power: Electricity on the Battlefield

by

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United States Army

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Abstract

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The U.S. Army's propensity to solve tactical problems through advances in high-technology solutions has created an increased requirement for electricity on the battlefield. For example, the largest portion of fuel used by a Stryker Brigade Combat Team in the tactical environment (36%) is used to generate electrical power in support of technology solutions, which is more fuel than used to supply ground vehicles or aviation. Congress, concerned with the strategic vulnerability of fuel supplies, has mandated the Army and other services reduce fuel requirements through efficiencies and the development of alternative energy sources. The U.S. Army has responded by increasing the energy efficiency of systems and platforms but has not addressed the doctrine or training shortfalls, which contribute to the lack of awareness among leaders and Soldiers of how wasted electricity could affect operations, budgets and lives.

The Other Operational Power: Electricity on the Battlefield

The adversary's use of indirect fire (IDF) from artillery or mortars has been one of the greatest casualty-causing and fear-producing weapons facing the American Armed Forces on the battlefield for the last 100 years and, until the very recent development of the United States (U.S.) Army's High Energy Laser Mobile Demonstrator (HEL MD), virtually impossible to interdict. The U.S. Army's HEL MD is a, a high-energy weaponized laser which destroys incoming IDF providing Soldiers protection from artillery and mortar attacks for the first time in history.

The Army successfully tested the HEL MD in 2013 engaging and destroying over 90 60mm mortar rounds and several drones.[1] The HEL MD's 10-kilowatt laser, acquisition and tracking sensors, its high capacity lithium-ion batteries to power the laser and a 60-kilowatt generator to charge the laser's batteries and run ancillary equipment, are mounted on the ubiquitous Heavy Expanded Mobility Tactical Truck (HEMMT). Eventually, the Army will upgrade the HEL MD laser to 100-kilowatts, a tenfold increase, which will enable the system to shoot down artillery rounds, cruise missiles or even airplanes. Viewed on a per shot basis, it will cost pennies worth of electricity to fire, require no delivery of heavy or bulky wooden ammunition crates and the system only needs two operators; eventually it may even become autonomous. However, while the benefits of this system protects Soldiers 24 hours a day, seven days a week, it requires a large, uninterrupted supply of electrical power.

The HEL MD is an example of other potential future high-energy systems. Instead of using a projectile launched from a gun barrel and propelled by gunpowder, this weapon uses only electrical energy. This electricity is produced predominantly by power generators using liquid fuel that has logistical as well as operational implications.

The Department of Defense's (DoD) Operational Energy Strategy notes, "rising military consumption of energy is a challenge for the core DoD national security mission. The Department needs to reduce the overall demand for operational energy and improve the efficiency of military energy use in order to enhance combat effectiveness and reduce risks and costs for military missions."[2] Not only is the need for energy reduction not yet fully recognized or appreciated by U.S. forces at the tactical or operational levels but also the policy for reduced fuel consumption will conflict with the anticipated operational need for increased requirements for electricity.

The HEL MD is an illustration of the U.S. Army's deepening reliance on electrical power. However, U.S. Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) systems, weapons, sustainment and medical systems are already dependent on electrical power to function. Although the U.S. Army has not historically tracked the electrical power requirements to operate in combat, its propensity to develop technical solutions to tactical problems has led to an increase in requirements for electricity across the Army warfighting functions. It is safe to assume this trend will continue as warfare becomes more technology based.

The vast majority of our electrical power generation equipment uses fossil fuel. The electrical power generators in a Stryker Brigade Combat Team use more fuel than any other activity in a tactical situation accounting for 36 percent of all fuel used on the battlefield in 2011 (comparatively aviation used 30 percent and ground vehicles used 24 percent).[3] Congress, recognizing the strategic vulnerability of our fuel supply, mandated the Army and other services reduce dependence on fossil fuel through conservation and alternate energy production methods. To better manage power production and distribution at the tactical level and meet increasing requirements for electrical energy with today's power generation technology, while simultaneously complying with the congressional mandate to reduce reliance on fossil fuel, the Army must address how it equips, trains and operates.

Electrical Power Generation Defined

Electricity is a form of power that the Army predominantly produces through some means of mechanical or chemical generation. Electrical power, a subset of operational energy, is the mechanically produced, observable energy we use to make our various systems operate. Joint Publication (JP) 1-02 defines Operational Energy as, "The energy required for training, moving, and sustaining military forces and weapons platforms for military operations."[4] A definition for Operational Energy is not included in Army Doctrine Reference Publication (ADRP) 1-02 which is the fundamental document describing what the Army has determined to be keys to success on the battlefield. However, the Army uses the JP 1-02 definition in its doctrinal publications and expands the definition to include water production and waste disposal.[5] Electrical power production is included in this definition through implication of the word "energy"; electricity, predominantly created using liquid fuel such as Jet Propellant (JP) 8 or gasoline, is required to operate and sustain combat systems.

Why Electrical Power Matters at the Tactical Level

The HEL MD is a weapon system relying entirely on the use of electricity rather than gunpowder to achieve an effect. However, this system, currently at 10-kilowatts, is only an example of how we are becoming increasingly reliant on electricity. All modern command post information systems, which enable Mission Command, C4ISR, many weapons' ancillary equipment and sustainment functions all, require electrical power to operate. Virtually all electricity for field-deployed systems is produced by mechanical power generators using liquid fuel. Delivering fuel has significant cost in people, combat power and money. Historically, the availability of electrical power has very rarely been a concern for tactical organizations. This is because when the proponents of a given Table of Organization and Equipment create authorization documents, they take great care to ensure a sufficient number of power generators are included to provide the requisite amount of electricity required to run all assigned equipment. Even our vehicles have evolved to include larger and larger engine mounted alternators or generators to run the myriad of on board systems such as radios, global positioning systems, various sensors and the Force XXI Battle Command Brigade and Below (FBCB2). So if it is as easy as adding another or larger power generator, why should we care about the increase in production of electricity? Today, almost all the electricity we tactically produce and use is generated using liquid fuel. Whether this electrical power is made by a trailer mounted generator outside the Tactical Operations Center or by idling vehicle engines to run onboard systems it is still liquid fuel making that electricity. That liquid fuel, usually JP-8, must be strategically positioned and then tactically transported by convoy to the point of use, sometimes on hostile or semi-secured roads and escorted with the appropriate level of combat power to ensure the safety of the vehicle crews and their valuable cargo.

In 2009, the Army Environmental Policy Institute produced a study on the casualties associated with fuel and water convoys in Iraq and Afghanistan; what they found was that the equivalent of about a company's worth of Infantry (132 people) were killed or wounded delivering fuel in Iraq in 2007.[6] This study was the result of an Urgent

Operational Needs Statement in 2006 by Major General Richard Zilmer, United States Marine Corps, who said, “By reducing the need for Class III resupply (petroleum) at our outlying bases, we can decrease the frequency of logistics convoys on the road, thereby reducing the danger to our Marines, Soldiers, Sailors and Airmen.”[7] The study first estimates the number of resupply related casualties from data provided by the Center for Army Lessons Learned. Then the Army Deputy Chief of Staff for Logistics, G4, provided the relative proportions of convoys by class of supply: about 50 percent of convoys were for petroleum, 20 percent of convoys were carrying water and the remaining 30 percent were for other classes of supply. The study then proportionally estimated the number of casualties based on number of convoys multiplied by the percentage of commodity. In 2007, there were 263 total casualties for resupply convoys in Iraq. About 50 percent of convoys were dedicated to fuel so there were roughly 132 casualties in Iraq delivering fuel in 2007.[8] Very frequently, studies determine the cost of items or procedures in dollars where this study determined the cost of delivering fuel in lives. This study determined the human cost of fuel delivery was relatively high even in a semi-permissive environment.

In addition to the human cost of delivering fuel, there is also a cost in combat power. In most tactical environments, a certain number of armed vehicles and personnel escort resupply convoys to ensure the convoy can arrive intact at its intended destination. Training Circular 4-11.46, Convoy Protection Platform Gunnery, dictates a gun truck to protected vehicle ratio of one gun truck for every five vehicles in the convoy.[9] Of course, the tactical situation will dictate the actual number but this can be a platoon or more of Military Police or Infantry dedicated to the defense of the convoy.

These resupply convoys can take anywhere from a couple of hours to several days to complete thereby preventing the escorts use in direct action against the enemy. In addition, any number of enabling forces such as engineer route clearance elements, armed aerial escorts, dedicated close air support and electronic warfare and Intelligence, Surveillance and Reconnaissance platforms might be dedicated in support of resupply operations. Ideally, these types of limited assets are better-used supporting offensive actions against an enemy rather than defensive actions in support of convoys but are necessary to ensure the protection of fuel resupply operations.

Finally, there is the actual cost of the fuel itself used to produce electrical power. The price per gallon of fuel the U.S. Government pays is not the same price at the local corner store. Studies show the price per gallon of delivered fuel is significantly higher than the cost of the fuel itself. By taking into account all the actions that must occur to deliver a single gallon of fuel, we derive what Congress calls the fully burdened cost of fuel. The FY 2009 Duncan Hunter National Defense Budget Authorization Act (NDAA) defined the fully burdened cost of fuel as, "the commodity price for fuel plus the total cost of all personnel and assets required to move and, when necessary, protect the fuel from the point at which the fuel is received from the commercial supplier to the point of use."[10] The Congressional Research Service noted in 2012 that the fully burdened cost to deliver fuel to remote locations in Afghanistan was up to $45 per gallon depending on where it was going and the delivery method used.[11] Using these numbers, the price of replacing fuel in a single destroyed 5,000 gallon fuel tanker could cost up to $225,000 not including the cost of the truck and tanker trailer. Compounding the cost in dollars is the additional cost in total volume of fuel required just to move fuel. Estimates are it takes about 1.4 gallons of fuel to deliver one gallon of fuel to the end user.[12] That equates to 7,000 gallons of fuel per 5,000 gallon delivery; meaning it takes a total of 12,000 gallons to fill a user's 5,000 gallon requirement at the point of use. This shows the actual cost in dollars of fueling our power generators and vehicles producing electricity to power our operations is quite a bit higher than most people realize. These facts, taken together, show why commanders should care where our tactically produced electricity comes from because the liquid fuel making it possible costs lives, combat power and a significant amount of money.

Congressional Actions Affecting Energy Use

Much of what the Army is doing to reduce reliance on liquid fuel produced electricity has its roots in Public Law. The U.S. Congress has recognized how critical energy has become to our military and have incorporated operational energy in no less than five laws passed since 2007. The John Warner NDAA was the first piece of legislation requiring the DoD to take measures to decrease fuel requirements in the Services. It explicitly states, "It shall be the policy of the DoD to improve the fuel efficiency of weapons platforms, consistent with mission requirements, in order to (1) enhance platform performance; (2) reduce the size of the fuel logistics systems; (3) reduce the burden high fuel consumption places on agility; (4) reduce operating costs; and (5) dampen the financial impact of volatile oil prices."[13] Further, this law amended Title 10, U.S. Code to include a chapter entitled "Energy Security." It included three sub sections: Energy Security Activities, Energy-Related Procurement and General Provisions.[14] Each of these subsections was specifically directed at the DoD and includes a number of requirements to increase use of renewable electrical power generation.

Congress also made certain prohibitions when it comes to the procurement of alternatives to petroleum based fuels. The Energy Independence and Security Act of 2007 banned the use of synthetic or biomass fuels if the greenhouse gas emissions exceed those of conventional petroleum products. Congress allows the DoD to procure fuels of this type but only for testing purposes.[15]

Probably the most comprehensive requirements placed on the DoD for energy considerations is the Duncan Hunter NDAA passed in 2008. Subtitle D of this act establishes reporting requirements to Congress, defines operational energy, mandates the consideration of energy in strategic level planning and acquisition and directs studies on solar, wind and alternatives to petroleum based fuels. The report required by this act includes operational energy use statistics for the past five years, estimates of energy demands, descriptions of each DoD initiative to comply with the national energy strategy and any recommendations to meet that strategy. Section 331 also fully defines the term Operational Energy, which is the same definition found in JP 1-02, as the energy required for training, moving and sustaining military forces and weapons platforms for military operations. However, the definition contained in Public Law goes further to specifically include, "…energy used by tactical power systems and generators and weapons platforms."[16] The difference between the congressional definition and the JP 1-02 definition is the omission of power generators and weapons platforms from the joint publication. This difference could potentially lead to misunderstandings between the Services and Congress in the reporting process because most reporting in the military structure comes from a lower organization to a higher organization (essentially company level to Congress through various levels of command). If the definition used by the lowest organization is different than what the highest organization uses then required information will potentially be incomplete, inaccurate or, at worst, contradictory.

The NDAA directed study for the use of solar and wind electricity production is aimed directly at expeditionary forces.[17] The study is required to look at feasibility of wind and solar for electric power production along with the sustainability, cost savings, fuel requirements reduction, environmental benefits and what opportunities exist for testing these technologies in current training programs.

Section 902 of this law establishes within the DoD, the Director of Operational Energy Plans and Programs appointed by the President. The duties laid out for the Director are to provide leadership and oversight to the Services with regard to Operational Energy plans and programs, establish energy strategy within the department, and monitor and review Operational Energy within the Department. Also included among the Director's duties is the requirement to coordinate Operational Energy initiatives among the Army, Navy, Air Force and Marines.[18] Section 902 also requires each to Service appoint a senior official, answering to the service secretary, whose sole duty is operational energy (currently the Honorable Katherine Hammack, Assistant Secretary of the Army for Installations, Energy and Environment (ASA (IE&E))). It states the Director is responsible for certifying that each service's budget is adequate for the implementation of the DoD's energy strategy. The U.S. Army must explain budgets not certified to Congress along with recommendations to bring the budget in line with the intent of Congress. This section of the law is important because, for the first time, the DoD has a single office responsible and, perhaps most importantly, accountable to Congress for the Department's energy strategy, programs and use.

Congress continued to emphasize the increasing importance of operational energy and power production with the 2011 NDAA. Most of the DoD related energy law enacted dealt with installation energy use. The most substantial change made in this legislation was that it elevated the Director of Operational Energy Plans and Programs to the Assistant Secretary of Defense for Energy Plans and Programs.[19] This structural change of reporting accountability significantly increased the influence and authority of the office reflecting Congress's evolving attitude toward operational energy and its recognition of the strategic implications of energy within the DoD. This act also authorized the study of micro grid technology that has the potential to significantly reduce the power requirement for the production of electricity in a tactical environment.

The 2012 NDAA rectified a significant oversight in previous legislation, which directed each service to designate a senior staff official responsible for operational energy, but failed to address requirements for the Joint Staff. The 2012 NDAA corrected this by directing the Chairman of the Joint Chiefs to appoint a senior staff member responsible for operational energy to coordinate with the Assistant Secretary in the same manner prescribed for each service.[20] This law also recognized the reliance the DoD has on contractors in a contingency operation. Section 315 requires the Department to address "energy efficient or energy reduction technologies"[21] when seeking contracts to support operations. This section stipulates: "(1) The technology or process achieves long-term savings for the Government by reducing overall demand for fuel and other sources of energy in contingency operations; (2) The technology or process does not disrupt the mission, the logistics, or the core requirements in the contingency operation concerned; and (3) The technology or process is able to integrate seamlessly into the existing infrastructure…"[22] The requirement for civilian contracted support to comply with the strategies developed by the DoD shows how Congress is increasing the emphasis on conservation and technologies to create efficiencies in the use of electricity and energy in general.

Although the Fiscal Years 2013 and 2014 Defense Authorization Acts did not include any significant legislation with respect to energy, it is likely Congress will remain very involved in the DoD's operational energy programs based on its previous attention to the matter. The laws Congress passed in the last 10 years are important for two reasons: It shows the amount of outside pressure put on the DoD to change how the services use energy; and it codifies conservation efforts in a way that moves beyond personalities. The substance of these laws clearly shows Congress is pushing the Armed Forces to change their culture with respect to energy in general but particularly the use of fuel, which it sees as a strategic vulnerability due to cost and the potential for shortages. This indicates how civilian authorities see energy resources as a strategic concern and a potential vulnerability in our Armed Forces that requires attention at the highest levels. These laws also make permanent the concerns of some senior military officials. It is clear from MG Zilmer's comments in 2006 that some senior leaders recognized the need to reduce the amount of energy used by the Armed Forces in the tactical environment. These acts take the concerns of individuals and make them the concerns of the services at large by encoding them in Federal Law.

Department of Defense and Army Policies on Energy

As one would expect, the Congressional actions taken in the laws described above have both directly and indirectly guided the development of the DoD energy policy. The basic policy consists of six main points. The first of these points is the

Department expects the services and agencies to continually advance the energy efficiency of systems, equipment and facilities (both permanent and temporary). This point is important because it drives the services to develop or improve technologies that decrease energy use both in terms of electrical and fuel requirements. Congress, concerned with the strategic vulnerability of energy, is forcing the DoD to ensure future systems which consume electricity are designed to use the least amount of electricity as possible thereby improving electrical power generation management (with a resulting decrease in fuel requirements). The second point requires the diversification of energy sources. This point relates directly to renewable electrical production capabilities such as wind or solar. Point three directs the services to include energy considerations in the acquisition and budget processes. The fourth point mandates that the services assess energy related risks to all activities and operations. In the fifth point, the policy encourages the services to use expertise in the energy field outside the DoD and in the civilian sector to develop and procure the technologies needed to meet policy requirements. Finally, the sixth point dictates that personnel are, [educated and trained]…in valuing energy as a mission essential resource."[23] This point seems to be an acknowledgement that service personnel take the availability of energy, and by extension electricity, for granted and implies a certain amount of careless waste (an issue that will be discussed further on). These points form the basic, overarching policy however, the services are given guidance that is more specific in Enclosure 2 of the DoD policy. This specific guidance covers the development of supporting doctrine, the procurement of energy efficient equipment and facilities, energy consideration in contract awards, the use of standardized power generators, directs the measurement of energy use for reporting purposes, integration of energy analysis in the procurement process, modeling and simulation tools for force development, assessment of energy related risks and it expands on the requirements for training personnel.[24] The policy is direct, thoughtful and provides each service with the guidance needed to meet the intent of Congress.

The Army policy on Operational Energy mirrors DoD Energy Policy, Number 4180.01. The Army policy emphasizes those actions which will have operational impacts, in fact, it sets the tone in the first sentence, “Army operational energy is a critical enabler for the range of military operational capabilities from the individual Soldier to the strategic levels.”[25] The Army’s policy addresses our need to conduct training to increase power production and distribution efficiency, develop alternative energy technologies, incorporate lower power consumption in current and future systems and change our culture to include energy as a combat multiplier. Further, it articulates to senior leadership that we, as an Army, are no longer operating in an energy-unconstrained environment. New technological solutions to tactical problems must function using the least amount of energy, or electricity, possible. This change is significant because in the past, the U.S. Army has developed new electricity consuming technologies without regard to across the board electrical consumption.

Where the policy is deficient is in how it defines operational energy differently than either the joint or the Congressional definitions. The Army Operational Energy Policy definition of operational energy begins almost identically to the definition in JP 1-02, it is “the energy used for training, moving, and sustaining military forces and weapons platforms for military operations.”[26] Then the Army policy goes on to include the rest of the definition used by Congress, "The term includes energy used by tactical power systems and generators and weapons systems."[27] Finally, the Army policy expands on the definition used by Congress by adding, "For the Army, operational energy also includes the energy associated with energy-related systems, information and processes required to train, move and sustain forces and systems for military operations."[28] This policy definition is not used in Army doctrine which use the less descriptive JP 1-02 definition. Again, another example of differing definitions that, as already noted, can lead to incomplete, inaccurate or contradictory reporting to Congress.

State of the Army Power Reduction Efforts

The public laws and policies described above provide the Army with guidance and direction to reduce overall energy consumption. These documents clearly outline the expectations of civilian and senior leadership and shape the general framework for the development of programs, structures and procedures to meet the intent of Congress, the DoD and the Army. The Army achieves this through the development of supporting doctrine, organizational structure, training and material solutions.

Doctrine

As noted previously, to achieve a reduction in the use of energy or an increase in efficiency, the Army must change how it conducts operations. It affects changes in operation by creating doctrine to help commanders and staffs develop solutions to military problems in a consistent and relatively predictable manner. The Army defines doctrine as the, "fundamental principles by which the military forces or elements thereof guide their actions in support of national objectives. It is authoritative but requires judgment in application."[29] Doctrine establishes a common professional language, tells the Army how it is going to operate and from doctrine we derive a sense of what is important for success on the battlefield. Although Congress defined operational energy and its subset of electric power generation in the Fiscal Year 2009 NDAA, the topic remains largely absent from doctrine. As previously noted, the Army uses the JP 1-02 definition of energy in doctrine that differs from the definition contained in the Army Operational Energy policy.

Doctrinally, power generation is the responsibility of Army Engineers and falls under their sub task of general engineering (Field Manual 3-34). Interestingly however, Army Doctrine Publication 4-0 lists general engineering as a subset of logistics. Engineering and Logistics are two entirely different career fields within the Army and their respective functions reside in different staff sections throughout the Army structure. This clear organizational split produces an unclear split of responsibility in doctrine, thus creating potential challenges to the planning and execution of operations. The Army's basic operational publications do not address this issue or the overarching program of operational energy.

The U.S. Army Capstone Concept, TRADOC PAM 525-3-0, describes the future operating environment and anticipated capabilities required for the Army. This document does not specifically address the concept of operational energy but it does describe the energy requirements in Appendix C; "Investments in power and energy capabilities and systems improve the quality of life for the Soldier. Investments are needed to…cultivate effective power and energy management, and enhance energy agility."[30] This passage describes both the material and human requirements to reduce energy requirements.

The Army Capstone Concept companion document, the U.S. Army Operating Concept, TRADOC PAM 525-3-1, also describes the need to develop power generation technologies and procedures to reduce fuel requirements and the logistical footprint. As with the Capstone Concept, these ideas are presented in an appendix and generally describes technological and material solutions required. In addition, this document does not address the overall goals of operational energy nor does it address the need for commanders to consider energy planning as part of the operations process.

Unified Land Operations, Army Doctrinal Publication (ADP) 3-0, is the "overarching doctrinal guidance and direction for conducting operations."[31] This doctrine, intended for senior level staff and commanders, was published in 2011 and does not address operational energy or the requirements outlined in previously mentioned publications to consider energy in the planning process. It is important to note that this document was published before Army policy mandated a consideration of energy in operational planning and execution. Another consideration is the Army tightly controls the actual content of this top level ADP to minimize the overall length and increase readability which may explain why energy is not included in this manual.

The doctrinal publications which most often drive a staff during the planning and execution of operations is Army Tactics, Techniques and Procedures (ATTP) 5-0.1, The Commander and Staff Officer Guide, and Field Manual (FM) 6-0, Commander and Staff Operation and Organization. These documents help commanders and staff turn the concepts contained in Unified Land Operations into executable orders through the Operations Process. Field Manual 6-0 and ATTP 5-0.1 lay out in detail what the staff and commanders should consider when planning operations and provides formats and instructions for operations orders, annexes and supporting documentation. Army Tactics, Techniques and Procedures 5-0.1 was published in 2011 but FM 6-0 was published in 2014 after the Army published its Operational Energy Policy in 2013 and does not provide any emphasis or mention the energy program. Further, FM 6-0 does not discuss risk associated with operational energy dependence. Both provide guidance to logisticians to include fuel considerations and a single, two-word line for engineers to address aspects of general engineering (where power production resides in doctrine although not specified in this manual). The operations process described in these manuals do not link the logistician's responsibility to provide fuel to the engineer's responsibility to provide electricity.

Although this was only a brief overview of the doctrine most likely to contain guidance to commanders on energy, the concepts are not yet widely addressed in other doctrine.[32] The normal update cycle for doctrinal publications is three years but at this time, it is unknown when the next updates will be published to add energy considerations to relevant publications.[33] The Combined Arms Command Doctrine Directorate is currently working to ensure the concepts of operational energy are included in future updates.[34]

Training

The Army has made efforts to ensure energy considerations are part of the formal military training process and for entry-level enlisted personnel; these should be fully implemented by 2019.[35] However, training at the unit and individual Soldier level is lacking and affects the operational effectiveness of organizations.

Both DoD and Army policy requires the training of personnel to establish a culture of energy awareness. Currently, there is very little training occurring although there are efforts underway to correct this for initial entry training Soldiers and Professional Military Education at the officer, non-commissioned officer and warrant officer levels. Most of these training courses under development will begin a pilot program in Fiscal Year 2015 for implementation in Fiscal Years 2017-2019.

Some of the initiatives already started are occurring at all levels of officer training. The Army War College offers an elective course in energy and national security. The Command and General Staff College includes energy as one of eight approved topics for research and includes energy considerations in its staff planning exercise. Battalion and Brigade commanders are exposed to energy considerations in their respective pre-command courses. Finally, new company level commanders and First Sergeants are provided with an information paper which familiarizes them with power generation equipment employment and management. Due to constraints on course length, most of these courses are for familiarization only and lack depth. Of particular concern is the Company Commander and First Sergeant's Course where the student is only provided an information paper. This is an issue because it is at the company level where power generation and distribution ultimately resides and yet they appear to receive the least amount of training among the developed courses.

Even with these training programs at the leader level, the Army lacks a training program at the company level to create efficiencies in power generation. Generally, at the battalion level and below, where most power is used and generated, no one is trained to design, install and manage an electrical power system. Generator operators are usually lower ranking enlisted personnel who are trained to place the generation equipment into operation but are not trained to develop an efficient distribution system or the theories involved with electrical energy. Power equipment mechanics are trained to diagnose and repair generators and only receive minimal training on distribution systems. The U.S. Army Ordnance School has developed a computer based course entitled Tactical Electric Power Equipment Grid Design (91D Power Planner Certification I) which trains Sergeant and Staff Sergeant Generator Mechanics in the design of "…power grid layouts. Assisting in correctly sizing, connecting and balancing loads on generators, suggesting cables, calculating voltage drops, estimating fuel consumption, and creating inventory lists of electrical equipment and suggested cabling…"[36] This training is open only to generator mechanics and other Military Occupational Specialties (MOS) are not allowed to enroll. Since most units do not have regularly assigned power generation mechanics, this contributes to the deficiency of trained personnel who can design and supervise efficient power production and distribution systems at the tactical level.

The lack of training on the system from production to the end user creates a situation where power is used inefficiently due to ignorance. This inefficiency, in many cases, results in units operating more generators than they actually need for operations thereby consuming more fuel. Conversely, it can create a situation where frequent power outages occur because overloaded generators shut down impacting the operation of C4ISR and other systems. In either case, there are potential operational impacts to the inefficient employment of power generation.

At the unit level, where power production and consumption occurs, there is no form of energy evaluation in the tactical environment. Almost every company level unit is required to have an Energy Conservation Officer who enforces conservation policies with respect to garrison operations but that Soldier's duties do not extend to the operational setting and as a result, there is no one monitoring how energy is used. Our Combat Training Centers, where units operate as they would in combat, do not evaluate units on how they use energy. Typically, a unit will receive feedback on how much fuel was used which is useful to compare between like units (this infantry battalion used less fuel than that one in the same situation). This does not provide a commander the information required to identify the inefficient use of electrical energy and implement corrective action. Further, units are not equipped with meters to measure electrical consumption at the point of use and the standard amount of energy a unit should use is not documented in doctrinal manuals in a way that a commander can compare his actual consumption against a known standard.

Finally, at the user level there is no training program to inculcate the efficient use of energy in Soldiers. Soldiers do not understand how the use of electricity directly equates to the number of fuel resupply operations they must perform. As a result, many systems are left running which could be turned off. Frequently Soldiers leave vehicles running for hours simply because no one told them to shut them down. In other cases, vehicles are left running to power a single radio which can easily operate using the vehicle battery. Until Soldiers and their leaders fully understand the impacts of wasting energy, both electricity and fuel, the Army will not achieve its goals of energy efficiency.

Unit Organization

The Army has developed a very robust structure at the department level and designated the Army Deputy Chief of Staff, G4 as the principal staff officer to, "Coordinat[e] with and supporting the ASA (IE&E) on issues, policies and programs related to energy security, including operational and tactical energy, and contingency bases."[37] The G4 ensures program managers, responsible for the development of Army equipment, do so in accordance with Army policy and ASA (IE&E) guidance. This ensures technical solutions to tactical problems are not developed in an energy-unconstrained manner. However, this staff coordinating structure does not extend to operational and tactical levels where most electricity is produced and consumed.

The staff responsibility for planning, coordinating and synchronizing energy (particularly power generation) at the brigade and below level is not clear. Brigade and above organizations normally have both logistics and engineer sections; battalions normally only have a logistics section. Doctrinally, operational energy is a logistics function along with general engineering which includes power generation (this is the only aspect of engineering part of logistics). However, in the orders production process described in FM 6-0, general engineering is in the engineer planning area and not included in the logistics planning process. This inconsistency makes responsibility for power production planning uncertain and contributes to the furtherance of ignorance with respect to operational energy. In any case, Logistics officers and Non-Commissioned Officers are not trained to determine power production and distribution requirements, capabilities or assess associated operational risk. Even within units that have Engineer Sections as part of their staff, the expertise to plan power generation and distribution is not present. Although Engineer officers receive some training on power production and distribution planning, it only provides basic familiarization.

They Army provides every unit with a necessity for electricity the power generation equipment to meet the requirement for tactical electrical consumption. However, the Army recognizes there are situations where unit generated power will not meet the total requirement. The 249th Engineer Battalion is the only organization in the Army dedicated solely to the production of electric power. This is a very capable organization with the mission to provide large-scale power generation to meet Army and Federal relief organization requirements across the spectrum of operations. The 249th is the only unit in the Army where MOS 12P, Prime Power Production Specialist, exists. "The Prime Power Production Specialist… supervises, operates, installs, maintains, and repairs electrical power plants and distribution equipment."[38] Among the training these Soldiers receive is how to assess power requirements and the development of distribution systems. Essentially, the Soldiers most qualified to determine requirements, design efficient distribution systems and monitor power consumption at the point of use are concentrated in one battalion.

Materiel Solutions

As shown by the development of the Army's HEL MD, the U.S. military is very good at developing technical solutions to tactical problems, which normally require increased use of electricity. However, the U.S. Army has also spent a great deal of effort developing power generation efficiencies and alternatives to fossil fuel power generation to meet its needs. All new contracts for materiel require the use of Energy Key Performance Parameters that specify the amount of energy the piece of equipment can use.

One of the least recognized consumers of electrical power is our ground vehicles. Over time, we have continued to add equipment such as radios, remotely operated weapons, optics, various detection devices, air conditioners, global positioning systems and many others. One of the U.S. Army's notorious gas-guzzlers is the M1 Abrams Main Battle Tank using about 17 gallons of fuel per hour just idling, which is approximately 83 percent of total operating time.[39] The U.S. Army developed an auxiliary power unit which provides electricity without running the vehicle engine saving about 74 gallons of fuel per day per tank. This equates to about 4,300 gallons of fuel saved in a single day for an Armored Brigade Combat Team by changing how electricity to power vehicle systems is produced.[40] Other systems are in development to achieve these types of power generation efficiencies for additional ground vehicles.

The Army is also making progress to increase efficiency and decrease the number of power generators required to provide electricity to tactical sites using smart micro grids. These systems have the capability to determine demand and adjust power production accordingly. For example, a unit may have 10 generators running at different locations at one time but only require the energy produced by three of them at that moment. Seven generators are running and using fuel but are not needed. The smart micro grid provides enough power generation capability to run the maximum required electrical load but can sense when demand decreases and shuts down power generators not needed to meet demand. This system also senses when requirements increase and automatically turns power generators on to meet the new demand. These systems can incorporate wind and solar power generation capabilities and energy storage systems as well. With this kind of system, the Army can reduce the number of generator required by a unit and increase the efficiency of the system thereby decreasing fuel resupply requirements. Along with this, the Army has also developed better generators such as the Advanced Medium Mobile Power System which use 15 percent less fuel than current power generators.[41]

Alternative energy sources such as solar are also under development with some systems already operationally tested. These systems have applications but are not yet suitable for large-scale power production. The Army's systems include capabilities at the platoon and below level using solar panels to charge batteries and very small, efficient power generators to run limited electronic devices. Of note, the U.S. Marine Corps has developed the Ground Renewable Expeditionary Energy System which consists of stackable 1,600-watt solar panels and a battery storage system. They tested this system in Afghanistan and it was able to entirely power two small patrol bases and reduce fuel consumption at a third base by 90 percent.[42]

In addition to these initiatives, the Army is developing methods to increase energy efficiency for expeditionary structures. Estimates are that heating and cooling systems consume as much as 70 percent of base camp energy requirements.[43] The use of solar shades, rigid doorways and tent liners has reduced electrical load requirements by as much as much as 85 percent. Coupled with the use of micro grid technology in power production these item reduced fuel consumption by approximately 35 percent.[44]

These are only a few examples of the materiel solutions the Army is developing to decrease electrical requirements and increase electrical production and distribution efficiency. There are many other projects and potential solutions under consideration or in development. The risk to further advances in materiel solutions is a decrease in resources, specifically the risk posed by sequestration. Materiel solutions cost money to develop and procure and are therefore subject to prioritization for funding.

Standardize the Definition of Operational Energy

Operational energy is defined slightly differently at the Congressional, DoD, Department of the Army and Joint levels which can lead to inaccurate reporting.

Operational energy is not defined in most Army doctrine manuals; definitions not found in Army manuals default to the definitions in Joint Pub 1-02 which differs from Army policy by not including power generation. I recommend ADP 3-0 include the Army Operational Energy Policy definition for clarity and consistency of implementation at the lowest levels. This definition should also be included in all doctrinal manuals that act as base doctrine for unit types (for example, FM 3-90.6, Brigade Combat Team).

Classify Power Generation as a Field Service

Doctrine places electric power generation within the general engineering aspect of Engineering. Doctrine also places general engineering under the logistics function of sustainment along with field services, fuel supply, maintenance and transportation. This arrangement creates an ambiguous organizational boundary where the planning, execution and staff oversight functions of power generation can be overlooked. Field Services include “aerial delivery, clothing and light textile repair, food services, shower and laundry, mortuary affairs, and water purification.”[45] Electric power generation naturally fits into this category of necessary supporting activities within the logistic realm. Placing power generation into the category of field services will consolidate those functions under one staff section’s (G/S-4) responsibility instead of splitting it between two. In addition, orders templates included in ADRP 5-0 should include a specific section for power generation.

Incorporate Operational Energy into the Combat Training Centers

Although commanders are receiving some training in operational energy and power generation, they are not given the tools to see their unit’s performance from this perspective. Because they cannot evaluate their unit’s performance against a known standard, they cannot make improvements to energy efficiency. Each unit specific doctrinal manual should include a baseline energy consumption chart (fuel, power, water, etc.) to assist commanders with understanding how their units should be performing as doctrine does for any other tactical task. Units should be equipped with simple metering devices to determine how much electricity they are actually using. At the Combat Training Centers, units' energy consumption should be monitored and feedback provided to commanders measured against their unit's doctrinal standard; again, like any other task.

Expand Energy Conservation Officer Duties to Include the Operational Environment

Unit Energy Conservation Officer duties and training should be expanded to include the operational environment. At the unit level, where power is consumed, there is no one appointed to monitor the unit's performance with respect to energy. Rather than create a new appointment requirement, simply expand the existing requirement to include aspects of operational energy in a field environment. Training should enable these Soldiers to identify over or under loaded power generation, make appropriate corrections, analyze power usage and advise the commander on ways to improve unit performance with respect to electrical power consumption. They should also be familiar with available energy alternatives. This can be accomplished by opening the 91D Tactical Electric Power Equipment Grid Design to non-generator mechanic MOSs.

Include a Power Production Subject Matter Expert at the Brigade Level

There are no power generation subject matter experts on brigade level staffs to provide oversight and management for the planning, coordination, execution and assessment of operational energy activities. In support of the findings of the Army Science Board report conducted in 2010, the Army should place a Prime Power Production Specialist Non Commissioned Officer of the appropriate rank in either the

Brigade S-4 or Engineer Section to assist the commander with meeting the goals of the operational energy concept.[46] This Soldier should provide training to unit representatives, monitor subordinate unit energy programs, provide expertise and assistance where needed, conduct planning activities concerning operational energy and the establishment of electrical production and distribution systems.

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