ACORE
AMERICAN COUNCIL ON RENEWABLE ENERGY

OCTOBER 2018
ISSUE **BRIEF**

The Role of Renewable Energy in National Security

Overview

Over the past century, access to cheap and reliable electricity has become increasingly essential to the functioning of our economy, way of life and national security. The United States has long recognized the dangers associated with reliance on foreign energy sources and vulnerable supply chains for both fuel and electricity, and has promoted secure, domestic sources of energy.

Powered by inexhaustible sources of free domestic fuel, renewable energy provides a growing and vital contribution to America's national security. Unlike conventional methods of producing electricity, renewable energy generators do not rely on fuel supply chains that can be disrupted intentionally or by natural events. Unlike combustible fuels, renewable energy does not pose a risk of dangerous leaks or explosions that threaten human health and public safety. Renewable energy generation facilities can also be constructed within a short timeframe. Typically dispersed throughout different regions, they are also less vulnerable to acts of terrorism. Additionally, renewable energy generators enhance the reliability and resilience of the entire electrical grid during high-impact events, especially when combined with energy storage and other advanced grid technologies. In cases where continuity of power supply is vital for national defense operations, renewable power and enabling technologies, such as storage, can be combined to form self-sustaining microgrids.

The compelling national security advantages of renewable power have been recognized for years by national security experts, the U.S. Congress and a host of senior officials at the U.S. Department of Defense (DOD). For more than a decade, DOD officials have sought to deploy renewable technologies at military facilities throughout the country and in support of forward operations, where they reduce risk from exposed fuels lines and dramatically reduce casualties associated with fuel-supply convoys.

The pages that follow provide an in-depth look at the range of qualities renewable energy offers in support of a resilient and secure electricity system. This paper also summarizes the impressive track record of renewable energy in supporting the mission of U.S. Armed Forces.

The Evolution of U.S. Energy Security Policy

Throughout American history, the need for secure energy sources has been an ever-present concern. Early examples of federal action to promote energy security include the creation of the Naval Petroleum Reserve in 1912 by President William Howard Taft in anticipation of an impending oil supply shortage that could weaken U.S. naval power.[1] More recently, the Energy Policy Act of 2005 and Energy Independence and Security Act of 2007 took significant steps to enhance domestic electricity resilience and security.[2] The "Energy Policy of the Department of Defense," which President George W. Bush signed into law in 2007, recognized the security

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[1] *See* 10 U.S.C. § 7420(2), defining "naval petroleum reserve."

[2] Energy Policy Act of 2005, Pub.L. 109-59 (Aug. 8 2005); Energy Independence and Security Act of 2006, Pub.L. 110-140 (Dec. 19 2007).

benefits of renewable power and called on DOD to produce or procure 25 percent of its electricity from renewable sources by 2025.[3]

When National Security and Resilience Are Used to Justify a Bailout

The role of energy sources as they affect national security has recently come to the forefront of a national debate. Despite the host of security benefits associated with renewable energy, the Trump administration's rhetoric and proposals on energy security and resilience have narrowly focused on efforts to subsidize coal and nuclear power.

In August 2017, the Department of Energy (DOE) released a Grid Reliability Study, quickly followed by a DOE Notice of Proposed Rulemaking (NOPR), to the Federal Energy Regulatory Commission (FERC).[4] The NOPR sought to guarantee cost recovery for aging coal and nuclear plants that would otherwise retire because they can no longer compete economically. Despite clear evidence that fuel supply was very rarely a reason for electricity supply interruptions, DOE asserted that 90 days of on-site fuel supplies were necessary to ensure grid resilience in an effort to justify proposed subsidies.[5] FERC rejected the rulemaking in a unanimous decision in January 2018.[6]

Then, in May 2018, a leaked DOE memo revealed a draft administrative plan offering a different rationale for such subsidies. The memo called for an order that would require electricity grid operators, utilities and ratepayers to purchase electricity from select coal and nuclear plants identified by DOE at an unspecified subsidized price, on the basis that such action is essential for national security. Soon after, the White House issued a statement directing DOE Secretary Rick Perry to prepare steps to prevent the loss of coal and nuclear power plants.[7] The DOE memo offered no serious analysis in support of its assertion that coal and nuclear subsidies would further energy security and grid resilience. After months of speculation on what the administration might propose, an October 15 media report indicated that the White House had put these plans on hold amid internal opposition from multiple Presidential advisors on both the National Security Council and the National Economic Council.[8]

While the administration appears to have shelved this latest plan over concerns about the cost to electricity customers, there is every reason to believe that the President and Energy Secretary Rick Perry remain committed to finding a way to bail out aging coal and nuclear power plants that are no longer economically viable. Through the Grid Reliability Study, DOE NOPR and DOE bailout proposal, administration officials and DOE leadership have repeatedly sought a method to compensate coal and nuclear power plants on the grounds of national security and grid resilience. **In providing preferential treatment for aging coal and nuclear facilities that are no longer economically competitive, such interventions would discourage**

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[3] Energy policy of the Department of Defense. 10 U.S.C. § 2991(e).

[4]Staff Report to the Secretary on Electricity Markets and Reliability, Department of Energy. *Available at*, https://www.energy.gov/downloads/download-staff-report-secretary-electricity-markets-and-reliability; Grid Resiliency Pricing Rule, Department of Energy. *Available at*, https://www.energy.gov/sites/prod/files/2017/09/f37/Notice%20of%20Proposed%20Rulemaking%20.pdf

[5] The Real Electricity Reliability Crisis, Rhodium Group (2017). *Available at,* https://rhg.com/research/the-real-electricity-reliability-crisis-doe-nopr/

[6] Order terminating rulemaking proceeding, initiating new proceedings, & establishing additional procedures, Federal Energy Regulatory Commission, Docket Nos. RM18-1-000. *Available at,* https://elibrary.ferc.gov/idmws/file_list.asp?document_id=14633130

[7] Eric Wolff, Politico, Trump calls for coal, nuclear power plant bailout. *Available at,* https://www.politico.com/story/2018/06/01/donald-trump-rick-perry-coal-plants-617112

[8] Eric Wolff and Darius Dixon, Politico, Rick Perry's coal rescue runs aground at White House. *Available at,* https://www.politico.com/story/2018/10/15/rick-perry-coal-rescue-trump-850528

investment in the grid and reduce the use of renewable energy, even as renewable generation has proven more reliable and resilient in the face of extreme weather events and other sources of grid stress.

The Value Renewable Energy Brings to National Security

Threats to electricity supply fall into three categories: (1) *weather* (e.g., drought, earthquake, flood and storm surge, hurricane, ice storm, tornado, tsunami); (2) *anthropogenic* (e.g., cyberattack, physical attack, intentional electromagnetic pulses (EMPs), major operation error); and (3) *other events* (e.g., volcanic event, space-based electromagnetic event, natural fuel supply disruption). **As described below, the most pervasive forms of renewable energy generation, wind turbines and solar photovoltaic (PV) panels, have fundamental characteristics that make them uniquely capable of withstanding many of these threats.** This resilience benefits both the larger U.S. electric grid, which the economy and many national defense facilities rely upon, as well as critical defense operations and infrastructure, including domestic facilities, bases on foreign soil and forward operations.

Characteristics of renewable energy facilities that make them particularly valuable from a national security perspective include the following:

1. **Zero Reliance on Global Fuel Supply.** Renewable energy sources are not dependent on global marketplaces that can be vulnerable to volatile price spikes or unexpected changes to fuel availability.
2. **Free and Inexhaustible Fuel.** Renewable electricity relies on naturally occurring, free and self-replenishing sources of fuel such as sunlight, wind, the earth's heat or the kinetic energy of a flowing river. While some of these fuel sources can vary temporally, they are steady over annual periods, and advanced modeling can accurately predict their availability.
3. **Smaller, Decentralized Power Generation.** Large centralized power facilities present an important national security vulnerability. Renewable energy can be economically deployed in much smaller units. Rooftop solar, for example, can be installed on homes and commercial buildings where it is either consumed or feeds back into the grid. Utility-scale wind and solar can be economically built in electrical capacities varying from one megawatt (MW) to over a gigawatt (GW). Given the logistical challenges of constructing expensive centralized generation facilities and fuel pipelines for coal and nuclear plants, the complexities of waste disposal and the practical challenges of siting new facilities, there is a tremendous incentive to build these plants as large as possible and then to transport and distribute energy long distances from these centralized power plants.
4. **A Bountiful Resource Available at Point of Use.** The United States is blessed with particularly abundant renewable energy resources, though almost every region of the world has the potential to harvest substantial wind and solar energy.[9]
5. **Rapidly Deployable.** Renewable energy can be built and deployed far more quickly than traditional fossil or nuclear generation. From initial siting and analysis to electricity production, large utility-scale wind or solar farms (over 250 MW) are typically constructed and brought online within one to three years.[10] Coal and nuclear generation, on the other hand, usually take many years to construct, sometimes more than a decade, and substantial, unexpected delays during nuclear power plant

[9] A 2012 National Renewable Energy Laboratory (NREL) study found that the U.S. has adequate renewable energy resource potential with current technologies to realistically achieve 80% renewable energy penetration by 2050. Renewable Electricity Futures Study, National Renewable Energy Laboratory (2012).

[10] Development Timeline for Utility-Scale Solar Power Plant, Solar Energy Industries Association. *Available at,* https://www.seia.org/research-resources/development-timeline-utility-scale-solar-power-plant; Assumptions to the Annual Energy Outlook 2018, U.S. Energy Information Administration. *Available at,* https://www.eia.gov/outlooks/aeo/assumptions/pdf/electricity.pdf

construction are common.[11] A 500 kilowatt (kW) rooftop solar project with storage can be completed in just a few months.[12]

Renewables Enhance Resilience when the Grid is Stressed from Severe Weather Events

Recent severe weather events, during which other electricity generation sources have failed, have repeatedly demonstrated the value of renewable energy for grid resilience. A loss of electricity on the electric grid can threaten U.S. lives, infrastructure and the economy. Additionally, most DOD facilities are still reliant on the grid. Extreme weather episodes are by far the most prevalent threat to domestic electricity supply. Between 2012 and 2016, severe weather events represented 96 percent of the total customer-hours disrupted.[13] While vulnerabilities in transmission and distribution networks caused most of these outages, threats to generation infrastructure are an important and relevant part of the operational security of the bulk power system. **Renewable energy generators have repeatedly proven their ability to respond to and recover from extreme weather events such as cold snaps and hurricanes.**

During the Polar Vortex in January 2014, wind power in the Mid-Atlantic and Great Lakes regions performed well and benefited ratepayers, while many conventional power plants failed due to the extremely cold weather. Even as coal generation facilities had to be taken offline due to frozen coal piles, wind turbines generated power over four times greater than expected capacity during this event. Wind energy's performance while demand was high and other sources dropped off-line helped avoid extreme price spikes, and saved electricity consumers in the PJM region an estimated $1 billion in just two days.[14] PJM claimed that wind power "had a positive impact on supply [during the Polar Vortex] and contributed to PJM's ability to maintain reliability**."[15] A later PJM fuel-security analysis found that future portfolio mixes with large amounts of wind energy tended to be more resilient to extreme weather events, because wind energy output tends to increase while severe weather causes output to decline from other energy sources.[16]**

In September 2017, Hurricane Harvey took down hundreds of power lines in Texas and knocked offline more than 10 GW of electricity generating capacity. While some wind turbines in the coastal region went into scheduled shutdown when the hurricane made landfall and wind speeds surpassed 55 mph, the periods before and after landfall saw increased levels of wind generation and limited damage to turbine infrastructure.[17]

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[11] Mycle Schneider and Antony Froggett, World Nuclear Industry Status Report (January 1, 2014). *Available at* http://journals.sagepub.com/doi/10.1177/0096340213517215.

[12] *See e.g.* Taking the First Step: Understanding the Solar Timeline, Solect Energy. https://solect.com/taking-the-first-step-understanding-the-solar-timeline/

[13] The Real Electricity Reliability Crisis, Rhodium Group (2017). *Available at* https://rhg.com/research/the-real-electricity-reliability-crisis-doe-nopr/.

[14] Greg Hresko and Michael Goggin, Wind energy saves consumers money during the polar vortex, American Wind Energy Association (Jan. 2015). *Available at* *http://awea.files.cms-plus.com/AWEA%20Cold%20Snap%20Report%20Final%20-%20January%202015.pdf*.

[15] Analysis of Operational Events and Market Impacts During the January 2014 Cold Weather Events, PJM Interconnection at 21 (May 2014). *Available at* https://www.pjm.com/~/media/library/reports-notices/weather-related/20140509-analysis-of-operational-events-and-market-impacts-during-the-jan-2014-cold-weather-events.ashx.

[16] PJM's Evolving Resource Mix and System Reliability, PJM Interconnection (March 2017). *Available at,* https://www.pjm.com/~/media/library/reports-notices/special-reports/20170330-pjms-evolving-resource-mix-and-system-reliability.ashx.

[17] Hurricane Harvey cause electric system outages and affected wind generation in Texas, U.S. Energy Information Administration (Sep. 2017). https://www.eia.gov/todayinenergy/detail.php?id=32892.

A few weeks after Hurricane Harvey hit Texas, Hurricane Maria wiped out the Puerto Rican power grid, causing the second largest blackout in history.[18] In the face of widespread blackouts, solar power, energy storage and microgrids were rapidly deployed to quickly bring power back to critical infrastructure facilities such as hospitals and emergency services. As Puerto Rico continues to recover from the storm, technology solutions – including residential solar and energy storage systems – have been identified as vital for efforts to increase resilience in the island's decimated power system.

More recently, in September 2018, Hurricane Florence slammed into North Carolina. While power generation was lost for large areas of the state, press reports indicated that most solar power facilities were back on line quickly, even as coal and nuclear facilities had continuing problems.[19] Flooding of coal ash ponds at a retired coal-fired plant near Wilmington led to a dam breach and serious concern about contaminination by heavy metals as water flowed into the Cape Fear River.[20]

In summary, renewable energy has demonstrated the capability to perform well and promote grid resilience during and after potentially catastrophic, high-impact events. **Proposals to subsidize continued operation of coal and nuclear generators that have often had to shut down in the face of these same events would undermine, rather than promote, grid security.**

Decentralized Generation Improves Electricity Supply Security

The ability to deploy renewable energy close to load centers and in smaller capacity units is an important physical security advantage that bolsters grid resilience. Whereas large, centralized fossil fuel and nuclear power plants have traditionally supplied the U.S. power grid, renewable power installations can be built in a range of plant sizes that can be located at, or close to, load and fed into either centralized transmission or distributed systems. **Geographically dispersed solar, wind, hydro and other renewable energy installations of all sizes reduce the risk that a single point of failure will disrupt the functioning of the bulk power system.**

A natural or intentional event that disables a smaller facility, or the transmission connected to a smaller facility, will have a lower impact on the overall grid performance and is less likely to cause widespread blackouts. Distributed energy resources (DERs), such as residential solar, community solar and energy storage that further disburse power supply enhance the resilience of the grid and diminish the stress placed on transmission systems. **The proximity of DERs to load on the distribution system reduces reliance on vulnerable grid infrastructure that transports energy to customers.[21] In this fashion, renewable energy makes the system less vulnerable to outside events**.

DERs are also an essential component of microgrids, which can be islanded during grid outages to supply power to critical facilities on the distribution system, such as shelters, hospitals, communication

[18] Trevor Houser and Peter Marsters, The World's Second Largest Blackout, Rhodium Group (April 2018). *Available at,* https://rhg.com/research/puerto-rico-hurricane-maria-worlds-second-largest-blackout/.

[19] Adam Freed, USA Today, Message from Hurricanes Michael and Maria: Renewable energy makes more sense than ever. *Available at*, https://www.usatoday.com/story/opinion/2018/10/14/hurricane-michael-maria-renewable-energy-infrastructure-sustainable-solar-wind-column/1575967002/

[20] Brady Dennis, Steven Mufson and Juliet Eilperin; The Washington Post, Dam breach sends toxic coal ash flowing into a major North Carolina river. *Available at*, https://www.washingtonpost.com/energy-environment/2018/09/21/dam-breach-reported-former-nc-coal-plant-raising-fears-that-toxic-coal-ash-may-pollute-cape-fear-river/

[21] Toward Resilience, Defining, Measuring, and Monetizing Resilience in the Electricity System, Institute for Policy Integrity at 26 (2018). *Available at*, https://policyintegrity.org/files/publications/Toward_Resilience.pdf.

centers and national security installations.[22] Such microgrids provide especially important security benefits during extreme weather events or other times of crisis.

Multiple states across the U.S. have undertaken state-level grid modernization efforts that focus on improving resilience by investing in DERs and microgrids. In 2016, in the aftermath of Hurricane Sandy, the New Jersey Board of Public Utilities funded a series of feasibility studies focusing on the cost-effective deployment of microgrids, renewables and storage to prepare for and respond to future storms.[23]

Meanwhile, in 2015, New York launched its Reforming the Energy Vision initiative, which aimed to "further other resiliency efforts by promoting the development of clean, local energy resources that strengthen and improve the reliability of the grid."[24] The plan includes efforts to reduce market barriers for community solar development, develop demonstration projects for microgrid integration and increase deployment of other DERs.[25] Many other states, cities, businesses and communities across the country have identified DERs, microgrids and other renewable energy infrastructure as key ways to modernize and protect their power grids.

Renewable Energy's Role in Cybersecurity

The grid is becoming increasingly interconnected, and communications more centralized, as we continue to deploy new technologies that modernize its infrastructure. Meanwhile, the ability of sophisticated attackers to hack into and affect large areas of the power system has increased. Cybersecurity threats to grid infrastructure have thus become a significant focus of recent efforts to bolster system resilience and national security. Earlier this year, the Department of Homeland Security and the Federal Bureau of Investigation issued an alert that Russian actors had already begun targeting energy and other crucial infrastructure sectors.[26]

Utility-scale wind and solar plants communicate with grid and power plant operators via supervisory control and data acquisition systems and are connected to the grid through power substations, as are most other generators on the grid. Efforts to study and address cyber threats to the grid at these access points include the Department of Energy's Multiyear Plan for Energy Sector Cybersecurity, which aims to understand the threats to generation, transmission and distribution system infrastructure, and the cybersecurity team at Sandia National Laboratory, which has been researching grid cybersecurity for decades.[27]

Today, American renewable energy companies are at the forefront of cybersecurity strategies, employing some of the most sophisticated defense software and hardware available. Additionally, renewables benefit from their

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[22] Enhancing the Resilience of the Nation's Electricity System, The National Academics of Sciences at 106-7, Engineering, and Medicine (2017). *Available at* https://www.nap.edu/catalog/24836/enhancing-the-resilience-of-the-nations-electricity-system.

[23] DER Microgrid Feasibility Studies, New Jersey Clean Energy Program. Last accessed September 21, 2018. http://www.njcleanenergy.com/commercial-industrial/programs/der-microgrid-feasibility-studies

[24] 2015 New York State Energy Plan, New York State. Last accessed September 21, 2018. https://energyplan.ny.gov/Plans/2015.aspx.

[25] Community Solar, New York State. Last accessed September 21, 2018. https://www.nyserda.ny.gov/All-Programs/Programs/NY-Sun/Solar-for-Your-Home/Community-Solar; REV Demo Projects, New York State. Last accessed September 21, 2018. https://rev.ny.gov/rev-demo-projects-1; The New York State Energy Storage Roadmap, New York State. Last accessed September 21, 2018. https://www.nyserda.ny.gov/All-Programs/Programs/Energy-Storage/Achieving-NY-Energy-Goals/The-New-York-State-Energy-Storage-Roadmap.

[26] Russian Government Cyber Activity Targeting Energy and Other Critical Infrastructure Sectors, U.S. Computer Emergency Readiness Team (March 2010). Last accessed September 21, 2018. https://www.us-cert.gov/ncas/alerts/TA18-074A.

[27] Multiyear Plan for Energy Sector Cybersecurity, U.S. Department of Energy, Office of Electricity Delivery & Energy Reliability (March 2018). *Available at,* https://www.energy.gov/sites/prod/files/2018/05/f51/DOE%20Multiyear%20Plan%20for%20Energy%20Sector%20Cybersecurity%20_0.pdf.

decentralization and from the lack of a fuel supply chain, which presents an additional point of cyber vulnerability for other generators.

A Closer Look at Direct Renewable Energy Use by the DOD

The U.S. DOD is the largest single consumer of energy in the world. Energy security and resilience are crucial components of the DOD's ability to conduct its global mission, which is to "provide the military forces needed to deter war and to protect the security of our country."[28] As noted above, DOD has a goal to produce or procure 25 percent of its total facility energy use from renewable sources by 2025. The military services have each set additional goals designed to reduce fossil fuel consumption. In 2012, President Barack Obama signed an executive order committing the U.S. Army, Air Force and Navy to each deploy at least 1 GW of renewable energy projects on or near their installations by 2025.[29] The Navy announced that it had successfully procured 1 GW of renewable energy ahead of schedule in 2015.[30] **"The efforts the military have undertaken over the last five years to add renewables and efficiency will ultimately result in a force that has greater endurance, greater mission stay-time, and greater lethality," explained U.S. Navy Captain (Ret) Jim Gourdreau**.[31]

Domestic Renewable Energy Use

The DOD has long recognized the importance of resiliency at its critical infrastructure and installations. Long before the DOE NOPR sparked FERC's recent docket examining resiliency, a 2013 executive order directed all federal government agencies to develop "the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions."[32] Renewable energy can play a major role as part of this strategy, given its ready availability, uninterruptable supply chain and ability to produce power at the site and avoid reliance on a potentially vulnerable electric grid. In explaining how solar power can help boost resilience at Army bases, Michael McGhee, the Executive Director of U.S. Army Office of Energy Initiatives said, "[w]e are required to be ready no matter what the circumstances. What we are looking at when we see renewables is a self-resupplying power source."[33] **As explained by Former Assistant Secretary of the Navy Dennis McGinn, "[a]t Parris Island, the Marines have developed a project to expand power generation on the base and use solar energy, battery storage and microgrid technologies to help power mission-critical assets in the event of a grid outage. Those investments represent critical insurance against power outages interfering with vitally necessary training rotations."** [34]

Furthermore, as the cost of renewable energy continues to decline, it is quickly becoming the cheapest available source of electricity which can free significant defense spending for other essential mission expenses.

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[28] https://www.defense.gov/our-story/

[29] Fact Sheet: Obama Administration Announces Additional Steps to Increase Energy Security (2012). Available at, https://obamawhitehouse.archives.gov/the-press-office/2012/04/11/fact-sheet-obama-administration-announces-additional-steps-increase-ener

[30] Department of the Navy Celebrates Virginia Solar Deals (2016). Available at, https://www.navy.mil/submit/display.asp?story_id=95981

[31] Herman Trabish, Utility Dive, Will Trump disrupt the US military's clean energy mission? (Feb 2017) https://www.utilitydive.com/news/will-trump-disrupt-the-us-militarys-clean-energy-mission/434465/

[32] Exec. Order 13653 (November 1, 2013). *Available at*, https://obamawhitehouse.archives.gov/the-press-office/2013/11/01/executive-order-preparing-united-states-impacts-climate-change.

[33] Financial Times, US Army bases install more solar panels, despite Trump skepticism. *Available at,* https://www.ft.com/content/7c23057e-a3cc-11e8-8ecf-a7ae1beff35b

[34] Dennis McGinn, Utility Dive, Bad for the military, bad for the public: A retired Vice Admiral on Trump's power plant bailout plan. *Availble at*, https://www.utilitydive.com/news/bad-for-the-military-bad-for-the-public-a-retired-vice-admiral-on-trumps/532516/

Much like the recent surge in large corporate purchases of renewable energy via long-term power purchase agreements (PPA), large military installations such as Fort Hood in Texas are also signing large long-term PPAs to hedge against rising electricity prices. Fort Hood's 15 MW onsite solar farm and 50 MW offsite wind PPA are projected to save the base over $100 million over the lifetime of the projects. Even small renewable projects can have significant impacts on military operational budgets. The remote Tin City Long Range Radar Station in Alaska installed a 250 kW wind turbine project that is reducing the base's reliance on imported diesel to run generators by 30-35 percent and will save the base $443,000 per year (see Appendix I for additional examples of DOD renewable use).

The need for increased military's use of renewable energy is apparent given that, according to a DOD report, U.S. military facilities had 701 power outages in 2016 that lasted eight hours or longer, with an average cost of $500,000 per day.[35] These power outages are primarily due to mechanical failures and the loss of electricity through the public power grid.

Renewable Energy Use at Forward Operations

Many forward operating bases are remote, temporary and located in unstable or hostile regions where they rely on supply convoys to provide combustible fuel for electricity generators. Such convoys can be vulnerable targets for attacks, and rapid deployment of renewable power on these bases has been shown to be able to save American service men and women's lives. According to a study commissioned by DOD, one in 24 fuel convoys in Afghanistan in 2007 resulted in a casualty. Renewable energy can dramatically lower the reliance on such convoys and therefore the frequency of casualties**. In the words of Colonel Brian Magnuson, director of Marines' expeditionary energy office, "[solar power and advanced batteries] are a way to become more effective in combat. This is about war-fighting capability**."[36]

Conclusion

With no vulnerable fuel supply lines, free and inexhaustible fuel, greater decentralization and the potential for rapid deployment, renewable power enhances the security of the bulk power grid. Any serious discussion of U.S. grid resilience and national energy security should consider the immense benefits of a more decentralized grid that is not reliant on global fuel markets, and the advantages of modern technologies that allow for isolated microgrids to support critical facilities. With costs decreasing by the day, renewable energy plays an important and increasing role promoting the security of the nation's electrical grid and supporting the Armed Forces.

[35] Annual Energy Management and Resilience Report, Fiscal Year 2016, Office of the Assistant Secretary of Defense for Energy Installations, and Environment. (July 2017). *Available at*, https://www.acq.osd.mil/eie/Downloads/IE/FY%202016%20AEMR.pdf.

[36] Timothy Gardner, Reuters, U.S. military marches forward on green energy, despite Trump. (March 2017). https://www.reuters.com/article/us-usa-military-green-energy-insight/u-s-military-marches-forward-on-green-energy-despite-trump-idUSKBN1683BL

Appendix I

Examples of DOD Domestic Renewable Use

Base	Location	Technology	Size	Renewable Energy Description	Year Installed
Redstone Arsenal	Huntsville, AL	Solar + Storage	10 MW w/ 1 MW battery	After tornados took down transmission lines, the base had to run on unreliable generators for days. In response to this event they installed a 10 MW PV microgrid capable plant with 1MW battery storage back-up, electricity bought at or below utility rate	2011
Ford Hood	Fort Hood, TX	On-Site Solar + Off-site Wind	15 MW solar / 50 MW wind	The military post installed a 15 MW on-site, microgrid-capable solar array, and signed a PPA for a 50 MW wind turbine project in West Texas. The project is projected to save the base over $100 million over the lifetime of the project, which is money that is freed to support the military's mission in other ways, with zero up-front costs.	2017
Schofield Barracks	Oahu, HI	Biodiesel	50 MW	US Army installed a 50 MW biodiesel plant on the island of Oahu. The base leases the plant to Hawaiian Electric (HECO), but reserves rights to use the electricity in event of a disaster or emergency. According to HECO "It will be the only power plant on Oahu that is located inland, immune from the potential impacts of storms, tsunami and rising sea level. Sited on a secure Army base, the facility can be a key component of recovery in the event of an emergency that affects the power grid."	2018
Robins Air Force Base	Robins, GA	Solar	139 MW	Approved in 2017 and expected to commence construction in 2018, Georgia Power is working on a 139 MW solar facility located next to Robins Air Force Base. The solar array will typically produce electricity for the broader grid but is tied into the base and will be exclusively available to the base during an emergency. This is designed to exclusively help the base meet its resiliency and security goals.	2019 (Expected)
Davis-Montham Air Force Base	Tucson, AZ	Solar	16.4 MW	Commissioned in 2014, a 16.4 MW solar PV project will deliver 35% of the base's electricity needs for 30 years and will save the base $500,000 annually in energy costs. The project was developed and is owned by third parties and sells the electricity to the base through a PPA. At the time this was the largest solar PV project on an Air Force Base.	2014
Fort Huachuca	Fort Huachuca, AZ	Solar	17.4 MW	The 155-acre project leverages private financing and is expected to exceed 18-megawatts of clean power and provide 25 percent of the military base's power. Tucson Electric Power (TEP), Fort Huachuca's electric provider.	2015
China Lake Naval Base	China Lake, CA	Geothermal	13.78-MW	118-acre photovoltaic plant onboard the Station, bringing the solar power array on line. The plant, which is reportedly generating more than 30% of China Lake's annual energy load	1987