A 114-acre renewable solar energy complex, located at Redstone Arsenal, Alabama, Feb. 23, 2018. The complex generates about 10 megawatts, alternating current, on-site solar renewable energy. (U.S. Army photo by Megan Gully)

The Use of Renewable Energy Sources in the Military

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The following article by Sgt. Maj. Isaac Migli is the winning submission from this year's U.S. Army Sergeants Major Academy "Mad Scientist" Writing Contest to better understand the impact of emergent technology on Army leadership, formations, and warfighting.

On September 14, 2019, the Iranian military launched a swarm of missiles and drones on the oil fields of Saudi Aramco, a Saudi Arabian state-run oil company. The calculated attack was an assault on a key U.S. ally in the region and an affront to American hegemony worldwide. Conceivably, Iran designed the attack to affect the U.S. without actually committing an act of war, which would have most likely led to retaliation from the U.S., Saudi Arabia, and Israel. While the attack did not meet the definition of an act of war, it did have global ramifications, knocking out 5% of the world's oil supply with 18 drones and three missiles, and causing a 20% spike in crude oil prices (Reuters Staff, 2019). The event highlighted the impact low-tech or ill-equipped actors can have not only on the global economy, but also on militaries who are dependent on oil for their operations. To prevent future impacts, the Department of Defense (DOD) should utilize closed and controllable renewable energy sources to prevent outside influences on military operations while also improving mission efficiency.

Vulnerabilities

The National Resources Defense Council ranks the U.S. as "the world's largest single consumer of energy" (Haig, 2018, para. 2). The majority of this energy con-

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sumption, especially from the U.S. military, is from fossil fuels, with the by-product, carbon dioxide, a problem because it affects the environment with greenhouse gases, creating a vulnerability in terms of initial product cost and secure delivery to the consumer, often inside hostile territory ("CO2 Emissions," n.d.; "Operational Energy," n.d.). As demonstrated by the Iranian attack on Saudi Arabian oil fields and resulting spike in global energy costs, adversaries are becoming increasingly aware of this vulnerability.

The second major vulnerability is that U.S. military bases are integrated with Industrial Control Systems (ICS) and Supervisory Control and Data Acquisition (SCADA) networks which control a variety of power, water, communication, and transportation infrastructure stateside. Currently, these bases are linked to the state and municipal ICS/SCADA grid systems, with backup power via short-term fossil fuel stockpiles running generators (Marqusee et al., 2017). This reliance on ad-hoc ICS/SCADA systems and public energy is dangerous because an attack on these systems could disrupt U.S. military operations across the globe.

To illustrate the danger in trusting these systems, Iranian hackers have already successfully infiltrated the ICS/SCADA networks of several countries worldwide, including telecommunications and energy grids in the U.S., along with the U.S. Navy's Marine Corps Intranet (Finkle, 2014). An attack on any U.S. grid could cause a domino-effect breakdown to all operations in the system (Yang et al., 2017). In order to increase security, and protect against the associated fuel and energy vulnerabilities, the U.S. military must approach these issues with a three-phase solution.

(U.S. Army photo by Sgt. Sarah D. Sangster taken Feb. 5, 2020) U.S. Army Sgt. Kevin Henry, a Petroleum Supply Specialists assigned to 25th Aviation Regiment, checks fuel during training in Forward Arming and Refueling Point procedures at Schofield Barracks, Hawaii, Feb. 5, 2020.

Phase 1

The first phase in repairing the energy grid vulnerability is to remove U.S. military bases from local power grids while implementing renewable energy systems. This will limit the susceptibility to cyberattacks and reduce reliance on fossil fuels.

U.S. Department of Energy (DOE) is already working on a decentralized power solution called Autonomous Energy Grids (AEG). These AEGs are made up of Network Optimized Distributed Energy Systems (NODES) that form a self-contained, smart energy community that could provide resources for one installation, while sending excess energy, or requesting enough to cover a deficit from other installations on the AEG. Because this new system is self-contained and largely self-reliant, an attack on one NODES would not cause a cascading effect to others (O'Neil, 2019).

In addition, because the system is standardized, DOD technicians can maintain and operate between different installations, despite the actual source of the energy itself, which could be tailored specifically to the environment of the installation. For example, Fort Huachuca, Arizona, situated in the Sonoran Desert, may consider a combination of nuclear and solar power as its main power source; Fort Bliss, Texas, a combination of solar power and wind; while Naval Base San Diego, California, may instead rely on wave and tidal generators.

For this new system to be secure, any outflow from bases must also be restricted. For example, Fort Bliss currently has a number of solar power panels which feed back into the local economy at subsidized rates. This practice would stop because any connection to the local grid means a potential vulnerability and weakened internal system. This shift of energy grids would not just affect the military base, but also impact the local community, many of which rely on military installations for economic reasons, especially energy costs paid to the local energy provider for day-to-day base operations.

In the short-term, there are financial hurdles and risks for all parties currently involved. Implementing major technological advancements and overhauling a previous operating system can be costly, however, the long-term benefits and financial rewards of pioneering clean and renewable energy sources while also reducing avenues of attacks for enemies is too great to ignore.

Phase 2

The second phase requires research and development of an interoperable, non-petroleum-dependent vehicle system that uses renewable resources. Commanders could tailor a number of variants and power options for specific missions and usages such as reconnaissance, logistical supply, route clearance, infantry delivery, gunnery options, and intelligence collection platforms.

While it will be costly and difficult to develop electrical vehicle systems that can survive the rigors and demands of combat, the military could partner with the civilian sector to accomplish this task. Tesla is already developing solar banks and battery-powered trucks, while General Motors Co. is releasing an electric "Hummer" in 2021 which reportedly has a powertrain supporting up to 1,000 horsepower, which is double the Army's current Heavy Expanded Mobility Tactical Truck's 500 horsepower ("Zero Limits Look Like This," n.d.; "Oshkosh Defense," 2018). This relationship could benefit both parties as the military would rapidly advance their warfighting technology, and civilian corporations would stand to profit off the product and research.

Completely removing the reliance on petroleum from military operations is a long-term goal. A first step could be the DOD mandating all government-owned non-tactical vehicles on stateside military bases convert to electric. This large-scale implementation could give investors and researchers the time and incentive to develop options for a full-scale non-petroleum program in the future.

Phase 3

After the DOD has removed military bases from the national and local power grid networks, shifted to renewable and reliable operational energy sources, and fielded the military with non-petroleum dependent vehicles, the final phase is to shift Army training and doctrine to account for the pivot away from fossil fuels. This step would involve disruption to the current structure and way of life of the Army. Not only will new equipment need to be fielded, likely brigade by brigade much like the Interim Armored Vehicle [Stryker] was rolled out in the early 2000s, but obsolete military occupation specialties (MOS) like the 92F petroleum supply specialist ("refueler") will need to retrain and reclassify into different sustainment specialties with an emphasis on the technical expertise needed in each new system. Additionally, sustainment doctrine like *Army Doctrine Publication* (ADP) *4-0: Sustainment* (2019) would need a complete overhaul. Standard operating procedures, from Theater Sustainment Command down to each tactical resupply convoy, would need significant revisions to accommodate the new technology.

The Future

The U.S. Army is already taking steps to advance technology for the future fight. They've awarded several contracts to robotics and technology firms to develop unmanned autonomous resupply vehicles consisting of modular kits with scalable architecture, footwear-mounted location devices for Soldiers to keep track of their units in GPS and network-denied environments, and the ability to 3D print replacement parts through open network architecture that will enable units to repair and even upgrade vehicles as technology evolves downrange (Ball, 2019; Judson, 2019; Sheftick, 2020).

An autonomous combat vehicle demonstrates its capability during a demonstration of technology and equipment from weapons and defense industry vendors hosted by U.S. Army Futures Command at Texas A&M University, May 16, 2019. (U.S. Army photo by Luke J. Allen)

Imagine removing the requirement for petroleum resupply in the field by providing infantry units with solar-powered mine-resistant high-mobility multipurpose wheeled vehicles with swappable and easily deliverable power packs in low sunlight situations. Or tanks with small nuclear reactors which can run indefinitely and can 3D print all repair or replacement parts. Drone delivery, already being pioneered by Amazon in the private sector and hailed as the "future of e-commerce fulfillment," can provide fuel cells in combat areas (Business Insider Intelligence, 2020, para. 2).

Soldiers can also supplement power sources with their own movements. The Army is already developing wearable kinetic harvesters in the form of backpack frames and boot soles that power small generators (South, 2019). The military's use of these types of technology can reduce the manpower and risk costs associated with fuel sustainment that can be detrimental to Soldiers on the battlefield.

The DOD can even reduce and eliminate radiation from nuclear reactors by taking advantage of new biological developments showing that certain types of fungus found at the Chernobyl disaster site actively eat and safely negate nuclear radiation (Thompson, 2019).

Conclusion

Shifting the military from fossil fuels to renewables in both stateside grids on military installations and in fielded equipment will harden it against resource shortages and cyberattacks from near-peer and non-state actors. As the U.S. reduces its fuel consumption, it also becomes less vulnerable to interference from regional hegemons like China and Russia who could restrict shipping lanes in the event of a conflict. A renewable powered military will not only be less vulnerable, but able to sustain operations exponentially longer while also reducing their carbon footprint for future generations. ■

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