


Department of Defense Installation Energy

OSD Energy Resilience Overview

Energy Planning for Resilient Military Installations

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OASD (Energy, Installations & Environment)

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DoD Energy Resilience (ER)

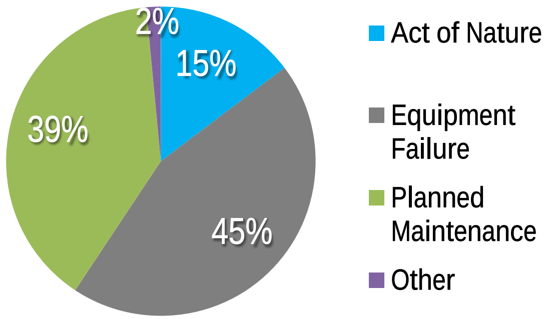
❑ Policy Drivers

- Multiple requirements through FY2017/2018 NDAA;
- DoD Instruction 4170.11(updated 16 Mar 2016), Installation Energy Management, Energy Resilience
- Title 10, Section 2925(a);
- ASD(EI&E) Memorandum on Power Resilience;
- Unified Facilities Criteria (such as Electrical Series).

❑ DoD Policy Initiatives

- ✓ DoDI 4170.11 change on energy resilience (complete)
  - ✓ Ensures performance against existing requirements
  - ✓ Encourages cost-effective solutions to improve mission assurance
- Implementing guidance
  - ✓ Operations, maintenance, and testing (OM&T) (complete)
  - ✓ Energy Resilience and Conservation Investment Program (ERCIP) (complete)
  - ✓ Energy resilience, mission integration, metrics (in-progress)
- Budgetary execution
  - ✓ Business case analyses (BCA) framework (MIT-LL) to prioritize budget resources or alternative financing projects for energy resilience (complete)
  - ✓ Rating alternative financing projects to accelerate adoption of energy resilience projects – Defense Energy Resilience Bank (DERB) (in-progress)

FY 2016 Utility Outages



- *Utility disruption data is required under Title 10, 2925(a)*
- *Disruption data informs on-going metrics guidance*

Details on OASD(EI&E) Energy Resilience Initiatives:
http://www.acq.osd.mil/eie/IE/FEP_Energy_Resilience.html

DoD energy resilience is the ability to prepare for and recover from energy disruptions that impact mission assurance on military installations.

Energy Resilience Overview
Inclusion of Mission-Based Decision-Making

Critical Mission Operations (Sample - For Training Purposes Only)			
Global Intelligence, Surveillance, and Reconnaissance (ISR)	Power/Force Projection – Mobilizing, Deploying, and Demobilizing	Strategic Command Communication - Command and Control	Life, Health, and Safety Operations

- ❑ Step 1 – Criticality of mission and supporting functions
  - ➢ Services and Defense Agency provided during PR review in 2014
  - ➢ Validated through MIT-LL was the need for broader and strategic energy resilience framework, inclusive of:
    - Service and Defense Agency Warfighting Missions
    - Emergency, Recovery, and Response Missions
    - Supporting Installation Infrastructure
- ❑ Step 2 – Mission requirements of those critical mission operations
  - ➢ In terms of 'resilience' – what disruption risk is appropriate? (e.g., availability, downtime, etc.)
- ❑ ODASD(IE) has commissioned follow-on MIT-LL review to establish a framework to integrate mission and installation requirements

Important questions:

- ➢ Mission operator coordination?
- ➢ Were mission dependencies evaluated?
- ➢ Were mission-to-mission solutions reviewed and identified?
- ➢ Were risk-based mission requirements developed and considered?
- ➢ Is an infrastructure solution required or needed?

DoDI 4170.11 requires alignment to critical energy requirements (critical mission operations) and allows for expanding solutions beyond standby generators.

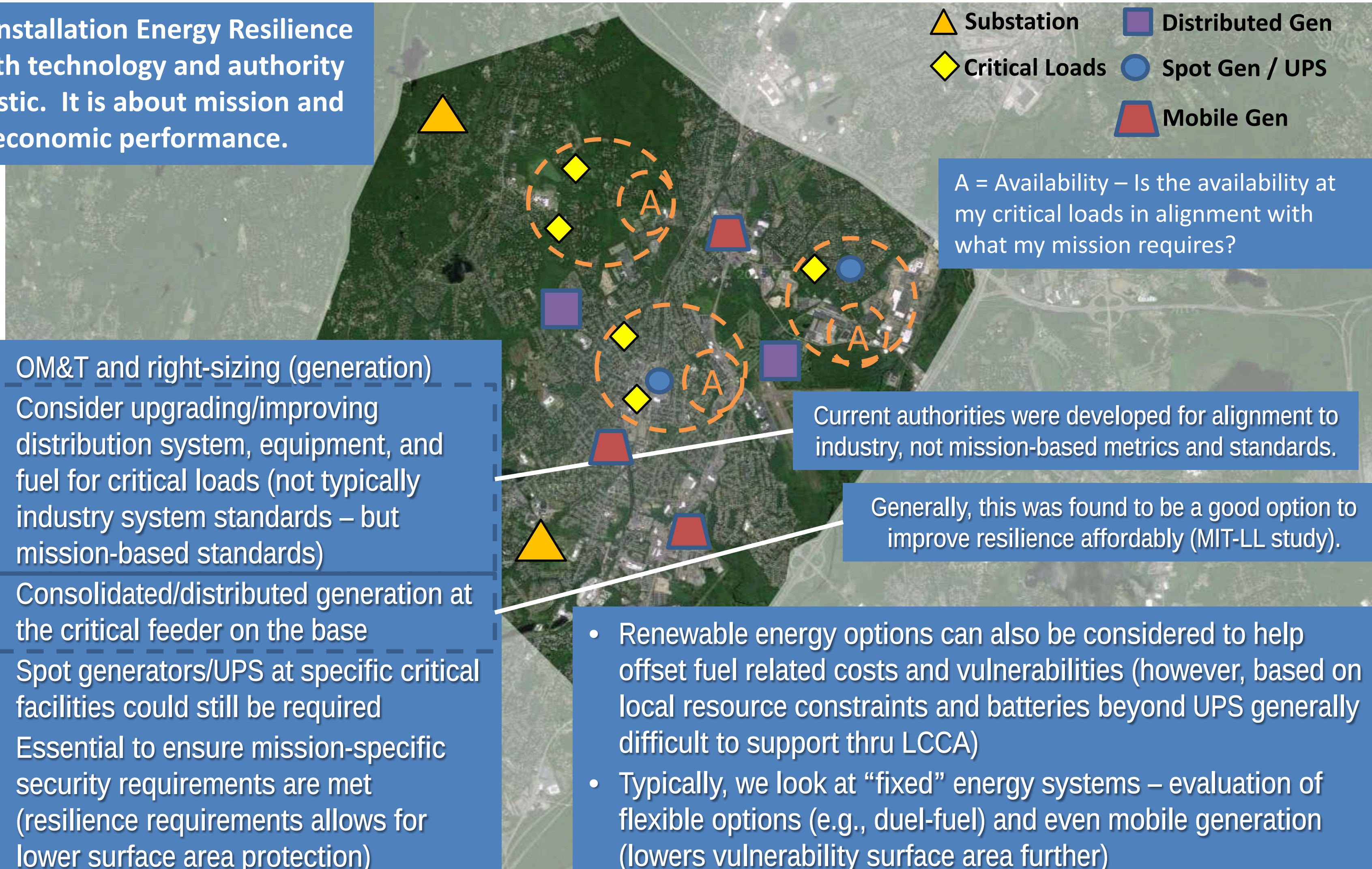
Resilience allows for a comprehensive, strategic framework and extends beyond traditional "building-by-building" or "generator-by-generator" designation for resilient designs. Important to establish a holistic and strategic resilience framework that integrates mission and installation stakeholder communities that encourage mission-based decision-making.

DoD Energy Resilience
Base-Level Critical Loads Example – Base Grid

Acquisition, Technology and Logistics

Example Case – Not an actual installation (solutions will vary based on mission requirements of military installations)

DoD Installation Energy Resilience is both technology and authority agnostic. It is about mission and economic performance.



A = Availability – Is the availability at my critical loads in alignment with what my mission requires?

Current authorities were developed for alignment to industry, not mission-based metrics and standards.

Generally, this was found to be a good option to improve resilience affordably (MIT-LL study).

- OM&T and right-sizing (generation)
- Consider upgrading/improving distribution system, equipment, and fuel for critical loads (not typically industry system standards – but mission-based standards)
- Consolidated/distributed generation at the critical feeder on the base
- Spot generators/UPS at specific critical facilities could still be required
- Essential to ensure mission-specific security requirements are met (resilience requirements allows for lower surface area protection)

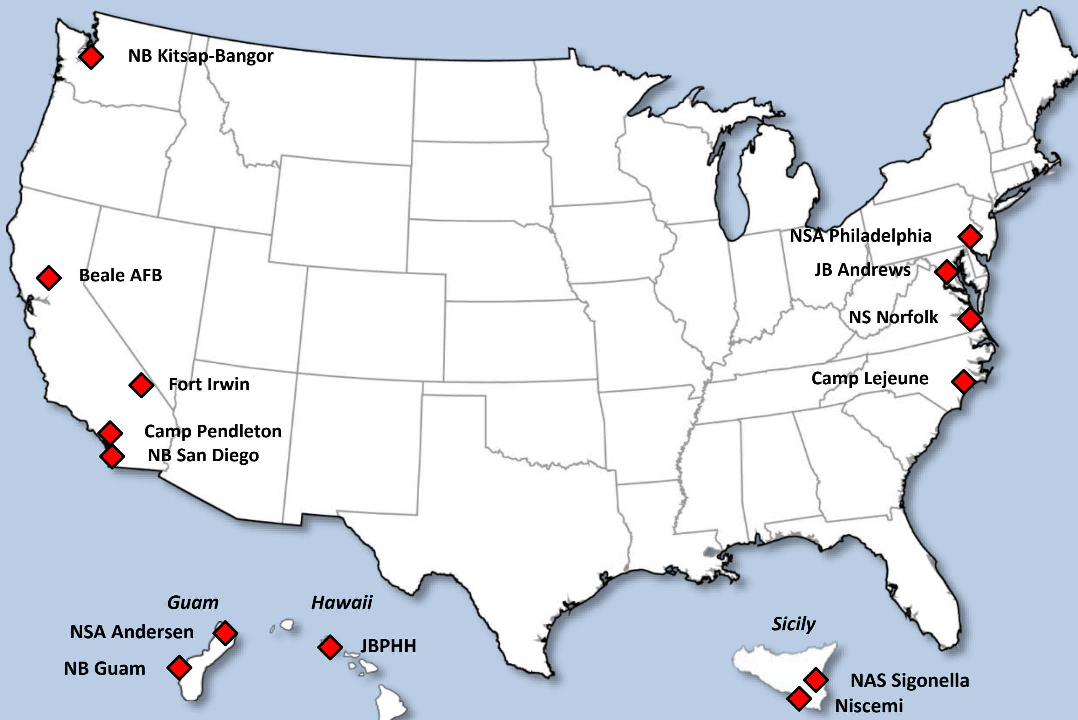
- Renewable energy options can also be considered to help offset fuel related costs and vulnerabilities (however, based on local resource constraints and batteries beyond UPS generally difficult to support thru LCCA)
- Typically, we look at “fixed” energy systems – evaluation of flexible options (e.g., duel-fuel) and even mobile generation (lowers vulnerability surface area further)

MIT-LL Study/Review

DoD Energy Resilience Initial Study Overview

<u>Study Problem Statement:</u> How does DoD meet its current requirement for cost-effective and reliable energy resilience solutions for critical mission operations?

- To implement energy resilience solutions, the study aligned to DoD requirements:
  - Identify critical energy requirements aligned to critical mission operations on military installations (in partnership with DoD mission assurance communities) [Mission assurance policy and doctrine]
  - Develop life-cycle cost analysis for reliable energy resilience solutions [Title 10/NIST Handbook/Financial Regs]
  - Review/compare energy solutions beyond typical backup or standby generators [DoDI 4170.11/LCCA]
- How are the MIT-LL studies/reviews helping to address this problem?
  - Development of a framework for energy resilience business case decisions
  - Uses *mission requirements* as the lens to evaluate options in a *technology agnostic* and *capability focused* approach
  - Aligns energy resilience solutions to prioritized *critical energy loads* for the military installations
  - *Analysis of alternatives (AoA)* comparing current baseline (generators) vs. over 40 potential energy resilience options
  - Considers site-specific constraints



DoD-Wide Recommendations

Sample of Findings

These are not necessarily new requirements – further prioritization and awareness is required within the installation energy portfolio.

- Communication
  - Encourage routine meetings between installation energy leads and mission operators to determine and prioritize ‘critical’ mission operations and energy requirements across the entire base
    - Improve guidance to determine prioritized energy load calculation for critical mission operations
  - Coordinate and collaborate throughout the base to ensure critical interdependent mission requirements are met during energy outages
- Technical
  - Understand your current energy systems and infrastructure; do not site energy systems on unreliable grid
  - Prioritize/ensure energy resilience systems are only placed on critical energy loads and appropriately sized
  - Standardize a process to ensure OM&T of energy systems (e.g., generators, UPS, etc.) for full reliability picture, and to help determine baseline resilience metrics to inform future decisions
- Cost and Performance Data
  - Encourage tracking of the appropriate LCCA data (capital, operation, maintenance, and testing) of energy generation and infrastructure to replicate and justify the business case for future energy resilience decisions
  - Encourage tracking of performance data that aligns to mission requirements – availability/reliability of energy systems and infrastructure (outage data, failure rates, etc.) to assist in tradeoff decisions between cost/mission
    - Helps to identify cost-effective and prioritized remediation for reliability risks on the base’s distribution system
    - Allows for development of performance metrics (availability, reliability, and cost metrics for use in RFPs, contracts, etc.)

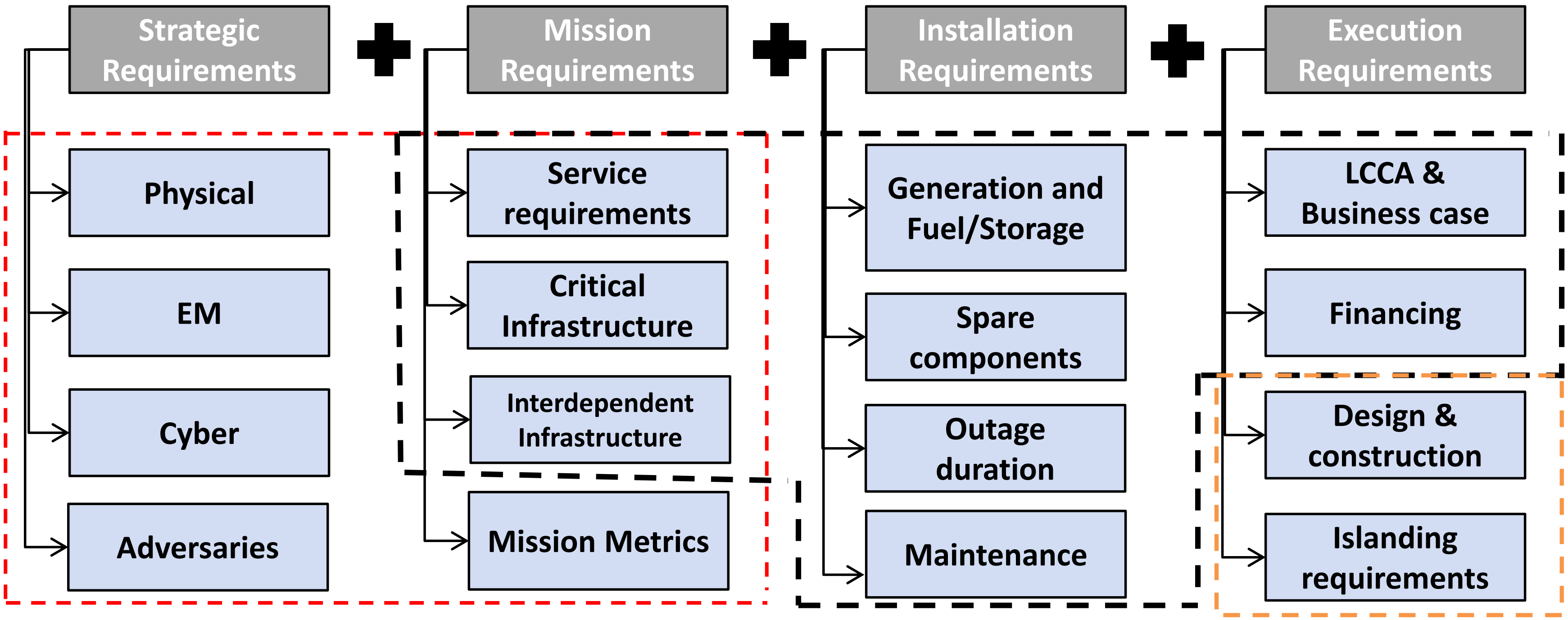
These recommendations continue to shape policy across the DoD through continued collaboration with the Military Services and Defense Agencies.

Next Steps

DoD Requirements for Resilience

How do we translate (and share this information where it already exists) with installation support personnel?
"Capture" + "translate" to installation personnel

AT&L Funding Pursuits:
- AT&L Study Funds
- ERCIP
- PPBE (indirect – Services)
- Alternative Financing (DERB)



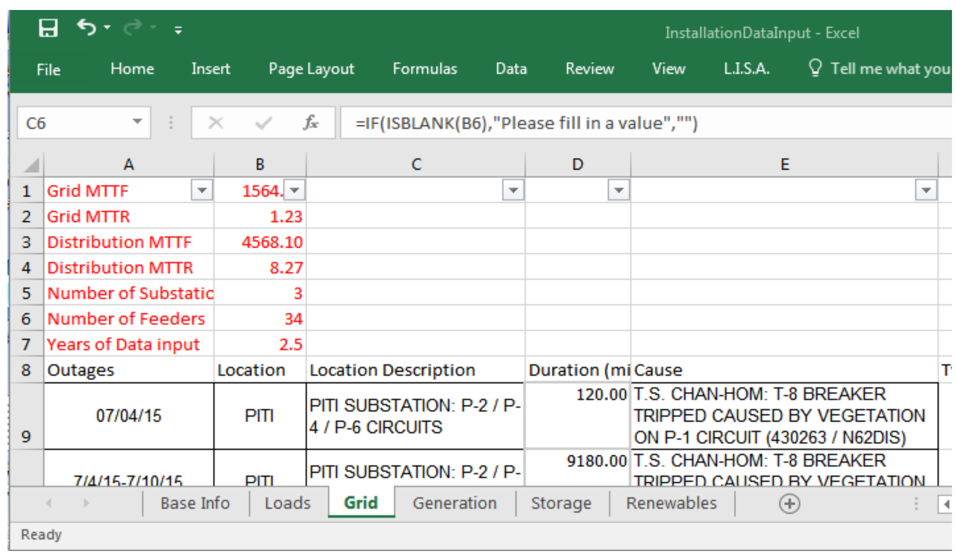
Additional understanding – follow-on MIT-LL study (ODASD(IE) Funded)

ERA MATLAB & DERB study/tools (ODASD(IE) Funded)

Other considerations for site and project execution/implementation

Energy Resilience LCCA Status
Next Steps – Tool Development/Transfer

- Demonstrated on multiple military installations
  - Allows refinement of capabilities and continued focus on mission requirements at the site-level
  - Investigating best way to roll out to wider user-base
  - Added scenarios for long duration outages
- Excel front end developed for user-interface for MATLAB to enable input from military installations
- Transfer the ERA Tool to the DoD (online, hosting, etc.) thru follow-on MIT-LL study



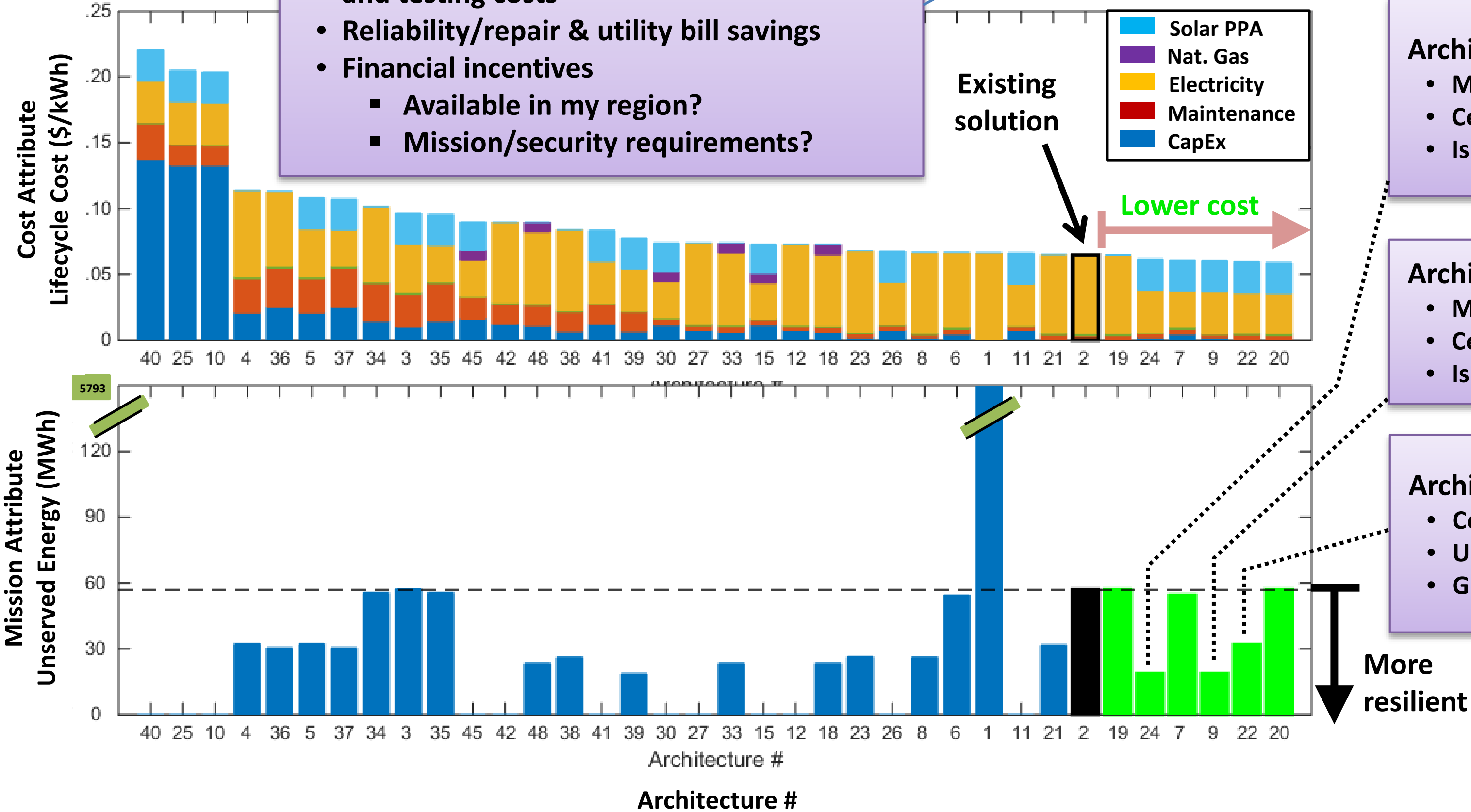
Energy Resilience Analysis of Alternatives

Optimizing to meet mission requirements {historical outages}

LCCA Value Streams (Direct):

- Right-sizing to mission requirement
- Reduce capital, operations, maintenance, and testing costs
- Reliability/repair & utility bill savings
- Financial incentives
  - Available in my region?
  - Mission/security requirements?

Value streams were aligned to existing LCCA requirements for project-level submissions (see DoDI, NIST Handbook, FM regs, ERCIP, etc.)



Architecture #24 assets:

- Microgrid
- Central & building generators
- Islandable solar

Architecture #9 assets:

- Microgrid
- Central generators
- Islandable solar

Architecture #22 assets:

- Central & building generators
- UPS
- Grid-tied solar

High-cost options typically include advanced/large-scale microgrids (can lead to large-scale distribution system upgrades), battery integration, and/or fuel cells

Low-cost options include generators, targeted/centralized generators and/or microgrids, and/or solar (near the point of use – focused on mission requirements of the base)

- Request for Information (RFI) [Issued: March 2017; Closed: April 2017]
- Request for Quotation (RFQ) [Issued: August 2017; Closed: September 2017]
    - https://www.fbo.gov/?s=opportunity&mode=form&id=0a0fbddffcc55915f4ea7b6f0fbe22b5&tab=core&_cview=0

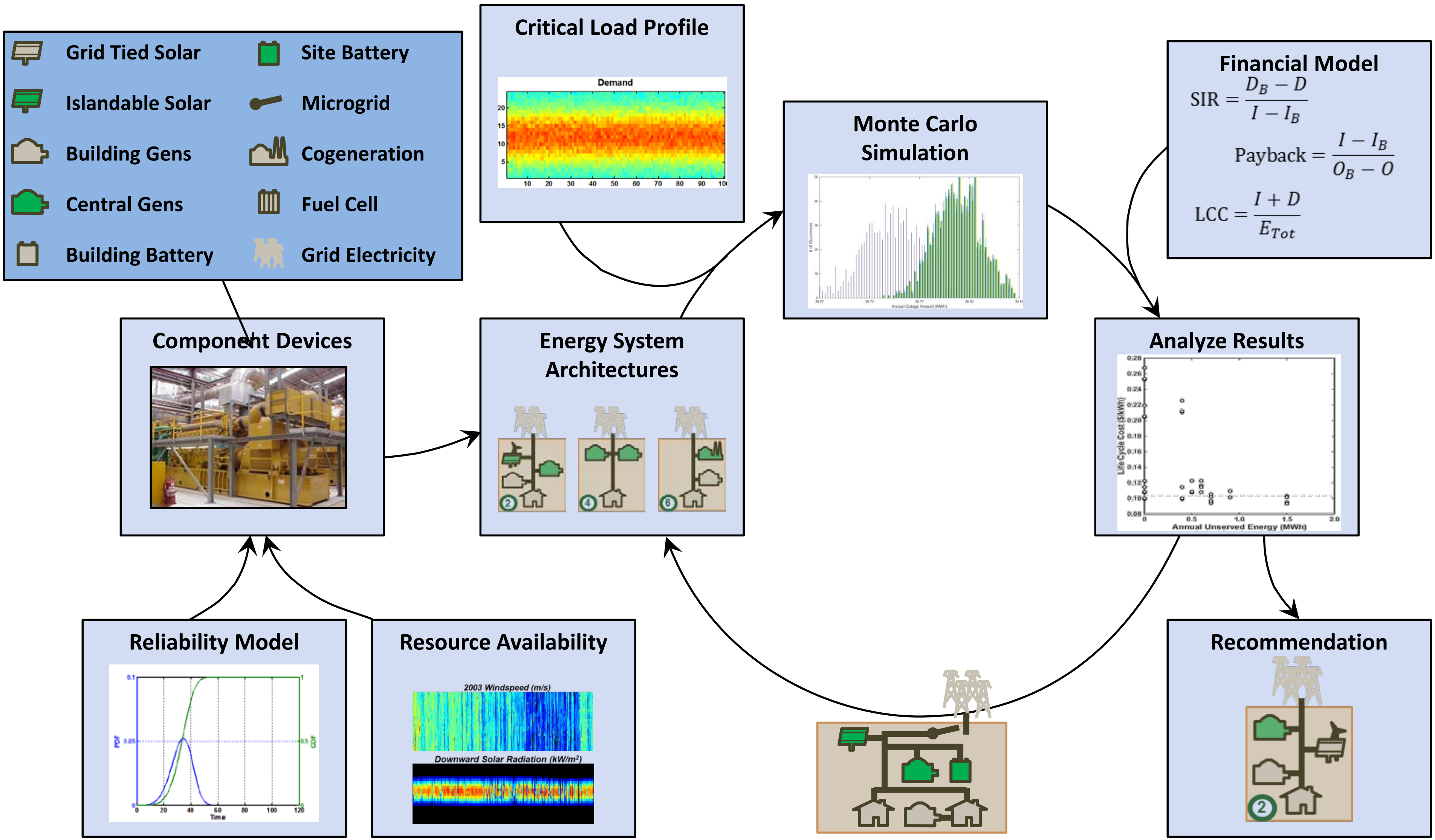
- Study Overview
    - Use the results of the MIT-LL energy resilience framework to better translate DoD mission requirements to financial and lending institutions
    - Review challenges to accelerate alternative financing of energy resilience projects
    - Recommend appropriate policies and procedures to overcome challenges for wider-scale adoption of alternative financing for energy resilience projects
    - Develop a financing tool to provide key DoD and financial institution stakeholders metrics for risk-informed project ratings and alternative financing decisions

These next steps are being collaborated and coordinated with the Military Services and Defense Agencies to help shape future policy and processes across DoD.

BACKUP

DoD Energy Resilience Analysis Methodology

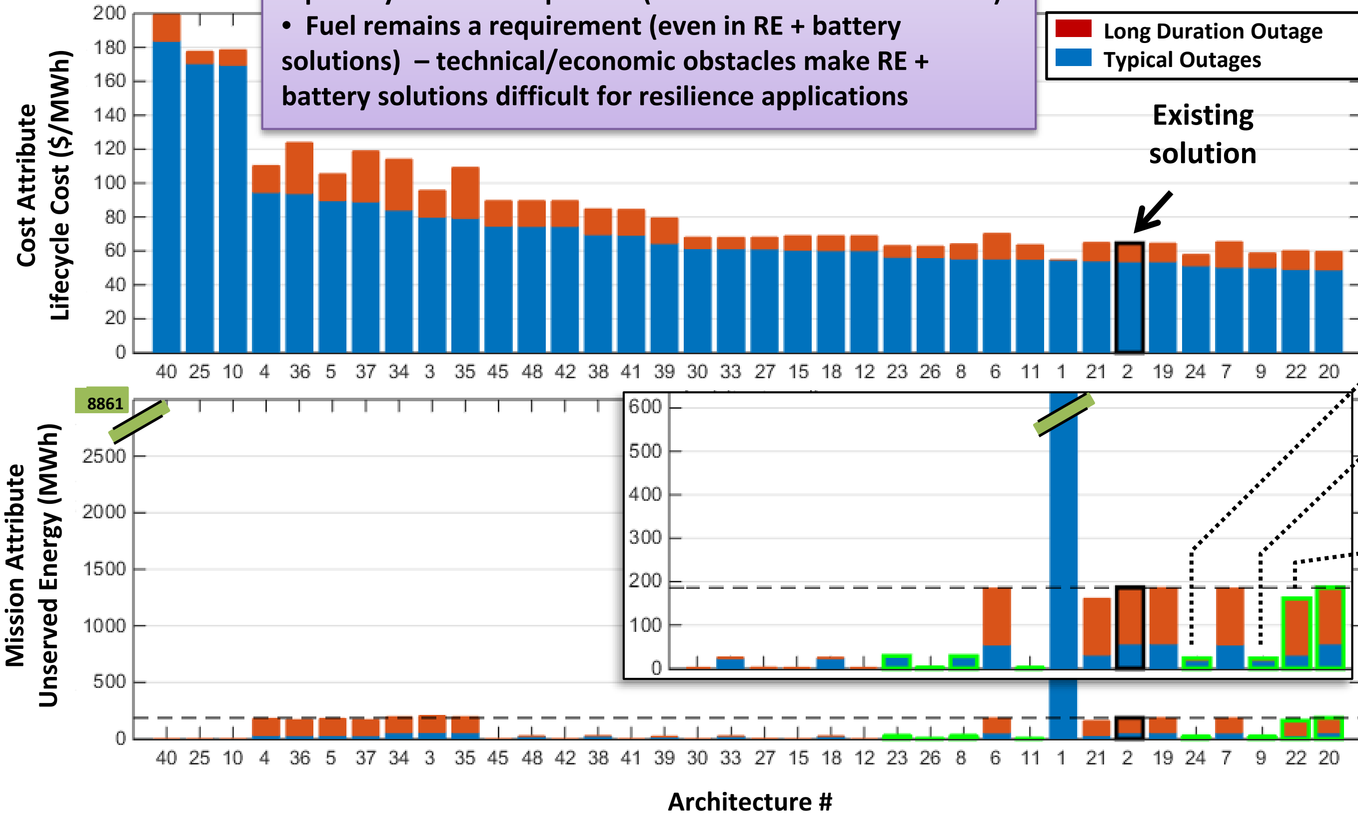
Acquisition, Technology and Logistics



Energy Resilience Analysis of Alternatives
Optimizing to meet mission requirements {2 week outage}

Important valuation highlights:
- Results / outcomes not dramatically changed
- Least cost solution(s) to meet requirement remains stable
- AoA allows direct LCCA value streams to be considered equitably for fair comparison (all receive customized value)
- Fuel remains a requirement (even in RE + battery solutions) – technical/economic obstacles make RE + battery solutions difficult for resilience applications

Any generalized non-direct benefits will drive down the costs of all solutions (e.g., productivity savings, food spoilage, etc.)



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Yes, lessons learned! We started the effort back in Dec 2012.

Lessons Learned

1. Collaboration of critical mission operations and mission requirements is a necessary first step to achieve energy resilience (don't assume a technology or execution path)
   - ❑ Did you also consider mission-to-mission solutions? Do you need an infrastructure solution?
2. Determination of critical loads is important to assign prioritization, reduce vulnerability risks, and to consider cost-effective options to what our mission requires
   - ❑ What exactly are my mission requirements and the level of performance I expect at those critical loads identified?
3. Availability/reliability of distribution system and current energy systems at critical loads in question require consideration prior to implementing any new energy system or generation options
   - ❑ What is current level of availability performance (i.e., current resilience)?
   - ❑ Am I operating, maintaining, and testing my current systems and equipment?
   - ❑ Is further resilience required? What types of resilience are possible on my base?
   - ❑ What are my options? (e.g., upgrade current systems, pursue new systems, etc.)
4. Consideration of various technologies, inclusive of fossil and renewable energy options are necessary when considering distributed and continuous power to ensure mission performance

Think about costs/tradeoffs as you increase complexity of solutions.

DoD Lessons Learned

5. "New" upgrades, distributed energy resources and other technologies can provide an installation greater flexibility in servicing critical loads, however, the Component must understand their current level of resilience and if the mission requires additional resilience. Examples:
   - First consider upgrading/improving distribution system, equipment, and fuel for critical loads
   - Consolidated/distributed generation at the substation/critical feeder level
   - Spot generators at specific critical facilities can continue if additional resilience is required
   - Renewable energy options can also be considered to help "offset" fuel related costs and vulnerabilities (needs to tie back to mission requirements and capabilities)
     - Remember, you are remediating disruption risks, so fuel is likely still needed
     - Difficult to consider a renewable "only" option since fuel outcompetes batteries when considering cost/technical tradeoffs in a disruption scenario (difficult to size batteries to MW-level critical loads: not a R&D project)
   - Typically, we look at "fixed" energy systems – evaluation of flexible options (e.g., duel-fuel) and even mobile generation can also be considered to remediate disruption risk

Think about costs/tradeoffs as you increase complexity of solutions.

6. Energy resilience metrics are needed to help right-size solutions that align to what our *mission requires*
   - How do we know if we are getting the right resilience from vendors/contracts today? Are we building in energy resilience metrics into our contracts?

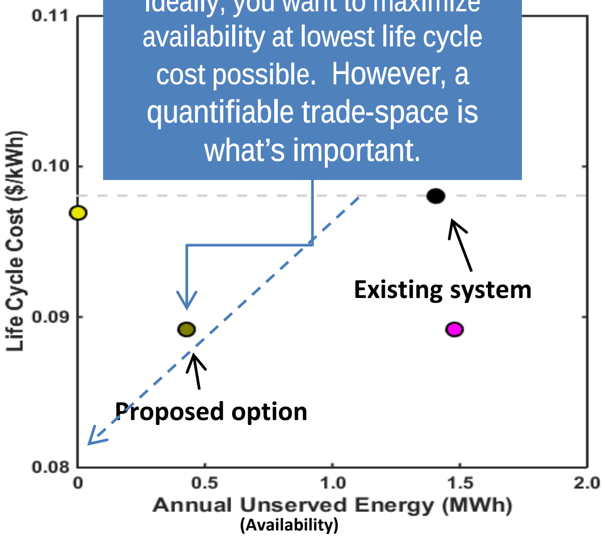
Whatever the solution, don't forget about mission performance

Bottom-Line Up Front (BLUF) Study Results Overview

Acquisition, Technology and Logistics

Cost attribute: life-cycle costs ($/kwh)
Mission attribute (availability): annual unserved energy (MWh)

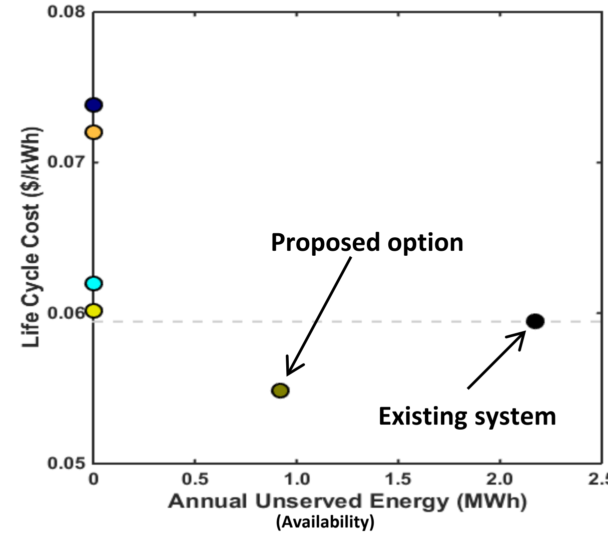
Ideally, you want to maximize availability at lowest life cycle cost possible. However, a quantifiable trade-space is what's important.

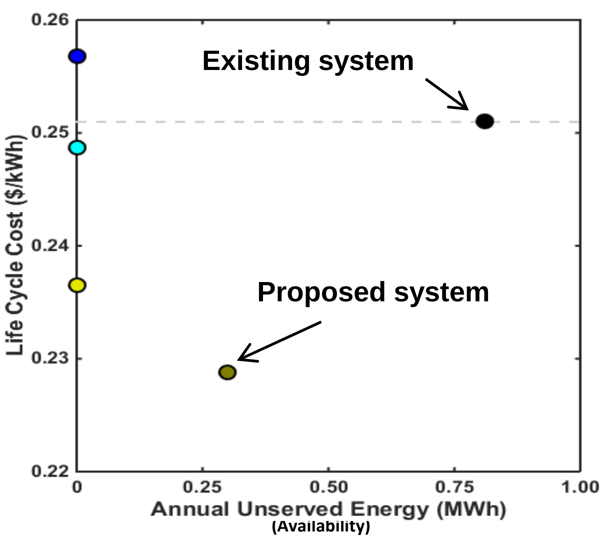


Findings/Results (generalized)

- Critical Energy Loads: 6 MW to 21 MW
- Generators: 50 to 350 generators
- Reductions in costs: 0.2¢/kWh to 2.2¢/kWh,
- Availability improvements: 0.3 MWh to 1.2 MWh
- Base characteristics: Isolated location with frequent outages, integrated/urban base with reliable power, etc.

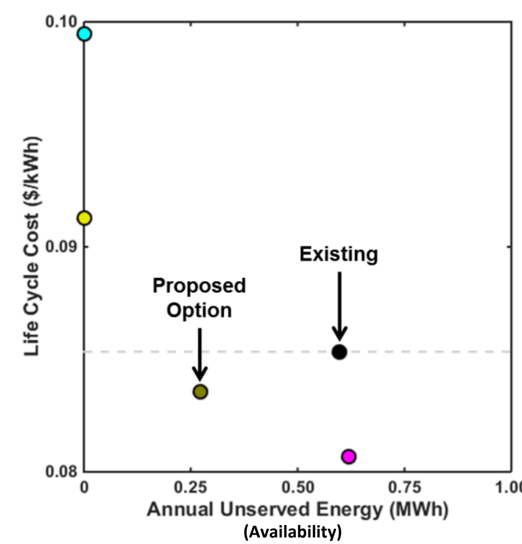
	Generator	Microgrid	UPS	PV	CHP	FC
● (black)	X					
● (blue)	X	X	X			
● (yellow)	X	X	X	X		
● (green)	X		X	X		
● (magenta)	X			X		
● (olive)	X	X		X		
● (orange)	X	X	X	X	X	
● (cyan)	X	X	X	X		X
● (navy)	X	X	X	X	X	X





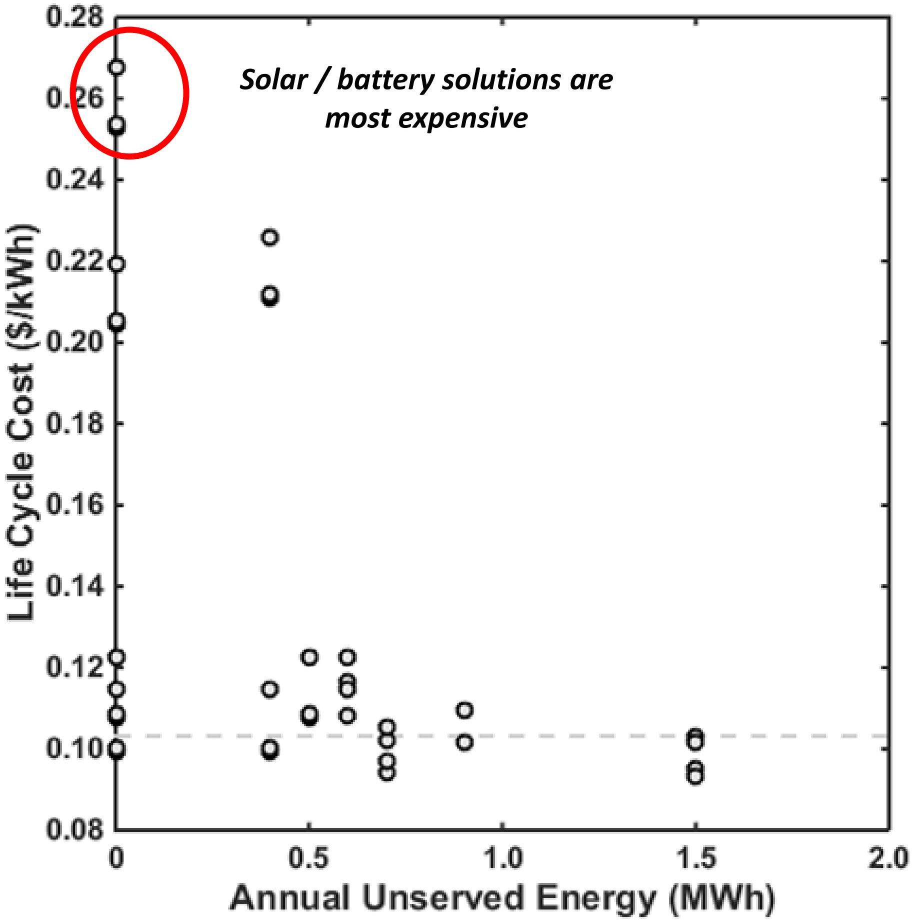
Framework allows for quantifiable tradeoffs between cost and mission assurance attributes.

Results across diverse bases indicate that more cost-effective and reliable energy resilience solutions exist to support critical mission operations on our military installations.



Model Results

- 1000 annual Monte Carlo simulations performed
- Life-cycle cost (LCC) is calculated over 10 years (customizable based on economic requirement)
- Unserved energy is aligned to outages experienced by the installation, and those expected by technology mix reliability (various outage scenarios have been investigated)
- High-cost options typically include advanced/large-scale microgrids (leading to large-scale distribution system upgrades), battery integration, and/or fuel cells
- Low-cost options include generators, targeted/centralized generators and/or microgrids, and/or solar (near the point of use – focused on mission requirements of the base)



DoD Energy Resilience
Energy Resilience Project/Program Questions

1. Does the project proposal have support/commitments from those mission operators/tenants impacted (e.g., commit docs)?
2. Does the project directly remediate disruption risks to critical mission operations on the base?
3. What types of critical mission operations are risks being remediated for? What are the mission requirements of the identified critical mission operations (e.g., <u>downtime</u> risk tolerance requirement used to help determine energy resilience metrics such as availability, reliability, and quality thresholds)?
4. What is the critical load amount (e.g., kWs, MWs, etc.) of the identified critical missions? What portion of the critical load is being impacted by the project (if different from amount provided)?
5. Is the base currently compliant to near-term energy resilience requirements (e.g., current level of reliability is aligned to what missions require, generator and other system OM&T, etc.)? Does it actually require "more" resilience?
6. What are the components of the project (e.g., generation, infrastructure, equipment, and fuel) that are being paid for that are tied to the critical load in question <u>and</u> that are also needed to remediate disruption risk?
7. Does the project remediate a risk? This is determined by the current state of the availability/reliability and the improvement expected to meet the mission requirements at the critical missions identified? Provide quantification of resilience metrics to confirm (e.g., technical metrics: availability, reliability, and quality).
8. Has there been an independent government life-cycle cost assessment conducted, and an analysis of alternatives conducted? Have the cost and mission tradeoffs been assessed across the alternatives (inclusive of upgrades)?
9. Have the appropriate stakeholders coordinated on the project selection (e.g., installation support, financial, and mission operator/tenants)? Is there commitment to sustain the project over its life? Have each stakeholders' budgets been reviewed to identify "fair share" contributions to implement/execute the project?
10. Have the near-term execution impediments been remediated prior to project selection (e.g., infrastructure ownership, integration of power systems, land ownership, host-tenant/installation-mission agreements, etc.)?
11. What are the base's plans to include energy resilience metrics to ensure performance? Describe how energy resilience metrics will be included in contracting to ensure contractor/vendor performance, and ensure missions requirements are met.

Typical questions to better understand if you are pursuing an energy resilience program/project.

$1M in Capital and $100k/yr in OM&T

Acquisition, Technology and Logistics

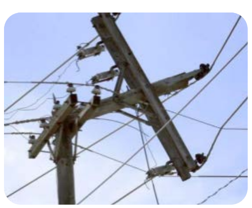
Generators Only

(2MW load, n+1 configuration, >99.9975% reliability)

3  **1MW diesel generator†**

1  **Technician with annual training***

268  **45 gallon barrels of diesel fuel**

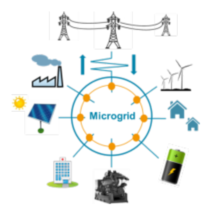
72  **Hours of electrical outage system can withstand**

Microgrid, Solar PV, & Storage

(0.25MW load, n configuration, >99.5% reliability)

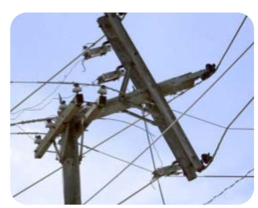
1  **250kW Solar PV Farm**

1  **1MWh battery system**

1 

Basic microgrid control system

1  **Advanced technician with annual training***

12  **Hours of electrical outage system can withstand**

*Cost of maintenance included in technician cost
†Fuel tanks included in generator cost

Cut-Out of Select Assumptions
For Comparison Purposes

DoD assumptions used in MIT-LL analysis[1]:

- $300 per kW for generators (aligned to 1 MW generators)
- $1 per watt for solar PV installed (aligned to utility scale projects)

Industry (Lazard) assumptions used in its analysis[2]:

- $500 per kW for generators (commercial applications)
- $2 per watt for solar PV installed (commercial applications)

Differences in assumptions are based on addressing needs of specific customers, and aligned to meet a user need or requirement. Explained further below.

[1]The analysis on slide 1 has been aligned to DoD assumptions for customization to DoD mission and project-level requirements. The MIT-LL model used is dynamic and can be customized to address specific user needs, as appropriate.
Reference: https://www.ll.mit.edu/mission/engineering/Publications/TR-1216.pdf

[2]Lazard builds its analysis and assumptions for commercial and industry customers.
Reference: https://www.lazard.com/perspective/levelized-cost-of-energy-2017/
Reference: https://www.lazard.com/perspective/levelized-cost-of-storage-2017/

POC: Ariel Castillo, Ph.D.; Defense Department; Senior Energy Resilience Program Manager; ariel.s.castillo.civ@mail.mil

Resilient Technology Comparison

Acquisition, Technology and Logistics

Metric	Generators and Fuel	Microgrid, Solar PV, and Storage
Average Critical Load	1 MW	
Project Area Required	53 m^2	10,000 m^2
Storage Volume Required	8.5 m^3	95 m^3
Fuel/Storage Energy Density	3200 kWh per m^3 †	589 kWh per m^3 ‡
Training Requirement	Simple	Complex
Security Concerns	Physical, EMP	Physical, Cyber, EMP

* General values provided for training purposes. Values may differ depending on the installation.
† Diesel fuel consumed in 33% efficient generators.
‡ Lithium ion batteries with 15% roundtrip efficiency loss.

POC: Ariel Castillo, Ph.D.; Defense Department; Senior Energy Resilience Program Manager; ariel.s.castillo.civ@mail.mil

Reference: https://www.ll.mit.edu/mission/engineering/Publications/TR-1216.pdf

How do I build in ER metrics into contracts?

An example – Concept Only

Acquisition, Technology and Logistics

Availability Failure Penalty Table						
Allowable Down Time		None	60 Seconds	10 Minutes	20 Minutes	30 Minutes
Mission/Building/Equipment Affected		Insert appropriate mission/facility	Insert appropriate mission/facility	Insert appropriate mission/facility	Insert appropriate mission/facility	Insert appropriate mission/facility
Actual Down Time	30 Seconds	Insert $ amount				
	60 Seconds	Insert $ amount	Insert $ amount			
	5 Minutes	Insert $ amount	Insert $ amount			
	10 Minutes	Insert $ amount	Insert $ amount	Insert $ amount		
	15 Minutes	Insert $ amount	Insert $ amount	Insert $ amount		
	20 Minutes	Insert $ amount	Insert $ amount	Insert $ amount	Insert $ amount	
	25 Minutes	Insert $ amount	Insert $ amount	Insert $ amount	Insert $ amount	
	30 Minutes	Insert $ amount	Insert $ amount	Insert $ amount	Insert $ amount	Insert $ amount
	35 Minutes	Insert $ amount	Insert $ amount	Insert $ amount	Insert $ amount	Insert $ amount
	40 Minutes	Insert $ amount	Insert $ amount	Insert $ amount	Insert $ amount	Insert $ amount
	45 Minutes	Insert $ amount	Insert $ amount	Insert $ amount	Insert $ amount	Insert $ amount
	50 Minutes	Insert $ amount	Insert $ amount	Insert $ amount	Insert $ amount	Insert $ amount
	55 Minutes	Insert $ amount	Insert $ amount	Insert $ amount	Insert $ amount	Insert $ amount
	60 Minutes	Insert $ amount	Insert $ amount	Insert $ amount	Insert $ amount	Insert $ amount
	65 Minutes	Insert $ amount	Insert $ amount	Insert $ amount	Insert $ amount	Insert $ amount
	70 Minutes	Insert $ amount	Insert $ amount	Insert $ amount	Insert $ amount	Insert $ amount

Your missions are important, make sure to measure/demand performance.
Do this early and often, or you will lose negotiating leverage and pay for it later.