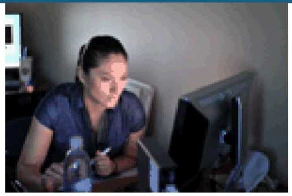
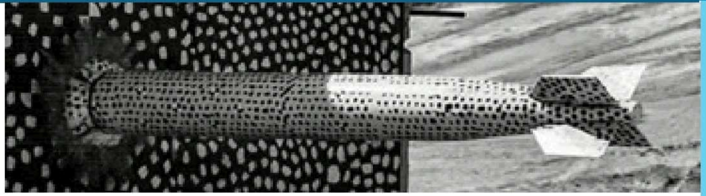
SAND2020-0166PE

Microgrid Feasibility Approach and Tools





Summer Ferreira Ph.D

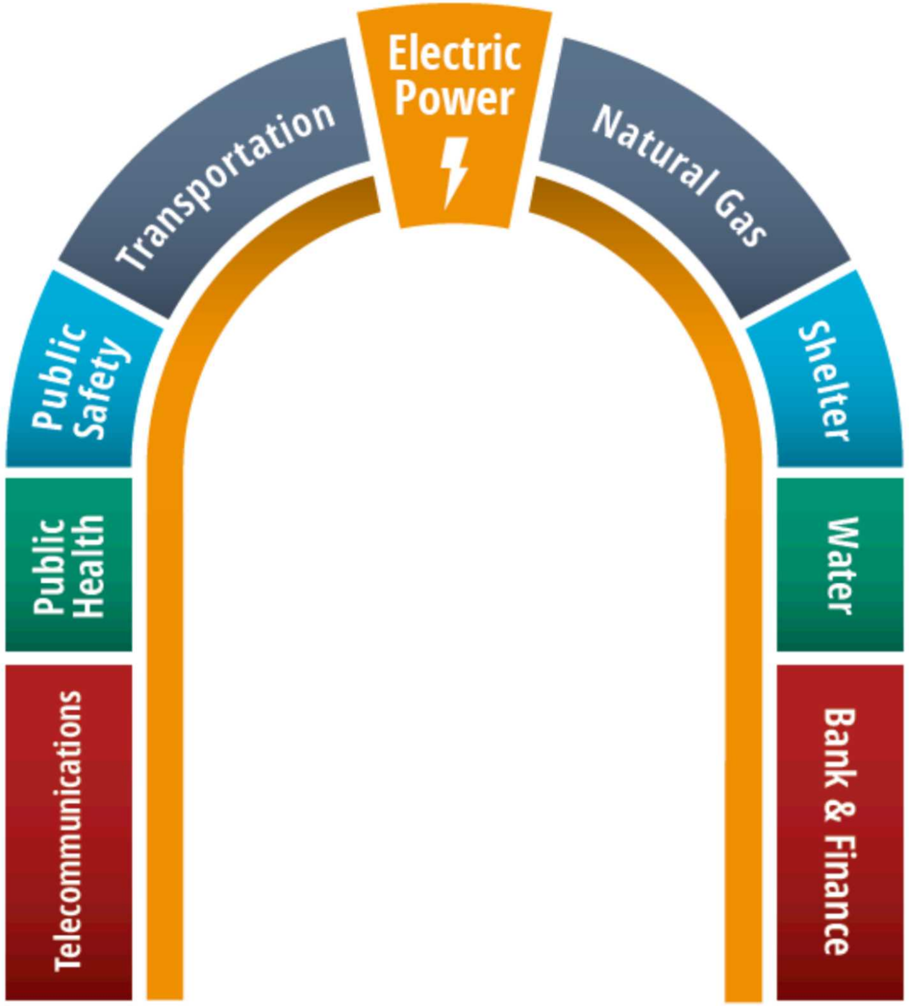
Manger Renewable and Distributed System Integration

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Microgrid Feasibility –Outline of existing work

- Resilience design from a consequence based approach-Leveraging resilient community approach for DOD areas
- Microgrid Design Tool –Applications to DOD installations
- Standards and Regulations for Microgrids—Where we are and gap areas

ENERGY RESILIENCE and COMMUNITY RESILIENCE



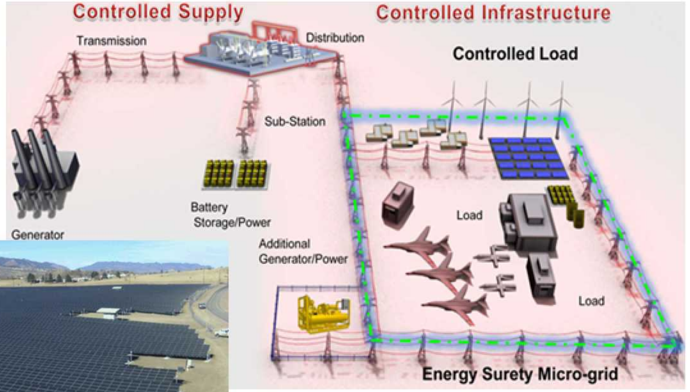
The grid is the keystone infrastructure – central to the web of interconnected systems that support life as we know it

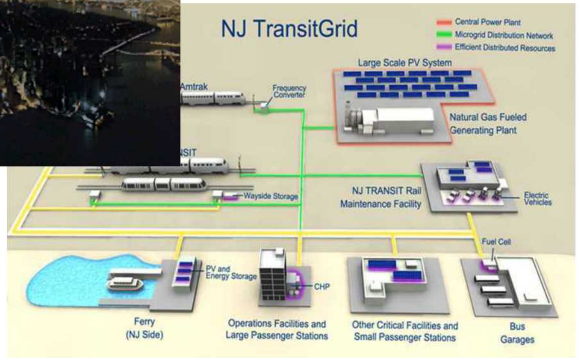
Sandia and Energy Resilience

Sandia National Laboratories is a national leader in the development of resilience solutions for Government and Civilian sectors

Broad applications and partnerships

- DOE, DHS and DOD
- Municipal and State agencies
- Research collaborations
- International interactions





Resilient Cities work

Project and Demonstration Partners

City + Utility Stakeholder Advisory Group

Input From Additional Stakeholders

Military Installations – SPIDERS

- SPIDERS built three microgrids, each with increasing capability, which function as permanent energy systems for their sites
  1. Joint Base Pearl Harbor Hickam
  2. Fort Carson
  3. Camp Smith

PACOM, NORTHCOM, DOE, DHS

DOE National Laboratories

Military Services

Military Facilities Organizations

Local Utility Companies

States of Hawaii & Colorado

SPIDERS Overview

PEARL HARBOR / HICKAM AFB CIRCUIT LEVEL DEMONSTRATION

- Renewables
- Storage
- Energy Management

FT CARSON MICRO-GRID

- Large Scale Renewables
- Vehicle-to-Grid
- Large scale storage
- Critical Assets
- Demonstration to tie in with COOP Exercise

CAMP SMITH ENERGY ISLAND

- Entire Installation Smart Micro-Grid
- Islanded Installation
- High Penetration of Renewables
- Demand-Side Management
- Redundant Backup Power
- Makana Pahili Hurricane Exercise

TRANSITION

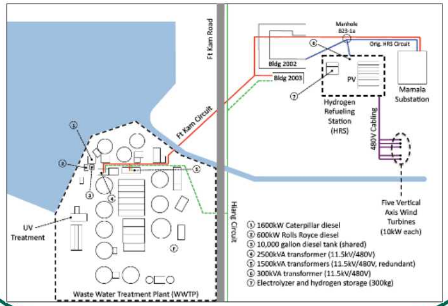
- Template for DoD-wide implementation
- CONOPS
- TTPs
- Training Plans
- DoD Adds Specs to GSA Schedule
- Transition to Commercial Sector via DOE
- Transition Cyber-Security to Federal Sector and Utilities

CYBER-SECURITY

SPIDERS Analysis Results

Pearl Hickam AFB

- Designed for:
  - The optimal mode of diesel generator operation
  - The size of the H_2 fuel cell
  - The mode of operation of the H_2 fuel cell
  - The amount of additional H_2 storage to install
- In order to Optimize:
  - Diesel Fuel Deferred (thus cost and CO_2 emitted)
  - Critical Load Not Served
  - Generator Efficiency



Fort Carson

- Designed for:
  - Use of the existing 2MW solar PV
  - Boundaries of the microgrid (what buildings to include)
  - Addition of energy storage system (sizing & placement)
  - Other backup generation options (additional diesels, etc.).
- In order to Optimize:
  - (thus cost and CO_2 emitted) Diesel Fuel Deferred
  - Critical Load Not Served
  - Generator Efficiency
  - Dispatch Minimization

Camp Smith

- Designed for:
  - Energy resources, existing and new
  - Load management by tier
  - Addition of new power plant along with feeder connections
- In order to Optimize:
  - Diesel Fuel Deferred (thus cost and CO_2 emitted)
  - Critical Load Not Served
  - Generator Efficiency
  - Capital costs

What is MDT and what is the Value Proposition

- MDT is a visual design and trade-space optimization capability for microgrids.

Using the MDT, a designer can:

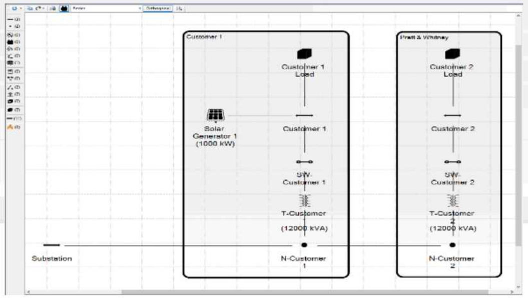
- Effectively search through very large design spaces for efficient alternatives
- Investigate the simultaneous impacts of several design decisions
- Have defensible, quantitative evidence to support decisions
- Identify “no brainer” choices to reduce the number of design considerations

History

- **SPIDERS** (2011)
- **DOE OE Funding** (2014)
- **v1.0 Publicly Released** (2016)
- **USMC SYSCOM Funding** (2016)
- **Use for GMLC and Others** (2017-*)
- **R&D 100 Award** (2017)

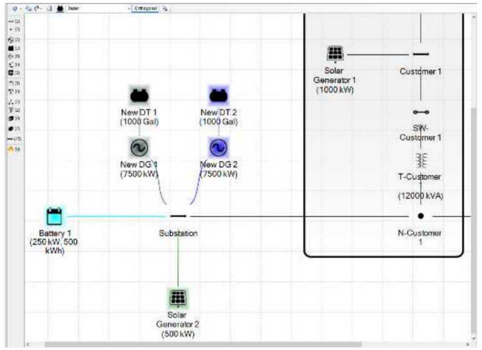
MDT Process

Define Baseline System



Investigate Results

Specify Design Options



Optimize

Define Design Objectives

Metric	Limit	Objective
Energy Availability	98%	99.999%
Fuel Burn Rate	100 Gal/hr	65 Gal/hr
Renewable Penetration	25%	60%

MDT Tool case studies

The US Marine Corps Expeditionary Energy Office (E2O) used the MDT to assess microgrid power systems and *Mobile Electric Hybrid Power Sources (MEHPS)* for expeditionary units and brigades.

Over **50 microgrid models** were developed in the MDT and used to provide design support for these islanded power systems.

The SPIDERS Program used a predecessor to the MDT to develop the preliminary microgrid designs for 3 military bases.

- Joint Base Pearl Harbor–Hickam
- Fort Carson
- Camp Smith

These microgrids are currently in operation on these installations

The City of Hoboken, NJ used a predecessor to the MDT to develop the preliminary microgrid design for backup power in response to Hurricane Sandy.

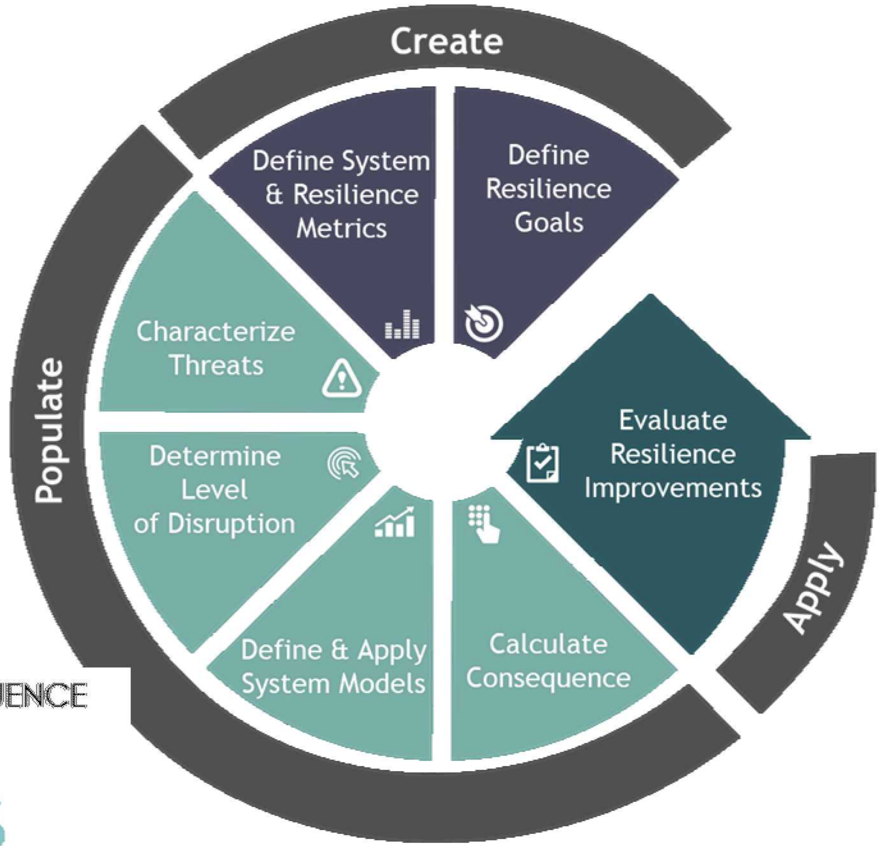
The primary goals of this design effort were to mitigate the impacts of extreme flooding on the distribution systems and electricity service throughout the city.

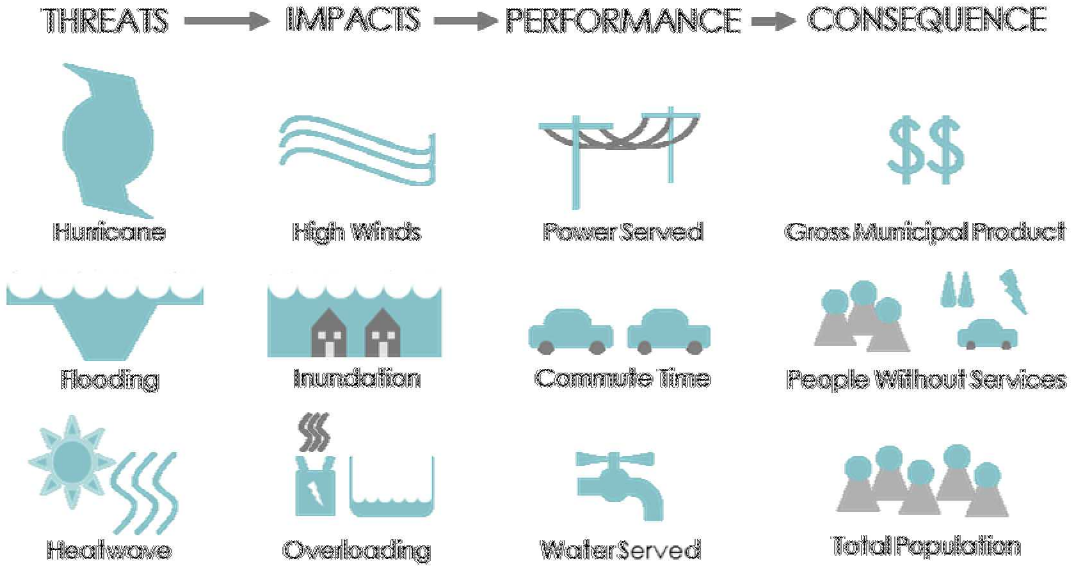
Other Past and Current uses of the MDT include:

- Remote community power system assessments for villages in Alaska (Shungnak, Cordova).
- A backup power system assessment and Microgrid Design of the UPS Worldport facility in Louisville, KY.
- A backup power system assessment and Microgrid Design of the city of New Orleans, LA.

Resilience Analysis Process

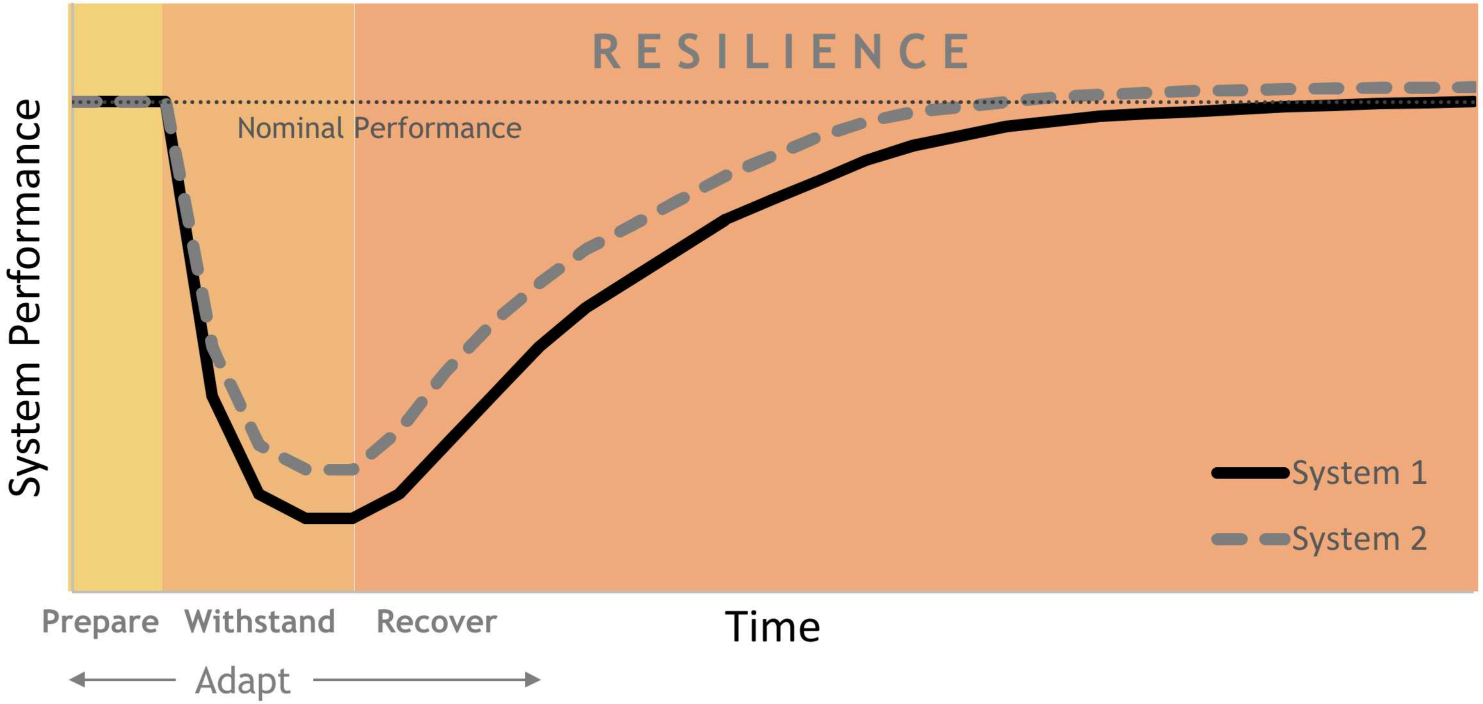
- Performance-based resilience metrics
- Threat-informed analysis
- Extending from performance to consequence
- Weighing resilience against other dimensions (e.g. efficiency)





Watson et al. (2014) Conceptual Framework for Developing Resilience Metrics for the Electricity, Oil, and Gas Sectors in the United States. SAND2014-18019

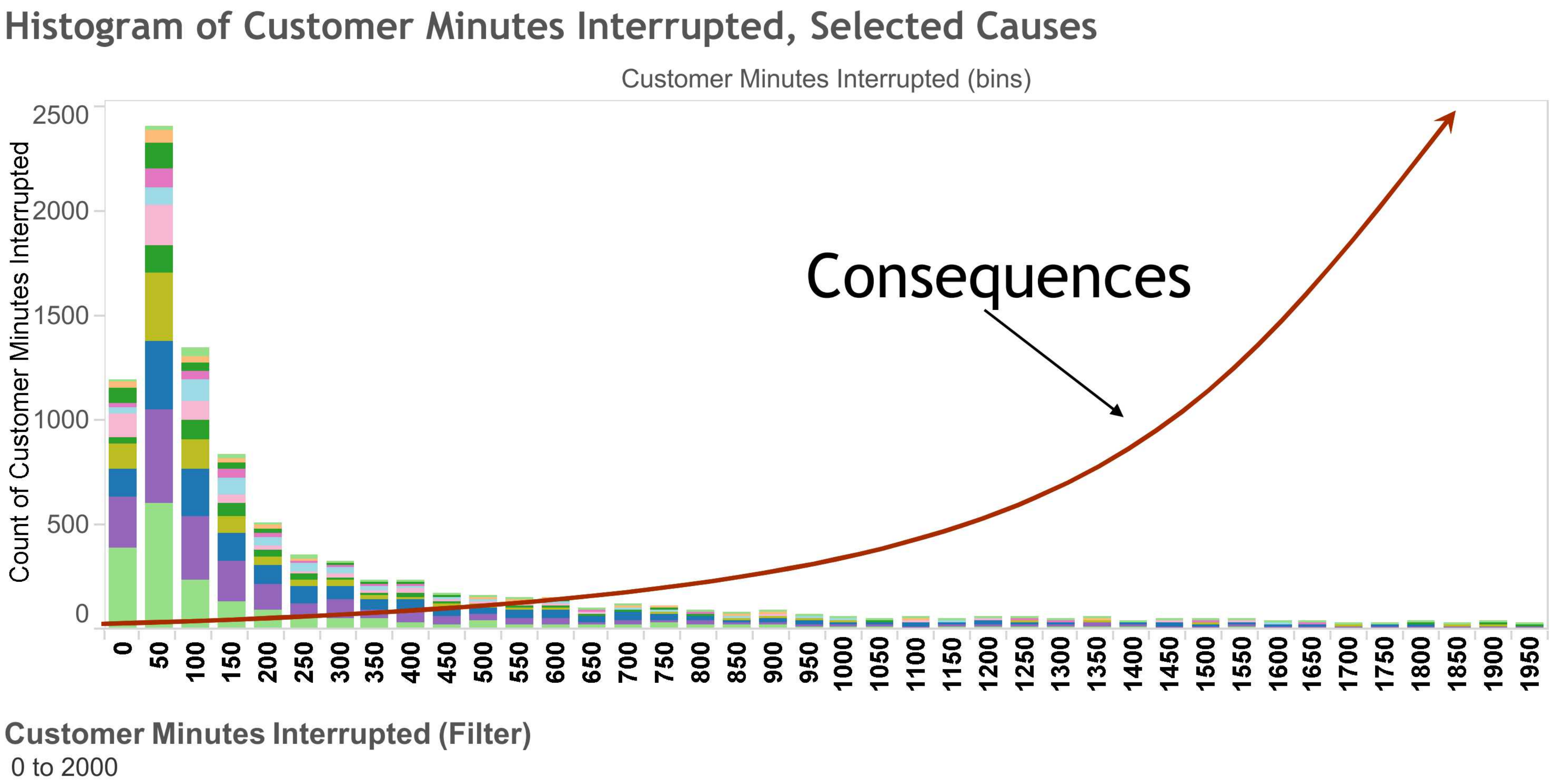
Mathematical Framework for Energy Resilience



1. Resilience is contextual – defined in terms of a threat or hazard
   - A system resilient to hurricanes may not be resilient to earthquakes
2. Includes hazards with low probability but potential for high consequence
   - Naturally fits within a risk-based planning approach

A resilient energy system supports critical functions by preparing for, withstanding, adapting to, and recovering from disruptions

RESILIENCE for GRID PLANNERS



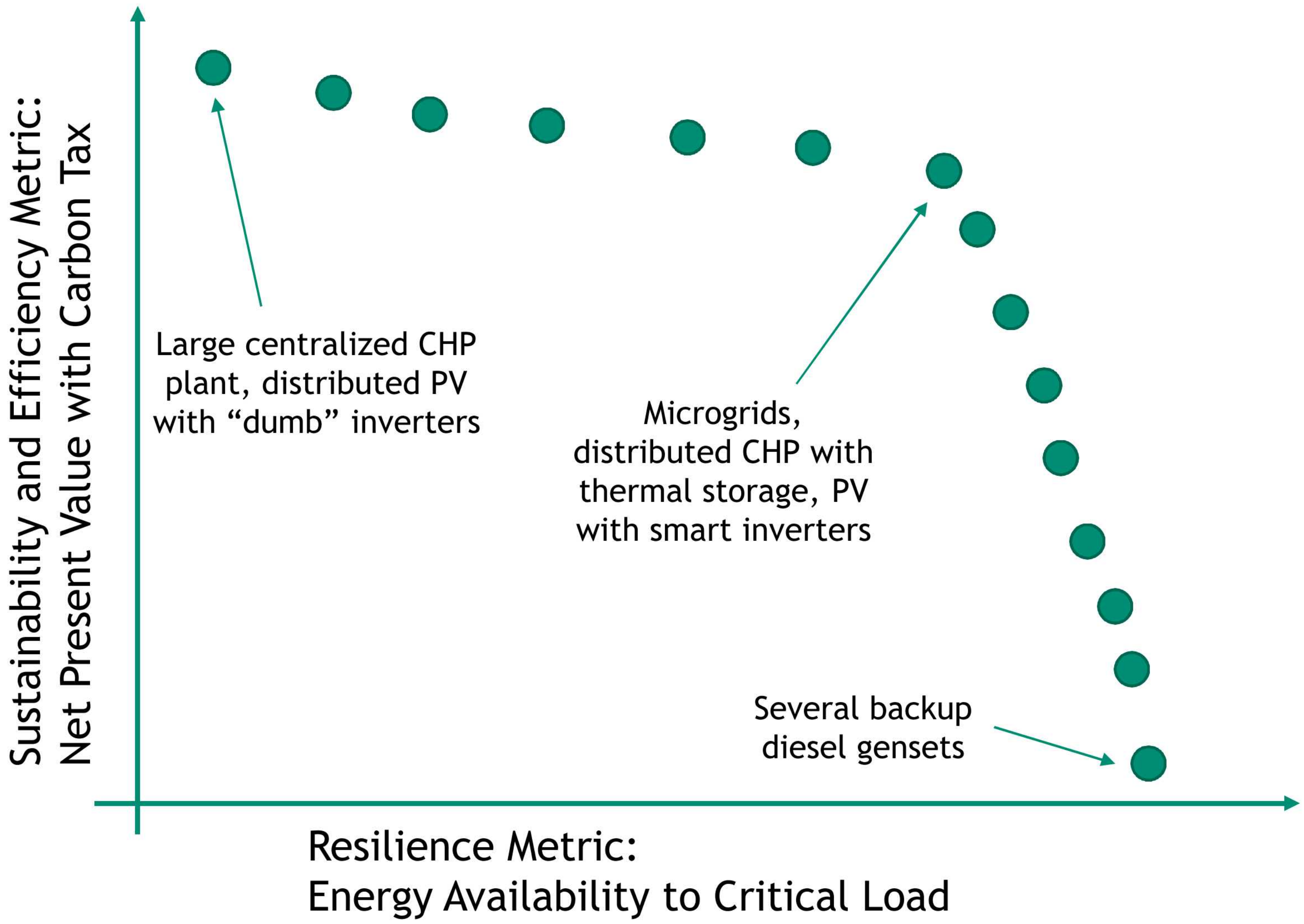
Power system planners currently use reliability metrics and criteria to ensure a reliable grid. There is no standardized or accepted practice for resilience.

QUANTIFYING CONSEQUENCE

Measure Classification	Common Examples
Community Measures	Number of People Without Necessary Services
	Lives at Risk
	Societal Burden to Acquire Services
Economic Measures	Gross Municipal Product / Net Economic Losses
	Change in Capital Wealth
	Business Interruption Costs
National Security Measures	…

Planners can be using metrics of consequence to their communities to define and plan for resilience

WEIGHING RESILIENCE AGAINST OTHER GOALS



Puerto Rico – Municipalities and Proposed Microgrid Locations

SNL and ORNL have partnered with the Puerto Rico Industrial Development Company (PRIDCO) to investigate the potential of industrial-scale microgrids in strategic locations on the island to bolster the resiliency of these and (potentially) surrounding locations.

GOVERNMENT OF PUERTO RICO
Department of Economic Development and Commerce

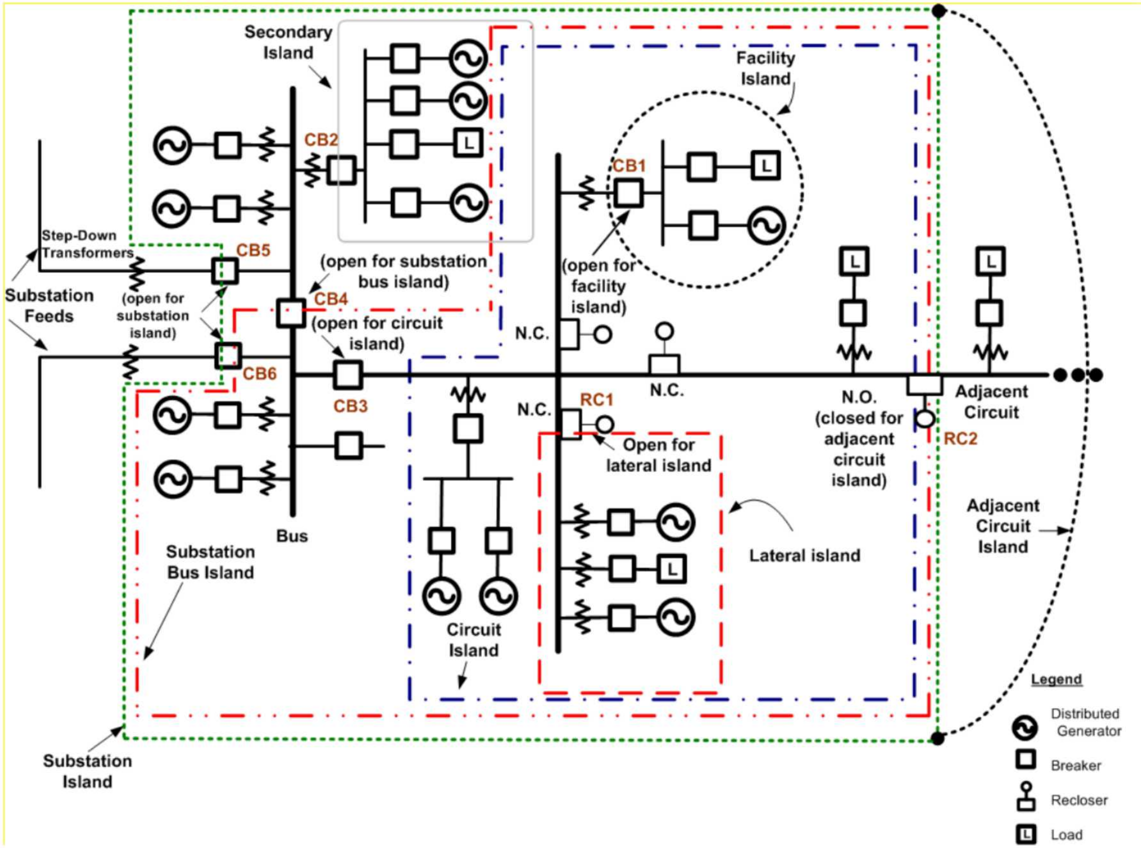
PRIDCO

Standards and Regulation considerations

IEEE 1547.4 Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power System.

Guide Covers:

- Impact on voltage, frequency, and power quality
- Inclusion of point of common coupling
- Protection schemes and modifications
- Monitoring
- Information exchange and control
- Load requirements of customer
- Understand characteristics of DER
- Identifying steady-state and transient conditions
- Understanding interactions between devices
- Reserve margins, Load shedding, demand response, cold load pickup



Normal Mode of Operation

- Grid-connected and operating in accordance of 1547-2018
- Knowledge of system operation facilitates smooth transfer

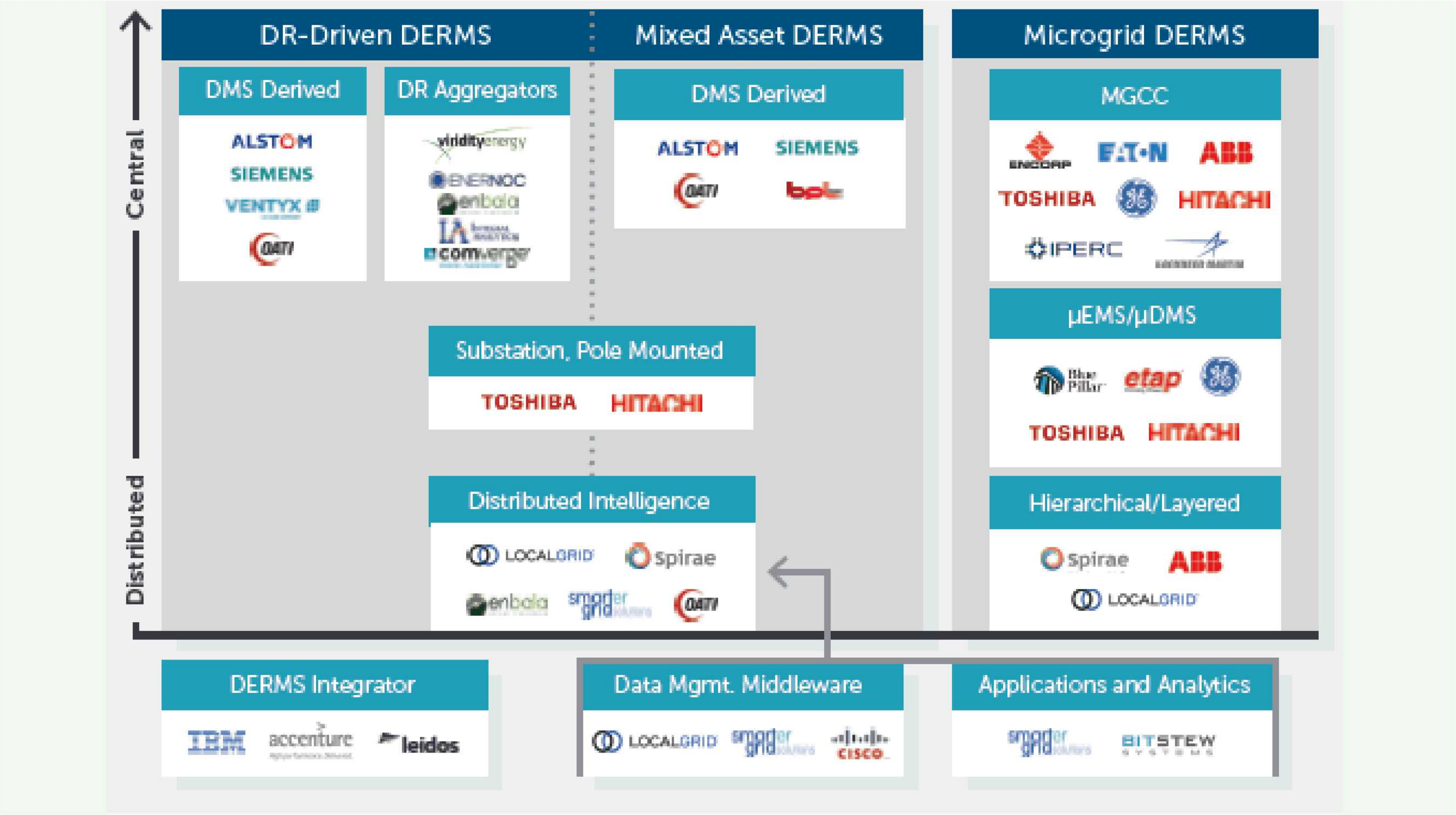
Transition results from scheduled or unscheduled events

Standards and Regulations

DERMS Vendor Taxonomy

Source: GTM Research

Vendors approach this market with a variety of perspectives and diverse experiences.



Standards and Regulations – IEEE 1547/1547.4

- IEEE 1547 –All grid connected assets must meet IEEE 1547.
  - Areas that need exploration are synchronization for connection after black start.
  - Protections of microgrid assets
- IEEE 2030 –A system of systems approach to smart grid interoperability lays the foundation on which IEEE Std 2030 establishes the SGIRM as a design tool that inherently allows for extensibility, scalability, and upgradeability. The IEEE 2030 SGIRM defines three integrated architectural perspectives: power systems, communications technology, and information technology.
- IEEE 519 and 1459 –There is controversy about the application of power quality standards like which has not been resolved.

Conclusions

Significant learning from previous microgrid designs, existing system integration standards that pertain to microgrids, and resilience metrics work can be applied, or adapted in DOD applications

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