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Perspective: Enabling Factors for Achieving U.S. Army Microgrid Goals

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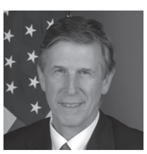

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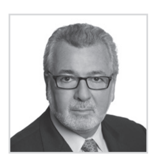

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Climate Security

In this Report

The U.S. Department of Defense's (DoD)'s core mission is to provide the military forces needed to deter and win wars, as well as to protect the security of the U.S. and its allies. In support of this mission, DoD has framed climate change as a "threat multiplier" which can undermine and destabilize operations and readiness. As such, planning and preparing for the impacts of climate change, including greenhouse gas (GHG) emission has become increasingly become a planning and operational priority.

DoD is the nation's biggest energy consumer. It is deeply invested in enhancing energy resilience on installations while simultaneously reducing GHG emissions. Issued in April 2023, the enterprise-wide DoD Plan to Reduce Greenhouse Gas Emissions emphasizes on-site clean energy generation and storage, increased efficiency measures, and incorporation clean energy powered-microgrids. As part of the enterprise-wide effort, the U.S. Army, the largest consumer of installation energy in DoD, released the Army Climate Strategy (ACS) and the ACS Implementation Plan for Fiscal Years 2023-2027 (ACS-IP). While U.S. Navy has a requirement for installations to be able to operate off-grid for two weeks by 2025, the Army has set an ambitious goal to place a microgrid on all 130 Army installations by 2035.

To meet the 2035 microgrid goal, the pace of microgrid design and deployment will need to dramatically increase. To do so, there are several enabling factors that can facilitate the Army's achievement of its microgrid goals. This report outlines four key areas which require significant research and development, as well as three other supporting factors that will impact the Army's success.

IN BRIEF

- In 2023, DoD issued its first ever enterprise-wide Plan to Reduce GHG Emissions, which includes a goal to reach 100% carbon pollution free electricity by 2030. 37% of DoD's total GHG emissions come from installations, making installations a core target for emissions reduction.
- The U.S. Army has more than 130 installations worldwide, and only 25 microgrid projects scoped and planned through 2024. Therefore, it is critical to invest in robust microgrid research, development, testing, and evaluation (RDT&E) activities in four critical areas—software, base load generation, battery storage, and physical & cyber security—to achieve the U.S. Army's energy resilience goals and end states.
- DoD's Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP) are two complementary research programs whose continued robust funding is critical to installation energy resilience and microgrid deployment.
- The Army Office of Energy Initiatives (OEI) manages and identifies funding for energy resilience and energy security projects, including microgrid feasibility assessments (MFAs), which provide crucial data for energy stakeholders and decision-makers. Ensuring OEI is fully staffed and funded will help achieve Army's microgrid goals.
- Permitting reform, personnel, and public private partnership are other key enablers for deployment of microgrids on installations.

About the Authors

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Background

Strategic Context

The Department of Defense (DoD) manages infrastructure for more than 284,000 buildings and facilities which are critical to our national security and maintaining mission assurance. Mission assurance—the process to protect or ensure the continued function of resilience of capabilities and assets in any operating environment—is inherently complex, but even more so in the face of climate change.[1] From an increase in extreme weather and severe weather events, to cyber threats and aging infrastructure, how DoD manages its energy portfolio continues to be of paramount importance for both routine peacetime activities and combat operations.

The energy systems that power installations and DoD facilities are directly tied to keeping our nation safe and secure. These systems manage everything from deployment and maintenance of weapons systems to exercises and personnel training.[2] However, most installations and facilities rely on commercial power from the same privately owned utility companies that provide electricity to civilian homes and businesses. As such, DoD facilities are subject to the same disruptions that impact communities, businesses, and individual households. From rolling blackouts to flooding and strong winds—even the shortest power outage can cripple the critical systems on which our military relies.

Bearing this in mind, DoD has emphasized and prioritized energy resilience. Over the past two decades, DoD has undertaken countless actions to enhance resilience, including a strategic interagency partnership with the Department of Energy (DoE) to strengthen coordination, explore cost-effective and optimized energy assets, and pursue the procurement and deployment of advanced energy resilience technologies.[3] DoD has also updated standards and metrics for energy resilience,[4] issued guidance for the use of easements, and mandated black start (energy resilience readiness exercises (ERREs)) exercises to identify gaps in capabilities.[5]

Microgrids and the Military

> "The Army's ability to accomplish its mission of protecting U.S. national security interests at home and abroad depends on resilient, uninterrupted access to energy."
>
> Honorable Ryan D. McCarthy
> Former Secretary of the Army
> U.S. Army Installation Energy and Water Strategic Plan

Microgrids have emerged as a key enabler of installation energy resilience. A microgrid is a method of decentralized electricity generation in which local energy generating resources are connected to a local control system and used to power a facility. Though there are nuanced definitions, any description will include the words "local" or "localized" —as microgrids operate in small area "islanded" from a commercial grid. Unlike centralized commercial electricity grids, which power most homes and businesses in the U.S. today, microgrids can disconnect from the centralized grid to operate independently during outages.[6] The small microgrid network contains both power generation capabilities and energy users, as well as a method to transmit the generated energy to the end user.

For several decades, the military has used microgrids in austere locations without access to a centralized power grid to facilitate reliable and secure energy to power operations and execute missions. These traditional microgrids have used diesel generators, but with technological advances, many are now leveraging renewables such as wind, solar, geothermal and hydropower.[7] Specifically, solar photovoltaic (PV) cells are providing enhanced energy resilience and substantial GHG emissions reductions.

As the U.S. continues to emphasize GHG emissions reduction at the federal policy level, microgrids have become extremely popular in both the civilian and military sectors. They can reduce energy costs for individuals and businesses and can also enhance resiliency and reliability. For the military, these benefits can serve a dual purpose for both day-to-day operations and maintaining power for mission-critical systems if there is a disruption. Because microgrids operate with a small physical footprint and operate separately from larger grids, they are inherently less vulnerable to many modern threats—be it severe weather or direct attack. As such, microgrids are particularly valued as a risk mitigation and energy resilience measure for military installations which maintain critical national security functions.

Notably, between 2011-2015, DoD and DoE partnered to "create fully independent and secure microgrids that [were] resilient to power disruption, protected against cyber-attack, and reflect more sustainable energy practices."[8] The project—called the Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS)—selected three installations to demonstrate how microgrids could improve reliability for mission-critical loads, reduce reliance on fuel, reduce operational risk for energy systems, and enhance flexible electrical energy.[9] The three installations, Joint Base Pearl Harbor-Hickam (Hawaii), Fort Carson (Colorado), and Camp H.M. Smith (Hawaii), were fully functional when completed and provided valuable lessons learned for next generation deployment, management, and operations.[10]

Figure 1: MCAS Miramar Microgrid; DoD Plan to Reduce GHG Emissions; 2023.

Perhaps the most appropriate example of the operational and financial benefits of a microgrid can be seen at Marine Corps Air Station (MCAS) Miramar in San Diego, California. In 2011, MCAS Miramar partnered with DoE/National Renewable Energy Lab (NREL) to create a tailored design concept for the installation, which was subsequently designed and built by Schneider Electric and Black & Veatch.[11] The project was completed and brought online in March 2021, and uses a combination of solar thermal energy, natural gas, diesel, and battery storage which can fully power the installation on its own for up to 21 days.[12] The installation can produce thirteen megawatts of power, which creates significant energy resiliency for the base, as the average load demand is seven to eight megawatts and critical functions only require three to six megawatts of power. This capability is critical for mission assurance and flightline operations, but it also provides resiliency for the community. Notably, in the summer of 2022, San Diego Gas and Electric (SDG&E) requested backup power assistance from MCAS Miramar on three different occasions, which prevented rolling blackouts for nearly 3,000 area homes.[13] Furthermore, the investment in the installation's microgrid has significant financial benefits, with current estimates projecting approximately $90 million in energy savings.[14]

Strategic Guidance

DoD Plan to Reduce GHG Emissions

As part of the FY22 National Defense Authorization Act, DoD was required to create and submit a DoD Plan to Reduce GHG Emissions, as well as report annually on its progress toward meeting emissions targets.[15] In April 2023, DoD published its first ever enterprise-wise GHG emissions reduction plan, which describes strategies and priorities for both installations and operations to reach its goal for 100% carbon-pollution free electricity by 2030. The primary objective of the plan is to increase resilience and protect against natural and man-made disruptions through four primary means:

1) reducing operational and installation energy demand;
2) using distributed, alternative energy supplies;
3) improving installation resilience; and
4) enhancing operational flexibility while simultaneously reducing GHG emissions.

According to the report, DoD's emissions have been trending downward since tracking and reporting began in 2010.[16] As part of DoD's plan to reduce GHG emissions from installation energy (IE) use even further, the plan emphasizes on-site clean energy generation and storage, increased efficiency measures, and incorporation clean energy powered-microgrids, which will be deployed at mission-critical installations first.[17]

U.S. Army Installations Strategy (AIS)

Issued in 2020, the inaugural AIS provides the Army's strategic direction for creating "modern, resilient, sustainable installations, enhancing strategic readiness in a contested multi-domain operations battlespace, while providing quality facilities, services, and support to soldiers, families, and civilians."[18] AIS has a line of effort for "Strengthening Readiness and Resilience," which calls for Army energy and water systems to be resilient, cyber-secure, and efficient. Although it does not specifically mention microgrids, it does mandate that the Army "take actions to ensure the robustness of key systems and capabilities, including facility and industrial control systems of all types" to foster resiliency, efficiency, and affordability.[19]

U.S. Army Installation Energy and Water Strategic Plan

Like the rest of the DoD enterprise, the U.S. Army understands the criticality of energy and water to support missions, routine operations, and lethality. In alignment with the AIS, the 2020 Army Installations Energy and Water Strategic Plan emphasizes three goals: 1) resilience; 2) efficiency; and 3) affordability to sustain critical mission infrastructure and mitigate risks posed by potential energy and water interruptions.[20] It calls for the completion of all Installation Energy and Water Plans (IEWPs) for all Army installations by September 2021, as well as other reporting mechanisms to inform planning and vulnerability assessments. Microgrids, energy storage, onsite generation, backup generation, and utilities and infrastructure are the five resilience assets listed that enable and reinforce installation energy resilience. The plan also outlines objectives and targets for optimizing energy and water use, developing data strategies for energy and water, and reducing costs.

> "Vulnerabilities in the interdependent electric grids, natural gas pipelines, and water resources supporting Army installations…jeopardize mission infrastructure, installation security, and the Army's ability to project power and sustain global operations."
>
> U.S. Army Installation Energy and Water Strategic Plan

U.S. Army Climate Strategy (ACS) and FY 2023-2027 Implementation Plan (ACS-IP)

In 2022, the U.S. Army released the ACS and ACS-IP in support of the Army's core purpose— "to deploy, fight, and win the nation's wars by providing ready, prompt, and sustained land dominance as part of the joint force."[21] Both documents acknowledge the climate related risks that pose a direct threat to when, how, and where the Army operates and which is already making mission assurance more challenging. Energy resilience, defined as "the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions," is a core guiding component of both documents.[22] The ACS specifies a desired End State, three overarching goals, and three lines of effort (LOEs): 1) installations; 2) acquisitions & logistics; and 3) training.[23] For LOE 1, the Army has several intermediate objectives that are directly tied to the rapid deployment of microgrids, as seen in Figure 2.[24]

ACS END STATE AND GOALS

The Army will be a resilient and sustainable land force able to operate in all domains with effective mitigation and adaptation measures against the key effects of climate change, consistent with Army modernization efforts.

- **Achieve 50% reduction in Army net GHG pollution by 2030,** compared to 2005 levels
- **Attain net-zero Army GHG emissions by 2050**
- **Proactively consider the security implications of climate change in strategy, planning, acquisition, supply chain, and programming documents and processes**

Figure 2: ACS End State and Goals; 2022; U.S. Army Climate Strategy.

As a complement to the ACS, the ACS-IP is "a blueprint for the Army's enterprise-wide climate change adaptation and mitigation measures through FY27."[25] Microgrids are intended to serve as a key enabler of infrastructure resilience, infrastructure sustainability, and mitigation of GHG emissions.[26] For each of the next five years, the ACS-IP tasks specific Army integrators, executors, and oversight offices to develop and complete 15-20 microgrids per fiscal year at designated priority installations.

LINE OF EFFORT 1: INSTALLATIONS

STRATEGIC OUTCOME:

Enhance resilience and sustainability by adapting infrastructure and natural environments to climate change risks, securing access to training and testing lands into the future, and mitigating GHG emissions

INTERMEDIATE OBJECTIVES:	
1.1	Install a microgrid on every installation by 2035
1.2	Achieve on-site carbon pollution-free power generation for Army critical missions on all installations by 2040
1.3	Provide 100% carbon-pollution-free electricity for Army installations' needs by 2030
1.4	Implement installation-wide building control systems by 2028
1.5	Achieve 50% reduction in GHG emissions from all Army buildings by 2032, from a 2005 baseline
1.6	Attain net-zero GHG emissions from Army installations by 2045
1.7	Field an all-electric light-duty non-tactical vehicle fleet by 2027
1.8	Field an all-electric non-tactical vehicle fleet by 2035
1.9	Continue to advocate for an expanded Army Compatible Use Buffer
1.10	Include climate change threat mitigation into Army land management decisions
1.11	Incorporate the latest climate and environmental science into stationing, construction, and fielding decisions

Figure 3: LOE 1: Installations, Strategic Outcome, Intermediate Objectives, U.S. Army Climate Strategy, 2022.

Microgrid Design and Deployment

Microgrids are complex to design and deploy, as each microgrid location has different energy demands and requirements. Most have two central software components: design software and load management and control software. Together, this software forms the backbone of every microgrid. Standard design software typically performs a validation to determine if a microgrid system can generate the order of magnitude of power needed. During the design and testing phase of a microgrid project, robust software packages are needed to carefully track energy movement throughout the system while the generation sources are turned off and on as needed. Load validation is a critical part of this process. Once the microgrid system is functional, specialized load management software governs the flow of electricity through the microgrid, controls generation resources based on demand, and is responsible for connecting or disconnecting from the larger, commercial energy grid. However, this only holds true if the placement of control systems, transmission lines, and generation assets is carefully considered during planning and construction.

There are numerous microgrid design software that are publicly and commercially available, such as the NREL Systems Advisor Model, NREL's Renewable Energy Optimization Tool, and the Canadian government's RETScreen tool.[27] These widely available tools are useful in evaluating general technical and economic feasibility, and play an important role in determining the optimal configuration and size of each component to ensure the designs are technically sound and cost effective. Microgrid software developments have also already facilitated major advancements in modeling battery storage, monitoring degradation, and accounting for detail cost predictions and performance modeling.

Figure 4: Army Engineers spur development of tactical microgrids; U.S. Army DEVCOM; CC BY 2.0

As the "central brain" of an operational microgrid, the load management and control software controls and integrates energy generation equipment, such as solar photovoltaics, electricity users, and all the transformers and inverters in between. Load management control software works with existing power systems while maintaining control of the energy system through various states of operation, including communicating the microgrid operating status. How well it communicates ultimately determines the "success" or "failure" of a microgrid since it directs the transition between connection to a grid versus "islanded" status.

Batteries in microgrid systems are also essential elements of the energy system. Power is moved between and through batteries, which can subsequently be used to support momentary load increases or long-term generation deficiencies. Battery size and safety considerations are of paramount importance, as are the physical location and proximity buildings.

Concept and proposal generation, proposal evaluation, design, construction, testing, and sustainment can take years depending on the load demand of the installation, the complexity of the microgrid system, and the existing infrastructure. The ultimate design and construction of microgrids are executed by private sector partners, meaning that the design software must meet the needs of both the private entity for constructing the microgrid and the military for validating and approving the design.

Key Research, Development, Testing, and Evaluation (RDT&E) Considerations

Software

Microgrids are complex energy systems that rely on software tailored to the specific needs of the end user. But for microgrids to be most effective across the Army enterprise, both design software and load management software need to be based on a common set of standards that are flexible enough to meet the specific requirements at each installation. For example, a standard could require use of existing installation electrical infrastructure in the microgrid design. However, naming which pieces of existing infrastructure to use would be difficult as each installation has a different infrastructure makeup with various pieces and ages of equipment.

As mentioned previously, there are numerous widely available microgrid design software available, but they lack both the specifications and technical capabilities needed to be effective on installations. However, these baseline design softwares can still be useful for military installations—simply by reconfiguring them with installation specifications which advance their technological capabilities. For example, Sandia National Laboratories' Microgrid Design Toolkit was modified for use in the SPIDERS project.[28] While existing software tools focus on economic optimization in the design process, to be most effective for the Army, microgrid design software will need to go further and provide more detailed resiliency and feasibility data that aids in both the initial design and quantifies the impact of adjustments to the system in the years following installation.[29] Such design software would ideally include load validation that can adjust throughout the lifespan of the microgrid. In doing so, the design will allow each installation to assess microgrid expansion capabilities and impacts of increasing load demands. As such, and to expedite microgrid deployment, it is critical for the Army to develop specifications for design software.

Standardizing microgrid design software will undoubtedly be challenging, as each installation has a unique set of power demand needs and existing architecture. However, if the design procedures used and requirements for microgrid model outputs are standardized, such as via an updated Unified Facilities Criteria (UFC) for microgrids, it would establish a common list of requirements for planning that can then be leveraged to streamline construction and operations.

Similarly, load management must communicate with the broader electricity systems while simultaneously protecting energy data. They also need to be capable of severing and restarting connections with each component of the microgrid system to ensure security and prioritize critical missions. Most Army installations already have some type of supervisory control and data acquisition (SCADA) system which controls the electricity on an installation. These existing systems must seamlessly interface with new microgrids coming online. Though certainly a planning challenge, this kind of innovative system has already been proven possible during the SPIDERS program at Camp Smith.[30] A state-of-the-art microgrid with hardware and software specifically designed to be a cyber-secure management system was built and integrated with the existing system.

Renewable Base Load Generation

Base load is the consistent, minimum level of demand on an electrical grid that is always available for customers to use. Base load generation technologies are vital to validating a microgrid's ability to meet load demand during peak energy usage. In the U.S., base load generation typically comes from power plants which use coal, natural gas, nuclear, hydropower, or geothermal.[31]

The Army has an objective to achieve 100% carbon pollution free electricity on installations by 2030, so although it is not explicitly stated, it can be assumed that the yet-to-be installed microgrids will leverage renewable energy rather than fossil fuels for base load power. But much like the civilian sector, the military integration of renewables faces several challenges, namely, that renewables such as wind and solar are intermittent and require storage capabilities that are currently insufficient.

Though promising, renewable generation technologies such as hydropower, geothermal, small modular nuclear (SMR), microreactors, and hydrogen fuel are still largely in the research phase. RDT&E activities at Idaho National Laboratory have shown some promise for leveraging hydropower for base load generation, but widespread adoption remains limited due to geographic and environmental limitations.[32]

Geothermal power, while note entirely renewable, is already operating in two plants on China Lake Naval Air Weapons Station in California, but the scalability of geothermal generation is also limited by geography and extensive permitting processes.[33] NREL continues to analyze the potential resilience benefits of geothermal technologies, which have the potential to provide 24/7 power, heat, and cooling, as well as storage.[34]

Meanwhile, SMR have been used by the U.S. Navy for decades and are just emerging as technically and financially feasible options for carbon-free generation.[35]

Even so, solar PV remains an ideal resource for power generation in microgrids because of its modularity and relative ease of access. Solar is used on several Army installations already. Fort Moore (formerly Fort Benning in Georgia) has a solar PV system capable of producing 30MW of electricity, which can power 4,300 homes per year.[36] Fort Huachuca (Arizona) has a solar PV system capable of supplying 18MW of electricity, amounting to twenty five percent of the installation's electricity demand.[37] Fort Detrick (Maryland) is home to a 15MW solar PV field, which serves 12% of the installations annual electric load and reduces annual carbon dioxide emissions by 19,000 metric tons.[38]

Figure 5: Solar Project at Fort Hunter Liggett; March 2013; U.S. Army Corps of Engineers; Photo by John Prettyman

Battery Storage

Battery storage remains the predominant solution to renewable intermittent generation, with battery duration being one of the most critical criteria for energy storage systems. Most batteries today are made from lithium-ion materials and have historically entailed high capital costs and offer relatively short duration for storage. However, the recent surge in interest by both the civilian sector and DoD to adopt electric vehicles has led to battery price reductions for the market overall. Similarly, according to DoD's Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP), battery energy storage systems (BESS) have already made "significant advancements in capacity, cost, and market penetration.[39] A recent report highlighted the value of battery storage in military microgrids, noting that when "integrated into a microgrid, battery energy storage can play a key role in DoD energy assurance by providing increased energy reliability at lower lifecycle costs than a microgrid without battery storage."[40] In 2021, Fort Hunter Liggett (California) broke ground on the Army's first fully solar and battery powered microgrid, positioning it to be the first Army installation to achieve net-zero for critical operations. The installation will be able to generate and distribute electricity without any connection to the commercial power grid for 14 days.[41]

Alternative long-duration energy storage options, like flow batteries, are also showing promise. Flow batteries dissolve solid-state charge storage materials and then pump solutions through electrodes—creating the potential for longer lifetimes than lithium-ion.[42] This reconfiguration of where energy is stored can lead increased capacity and power but can degrade at a faster rate.

Regardless, batteries remain the most feasible baseload generation enabler. Conducting additional RDT&E activities to optimize charge and discharge cycles, explore feasibility of flow batteries, and optimize and/or reduce battery costs remains crucial for widespread microgrid adoption and deployment.

Figure 6: Flow Battery at INL's microgrid test bed; Photo by Idaho National Laboratory; CC BY 2.0.

Physical & Cyber Security

While microgrids promise to be a method of increasing military energy resilience, they still present some vulnerabilities which require careful planning and preparation. Microgrid control systems are decentralized and can be housed in discrete locations on military facilities with multiple dispersed generation sources, so routine installation access control and security operations provide a more robust level of physical security than commercial facilities. However, like their commercial counterparts, microgrids are still vulnerable to insider threats as well as environmental and weather hazards. High wind, extreme heat, and heavy rainfall, which are increasing in intensity and frequency due to climate change, all impact microgrids just as in the commercial sector.

Similarly, since microgrids operate both computer and information networks, cyber-security is paramount. DoD has focused Energy Resilience and Conservation Investment Program (ERCIP) funding to construct cyber-secure microgrids which integrated advanced power management features, on-site generation, and energy storage.[43] SERDP/ESTCP is also conducting research on distributed decision-making approaches which can create additional layers of cyber security by leveraging a microgrid control architecture based on a distributed platform vice a central processing unit.[44] If successful, this would reduce the risk of a system-wide failure from a cyber-attack.

Dedicating appropriate research and resources to cyber and physical risk mitigation is paramount for ensuring microgrids lead to energy and installation resilience.

Other Enabling Factors

In addition to technological and research considerations, there are several other factors and partners which impact the U.S. Army's microgrid goals.

Strategic Environmental Research and Development Program (SERDP)/Environmental Security Technology Certification Program (ESTCP)

SERDP and ESTCP are DoD's complementary programs which "harness the latest science and technology to develop and demonstrate innovative, cost-effective, and sustainable solutions to meet DoD's environmental and installation energy and water challenges."[45] Established by Congress in 1991, SERDP is a partnership between DoD, DoE, and the Environmental Protection Agency (EPA) whose lab-focused activities identify high-priority science and technology investment opportunities which address DoD installation and operational requirements.[46]

ESTCP, meanwhile, focuses on pilot and field demonstration of environmental and energy technologies which capitalize on previous SERDP investments. ESTCP's Installation and Water program area has dedicated research lines of effort for smart and secure installation energy management as well as distributed generation. ESTCP is continually evaluating and demonstrating microgrid components, control systems, and design tools to improve interoperability and reduce life-cycle costs.[47] Continued robust funding for both programs is critical for DoD's installation energy resilience efforts.

With over 130 installations worldwide[48], and only 25 microgrid projects scoped and planned through 2024, it is critical that SERDP/ESTCP continue to be fully funded and invest in robust microgrid RTD&E activities which can benefit the entire DoD enterprise and beyond.

Army Office of Energy Initiatives (OEI)

Army's OEI, housed under the Assistant Secretary of the Army for Installations, Energy, and Environment (ASA IE&E), is the Army's central program management office responsible for the development, implementation, and oversight of privately financed, large-scale energy projects focused on enhancing energy resilience, energy security, and sustainability.[49] OEI leverages private financing (easements; leases); direct funding sources (Energy Resilience Investment Program funds); and third-party financing (Energy Savings Performance Contracts (ESPCs) and Utility Energy Service Contracts (UESCs) to facilitate energy resilience.[50]

According to the ASA IE&E FY2020 Year in Review, OEI helped facilitate Energy Security Assessments across 17 installations, some of which were Microgrid Feasibility Assessments (MFAs).[51] MFAs provide the data needed to make informed decisions about microgrids, including technical, financial, market, and operational feasibility.[52] Like SERDP/ESTCP, OEI is a key partner for planning and implementing microgrids.

Permitting

Microgrids require permits to construct and operate. The process can be lengthy, resource intensive, and spans multiple state and federal entities, including the Federal Energy Regulatory Commission (FERC) and state regulators, as well as the Council on Environmental Quality (CEQ)/National Environmental Protection Act (NEPA).

As ASP has written about before, simplifying and streamlining the permitting process for renewable energy and clean energy project is essential to the clean energy transition as well as the widespread adoption of microgrids.[53] There is broad consensus that the permitting approval process needs to be expedited, but how to do so remains a contentious issue.

Even so, there has been some movement at the federal level to expedite approvals. In 2021, FERC issued Order 2222-A, which removed some barriers for aggregated distributed energy resources unlocking new potential for microgrids.[54] Even though FERC may play a limited role in installation microgrids since installation microgrids typically only operate in one state, the summer 2023 developments are likely to play a pivotal in facilitating commercial and technological advances and create a more hospitable regulatory environment. For example, As part of the federal government's debt ceiling deal in June, the Fiscal Responsibility Act of 2023 (FRA) made several important modifications to NEPA, including page limits and shorter timelines, that will expedite the process.[55] The following month, CEQ released the latest proposed NEPA provisions, which incorporates the FRA deadlines and page limits, and has several other modifications aimed to streamline the notoriously cumbersome process while maintaining protection for the environment.[56] Also in July, FERC issued Order 2023, which will alleviate some of the ongoing interconnection challenges between microgrids and commercial grids.[57]

How permitting reform evolves over the next year will be a key factor in how quickly microgrids can be scaled and adopted.

Personnel

Like their commercial counterparts, microgrids are complex systems which require diligent maintenance and sustainment and thus, the personnel to do so. But with an estimated 50% of the civilian utility workforce retiring within ten years, private sector competition for energy personnel will be more challenging than ever.[58]

Uniformed personnel recruitment has already been deemed a crisis, but manpower with the skills to design, implement, and maintain energy systems also remains a major challenge for installations.[59] At the 2023 DoD Climate Resilience Workshop, Assistant Secretary of the Army for Installations, Energy, and Environment Rachel Jacobson lamented that manpower at Army installations had essentially been gutted, and that DoD and the Army must do better to ensure fair wages and improve the hiring process. At the same event, Assistant Secretary of Defense for Energy, Installations, and Environment Brendan Owens agreed with A/S Jacobson's analysis and acknowledged that personnel for climate and energy resilience tasks are under-resourced throughout DoD.

Notwithstanding, there are innovative personnel solutions underway. West Point has established the Sustainable Infrastructure, Resilience, and Climate Consortium to educate cadets on sustainability and readiness.[60] The Naval Postgraduate School also operates a microgrid research group and a Microgrid Lab to allow students to experiment with different technologies for renewable generation, energy storage, and power distribution.[61]

Partnering with civilian personnel in the community can potentially help fill capability and capacity gaps. The Army has already demonstrated how innovative partnerships can fill personnel gaps by leveraging an Intergovernmental Support Agreement to partner with Auburn University on natural resource management at installations in the southern U.S.[62] Adopting other similarly innovative programs in the energy sector have the potential to provide mutually beneficial opportunities to private partners.

In the longer term, additional uniformed and civilian personnel will still be required to maintain microgrids and other energy infrastructure on installations. A 2023 report from the Center for a New American Security provided an in-depth analysis on civilian workforce challenges across the national security and defense enterprise, which are applicable to DoD. *The Future of Civilians in National Security* provided specific recommendations for Congress and Departments/Agencies to increase a "competitive talent pool with the precise knowledge, skills, experiences, and interests required to work in national security."[63] The Army and DoD writ large stands to benefit enormously from participating in working groups and/or other efforts designed to reform the civilian hiring process.

Public-Private Partnerships

Public-private partnerships between installations and defense communities can play a vital role in advancing microgrid adoption. These partnerships can help manage costs, expedite construction, and ensure widespread benefits and support for installation communities.

The proof of concept has been validated with several installations already. When designing and constructing its microgrid, MCAS Miramar partnered with NREL and local & state utility companies to establish one of the most innovative microgrid set-ups, fostering both installation and community energy resilience.[64] The Miramar Summer Incentive was coordinated by the California Public Utility Commission, San Diego Gas & Electric, MCAS Miramar, and Navy Facilities Southwest and allows the MCAS Miramar microgrid to operate with the city's grid—saving the community from having to endure rolling blackouts during a summer 2022 heat wave.

Marine Corps Logistics Base (MCLB) Albany (Georgia) also leveraged a public-private partnership with the local Chamber of Commerce to achieve its net-zero milestone. As of May 2022, the installation is "net-zero"—the first

DoD installation to meet this milestone.[65] Through a whole-of-community effort, Marines, civilian base workers, Albany State University, and Albany Technical College students, as well as Proctor & Gamble, and Georgia Power all played a role in the net-zero achievement.[66] Since almost all energy infrastructure is privately owned, pursing more public-private partnerships have transformative potential for energy resilience on installations.

Conclusion

The Army has set an ambitious goal of deploying a microgrid on every installation by 2035, but by focusing its efforts, their end states are achievable. Their goals, while ambitious, are possible, but requires focused RDT&E, federal interagency cooperation, and robust, skilled personnel who understand both the technical aspects of microgrids as well as navigating existing permitting and funding bureaucracy. By considering these elements, U.S. Army can greatly enhance both their energy security and energy resilience.

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