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Sandia National Laboratories

RESILIENT COMMUNITIES:
A consequence-based approach, microgrids, energy storage, and power electronics

PRESENTED BY

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Grid Reliability is Not Enough

North American Electric Reliability Corporation (NERC) defines grid reliability as a combination of grid adequacy (having sufficient generation to meet load) and grid security (having the ability to withstand disturbances).

Conceptually sound but incomplete framework for the nation's 21st century smart grid

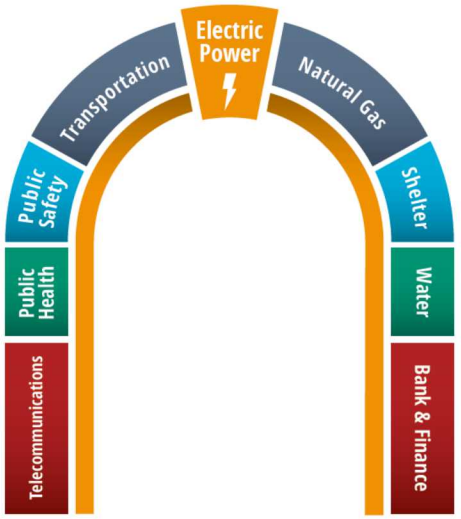
Our nation requires a grid that adapts to:

- Large-scale environmental and unnatural events
- Remains operational in the face of adversity
- While minimizing the catastrophic consequences that affect the quality of life, economic activity, national security, and critical-infrastructure operations.

Concept of Reliability must be augmented with resiliency approach

- One that looks at the grid not strictly as a flow of electrons but as a grid that serves and impact people and societies in multiple ways (electric power, water, sewages, shelter, medical, food, transportation, etc.).
- It is the consequences, not outages per se, that matter.

Understanding the Consequences



The complex network of electrical infrastructure is critical to

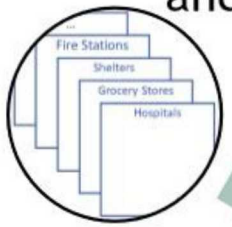
- Economic well-being
- Quality of life
- Keystone and central to interconnected systems that support life as we know it
- Grid owners and operators work hard to ensure reliable operation and able to withstand the effects of any single component failure.

To strengthen the grid resilience or ability to minimize the consequences of extreme weather (hurricanes, floods, forest fire, etc.) or malicious physical or cyber-attacks grid planners and operators must

- Understand the consequence of specific threats to the system
- Have the ability to prepare and react to them

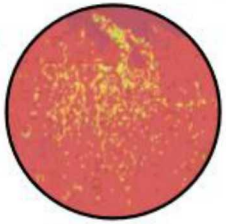
Sandia Analysis Process

1 Infrastructure Data and Threat Analysis

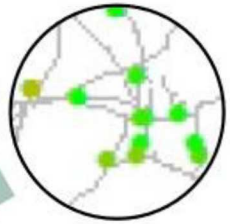


2 Determine Locations Providing High Service Levels

Tool: ReNCAT

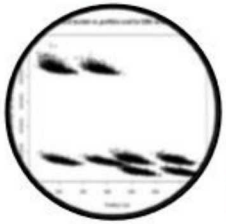


3 Examine Candidate Microgrid Locations



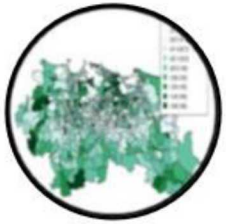
4 Finalize Candidate Microgrid Locations

5 Cost/Benefit Tradeoff Analysis



6 Visualize Metrics and Resilience Options

Tool: MPEx



Resilient Community

Sandia is working several utilities to enhance resilience of the grid

- American Electric Power – analyzing resilience against extreme weather events and physical security threats and providing cost effective planning and operational solutions to maximize resilience to the events.
- New Jersey Transit Corporation – helped developed the nations largest electric microgrid after Superstorm Sandy.
- City of New Orleans and Entergy – develop priority distribution upgrades and advanced microgrid pilot projects that help bolster community-level resilience.

Others include:

- Pittsburg and Duquesne Light
- National Grid
- San Antonio and CPS Energy
- PREPA

GMLC activities:

- Foundational Resilience Metrics Project – standardize resilience metrics within DOE and in the future to utilities and regulators.
- Designing Resilient Communities Project – developing a process for utilities and cities to work together on population these standardized resilience metrics with an eye toward getting cost recovery from the regulator for a resilient investment.

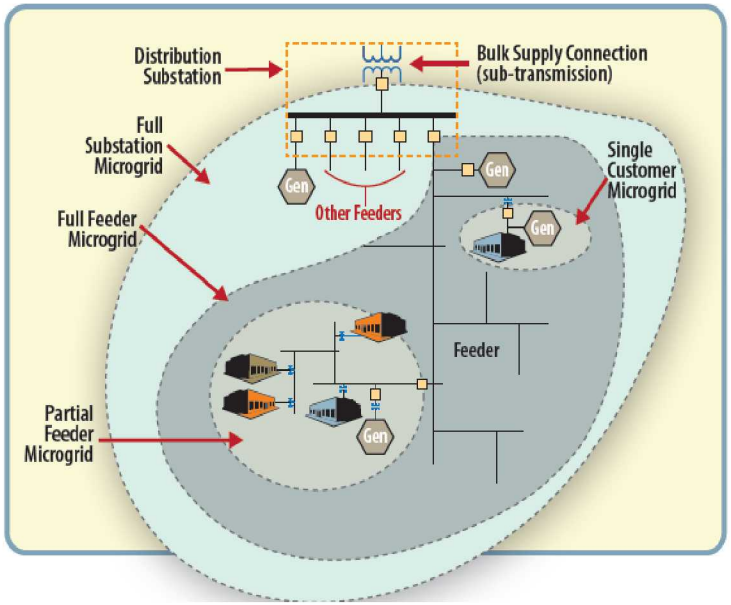
Microgrid – Resilience Nodes

Microgrid – hardened electrical infrastructure that the connects multiple buildings through a system of localized power generation and automatic controls, ensuring access to electricity for these buildings even if the bulk of the city's power grid goes down.

- Local generation – thermal sources (natural gas or biogas generators and renewables)
- Consumption – electricity, heat, and cooling
- Energy Storage and Power Electronics - power quality, frequency and voltage regulation, power smoothing, backup, etc.

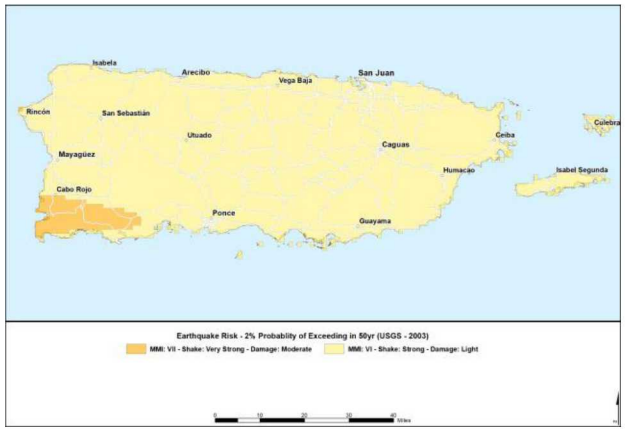
Sandia calls these microgrid hubs "resilience nodes"

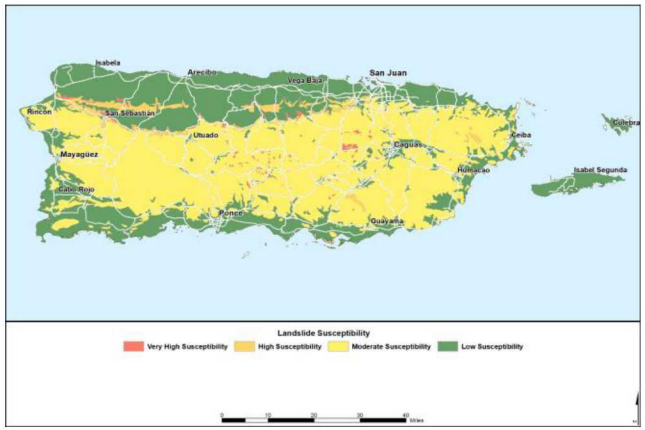
- Improves the availability of essential services (electric power, drinking water, sewerage, medical services, food, transportation, etc.) to nearby neighbors by enabling enhanced adaptation, response and recovery from electric grid disruptions

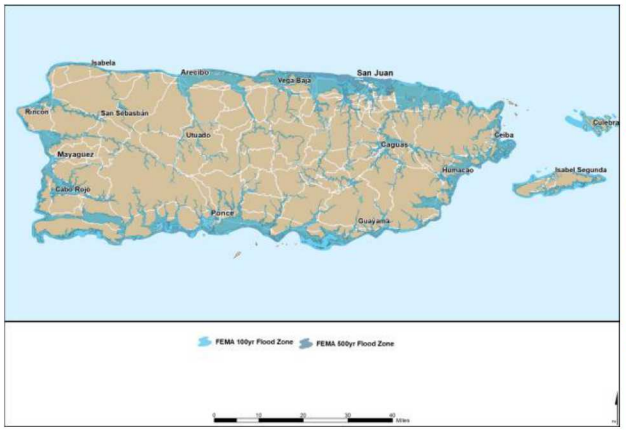


Microgrid Design Toolkit – decision support software tool for microgrid designers in the early stages of the design process.

Threat Characterization



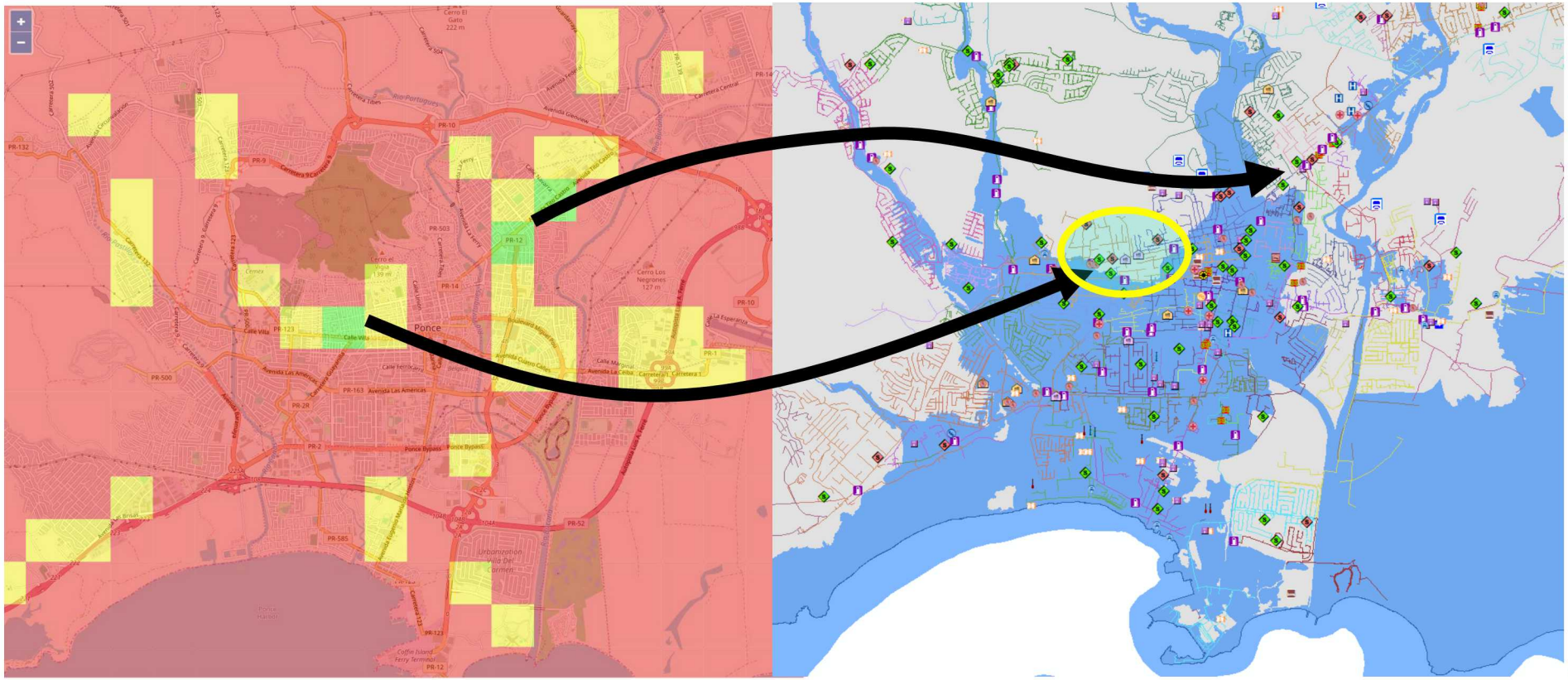




Hazard	Source	Threat Profile Used	50-yr Probability of Exceedance	Link
Flooding	FEMA FIRM	100-yr and 500-yr (return period)	39% (100-yr) 9.5% (500-yr)	www.fema.gov/flood-mapping-products
Wind	ASCE	100-yr and 700-yr (return period)	39% (100-yr) 6.9% (700-yr)	windspeed.atcouncil.org/
Landslide	USGS	Susceptibility: highest, high, moderate, low	N/A	pr.water.usgs.gov/public/online_pubs/mism_i_1148/index.html
Earthquake	USGS	Structure Damage: Moderate, Light	2%	earthquake.usgs.gov/hazards/hazmaps/islands.php#prvi

Jeffers et al. (2018) Analysis of Microgrid Locations Benefitting Community Resilience for Puerto Rico. SAND2018-11145

Filtering of Highest-Value Microgrids



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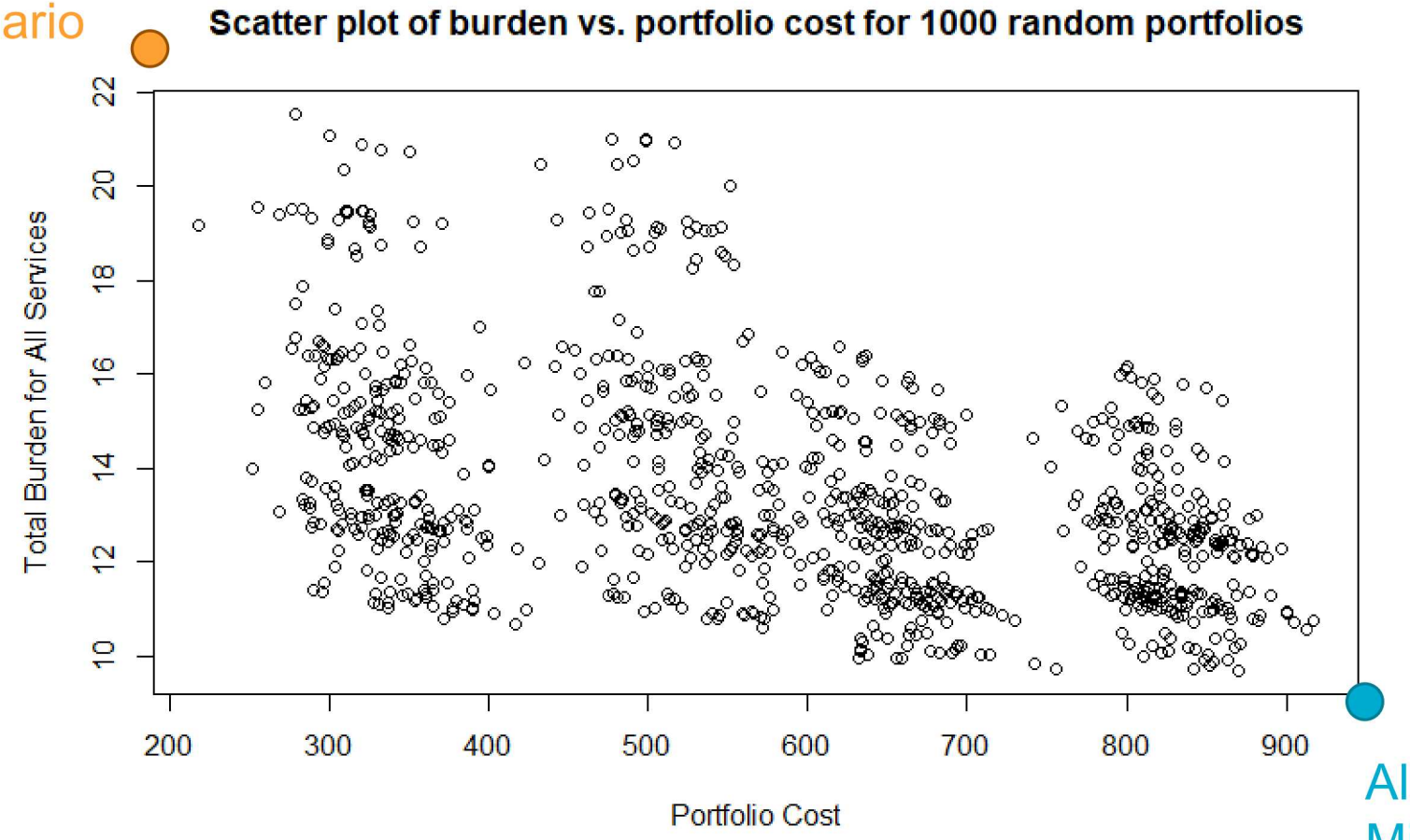
Portfolio evaluation

"Do nothing" scenario



All Microgrids

A large decrease in burden can be achieved for relatively low cost compared to all microgrids

Contacts and Additional References

Sandia Grid Resilience

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Energy Storage and Power Electronics

- Stan Atcitty, 505-284-2701, satcitt@sandia.gov

References

- R. F. Jeffers, M. J. Baca, et al, "Analysis of Microgrid Locations Benefitting Community Resilience for Puerto Rico", SAND2018-11145, Sept., 2018
- R. F. Jeffers, M. Hightower, et al, "A Grid Modernization Approach for Community Resilience: Application to New Orleans, LA", SAND2017-11959, Oct., 2017
- Link for Grid Resilience at Sandia, https://energy.sandia.gov/energy/ssrei/gridmod/resilient-electric-infrastructures/
- Article on New Orleans work, https://www.energy.gov/articles/strengthening-community-resilience-new-orleans
- Link for Energy Storage and Power Electronics at Sandia, https://www.sandia.gov/ess-ssl/