1982-2012

Business Executives for National Security

30 YEARS

# POWER THE FIGHT:

## Capturing Smart Microgrid Potential for DoD Installation Energy Security

Fall 2012

Prepared by the

# BENS TASK FORCE ON MICROGRIDS

## Chairman

*Robert Catell, former Chairman and CEO KeySpan Corporation and Chairman of National Grid US*

## Steering Committee

Paul Bollinger, Jr., Boeing Energy
*Norman Chambers, NCI Building Systems, Inc.**
*Mark Gerencser, Booz Allen Hamilton**
Rahul Gupta*, PwC*
Judy Marks, Siemens Government Technologies
Don McConnell, The Tarrington Group
*William F. Murdy, Comfort Systems USA**
Gary Rahl, Booz Allen Hamilton
*Eric Spiegel, Siemens Corporation*
*Jeff Stone, APR Energy*
*Jeff Weiss, Distributed Sun*

## BENS Members

*Keith Butler, MITRE*
*Ed DeSantis, PRISM Technologies Inc.*
*Greg DeSantis, PRISM Technologies Inc.*
*Andrew Evans, AGL Resources*
*Rob Goodin, Goodin McBride, LLP*
*David McDonald, McDonald Foundation*
*Dr. Robert McGrath, Georgia Tech Research Institute*
*Tom Noonan, JouleX*
*Ted O'Shea, ABM Industries*
*Rear Admiral Mike Shelton, USN (ret.), EMCOR Government Services*
*Leslie Sibert, Georgia Power Company*
*Major General David Whaley, USA (ret.), ABM Industries*

## Advisors

Dr. Samuel Aronson, Brookhaven National Laboratory
Don Colvin, FedEx
Chip Cotton, GE Global Research
Ed Bursk, Siemens Government Technologies
Alex DeBoissiere, UIL Holdings Corp.
David Dykes, Georgia Power Company
Brad Fiebig, Lockheed Martin Electronic Systems MFC
Tim Galpin, Johns Hopkins University Applied Physics Lab
Jacob Lamm, CA Technologies
Rex Luzader, Power Analytics Corp.
Fred Lowther, Dickstein Shapiro, LLP
David Manning, NYS Smart Grid Consortium
Paul Marks, Lockheed Martin
Bill McCracken, CA Technologies
Gil Metzger, Lockheed Martin
Tim Noonan, Boeing Energy
Milos Ribic, Expansion Capital Partners
Dr. Bradley Schoener, MITRE
Dr. Yacov Shamash, Stony Brook Univ.
Major General Todd Stewart, USAF (ret.), Michigan Technological University

* Denotes Members of BENS Board of Directors
*BENS Members are italicized*

## WHO WE ARE

Business Executives for National Security (BENS) is a nonpartisan, nonprofit organization of senior executives that volunteer time, expertise, and resources to assist defense and homeland security leaders on a variety of national security challenges.

## OUR MISSION

Apply best business practice solutions to our nation's most challenging problems in national security, particularly in defense and homeland security.


## ACKNOWLEDGMENTS

BENS gratefully acknowledges the expert contributions of our membership, their colleagues, and their staff. We would also like to acknowledge the assistance received from the Department of Defense as well as the leaders and installation commanders within the U.S. Army, Navy, Air Force, and Marine Corps.

Additionally, we would like to thank ACORE, Colorado Springs Utilities, Construction Engineering Research Laboratory, Dahlgren Mission Assurance Division, Dominion Virginia Power, Edison Electric Institute, Hawaiian Electric Company, Georgia Tech Research Institute, Georgia Power, MIT Lincoln Laboratory, the National Renewable Energy Laboratory, and the Perfect Power Institute for the expertise and insights that they have shared.


# About Us

# PREFACE

This report provides a businessperson's perspective on the implementation of microgrid technology on domestic military installations as a means of enhancing their energy security. Microgrids require substantial up-front capital investment, and overall capital spending on microgrid technologies by the military is expected to reach at least $1.6 billion annually by 2020.

BENS identifies and describes the alternative business models available to the military for the ownership and operation of microgrids and to assess the benefits and drawbacks of these approaches in terms of access to capital, economic efficiency, speed to market, energy security, integration of renewable sources of energy and other related considerations. In the course of its work, BENS has looked carefully at the appropriate size and scope of installation microgrids and offers recommendations regarding sensible physical boundaries and suggestions as to how the Department of Defense (DoD) and other government agencies might enhance the energy security and resilience of areas surrounding military installations in the event of prolonged grid outages caused by natural disasters, malicious attack, or unexpected disruption. In addition, BENS examined major non-technical impediments to broad microgrid deployment, including disparate state regulatory environments, military procurement practices, disaggregation of the military's own organizational capabilities, and legacy obligations arising from previous utility privatization programs. Finally, BENS provides a financial modeling tool that allows DoD to quantify the economic value of microgrids at different installation locations around the country and under alternative business models. This tool is intended to help DoD identify where their deployment makes the most economic sense.

BENS believes that a concerted and well-organized effort by DoD to roll out microgrid technology on a widespread basis at its installations in the United States offers important benefits, not only in terms of enhancing the military's own energy security but also by exerting broad influence on both the pace of implementation of key energy technologies beneficial to all citizens and on regulatory policies which today often serve to restrain innovation and efficiency. We commend the leadership of DoD and the individual military branches for attaching high priority to this initiative, and we encourage them, Congress and the federal government to work with providers of electricity and related technologies and services to continue to update and improve system efficiency and resilience.

More than 40 BENS members, their colleagues, and their staffs contributed to this report. We are grateful for their generous assistance and submit this report to the Department of Defense, and other stakeholders to promote and implement proficient and effective establishment of smart microgrids on our nation's most critical military installations.

Robert B. Catell

Robert Catell (Study Chairman)
Chairman
Advanced Energy Research & Technology Center
at Stony Brook University

Monty Meigs

General Montgomery Meigs, USA (Ret.)
President & CEO
Business Executives for National Security

# TABLE OF CONTENTS


Executive Summary 6

Introduction 14

Section I
— Financial Modeling of Defense Installation Microgrids 16

Section II
— Analysis of Alternative Ownership/Operation Business Models 25

Section III
— Size and Scope Criteria for Defense Installation Microgrids 36

Section IV
— Assessment of Impediments to Microgrid Development 42

Section V
— Perspectives on Implementation Considerations 51

Appendix 58


Contents

## EXECUTIVE SUMMARY

Nearly 99% of the more than 500 DoD installations nationwide are dependent on the commercial grid for power.

While the U.S. commercial grid is reliable and resilient, power outages have occurred with greater frequency in the last decade, leaving installations increasingly susceptible to power loss and mission disruption. Complicating this problem, many installations are located at the outer reaches of local transmission and distribution networks, leaving those installations more vulnerable to power interruption, with longer recovery times.

Fixed military installations are vital to our nation's security. Loss of their full capabilities due to outages would diminish our nation's warfighting potential in a crisis. Installations, historically springboards for warfighter deployment, have increasingly become command centers for essential support operations, as well as staging areas for critical humanitarian and homeland defense missions. If an installation loses power today, this would not be a merely local event. Global missions might also be strained.

In 2008, the Defense Science Board highlighted the vulnerability of fixed military installations on an aging commercial grid in a seminal report on energy, More Fight—Less Fuel. Increasingly, military planners seeking to lessen this national security vulnerability are turning to microgrids.

What is a microgrid? It is an integrated system of electricity generation, distribution infrastructure—and, if needed, energy storage—that enables an installation to maintain power while it is disconnected from the commercial electric grid. Along with energy security, microgrids can be also paired with communication and control technology to boost energy efficiency, as well as promote renewable energy integration to become a "smart microgrid."

### DoD views smart microgrids as a "triple play" of benefits[i] for military installations:

- *Increased efficiency for facilities through command-control technology that better regulates and distributes power*
- *Deployment of renewable energy that helps meet congressionally mandated goals*
- *And, most importantly, energy reliability for fixed installations critical to military operations.*

DoD has already partially addressed these concerns about installation energy surety with investments in efficiency and renewable energy. DoD has also increased the emphasis on energy efficiency and conservation through the development of higher standards for building sustainment, restoration, and modernization, as well as energy-efficiency investment programs.

On the supply side, DoD has increased the development of on-site renewable energy resources, and improved its own expertise as a buyer of renewable energy projects. Renewable sources of energy may ultimately make an important contribution to installation energy security by generating electricity without depending on a supply chain of fuel.

DoD also has made specific progress on microgrids. DoD, for example, established an Installation Energy Test Bed within the Environmental Security Technology Certification Program to examine the application of microgrids for the military. This energy test bed validates emerging innovative technologies and invests in further developments that can quickly make microgrids or smart microgrids suitable for installation use. The Installation Energy Test Bed has funded ten demonstrations of microgrid technologies, and is testing technologies from multiple vendors at installations nationwide including among others, Marine Corps Air Ground Combat Center Twentynine Palms, LA, Fort Bliss, TX, Fort Sill, OK, and Joint Base McGuire-Dix-Lakehurst, NJ. DoD has also commissioned a study by the Massachusetts Institute of Technology's Lincoln Laboratory to catalog and assess nearly 50 examples of DoD approaches to ensuring the availability of electric power for key installation missions. About one-half of those examples deal with microgrids or "microgrid-like" approaches.[ii]

This analysis, conducted by the Business Executives for National Security (BENS) Microgrids Task Force, complements these efforts by focusing on the business factors that influence the opportunity for smart microgrid development and deployment. In its analysis, the Task Force examined the potential cost and value of various approaches, alternative business models and financing, the size and scope criteria, and impediments for smart microgrid development and implementation. The Task Force also offers recommendations as enabling actions and steps for DoD to pursue.

## KEY INSIGHTS

- *Installation energy security does not require a technological breakthrough.*
- *Commercially available technologies that can improve power surety at a military facility exist today. Development of energy security solutions, including smart microgrids, will depend more heavily on the creation of adequate business models that distribute costs and benefits among key stakeholders, while delivering the performance characteristics DoD needs.*
- *The appeal of microgrids to third-party financers who can access capital markets more easily than DoD will be a critical driver of successful development.*
- *Smart microgrid development will also depend on direct government funding that can ensure implementation and reduce funding uncertainties in these times of austerity.*
- *The cost advantages of third-party financing, and development, is significant.*
- *Most microgrid projects will require the creation of new power sources on the installation. Capital cost for the new generation assets greatly drive project economics rendering most projects that involve full government ownership and operation of these assets more costly – 20% or more – than approaches*

*that take advantage of third-party financing. Many third-party opportunities will also involve renewable generation, which has experienced significant price declines. The growing abundance of natural gas is another significant factor. One of the most effective existing energy security solutions observed by the Task Force was the energy system using a natural gas peaker plant at Robins Air Force Base.*

## FINANCIAL MODELING OF SMART MICROGRID APPROACHES

The Task Force developed a financial modeling tool that illustrates the potential cost and value of various possible smart microgrid approaches at installations nationwide. Using this modeling tool, the Task Force concluded that microgrids with significant renewable generation assets can be achieved at reduced annual energy costs to DoD, but that these projects are heavily dependent on the locations of the installation and access to third-party capital. Such circumstances are currently available in only a handful of States.

As an example, Joint Base Pearl Harbor-Hickam in Hawaii could lower their annual energy costs by several million dollars a year, and become 50% renewable, through a power purchase agreement with an independent power producer. This approach would provide several million dollars in annual savings that could be leveraged to pay for other needed capital improvements to the installation's energy system, including its smart microgrid.

In total, the Task Force determined approximately 25% of domestic installations can implement smart microgrid projects that would reduce annual energy costs.

In general, these installations are located in States with higher-than average current electricity prices that may represent approximately $1.5 billion of DoD's total annual installation energy cost. If the modeling of Joint Base Pearl Harbor-Hickam is indicative, reductions in annual energy cost of 15-20% are possible, meaning DoD could achieve net savings on the order of $225 million annually from development of microgrids at appropriate installations.

At many installations, microgrids may operate at an increased cost to DoD, at a "security premium." The security premium for installation power surety needs to be further explored by DoD to justify increased cost at specific locations. Nationwide, the "most economic portfolio" of energy security solutions will likely include privately financed microgrids, other arrangements with utilities serving DoD's bases, and government-financed solutions.

A higher percentage of DoD installation microgrid projects would be economically advantageous if they included both new generation and demand-side services (energy efficiency and ancillary services) in a "bundled" project implementation. DoD's historical approach to demand-side services has been decentralized and performance data from previous investments is not broadly available, so it is difficult to comprehensively quantify the impacts of these services. However, the experience of Task Force members strongly suggests that the cost savings from such demand-side services (energy efficiency, in particular) could be of a similar range to those from new generation development using third-party approaches (15-20%). DoD should explore approaches to identify and include these potential savings from demand-side services in microgrid development projects.

## ALTERNATIVE BUSINESS MODELS AND FINANCING

Another factor DoD must consider is the ownership and operation of a smart microgrid and its implications for capital investment, operational responsibility, and economics. The spectrum of these models range from:

- *Government-owned, government-operated*
- *Government-owned, contractor-operated*
- *Contractor-owned, contractor-operated*[1]

Most projects that involve government ownership of capital-intensive generation assets are more costly than approaches that take advantage of third-party financing opportunities that employ a contractor-owned, contractor-operated model, or a

[1]The implications of each of these models are discussed in Section II.

hybrid government-owned, government-operated model that captures tax and subsidy benefits.

Before the most favorable ownership/operation arrangement for individual on-base infrastructure can be determined, DoD needs more insight into on-base electricity management. It is clear, however, that DoD can institute specific actions to maximize the value it receives from capital markets. Chief among these is the adoption of a Levelized Cost of Secure Energy metric that incorporates both the levelized cost of energy concept commonly used in commercial transactions, and the costs of on-base infrastructure improvements required to make an installation ready for a smart microgrid.

## SIZE AND SCOPE CRITERIA OF SMART MICROGRIDS

The size and scope of an installation smart microgrid in relation to its adjacent community will also become a factor as DoD moves forward in development. There are legitimate mission assurance interests for providing power beyond an installation's physical boundaries, as well as a potential saving of project cost through economies of scale, and the selling of power back to local utilities.

Many technologies used in the development of microgrids, such as energy generation, could also benefit from larger development because they marginalize capital cost. Greater size could enable an installation to assist with homeland defense operations in times of crisis by powering essential public infrastructure like water and sewage treatment plants. Moreover, available power from an oversized grid could address the overarching concern that current federal emergency power restoration capabilities and approaches are not effective in meeting future emergencies stemming from catastrophic outages caused by major storms, natural disasters or cyber attack.

Unfortunately though, as discussed in Section III, the challenges and obstacles to creating large, community-scale smart microgrids outweigh these positive benefits for two main reasons:

**First**, utilities already have an obligation to serve everyone in the community. By extending electrical service beyond the fenceline of an installation, DoD directly enters the realm of existing electric utilities. A community-scaled microgrid would be inherently excessive – raising electricity costs to consumers – and creating a new "electrical boundary" in a community that raises equity and safety issues. The relationship of the installation to its current utility poses the most direct challenge to the adoption of an oversized microgrid.

**Second**, at the size needed to capture significant cost benefits from economies of scale – which our analysis shows is at 10 times an installation's annual energy use – the microgrid ceases to be a microgrid. Extending a microgrid to cover community needs at this scale likely implies a more complex network of generation assets, substations, transmission and distribution lines, as well as microgrid management technology and even customer billing systems. At this level, a microgrid is really operating more like the commercial grid itself. And due to its increased footprint, it would become vulnerable to a greater range, frequency and magnitude of service disruption risks. Expanded grids could also entangle DoD in state utility regulation, which could be major obstacle to the cost-effective operation of the microgrid.

For these reasons, the Task Force believes DoD should carefully explore non-microgrid solutions that meet its mission assurance objectives beyond the installation boundary. Encouraging commercial smart grid investment nationally, promoting net metering in the community, and establishing regional power restoration contingency plans and equipment are examples of more effective, alternative solutions.

## NON-TECHNICAL AND TECHNICAL IMPEDIMENTS FOR SMART MICROGRIDS

There are both non-technical and technical impediments to microgrid development.[2]

The principal non-technical issues that may impede microgrid deployment fall into four main areas: prior electric utility privatization actions within DoD, state utility law and regulation, alignment of DoD acquisition processes with commercial

[2] See Section IV.

*Full government ownership and operation can be 20% more costly than third-party financing.*

norms, and the aggregation of relevant installation energy management efforts within DoD. The principal technical issues include elevated electrical shock hazards, ability to parallel with the local utility, and diminished power quality.

Largely, these impediments exist because smart microgrids represent a paradigm shift in both the role of electric power in military operations, and the relationship between DoD installations and the commercial grid. In the past, electricity was viewed as a relatively simple commodity, and DoD as a cumulatively large, but otherwise straightforward customer. In the new paradigm, power surety at installations is increasingly critical to military activities and the most cost-effective and lasting means of gaining power surety is to renovate the current electrical infrastructure with new technology.

To that end, the most significant obstacle to development are the non-technical impediments arising from DoD itself.

DoD's utility privatization program could limit the level of renovation sought by installation managers, DoD's acquisition process, and disaggregation of installation energy initiatives. DoD can best address these impediments by simultaneously increasing its own learning around smart microgrid development (sizing and local business models), and engaging with national-level stakeholders.

## CONCLUSIONS

Smart microgrids are a watershed opportunity for DoD. Along with technological benefits that improve on-site energy efficiency and integration of sustainable renewable energy sources, smart microgrids provide the level of energy security military commanders need to maintain full operation. The commercial grid is experiencing more frequent and longer-duration outages and installation reliance on the commercial power grid has become a vulnerability. Neither DoD, nor the electric power or finance industries, are fully ready to meet these challenges, but all of these key stakeholders have begun to come together to resolve them.

DoD has made strong progress and achieved impressive initial milestones in installation energy management. Utilities and their regulators are beginning to see the potential of partnering with DoD. And the finance sector has many participants who are actively seeking productive ways to deploy capital to accelerate activity.

# RECOMMENDATIONS

## DOD SHOULD ESTABLISH ENERGY SECURITY REQUIREMENTS FOR DEFENSE INSTALLATIONS.

A common energy strategy that highlights energy security on an installation as paramount would set the foundation for DoD and the Services. By clarifying purpose and strategy toward procuring and sustaining installation energy, a "design basis" can be established that determines how much energy security is worth at each installation so that system designers can develop systems with clear knowledge of the type of threats and duration of outage their designs need to anticipate. Costs of a secure microgrid system will inevitably vary by installation. DoD needs to determine the critical mission supported by each installation and the amount it is willing to spend to ensure a specific installation is always fully operational.

For a DoD smart microgrid strategy, it should establish a common basis for system design that clearly defines "efficiency" and "effectiveness" requirements for the adequacy of a smart microgrid. The BENS Task Force believes an effective smart microgrid must have four key characteristics:

1. *An ability to disconnect from the commercial grid and restore power without relying on the external electric power transmission network.*
2. *An ability to integrate renewable energy.*
3. *Sustainability for periods measured in weeks or months, not days.*
4. *An ability to withstand cyber attack.*

## DOD SHOULD DETERMINE AN ORGANIZATIONAL APPROACH TOWARD SMART MICROGRID DEVELOPMENT THAT SUPPORTS TIMELY DECISION MAKING.

If implementation of microgrid policy is delegated to each of the military departments, variability of circumstances at each installation is likely to drive very different decisions in the design and acquisition of microgrids, an added complexity that could affect cost. Industry providers are likely to encounter very different technical bases for microgrid designs, and very different acquisition timelines, processes and selection criteria across the military departments. This kind of approach is unlikely to capitalize on the best value industry can deliver.

DoD should consider centralizing the procurement and technical authorities needed to execute a microgrid development program. Several different approaches include creation of a separate implementation office within Office of the Secretary of Defense, designation of an Executive Agent, or establishment of a joint program executive office. Whatever approach is taken, it is essential that the centralized authority has the resources – fiscal and human capital – procurement authority, and technical acumen needed to be a responsive, sophisticated customer for industry. A streamlined decision and approval processes for project selection, with technical and procurement authority centralized within DoD focused on microgrid development, would spur greater competition amongst investors and ensure DoD receives its greatest value for its investment.

## DOD SHOULD BEGIN A DIALOGUE WITH LEADERSHIP FROM KEY SECTORS – ELECTRIC POWER AND FINANCE – TO BUILD MODEL AGREEMENTS THAT SUPPORT MICROGRID DESIGN, OPERATIONS, AND INVESTMENT.

The level of interest of electric utilities in microgrids of depends on their local grid conditions. The National Association of Regulated Utility Commissioners (NARUC), in passing its referendum on Defense microgrids, expressed both interest and apprehension in the approaches DoD might take. Similarly, the finance industry sees possible opportunity in productively deploying capital to develop microgrids, but is unclear on how DoD will acquire them, and what rules apply. DoD should initiate


or reengage with the leadership in these sectors to develop microgrid concepts that will support ideal agreements and terms, and reduce the degree of variability in microgrid architecture and contract parameters across the DoD installation portfolio.

## DoD should use congressional testimony and outreach to describe the benefits of legislative changes that would remove impediments to investment in smart microgrids and to expand the pool of investors.

Seeking regulatory and legislative provisions that support cost-effective smart microgrid development nationally would also aid in DoD's efforts. For example, provisions like the expansion of real estate investment trusts for energy purposes and the use of alternative fuel sources that some Services do not consider, like natural gas, should be pursued. Current and future budget constraints make funding for microgrid development difficult, and therefore require investment from beyond DoD's traditional funding streams like direct congressional appropriations. Private financing, including investment from utilities, allows DoD to push large investment cost burden to willing third parties that can develop new energy technologies quickly.

## DoD should shift future investments away from research into smart microgrid technology, focusing on applying knowledge to the development, testing, and evaluation of at-scale smart microgrids under varying business model environments.

DoD needs to increase its insights and capabilities regarding microgrid development, with particular emphasis on business models. The Task Force is confident simultaneous learning and implementation is the most effective approach. The DoD portfolio is complex and diverse and some of the challenges to smart microgrid development will not be recognized until full development is occurring. Many aspects will be seen through practice and experience, not analysis.

## Approximately 25% of domestic military installations can lower their annual energy costs with a smart microgrid solution.

### DOD SHOULD PURSUE 6 TO 8 AT-SCALE MICROGRID DEVELOPMENT PROJECTS AS A TEST AND EVALUATION PROGRAM.

DoD needs to gain key insights into how alternative technological choices influence the development of successful microgrid business models. It also needs to develop multidisciplinary capabilities (acquisition, finance, engineering, law, business analytics) needed to successfully envision, analyze, and negotiate the development of a successful DoD microgrid with the full range of industry participants in the separate States.

Development of smart microgrids requires significant upfront capital for DoD to upgrade its installation's distribution networks. To attract this capital, accelerated development of microgrids would lower market costs for the new technology, as well as incentivize direct, private investment into new energy technology projects at individual installations.

Speed to market is very important when negotiating a development deal with a commercial third party because each party is simultaneously accessing capital and sourcing materials for other government or non-government proposals. Each microgrid project is subject to variable priced market constraints, and any delay in the final contract and start date would push the third party to pursue more near-term projects.

DoD installations within the United States have taken on increasingly direct and real-time roles in military operations, a trend that is likely to continue. The nature of these roles demand levels of power surety for installations greater than ever before, while making the vulnerability in near-total reliance installations on the commercial electric power grid  unacceptable. The commercial grid serves installations well today and, over the next decade, "smarter" technologies hold promise to improve the resilience and reliability of the grid even further.

The commercial power grid will evolve, and in the course of this evolution will create opportunities for DoD to realize the triple play of benefits – security, efficiency, and renewables – that smart microgrids can offer at its installations. As this report highlights, what's needed is a greater focus by DoD – on both its internal capabilities, and externally with an expanded set of key stakeholders — to develop business models that work for all involved.

The recommendations of the BENS Task Force in this report, if implemented, will enable DoD to be ready for these opportunities, leveraging its accomplishments, and placing it on a new trajectory to a more secure future.

Nearly 99% of the more than 500 installations nationwide depend on the commercial electric grid.

## INTRODUCTION

Military installations today rely almost exclusively on the commercial grid for electricity. Nearly 99% of the more than 500 installations nationwide depend on commercial energy and transmission for daily electrical power.[iii] While the commercial grid is reliable and resilient, the military's reliance on that grid creates vulnerability to power loss from natural disasters, human error (as seen in the 2003 Northeast blackout), or worse, a man-made attack. Loss of power hampers continuity of military operations. For the critical infrastructure behind military missions, this vulnerability could pose serious risk to national security.

Fixed installations today are vital to our nation's fighting edge. They are no longer mainly spring boards for our warfighters to deploy. Rather, they are increasingly command centers for essential support operations down range and platforms for critical humanitarian and homeland defense missions. Loss of their full capabilities diminishes our warfighting potential and ability to recover in times of crisis.

To address this vulnerability, the Department of Defense (DoD) plans to invest heavily in microgrid technology designed to supply continuous power in the event of grid failure. DoD microgrid investment is estimated to reach $1.6 billion annually by 2020.[iv]

Moreover, DoD foresees microgrids coupled with intelligent energy technology as a way to increase energy efficiency on installations and integrate on-site renewable energy sources. Microgrids with intelligent energy technology, or "smart microgrids" – with the ability to disconnect from the commercial grid and distribute power as needed to support operations on base – can dramatically improve the reliability of power to military installations, and allow them to operate continuously and independently during extended power outages.

Along with reliability, smart microgrids improve the quality of power and reduce the loss revenue from power quality. Billions of dollars in annual loss is attributed to insufficient power quality.[V]

Smart microgrid development is also a systems approach that allows DoD to meet energy, environmental, and security goals simultaneously. While current energy projects help DoD meet renewable energy and greenhouse gas reduction targets, they do not yet provide energy security. Efficiency projects help reduce annual energy costs and meet efficiency targets, but do not provide security either. If energy projects going forward used smart microgrid integration as its foundation, DoD could pursue efficiency and renewable use while also providing energy security to an installation.

In this report, Business Executives for National Security (BENS) brings a business focus to the microgrid opportunity.

## BENS BUSINESS-BASED FOCUS HAS TWO DIMENSIONS:

**First**, highlighting microgrids' costs and their sources of economic value, as well as the business model(s) that could most effectively allocate these costs and values to drive microgrid deployment.

**Second**, as leaders of business enterprises, we offer observations on impediments to microgrid deployment, and organizational and strategic approaches to overcoming them.

Energy security on an installation is not primarily a technology challenge. Commercially available technologies exist that can provide the energy security DoD requires. DoD has made many investments in research and development of microgrid-related technologies, and has a strong understanding of relevant technologies.

The development of smart microgrids on military bases will be to a large degree determined by whether an adequate business model can be developed that will deliver the performance sought by DoD at its installations and at an acceptable cost. For DoD to implement smart microgrids on its installations as quickly as possible, the business case for microgrids must be appealing to third-party developers who can access capital markets more easily than the department. Absent such a business case, smart microgrid development will depend on direct government funding that will delay implementation and introduce funding uncertainties.

Given the right circumstances, third-party investment can be spurred and capital cost for smart microgrid development can greatly diminish. These circumstances are currently available in a handful of States, but DoD, given its size, is well positioned to successfully advocate to similar third-party investment-friendly areas nationally.

# Section I

## FINANCIAL MODELING OF DEFENSE INSTALLATION MICROGRIDS

Central to a business focus on microgrids is an understanding of both the costs and sources of economic value microgrids offer. Solutions for providing energy security on a military installation fall along a spectrum of microgrid models with particular costs and values.

At one end of this spectrum is the provision of emergency electric power on a building-by-building basis through the use of backup generators. This is the most prevalent emergency power solution provided on military installations today. Because these generators are generally not connected to one another or integrated with the commercial grid, they do not create economic value beyond the installation on which they are deployed. As a result, their entire cost (procurement, operations, maintenance) is borne entirely by the DoD.

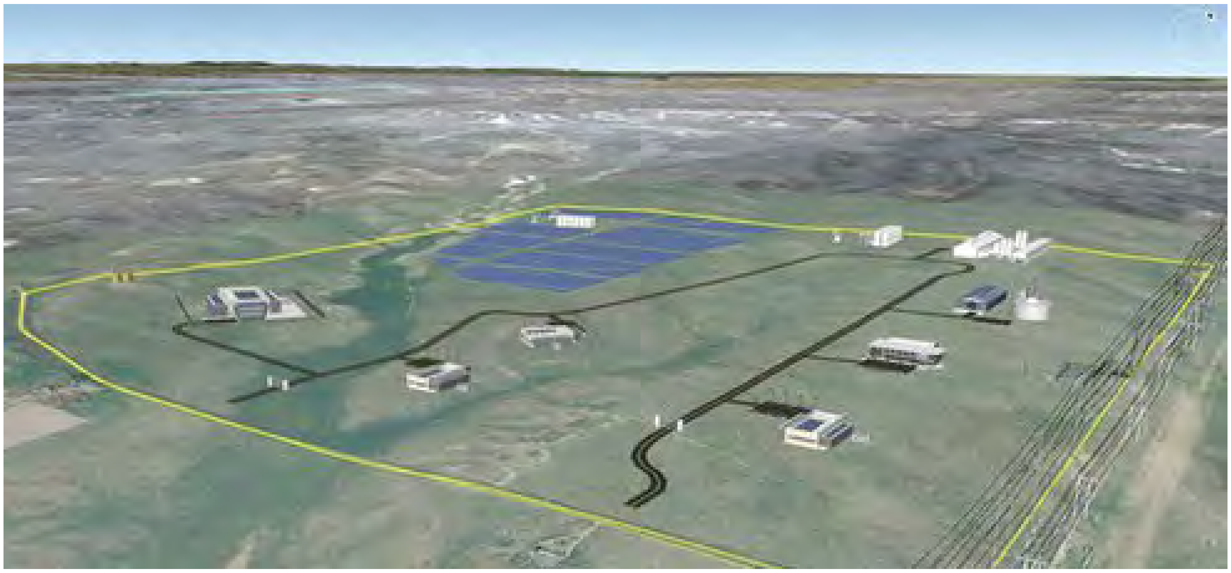
At the other end of the spectrum is the fully utility-integrated, smart microgrid which, in addition to providing secure power to an installation through on-site generation and distribution, offers benefits that have economic value beyond the installation fenceline. These benefits can include: provision of needed additional generation, enrollment in demand-response programs, and for those installations located in wholesale electricity markets, the selling of energy efficiency or ancillary services that help improve grid stability and operation. In between these two poles is an enormous variation of partial energy security approaches, many of which are represented in DoD's portfolio of military installations.

The BENS Microgrid Task Force developed a financial modeling tool to help illustrate the costs and value of approaches to energy security along this spectrum. The financial modeling tool uses scenario analysis to assist in understanding the value of a microgrid project. The inputs to the model are based on DoD-supplied data or reasonable estimates from industry practice or experience, and broadly cover three areas: (i) system requirements, (ii) operating characteristics and cost, and (iii) market dynamics.

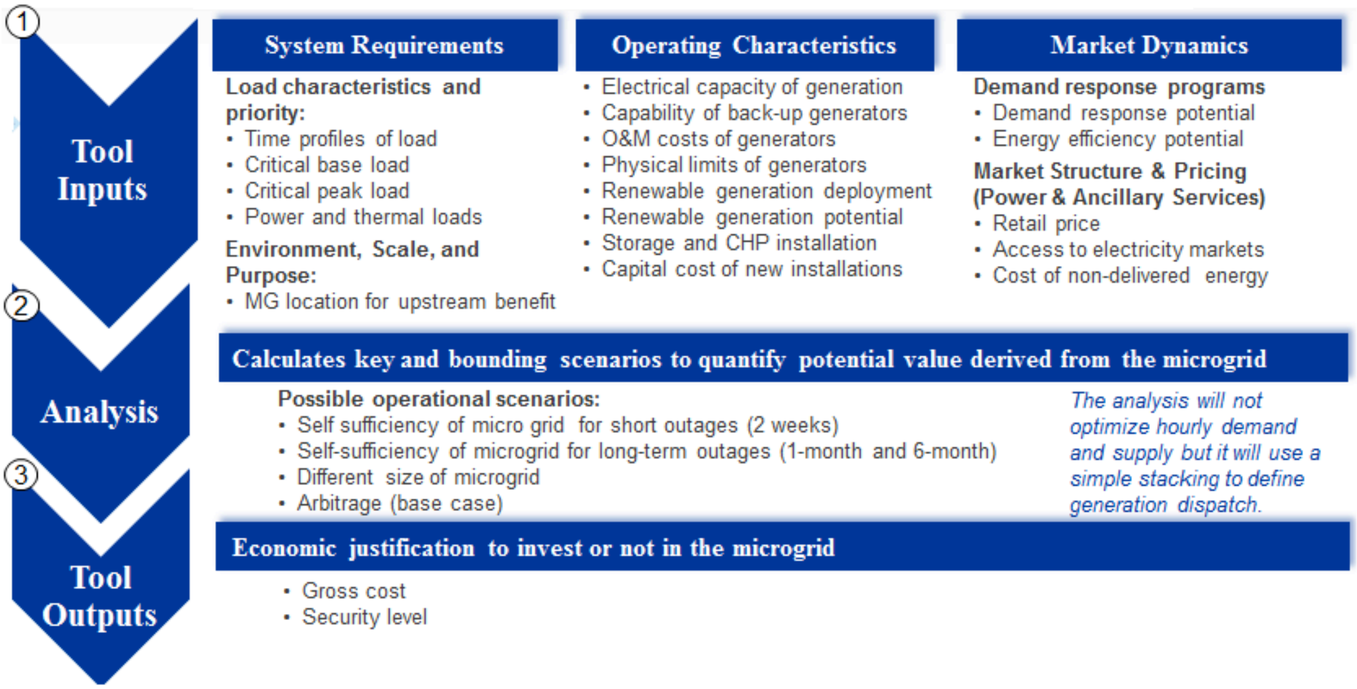
The system requirements for the microgrid include characterization of load (time profiles of load) and its priority (e.g., mission critical load that is always on, high-priority load that is interruptible for short periods of time and low priority load that is interruptible for longer periods of time). The annual hourly demand is used to determine generation economic dispatch for each hour during the year. The tool provides different options of supplying load at a military base. Electric power can be supplied from a number of options and combinations: A grid (utility or load serving entities), from one or more distributed (microgrid) generator locations at the base, and/or backup generators.

The operating characteristics of the microgrid include: Electrical capability of generation and back-up generators, generator type, and physical limits of generators. Together with operation and maintenance (O&M) costs, these characteristics are used to determine the operating cost of the microgrid. The calculated energy cost for an installation will be a combination of electricity price and the microgrid operating cost. The tool also determines capital expenses of a microgrid based on generators' overnight cost, cost of the microgrid, and cost of different demand programs (e.g. energy efficiency and demand response). The tool has the ability to fill-in predefined data for solar and wind generation profiles based on an installation's geographic location. The modeling tool accommodates as separate inputs microgrid generators that might be owned by DoD and those that might be owned by a third party, such as an independent power producer (IPP) or a utility. In the latter cases, a military installation will use one of its statutory authorities (e.g., for enhanced use leasing, or entering into a power purchase agreement) to structure an agreement with the third party. As a result DoD would not be responsible for capital investments and operating and maintenance costs. In the examples that follow, all of these third parties are described generally as IPPs.

The market dynamics area includes potential of demand response programs, electricity pricing and market structure and cost of undelivered energy—the cost impact to the installation of a power outage. The tool allows electricity price to be defined as a retail price or as a locational marginal price (if a base has access to the wholesale electricity market). The tool has ability to fill-in predefined data for electricity prices based on an installation's geographic location. In addition, the model allows the assumption that the installation has an option to sell excess power back to the grid.



## TABLE 1
## MICROGRID FINANCIAL MODELING TOOL




The financial modeling tool includes three different situations linked together to quantify potential value derived from a hypothetical microgrid project. The possible operational situations include:

- *Arbitrage (i.e., routine buying and selling of power or demand management for economic gain)*
- *Self sufficiency of the microgrid for short-term outages (2 weeks)*
- *And, self sufficiency of the microgrid for long-term outages (1 month and 6 months).*

The output of the financial tool presented in this report is a comparison of one or more microgrid cases to the status quo in terms of annual electricity costs for a given installation. The outputs of the model are not suitable for engineering a microgrid at a specific installation, but is very helpful in characterizing the likelihood that particular high-level business models (i.e., leveraging third-party capital) and technical approaches (i.e., renewable vs. other generation) can be brought together at a specific installation to achieve a microgrid solution at a cost that is the same or lower than current expenditures for electricity with increased security. The model does not include additional expected savings from implementation of demand-side management activities (particularly energy efficiency). Although DoD has made significant accomplishments in this area, program implementation has been largely decentralized and reliable performance data is not widely available. The experience of Task Force members strongly suggests that cost savings from such activities could positively impact project economics, and should be part of location-specific microgrid feasibility analyses.

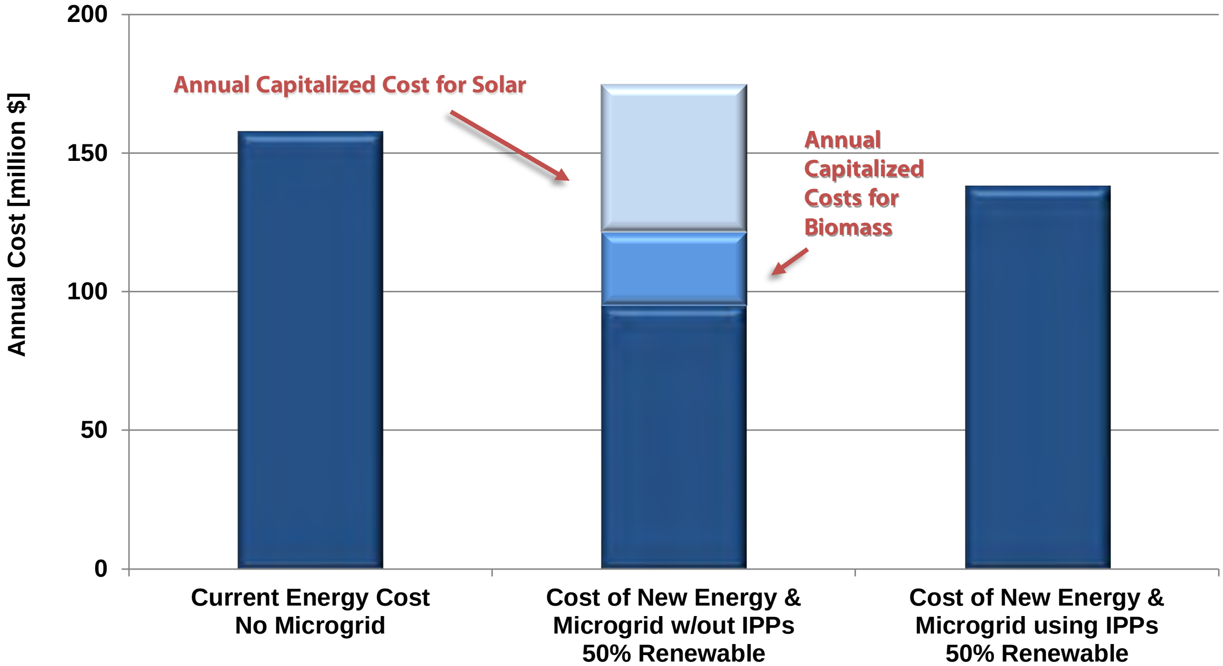
While conducting this study, the BENS Microgrid Task Force visited nearly a dozen military installations, and considered available data from multiple others. To illustrate the financial modeling tool, the Task Force presents sample model outputs from three installations: Joint Base Pearl Harbor-Hickam, HI; Fort Bragg, NC; and, the U.S. Air Force Academy, CO. We also provide a description of an energy security solution in place at Robins Air Force Base, GA.

## JOINT BASE PEARL HARBOR-HICKAM (JBPHH), HAWAII

JBPHH in Hawaii is located in a site that is very favorable for renewable energy generation. There is an abundant solar resource, sufficient biomass availability, and strong financial incentives provided by the state of Hawaii. Additionally, the commercial grid on the island of Oahu experiences outages on a regular basis, and the price of electricity from the grid is the highest in the United States.

The financial modeling tool was used to compare current operations at the installation to a hypothetical future microgrid that uses various combinations of three on-site generation assets: Diesel generators, solar photovoltaic arrays, and a biomass plant. One output of the model is portrayed in the figure below. As the Figure 1 depicts, there is a least one microgrid scenario in which the annual energy cost to the base is reduced 15 to 20%. The scenario depicted relies upon a third-party capital provider (Independent Power Producer – IPP), with renewable sources providing 50% of the power needed for the base under an assumed 20-year power purchase agreement. An alternative scenario, the middle bar, also is depicted in the figure. It portrays a comparable project financed solely through DoD funding. The scenario results in higher annual costs despite annualizing the capital costs over the same 20-year period. Both scenarios account for improvements to the electrical infrastructure that facilitates microgrid operations, but as stated earlier, these estimates do not reflect a specific engineering analysis.

### FIGURE 1
### JOINT BASE PEARL HARBOR-HICKAM SCENARIOS




**Notes:**

- All cases use back-up generators only during an outage
- IPP Microgrid case assumes a 20 year PPA that buys solar electric energy @ $185/MWh and biomass electric energy @ $215/MWh
- Solar IPP uses federal incentives – corporate tax credit (ITC) and is able to achieve 20 percent return on capital investments over 20-year period and WACC = 14%
- Bio IPP uses federal incentives – corporate tax credit (ITC) and PTC. It is able to achieve 20 percent return on capital investments over 20-year period with WACC = 14%
- Microgrid cost: $5 million (includes: SCADA, remotely controlled equipment, AMI; does not include T&D infrastructure upgrade)
- IPP calculation produced negative income tax for some years. It is assumed that these losses will be rolled up to higher company levels.

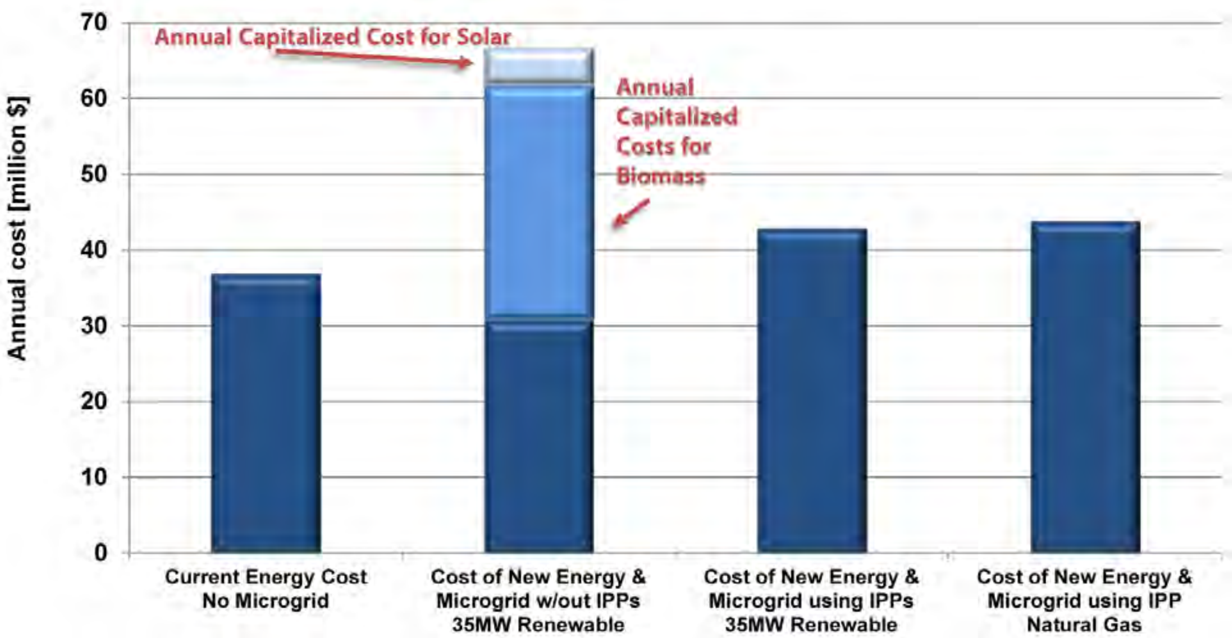
Sources: (1) SNL Financial Database (2) Ventyx Velocity Suite Database

## FORT BRAGG, NORTH CAROLINA

Like JBPHH, Fort Bragg has access to solar and biomass resources sufficient to provide power for its needs. The incentive programs in North Carolina, however, are not nearly as strong as in Hawaii, electricity prices are lower, and grid performance is more reliable. In the renewable-based scenarios examined for Fort Bragg, the reduced level of state support resulted in higher annual energy costs than the status quo, or base case. Because of this, we also examined the economics of entering into a 20-year power purchase agreement with an IPP for an on-base natural gas microgenerator. Although natural gas does not enjoy the support of incentive programs, and does not provide the black-start advantages of renewable sources for longer-duration outages, the current low price of natural gas results in annual energy costs very similar to the renewable scenario (but still higher than the base case).

With no microgrid scenario resulting in lower annual energy costs, it is nonetheless possible to estimate the increased cost for the added energy security, or "energy security premium" for each scenario – the additional cost incurred to achieve power surety. In the scenarios considered above, these values are \$5.95 Million/yr (renewables from IPP), \$6.85 Million/yr (natural gas from IPP), and \$29.67 Million/yr (renewables using DoD funding). In context, these are 16-19% increases above the base case for the IPP scenario, and an 80% increase for the DoD-funded scenario.

**FIGURE 2**
**FORT BRAGG SCENARIOS**




**Notes:**
- All cases use back-up generators only during an outage
- IPP Microgrid case assumes a 20 year PPA that buys solar electric energy @ \$170/MWh and biomass electric energy @ \$70/MWh, and natural gas @ \$83/MWh
- Solar IPP uses federal incentives – corporate tax credit (ITC) and is able to achieve 20 percent return on capital investments over 20-year period and WACC = 14%
- Bio IPP uses federal incentives – corporate tax credit (ITC) and PTC. It is able to achieve 20 percent return on capital investments over 20-year period with WACC = 14%
- Microgrid cost: \$5 million (includes: SCADA, remotely controlled equipment, AMI; does not include T&D infrastructure upgrade)
- IPP calculation produced negative income tax for some years. It is assumed that these losses will be rolled up to higher company levels.

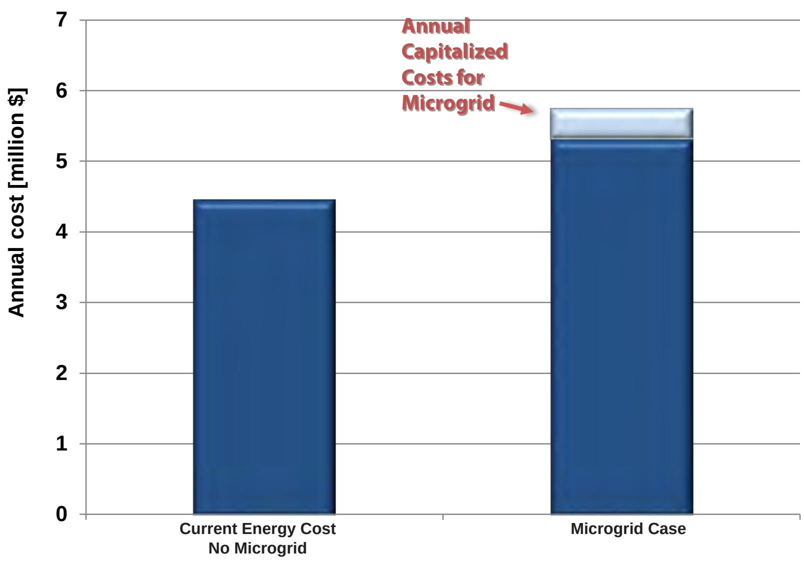
Sources: (1) SNL Financial Database (2) Ventyx Velocity Suite Database

## U.S. AIR FORCE ACADEMY, COLORADO

The U.S. Air Force Academy represents a very different environment from the first two examples. Its location in Colorado has very strong solar and geothermal resources, as well as limited wind and biomass, and the state offers strong incentives for renewable development. The current price of electric power for the Academy, however, is very low, and service is highly reliable. (Additionally, the state's mandated renewable goals are often oversubscribed, but this factor was not considered in the analysis). The total annual demand for electricity at the Academy is also considerably lower than at JBPHH or Fort Bragg. This is expected, given the mission of the Academy in comparison with these other bases.

Similar to Fort Bragg, no microgrid scenario resulted in lower annual energy costs because the price of the power purchase agreement is higher than the current utility price. The estimated additional cost for the increased energy security is about $1.3 million per year or about a 30% increase from current energy costs.

### FIGURE 3
### US AIR FORCE ACADEMY SCENARIO




- Total annual energy cost increases ~20%. Energy cost increase because of the PPA.
- PPA provides uninterrupted supply (24/7) to the critical load during the year.
- Undelivered energy cost decreased 24%.

**Notes:**

- Both cases use back-up generators only during an outage
- Electricity price $0.0572/kWh (peak hours) and $0.0321/kWh (off-peak hours)
- Peak demand 17.2 MW
- Base load demand 10 MW
- Critical demand 1.34 MW
- Back-up: 4.48 MW (diesel) @ $140/MWh and $7.4/kW-year
- Microgrid: 6.53 MW (solar) @ $10/MWh and $0/kW-year
- Undelivered energy cost for critical demand $120/MWh
- Undelivered energy cost for non-critical demand $30/MWh
- IPP: 1.34 MW (gas) @ $120/MWh and $0/kW-year
- IPP is able to achieve 20 percent return on capital investments over 20-year period with WACC = 14% and operating the unit 24/7
- Microgrid cost: $3 million (includes: SCADA, remotely controlled equipment, AMI; does not include T&D infrastructure upgrade

Sources: (1) SNL Financial Database (2) Ventyx Velocity Suite Database

## ROBINS AIR FORCE BASE, GEORGIA

Robins AFB has a unique energy security system. In an innovative arrangement, the installation provides its utility, Georgia Power Company, with land to site a natural gas peaker plant that supports the utility's operations in exchange for dedicated power in case of local outage. Georgia Power paid for and operates the plant. Robins AFB and the utility have operated this plant and the installation's electrical infrastructure in an islanded mode successfully. The peaker plant is able to operate using either natural gas or diesel. An estimated 2 to 3 week supply of diesel fuel is stored on base should an extended outage also disrupt the supply chain for natural gas to the installation. The Robins AFB example is not a case of a fully utility-integrated microgrid that delivers power as well as demand-side services on a nearly real-time basis. But it is a strong cost-effective energy security solution for the specific context of the installation.

# CONCLUSIONS FROM THE FINANCIAL MODELING OF INSTALLATION MICROGRIDS

DoD currently operates more than 500 fixed installations across the United States. Against this portfolio, we recognize that drawing conclusions on the basis of several site visits and scenario analyses can be misleading. However, based on all of the data the BENS Microgrid Task Force reviewed in its site visits and briefings, and the results of multiple evaluations conducted, we have a high degree of confidence in the following conclusions:

**1) DOD INSTALLATION MICROGRIDS WITH SIGNIFICANT RENEWABLE GENERATION ASSETS CAN BE FINANCIALLY BENEFICIAL:** As seen in the analysis of Joint Base Pearl Harbor-Hickam, a microgrid powered by a high-level of renewable sources (50% in this case) can result in a higher level of power surety for the base at reduced annual energy cost to DoD. Using the financial model tool, we have determined approximately 25% of domestic installations can implement smart microgrid projects that would reduce annual energy costs. In general, these installations are located in States with higher-than average current electricity prices that may represent approximately $1.5 billion of DoD's total annual installation energy cost. If the modeling of Joint Base Pearl Harbor Hickam is indicative, reductions in annual energy cost of 15% are possible, meaning DoD could achieve net savings on the order of $225 million annually from development of microgrids at these installations. This conclusion is important because of the unique black start capabilities that renewable sources potentially provide installations in the case of an extended outage.

---

**2) THE ECONOMICS OF MICROGRID PROJECTS ARE HEAVILY DEPENDENT ON SPECIFIC LOCATIONS OF INSTALLATIONS:** Just as the Pearl Harbor example showed positive financing of a renewables-focused microgrid, Fort Bragg showed the inability of a renewables-focused (or natural gas-focused) microgrid to drive an energy security solution that also reduces an installation's annual energy budget. On the other hand, the availability of land at Robins AFB, and the installation's location on the grid, provide for an alternative energy security solution using peaker plants. The major factors that affect project economics are location-specific: State incentives for renewable generation, the quality of available renewable (or even possibly non-renewable) resources, the cost of electricity, and the current stability and adequacy of the local grid. Through its existing renewable energy efforts, DoD has grown significantly in its understanding of some of these factors. The Task Force developed a prioritization framework that brings a comprehensive set of factors together, and provides it in the Appendix for DoD consideration.

**3) Many DoD installation microgrids will operate at a "security premium" that DoD needs to explore further:** The Fort Bragg example highlighted that many microgrid solutions will result in a higher annual cost of energy than some installations are currently paying. The difference in cost will constitute a premium that DoD should be willing to pay to ensure continuous power to the missions, particularly critical missions, at the installation. In the Fort Bragg example, the minimum security premium was 16 to 18% above current energy costs. In the course of this study, the BENS Microgrid Task Force came across other values for this security premium. For example, the microgrid for the National Interagency Biodefense Campus at Fort Detrick delivers electricity that is over 150% more expensive than the utility-provided power to the installation. The development of a more complete situational awareness of the economics of backup generation currently in use at DoD installations, combined with consideration of the criticality of missions at specific bases, and the costs of alternative microgrid approaches, will all enable DoD to develop a specific policy regarding the idea of a security premium.

**4) A "most economic portfolio" of DoD installation microgrids would likely be a combination of technologies and business relationships with serving utilities:** Even the limited number of examples described above demonstrates the diversity of circumstances (technical, economic, and regulatory) across the DoD portfolio of over 500 installations. If project economics were heavily weighted as the factor driving the specific microgrid design selection, there would be no single template that would emerge as a "typical" DoD installation microgrid. The BENS Microgrid Task Force finds this to be an inevitable outcome given the diversity already inherent in the portfolio of installations. This situation drives management, organizational, and strategic considerations for decision-making that are explored further in later sections of the report. However, the incorporation of microgrids into the DoD energy portfolio of efficiency and renewables is of paramount importance if energy security is to be achieved. Meeting current Federal energy goals will not provide the desired or necessary energy security to support critical missions without smart, secure microgrid technology. In this respect, the definition of energy security by DoD and the inclusion of microgrids in this equation is an important first step towards addressing the Defense Science Board's (2002 and 2008 energy reports) critical observation of DoD's current installation energy posture.

# Section II

## A SPECTRUM OF BUSINESS MODELS

This section explores how business models may affect the successful development and deployment of microgrids at military bases. "Business model" refers to the allocation of the costs and benefits of microgrid development described in Section I among different parties, and the assignment of control and decision-making regarding microgrid operations. Given the emphasis on capital costs associated with microgrid development – particularly for generation assets – DoD needs to develop core competencies in accessing capital markets. This Section also discusses actions DoD must undertake to better capture the potential value of these markets.

There is a spectrum of different models for ownership and operation of a microgrid, and each model has different implications in terms of capital investment, operational responsibility, economics, and other factors.

Other studies have characterized this spectrum of business models in many different ways.[3] In government programs, available alternatives are described as one of three models:

- *Government-owned, Government-operated (GOGO)*
- *Government-owned, Contractor-operated (GOCO)*
- *Contractor-owned, Contractor-operated (Privatized)*

While each end of this spectrum is clear by definition, the term "GOCO" in the context of DoD installation microgrid development actually describes a range of hybrid approaches, in which DoD and one or more third parties provide different elements of the up-front investment needed. The specific responsibilities and relationships can vary under GOCO approaches. Taken literally, the term would imply that DoD makes all the capital investments needed to develop the microgrid, and outsources operating responsibility. In practice, this has been less common than the use of Enhanced Use Leases and/or Power Purchase Agreements in which DoD has made relatively smaller upfront capital contributions (in some cases none), with the bulk of the capital for generation assets provided by others. In an effort to be clearer about the possibilities, we introduce the term "GOGO (third-party)" to describe the arrangement in which the Government owns and operates the on-base electrical power system and may own and operate some on-base generation, but also has entered into an arrangement with a third party that owns and operates some (and possibly all) on-base generation assets. This enables us to more easily analyze a range of relevant alternatives, but it should be recognized that even the term GOGO (third-party) does not definitively describe a single relationship. The examples analyzed in Section I begin to highlight some of the possible hybrid approaches.

## GOGO (THIRD-PARTY) EXAMPLES

For example, the positive project economics described in Section I for a microgrid at Joint Base Pearl-Harbor Hickam relies on third-party ownership (and possibly financing) of the significant renewable components. Under this arrangement, the third party would own the renewable generation asset, capture its tax and subsidy benefits, and retain responsibility for its operations and maintenance. The Government retains ownership of the land on which the renewable project sits, most likely offering an enhanced-use lease to the renewable developer, with a power purchase agreement that defines the price to be paid by DoD for the power generated. The on-base distribution infrastructure will be owned and operated as it is currently – in this case, by the DoD (Navy). Interconnection agreements need to be established both between the renewable resources and the commercial grid (for the transmission of power not needed by the base during normal operations), as well as between those resources and the on-base system. Under the example at JBPHH, the operation of renewable generation would contribute to the base's power under normal conditions as well as during an outage.

The example of the on-base natural gas units at Robins AFB highlights important similarities and differences. As at JBPHH, the land needed for the generation plants was made available to a third party (in this case, Georgia Power) via an enhanced use lease. However, the plants sited by Georgia Power are natural gas peaker plants and, unlike the notional microgrid at JBPHH, will not under most circumstances contribute to the base power. As a result the local public utility commission allowed the cost of the plant to be included in the rate base for service across the utility's area of operation. The base draws its power from the commercial grid under normal circumstances, with the option of being islanded during an extended outage. Operation of the units during an outage therefore requires both technical and business arrangements with Georgia Power.

The differences between the JBPHH and Robins AFB examples are dwarfed by those likely to be encountered in a fully utility-integrated microgrid. As briefly described elsewhere in this report, such a microgrid will be able to operate in parallel with the commercial grid during normal operations, and in an islanded mode during an outage. In its fully realized form, the microgrid will be able to participate in demand response programs, and provide ancillary services to the grid, both of which are important contributors to the economics of the microgrid. This arrangement will require flexibility in operating the generation and distribution assets of the microgrid that can only be accomplished via a single point of control for the system and its assets. Under either a GOGO or privatized system, this consolidation of system control is straightforward, and the allocation of benefits (i.e., revenue, surety, and security) from system operations is clear. Under a GOGO (third-party) arrangement, though, this adds significant complexity. While one entity can be designated as having technical control of the system, there also needs to be a process for allocating the benefits to the specific elements of the system that contributed to them.

[3] For example, "Microgrids: An Assessment of the Value, Opportunities and Barriers to Deployment in New York State". NYSERDA. September 2012.

## COST CONSIDERATIONS

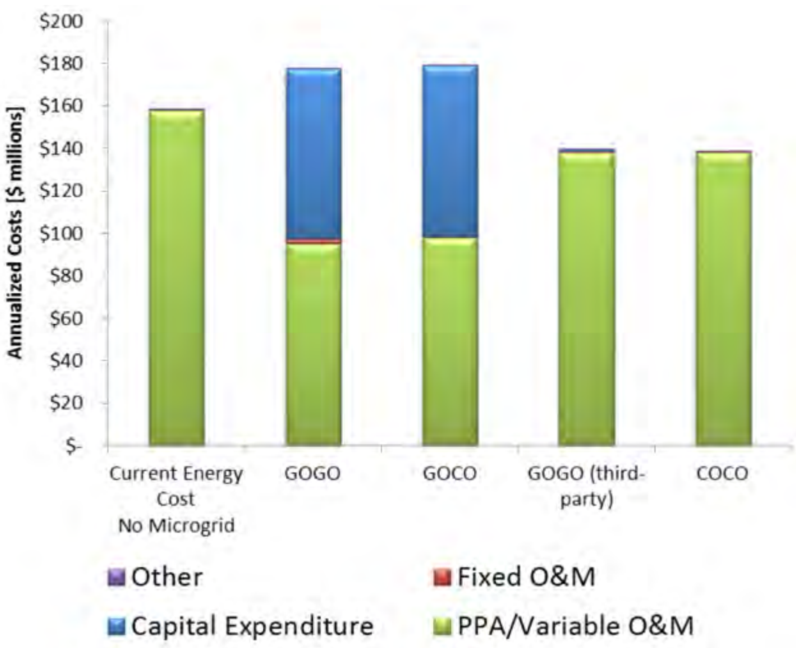
The JBPHH example is used to further explore the cost implications of various owner/operator business models. In the example, 50% of the base power is provided from renewable sources (solar and biomass), the development of which requires initial capital expenditures. Figure 4 below captures the result of the owner-operator analysis. In this figure, the base case represents the status quo on JBPHH, without the energy security benefits that a microgrid would provide. The necessary capital expenditures required clearly drive the GOGO and traditional GOCO cases higher in terms of cost. GOGO (third-party) benefits from the third-party financing that tax incentives and state subsidies make possible, while retaining the on-base distribution under the ownership of the DoD. The COCO (fully privatized) case is also presented.

## NON-COST CONSIDERATIONS

While understanding project economics and the relative costs of different owner/operator business models is important, there are also non-cost considerations that may be more determinative of the best approach for development of a microgrid at a given base. These factors include:

**Mission:** DoD's portfolio of 500 installations supports a wide range of military missions and activities. During site visits, BENS members had a glimpse of this diversity, including (to name just a few): academics (US Air Force Academy), military operations (Naval Station Norfolk), industrial operations (JB-PHH), logistics (Robins AFB), and unified command operations (Camp H.M. Smith). While all installation missions play a role in the value chain for supporting our combat forces, and are supportive of other Defense missions, the continuity of electrical power may be more critical to some missions than others.

### FIGURE 4
### RELATIVE ECONOMICS OF MICROGRID BUSINESS MODELS JBPHH EXAMPLE




**Notes:**

- All cases use back-up generators only during an outage
- IPP Microgrid case assumes a 20 year PPA that buys solar electric energy @ $185/MWh and biomass electric energy @ $215/MWh
- Solar IPP uses federal incentives – corporate tax credit (ITC) and is able to achieve 20 percent return on capital investments over 20-year period and WACC = 14%
- Bio IPP uses federal incentives – corporate tax credit (ITC) and PTC. It is able to achieve 20 percent return on capital investments over 20-year period with WACC = 14%
- Microgrid cost: $5 million (includes: SCADA, remotely controlled equipment, AMI; does not include T&D infrastructure upgrade)
- IPP calculation produced negative income tax for some years. It is assumed that these losses will be rolled up to higher company levels.

Sources: (1) SNL Financial Database (2) Ventyx Velocity Suite Database

**Security:** If continuous electrical service is essential to an installation's mission, and the mission is operationally critical for DoD, then DoD should strive to maintain a level of operational control commensurate with its responsibility for security. Security is an area that would strongly benefit from additional policy clarification by DoD *(see "Is the Security of Electrical Infrastructure on Military Installations An Inherently Governmental Function?")*.

**Capturing future innovation:** Many military installations have rudimentary power control and monitoring systems, and aging on-base transmission, distribution and generation assets. These indicated historical underinvestment in on-base electrical infrastructure. Exceptions were installations where utility privatization had resulted in development of new power distribution networks on base. (Utility privatization may raise separate challenges, some of which are discussed in Section IV). The next ten years are likely to witness significant transformation in the electrical grid in the United States. As DoD considers the potential of microgrids for energy security, it should also seek an owner/operator model that will better enable it to take advantage of business model and technological innovations in the commercial electrical grid.

## COMPARISON OF BUSINESS MODELS

Table 2 below summarizes the features and advantages/disadvantages of the business model options discussed above.

### TABLE 2

| | GOGO | GOCO | GOGO (third-party) | COCO/Privatized |
|---|---|---|---|---|
| **Business Model** | Government makes the capital investment and has responsibility for operating the microgrid system; all costs and benefits accrue to Government | Government makes the capital investment and outsources responsibility of operating the microgrid system; terms of operating contract dictate distribution of operational costs and benefits | A range of hybrid approaches regarding capital investment and operations; always involves third-party operation of some element of the microgrid system. Contract(s) dictate distribution of operational costs and benefits. | Private entity builds, owns, and operates microgrid system on DoD facility and sells power to DoD under a PPA. All costs and benefits accrue to Contractor. |
| **Relative Cost to DoD (annual energy cost)** | Second highest cost to government (slightly less costly than GOCO in JBPHH example) | Highest cost to government (slightly higher than GOGO in JBPHH example) | Second lowest cost to government (slightly higher than COCO in JBPHH example; 21% cheaper than GOCO) | Lowest cost to government (slightly lower than GOGO (third party) in JBPHH example; 22% cheaper than GOCO) |
| **Advantages to DoD** | Ensures DoD gets the system it wants.<br><br>Government can provide the lowest cost capital | Ensures DoD gets the system it wants.<br><br>Government can provide the lowest cost capital.<br><br>DoD does not have to handle microgrid operations. | Low cost option.<br><br>Preserves DoD control of on-base electrical infrastructure, allowing for upgrade as commercial grid technology advances | Lowest cost option<br><br>Allows DoD to focus on mission, not microgrid operations at bases. |
| **Disadvantages to DoD** | Call on capital in tightening budget environment.<br><br>Burdensome MILCON funding process.<br><br>Operation of a microgrid is not a DoD core competency. | Call on capital in tightening budget environment.<br><br>Burdensome MILCON funding process. | Some facilities will be in markets/regions for which the economics will not be attractive for private sector investment. | Some facilities will be in markets/regions for which the economics will not be attractive for private sector investment.<br><br>Reconciling private sector financial interests with DoD interests (i.e. security, capturing future innovation) may be difficult in certain geographies. |
| **Other factors** | Does DoD have the requisite expertise and procurement process flexibility to acquire the best system for each facility? | Depending upon competition and system details, cost of operating contract may be significantly higher-making this option even more unattractive financially. | Depending upon details and size of microgrid (i.e. sized to serve more than just the DoD facility) potential for additional cost savings and additional revenue streams to DoD, e.g., Enhanced Use Leases. | Depending upon details and size of microgrid (i.e. sized to serve more than just the DoD facility) potential for additional cost savings and additional revenue streams to DoD, e.g., Enhanced Use Leases. |

# IS SECURITY FOR ELECTRICAL INFRASTRUCTURE ON MILITARY INSTALLATIONS AN INHERENTLY GOVERNMENTAL FUNCTION?

In September 2011, the Office of Management and Budget (OMB) clarified the definition of 'inherently governmental function' as one that must be performed by federal employees because it is "intimately related to the public interest." They further clarified that those functions that are essential to an agency effectively performing and maintaining control of its mission and operations, are inherent. The guidance provides no mention of installation energy security specifically, but does specify "security operations performed in direct support of combat as part of a larger integrated armed force" as an inherently government function.

With the changing nature of combat operations (e.g., the use of unmanned aerial systems), there clearly are activities conducted at certain domestic military installations that directly support battlefield operations in real time. In cases like these, it can be seen why a base's energy infrastructure might be considered an essential part of an "integrated armed force" and why there might be a valid policy reason for favoring government ownership and operation using military personnel or civilian employees over business arrangements emphasizing private sector involvement. However, existing guidance on this point is far from clear, and several practical considerations militate against a determination that installation energy security is an inherently governmental activity.

First, most installations are characterized by a variety of mission-related activities, very few of which involve the kind of immediate operational nexus described above. Second, there is no objective basis on which to assert that power generation and distribution is a core competency of the military or, more important, that circumstances arising in the context of microgrid deployment will require it to become one. During its visits to domestic installations, BENS observed a generally positive correlation between the quality of electrical infrastructure and the presence of privatized operations or third-party investments in critical electrical assets. Third, private sector utilities and their suppliers have demonstrated a longstanding institutional capability to fund and upgrade power generation and distribution infrastructure, whereas prospective constraints on defense spending imply intensified competition for military funds in general and a lack of visibility for funding required specifically for installation energy security projects.

In addition to the “integrated armed force” rationale, advocates of a larger role for the government in installation energy activities assert that it is needed to ensure rapid technology development and adoption. Some stakeholders have expressed specific concerns that the capital markets are disinclined to offer third-party financing for technologies that are not well proven and that private contractors will be reluctant to introduce cutting edge microgrid technology for fear that poor equipment performance will expose them to contractual penalties in their dealings with the military. These are not unreasonable concerns, and they can and should be resolved early in the microgrid deployment process.

DoD has the ability to create effective incentives for ongoing technology introduction simply by structuring and negotiating commercial agreements with third party providers that reflect these expectations as an overall part of a “security premium” justified by various factors. Traditional contracting authorities (e.g., ESPCs) based solely on efficiency improvements are unlikely to efficiently accommodate situations where new investment (e.g., cyber security technology or experimental storage systems) raises operational costs, either initially or over time. As to concerns about the availability of financing for advanced technologies, these simply appear overstated, especially given the fact that many of the private sector entities most likely to be active participants in installation energy projects have the capacity to underwrite or finance them internally without any need for external funding from the capital markets.

## MAXIMIZING VALUE FROM CAPITAL MARKETS

The development of secure DoD installation microgrids likely requires both the modernization of on-base electrical infrastructure, and construction of new on- or near-base generation assets. Because of the uncertainty of future federal budgets, and the 5-year planning and programming cycle of DoD budgets, access to capital markets is an important enabler for accelerating the development of microgrids while maintaining a relatively low cost of capital. DoD needs to access these markets effectively. This section describes actions DoD can take to maximize the benefit it receives when microgrid developers access these markets.

As shown in the JBPHH example, a confluence of factors are present at some bases that result in very favorable economics for renewable generation, which (as stated earlier) has an operational advantage – black start capability – over other forms of generation in the event of a prolonged outage caused by a system-level event. These factors include a strong renewable resource availability, high electricity prices, and incentives and subsidies for renewable development. While some of these factors are present regardless of which entity owns the generation asset, access to most incentives and subsidies (e.g., tax credits, accelerated depreciation, generation subsidies) are not available to DoD and other federal agencies. DoD captures these benefits by entering into business arrangements with third-party developers who, in turn, access capital markets in order to obtain the up-front resources needed for the project. Capital markets can be valuable to non-renewable projects as well; we expect them to play a role as DoD's microgrid and energy security efforts evolve. For purposes of the discussion that follows, we focus on renewable energy initiatives because they represent the most complete set of considerations when accessing capital markets.

The financial structure of renewable projects tends to be very complex, involving multiple stakeholders (e.g., sponsor, land owner, developer, utility, lender, tax-equity investor, electricity purchaser) and multiple interlocking contracts and financial and credit agreements. Given this complexity, commercial renewable energy projects proceed with much greater "speed to market" than is typical for federal government procurement cycles. This speed to market is important in these transactions because it minimizes two variables that could change a party's interest in any "deal": interest rate volatility in the market (preserving project economics), and uncertainty in the policy/requirements environment (preserving clear rules for project success, technically and economically). In commercial transactions, inputs change every quarter, developers are responsive to market prices and conditions, and they invest and direct resources accordingly. For example, state-level energy incentives change often, and the cost of some renewable energy technologies, like solar, is materially falling each quarter. As a result, the DOD needs to find a way to emulate the speed of commercial transactions. A decision process that takes years (as opposed to months) will only add cost and risk to the DoD.

Over the past few years, DoD has improved its capability in renewable energy project transactions; however, it has not yet developed a repeatable process with a high speed to market. Going forward, we expect development of microgrids to add entirely new layers of complexity in deal making. Such deals will include not only generation assets, but also more complex allocation of benefits that might accrue from demand-side efforts or ancillary services as described above. This greater complexity of deals will increase the pressures on involved stakeholders, heightening the need for either greater speed to market, or a higher degree of predictability in requirements and policy. To help achieve this speed and stability, DoD would greatly benefit from the following material or policy/process actions:

- ***Give higher priority to upgrading on-base electrical infrastructure to a common "microgrid readiness standard" through MILCON or other means:*** *Most bases, even those that have privatized utility service, will require significant infrastructure investment to maximize the value of any microgrid development. While project economic factors vary significantly by location with respect to on-base generation, this is less true for electrical infrastructure. If DoD were to upgrade the electrical infrastructure of its bases to a common standard of "microgrid readiness," this would go a long way to standardize the interface requirements for generation that needed to be developed. Utility privatization is likely to be a major impediment to accomplishing this, and is discussed in Section IV.*

- ***Embrace open technical standards rather than one-off or proprietary designs:*** *The use of open standards is common in commercial practice, and their use will offer DoD two advantages: They will increase the speed of response by developers because they can leverage existing designs and equipment, and they will minimize any risk premium that sources of capital might impose on more unique technical approaches that might be less proven.*

- ***In any competitive acquisition process for microgrid development, emphasize functional and performance requirements for microgrids over detailed design or equipment requirements:*** *If DoD were to take a performance-based approach to the acquisition of microgrids, it would give project developers the flexibility to design technical solutions that meet DoD requirements while also accessing sources of capital on the most favorable terms. The implication for DoD, however, is that it would need to enhance its organizational capabilities so that it can adequately judge the technical merits and risks associated with what is likely to be a highly diverse set of proposals.*

## LEVELIZED COST OF SECURE ENERGY

Another area in which DoD can better align with commercial practice is in understanding and presenting the economics of energy use and potential microgrid solutions at individual bases. Commercial developers and investors typically use the concept of "levelized cost of energy (LCOE)" to quickly compare the economics of various generation alternatives. Levelized cost of energy is an "all-in" metric for energy cost, in that it typically includes capital costs, real estate costs (property taxes, site lease), fixed and variable operations and maintenance (O&M), performance (capacity factor), fuel costs, and other factors affecting the life-cycle costs of a generation asset (such as deal structure and financing). For renewable generation projects, incentives and subsidies are also included, and renewable developers and financiers commonly have models that include these in the LCOE for projects.

The BENS Microgrid Task Force recognizes that DoD is making great strides in developing more granular insight into its energy consumption and costs at individual installations, and an ability to roll this data up to an enterprise level. As it moves forward with microgrid efforts, we recommend that it leverage this data by embracing a "levelized" metric for microgrid projects, a Levelized Cost of Secure Energy (LCOSE). We would envision the LCOSE metric to be composed of two parts:

- *an LCOE measure akin to what is used in commercial practice today, but also including the avoided life-cycle costs of any on-base back-up generation that a microgrid would render unnecessary (or, conversely, ensure that the LCOE for the base case include all of these costs); and*

- *a life-cycle measure of electrical infrastructure upgrades needed to make an installation "microgrid ready". Such upgrades might include: distribution/transmission, building metering and control (AMI), IT upgrades, microgrid management system, and energy storage.*

The use of an LCOSE metric would enable DoD to communicate its system requirements and objectives in terminology consistent with commercial practice (supporting a best-value selection of generation) and also isolating those factors that go into a "security premium" at an individual installation. Consistent with the Fort Bragg and US Air Force Academy examples in Section I (and other anecdotal cases), the BENS Microgrid Task Force found the high level of grid reliability on a day-to-day basis and relatively low current cost of electricity to most installations meant that a microgrid solution is difficult without increasing the annual energy cost to the installation. The LCOSE measure would enable DoD to quantify the total costs of added power surety, which would support needed policy making by DoD around the issue of a security premium for bases.

# CONCLUSIONS FROM THE ANALYSIS OF ALTERNATIVE OWNERSHIP/OPERATION BUSINESS MODELS

The same caveats that applied in Section I regarding microgrid economics at military installations apply here in terms of business models: the DoD installation portfolio is highly diverse, and it is unlikely that a single business model will be the most favorable approach at each installation. Based on the data and analysis considered by the BENS Microgrid Task Force, the following conclusions are offered:

**1) THE COST ADVANTAGES OF THIRD-PARTY FINANCING/DEVELOPMENT OF ON-BASE GENERATION NEEDED FOR MICROGRIDS ARE SIGNIFICANT.** Most DoD installation microgrid projects will require the development of on-base power generation. In these cases, the capital cost for the new generation assets are a major driver of project economics, rendering most projects that involve Government ownership of these assets (i.e., the GOGO, or traditional GOCO) much more expensive (20% or more) than approaches that take advantage of third-party financing opportunities (GOCO, or GOGO (third-party)). Most of the third-party opportunities involve renewable generation, but this is not exclusively the case; in fact, the most effective existing energy security solution observed by the BENS Microgrid Task Force was the natural gas peaker plants on Robins AFB.

**2) DOD NEEDS MORE INSIGHT INTO ON-BASE ELECTRICITY MANAGEMENT BEFORE THE MOST FAVORABLE OWNERSHIP/OPERATION ARRANGEMENT FOR ON-BASE INFRASTRUCTURE CAN BE DETERMINED.** During its site visits, the BENS Microgrid Task Force generally observed on-base electrical infrastructure that had not been adequately invested in. However, the commercial electric grid itself is still in the early stages of what we expect to be a dramatic transformation. Therefore, past performance is less important than identifying the future approach that will most cost effectively raise the performance level of on-base electrical infrastructure to support microgrid deployment, ultimately to the level of full utility-integration. This is an open question deserving greater exploration, and deepening its understanding of the possibilities in this area should be part of DoD's next steps in microgrid development.

**3) DOD IS DEVELOPING ITS CAPABILITIES IN RENEWABLE PROJECT TRANSACTIONS, AND IN ENERGY DATA MANAGEMENT, BUT FURTHER IMPROVEMENTS IN EACH ARE IMPORTANT TO IMPLEMENTING A SUCCESSFUL MICROGRID STRATEGY.** Ultimately, these capabilities will be critical to understanding the economics of alternative approaches to microgrid development at individual bases, and working with third-parties (developers, financiers, utilities, etc.) to structure microgrid deals. The BENS Microgrid Task Force observes that multiple business models are likely to be used throughout the DoD installation portfolio. A wider range of approaches is available if the Government as buyer has developed strong analytical and business capabilities.

---

**4) THIRD-PARTY APPROACHES RELY ON EFFECTIVE ACCESS TO CAPITAL MARKETS; DOD CAN INSTITUTE SPECIFIC ACTIONS TO MAXIMIZE THE VALUE IT RECEIVES FROM THESE MARKETS.** Chief among these actions is the adoption of a Levelized Cost of Secure Energy (LCOSE) metric that incorporates both the levelized cost of energy (LCOE) construct that is commonly used in commercial transactions, and the costs of on-base infrastructure improvements required to make an installation microgrid ready.

# Section III

## SIZE AND SCOPE CRITERIA FOR DEFENSE INSTALLATION MICROGRIDS

DoD views its activities on fixed installations through a lens of mission assurance and resilience, focusing on the availability and integrity of needed resources to support the installation's critical mission requirements under future likely risk scenarios.

For this reason, the BENS Microgrid Task Force was asked to evaluate whether DoD should consider "oversizing" microgrids beyond the electrical needs of its installations so that an installation could supply power to affected surrounding communities in the event of a prolonged electrical outage.

Since many installations have personnel (military and civilian) who live off-base (about 70% on average), oversizing would have a clear linkage to mission assurance. It also would enable an installation to maintain its own mission readiness by helping local civilian agencies to sustain public infrastructure services (such as water and sewage treatment) used both by the installation and the community. Furthermore, there appears to be a general concern that traditional emergency power restoration capabilities and approaches undertaken by federal and state agencies may not be effective in meeting future contingencies, such as catastrophic outages caused by major storms or natural disasters, cyber attack, or electromagnetic pulse. Extended outages might also create the challenge of preserving public order, which could conceivably be exacerbated in a situation where a DoD installation is powered but the surrounding community is not.

Many of the large renewable energy power projects currently being developed on or planned for military installations will have significant excess capacity relative to the needs of their host installations. We do not consider this arrangement, in which excess power is sold into the commercial grid, to constitute an "oversized" microgrid. For purposes of this section, we consider an oversized microgrid to specifically mean the generation, transmission, and distribution system needed for the provision of secure electric power to the base and a significant portion of its surrounding community, with an ability to operate parallel to the commercial grid or in an islanded mode. We refer to this kind of microgrid as a "community-scale microgrid." We examine the question of microgrid size and scope from three perspectives: potential positive scale effects on project economics, the impacts on business models and relationships with key stakeholders, and other practical implementation challenges, including regulatory and compliance challenges.

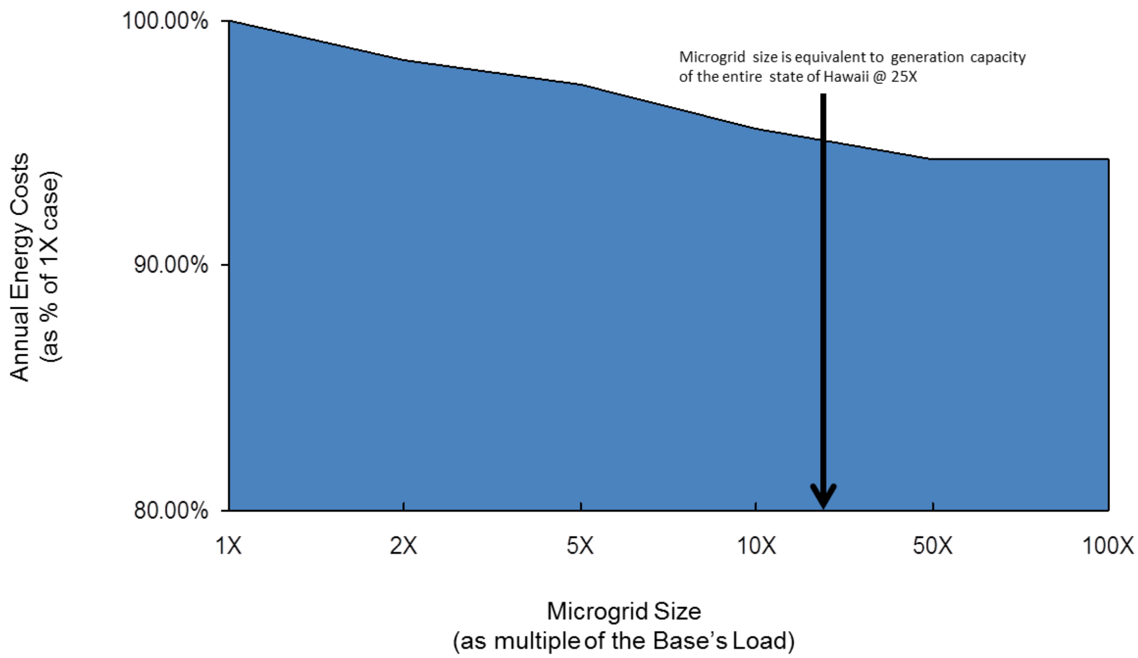
## EFFECT OF COMMUNITY-SCALE MICROGRIDS

The BENS Task Force looked at the concept of increasing the size of a microgrid at Joint Base Pearl Harbor-Hickam (JBPHH) to create a community-scale microgrid. In Section I, our analysis showed that a microgrid at JBPHH had the potential to reduce annual energy cost by 15-20%. For this analysis, we compare annual energy costs against this initial microgrid case, as the size of the microgrid increases. The results of this analysis are shown in Figure 5 below.

As the figure indicates, increasing the size of the microgrid does decrease the annual energy cost compared to the base case. These scale effects are not dramatic: Increasing the size of the microgrid to address the entire State of Hawaii only would yield approximately a 5% reduction in annual energy costs.

This analysis highlights the positive impact of microgrid scaling on project economics. In fact, the scale impact is lessened for JBPHH due to the high cost of fuel; fuel costs being the major driver for gas turbine technology. At lower fuel costs, we would see a greater decrease in costs due to increased scale. However, this notional analysis is unconstrained, and therefore unrealistic. It ignores the lack of interconnection among Hawaii's islands, and assumes unlimited demand for every additional increment of microgrid capacity. Most importantly, it does not account for legal or regulatory impediments to development of a microgrid of this size. These impediments are very significant, and are discussed in greater length in Section IV of this report.

### FIGURE 5
### IMPACT OF MICROGRID SCALE AT JBPHH



## IMPACT ON BUSINESS MODELS AND KEY RELATIONSHIPS

While the analysis above demonstrates the potential economies of a community-scaled microgrid, there are major challenges to capturing these benefits in a viable business model (i.e., one that allocates costs and revenues in a mutually acceptable manner to all parties involved). The most imposing challenge would be the relationship of the Defense installation to its current utility (and other utilities that may serve the community surrounding an installation) under such a microgrid arrangement.

By extending electrical service beyond the fenceline of an institution, DoD directly enters the realm of existing electric utilities. Such an operation would become immediately entangled with existing utility operations, assuming DoD develops a microgrid in tandem with the local utility itself (a necessity in regulated markets), or with a qualified independent power producer (in deregulated markets). This situation raises a number of obstacles:

- ***Utilities already have an obligation to serve everyone in the community, so a community-scaled microgrid's capability would be inherently excessive – raising electricity costs to consumers:*** *A fundamental requirement underlying the electric utility industry is that utilities have an obligation to serve everyone in their service territory who requests service (and has an ability to pay). If DoD were to develop a community-scaled microgrid with excess generation assets, the costs of these assets would necessarily be incorporated in the electricity rates of customers in the utility's service territory. The same would be true of any electrical infrastructure costs needed to establish the microgrid. DoD would not have a choice to exclude them: In order to operate both in parallel and island mode, the microgrid would need to be adequately interconnected to the grid, and therefore would be the responsibility of the local utility, and subject to incorporation in its rate base. Although the specific mechanisms would differ, the result would hold whether DoD installations are located in regulated or deregulated electricity markets.*
- ***A community-scale microgrid would likely create a new "electrical boundary" in a community, raising equity and safety issues:*** *To maximize the mission assurance benefit of a community-scale microgrid, DoD would need to size the microgrid in the way described above to comprehensively cover the geographic scope of where its on-base personnel and families live in the surrounding community. (Complicating this boundary is the fact that the surrounding community for some installations is served by multiple utilities, each with different service territories). Unless DoD were committed to develop a microgrid sized to include every member of every service territory in a community, the microgrid would necessitate the development of a new electrical boundary. This electrical boundary would define the demarcation between those customers included within a microgrid's operations, and those excluded. Since the costs of the microgrid would be borne by all users in a service territory, customers outside the electrical boundary would in effect be providing a subsidy to the DoD. With respect to safety, if the commercial grid were to fail in the utilities service area that overlaps with the DoD microgrid boundary, power could be "hot" within the microgrid area. This would make working on faults in the service area contained within the DoD boundary particularly challenging for the utility as it works to bring the commercial grid back up for all customers.*

The challenges and obstacles to creating large, community-scale smart microgrids outweigh positive benefits.

Consistent with concerns raised above, the Board of Directors of the National Association of Regulated Utility Commissioners (NARUC) recently issued a resolution on Defense installation energy. Concerned that DoD's efforts to "deploy grid-scale onsite energy may result in stranded generation and transmission investments resulting in increased rates for remaining customers," NARUC encouraged "DoD to coordinate with State utility regulators and utilities" on installation energy matters. [vi]

## OTHER CONSIDERATIONS

Even if the business model and safety concerns highlighted above could be resolved, there are two other considerations that would argue against the establishment of a community-scale microgrid:

**First**, at the sizes needed to capture significant scale benefits (beginning at 10 times an installation's annual energy use), a community-scale microgrid ceases to be a microgrid. Extending a microgrid to cover community needs at this scale likely implies a more complex network of generation assets, substations, transmission and distribution lines, as well as microgrid management technology and even customer billing systems. At this scale, a microgrid is really operating more like the commercial grid itself, and due to its increased footprint, becomes vulnerable to a greater range, frequency and magnitude of service disruption risks. It also potentially entangles DoD in state utility regulation, which could be major impediments to the cost-effective operation of the microgrid. (State utility law and regulation are characterized further in Section IV.)

**Second**, the community-scale microgrid concept extends DoD's physical and cybersecurity objectives beyond the installation fenceline. In a community-scale microgrid, assets critical to operation of the expanded network would very likely (perhaps necessarily) be located outside of the DoD installation. However, DoD would retain a major interest in the physical and cyber security of the network and its components. It is unclear whether DoD would have the authorities needed to project and protect its programs into the community, or whether business arrangements with the network operator (i.e., the local utility) would provide sufficient risk mitigation without greatly adding expense.

# CONCLUSIONS FROM THE CONSIDERATION OF SIZE AND SCOPE CRITERIA FOR DEFENSE INSTALLATION MICROGRIDS

There may be cases where economics and sustainability will support the oversizing of microgrids relative to the needs of a single installation; for example, where one microgrid serves multiple bases located in a single geographic or metropolitan area. But based on our experience and analysis there are few, if any, circumstances in which it would be advisable or cost-effective for DoD to develop a community-scale microgrid to ensure continuity of power outside of the base perimeter during prolonged outages. Our concerns relate to how the scope of expanded activity would be defined, and to the costs and risks of operating excess generating capacity in competitive energy markets. Based on the data and analysis considered by the BENS Microgrid Task Force, the following conclusions are offered:

**1) DoD has a legitimate mission assurance interest in the surety of electrical power beyond its installations' physical boundaries:** The increasing interdependence of military bases and their surrounding communities underscores DoD's strong interest in power system reliability. At most bases, the majority of personnel who work on the installation live off-base in the surrounding community, and many bases rely on critical infrastructures (water, sewage and water treatment, firefighting) in the surrounding community on either a primary or back-up basis.

---

**2) The challenges and obstacles to creating a community-scale microgrid greatly outweigh the positive benefits:** Many technologies used in the development of microgrids do benefit from development at larger scale (i.e., generation); however, the scale itself introduces overwhelming complications and challenges. While it is hard to generalize across the entire DoD installation portfolio, there are several types of challenges that would likely be endemic to the development of community-scale microgrids: they would add infrastructure that would be required to be captured in the electricity rate base; they would create a new "electrical boundary" in the surrounding community that raises equity and safety issues; they would be subject to a range of natural and intentional threats more like the commercial grid; and would create jurisdictional issue for DoD by extending their physical and cyber security concerns outside the installation. Because of these challenges, there are no generally applicable criteria for the size and scope of a Defense installation microgrid. *Until DoD develops experience in engaging with Defense communities in microgrid development, the BENS Microgrid Task Force believes that the substations and feeder circuits serving an installation mark the most sensible delineation for a Defense installation microgrid.*

**3) The best current examples of community-scaling of a microgrid component are the on-base natural gas peaker plants at Robins AFB and Tinker AFB, which were developed in collaboration with each installation's local utility; this represents one model for moving forward.** These peaker plants primarily serve the commercial grid. They are utility-owned, and their investment and operating costs are blended into the utility's rate base. During outages, their host installation has negotiated an agreement with the utility to provide power to the base on which they are located, but they are capable of producing significantly more power than the base needs, and excess power could be used to keep the surrounding community powered. Although this is not a fully utility-integrated, nor microgrid by definition, it is a positive example of a mission assurance approach. The BENS Microgrid Task Force encourages DoD to explore its installation portfolio for further opportunities to deploy this approach, particularly within a fully utility-integrated microgrid project.

**4) While it develops further capability and experience in microgrid development, DoD should explore non-microgrid solutions to meeting its mission assurance objectives that extend beyond the installation boundary.** The BENS Task Force believes the appropriate focus of DoD's efforts is to work with existing participants in electricity markets, especially its local utilities, to achieve its objectives. The Task Force recommends that DoD explore non-microgrid solutions that may avoid the obstacles described in this section. An example would be the establishment of regional pools of large, rapidly deployable mobile generators and distribution assets to meet extraordinary requirements outside of DoD installations during prolonged outages. Assets domiciled in these strategic reserves could include diesel and natural gas reciprocating generators in the 1MW-2MW class, as well as newer and higher-output containerized dual-fuel turbine generators in the 5MW and 20MW-30MW classes, portable 8MVA substations and containerized GSU transformers of 23MVA-70MVA configurable to accommodate various medium and high voltages up to 138 kV. "Fast track" power equipment and services capable of meeting large, long-term requirements of this type are commercially available in the private sector and are used extensively in the United States and in other areas of the world where electricity is in short supply or where natural disasters or industrial accidents have taken power generation plants or major substations off line for long periods of time. The Task Force notes that the Services' rapid response and restoration commands own only enough mobile power equipment in the aggregate to sustain the needs of a few large domestic bases and that many of the units owned by these commands are too small and located too far away to be deployed effectively against major outage events. The ability of newer gas turbine generators to operate on either liquid fuels or natural gas is one new way to decrease supply chain vulnerability.

# Section IV

## ASSESSMENTS OF IMPEDIMENTS TO MICROGRID DEVELOPMENT

Based on our site visits and the analyses described in previous sections of this report, the BENS Microgrid Task Force believes Defense installation microgrids are technologically within reach. As we have outlined, positive project economics for microgrids are possible in some areas of the United States, enabling a relatively high level of on-base renewable generation. In other locations, system needs by utilities may enable other types of solutions, such as the natural gas peaker plants co-located with Robins and Tinker Air Force Bases. For most bases, however, achieving energy security through a microgrid solution will result in a net cost increase over current conditions. Previous sections of this report have given some indication of steps DoD can take to maximize the effectiveness of a microgrid program for installation energy security. This section takes the reverse perspective, looking at major impediments to broad microgrid deployment, and suggesting actions DoD can take to overcome them.

In this section, we assess the major non-technical and technical impediments identified during the study phase of our report. Our views are informed by briefings presented by DoD, DOE's National Renewable Energy Lab, Georgia Tech and other entities engaged in research and demonstration projects funded by DoD and DOE. We also draw on our site visits, and our Task Force members' familiarity with commercially available energy generation and management technologies, and with islanded local electric power systems operated by the private sector that meet similar functional objectives to those articulated by DoD for installation microgrids.

# NON-TECHNICAL IMPEDIMENTS

The principal non-technical issues that might impede microgrid deployment fall into four main areas: prior electric utility privatization actions within DoD, state utility law and regulation, alignment of DoD acquisition processes with commercial norms, and aggregation of relevant installation energy management efforts within DoD.

## DOD UTILITY PRIVATIZATION

Beginning in the late 1990s, DoD began a process of utility privatization, under the premise that the delivery of utility services to its installations is not a core military function, and that significant cost savings could be possible if these services were outsourced. In the National Defense Authorization Act for Fiscal Year 1998, Congress authorized DoD to begin privatizing its 2,600 utility systems, valued at $50 billion. Internally, the DoD issued Department of Defense Reform Initiative Directive (DRID) #9 in December 1997 to launch the process of utility privatization. Within the first 12 months, it became clear that utility privatization would not be as straightforward as initially considered.

DoD issued DRID #49 in December of 1998 to "reset the goal for this initiative, establish the approach to its management and oversight, and convey guidance for assessing exemptions, conducting the divestiture of utility assets using competitive procedures, and performing economic analyses of the transactions." [vii]

DRID #9 established a completion goal of January 1, 2000; DRID #49 extended this deadline to September 30, 2003. Since DRID #49, DoD has revised this deadline a number of times with recent estimates placing completion as late as 2017. [viii] A number of factors have made the privatization process more difficult than the DoD originally anticipated, including difficulties with contract management, oversight, and administration of utilities privatization contracts. [ix] The Government Accountability Office has highlighted these difficulties, as well as the challenge of comparing the life-cycle costs under Government and contractor ownership alternatives.[x]

The most direct impact of electric utility privatization on microgrid development (at installations where privatization has occurred) is that it adds yet another level of complexity (and stakeholder) that must be factored into the business model design. At such bases, the electrical infrastructure on the base is now owned and operated by a service provider under a 50-year contract. The utility privatization contracts call for the operation, maintenance, and scheduled upgrade of this on-base infrastructure over the life of the contract, but were not written with microgrid development in mind. Therefore, they generally do not include convenient reopener provisions that would allow modification of the installation's utility infrastructure. In practice, this likely means that microgrid development will require negotiation with the privatization contractor, either to coordinate or incorporate microgrid development into a scheduled upgrade of on-base infrastructure, or to pursue a contract change for microgrid development outside of a scheduled upgrade. Either way, the Task Force believes this could negatively impact the project economics for microgrid development significantly.

The Task Force also observes that the utility privatization program in DoD is based on a view of the role of electric power in military operations that is in conflict with the premise underlying microgrids. In the mid-1990s, when the privatization efforts began, electric power (and other utilities) were viewed as commodity goods that played no strategic role in an installation's military mission. Since then, the acceleration of sophistication in Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) systems, as well as the operation of unmanned aerial systems for combat and surveillance in theater, has greatly increased the strategic importance of electric power surety for some military installations. These mission critical activities are often controlled from CONUS military bases, which serve to put greater importance on energy surety and security. Since the authorizing legislation for utilities privatization allows, but doesn't require DoD to privatize these systems, the BENS Microgrid Task Force believes DoD should revisit its policy in this area so as not to create any impediments for microgrid development at bases where power surety is critical. Specifically, DoD should identify bases where power surety is particularly critical, and if utility privatization is not yet complete, it should suspend the privatization activities until they can be reconsidered in the context of microgrid development. Specifically, issues such as advanced meter infrastructure (AMI) security standards, the ability to break-out billing information for individual buildings needs to be addressed and resolved.

## STATE UTILITY LAW AND REGULATION

The relatively short history of utility privatization at DoD installations (ranging from full-scale deployment by the Army to a much more limited approach by the Navy) also reinforces an idea introduced earlier in this report: The relationship of individual installations to their local utility are highly individualistic, creating a great diversity of relationships and circumstance across the DoD installation portfolio. In part, this is driven by decades of interactions between installations and their utilities. But it also is heavily influenced by state (and occasionally local) law and regulation governing utilities, and the BENS Microgrid Task Force considers state law and regulation a major non-technical impediment to the effective implementation of a consistent, enterprise-level microgrid program across DoD installations.

In most States, existing utility law does not recognize the concept of a microgrid (with the exception of California, which has adopted a functional definition of a microgrid). Therefore, microgrid developers are likely to fall under one or more existing definitions originally developed for other concepts:[xi]

- *Depending upon the state, the ownership model, and whether public ways (roads) are crossed, a physical microgrid might be classed as a public distribution utility by existing law, which would subject the microgrid to various regulatory proceedings and controls, such as the "obligation to serve," or the role as "provider of last resort." This is particularly problematic for the concept of a community-scale microgrid, as discussed in Section III;*
- *Microgrids that incorporate various technologies and receive rebates and/or tax incentives may or may not fully qualify for those incentives if the technology is embedded in the microgrid and not separately metered at a grid interconnection point. Wind generation and the production tax credit are a possible example;*
- *Depending on the scope and scale, efforts to generate revenue from microgrid operation through demand response and ancillary services fall under regulations designed for Energy Service Companies (competitive energy retailers) and Demand Response aggregators, which could place limits on the ability of the DoD installation to pool generation and load off-grid;*
- *Depending upon the state, a DoD installation microgrid may have to deal with "exit fees" when the installation operates in islanded mode and, with certain net metering restrictions, this also may limit the demand response and ancillary services potential of the microgrid;*
- *If a microgrid includes thermal storage (e.g., using chilled water or ice), then it may fall under constructs originally developed to regulate steam heating utilities.*

As discussed in Section III, the larger a microgrid becomes in size and scale, the more susceptible it is to these kinds of impediments. The discussion above further bolsters the view of the BENS Microgrid Task Force that the substations and feeder circuits serving an installation mark the most sensible delineation for a Defense installation microgrid. Even so, these points highlight the key relationship between the installation, its local utility, and state utility regulator. While certain legal options do exist for DoD to circumvent these impediments (e.g., 40 USC 591 provides an exception that allows the military to use a source other than the local utility provider when the utility is unwilling or unable to provide the standard of service required), the Task Force recommends against this kind of confrontational approach. The Task Force instead recommends that DoD should seek to initiate a dialogue among key utility industry stakeholders (Edison Electric Institute [EEI], American Public Power Association [APPA], National Association of Regulated Utility Commissioners [NARUC]) at the proper time, to forge model agreements and approaches that may alleviate the impediments described above.

## MISALIGNMENT OF DOD ACQUISITION PROCESSES WITH COMMERCIAL NORMS

As described in Section II, the BENS Microgrid Task Force sees great value to DoD in leveraging third-party financing and development of installation microgrids. Private developers and financiers are able to take advantage of tax and accounting provisions that are unavailable to DoD. DoD will maximize its benefit from the private sector by aligning its acquisition and decision processes to commercial practices, to the maximum extent practicable. The Task Force observed, however, that DoD's acquisition processes are largely misaligned with commercial norms, proceeding at a much slower pace than commercial transactions and causing private sector respondents to either add costs to accommodate unusual provisions (increasing final costs to the government), or opt out of the federal opportunities (reducing the benefits of competition to the government).

In the following discussion, the Task Force uses the U.S. Army's Multiple Award Task Order Contract (MATOC) to illustrate several key differences between government and commercial practices. The MATOC will ultimately represent a $7 Billion program in the Army to procure renewable and alternative energy for installations through Power Purchase Agreements (PPA) of up to 30 years. To its credit, the Army released a draft Request for Proposals (RFP) for public comment in February 2012; its efforts to gather private sector inputs are commendable. In August 2012, it released its final RFP for the MATOC. The Task Force has found the following provisions most significant as departures from commercial practice:

- *Use of a bid ceiling price: The MATOC RFP requires bidders to provide a maximum $/kWh ceiling price for their bid, presumably to set an overall ceiling for an individual awardee's MATOC. Given the tremendous variability in electricity rates and renewable incentives by state and over the duration of the MATOC, such projections at this time are highly speculative. Ultimately, this ceiling price is superfluous given that individual Task Orders will be awarded based on a competitive solicitation that will require contractors to bid their best price offering. But including this requirement at the base contract level runs the risk of sending a confusing signal to bidders, who are unaccustomed to such requirements in commercial transactions. This confusion becomes important if it carries over into individual task order responses. A preferred alternative would be to allow contractors the option of proposing a maximum initial PPA price in terms of a percentage of avoided electricity costs (i.e., "90%") rather than a maximum unit price per kilowatt hour. This allows the Government to assure itself a guaranteed savings minimum while allowing contractors the flexibility to structure their proposals to meet their own business models. However, for purposes of setting an overall ceiling in the MATOC it would require that the Army have a clear understanding of the current costs of electricity at its installations.*

- *Army retention of Renewable Energy Certificates (RECs): The BENS Microgrid Task Force recognizes that the requirement for the Army to retain RECs generated by its renewable energy projects stems from the Energy Policy Act of 2005 and specific Executive Orders. Nonetheless, this requirement is a serious impediment to the promotion of distributed on-site renewable power generation at Army installations. RECs are a critical source of revenue for third party renewable energy project finance, and retention of any produced RECs by the Army would require an increase in the PPA price offered by a project developer. This problem is further exacerbated in the case of solar RECs (SRECs), as SRECs are generally worth considerably more to a solar project owner than any other comparative technology's associated REC. In response to this restraint, the Army (and other Services) have begun the practice of REC "swapping" – allowing the solar project owner to procure lower priced non-solar RECs from an acceptable American REC market to be provided to the Army in place of project SRECs. This is a useful work-around, but it still imposes a PPA price increase to the Army under the MATOC. The Task Force believes DoD should seek legislative relief from the REC retention requirement, and propose an alternative mechanism for demonstrating its compliance with renewable energy mandates.*

- *Tax credit-ineligible incremental upfront requirements: The MATOC RFP includes numerous incremental upfront process requirements that differ from what is normally encountered in commercial development. These requirements typically involve a more prescriptive set of plans, compliance requirements, and security processes than in commercial development. Although individually minor,* *the cumulative impact of these requirements will be to increase project development costs materially. Of concern, these costs will not be eligible to receive the 30% federal investment tax credit (ITC) or accelerated federal tax depreciation incentives. The rules for determining the basis for these federal incentives exclude costs not directly associated with physically installing a renewable energy generator. To the extent that state and federal policy economics do not allow the full increment of these costs to be borne by third party finance, the Army should pay for the incremental costs – either through their direct funding, or as a fee supplement within the PPA.*

The Task Force has an overall concern about the speed of the DoD acquisition process compared to typical commercial practice. While the MATOC will identify a universe of qualified bidders, it is unclear how protracted the Army's decision process involving individual task orders will be if the DoD budget is constrained and the ability to properly staff a new EITF contracting office is challenged. The Task Force also is concerned that individual task order RFPs will be nearly as complex themselves as the MATOC RFP. If this is the case, it bodes ill for a future microgrid program pursued in the same manner as the MATOC, because (as we have said elsewhere in this report) microgrids are more complex than renewable and alternative energy systems.

In addition, the importance of microgrids in the draft RFP MATOC appears to have lessened in the final RFP. Microgrids could be called for, but not quoted unless asked for in the Alternative PPA Contract Line Item Number (CLIN) for each individual Task Order. (CLINs 0006, 0012, 0018, 0024, 0030, 0036, & 0042 would be the "operative" Microgrid offerings.) It states in section C.4.k. of the MATOC: "Alternative energy technologies" for the purpose of this contract means all other future renewable and current and future technologies to effect the utilization of a useable form of energy, e.g., electrical, gaseous, fuel or other. A broad definition of the term is taken and it includes but is not limited to such items as fuel cells, thermal recovery systems, ocean oscillation power generation systems, energy storage, batteries, micro-grids, low-head flow turbines and other hydroelectric technologies that do not require construction of a dam to implement.

It appears that microgrids are now listed in a separate category from the other CLINS and are categorized as another alternative energy technology. The Task Force views this as a categorization of microgrids as separate and distinct technology and not an integral part of all energy resources added to an installation. This segmentation of energy resources and microgrids creates the distinct and very real possibility that Army energy projects executed under the $7 billion MATOC may not include microgrids. This could be viewed as a lost opportunity to create energy security while large amounts of renewable energy are added to the installations and potentially the commercial grid.

## Disaggregation of DoD Installation Energy Programs

Microgrids represent a logical framing construct for DoD's suite of installation energy programs, because a fully utility-integrated microgrid requires generation, energy efficiency, demand response, and energy management (from the installation to enterprise level). In an ideal construct, the component parts (generation, efficiency, etc.) would be optimized as programs in support of energy security and microgrids. The structure of energy initiatives and programs at DoD has evolved in ways that seemed logical against emerging opportunities, but not so logically from an overall strategic viewpoint. The Task Force commends DoD for the strength of some of its programs, but considers the disaggregation and the lack of a cohesive, long-term microgrid implementation plan of these programs as a potentially significant impediment. We recognize that DoD is already beginning to take steps to address this issue, and we encourage it to accelerate and extend its efforts.

For example, one of the challenges in understanding the potential of microgrids is the lack of a reliable current baseline of energy use across the portfolio of DoD installations. DoD has recognized this challenge, and is moving forward on actions to fill this fundamental gap. The centerpiece of this effort is the development of an Enterprise Energy Information Management (EEIM) system that will collect installation energy data systematically across the Services. Accompanying the development of the EEIM system, DoD is revising its policy so that the installation of advanced meters proceeds where their economics make sense, more granular data is collected from such meters, and necessary security is in place so that data is usable across many levels within DoD, from headquarters to the field.

While the development of the EEIM system will represent a major milestone, it will not fully address the impediment that disaggregation of installation energy programs represents. As we have said elsewhere in this report, the BENS Microgrid Task Force believes there is great military value in the fully utility-integrated microgrid, which requires an economic packaging of on-base generation, energy efficiency, and demand response – and the use or retirement of existing backup generation assets. Across these elements of installation energy management, DoD's programs remain significantly fragmented. Energy efficiency has been conducted through the use of both third-party energy savings performance contracts (ESPCs) and utility energy service contracts (UESCs) as well as directly funded through DoD's Energy Conservation Improvement program (ECIP). Enrollment in demand response programs, where it happens, is usually initiated at the installation level, and there currently is no repository of information about these efforts. Likewise, procurement of back-up generators seems historically to have been funded from multiple budgets, with no transparency of what resources have been procured, at what cost, or what their current condition and readiness is now. Additionally, other initiatives such as the Army's NetZero installation program focus only on renewable energy (i.e., not on-base thermal energy sources), not on creating the most cost-effective energy security solution for an installation.

To leverage private sector capital and risk-sharing, the design of microgrids requires a clear line of sight to all of these activities, and the ability to optimize the outcome among them. Based on the inputs we received during our site visits, interviews, and research, the BENS Microgrid Task Force does not believe this clear line of sight currently exists. Failure to understand the limitations or opportunities in any given area may foreclose possible deals, and restricts the ability of the DoD from capturing the maximum value in a microgrid design. It is beyond the scope of this report to engineer the specific solution for DoD to address this lack of coordination, but we believe that effective approaches will include both policy and organizational changes that may require legislative action.

# TECHNICAL IMPEDIMENTS

In addition to the non-technical impediments described above, the Task Force observed several technical impediments that came up repeatedly during the course of this study. The principal technical issues that might impede the microgrid deployment effort map out into three main areas:

- *Shock Hazard: This issue involves the ability to detect and locate short circuit faults and take steps to protect against inadvertent backfeeding of electricity from a microgrid into the outside grid during a utility outage. "Lineman's risk" of this type exists whenever a utility interconnects with a proprietary energy system. Where microgrids are comprised of thermal generation assets (e.g., diesel or natural gas powered generators or turbines), this risk is easily managed. Where inverter-based renewable energy sources are integrated into a microgrid, fault detection and protection are more complicated but still achievable. Historical concerns about backfeeding are one reason why all renewable energy systems located on military installations currently shut down during grid outages.*

Finding ways to safely integrate renewables into electric power systems is a high priority for utility operators around the world. The technical challenges are well understood. System design and operating practices for integrating distributed resources and islanded systems with area utilities are the subject of a recent IEEE standards document (IEEE 1547.4), and new sensor and controls products intended to facilitate greater renewables integration are being introduced regularly. The Task Force is of the view that commercially available technologies are sufficient to provide effective solutions to identifiable shock hazards arising in installation-scale microgrids meeting DoD's defined objectives.

- *Ability to Parallel with the Local Utility: Many of the backup generators currently in place at domestic installations were manufactured prior to the introduction of advanced microprocessor control systems and, as a result, simply lack the technical ability to parallel with an outside utility. Modern diesel and natural gas reciprocating engine power modules and combustion turbine generators in the size categories most relevant to installation microgrids (i.e., 1MW-2MW and 5MW-30MW per unit, respectively), are fully capable of paralleling with other similar units and engaging in unit-to-utility paralleling. As a result, these assets are able to act as a single controllable entity with respect to the local utility – one of the key functional objectives established for installation microgrids. Accordingly, this issue can be resolved most readily through investment in newer thermal generation assets as part of an overall installation microgrid deployment program.*

- *Power Quality: In principle, microgrids offer the potential for overall improvements in power quality at many installations. However, the ability of a microgrid to maintain stable voltage and frequency over time is a particular concern where intermittent renewable power sources are not adequately balanced by a source of synchronous power. In this role, diesel and natural gas reciprocating generators and combustion turbines supply electricity of high quality, and individual units can be networked to achieve high levels reliability. In fact, power for most Olympic broadcasting is supplied by purpose-built microgrids utilizing portable thermal generation assets rather than utility service. Given the ability of thermal units to provide stable "prime" power in these critical applications, concerns about power quality need not impede microgrid deployment. As alternative stabilizing energy devices, such as storage and flywheels, become available, their cost effectiveness can be measured against the value provided by thermal generation assets.*

# CONCLUSIONS FROM THE ASSESSMENT OF IMPEDIMENTS TO MICROGRID DEVELOPMENT

This section describes a great number of non-technical and technical impediments to the development of microgrids on DoD installations. In large part, these impediments exist because microgrids represent a paradigm shift in both the role of electric power in military operations, and the relationship between DoD installations in the Nation's power grid. In the past, electricity was viewed as a relatively simple commodity, and DoD as a cumulatively large, but otherwise straightforward customer. In the new paradigm, power surety at installations is increasingly critical to military activities at installations, and the most cost-effective means of gaining power surety is to transform the role of the installation in its local grid operations. To accomplish this, existing rules must be revisited, and long-standing assumptions re-examined. In the view of the BENS Microgrid Task Force, each of these impediments is significant, but none necessarily prohibits DoD from moving forward in its microgrid development efforts.

Based on the data and analysis considered by the BENS Microgrid Task Force, the following conclusions are offered:

**1) The most significant impediments to DoD installation microgrid development arise from within DoD itself – its utility privatization program, acquisition process, and disaggregation of installation energy initiatives:** Each of these impediment classes exist for legitimate reasons – they are either trying to create a positive outcome for DoD under the current paradigm of electric power investment, or are aimed at ensuring sufficient deliberation in the expenditure of public money. But the paradigm shift to microgrids, and the great potential it holds, demands that DoD take a new look at its own programs, processes, and policies. It is beyond the scope of this report to engineer the full range of specific actions DoD should take, but we feel strongly that both policy and organizational changes are needed to allow DoD to be more effective.

**2) STATE UTILITY LAW AND REGULATION CREATE IMPEDIMENTS. DOD CAN BEST ADDRESS THESE BY SIMULTANEOUSLY INCREASING ITS OWN UNDERSTANDING OF MICROGRID DEVELOPMENT (SIZING AND LOCAL BUSINESS MODELS), AND INCREASED ENGAGEMENT WITH NATIONAL-LEVEL STAKEHOLDERS::** The diversity within the DoD installation portfolio eliminates the possibility of a simple, one-size-fits-all microgrid solution for all bases – either in terms of policy or technology. Similarly, the impediment of state utility law and regulation cannot be overcome analytically. The BENS Microgrid Task Force believes that DoD needs to increase its practical experience in microgrid development to gain insights into these issues and possible solutions. This learning and experience, rather than additional investment to understand the scientific and technological underpinnings of microgrid components, should be the focus of DoD's next step in microgrid development. As it gains this experience, it should initiate a dialogue, or reengage, with the national-level stakeholder organizations for the utility industry, and forge model agreements and approaches that will support the further scaling-up of DoD's microgrid efforts.

# Section V

## PERSPECTIVES ON IMPLEMENTATION

Approaching this issue as if we were operating a business that was confronted with the kind of energy security challenge – and opportunity – DoD has before it, BENS Microgrid Task Force proposes the following next steps. Like all BENS efforts, the Task Force shares this perspective because our work does not end at recommendations; it strives for change, impact, and resolution of the energy security challenges facing DoD and its installations. The Task Force describes each proposed next step in a way that will enable DoD leadership to take action, but recognizes that there may be multiple alternative approaches available to DoD leadership to arrive at the same outcome. Our intent is not to dictate the specific approach to DoD.

The BENS Microgrid Task Force believes the reliance on the commercial electrical power grid is an enduring vulnerability to energy security on DoD installations in the United States. The commercial grid is experiencing more frequent and longer-duration outages. While these outages are currently measured annually in hours rather than days, the grid remains susceptible to both malicious attack and unintentional disruption. This situation is expected to only get worst in the future. Over the next decade, "smarter" technologies hold the potential to ultimately improve the resilience and reliability of the grid (albeit unevenly, given the grid's fragmented nature). DoD has a military interest in the evolution of the grid, and this next stage offers a window of opportunity in which DoD and the electric power industry can mutually benefit in specific locations around the country through the development of utility-integrated secure microgrids. The commercial power grid will evolve – the question is whether DoD will take advantage of the opportunity to shape this evolution at its installations so that it benefits military readiness to the maximum extent possible.

Neither DoD, nor the electric power or finance industries, are fully ready to take advantage of this opportunity. Yet all of these key stakeholders have begun to move toward convergence. DoD has made strong progress and recognized impressive initial achievements in installation energy management. Utilities and their regulators are beginning to see the potential of partnering with DoD. And the finance sector has many participants who are actively seeking productive ways to deploy capital to accelerate activity. The proposed actions laid out below, if executed over the next few years, can bridge the remaining gaps. For DoD, many of the actions described accelerate and expand upon what DoD has already begun to build in its installation energy program.

However, the BENS Microgrid Task Force believes a change in emphasis is needed for DoD's installation energy security activities, away from research and toward realizing on-the-ground implementation. The proposed actions described below are divided into two parts. First, there are a series of steps to complete the foundation needed to identify and move forward on microgrid opportunities. Second, we believe DoD needs to increase its insights and capabilities around microgrid development, with a particular emphasis on business models. Given the diversity in the DoD installation portfolio, we are sure this will best happen by simultaneously learning and implementing. For this reason, we propose a test and evaluation program, focused on ultimately delivering full-scale microgrids at 6-8 key installations.

Some of the actions we propose can be accomplished relatively quickly; others will require several years to complete. For each proposed action, we identify both the timeframe for starting the action, and the timeframe in which anticipated impact should be realized. Our terminology is not precise, but generally suggests the following timeframes:

1) **Immediate**: Within 3 months
2) **Near-term**: Within 12 months
3) **Medium-term**: 12-36 months
4) **Long-term**: 36 months and beyond

# COMPLETING THE FOUNDATION FOR MICROGRIDS

The previous sections of this report describe the high degree of variability we observed across many factors that are important to the question of microgrids at DoD installations. The condition of on-base electrical infrastructure, state regulatory environment, existing energy security technology, installation energy programs, and business relationships with local utilities all created an enormous number of permutations across the DoD installation portfolio. In this highly diverse environment, DoD would benefit from some "stakes in the ground" – specifically defined requirements, approaches and relationships that would give it a starting point for more systematically analyzing individual microgrid project economics and business models.

**1) Establish energy security requirements for Defense installations.** During the course of the study, the BENS Microgrid Task Force was surprised that objectives and requirements for energy security were not more specifically defined. In particular, DoD needs to establish how long it expects an installation to be able to operate in islanded mode (i.e., the "design-basis outage") and how much on-base energy or fuel/energy storage is needed (as measured by days of full-base operations or only mission critical infrastructure).

The design-basis outage is a fundamental requirement statement of energy security for DoD; without it, there is no way of determining whether a microgrid is even required as a solution for mission assurance. The design-basis outage could be determined through examination of publically available information such as recent weather-related outages, as well as classified information describing malicious threat to the commercial grid, such as cyber attack or other forms of terrorism. The determination of design-basis outage might also be tied to the criticality of mission at an individual installation. As such, the determination of the design-basis outage involves information that is beyond our purview.

On-base energy or fuel storage is also an important requirement tied to the needs of an individual installation. If an installation (based on its mission and design-basis outage) would best be served by a secure microgrid solution, the amount of on-base energy/fuel storage would be tied to the mix of renewable and conventional sources of electricity powering the installation's microgrid. Generally speaking, the higher the proportion of renewable energy sources, the less on-base storage is needed. A microgrid that is entirely powered by conventional sources (e.g., natural gas) would likely require enough fuel storage for the entire design-basis outage. At a minimum, the BENS Task Force believes an effective smart microgrid must have four key characteristics:

- *Ability to disconnect from the commercial grid, "island", and "black-start" capable, meaning on-site power sources restore power seamlessly in case of grid failure*
- *Ability to integrate renewable energy.*
- *Sustainable for periods measured in weeks or months; not days.*
- *Ability to withstand cyber attack.*

Design – basis outage and on-base energy or fuel storage are necessary to frame the project economics for any energy security solutions at installations. Without them, the analysis of possible solutions at individual installations is unconstrained – there is no target against which microgrids or any other energy security solution can be compared.

**Timeframe for starting—**

**Immediate**

------------------------------------

**Timeframe for anticipated impact—**

**Medium-term**

**2) Determine the organizational approach for microgrid development that will support timely decision-making and development of an enduring capability within DoD.** The high degree of diversity in the DoD installation portfolio creates a significant challenge in trying to create a uniform approach to microgrid development. Given this, traditional approaches to implementation are also challenged. The BENS Microgrid Task Force believes strongly that traditional implementation approaches – with OSD providing policy direction and oversight, and the Services applying resources and leading implementation, will not succeed. If implementation of microgrid policy is delegated to each of the Services, the variability of circumstances at each installation is likely to drive very different decisions in the design and acquisition of microgrids. Industry providers are likely to encounter very different technical bases for microgrid designs, and very different acquisition timelines, processes and selection criteria across the Services. This kind of approach is unlikely to capitalize on the best value industry can deliver. Additionally, the Task Force believes that DoD does not currently have all of the technical or business capabilities in-house to consistently deliver best value for taxpayer dollars expended on microgrid development. Attempting to build this capability across the Services simultaneously would only exacerbate this shortfall.

If this were a private sector initiative, a central organization would be established, invested with the technical and procedural authorities needed to succeed under effective corporate oversight. We recognize that DoD's experience in utilities and housing privatization may suggest a different path than centralization (although those programs were financially driven), and that a range of options are available. Whatever approach DoD selects, the BENS Microgrid Task Force believes it should exhibit the following attributes: A single technical authority capable of analyzing alternative microgrid designs and assessing their acceptability from an engineering perspective; a single point of interface for the electric power and finance industries, with capability in business analytics to conduct economic tradeoff analyses; sufficient discretionary authority to maximize the flexibility of DoD's acquisition and procurement processes; and the organizational resources to compile project information, lessons learned, and key insights, for feedback into organizational processes and reporting of progress to higher authorities. The efforts of the DoD Office of Operational Energy Plans and Programs is an example of this OSD driven effort that could benefit all of the Services with respect to microgrid development. In this respect, the DoD Office of Installations and Environment should be considered a central and guiding resource to direct the microgrid program.

**Timeframe for starting—**

**Immediate**

------------------------------------

**Timeframe for anticipated impact—**

**Near-term**

**3) Begin dialogue with leadership from key sectors – electric power and finance – to build model agreements that support microgrid design, operations, and investment.** The ultimate energy security solution envisioned by the Task Force is the fully utility-integrated microgrid, with generation sized to support market conditions and developed using third-party finance. This form of microgrid is as novel to the electric power and finance industries as it is to DoD. Though technologies exist to deliver microgrids, a business model needs to be worked out among these key stakeholders. Electric utilities (both public and investor-owned) have a level of interest in microgrids that depends on their local grid conditions. The National Association of Regulated Utility Commissioners, in passing its referendum on Defense microgrids, expressed both interest and apprehension in the approaches DoD might take. Similarly, the finance industry sees possible opportunity in productively deploying capital to develop microgrids, but is unclear on how DoD will acquire them, and what rules apply. Over time, DoD will benefit greatly from having a higher degree of standardization in the processes and approaches used for microgrid development. The BENS Microgrid Task Force believes significant progress is possible in this regard, but will be hard-earned. DoD should initiate or reengage with the leadership in these sectors to develop microgrid concepts that will support ideal agreements and terms, and reduce the degree of variability in microgrid architecture and contract parameters across the DoD installation portfolio. It is important that DoD pursue these dialogues in concert with determining its organizational approach; it is important that these dialogues include representatives from both the policy and implementation spheres within DoD.

**Timeframe for starting—**

**Near-term**

------------------------------------

**Timeframe for anticipated impact—**

**Medium-to-Long-term**

**4) Use Congressional testimony and inquiries to describe the benefits of legislative changes that would remove impediments to investment in microgrids, and expand the pool of investors.** While federal departments and agencies are appropriately prohibited from lobbying Congress, they do have multiple opportunities throughout the year to communicate the impact of legislative requirements on agency performance. DoD should use these opportunities to describe improvements that would strengthen investment in Defense microgrids. First, the BENS Microgrid Task Force strongly believes that DoD should welcome the removal of the requirement that it retain Renewable Energy Credits (RECs) associated with on-base development of renewable power. The retention of these credits, even partially mitigated by REC swapping techniques, reduces the attractiveness of these projects to outside investors, who count on the sale of the RECs as a significant source of return. Additionally, if initial microgrid development efforts are successful, scaling of the program by DoD will benefit from having larger pools of investors to compete for projects, and to be in a position to offer highly competitive terms for larger bundles of projects. Many projects are likely to have a renewable energy generation component, and a greater number of investors would be more likely to get involved if they could participate in one or more tax-advantaged investment structures: Master limited partnerships (MLPs) or real estate investment trusts (REITs). Making either available to investors in renewable energy or microgrids would require a modification of the tax code. MLPs broaden the investor pool because of favorable tax treatment and are regularly used in the energy field, but are expressly limited for infrastructure for deployable resources. Alternatively, REITs are structured to reduce or eliminate corporate tax exposure.

Careful work will be needed to broaden the availability of these investment structures, but the results could be very valuable to DoD when microgrid development at scale becomes a reality.

**Timeframe for starting—**

**Medium-term**

**Timeframe for anticipated impact—**

**Long-term**

# SHIFTING FROM RESEARCH TO IMPLEMENTATION

In the past few years, DoD has invested significantly in basic and applied research to increase its understanding and advance the suitability of technology critical to the performance of secure microgrids at DoD installations. These efforts have included a Joint Capability Technology Demonstration project known as the Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS), and a Smart Microgrid and Energy Storage effort within the Installation Energy Test Bed under the Environmental Security Technology Certification program (ESTCP). Based on the emerging results of these efforts, and the knowledge base of the BENS Microgrid Task Force members, we believe there are no current technological hurdles to the development of microgrids that are able to meet a broad range of performance objectives.

This does not mean that conditions are currently suitable for the deployment of microgrids across the entire DoD installation portfolio. As we have described in this report, the component technologies in a DoD installation microgrid need to not only perform, but to perform at a cost and in a context that supports an acceptable business model for a range of key stakeholders – the DoD chain of command, the local utility, the utility regulator, third-party developers and financiers, and more. While there has been great learning about technology, there is additional learning remaining about the creation of successful microgrid business models, and that should be the focus of DoD's next major effort in energy security.

The BENS Microgrid Task Force recommends that DoD shift its future investment away from research into microgrid technology, and should instead focus on applying all available knowledge to the development, test and evaluation of at-scale microgrids under varying business model environments. The DoD portfolio is complex and diverse in most aspects that pertain to development of microgrids; finding the "simplicity on the other side of complexity" comes through experience, not analysis.

Specifically, the BENS Microgrid Task Force recommends that DoD pursue 6 to 8 at-scale microgrid development projects as a test and evaluation program, with two goals in mind: gaining key insights into how alternative technology choices influence the development of successful microgrid business models, and developing the multidisciplinary capabilities (acquisition, finance, engineering, law, business analytics) needed to successfully envision, analyze, and negotiate the development of a successful DoD microgrid with the full range of industry participants. The product of this test and evaluation effort should be an operational microgrid at each installation, and the key insights to structure future policy and implementation activity to support expansion across the DoD installation portfolio.

The Task Force believes 6 to 8 projects represent a scale of activity that should be manageable for DoD, while at the same time covering a broad enough range of specific circumstances to provide insights into future program direction. For this report, we developed a microgrid suitability screening tool and have applied it in generating this list, but DoD ultimately will need to select the number and specific installations itself for this test and evaluation program. We are aware that programs within the DoD, such as the efforts being led by the Army's Energy Initiatives Task Force, have developed their own screening tools and these are a starting point for generating a list of candidate bases. Based on our site visits, study, and experience, the BENS Microgrid Task Force provides the following recommendations of installations to include in a test and evaluation program, and we include a summary of our rationale for each (listed in no particular order):

**1) Hawaii – Camp H.M. Smith:** Hawaii has the highest-priced electricity in the U.S., and experiences frequent intermittent outages. Hawaii also has relatively strong incentives for renewable energy development. Camp Smith is the home of Pacific Command, of rising importance with the increasing strategic emphasis on the Pacific Rim by DoD. Camp Smith also is included as the culminating base of the SPIDERS JCTD effort, so some baseline data gathering and electrical system characterization presumably has been completed.

However, if Camp Smith were selected to be within the test and evaluation program described above, the BENS Microgrid Task Force would strongly recommend that it be removed from any SPIDERs JCTD planning, and that a management structure be employed other than that used in SPIDERS. The fragmentation of management responsibilities within SPIDERS across sub-elements of three Cabinet-level agencies (DoD, DOE, DHS) is appropriate for the purpose of sharing the key insights of a research program, but is not at all suitable for the development of an operational microgrid. The SPIDERS management structure does not demonstrate any of the key organizational attributes described earlier in this section.

**2) California–Multiple options:** California has the strongest state incentives for renewable energy development in the United States. California also has multiple candidate bases for a microgrid test and evaluation effort, with critical missions conducted at several locations in the state. Microgrid technology is already deployed to cover a portion of base operations at the Marine Corps Air Ground Combat Center Twentynine Palms. The BENS Microgrid Task Force applauds the effort that has been made at Twentynine Palms, but considers looking at a different site; perhaps with a focus on the viability of a cyber-secure or community-scale microgrid (as described in Section III). Candidates for this effort might include the U.S. Navy's energy security plan across multiple bases in the San Diego area, or the U.S. Army's National Training center at Fort Irwin.

**3) Alabama – Redstone Arsenal:** Redstone Arsenal is home to the U.S. Army Aviation and Missile Command (AMCOM), the Space and Missile Defense Command, numerous Program Executive Offices (PEO), and major components of the Defense Intelligence Agency and the Missile Defense Agency. It also is a directly served customer of the Tennessee Valley Authority, which plays a unique role in the bulk power market in the United States. In April 2011, damage from strong tornadoes in the Tennessee Valley caused an extended outage at Redstone Arsenal. Data from that outage, and the work-arounds employed for mission continuity, would provide very useful business case data for microgrid development. Alabama has little to no state support for renewable energy development, so this case would examine a different range of technologies. An alternative in the TVA operating area would be Ft. Campbell, KY.

**4) New Jersey – Joint Base McGuire-Dix-Lakehurst:** New Jersey has very strong state incentive for solar energy, and JB MDL is a large base in terms of physical area. The solar resource in New Jersey is not particularly strong, making development of a microgrid an interesting business case. The base has a strong readiness and deployment focus, and is home to a C-17 squadron.

**5) Texas – Fort Bliss:** Fort Bliss is already the site of a microgrid R&D project in DoD through ESTCP's Installation Test Bed program, as well as a microgrid for its new headquarters under the ESPC. The microgrid proposed by the Task Force should incorporate the entire installation, assuming the UPC owner, Rio Grande Electric Cooperative, allows the microgrid to overlay their distribution network on the "old cantonment" area. The proposed 20MW solar project to be built by El Paso Electric on Fort Bliss also should be incorporated into the larger microgrid. This location would introduce many of the specific challenges raised in the Task Force report , as well as having multiple microgrids incorporated into a single system. An alternative within Texas would be Fort Hood, which is located in in east-central Texas, and is within the area of responsibility of the Electric Reliability Council of Texas, which governs the generation, transmission and sale of power in most (75%) of the state.

**6) Florida – MacDill Air Force Base:** Florida has very limited incentives for renewable energy generation, and a mix of available energy resources. MacDill's location near Tampa, Florida makes it susceptible to disruptions caused by severe weather, especially hurricanes. MacDill is home of the 6th Air Mobility Wing, and  two unified combatant commands: Central Command (USCENTCOM) and Special Operations Command (USSOCOM). The host of mission critical infrastructure on the base will make it very attractive for a microgrid.

# STUDY & APPROACH

BENS developed this analysis to help the Deputy Under Secretary of Defense for Installations and Environment analyze the benefits and risks associated with DoD's potential investment in microgrid technology as well as offer recommendations to assist DoD as they move toward more sustainable energy resources. Specifically, we were asked by the office of the Deputy Secretary of Defense to recommend the criteria for establishing a microgrid on domestic installations and provide various business models of microgrid ownership and operation; the impediments to broad deployment; and, the criteria that would help determine the size of the grid on an installation. The work, which spanned between September 2011 – June 2012, involved over 40 BENS members and energy management experts and included on-site analysis of a representative sample of active DoD installations (Fort Bragg, Fort Lewis, Fort Carson, US Air Force Academy, Robins AFB, NSB Norfolk, Joint Base Little Creek, Joint Base Pearl Harbor-Hickam, Camp H.M. Smith, Twentynine Palms). Along with diversity of mission, these installations were chosen by the Task Force because they represented differing regions in the country, varying environmental and economic circumstances, and varying availability in energy resources. The BENS Task Force examined both the supply of electric power (external + on-site), the demand for power and the efficiency of existing assets/technology, and the potential and need for a microgrid on each installation.

Furthermore, the Task Force met with and were briefed by major energy experts and microgrid stakeholders on the various issues surrounding microgrid investment both commercially and for government use. These groups included ACORE, Colorado Springs Utilities, Construction Engineering Research Laboratory, Dahlgren Mission Assurance Division, Dominion Virginia Power, Edison Electric Institute, Hawaiian Electric Company, Georgia Tech Research Institute, Georgia Power, MIT Lincoln Laboratory, the National Renewable Energy Laboratory, and the Perfect Power Institute.

## MICROGRID PROJECT PRIORITIZATION TABLE

### Top Ten Locations for Microgrid Projects Using Preliminary Scores

| | Installation Name | | State | Critical Mission Score | Renewable Resources Score | Electric Power Price Score | Business Environment | Overall Score |
|---|---|---|---|---|---|---|---|---|
| 1 | Kaneohe Bay MC Base<br>Camp H.M. Smith | MC<br>MC | HI | 25.00 | 5.41 | 25.00 | 9.73 | 65.15 |
| 2 | Fort Shafter<br>Tripler Army Medical Center | Army | HI | 25.00 | 4.06 | 25.00 | 9.73 | 63.79 |
| 3 | Schofield Barracks<br>Barbers Point NAS<br>Pearl Harbor Naval Complex | Army<br>Navy<br>Navy | HI | 25.00 | 3.38 | 25.00 | 9.73 | 63.12 |
| 4 | Hickam AFB | AF | HI | 25.00 | 3.04 | 25.00 | 9.73 | 62.78 |
| 5 | Fort Irwin<br>Barstow MC Logistics Base | Army<br>MC | CA | 25.00 | 10.65 | 7.98 | 13.02 | 56.65 |
| 6 | Twentynine Palms MC Air | MC | CA | 25.00 | 10.24 | 7.98 | 13.02 | 56.24 |
| 7 | China Lake Naval Air Weapons Station | Navy | CA | 25.00 | 8.19 | 7.98 | 13.02 | 54.19 |
| 8 | Los Angeles AFB<br>Fort MacArthur | AF<br>Army | CA | 25.00 | 7.37 | 7.98 | 13.02 | 53.37 |
| 9 | Point Mugu Naval Air Station | Navy | CA | 25.00 | 6.96 | 7.98 | 13.02 | 52.69 |
| 10 | Edwards AFB<br>Vandenberg AFB<br>Presidio of Monterey<br>El Centro Naval Air Facility | AF<br>AF<br>Army<br>Navy | CA | 25.00 | 6.55 | 7.98 | 13.02 | 52.55 |

***Note: New London, CT, Submarine Base is the highest ranked (5erd) outside of HI and CA with score of 51.22***

# END NOTES


i Cheryl Pellerin. DoD Gives High Priority to Saving Energy. American Forces Press Service. 2011. http://www.defense.gov/news/newsarticle.aspx?id=65480

ii S.B. Van Broekhoven, et al. Microgrid Study: Energy Security for DoD Installations. MIT Lincoln Laboratory. 2012. http://serdp-estcp.org/content/download/15304/175087/version/3/file/MIT+LL+DoD+Microgrid+Study+TR-1164+18Jun12.pdf

iii George V. Hulme. Despite years of talk, utilities remain compromised, vulnerable. CSO Online. www.csoonline.com/article/684287/despite-years-oftalk-utilities-remain-compromised-vulnerable

iv Pew Project on National Security, Energy and Climate. From Barracks to the Battlefield: Clean Energy Innovation and America's Armed Forces. 2011. http://www.pewenvironment.org/uploadedFiles/PEG/Publications/Report/DoD-Report_FINAL.pdf

v Electric Power Research Institute. *Estimating the Costs and Benefits of the Smart Grid: A Preliminary Estimate of the Investment Requirements and the Resultant Benefits of a Fully Functioning Smart Grid. 2011*. http://ipu.msu.edu/programs/MIGrid2011/presentations/pdfs/Reference%20Material%20-%20Estimating%20the%20Costs%20and%20Benefits%20of%20the%20Smart%20Grid.pdf

vi DNational Association of Regulatory Utility Commissioners: Committees on Electricity and on Critical Infrastructure. Resolution Encouraging the Department of Defense to work with State Utility Regulators and Utilities. 2012. http://www.naruc.org/News/default.cfm?pr=325

vii Deputy Secretary of Defense. Department of Defense Reform Initiative Directive #49 - Privatizing Utility Systems. 1998.

viii Puthoff, LTC Frederick A, US Army. Utilities Privatization—Is the US Army on the Right Circuit?. 2009.

ix Puthoff.

x Government Accountability Office. Defense Infrastructure: Management Issues Requiring Attention in Utility Privatization. Report to the Subcommittee on Readiness, Committee on Armed Services, House of Representatives. 2005. http://www.gao.gov/assets/250/246287.pdf

xi Masiello, Ralph. email message to Robert Catell. August 8, 2012.

## KEY BENS STAFF

Henry Hinton, Chief Operating Officer
Clinton Long, Director of Communications/Web
James Whitaker, Director for Policy

## CONTRIBUTIONS

Gary Leatherman, Booz Allen Hamilton
Kara Mountcastle, BENS
Marija Prica, Booz Allen Hamilton

1982-2012
30 YEARS

**Business Executives for National Security**

1030 15th Street, N.W.
Suite 200 East
Washington, D.C.  20005

www.bens.org