Slide 1 – Thank you for inviting me back to speak. So, I was looking at the presentation in Phoenix and noticed something. This topic of “energy resilience” was embedded in one of the sessions within the Integrated Energy track. Last year, it was its own track w/ a great selection of sessions. And this year, well, it looks to be a major priority within many of the tracks and sessions. It’s great to see the level of interest and priority growing.

So what is DoD ER? DoD 4170.11 codified a DoD definition, as energy resilience is the ability to prepare for and recover from energy disruptions that impact mission assurance on military installations. It also codified the term critical energy requirements, as critical mission operations on military installations or facilities that require a continuous supply of energy in the event of an energy disruption or emergency.

So, as we think about ER or resilience in general for that matter, there are common themes reflected in this definition: 1) disruption/changing conditions (the power is out) (2) plan, 3) absorb/recover, (4) adapt. And those are the underlying themes, but what’s most important that we cannot forget is that these themes align to an organization’s mission or core purpose, for DoD that means our mission assurance, readiness, and our national security objectives.

In terms of energy, what does that mean & how can energy resilience be achieved? Some examples to get you thinking (caveat: all aligned to critical energy requirements or critical energy loads):

- OM&T and reliability of existing infrastructure/systems;
- Redundancy – generators and UPS
- Diversification/flexibility – duel fuel sources, alternative distributed energy sources (inclusive of fossil and/or RE sources)
- Recovery/response – contingency/emergency response plans, and even portable generation & repair equipment/spares

These solutions must be aligned to critical missions and critical loads to ensure energy is provided when and where it’s needed during a disruption (availability).

Slide 2 – What is our office doing now?

Last year, I had discussed we were pursuing guidance and tools to support energy resilience requirement within the DoDI 4170.11 change published in March 2016. Over the course of this last year, our office issued operations, maintenance, and testing guidance – and, are presently coordinating an energy resilience strategy, planning, and metrics guidance. We also updated guidance within ERCIP to support energy resilience pursuits. In many respects, we are now flush with policy, requirements, and guidance – and are well beyond the buzzword stage.

We also completed the MIT-LL study shortly after last year’s Energy Exchange and published the report. The MIT-LL study assisted in the development of a framework to make cost-effective decisions for reliable energy resilience solutions. It demonstrated that there is not a need to develop a “premium” for energy resilience decisions – instead, that it is critical to right-size energy resilience solutions to meet mission requirements and to then fairly perform a life-cycle cost analysis across all available energy resilience solutions. I’d mention that the study’s approach was aligned to the energy requirements in DoDI 4170.11.
Further, we issued a RFI to review the potential of alternative financing for energy resilience projects. The results of the MIT-LL framework will also help inform this upcoming study and assist translating our requirements to industry. Through the upcoming alternative financing study, we will investigate the development of a financing tool to provide key DoD and financial institution stakeholders metrics for risk-informed project ratings and alternative financing decisions. I would also mention that as early as Monday, we released a draft RFQ that can be found in the previous RFI posting on FedBizOpps. And, just wanted to say thank you to Navy REPO and Air Force for volunteering to help with a lot of the leg work on the study.

So, we have been busy. Over the course of 1 year we have developed guidance, modified existing programs to include energy resilience, established a budgetary framework, & will be looking to use that framework to guide future investment decisions. The next steps are to share & transition the guidance and tools to the Services & Defense Agencies and to work collaboratively w/ them to implement energy resilience across DoD. We have began this transition over the course of the year as we begin to adopt energy resilience more widely across the DoD.

Slide 3 – What are some critical areas we continue to work on?

We continue to work on including mission-based decision-making to guide energy decisions. This is the first step in a resilience framework, and nothing can be claimed as an energy resilience solution without this critical step to ensure mission assurance and readiness. This means we must use mission requirements as the lens to evaluate energy resilience options in a technology-agnostic and capability-focused approach. We must become familiar with terms such as Global ISR, force projection, ICBM detection, life, health, and safety operations, among many other critical missions. We will need to also identify the mission dependencies, mission requirements, and the supporting infrastructure interdependencies that align to missions critical to our national security.

This type of “mapping” started back during our Power Resilience in 2014, and we continue to apply this type of mission-based decision-making in more detail through our work with MIT-LL. This type of mapping is important for many reasons, for example:

- It helps us identify our critical energy requirements and critical energy loads for our military installations (our priorities)
- It helps us answer important questions such as:
  - Are we currently accomplishing energy resilience in the most cost-effective, reliable, and secure way possible? (could be yes)
  - What are the most optimal energy resilience solutions?
  - Is an energy infrastructure solution needed, or do I need a mission/capability based solution?
- Finally, it allows us to build a more comprehensive and strategic framework that extends beyond traditional singular “building-by-building” or “generator-by-generator” prioritization.
  - What other solutions can help me achieve energy resilience affordably?

This is an important area where we have been working with our mission assurance counterparts, and mission & installation personnel will need to continue to collaborate.
Slide 4 – Finally, I would like to quickly discuss what the art of possible is and some observations over the years. Every point here is premised that you have gone through a mission decomposition, identified your critical loads, and they are also aligned to a state of disruption.

Right now:

- Prioritize and right-size your critical energy loads ruthlessly, and identify the level of resilience required at those critical loads (availability metrics)
- Have an OM&T plan in place to ensure systems will operate to sustain critical energy loads (e.g., generators, UPS, etc.)
- Upgrade, maintain, and track reliability of distribution system before siting new generation systems at critical loads (outages will continue)

Future:

- Cost-effective consolidated/distributed generation exist if prioritization, right-sizing, OM&T, and reliability have been accomplished at critical loads
- Spot generators and UPS can still be applied for facilities that require them to meet unique mission requirements
- RE (solar) seems to work well in certain regions (location-specific) and can assist in driving down costs in utility bill
- Batteries are not cost-competitive with fuel solutions for longer-term outages, and encounter technical/economic/security constraints
- UPS, however, works well for short-term interruptions and unique mission requirements
- Flexible (dual-fuel) and mobile generation can assist to lower vulnerabilities (surface area of attack)

A technology first approach may lead you to validate large-scale solutions that are oversized, cost more, and increase vulnerabilities and security-related risks – However, using mission requirements as the lens to evaluate options will provide the most cost-effective options to protect DoD’s national security interests.

Slide 5 – Transition Slide

Slide 6 – The study helped us develop a business case analysis framework, and quantified both costs & availability across over 40 potential ER options. The study was aligned to existing DoD policies and requirements for life-cycle cost analysis, which are listed on the slide. It was a mission-first, technology-agnostic approach that established a baseline for ER on a military installation (typically generators) and conducted an analysis of alternatives (AoA) to that baseline. The solutions were aligned to critical mission operations and critical energy loads for 4 military installations to demonstrate the framework, and the results were provided to the Military Services for further incorporation and adoption. The Military Services continue to consider and expand on the study results at this time. Since the purpose of the study was to develop a framework, inputs can be customized/catered for the unique site-level constraints of military installations. The outcome is an executable project based on regional, economic, or mission constraints for a military installation.
What are advantages of the framework?

- Allows for fair assessment and trade-offs between costs and risks across multiple technology options without a bias.
- Highlights the potential of more cost-effective & reliable options for ER, and that premiums are not necessary.
- Helps establish a process/lessons learned to define and collaborate on hard issues (e.g., What is critical? How much risk can I tolerate?).
- Allowed for targeted discussions and collaborations across multiple stakeholder groups (principally installation and mission community).
- Provides a justification for budgetary/alternative financing decisions that directly promote national security (everything aligns to critical missions).
- Can be used as a crosscheck for industry or vendor proposals.

**Slide 7** – The considerations of the analysis methodology are listed on this slide. The slide shows a simplified overview of component devices that were modeled (e.g., generators, centralized generators, solar, batteries, fuel cells, etc.). We also captured reliability figures of the component devices, and regional resource availability metrics such as wind speed and solar radiation.

The component devices were into potential energy resilience configurations or options, and then right-sized according to the critical load established for the military installation. A 1,000 trial Monte Carlo simulation optimized both technical and economic metrics to generate a recommended energy resilience for the military installation.

**Slide 8** – Ultimately, the MIT-LL study resulted in a trade-space to make risk-informed decisions that balance mission requirements and life-cycle costs. The solutions on the x-axis were all sized to the critical loads of the military installation. The mission attribute on the bottom chart is expressed in unserved energy – the amount of energy which is not serviced throughout the year and that leads to downtime to the mission. The less unserved energy, the more resilient the solution since it minimizes disruption to missions identified by the critical load. The dotted line represents the baseline unserved energy for the military base in question. Ideally, you want to identify the mission requirement that you build or design to prior to pursuing the technology option.

The chart on the top represents life cycle costs for each of the energy resilience solutions. The higher cost solutions result in advanced/large scale microgrids, potentially larger-scale distribution upgrades, battery integration, and/or fuel cells. The lower cost solutions are to the right of the existing solution, and are typically generators, targeted/centralized generators and/or microgrids, solar (can be placed near the point of use which limits larger infrastructure costs and vulnerabilities).

The value streams that help to identify these lower cost solution are:

- Right-sizing to the mission requirements (not oversizing solutions – load analysis);
- Reducing capital, operations, maintenance, and testing costs (centralizing generation);
- Reduce repair times/improve reliability (prioritized/focused OM&T);
- Utility bill savings (PPA for solar); and,
- Financial incentives (need to exist and cannot disrupt mission).
These are value streams that can be applied directly to existing LCCA, and align to existing policy and guidance requirements today. There is no need to layer additional intangible benefits to address mission requirements cost-effectively.

Slide 9 – So, I have been asked a number of times “What about longer-term outages?” We also have the ability to go further, but there does come a point when funding decisions need to be made, and risks require acceptance. After 2 weeks, there also is a question of just how much are you willing to invest given existing funding constraints and the fact that scenarios beyond this range may put your new, resilient infrastructure locally at risk. Moving the mission may be the most resilient and cost-effective option, or have a capability to perform the mission by different means. Lastly, we invest for about 1-3 days of outages locally with fuel reserves, so 14 days would be quite a great leap forward from historical terms (and likely still difficult to make funding justifications).

The results are really interesting here, however. We have made some claims that don’t seem to hold true based on the results.

- Overall outcomes are the same/stable (high cost are still high cost, and low cost are still low cost)
- Fuel – it’s still a requirement in the RE + battery solutions (we attempted greater sizing profiles, but the economics pushed 40, 25, 10 further left).
- Additionally, we often hear that these advanced technologies w/ battery integration will give you the additional benefit of the cost avoidance of fuel. This doesn’t seem entirely true based on these results, but there is an interesting reverse argument. Let’s say I like architecture 24 or 9, couldn’t I now say I avoid the capital costs associated with batteries during this 14 day outage? And, wouldn’t that then make 24 or 9 essentially free? I call this “gaming” the analysis – where we take the technology we like, and layer avoided costs of other technologies. The analysis here helps avoid those unfair comparisons.
- Really important, layering any generalized non-direct benefit that occurs during a “disruption” scenario does not materially matter in the overall outcomes. Since these are all resilience solutions, they all would receive any artificial “premium” that you would want to apply. Premium discussions have unfortunately developed into a means to justify specific/isolated technologies, they aren’t necessary to substantiate mission requirements cost-effectively.

To meet mission requirements cost-effectively, DoD should simply clearly define its mission requirements and apply sound life cycle cost analysis to make fair comparisons across various energy resilience solutions.

Slide 10 – The interesting thing here is that these were part of the policy update & further reinforced by the study. You can read through these, but I wanted to just pick a couple from cost/performance data since it’s most applicable to this session:

We need to do a better job capturing information we should already have. For example, to make an energy resilience budgetary justification we’ll need to capture LCCA data such as operations, maintenance, and testing costs associated w/ our current energy systems. Other LCCA data that’s important includes utility costs, rate schedules, and financial incentive programs in your region.
Further it’s important to track and record performance data, specifically outage data, repair rates, and information that leads to cost incurred out of O&M budgets. This type of performance data can also be used to establish mission performance metrics to help define mission requirements.

**Slide 11** – Transition Slide

**Slide 12** – The MIT-LL tool was developed in MATLAB, we spent some time also developing a user-interface tool for easier access. Not everyone is familiar with MATLAB, so we also develop an input tool for users. We are now investigating different ways to get the tool into the hands of a wider audience. The interface tool allows for the user to input the necessary metrics needed to come up energy resilience recommendations. The data/information is then imported into MATLAB which would conceptually run in the background, so the user does not have to be familiar with it – and, ideally, the output would be the results that I just discussed.

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**Slide 14** – Backup Answers:

- Do batteries offset vulnerabilities to my mission? Not necessarily, you have to think in terms of resilience and risk tradeoffs when considering batteries versus fuel. You do have to store a large number of batteries with a much greater surface area of attack to carry a critical load, pushing the batteries away from the critical load site, and increasing costs/risks. If a battery fails, the back-up plan is fuel. Fuel can be stored or distributed, which is an advantage in disruption and emergency scenarios. There is also a greater cost to paying for the same energy density levels of batteries versus fuel that you will need to consider.
- I’d ask that you think about delivering batteries at the scale of fuel during Hurricane Sandy, for example, or other longer-term duration outages with their respective scenario in mind. And, imagine how long it would have taken to recover critical functions without mobile generators and fuel. Remember, that was a large-scale disruption scenario, and we should learn that larger-scale / fixed solutions tied to large-scale distribution networks did not do well during that scenario. Localized, prioritized, and even flexible energy resources performed much better that were near the point of use, could be deployed, or were at alternative sites (mission alternative risk remediation versus infrastructure risk remediation).