Energy Exchange[SM]

Be Efficient And Resilient

U.S. Department of Energy

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Measuring Success in Resilience

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ODASD(Energy)

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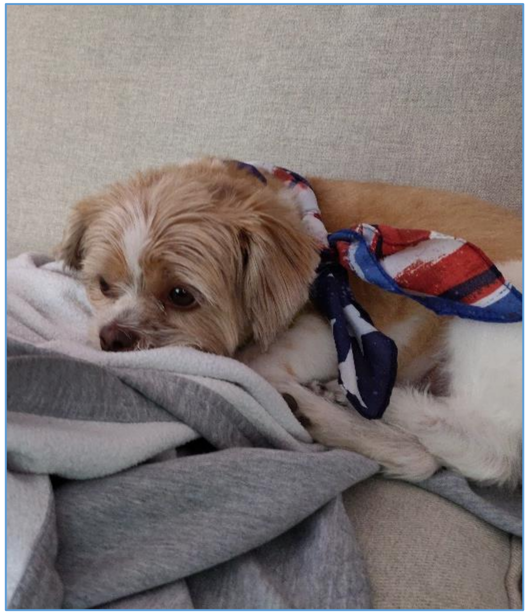
Installation Energy Resilience



DoD Requirements for Energy Resilience

Integration of risk and mission-based decision making is an integral aspect of energy resilience

Funding Impacts:
- Energy Resilience Conservation and Investment Program
- Planning, Programming, Budgeting, and Execution
- Alternative Financing

Strategic/Risk Requirements
- Physical
- EM
- Cyber
- Adversaries

➕

Mission Requirements
- Service requirements
- Critical Loads/ Infrastructure
- Interdependent Infrastructure
- Mission Metrics

➕

Installation Requirements
- Generation and Fuel/Storage
- Spare components
- Outage duration
- Maintenance

➕

Execution Requirements
- LCCA & Business case
- Financing
- Design & construction
- Islanding requirements

On-going collaboration between MIT-LL and INL

ERA Tool, Exercises, & DERB study/tools (ODASD(E) Commissioned)

Other considerations for site and project execution/implementation

Metrics span across these requirements

ER 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 and Interdependencies
- ❑ Step 2 – Mission requirements of those critical mission operations
  - ➢ In terms of 'resilience' – what disruption risk is appropriate? (e.g., availability, downtime, etc.)
- ❑ ODASD(Energy) has commissioned MIT-LL to establish and test resilience framework for mission and installation requirements
  - ➢ MIT-LL to collaborate with INL to broaden comprehensive and automated risk-based decision tools and exercises to inform DoD 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?

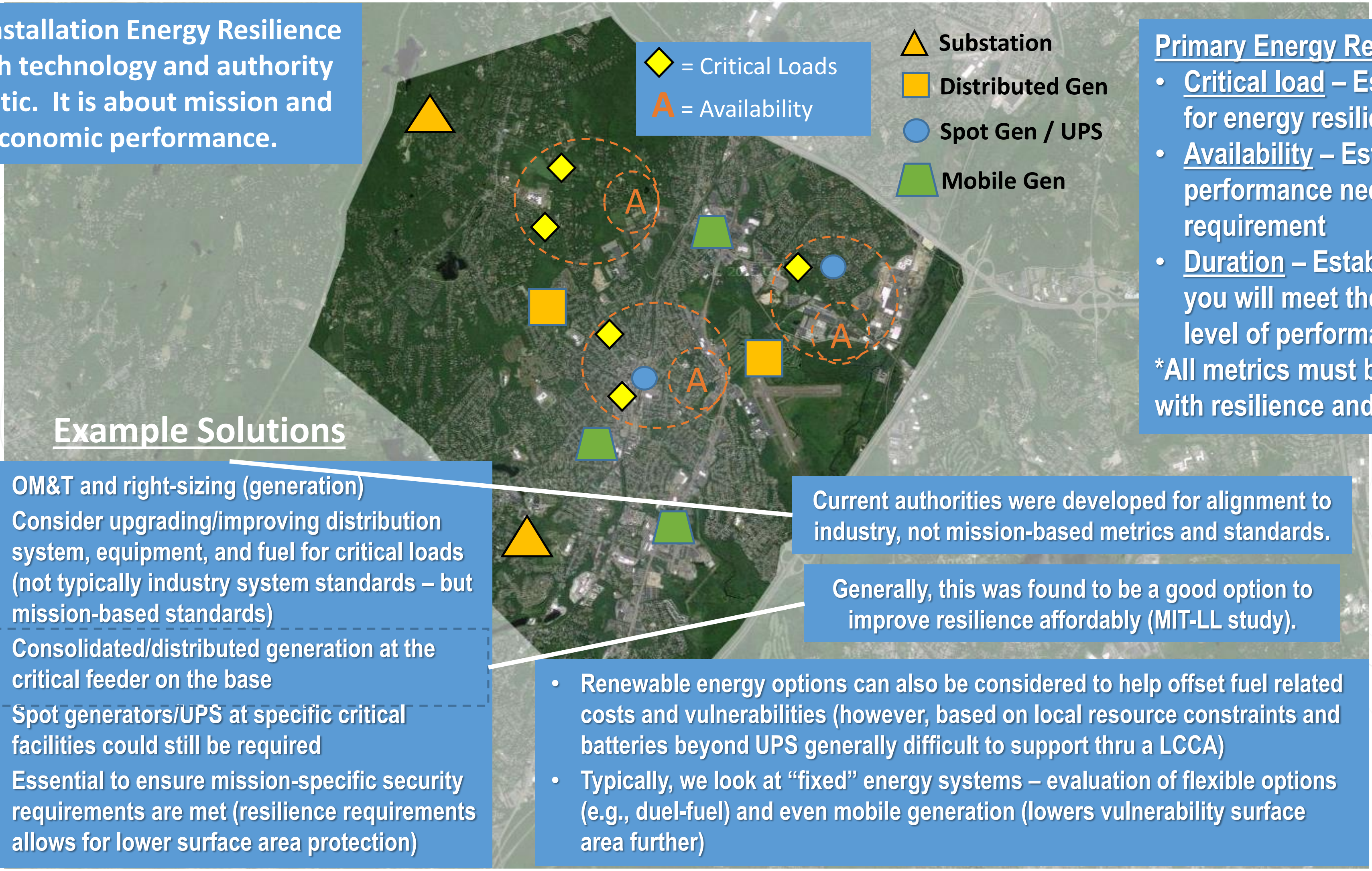
DoDI 4170.11 requires alignment to critical energy requirements to prioritize and inform mission-based metrics development.

Important to establish a holistic and strategic resilience framework that integrates mission and installation stakeholder communities that encourage mission-based decision-making.

Base-Level Metrics Example – Base Grid

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.



Primary Energy Resilience Metrics:

- **Critical load** – Establishes a requirement for energy resilience
- **Availability** – Establishes level of performance needed to meet that requirement
- **Duration** – Establishes period of time you will meet the requirement and the level of performance

*All metrics must be risk-informed to align with resilience and mission requirements.

Example Solutions

- 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)

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).

- 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 a 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)

DoD Energy Resilience Analysis (ERA) Tool and Exercises

DoD Energy Resilience

Tools, Assessments, and Exercises

- **Tools and assessments allow sites to understand risks to critical systems and inform project development**
- **Tabletop exercises investigate responses and capabilities during an extended simulated outage**
- **“Pull-the-plug” exercises provide awareness of actual system capabilities during a real outage**

- **Adverse weather events are damaging our electrical infrastructure**
- **Downstream effects may cause outages on DoD installations**
- **Real-world testing ensures preparedness for an outage scenario**

30 energy resilience base assessments and exercises completed

- *1/5 of the Department’s electricity consumption*
- *> $450 million in electricity costs*

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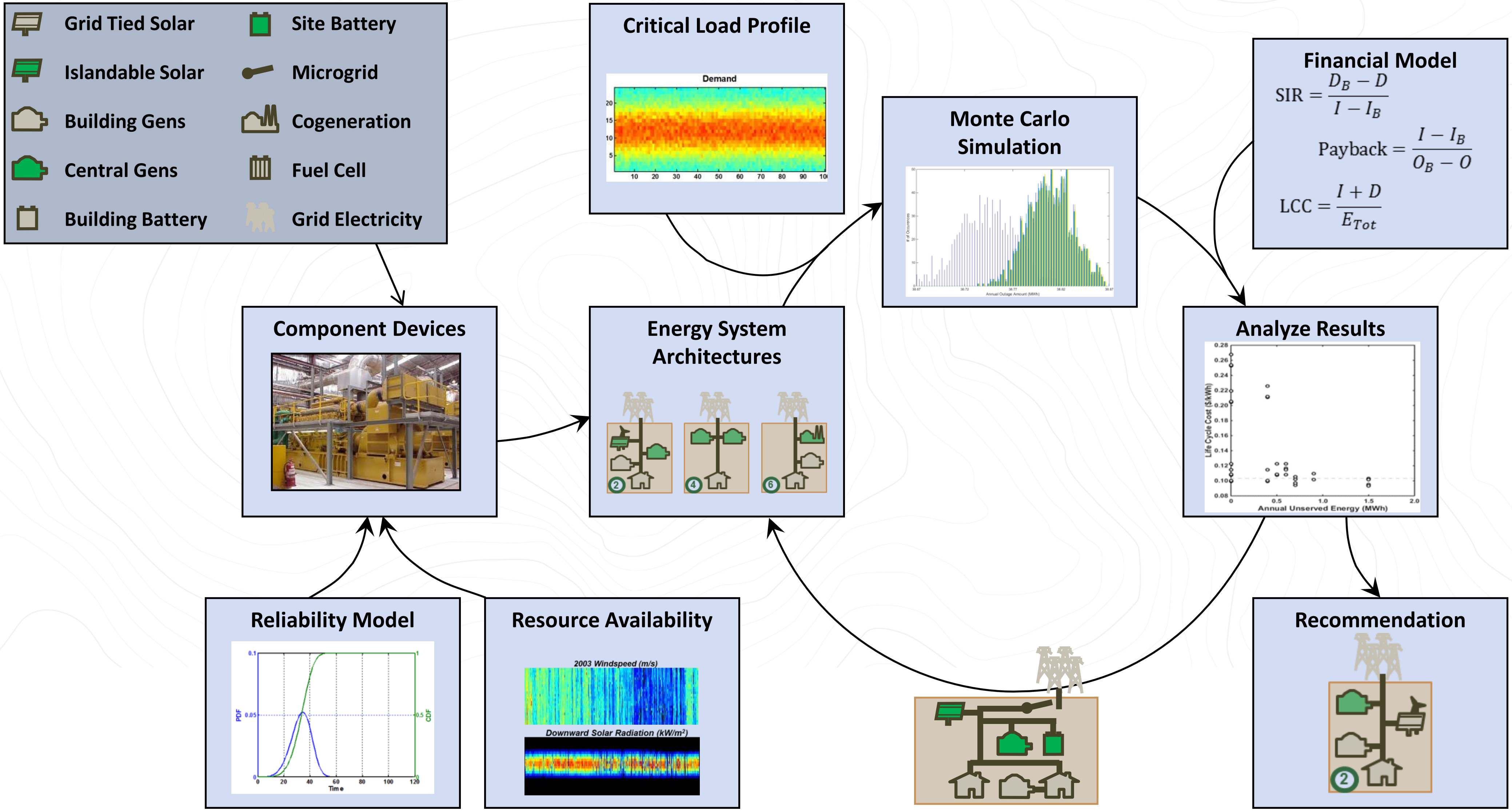
DoD Energy Resilience
ERA Tool Analysis Methodology



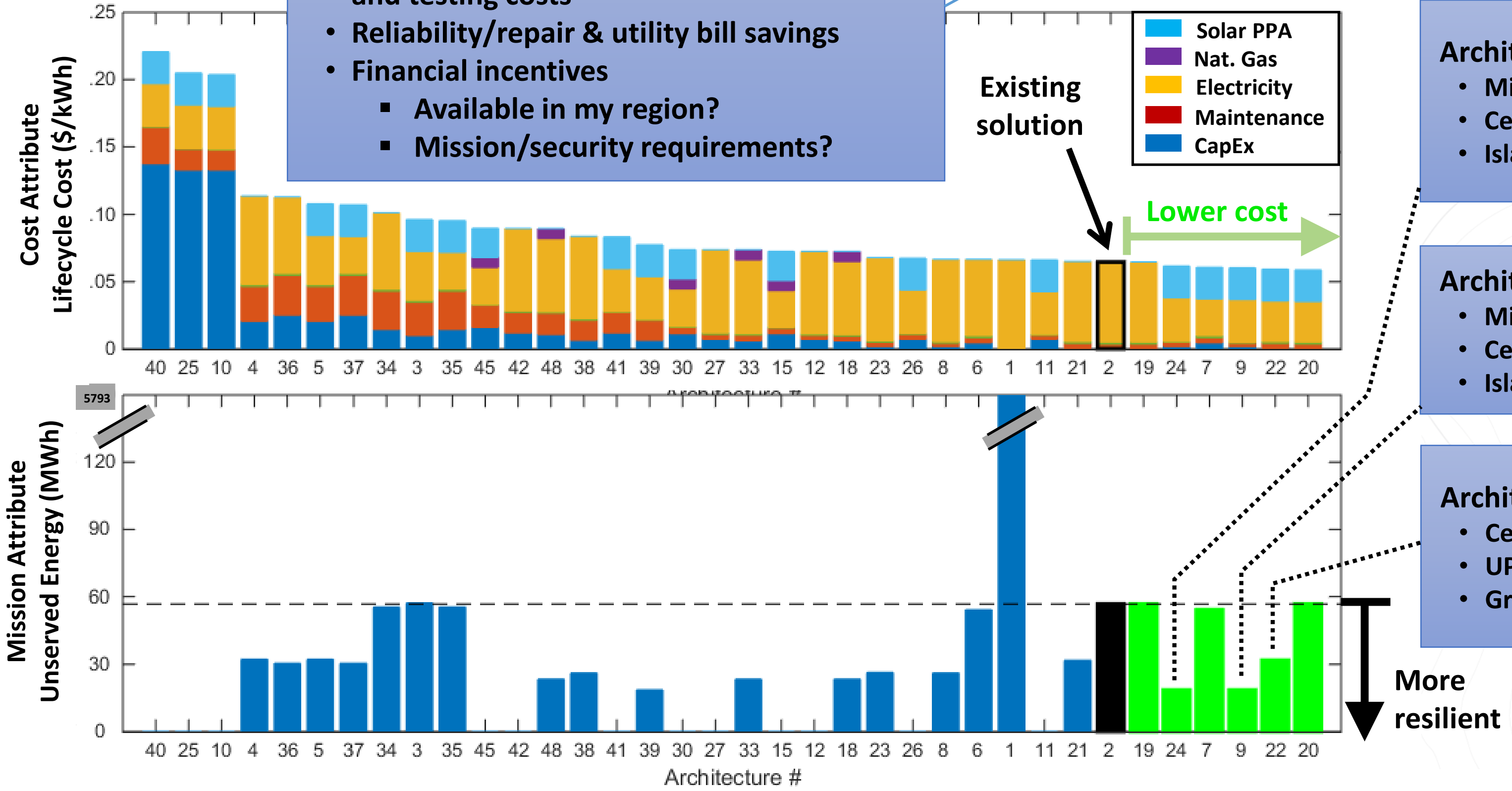
Energy Resilience Analysis of Alternatives

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

Architecture #

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)

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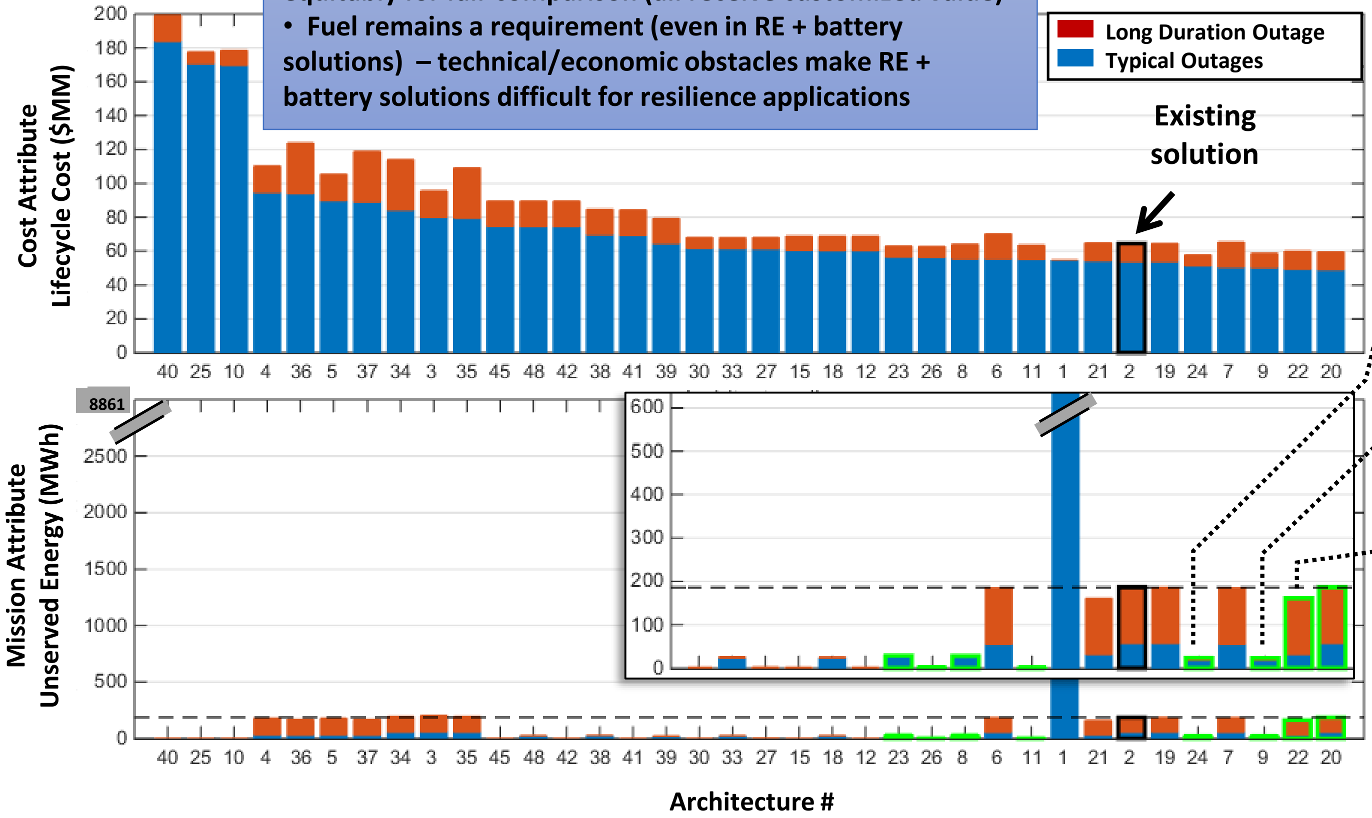
Energy Resilience Analysis of Alternatives

Optimizing to meet mission requirements {2 week outage}

Important findings and 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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Simplified View of Energy Resilience Metrics

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

Technical Metrics

Generators Only

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

Performance Measure

3  1MW diesel generator†

Sustainment

1  Technician with annual training*

268  45 gallon barrels of diesel fuel

Duration → 72  Hours of electrical outage system can withstand

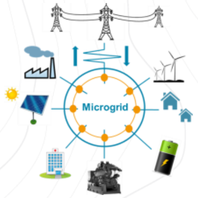
Microgrid, Solar PV, & Storage

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

Defined metrics allow for easier apple-to-apple comparisons across technology types.

1  250kW Solar PV Farm

1  1MWh battery system

1 

Basic microgrid control system

Mission drives requirements for technical metrics.

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

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Resilient Technology Comparison

Metric	Generators and Fuel	Microgrid, Solar PV, and Storage
Average Load (based on mission requirement)	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

Defined metrics allow for easier apple-to-apple comparisons across technology types.

*** 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.

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Defense Energy Resilience Bank (DERB) Study

Energy Resilience Project Development

Insights from Investors and Developers

Investors, lenders, and developers actively compete in the market to fund commercially viable, bankable infrastructure projects and are keenly interested in DoD energy resilience projects

Key Takeaways:

Awareness of Projects	Lenders are often unaware of resilience projects coming to market. They want to see more active, frequent and centralized sharing of information on project pipelines across service branches
Project Pipeline	Financiers want to see more regularity in the frequency, volume and size of projects in the DoD energy project pipeline. This will incentivize them to dedicate more resources to learn and engage in the market, and improve the DoD's commercial position in negotiations
DoD Commitment	DoD should demonstrate to the commercial market a long term and stable commitment to energy resilience projects given the significant repayment periods and previous examples of projects being postponed or canceled after agreements were signed
Procurement Cycles	Shorter procurement cycles and time to project closing will increase lender interest and improve commercial terms for the DoD
* **Standard Contract Terms**	All contracting offices should use standardized contract terms and conditions for TforC, TforD, and force majeure provisions, and include clear energy resilience requirements and performance terms for risk management. Economic valuation of threats such as natural, climate, physical, reliability, and cyber is possible.
Foreign Institutional Investors	U.S. lenders often look to resell their loans to secondary investors. Limitations on the ability to resell financings to foreign institutions limit the pool of available capital to finance resilience projects and can lead to higher long term financing costs paid the service branch

How do I evaluate ER metrics fairly in proposals?

RFI and RFP templates for cost based on mission requirements

Expected Costs ($000) to Deliver Energy Resilience Performance								
MW/Availability	90%	95%	97%	99%	99.9%	99.99%	99.999%	99.9999%
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Requesting total costs and dollars per energy unit protects the Government's financial interests, and aligns directly to mission requirements. Allows for technology agnostic comparisons to select best value technology to meet critical mission requirements.

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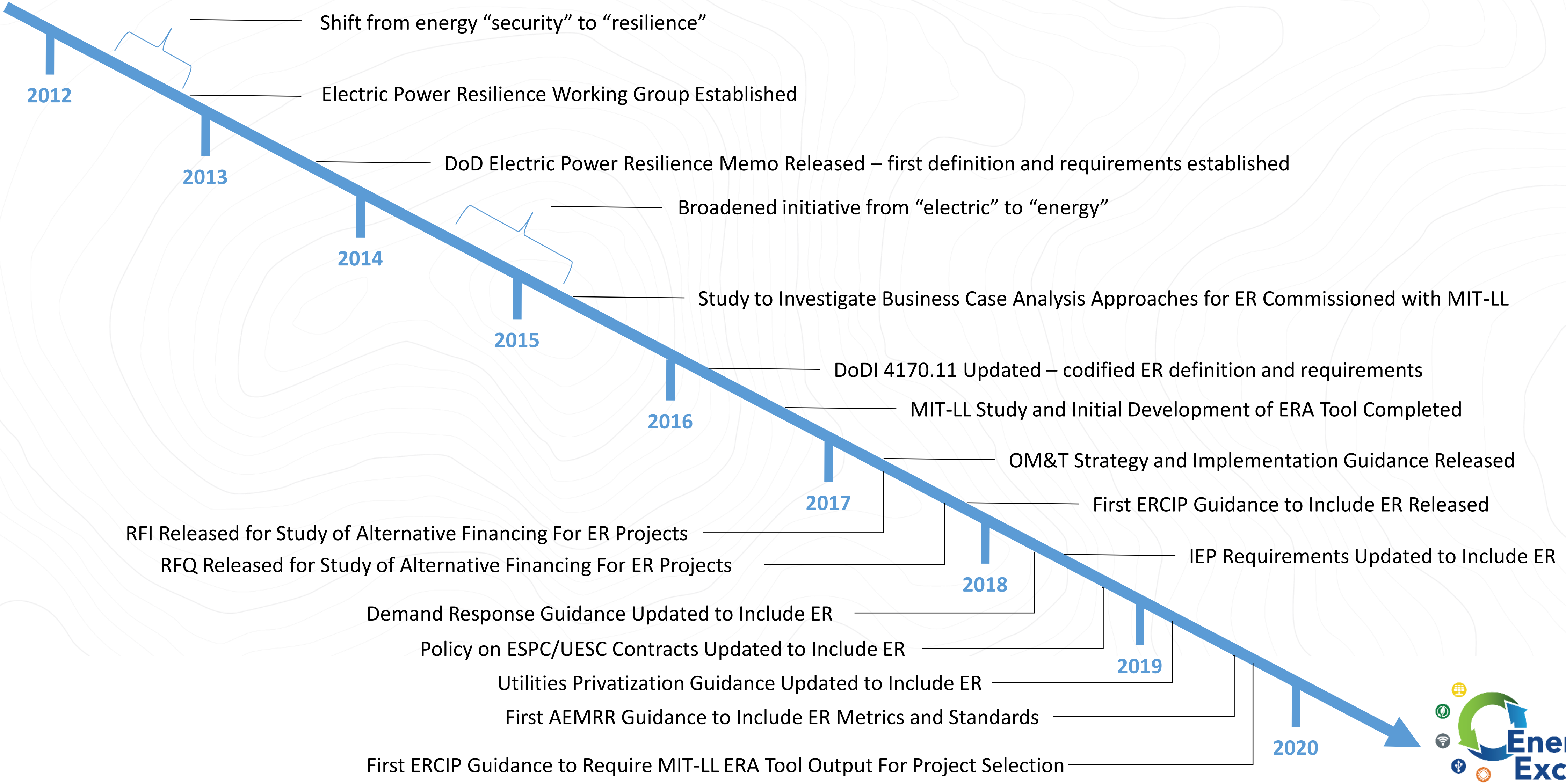
ODASD(Energy) Energy Resilience Timeline



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How do I evaluate ER metrics fairly in proposals?

RFI and RFP templates for cost based on mission requirements

Expected Life Cycle Costs ($ per kWh) to Deliver Energy Resilience Performance								
MW/Availability	90%	95%	97%	99%	99.9%	99.99%	99.999%	99.9999%
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Requesting total costs and dollars per energy unit protects the Government's financial interests, and aligns directly to mission requirements. Allows for technology agnostic comparisons to select best value technology to meet critical mission requirements.

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How do I build in ER metrics into contracts?

An Example – Concept Only

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.

DoD Lessons Learned

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

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:
   - <u>First</u> 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 <u>disruption</u> 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
6. Energy resilience metrics are needed to help right-size solutions that align to what our *<u>mission requires</u>*
   - 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?

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

Whatever the solution, don't forget about mission performance

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., downtime 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 and 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.

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