FEDERAL
ENERGY SOLUTIONS

Achieving 14-Day Resiliency: Key Strategies to Strengthen Energy Security

2 January 2019

LOCKHEED MARTIN

Energy


LD
AU
ID
SW
NR
+12%
AAPL
+66%
SSLT
+120%
TDSL
SSTD +26.8%
SSTD +26.8%
100%
STOCK 5
20%
34%
15%
31%
2013
2014
2015
99.99%
BAX
XRF
CSK
EEM
MQ
UCXY
VVX
AKB
8.70
9.57
26.63
10.81
+0.41
+0.02
20%
10%
15%
11%
50
40
30
20
10
Bid
Ask
Beta

A few days before Christmas, on December 23, 2015, a third party gained illegal entry to the computer and SCADA systems of Ukrainian Kyivoblenergo, a regional electricity distribution company. A quarter of a million customers lost power for up to six hours. The incident, though limited in scope, was a wakeup call for many in the energy industry of the vulnerability of power grids worldwide. "The cyberattacks in Ukraine are the first publicly acknowledged incidents to result in power outages," noted a 2016 2016 NERC analysis of the event.[1]

As recently as 23 July 2018, Rebecca Smith from the Wall Street Journal reported that Russian hackers had infiltrated hundreds of US utility control rooms. An official from the Department of Homeland Security said in the report that hackers had the capability to throw switches and disrupt power flows. The DHS now says there were hundreds of victims, not a few dozen as had been said previously.

As a result, awareness of the need to protect energy infrastructure from the consequences both cyberattacks and physical attacks has only grown. In a 2017 presentation by Commander Walter Ludwig of the Office of Assistant Secretary of Defense, Energy, Installations & Environment, the Department of Defense (DoD) stated its objectives[2]:

> "Improve the energy resilience of our military bases and cybersecure our building systems to ensure mission readiness and assurance; Optimize installation energy and water performance to reduce base operating costs."

In this context, on February 23, 2017 the U.S. Army issued Army Directive 2017-07 (Installation Energy and Water Security Policy) to strengthen the resilience of bases and the communities they serve. [3]

WHO IS AFFECTED?

At its face, the directive applies specifically to all landholding commands and installation tenants at enduring Active Army, Army National Guard, and U.S. Army Reserve installations, sites, infrastructure and facilities operated and/or maintained by federal funds both inside and outside the continental United States. The significance of the order goes beyond any one branch of the military, however. It reflects a broader set of goals articulated by the U.S. Department of Defense as a whole.

The Army directive is a starting point and may serve as a model as the DoD shares knowledge and hones its strategies. The order addresses critical assets – water and power – vital to basic human survival and critical to any military mission. The directive requires these base commanders worldwide to ensure access to power and water to sustain self-sufficient operations for a minimum of 14 days. As the aftermath of Hurricane Maria in Puerto Rico has demonstrated, catastrophic events may result in much longer outages. By implementing the directive, base commanders will establish a baseline from which they can learn and expand to establish greater resilience for their bases and the communities they serve.

RESILIENCE: WAYS & MEANS

In a statement on the directive, Acting Army Secretary for Installations Jordan Gillis noted that harnessing technology to improve efficiency and security and reshape installation services is going to be a big part of the solution. There are several reasons for this.

- **First, money:** the DoD's annual energy costs $4 billion a year in 2017 is the single largest base operating cost and smart energy innovations such as energy efficiency programs could help address this.[4] Since the directive does not include additional funding, getting "more from less" is going to be an important strategy.
- **Secondly, resilience requires the ability to microgrid.** As long as the military must rely on the external commercial electrical grid, it cannot be said to be fully responsible for its own resilience.

WORLD OF THREATS…

Energy resiliency can be at risk from natural and human actors. States and individuals alike may take aim at energy infrastructure, targeting cyber or physical weaknesses – or both. In "Why We Need Microgrid Cybersecurity: The Threat is Real" by Microgrid Knowledge Editor Elisa Wood writes that, "This new threat is worse because it often comes with less warning than acts of nature, offering little time to prepare. It carries the potential to take down larger swaths of the electricity system for longer periods of time because of the risk of cascading failures."

Increasingly severe weather is causing longer and more widespread outages at facilities, including DoD bases. In the aftermath of Hurricane Sandy, an August 2013 federal report examined the impact of weather-based outages on the economy. The report, "Economic Benefits of Increasing Electric Grid Resilience to Weather Outages," found that between 2003 and 2012, "weather-related outages are estimated to have cost the U.S. economy an inflation-adjusted annual average of $18 billion to $33 billion."[5]

The DoD, too, is experiencing threats from weather-related conditions caused by global warming. "On June 28, 2017, the House Armed Services Committee formally acknowledged climate change as a threat to national security through an amendment to the 2018 National Defense Authorization Act" reported the Environmental and Energy Study Institute (EESI), a nonprofit founded in 1984 by a bi-partisan group of members of congress.[6] "The amendment would direct each service branch to compile a list of the ten facilities under its command deemed the most vulnerable to climate change over the next 20 years. In particular, the process would include an evaluation of each base's energy security."

A 2018 report to the U.S. Department of Defense Strategic Environmental Research and Development Program (SEDERP) co-authored by the U.S. Geological Survey (USGS), National Oceanographic and Atmospheric Administration (NOAA), Deltares and the University of Hawaii found that climate change impacts including sea level rise could affect military bases – including the Ronald Reagan Ballistic Missile Defense Test Site in the Marshall Islands.[7] Because the Marshall Islands' altitude is greater than many other islands, any impacts observed there may serve as a something of a best-case scenario compared to islands at lower sea levels.

Washington Post environmental reporter Chris Mooney, writing about the report summarized the impact[8]:

> "The threats to the islands are twofold. In the long term, the rising seas threaten to inundate the islands entirely. More immediately, as seas rise, the islands will more frequently deal with large waves that crash farther onto the shore, contaminating their drinkable water supplies with ocean saltwater, according to the research.
>
> "The islands face climate-change-driven threats to their water supplies 'in the very near future'" according to the study, published in the journal Science Advances."

These elements – access to water and reliability of power – are precisely the focus of the DoD resiliency directive.

ENHANCING STRATEGIC RESILIENCY: ONE BASE AT A TIME

Compliance with the DoD goals will require leadership and problem-solving at the base level. Federal resources include neither detailed strategic instructions nor funding. It will come down to individual base commanders to harness new technology to get the most from their assets and to determine ways to reduce costs (and in some cases even generate revenue from) deployment of distributed resources.

Energy efficiency and microgrids will play a vital role. To achieve self-sufficiency at the 14-day level, each base must essentially be able to microgrid itself – if not as a matter of daily operation, at least it must be able to quickly sever connection and sustain itself. Efficiency must become not merely a tactic for emergency or "under siege" level situations (where every drop of water or kilowatt of energy is precious) but must be seen as an integral, strategic element to energy and resource management.

In the next section, we will delve more deeply into energy efficiency and microgrids and their role in establishing this resiliency.

MICROGRID AS A RESILIENCY STRATEGY

The current centralized power system of the United States is an attractive target, given its single point of failure and typically linear architecture, while microgrids with their varied, distributed resources (which may include generation and storage resources) offer multiple resources and a mesh-like architecture. Microgrid attackers would need to discover and compromise multiple unconnected points. There is no single vulnerable "bull's eye" for them to hone in on. And because microgrids use multiple sources of generation, this means that if one fails, another can take its place. For example, if solar panel management software is attacked, the microgrid could still generate electricity from its other sources, such as energy storage or combined heat and power.

For this reason, microgrids are widely seen as holding promise for maintaining or improving power resiliency even amidst growing threats. When a base can detach from its regional power grid, it becomes an island of power. They could even be set up as temporary or mobile power distribution, serving as an electrical oasis in emergency scenarios.

GAINING EFFICIENCY: A PENNY SAVED...

While Department of Defense (DoD) spending on energy has dropped significantly in recent years – the department lowered energy intensity in its facilities by 17 percent from FY 2003 to FY 2013, according to the EIA – installation energy is still a significant expense.[9] U.S. Army publication Stand To reported in October 2017 that total energy consumption for the same period was down "by 25 percent; however, costs have increased by 35 percent."[10]

The 2017 report, "Department of Defense Installation Energy Program," by Commander Walter Ludwig Office of Assistant Secretary of Defense Energy, Installations & Environment, provides further insights, observing that among installation expenses, the $4 billion energy expenditure "is the single largest base operating cost."[11]

Figure 1: DoD's Built Infrastructure

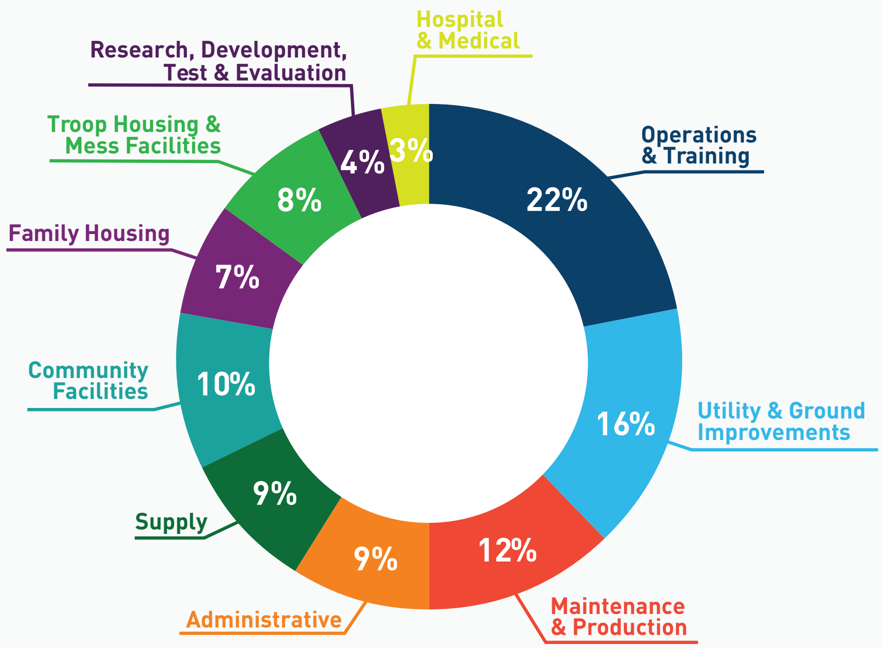
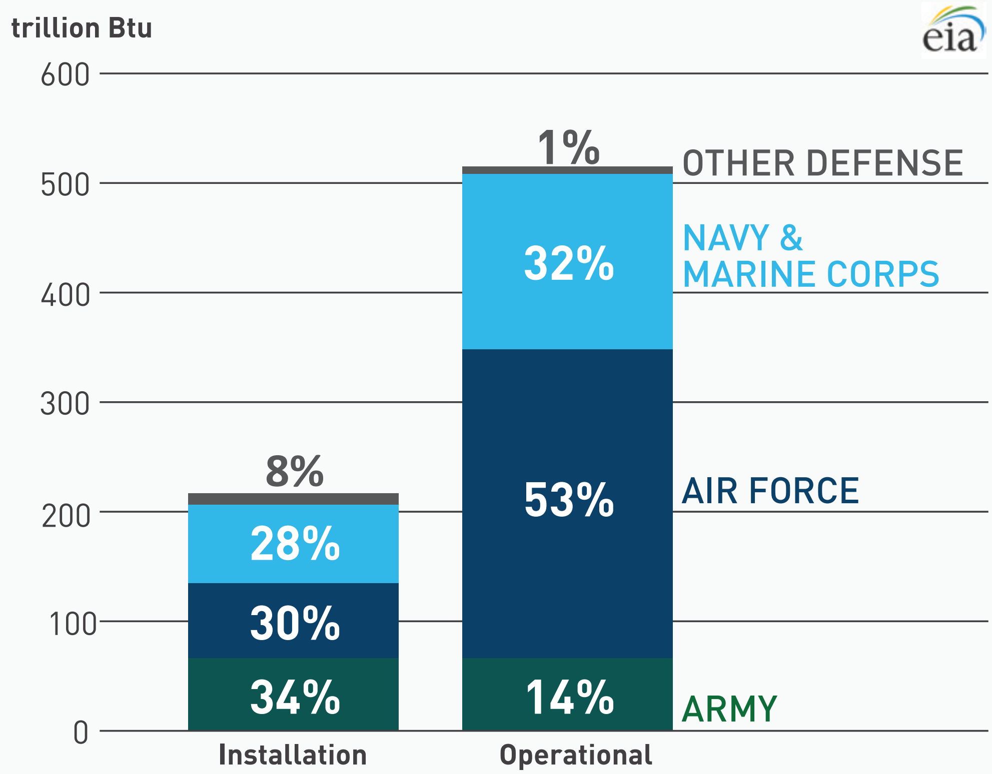


Figure 2: U.S. Defense Department energy consumption, 2013 fiscal year



Sources: FY 2013 Department of Defense Annual Energy Management Report.
FY 2013 Department of Defense Operational Energy Annual Report.

Of all branches of the military, Army spends the highest percent of its energy budget, 34 percent, on bases and other infrastructure, according to the EIA report. (Air Force has the highest expenditure on energy overall, but that is focused on operational expenses, not infrastructure.)

In 2016, the Army spent more than $1.1 billion on energy at its installations according to Stand To.[12]

The evidence is clear; managing costs for energy is an ongoing challenge for all military and for the Army in particular. Continuing to find new and effective ways to gain efficiencies is increasingly important.

OVERWORKED YET UNDERUTILIZED ASSETS

The diesel generators used by many bases are one area with potential for improvement. Many of these peak generation resources are both overworked and underutilized. Because the generators at most DoD bases have a greater load than they will ever need and they are not connected to the grid beyond the base. For example, one large domestic U.S. base has a 1.8 MW backup diesel. On the hottest day of 2017, the seven largest buildings at this base used 900 KW of power (a fraction of what those diesel generators store). Although each building fires up these generators daily, they are only used when needed and often go to waste.

This waste often appears a couple of ways:

- The overworking of the generators increases costs for the DoD because of the maintenance and repair needed;
- They largely never link to either the regional grid where they might sell power when it is needed, creating an enormous waste of energy, and;

- The same equipment could be used more effectively in a microgrid and even provide power into the regional grid, that can reduce costs for the base, or even become a potential source of income.

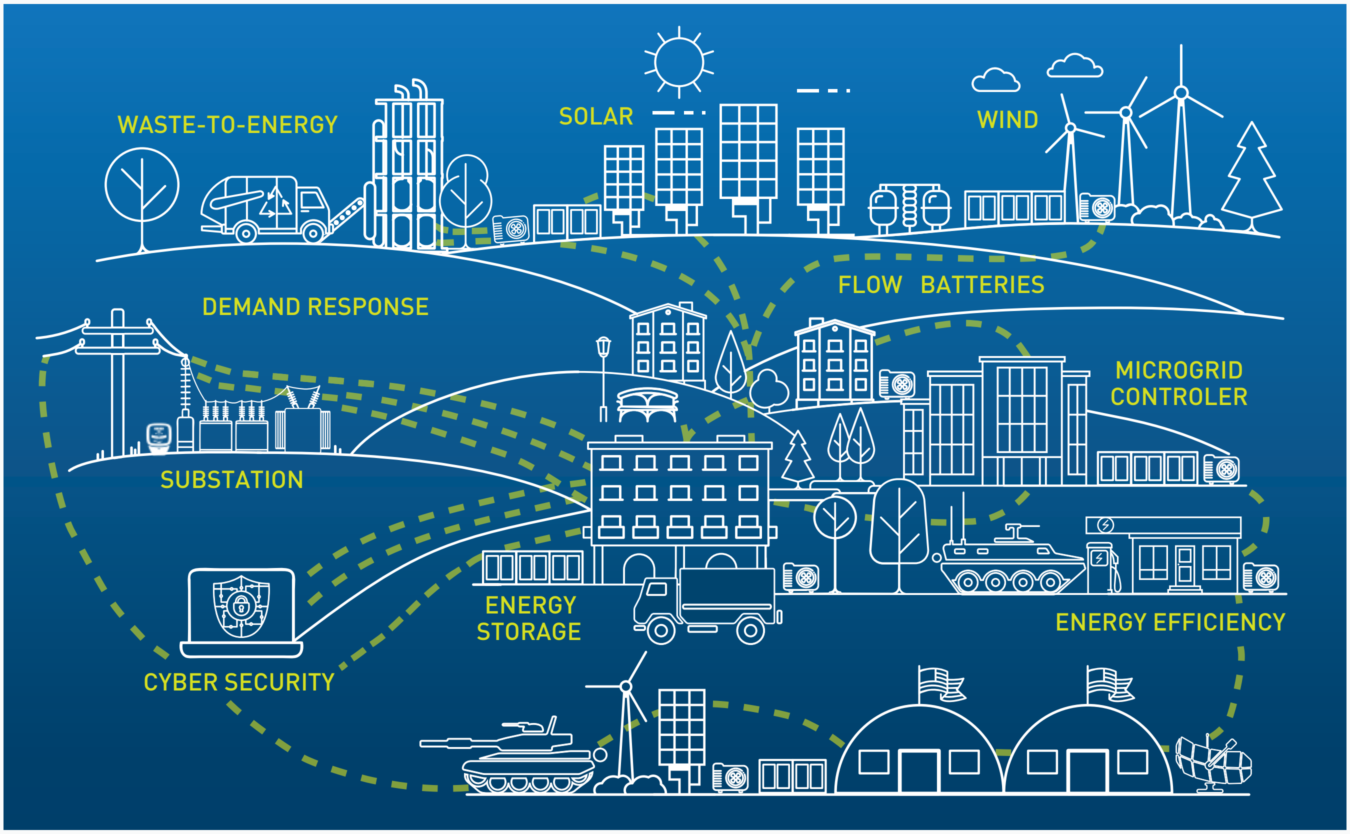
A January 12, 2017 study commissioned by the Pew Charitable Trusts stated that maintenance, inspection and testing of standalone generators on military bases are inadequate. For example, only 60 percent of bases perform the required testing. This un-flattering statistic leads directly to reliability issues within the generator fleet. It is widely known that many generators on military bases are old, and in some cases, past their intended life. This fact coupled with a lack of routine maintenance does not bode well for standalone generation, especially in the face of prolonged grid outages.

EMERGING ANSWERS: SMART TECH COMES OF AGE

Microgrids helps decrease energy waste by linking/connecting assets that would originally go unused. In a microgrid, a centralized controller optimizes the system to ensure the most efficient use of the distributed power resources while distributed controls connect a variety of power sources, loads and even energy storage units onto a common network.

This smart software can dramatically improve energy management. Within a base, energy loads serve different priorities. For example, some power is needed for mission critical operations; others may be required only in peak use situations.

Figure 3: Resilient Military Base Design



Energy management software, particularly those developed in recent years to manage distributed energy resources like solar panels and batteries, can help manage and optimize a combination of legacy generation resources, renewable generation resources and perhaps nuclear power sources. It also coordinate the use of a variety of energy storage technologies.

ENERGY STORAGE: THE KEY TO RESILIENCY

In fact, of all the energy resources in the mix, energy storage may be the most vital. Like hospitals and many institutions and large commercial operations, bases have long used energy storage – generally banks of batteries that can be relied on in the event of a power loss. Today, energy storage is taking new forms, from thermal storage to flow storage to a variety of chemistries beyond alkaline and lithium ion. Each of these technologies offers particular capabilities that can be matched to a variety of needs. For example, lithium has been used widely in pairings with solar PV. Power produced at one time of day or night then providing energy back into the grid at times when the sun doesn't shine. Base commanders can utilize similar techniques to manage peak energy costs as well as to increase resilience of their grid.

Energy storage has become a proven asset to any microgrid. However, flow battery technology will take microgrids to a new level. There are key attributes of flow batteries that will strengthen the resilient posture of any military base's grid. First and foremost is long duration; flow batteries can provide 6 to up to 24 hours of power. This is a critical feature that other battery technologies cannot provide. For example, a flow battery has the capability to be the single power provider during nighttime hours. Another equally essential flow battery attribute is its capability to deeply discharge. This is due to the ability to perform full charge-discharge cycles and operate multiple deep discharge cycles without capacity degradation. For resiliency purposes, a deep discharge capability offers a level of reliability that other batteries, such as lithium-ion, cannot provide.

SYSTEMS OF COMMAND AND CONTROL

By definition, a microgrid is a holistic approach, a system of systems. To manage the energy needs of a military base, it must encompass an asset management and optimization system, a distributed energy resource management system (DERMS) and potentially several other device management and control systems (such as for smart lighting systems and thermostats). It must integrate seamlessly and securely with military and civilian communications systems as well. To keep pace with changing technologies and whatever economic shifts affect them, the overall control system design must be designed with flexibility to allow the microgrid to scale up or down with the base's needs to maintain uninterrupted, high quality power. To uphold security, military microgrids require a role-based user interface, granting access only to approved users, and should be customized to the levels of control required by levels including:

- Executive Leadership (be it the commanding officer or a designated civilian head administrator),
- Utilities Managers and/or Plant Operators.

LEVERAGING THE MILITARY LEGACY OF INNOVATION

The U.S. military has a recognized history of leadership in microgrids and smart energy management. In a March 2017 story, "Energy Efficiency is Becoming an Essential Tactic for the U.S. Military" Public Radio International's Adam Wernick examined the impact of an experimental forward operating base deployed by three units of the US Marine Corps in Afghanistan since 2010.[13] "They carried mobile solar units and hooked up their computers, their radios and their artillery targeting software to solar arrays that had battery storage." The result, Wernick wrote, was being "able to fight the fight on a daily basis without moving liquid fuel in." The mobile bases, integrated with renewable energy, allowed the Corps "to completely reduce the need for fuel resupply in two of those units."

In Afghanistan, the Marines found that having extended energy resources within the base effectively advanced both the mission and security of the unit. Capt. Jim Goudreau, a former Deputy Assistant Secretary of the Navy with more than twenty years in the supply corps, told Wernick. "In real terms, that means a young Marine didn't have to go into harm's way simply to move fuel to that forward operating base," Goudreau explained.

"The Marine Corps recognizes that the enemy knows that we need fuel and, if they can interrupt [our] supply, then that gives them an advantage," Goudreau said. "Renewables themselves give, in the Marine Corps' case, greater agility, greater speed and greater self-sufficiency." It's not hard to see how microgrids, deployed across U.S. bases at large, could similarly advance security and resilience in the face of a variety of scenarios. The DoD's goals bring home the challenge of applying military microgrid lessons at home.

ROADMAP TO A MICROGRID

The process of converting to a microgrid scenario can seem daunting, yet, like any mission, it can be addressed systematically and strategically. Below is a high-level roadmap, based on numerous projects, one should consider when embarking on a microgrid initiative:

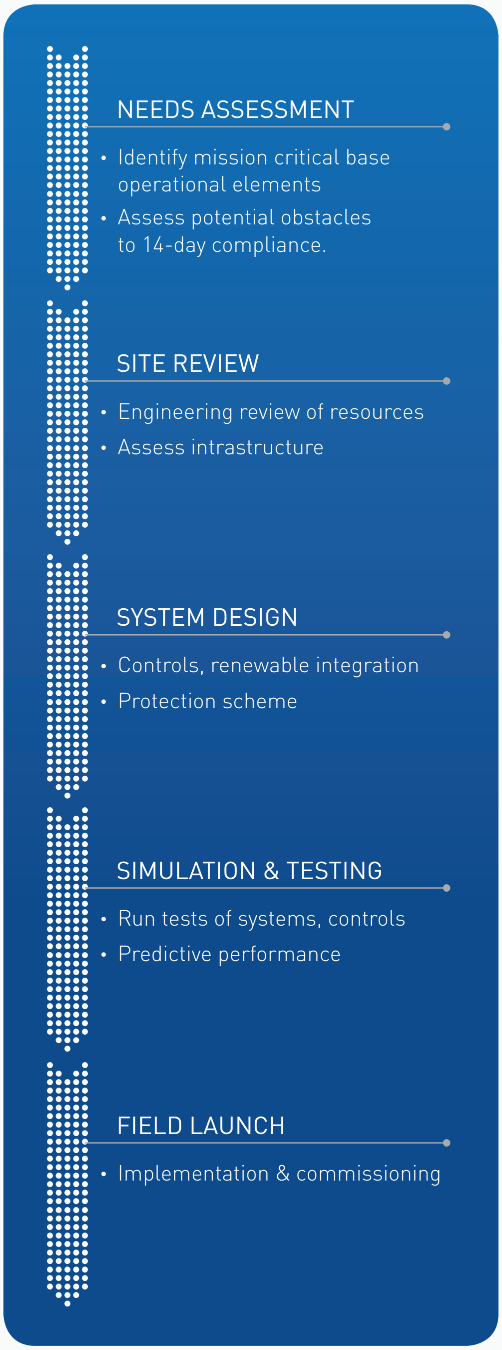
1. The process begins with a review of goals and priorities. What improvements can be gained in reliability, in sustainability? Where might efficiencies help reduce costs? What level of independence is desired? Talk with a microgrid consultant about your needs and learn what choices may be available to you.

2. An engineering site survey comes next. This includes a review of all physical assets and their load profiles. It also takes a look at existing infrastructure and the potential for energy generation and storage on site. Regional and federal regulations will come into play here as well as any existing operational and maintenance approaches already in place.

3. Next, engineers begin system design and modeling in earnest. They may specify and recommend a combination of generation and storage resources and should define the approach to integration. Here, they will customize controls and protections and apply algorithms to optimize management and control of the proposed microgrid and all its systems and assets.

4. Simulation and systems need to be tested, not only to identify any weaknesses in architecture but to assess performance and controls under a variety of conditions. If there are off-base elements, such as reliance on certain power sources, or, conversely, supply from the base onto the regional grid, these must all be modeled and examined. This will likely include an element of predictive performance.

5. Finally, the system is ready to be implemented. This includes verification, commissioning, and a customized approach to planning based on your personnel and location. The operations and maintenance plan will go into effect now as well.



TOWARD RESILIENCE AND EFFICIENCY

Ultimately, resiliency is about both a strong defensive stance and a robust approach to recovery. Power resiliency – keeping the lights on – directly supports the DoD's ability to fulfill its mission. Each base commander that can leverage microgrids and smart technologies to better resist threats and recover from them will be not only achieving compliance but advancing national security at the local level. Likely no two plans will take the identical approach, but the elements of efficiency programs and distributed energy resource management seem sure to play a central role in all.

Long-Term, Technology-Focused, Global Partner

STABLE, LONG-TERM PARTNER
Lockheed Martin Energy has an over 100-year history and a strong track record of honoring customer commitments.

FOCUS ON CONTINUOUS PRODUCT IMPROVEMENT
Lockheed Martin Energy employs a robust and continuous development process that includes incorporating industry and customer feedback and previous lessons learned into product design and development.

GLOBAL SCALE AND DEPLOYMENT
Lockheed Martin Energy operates in more than 40 countries and has a dedicated global team. SEEload® is deployed at some of the largest electric utilities in the United States, supporting over five million customers with over 500,000 active enrollments across several different DR programs on a single cloud-hosted production instance.

CYBERSECURITY EXPERTISE
With a focus on enhanced cybersecurity, security issues are core for all Lockheed Martin Energy products. As the world's largest defense contractor offering cyber security for customers including the army, Lockheed Martin Energy's history is rooted in designing cyber secure systems.

About Lockheed Martin Energy

Lockheed Martin Energy is a line of business within Lockheed Martin that delivers comprehensive solutions across the energy industry to include demand-response solutions, energy efficiency, energy storage, nuclear systems and bioenergy generation. Lockheed Martin's energy storage solutions include long duration offerings. Lockheed Martin Energy has energy storage solutions currently operating at U.S. military bases. For additional information, visit our website: **www.lockheedmartin.com/energy**.

Footnotes

[1] North American Electric Reliability Corporation, "Analysis of the Cyber Attack on the Ukrainian Power Grid," 18 March 2016, https://www.nerc.com/pa/CI/ESISAC/Documents/E-ISAC_SANS_Ukraine_DUC_18Mar2016.pdf

[2] U.S. Department of Defense, "Department of Defense Installation Energy Program," 2017, https://www.energy.gov/sites/prod/files/2017/11/f46/7-fupwgfall2017ludwig.pdf

[3] U.S. Department of Defense, "Army Directive 2017-07 (Installation Energy and Water Security Policy)," 15 Nov. 2017, https://www.energy.gov/sites/prod/files/2017/11/f46/7-fupwgfall2017_ludwig.pdf

[4] ibid., 2.

[5] U.S. Department of Energy Office, "Economic Benefits of Increasing Electric Grid Resilience To Weather Outages" Aug. 2013, https://www.energy.gov/sites/prod/files/2013/08/f2/Grid%20Resiliency%20Report_FINAL.pdf

[6] Environmental and Energy Study Institute, "Protecting the Grid from the Impacts of Climate Change," 7 Aug. 2017, https://www.eesi.org/articles/view/protecting-the-grid-from-the-impacts-of-climate-change

[7] Strategic Environmental Research and Development Program, U.S. Geological Survey, National Oceanographic and Atmospheric Administration, Deltares, University of Hawaii, "The Impact of Sea-Level Rise and Climate Change on Department of Defense Installations on Atolls in Pacific Ocean," Feb. 2018, https://www.serdp-estcp.org/Program-Areas/Resource-Conservation-and-Resiliency/Infrastructure-Resiliency/Vulnerability-and-Impact-Assessment/RC-2334/

The Washington Post, "The military paid for a study on sea level rise. The results were scary," 5 April 2018, https://www.washingtonpost.com/news/energy-environment/wp/2018/04/25/climate-change-could-make-thousands-of-tropical-islands-uninhabitable-in-coming-decades-new-study-says/?noredirect=on&utm_term=.70dea2cce12c&wpisrc=al_environment__alert-hse&wpmk=1

[9] U.S. Energy Information Administration, "Defense Department energy use falls to lowest level since at least 1975," 5 Feb. 2015, https://www.eia.gov/todayinenergy/detail.php?id=19871

[10] U.S. Army, "Army Energy Resilience," 11 Oct. 2017, https://www.army.mil/standto/2017-10-11

[11] ibid., 2.

[12] Ibid., 10.

[13] Public Radio International, "Energy efficiency is becoming an essential tactic for the US military," 18 March 2017, https://www.pri.org/stories/2017-03-18/energy-efficiency-becoming-essential-tactic-us-military


ENERGY IS EVERYWHERE.
IT JUST TAKES ENGINEERING TO UNLOCK IT.
AT LOCKHEED MARTIN
WE'RE ENGINEERING A BETTER TOMORROW.
The grid is changing and we can help your business change with it. From renewable energy integration to storage, efficiency, demand response and microgrids – we're applying innovative technology from the world's leading research and development company to help customers power their future. Because the energy challenge is an engineering challenge. And that's what we do best.
www.lockheedmartin.com/energy
LOCKHEED MARTIN
© 2017 LOCKHEED MARTIN CORPORATION

Lockheed Martin.
Your Mission is Ours.™

LOCKHEED MARTIN

Energy