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Operational Energy: A Decisive Enabler and Critical Liability in 21st Century Warfare

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Introduction

History has established that energy is a critical component of military power. This was true when Hannibal crossed the Alps, Napoleon invaded Russia and Patton broke out from Normandy. Energy drove the development of a nuclear-powered Navy and aerial refueling, and it will continue to be decisive to victory on the battlefields of the 21st century. Energy enables lethality, maneuverability, speed, endurance and operational reach. It also consumes resources, affects force structure and increases exposure to adversaries. Energy is both an enabler and a liability that is integral to military success in all domains.

Energy consumption places a significant demand on logistics formations, and current practices pose a liability on future battlefields. As the joint force evolves to operate in a multi-domain environment, it must aggressively increase energy effectiveness and resilience across all domains and reduce the demand placed on logistics formations. Victory on future battlefields is dependent on investment in innovative capabilities that increase lethality, reduce consumption of resources and minimize the exposure of logistics assets to increasingly effective enemy weapon systems.

The United States' competitors understand the relationship between energy and victory and are aggressively optimizing their energy use. To remain competitive against potential adversaries in an era of resource competition and expeditionary environments, U.S. military decisionmakers also need to understand this relationship as well as why the U.S. military must pursue innovative solutions that decrease energy demand. U.S. Central Command (USCENTCOM) has taken deliberate measures to increase energy efficiency and develop innovative opportunities for increased effectiveness in the energy and logistics environment.

Energy and the Demand by the Joint Force

The Department of Defense (DoD) is the nation's largest single consumer of fuel. According to the Office of the Under Secretary of Defense for Acquisition and Sustainment, the DoD consumed over 85 million barrels of fuel in 2017 at a cost of approximately $8 billion. The Air Force used the largest share, followed by the Navy and Army, respectively. Used to power ships, aircraft, combat vehicles and contingency bases, 55 percent of this fuel was purchased from outside the United States.[1]

The United States recognized the role that energy plays in national defense and codified the requirement for increased energy efficiency into law in 2012. The law discusses operational energy—defined as "energy required for training, moving and sustaining military forces and weapons platforms for military operations"—and mandates the development of transformational energy initiatives to enhance military capability, improve the performance of weapons and manage and assess energy risk.[2]

Despite efforts by all services to establish as well as increase investment in policies and systems to change behavior and reduce demand, energy consumption has remained relatively consistent since 2013. Without continued emphasis on energy demand reduction, the rapid development of advanced adversarial weapon systems and legacy energy utilization practices will "continue to challenge the assured delivery of fuel to combat forces."[3]

Operational Energy and the Changing Character of Warfare

The *2018 National Defense Strategy* identifies an increasingly complex security environment with both Russia and China as strategic competitors in every domain. The two countries have demonstrated a willingness to aggressively assert regional dominance and have implemented military modernization initiatives that leverage technology, encourage innovation, increase effectiveness and challenge U.S. dominance.[4]

Russia's invasion of Ukraine, Russian and Chinese development of anti-access/area denial weapon systems, Iranian refinement of swarm boat tactics and the emphasis of adversarial weapon systems that emphasize innovation, precision and extended range indicate that future conflicts will be significantly different from those of the recent past. War in the 21st century will be characterized by "sensor-rich militaries of peer states and proxies employing precision-guided munitions on highly lethal battlefields that can restrict joint force freedom of maneuver and action."[5] As described in the U.S. Army's multi-domain framework, the United States' adversaries "have demonstrated asymmetric capabilities that deny our access to theaters . . . and negate freedom of action at the operational and tactical levels."[6]

To succeed in this environment, the U.S. military must prepare for operations where sustainment systems would need to operate without the relative security of past conflicts. The United States can expect in the future that lines of communication will not be contiguous and that the enemy will attack with precision support areas and capabilities to degrade Army sustainment activities.[7] According to Chief of Staff of the Army General Mark A. Milley, in future high-intensity conflicts, "we will not have the luxury of having this massive amount of logistics behind us."[8]

Because of this increased threat, the joint force must integrate capabilities that can operate longer in more dispersed spaces. When he was commander of U.S. Army Training and Doctrine Command (the organization responsible for anticipating future threats), retired General David G. Perkins said that the military must develop logistics capabilities that "can operate in noncontiguous areas, cover vast areas and provide flexibility."[9]

Critical to this endeavor is reducing the overall sustainment demand of U.S. forces. The military must continue to prioritize investments in effective capabilities with extended range and reduced consumption rates.[10] As part of his confirmation as secretary of defense, retired Marine Corps General James N. Mattis reaffirmed his belief that the military "should explore alternate and renewable energy sources that are reliable, cost effective, and can relieve the dependence of deployed forces on vulnerable fuel supply chains."[11] Reduced energy consumption decreases the exposure of logistics assets and lets commanders prioritize logistics efforts on munitions and other classes of supplies that increase lethality. A reduction in energy demand also reduces cost and affords opportunities to invest financial resources previously allocated to sustainment functions on kinetic platforms that increase lethality.

Recognizing the correlation between energy efficiency and the opportunity for increased effectiveness, the U.S. military, the Defense Logistics Agency and the Office of the Assistant Secretary of Defense requested $13.4 billion over the 2017–2021 Future Years Defense Program for operational energy investments. These investments are designed to increase future warfighting capability, reduce operational and logistics risks and enhance mission effectiveness.[12]

Adversarial Advancements in the Energy Environment

Russia and China recognize the link between energy and military success and are implementing deliberate strategies that capitalize on the advantages associated with increased energy efficiency.

In late 2009, Russian Prime Minister Dmitry Medvedev identified energy efficiency as one of the priorities for modernization. This prioritization has created an influx of energy innovation, and the Russian Ministry of Energy now sponsors an annual conference dedicated to energy. During the first conference in 2017, one of the panel discussions focused on "diversifying the defense industry to support the energy sector."[13]

Russia is improving its power generation capability and using the improved systems to power its military bases not connected to the national power grid. These improvements increase resiliency, reduce operating costs and increase the sustainability of expeditionary locations. The cost reduction provides opportunities to reprioritize expenditures allocated for sustainment to increase investment in lethal capabilities.

Russia has also made notable energy advancements in the air, land and maritime domains. In December 2017, Russia's fifth-generation fighter, the Sukhoi Su-57, made its first flight with a new and more efficient engine. A derivative of the Saturn AL-41F1S, the engine "features increased thrust and fuel efficiency and is also expected to improve the fighter jet's stealth characteristics given the use of new composite materials."[14] The engine is also programmed for use in the Sukhoi Su-35 and Flanker series aircraft.

With the development of improved gas turbine engines for its maritime fleet, Russia has reduced its reliance on imported engines while significantly increasing efficiency. Most of the new Saturn engines produced in Rybinsk, Russia, are reported to operate at an engine efficiency of 36 percent, which is higher than the previously employed Ukrainian variants. These engines were to be integrated in the Russian Navy's frigates, smaller air-cushioned landing ships and other vessels, increasing their efficiency across the fleet.[15]

In 2016, the Chinese government implemented an ambitious five-year national renewable energy plan. The $360 billion initiative is integrated into its national security plan, contains tangible metrics and is being enforced with an "iron hand."[16] In 2017, China created more than half of all new global solar capacity and accounted for 45 percent of the $279.8 billion spent worldwide on all renewables.[17] This investment in renewable energy will translate into technologies that have military applications at austere expeditionary locations and will reduce vulnerabilities and China's reliance on logistically intensive forms of energy. China has enacted military-specific energy savings and emission reduction plans that promote efficient capabilities, facilities and training environments and that are linked to an energy strategy designed to enhance its "wartime ability to fight."[18]

The Chinese military is closely integrated with industry and academia in the development of cutting-edge technologies. The People's Liberation Army has taken a leading role as "an incubator and financier for some of the leading commercial efforts in renewable energy."[19] One example is China's $3.3 billion investment in the development of "molten salt" reactors that are a safer and more powerful form of nuclear energy. Once complete, the molten salt reactors will produce more power than uranium-based reactors while producing one-thousandth of the radioactive waste. The military applications of this technology range from aircraft carriers to drones.[20]

Chinese energy advancement in the maritime domain is also evident in the development of underwater drones. In 2017, the Haiyi underwater drone set records for both the deepest depth reached and farthest distance traveled. Utilizing a new and unique battery, it is reportedly capable of traveling 635 miles nonstop in 30 days. Although reports say it has yet to be weaponized, it could be used to search for U.S. submarines traveling in Chinese waters.[21]

These examples are illustrative of the advancements that China and Russia have made in increasing the effectiveness of key capabilities. When aggregated with other progress, these advancements reduce the countries' overall sustainment requirements and costs associated with logistics activities while simultaneously minimizing targeting opportunities that exist when military formations have large supply trains. Both China and Russia are leading exporters of military capability, primarily to Iran, North Korea and Syria.[22] These and other countries (potentially adversaries) will benefit from the energy investment and increased effectiveness of Chinese and Russian advancements.

USCENTCOM's Approach to Increased Energy Effectiveness

USCENTCOM recognizes how powerful leveraging operational energy is in accomplishing the *2018 National Defense Strategy*'s main priorities of improving lethality, strengthening alliances and increasing performance and affordability.[23] As with other commands, USCENTCOM uses large hubs to project combat power and provide support to the force. Based on the current operating framework of the joint force and the logistics demands of current capabilities, these hubs are essential to operations. However, this operating framework is also a vulnerability in future conflicts.

USCENTCOM's logistics enterprise averages the following daily: traveling over 26,400 miles; distributing 3.5 million gallons of fuel; loading and offloading over 2,600 tons of cargo; flying 60 intra-theater airlift missions; transporting about 645 passengers and 285 pallets of sustainment supplies; and serving 250,000 meals. The combatant command also rotates about 32,000 personnel a year.[24] These requirements consume enormous amounts of energy and increase the risk of adversaries interdicting already stressed supply chains.

USCENTCOM has taken a deliberate approach and is aggressively implementing proactive measures to increase resiliency, reduce energy demand and increase energy effectiveness. The command has developed a holistic energy strategy with specific objectives and milestones designed to institutionalize energy awareness and shape operations to reduce energy demand, cost and risk while simultaneously enhancing reach and readiness. USCENTCOM has also developed a framework that partners with industry and academia to encourage innovation.

The energy strategy has three specific objectives: increasing the warfighting capability; identifying and reducing operational energy risks through a deliberate planning process; and enhancing current mission effectiveness. These objectives provide the basic framework for the strategy.[25] Subordinate to these objectives are seven specific goals that provide increased specificity: including operational energy considerations in support contracts; promoting emerging energy-saving technologies; eliminating, mitigating or accepting operational energy risks in plans; eliminating operational energy capability gaps and vulnerabilities; implementing material and non-material solutions that enhance capability; reducing sustainment costs; and advancing energy behavior.

The targets provide tangible metrics tied to specific timelines and correspond to specific goals. The strategy includes 20 specific operational energy targets, including the following:

- include operational energy language that defines energy-savings performance in contracts;
- include energy-efficient design considerations in base-camp planning;
- implement cost-effective material solutions that increase efficiency and reduce energy consumption; and
- link component capability gaps with emerging technologies through the Joint Operational Energy Working Group and technology innovation forums.[26]

The USCENTCOM's energy strategy is nested in the *2018 National Defense Strategy*'s priorities for energy investment. Former Secretary of Defense Mattis said, "Investments in energy technologies should be prioritized according to the same standard as any other department decision." He said the DoD should invest in energy research and development and ensure the investments contribute to the department's primary missions, provide a positive return on investment, protect national security interests, enhance readiness and combat effectiveness, and reduce the vulnerability of U.S. servicemembers in battle.[27]

Innovative Energy Solutions

Through its components, USCENTCOM has integrated several energy-saving capabilities into its area of operations. When viewed independently, these initiatives appear specific in scope and limited in impact. However, when aggregated, they illustrate how small investments can result in reduced sustainment requirements and significant savings in demand and cost. They illustrate how combatant commands and their components, through focused energy investments, can provide flexibility and increase effectiveness. The following examples include advancements in air refueling operations, solar technology integration and biodiesel generation.

Example 1: Traditionally, the planning and scheduling of air refueling operations have been laborious and involved analog systems and hours of analysis. In 2017, elements from USCENTCOM's air component partnered with the Defense Innovation Unit-Experimental—an organization in the Office of the Secretary of Defense responsible for developing innovative solutions for warfighter needs—and Google to develop an automated system to assist in the planning and execution of refueling operations.[28]

Known as "Jigsaw," the software package uses simulation and modeling to optimize the calculation of fuel burn (the gas remaining after each offload) for each tanker; determine the time to fly to various offload points; and optimize locations to link up with aircraft requiring fuel. Jigsaw has halved planning time, reduced aircraft crew requirements by three to four crews each day and saved approximately 51,000 gallons of fuel each week.[29]

Example 2: Since 2016, USCENTCOM's service components have deployed approximately 2,000 solar light carts at multiple locations throughout its area of responsibility. These updated models are replacements for the traditional diesel-powered variants, are critical to force protection and enable 24-hour operations at expeditionary locations. The systems are quieter, do not require daily refueling, burn considerably less fuel and require less maintenance. Since their inception in 2016, the systems have resulted in a net savings of approximately $54 million and 13 million gallons of fuel.[30]

Example 3: Facing a dilemma with disposing of cooking oil from its dining facilities in Afghanistan, the U.S. Army Logistics Civil Augmentation Program invested in a turnkey automated system designed to convert used cooking oil into biodiesel. This biodiesel refinery can convert waste cooking oil into approximately 300 gallons of JP-8 jet fuel per day for use in solid waste incinerators. This equates to 110,000 gallons of JP-8 per year and a savings of approximately $1.6 million since inception in 2015.[31]

These three innovative solutions have resulted in an annual 6.3 million gallon reduction in USCENTCOM's fuel requirement. Operationally, this translates to an equivalent savings of approximately 700 C-17 Globemaster III fuel resupply sorties, similar to the ones used to conduct fuel resupply operations in support of operations in Iraq and Syria,[32] or 700 sorties that do not have to risk interdiction by an opponent's integrated air defense system. This also translates to 1,260 trucks that do not have to risk detection by enemy drones or targeting by enemy long-range rockets—techniques Russian forces employed in Ukraine with devastating effectiveness.[33] Furthermore, it increases force protection by denying 1,260 opportunities for insider threats to gain access to forward operating bases when contract carriers are used to resupply installations.

Continued integration of these types of capabilities is dependent on mechanisms that can rapidly identify, resource and field similar innovative solutions that increase energy and logistics effectiveness.

Organizing for Energy and Logistics Innovation

The requirement to be able to rapidly develop innovative solutions and agile acquisition mechanisms to meet the rapidly changing character of war is described in the *2018 National Defense Strategy* and reaffirmed in the imperatives of Multi-Domain Operations strategy. The *National Defense Strategy* says, "Current processes are not responsive to need; the Department [of Defense] is over-optimized for exceptional performance at the expense of providing timely decisions, policies and capabilities to the warfighter."[34] The DoD and associated services have implemented multiple unique strategies designed to augment the established research, development and acquisition process.

The Defense Innovation Unit, the Navy's Naval Innovation Process Adoption Cell, the Air Force's AFWERX, the Marine Corps's Next Generation Logistics (NEXLOG) and Special Operations Command's SOFWERX are all examples of specific initiatives in the DoD that possess acquisition and funding authority and are designed to accelerate commercial innovation and leverage emerging technologies best suited for employment by their respective organizations. To ensure similar innovative focus is applied to the challenges facing the Joint Logistic Enterprise (JLENT), USCENTCOM is pursuing a similar framework called LOGWERX.

LOGWERX is an attempt to ensure that USCENTCOM's logistics community is "Organized for Innovation" and chartered with the responsibility to develop logistics-focused processes and systems that are streamlined, integrated with industry and academia, and responsive to the logistics requirements specific to USCENTCOM's rapidly changing battlefield. These challenges include, but are not limited to, autonomous distribution networks, joint logistics common operating pictures, additive manufacturing and logistics support in an anti-access/area denial environment. LOGWERX will assist in addressing a shortcoming in JLENT, which has "no formal process to leverage innovation and technology acceleration as a compliment to the existing Joint Capabilities Integration and Development System."[35]

All combatant commands will be able to leverage the LOGWERX framework, which is intended for integration with all of JLENT. LOGWERX is "designed to provide enterprise-wide visibility of ongoing innovation across DoD, the interagency, coalition partners, academia and the global marketplace to enable the JLENT to optimize what it needs." LOGWERX will enable the command, component and service logisticians to openly engage industry and academia to harness the innovative resources of the private sector and universities. Crowdsourcing, hackathons and thought leader symposiums will inspire communities to consider the command's challenges in a new way and catalyze them into action.[36]

LOGWERX is a clear departure from accepted methodologies and processes as well as a pivot from traditional military processes. Focusing the nation's brightest minds on challenging problems offers an agile approach to product development. Transforming the current supply and demand model equates to increased survivability and flexibility while reducing footprint and warfighter risk.[37]

Although still in its infancy and lacking formal research, development, testing and evaluation funding and acquisition authorities, LOGWERX has experienced initial success as it pertains to increasing logistic responsiveness and reducing energy demand. These successes include the development of a joint logistics common operating picture, identification of "smart city" technologies and integration of more robust solar power generation platforms on construction projects within the USCENTCOM area of responsibility.

To address the challenges associated with maintaining visibility of critical commodities, USCENTCOM's logistics directorate set forth to integrate the numerous commodity reporting systems into a single database that provides up-to-date status on critical repair parts, fuel, water, munitions and other classes of supply of all major joint platforms, depots and logistics centers from across JLENT. The directorate used the LOGWERX framework and leveraged an ecosystem of expertise from many disciplines, including the program managers associated with the multiple digital and analog reporting systems that will require integration. The end state is a single geo-referenced database where users can click on a specific platform, depot or center and receive the current status of all critical supplies with current transient shipment status of those commodities en route to the designated location.

There is technology available that digitally optimizes fuel flow to installation infrastructure through the creation of a microgrid, and USCENTCOM is using the LOGWERX framework to explore the integration of this smart city technology at its enduring and expeditionary locations. Microgrids, defined as "an autonomously functioning local energy grid with control capacity," and smart city technology have proven to increase fuel efficiency by up to 50 percent, significantly reduce maintenance requirements and improve resiliency at enduring and contingency locations.[38]

USCENTCOM is also exploring the implementation of engineering criteria that promote the use of solar technology within its area of responsibility. Faced with increased energy requirements and the decreasing costs associated with solar technology, many of the countries in the Middle East are aggressively pursuing policies and investments that increase the use of solar power. This is evident in Saudi Arabia's $200 billion partnership with Japan in March 2018 to build the world's largest (200 gigawatts) solar power generation project.[39] By implementing design and construction criteria in line with the national policies of host nations, USCENTCOM could decrease the fuel demand of facilities, increase resiliency by creating redundant power sources and support the development objectives of their partner nations. A tertiary benefit is that partner nations would be more willing to invest in the construction of these facilities.[40]

Although these initiatives are still in development, the LOGWERX framework is demonstrating a tremendous potential to reduce energy and logistic requirements and quickly solve complex problems.

Conclusion

Energy is a crucial component to military success and will remain so for the foreseeable future. It is also a critical liability that consumes resources and force structure, increases exposure to adversaries, and places excessive strain on logistics formations. In an era of high-intensity conflict that emphasizes technology, standoff, precision and overwhelming fires, current logistics practices substantially increase operational and strategic risk.

Success in a multi-domain battle is dependent on the aggressive implementation of innovative policies, formations and capabilities that emphasize energy effectiveness and reduce sustainment demand. To achieve this, the U.S. military must continue to integrate with industry and academia and drive the rapid implementation of innovative solutions. Failing to do so significantly hinders the joint force's ability to achieve victory on the complex battlefields of the future.

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