EXECUTIVE SUMMARY

Financial Optimization of Electricity Security Assets at Military Installations: Including Case Studies of Dover Air Force Base, Fort Benning, and MCAGCC Twentynine Palms

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1 Executive Summary

1.1 Purpose of Study

This study is designed to contribute one helpful piece to a much larger puzzle: how best to invest in and pay for energy security at U.S. military installations. It does so by reviewing the tangible net revenues and cost reductions that current and future electricity assets on installations can achieve in energy markets, **beyond** whatever value is placed on their protection of mission or grid independence. The assets, such as conventional and renewable on-site generation, advanced energy management control systems, battery storage, and microgrids are generally put into service to enhance electricity security and control, but their revenue and cost saving potential from providing energy market services need to be understood in order to make optimal investment decisions and to create support for the acceleration and replication of high-value electricity security activities at appropriate installations.

1.2 Key Findings

- This study determined that substantial net financial benefits (equivalent to up to 14% of total annual electric costs, or well above $1 million annually for each mid-sized to large military installation) can be achieved from the participation of current and future electricity security assets in markets. Across U.S. Department of Defense (DoD) installations, there is conservatively the potential for annual net operating revenues of $132 million from such asset investments and uses.

- Tangible financial benefits in the form of extra revenues and lower electric bills from market participation were found across all three military installations studied, in three very different regional electric markets.

- The financial benefits arise from DoD installations responding to market price signals that exist for periods as brief as an hour or less to those enshrined in utility tariff rates and not changing for a year or more. The electricity markets offer price opportunities to DoD installations on an ongoing basis; the question is if and how installations will best respond to those price opportunities.

- An installation's access to time-of-use, day-ahead, or real-time energy pricing is a large driver of revenue and savings potential.

- The incremental financial benefits can, in some instances, pay for all capital and operating costs of new electricity security assets over 20-year useful asset lives. In most instances, the extra funds cover the annual operating costs of essential energy security investments.

- Total gross financial benefits increase as progressive packages of additional electricity security assets and uses are deployed. This study began with current installation assets and uses (status quo) and modeled financial optimization of those current assets, as well as additions of advanced energy management control

systems, advanced on-site conventional and renewable generation, battery storage, electric vehicle-to-grid, and microgrid technologies.

- From a technology perspective, the greatest increase in net financial benefits (equivalent to 5% to 7% of annual electric costs) generally occurs when advanced energy management control systems (EMCSs) that can manage installation electric loads in an integrated and centralized manner are deployed. These EMCSs often have far greater capability than the disparate building management systems (BMSs) currently in place. Though additions of EMCSs and other assets are modeled in a standard sequence in this study, in practice they can be added in various sequences with similar benefits.

- The capital costs of electricity security investment programs can be meaningfully reduced if they are implemented as part of a stepwise plan that builds from current installation assets and uses, integrates assets along the way (e.g., BMS with EMCS and renewable generation with battery storage), and concludes with a microgrid with the ability to island critical loads from the external electric grid.

- Key barriers to achieving greater electricity market benefits include the absence of a clear roadmap on what asset investments and uses will bring sizable benefits in given markets, delays in energy software adoption by installations, and the lack of a consensus view within DoD on the overall "value" of energy security/mission protection.

- When assessing the financial benefits of market participation, it is important to apply the proper metric (gross revenues, net operating revenues, or net revenues after operating and capital costs) depending on the decision at hand and to test results against low and high market price scenarios due to the volatility of many electricity prices.

1.3 Study-Wide Methodology

The report was based upon a case study methodology. The study team conducted detailed reviews and financial modeling of installations drawn from each of the Services and across three different electric markets (PJM, SERC/Southern Company, and California ISO). These major regional electricity markets, illustrated in Figure 1.1 below, host a large number of military installations and have different characteristics. PJM is a very open market with extensive price histories and many opportunities for large energy consumers to participate in electricity markets, SERC/Southern Co. is a market with traditional, vertically-integrated utilities, and California ISO (CAISO) has a range of markets but has not yet achieved high levels of energy consumer participation in them and has emphasized individual utility programs.

The installations nominated by each Service were Dover Air Force Base (Delaware) in PJM territory, Fort Benning (Georgia) in SERC/Southern Co. territory, and Marine Corps Air Ground Combat Center Twentynine Palms (California) in CAISO territory.[1] In addition to representing

[1] These installations are abbreviated as Dover AFB, Ft. Benning, and MCAGCC 29 Palms in the study.

Service and geographic diversity, these installations differ in other important respects. They range from mid-sized installations (Dover AFB with a peak electric demand of 13 MW) to large (MCAGCC 29 Palms at 33 MW peak demand) and very large (Ft. Benning with 77 MW peak demand). Their average external electricity prices vary from about $.06/kWh to $.20/kWh. The extent of electricity security asset deployment and use spans from almost exclusively building-specific back-up generators (Ft. Benning) to some experimentation in markets (Dover AFB) to an advanced stage of commissioning almost all asset types (MCAGCC 29 Palms).

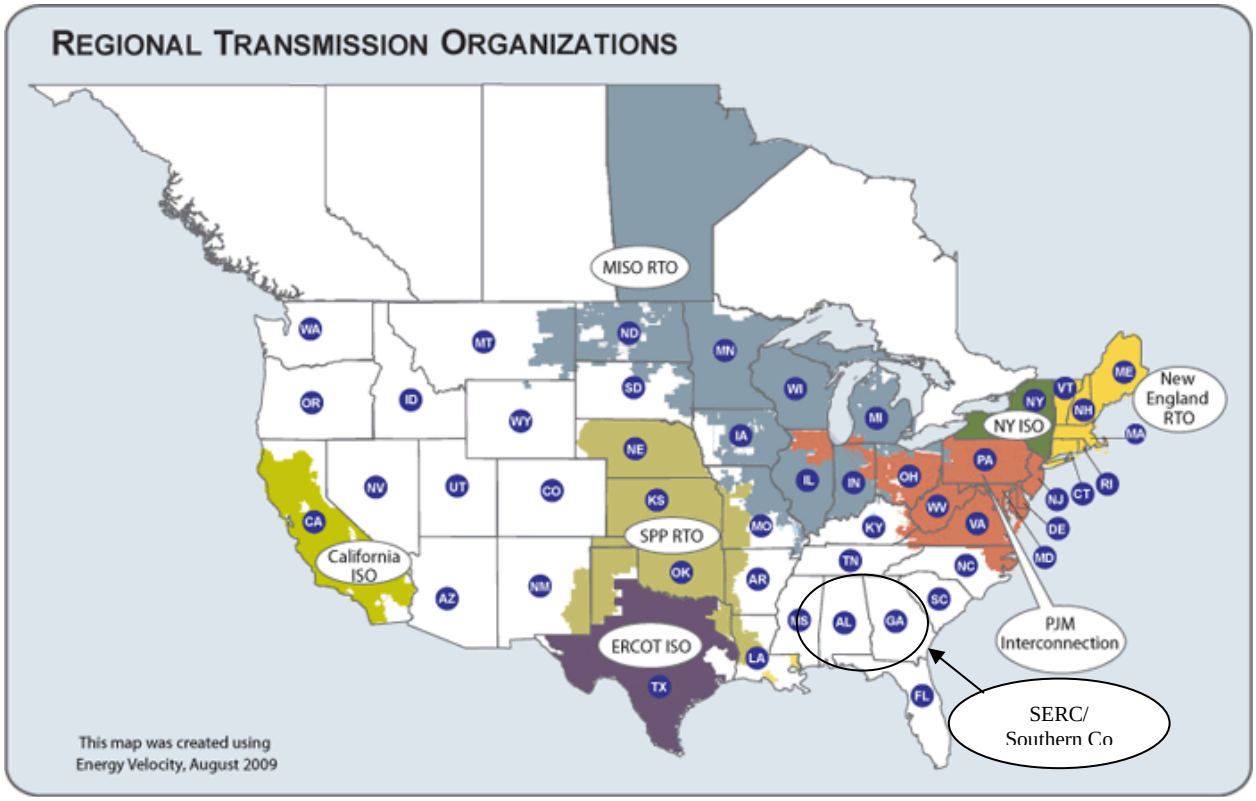

Figure 1.1: Regional Transmission Organizations (RTOs)/Independent System Operators (ISOs) in U.S. Electricity Markets[2]

The study evaluated how "packages" of electricity security assets and uses can create revenues and cost savings in electricity markets. Table 1.1 below presents the cross walk between the packages and the manner in which they can generate extra revenues or reduce costs.[3] The electricity asset and use packages analyzed were:

[2] Federal Energy Regulatory Commission, http://www.ferc.gov/industries/electric/indus-act/rto/rto-map.asp (accessed June 1, 2013).

[3] While substantial financial benefits were found, in total, from participation in electricity markets, not every revenue or cost-saving source yields meaningful benefits in every market. In some instances, the electricity market may not offer a given financial product to market participants or will have size or other restrictions that preclude a given military installation's participation in a market. In other instances, the current financial returns from participating in a market may be meager for a given type of electricity asset and not merit any detailed review.

Package 1: Current Assets & Uses at the Installation (Status Quo)

Package 2: Current Assets with Optimized Uses

Package 3: Package 2 + Additional Advanced On-Site Generation (Conventional and Renewable) and Advanced Energy Management Control Systems

Package 4: Package 3 + Battery Storage and Electric Vehicle-to-Grid

Package 5: Package 4 + Microgrid

Table 1.1: Matrix of Electricity Security Assets and Potential Revenue Sources

Potential Sources of Revenues and Cost Savings	Electricity Security Assets				
	Advanced On-Site Generation	Advanced Energy Management Control Systems	Electricity (Battery) Storage	Electric Vehicle-to-Grid	Microgrid
Reduced Overall Electricity (kWh) Consumption	X	X			
Reduced Demand (kW) and Energy (kWh) Charges, Including Time-of-Use Energy Charges	X	X	X	X	X
Power Factor Improvement	X				X
Emergency Demand Response (Capacity Market)	X	X	X	X	X
Other Capacity Sales	X		X	X	
Frequency Regulation	X		X	X	X
Spinning/Synchronous Reserve	X				X
Blackstart Capacity	X		X		X
Carbon Emission Offsets & Other Environmental Credits	X	X	X	X	X

In order to calculate the specific revenues and cost savings that could be achieved, a detailed financial model was built for each case study installation. In the model, baseline electricity generation and consumption profiles of each installation were established on an hourly basis from historic norms, and decision rules determined how the installation's electricity asset uses would change due to electricity market prices (e.g., for energy and ancillary services) occurring during that hour.

The alignment of hourly electricity demand, asset performance, and market prices is particularly important, as it allows prediction of how the military installation can perform against opportunities that arise over the course of a year and the effects of that participation on the

installation's normal utility bills. The electricity assets and uses modeled are generally inter-dependent, so actions taken in response to market price signals could have a series of effects on revenues, operating costs, and the installation's overall electricity demand at that time. The financial model produces, for each package of assets and uses, annual revenues and costs as well as differences in the installations' electricity consumption for each hour. Hourly data are summed across every hour of the year to arrive at the annual results presented in this report. The basic structure of the financial model is illustrated in Figure 1.2 below.

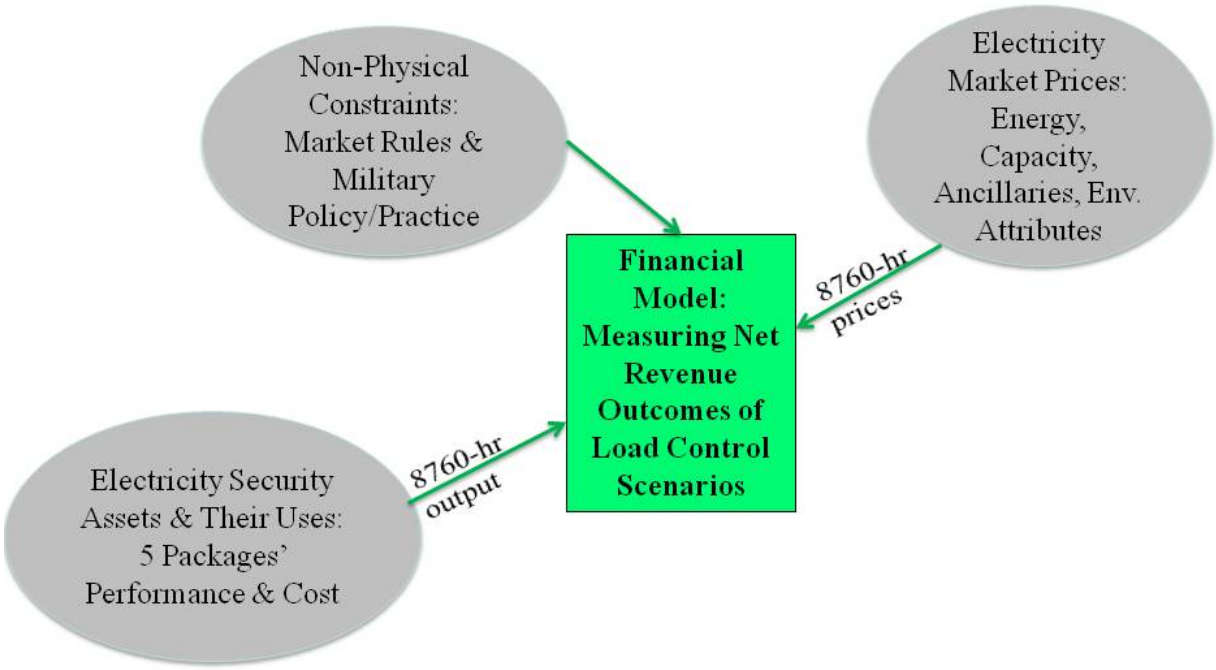

Figure 1.2: Overview of Financial Model for Calculating Revenues and Costs

Six annual financial metrics were provided for each installation as displayed in Table 1.2 below.

Table 1.2: Revenue Metrics and Market Price Scenarios Applied

Revenue Metric	High-Price Scenario	Low-Price Scenario
Gross Revenues	**X**	**X**
Net Operating Revenues	**X**	**X**
Net Revenues after Operating and Capital Costs	**X**	**X**

While all three revenue metrics are furnished in the study for reference, in practice the appropriate metric should be determined by the asset investment or use decision at hand. If an installation has already purchased assets and is operating them for other purposes (e.g., energy security) in a manner that can create new revenues, then "gross revenues" may be the best benchmark. If the assets have already been acquired, but would need to be operated incrementally to achieve revenues, then "net operating revenues" would likely be the right benchmark. Finally, if the assets have not yet been acquired, "net revenues after operating and capital costs" would properly deduct all direct costs from revenues.[4]

Applying different market price scenarios gives a better sense of financial outcomes than simply using a single reference price year. In this study, there were dramatically different results (up to 50% variation) between the high- and low-price scenarios. An example of the sharp differences between average real-time energy prices in high-price and low-price years is displayed in Figure 1.3 below, which is applicable to Dover AFB's regional electric market.

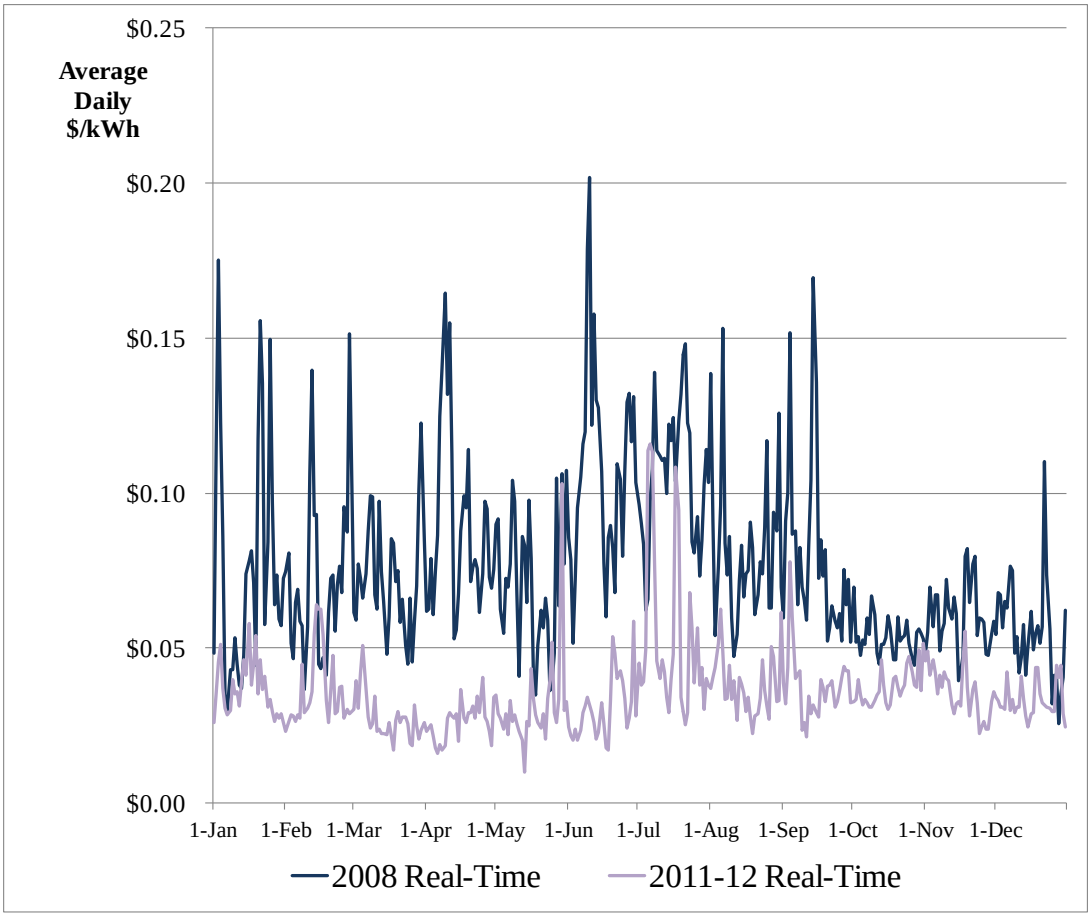

Figure 1.3: PJM Delmarva Zone Energy Prices from 2008 and 2011-12, Demonstrating Sharp Divergence between High and Low Price Years[5]

[4] "Net operating revenues" equal gross revenues minus (fixed and variable) operating costs. "Net revenues after operating and capital costs" equal net operating revenues minus annualized capital costs.
[5] Energy pricing data can be downloaded from the PJM website, http://www.pjm.com.

Figure 1.4 below illustrates the sharp volatility in electricity markets. This Figure contains the maximum and minimum hourly real-time energy prices for a delivery node adjacent to MCAGCC 29 Palms. Prices exceeded extremely high levels of $1/kWh ($1,000/MWh) at certain times, while being negative at other times.

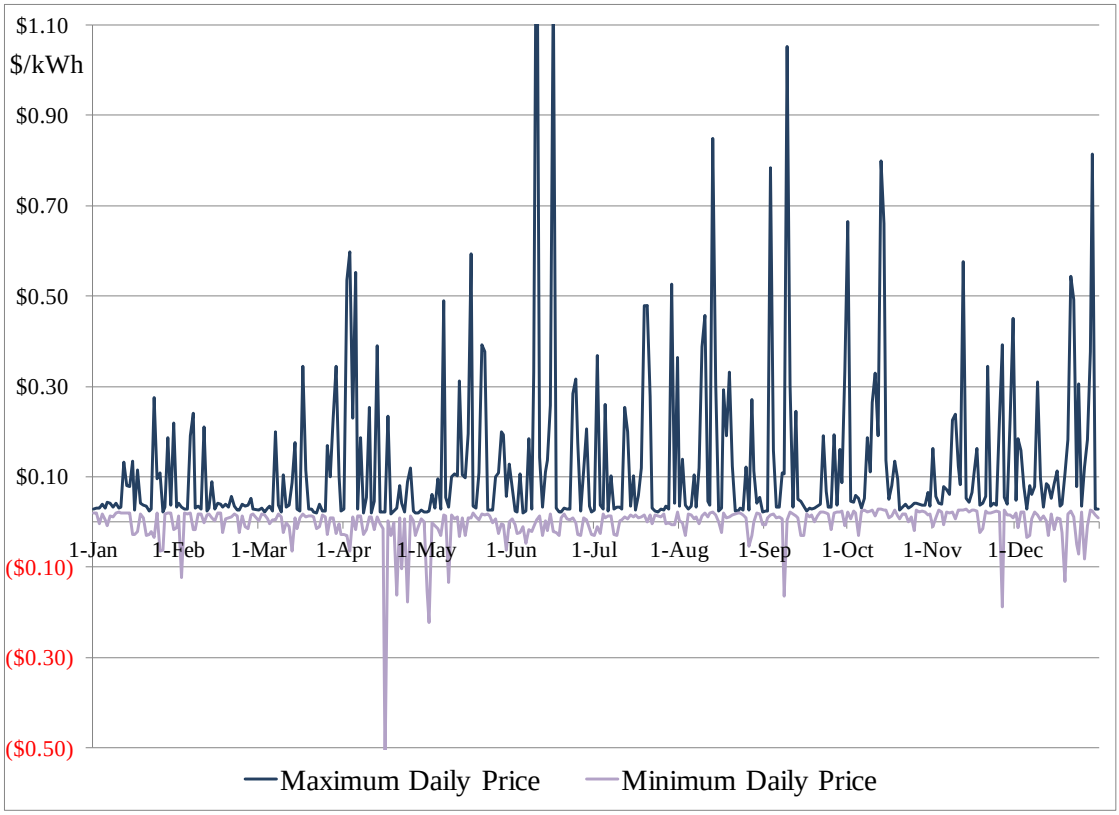

Figure 1.4: Daily Maximum and Minimum Hourly Real-Time Energy Prices for 2012 from CAISO HiDesert Node near MCAGCC 29 Palms[6]

The full methodology for this study is portrayed in Figure 1.5 below. This methodology could be extended without modification to review installations in additional electricity markets beyond the three markets included in this study.

[6] Pricing data for HiDesert_2_NO18 node can be downloaded from CAISO's Open Access Same-Time Information System (OASIS) at: http://oasis.caiso.com/mrioasis/logon.do.

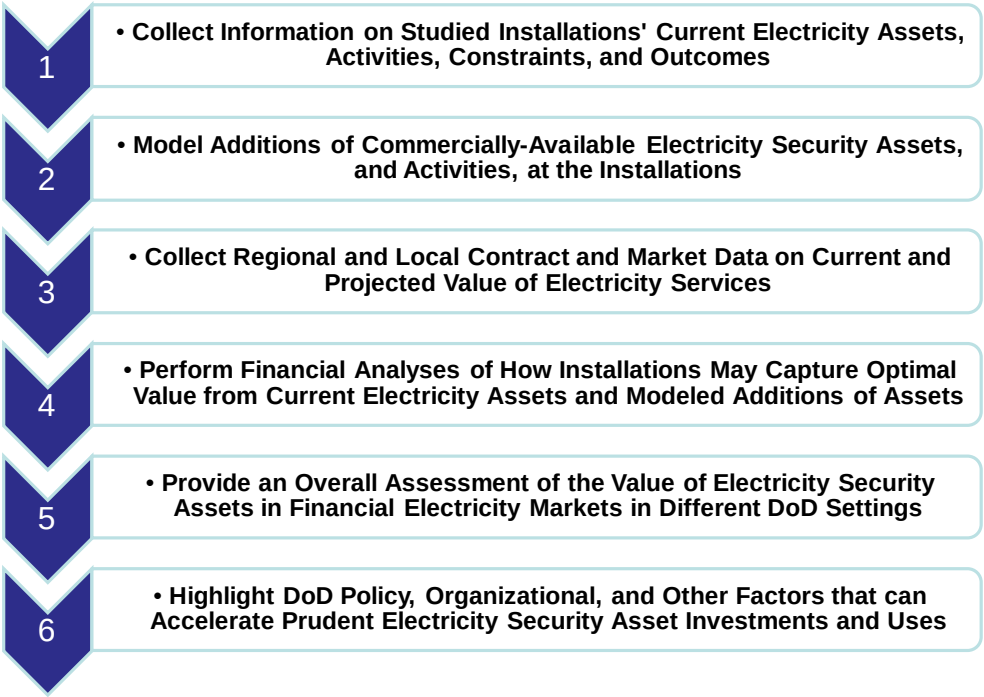

Figure 1.5: Overview of Analytic Methodology of Study

1.4 Case Studies of Dover AFB, Ft. Benning, and MCAGCC 29 Palms

The net operating revenue results for the case study installations are summarized in Figures 1.6 and 1.7 for high-price and low-price scenarios. These net operating revenues are in comparison to annual external electricity supply cost baselines of $7 million for Dover AFB, $23 million for Ft. Benning, and $3 million for MCAGCC 29 Palms.

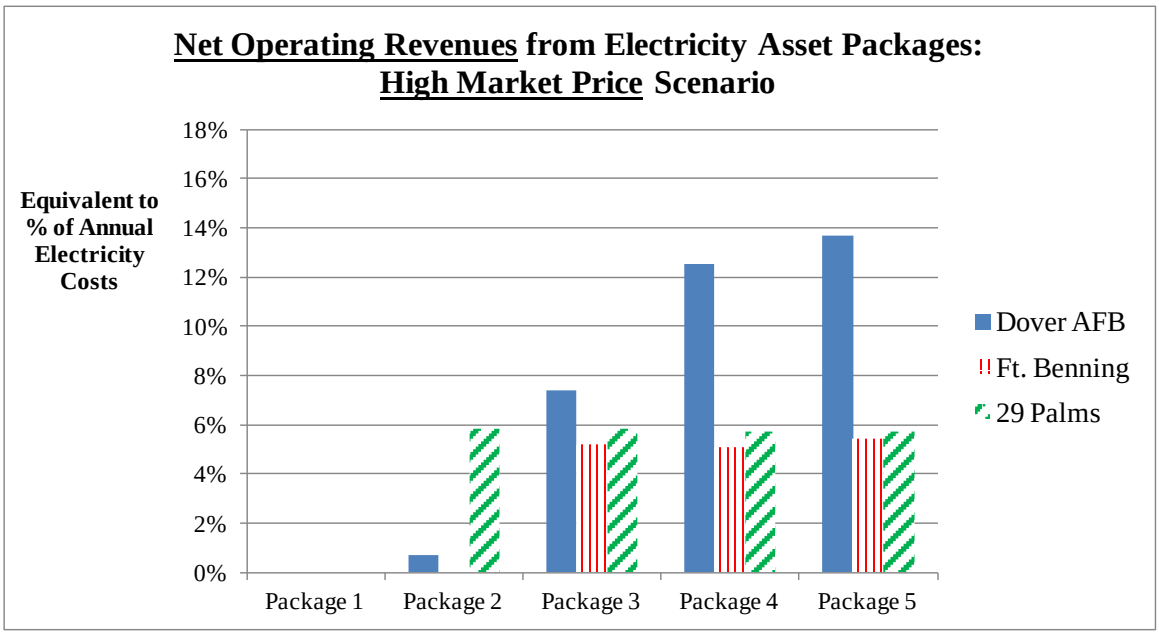

Figure 1.6: Net Operating Revenues in High-Price Scenario for three Case Study Installations

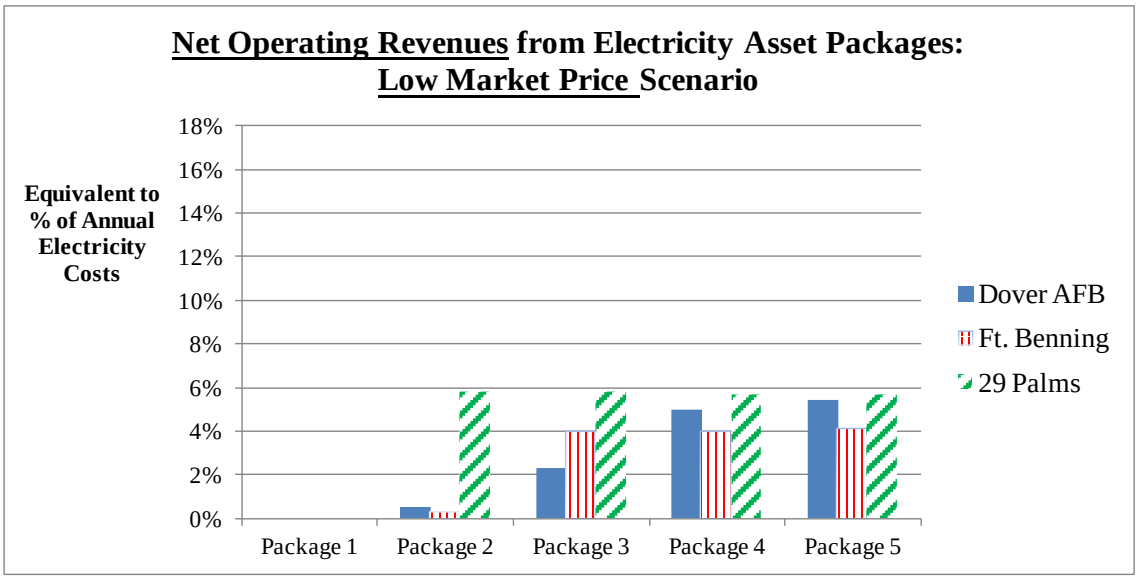

Figure 1.7: Net Operating Revenues in Low-Price Scenario for three Case Study Installations

This financial modeling indicated that all of the installations could receive incremental net benefits (net operating revenues) equal to 5% to 14% of their annual external[7] electricity costs.[8] Those benefits rise as progressive packages of electricity security assets are added, except in the case of MCAGCC 29 Palms. That base is an exception, within the study and the broader DoD, because it may have all of the modeled asset types other than electric vehicle-to-grid in operation, at meaningful scale, by the time of publication of this study.

For Dover AFB and Ft. Benning, the greatest increase in financial benefits occurs when package 3 is added. That package includes an advanced energy management control system (EMCS) and advanced on-site generation, such as solar PV and modern diesel generators environmentally permitted to be dispatched into markets. The reason that package 3 yields these outsized benefits is that it would allow the installations to participate in volatile hourly energy markets in PJM and

[7] Each installation's "external" electricity costs are the baseline used in this study for consistency. "External" electricity refers to power generated and purchased from outside the installation, as distinguished from internally-generated, on-site power. For Dover AFB and Ft. Benning, virtually all power consumed on-installation is acquired externally from their local utilities. For MCAGCC 29 Palms, in contrast, only about 10% of its electricity consumption is expected to come from external sources each year, with the balance produced by the on-site conventional and renewable generation assets listed in Table 1.3 below. Through its prior investments in these on-site generation assets, an energy management control system, battery storage, and a microgrid, the study estimates that MCAGCC 29 Palms achieves at least $5.6 million in annual net operating revenues before considering the enhanced assets and uses analyzed in this study.

[8] In this Executive Summary, net operating revenue results have been emphasized because that metric may be most relevant to DoD decision-making. That is because net operating revenues not only allow for a non-market based mission protection value to be added to this study's purely market-based calculations, but also include operating costs. The financial results for all three revenue metrics for each combination of installation, asset and use package, and price scenario are detailed in the full study.

Georgia Power[9], respectively, and, in the case of Dover AFB, permits increased electricity capacity to be enrolled in emergency demand response programs. Advanced EMCS and on-site generation facilitate the type of rapid and centralized control of integrated electric loads and assets that is essential to realizing fuller value from electricity markets. Key facts about the electricity assets and uses of the three case study installations are summarized in Table 1.3 below.

Table 1.3: Key Electricity Facts from Case Study Installations

Electricity Measure	Dover AFB (DE)	Ft. Benning (GA)	MCAGCC 29 Palms (CA)
Peak Electricity Demand (kW)	**13,000**	**76,500**	**33,000 (total); 20,000 (externally-supplied)**
Regional Electricity Market	**PJM**	**SERC/Southern Co.**	**CAISO**
Electricity Supplier	**City of Dover Utility**	**Georgia Power Utility**	**Western Area Power Administration for Generation; Southern California Edison Utility for Distribution**
On-Site Conventional Generation	**Building-specific back-up gensets**	**Building-specific back-up gensets**	**Three large cogeneration (7,200 kW, 4,500 kW, & 4,500 kW) units, 300 kW fuel cell, building-specific back-up gensets**
On-Site Renewable Generation	**No large systems**	**No large systems (Army EITF may pursue alternative energy projects at installation)**	**Over 20 solar PV systems totalling 5,644 kW AC**
Other Electricity Assets	**Building Management System (BMS), 17 ice storage systems**	**Various BMSs, new utility line**	**480 kWhr battery, BMSs, advanced EMCS, microgrid, upgraded utility distribution line and substation**
Current Demand Response (DR) Program Participation	**Emergency DR in PJM and Delaware Municipal Electric programs**	**Not eligible for utility program**	**Voluntary utility program**
Ancillary Service Markets	**PJM is among the most active markets for end-user participation**	**None available**	**CAISO has options, but extremely little participation by end-users**

[9] Ft. Benning is served by Georgia Power under a hybrid rate structure, with a historical baseline establishing certain charges, and electricity consumption above and below that baseline being determined by hourly market costs on the utility's system.

The table above indicates that Dover AFB and Ft. Benning can add many different types of electricity security assets and increase the integration of their assets if they acquire funding and wish to emphasize this type of mission protection.

The case studies could not have been completed without the strong support that all three installations provided. They provided the qualitative and quantitative data necessary for the study's detailed financial modeling and engaged their local utilities to provide additional information. The study authors are very appreciative of the Service-level endorsements and work of the installations and local utilities in bolstering this study.

1.5 DoD-Level Assessment of the Financial Benefits of Electricity Security Assets

Across DoD installations, the implementation of electricity security assets and uses has the potential to provide net operating revenues of almost 5% of annual electricity costs, or $132 million in total.[10] The level of potential revenues will vary from installation-to-installation, due chiefly to an installation's regional electricity market and its individual electricity rate structures, but also due to the nature of its critical loads and on-site assets. However, in most cases there should be meaningful levels (> 5% of annual costs) of extra revenue potential from enhanced use of current assets and the introduction of advanced assets.

The DoD-wide revenue estimate was based upon the net operating revenues found for the most advanced electricity asset and use package[11] at the three case study installations summarized in Table 1.4 below. The financial benefits are displayed as a percentage of total installation costs for external electricity supply.

[10] This total is obtained by multiplying the average net operating revenue results from asset & use package 5 across the three case study installations (4.8% savings) under the (conservative) low-price scenario by annual DoD installation electricity costs. DoD annual installation electricity costs were taken as $2.75 Billion based upon usage data of 30,511,238 MWh and an average per unit electricity cost of $90/MWh ($.09/kWh). For DoD electricity use and cost data, see Office of the Deputy Undersecretary of Defense (Installations & Environment), U.S. Department of Defense, *Annual Energy Management Report, Fiscal Year 2011*, published September 2012, page D-1, http://www.acq.osd.mil/ie/energy/library/FY.2011.AEMR.PDF (accessed November 25, 2012) and *Annual Energy Management Report, Fiscal Year 2009*, published May 2010, page C-3, http://www.acq.osd.mil/ie/energy/library/aemr_fy_09_may_2010.pdf (accessed June 5, 2013), respectively. This DoD electricity cost figure is consistent with a presentation from the Deputy Undersecretary of Defense (Installations & Environment). See Robyn, Dorothy, *DoD, Energy Security and Technological Innovation*, June 2012, page 4, http://www1.eere.energy.gov/solar/pdfs/sssummit2012_plenary_robyn.pdf (accessed June 7, 2013).

[11] Package 5 includes all current electricity assets at the installation plus, where gaps exist, modeled additions of an advanced energy management control system, advanced conventional on-site generation, on-site renewable energy generation, battery storage, electric vehicle-to-grid capability, and a microgrid.

Table 1.4: Revenues for Electricity Asset & Use Package 5 under Two Market Price Scenarios: Results Expressed as a % of Total Annual Electricity Costs				
Revenue Measure	**Market Price Scenario**	**Dover AFB (DE): ~$7 MM annual electricity budget**	**Ft. Benning (GA): ~$23 MM annual electricity budget**	**MCAGCC 29 Palms (CA): ~$3 MM annual external electricity budget**
Gross Revenues	**High**	**16.9%**	**6.9%**	**5.3%**
	Low	**8.0%**	**6.1%**	**5.3%**
Net Operating Revenues	**High**	**13.7%**	**5.4%**	**5.0%**
	Low	**5.4%**	**4.1%**	**5.0%**
Net Revenues after Operating and Capital Costs	**High**	**5.7%**	**-0.4%**	**3.3%**
	Low	**-3.0%**	**-2.4%**	**3.4%**

From region-to-region, the practical availability of energy market participation options for end-users like military installation varies widely. While similar types of programs (economic demand response, emergency demand response, ancillary services such as frequency regulation and spinning reserves) often exist across regional markets, the specific market rules and rewards of participation (unit prices) lead to far different levels of program uptake as portrayed in Figure 1.8 below.

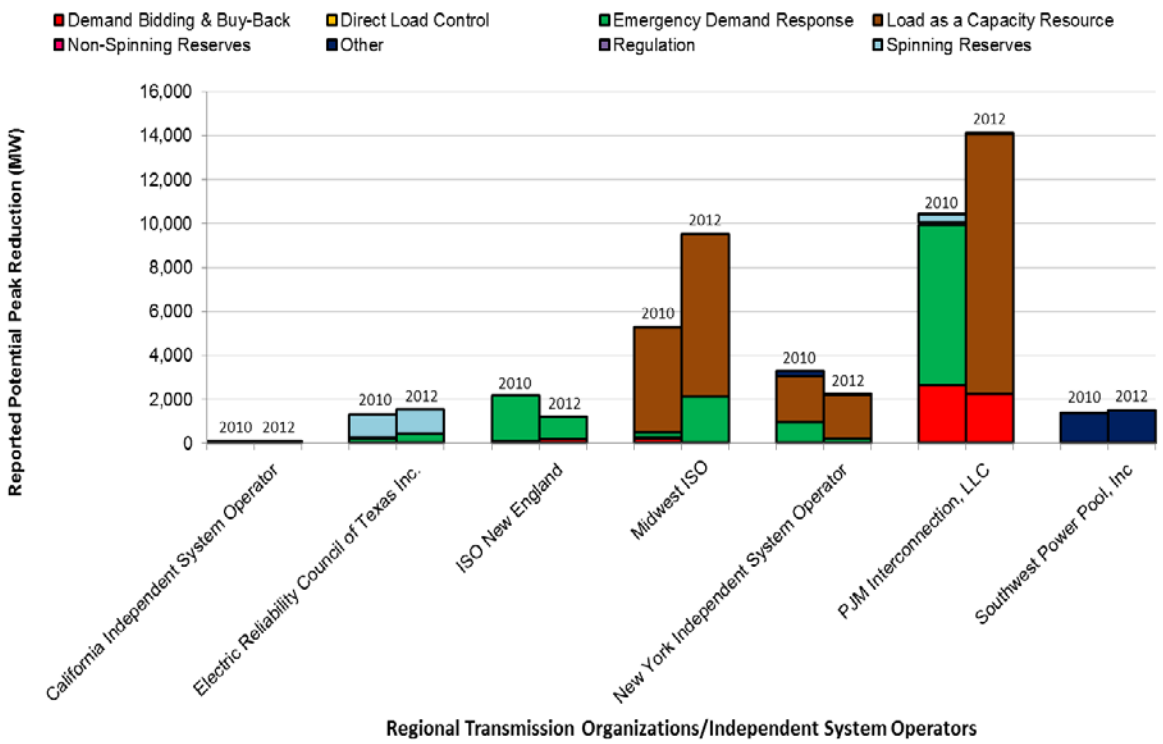

Figure 1.8: Peak Load Reduction Potential within Regional Electricity Markets[12]

Even if one accounted for the differences in the overall size of the RTOs/ISOs (e.g., 180,000 MW for PJM; 57,000 MW for CAISO; and 31,000 MW for ISO-New England)[13] listed in Figure 1.8, the difference in participation between regional markets is stark. Relative to their sizes, market participation is lowest in CAISO, Electricity Reliability Council of Texas (ERCOT), and Southwest Power Pool, as well as in SERC which is not an RTO or ISO and, therefore, not contained in the bar chart.

Beyond regional differences, there are electricity product-specific implications for DoD. Time-of-use (TOU) energy market availability, whether through regulated utility rates, competitive generation options, or economic demand response (DR) programs, is the largest driver of potential revenues from electricity security assets. This is because "energy" is generally the largest component of electricity bills, and its pricing can be volatile from period-to-period or

[12] Federal Energy Regulatory Commission, *Assessment of Demand Response & Advanced Metering Staff Report*, December 2012, page 25, http://www.ferc.gov/legal/staff-reports/12-20-12-demand-response.pdf (accessed April 11, 2013). CAISO, though, does have active utility-sponsored market participation programs that make up part of CAISO's participation deficit compared to other regions.

[13] See Bryson, Mike (Executive Director, System Operations) and Chantal Hendrzak (Director, Applied Solutions), PJM, *Welcome to Philadelphia*, slide 4, http://emmos.org/prevconf/2011/1_PJM%20Keynote_Chantal%20Hendrzak.pdf (accessed November 24, 2012); California ISO, *Company Information and Facts*, http://www.caiso.com/Documents/CompanyInformation_Facts.pdf (accessed April 10, 2013); and Giaimo, Michael (ISO New England) and William Ferdinand (Eaton Peabody), *ISO New England Overview*, slide 3, http://www.iso-ne.com/pubs/pubcomm/pres_spchs/2011/final_maine_jan20_11_post.pdf (accessed June 5, 2013).

hour-to-hour. Federal Energy Regulatory Commission (FERC) Order 745[14] has improved the revenue availability from economic DR for military installations and other energy consumers.

In addition, emergency DR programs that make capacity-based payments to installations can be material sources of revenue if significant DR capacity is enrolled in the programs. Electricity security assets such as advanced EMCSs and upgraded and re-permitted conventional generation can enable greater enrollment volumes and far greater ease of load management than many installations currently experience. Ancillary service revenues, while tangible in certain markets (e.g., PJM), are most-readily captured with the advent of FERC Order 755[15] by fast-response assets like batteries and do not currently offer the revenue potential of energy and emergency DR markets. Environmental market revenues are generally only meaningful for solar PV in states with compliance solar renewable energy credit (SREC) requirements.[16]

What this means for DoD is that investments in electricity security assets can be partially defrayed, or even completely paid for in some instances, by net revenues from electricity market participation. The potential revenues that can be achieved can vary greatly from installation-to-installation, but appear to be meaningful on a net operating revenue basis for at least most sizable military installations in the U.S., regardless of their region, Service, or current electricity asset or demand configuration. The highest net operating revenues are likely to be achieved in markets with TOU pricing, economic DR availability, and/or emergency DR availability if installations have responsive assets such as EMCS and conventional generation and in compliance SREC states for solar PV generation. When capital costs are included in the analysis, in addition to operating costs, electricity security investments can vary from being net positive to net negative financially depending on the military installation and whether the investment is measured against a high or low price scenario.

1.6 Non-Financial Implications for Physical Security, Cybersecurity, and the Environment

The introduction and use of electricity security assets on military installations can have important implications beyond the financial ones that are the primary focus of this report and their contributions to energy security. From a **physical security** perspective, the advanced assets have less risk of catastrophic breakage or explosion than DoD's existing paradigm of isolated back-up generators for every individual building containing critical loads. However, maintaining

[14] Essentially, where it has been implemented, FERC Order 745 allows end-users curtailing their load to receive the full hourly energy price for their locations, whereas previously they only received that hourly price minus their generation and transmission costs. For a discussion of the implementation of FERC Order 745, see Viridity Energy White Paper, *FERC 745 – More Money for Smart Energy User*, http://viridityenergy.com/wp-content/uploads/2012/02/White-Paper-FERC-745.pdf (accessed December 1, 2012).

[15] Under FERC Order 755 as implemented in PJM, for example, PJM will pay an asset owner not only for its capability to provide frequency regulation service during a given period, but also for its performance – reflecting the speed and accuracy with which it follows the PJM regulation signal. For reference, see Viridity Energy, *PJM Performance-Based Regulation Implemented as of October 1, 2012*, http://viridityenergy.com/news/performance-based-regulation-update/ (accessed December 1, 2012).

[16] These states include Massachusetts, New Jersey, Delaware, Maryland, Pennsylvania, and Ohio, as well as the District of Columbia. SREC markets tend to have volatile pricing, and the prices have dropped sharply in most of these states in recent years.

physical protection of the assets (EMCS and microgrids) that control installation-wide loads is an important security challenge that must be addressed.

Because gathering information on electricity loads, controlling those loads, controlling generation and storage assets, and participating in markets can require both software and telecommunications, there are important **cybersecurity** implications of enhancing electricity assets and their uses on military installations. The asset and use packages modeled in this study were designed in conformance with the industry standards of the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), and the National Institute of Standards and Technology (NIST).[17]

In practice, there are additional DoD cybersecurity requirements that are applied when these assets are introduced to installations, but it is not within the scope of this study to summarize all cybersecurity implications associated with installation electricity infrastructure and technologies. However, it should be pointed out that when installing assets and considering how to optimize net revenues and cost savings from these assets, there are methods of participating in electricity markets that should be followed to ensure maximum cybersecurity. First, installations must avoid the external asset interaction that non-military energy consumers often utilize to participate in electricity market programs (e.g., allowing demand response providers to monitor/control on-site load management and generation assets). Second, installations must address several layers of cybersecurity threats, including how much of assets' information network is "visible" to the outside world, how interconnected systems are authenticated, and how information is compartmentalized.

Investing in electricity security assets and participating to a greater degree in electricity markets brings **environmental**, in addition to financial, benefits. Some of the assets that enhance the security of the military's electricity supply -- renewable generation and electric vehicle-to-grid charging stations equipped with solar canopies -- directly substitute zero emission, local generation for fossil-fueled central station generation that would otherwise need to be shipped across the transmission and distribution infrastructure (with losses). Other electricity security assets -- energy management control systems and microgrids -- permit installations to shed electricity loads (i.e., become more energy efficient). Beyond the emissions reductions, this increased load control by the military reduces the need for grid operators and utilities to invest in transmission and distribution infrastructure and reserve fossil-fuel generation. Finally, some advanced on-site conventional generation, such as the combined heat-and-power/cogeneration units that provide almost continuous electricity to MCAGCC 29 Palms, often have lower greenhouse gas (GHG) emissions than would be the case if the same electricity volume was provided by central station generation.

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[17] Specifically, ISO/IEC 27000.2012 outlines acceptable best practices in the implementation of Information Security Management Systems and is used widely by large utilities throughout the United States. NIST IR 7628 and related documents provide best practice guidance for security regarding strategy, architecture, and higher-level requirements for energy infrastructure. Standards from the ISO/IEC 27000 family are available for purchase from the American National Standards Institute (ANSI) at http://webstore.ansi.org (accessed March 24, 2013); and NIST volumes are available from http://csrc.nist.gov/publications/nistir/ir7628/nistir-7628_vol1.pdf, http://csrc.nist.gov/publications/nistir/ir7628/nistir-7628_vol2.pdf, and http://csrc.nist.gov/publications/nistir/ir7628/nistir-7628_vol3.pdf (accessed March 24, 2013).

While the environmental effects of advanced electricity security assets and uses are not restricted to lowering GHG emissions, reductions in these emissions are a direct way to measure the environmental effects. For example, full implementation of electricity security assets and uses (package 5) at just Dover AFB and Ft. Benning would result in annual emissions reductions exceeding 21 million pounds of CO_2. One important finding of this study is that emissions reductions are greater in the high market price scenario than the low-price scenario because high prices encourage more load shedding activity.

Alongside these positive environmental effects, there are environmental risks from certain electricity security assets that must be properly managed. In particular, battery storage assets can contain toxic chemicals that pose risk of electrolyte leakage during their useful lives and that require careful end-of-life disposal.[18]

1.7 Conclusion and Recommendations

DoD will need to be creative in how it brings in the capital and makes its investments in electricity security. Part of that creativity involves being open to the electricity market price signals that are present every day, every hour, or even every sub-second in certain locations. Electricity market revenues can help bridge the gap between today's difficult-to-manage, building-by-building energy security paradigm and tomorrow's more integrated, sustainable paradigm for protection of critical loads.

Based upon this study's analysis, the authors have nine recommendations for accelerating and replicating the deployment of high-value electricity security assets:

(1) **Explicitly Include Electricity Market Revenues, and the Appropriate Revenue Metrics, in Electricity Asset Decisions**
Due to the substantial tangible financial benefits found in this study, DoD and the Services should explicitly incorporate market revenue and cost savings potential in their decision-making about which electricity security investments to make and how to sequence these investments to reduce long-term capital costs. DoD and the Services should also identify how optimized operation of current assets can pay for future asset investments. The appropriate metric – gross revenues, net operating revenues, or net revenues after operating and capital costs – should be used depending on the asset investment or use decision at hand.

(2) **Emphasize Integrated and Centralized Control of Assets when Making Investments**
With integrated control of assets via EMCSs and microgrids, installations will be able to achieve much higher levels of volume participation in electricity market programs (e.g., economic and emergency demand response) and much greater financial benefits than in an isolated state when loads cannot be combined and must be manually turned on and off on a building-by-building basis.

[18] While materials management concerns are briefly mentioned, formal "life-cycle analysis" of electricity security technologies is not within the scope of this study.

(3) **Make Individual Electricity Asset Decisions against a Long-Term Energy Security Plan**

One of the surprising conclusions of this study is that the costs of microgrids, the end state of many energy security investment programs, can be much lower than anticipated if an installation invests intelligently in progressive development of its electricity assets before capping them off and tying them together with a microgrid. The presence of an asset development plan will assure that earlier-stage investments are of the proper scale and compatibility with later investments.

(4) **Catalog Critical Load Data**

A key step in moving towards optimizing market participation of electricity security assets, and their capital investment, is assembling data (electricity usage and demand and how they track to mission critical activities) at the installation level and doing so in a relatively uniform manner.

(5) **Organize DoD Data, Tools, and Analyses for Evaluating the Financial Benefits of Electricity Assets**

At the DoD level, it would be appropriate to organize the data, tools, and analyses from electricity market studies by RTO/ISO and utility because the market rules and price signals are established by those entities. Doing so would allow installations to quickly access available information to both determine how they might achieve revenues and cost savings by using their current assets differently and inform their future asset investment decisions.

(6) **Advocate for Market Participation Rules that Increase Financial Returns from Electricity Security Assets**

At the RTO/ISO and the electric utility levels, there are a variety of participation rules that could be expanded to allow military installations to obtain greater revenues from market participation. DoD could advocate for strong adoption of FERC Order 745 and FERC Order 755 across all major RTO/ISO markets and for a lowering of minimum size requirements for participation in ancillary service markets. At the utility level, allowing “virtual net metering” or “meter aggregation” of renewable generation within an installation with multiple electricity meters would foster and reward greater solar PV investments.

(7) **Lower Programmatic, Policy, and Training Barriers to Deploying Current Assets in Electricity Markets**

Even when looking just at current electricity assets at installations, there are a number of enhanced uses that can deliver financial benefits. To achieve these benefits, DoD can adopt standard software upgrades for its assets more quickly, look for intermediaries to accept demand response penalty risks, and improve training of installation personnel on how they can respond to market price signals.

(8) **Use Renewable Energy Investments to Attract Private Capital**

Unlike other electricity asset types, there is a clear and compelling reason (tax incentives) for private capital to be attracted to renewable generation on military

installations. Where there is a need for private capital to advance electricity security deployment, installations should consider bundling renewable projects with other complementary assets (e.g., battery storage, energy management control systems, and/or microgrids).

(9) **Develop DoD Policy Guidance on the Overall Value of Protecting Mission/Critical Loads**

DoD should continue its work in defining the value of electricity security (i.e., mission protection and resilience), beyond the fairly straightforward electricity market analysis presented in this study, so that investment decisions can be evaluated in light of their tangible (money) and intangible (security) benefits.