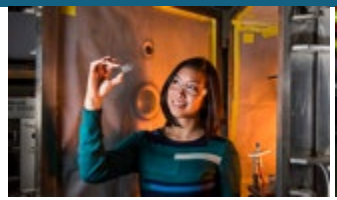
Sandia National Laboratories

DESIGNING RESILIENT COMMUNITIES:
Review Project Objectives and SAG Vision



PRESENTED BY

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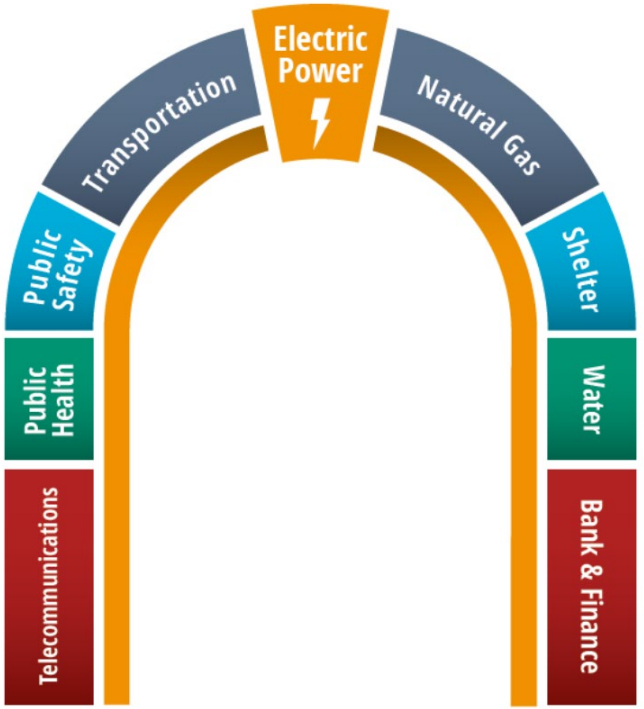
Goals and Objectives

ENERGY RESILIENCE enables COMMUNITY RESILIENCE

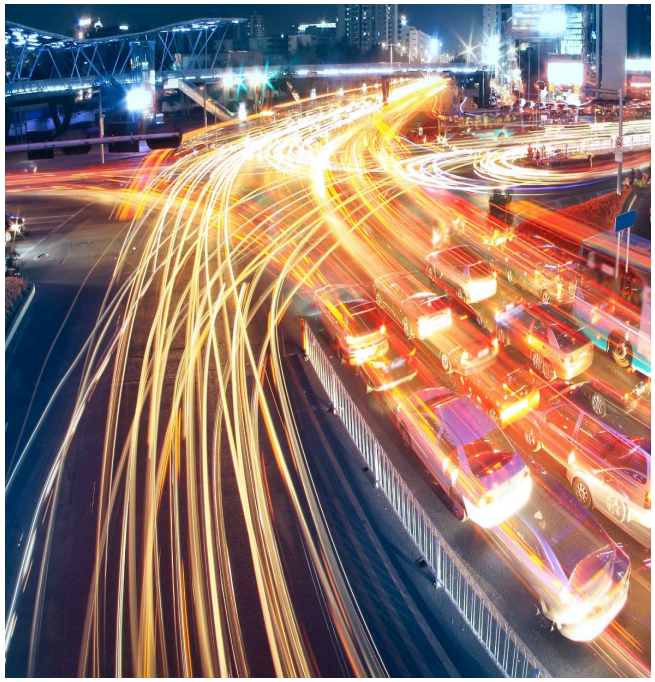
- We are using definition PPD 21 – resilience defined in context of multiple hazards, but not to be confused with sustainability and efficiency which are also important
- Grid planners are intimately familiar with reliability-focused planning – SAIDI and SAIFI metrics based on a collection of outages
- City planners may desire to keep critical services provided to the community
- Where do these metrics meet? It's in the loads, the feeders, the critical components of the grid that support our lives more than energy sales currently reflect



Goals and Objectives

CITIES PROVIDE OPPORTUNITY for ACTIONABLE ANALYSIS

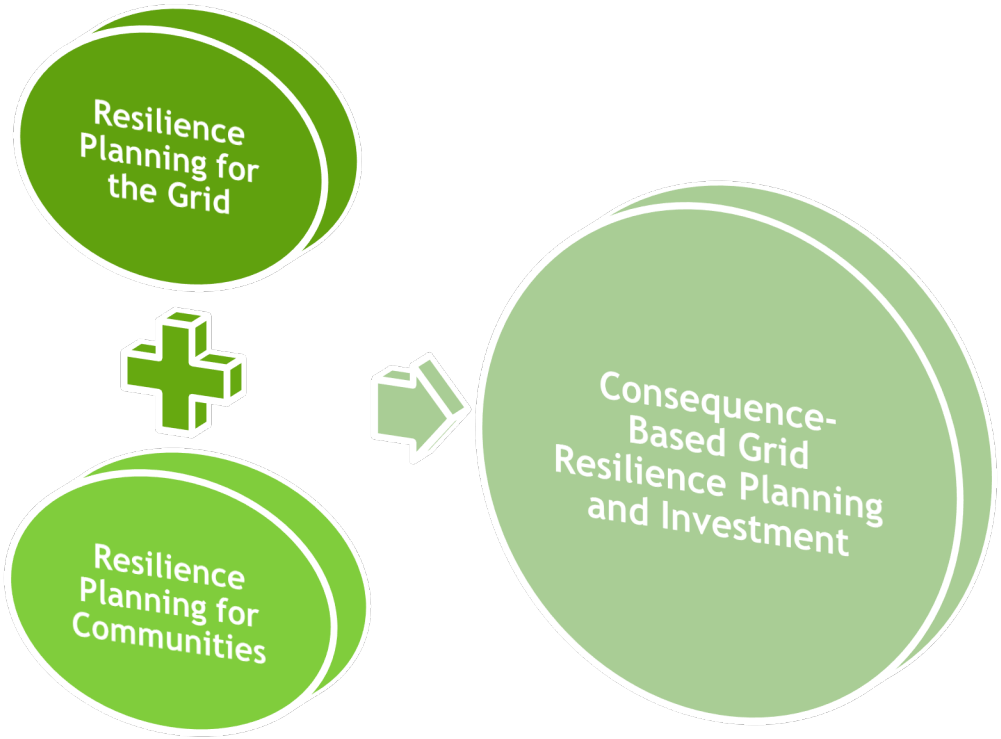
- Cities are where the rubber meets the road for improving the lives of people through investment in infrastructure resilience.
- Cities provide the opportunity for actionable analysis.
- Cities and their infrastructure owners are the first line of defense against major disruptions



DESIGNING RESILIENT COMMUNITIES OVERVIEW

Objectives:

1. Design, validate, and release a framework for alignment of community resilience planning and grid investment planning
2. Demonstrate – with two city/utility pairs – how to overcome the most critical technical challenges to (1)
3. Analyze – alternative regulatory frameworks and utility business models that may better internalize resilience benefits
4. Build – one or more community resilience nodes enabled by distributed energy resources



We are here today to begin to accomplish objective (1), while informing objectives (2), (3), and (4)

Designing Resilient Communities
Approach

GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Task 1: Development of a national framework for integrated, consequence-focused resilience planning

Resilient Community Design Framework

1. Determination of Resilience Drivers

- Determine Resilience Metrics and Threats
- Threat and Impact Forecasting

Stakeholders Engaged

- Local Government
- Electric Utilities
- State/Local Regulators
- Community Groups
- Infrastructure Owners

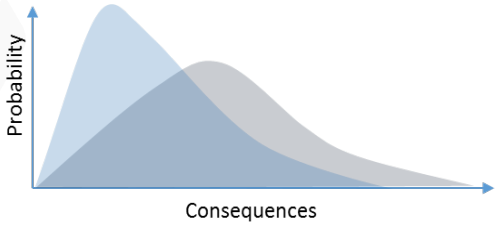
3. Resilience Alternatives Specification

- Resilience Technology Screening
- Regulatory Framework Screening
- Resilience Service Screening

2. Community Resilience Analysis

- Multi-Infrastructure Performance Analysis
- Consequence Estimation

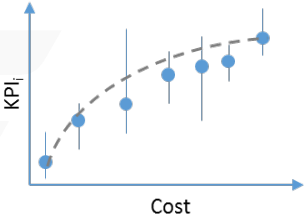
Resilience Performance Metrics



4. Evaluation of Resilience Alternatives

- Translation to Stakeholder KPI's
- Calculate Co-benefits (Reliability, Cost of Service, etc)
- Multi-Stakeholder Cost-Benefit
- Multi-Criteria Portfolio Evaluation

Portfolio Evaluation



Stakeholder Advisory Group Vision

To create and hold four national outreach meetings with a Stakeholder Advisory Group (SAG) that will inform the technical and policy solution space for designing resilient communities

1. Sandia and 100RC formed a Stakeholder Advisory Group (SAG) to inform the development and validation of the Resilient Community Design Framework.
2. SAG members can provide invaluable feedback regarding the unique aspects of their jurisdictions that enable or discourage alignment of community-focused resilience planning with electric utility investment.
3. SAG meetings provide opportunities for project partners to learn from each other and provide information about emerging methodologies and technologies that can enhance grid and community resilience elsewhere in the nation.
4. The input from the SAG informs our framework to align community resilience planning and grid investment planning and guide our work with partners.

SANDIA and 100 RESILIENT CITIES

Sandia is working with the Department of Energy and 100 Resilient Cities to bring actionable resilience analysis to cities

Key areas of concentration identified in July 2018 SAG Meeting

1. Defining, valuing and measuring resilience a clear need
2. Engaging stakeholders – the SAG has inherent value
3. Implementation - who does what in the process?
4. Rethinking regulatory frameworks and business models
5. Developing technical capabilities, especially to value a resilient grid's community benefits

HAWAII TACKLING REGULATION FOR RESILIENCE

BOSTON SMART UTILITIES VISION

NEW YORK INCREASING COORDINATION WITH CON EDISON

NORFOLK ST PAUL'S REDEVELOPMENT

Developing a Framework for Resilient Community Design

Determine Resilience Drivers

- Determine resilience metrics and threats
- Threat and impact forecasting

Community Resilience Analysis

- Multi-infrastructure performance analysis
- Consequence estimation

Resilience alternatives specification

- Resilience technology screening
- Regulatory framework screening
- Resilience service screening

Evaluation of resilience alternatives

- Translation to stakeholder KPIs
- Calculate co-benefits
- Multi-stakeholder cost/benefit
- Multi-criteria portfolio evaluation

What's different?

- Focus on measuring, predicting, and improving community performance during disruptions
- Link between grid performance and community performance is explicit
- No distinction between T vs. D investment
- Allows consideration of alternative regulatory approaches and alternative utility business models
- Resilience benefits ADD to blue-sky benefits (and could amplify)

Convergence on a common metric

- Resilience metrics can be used within multiple planning processes
- Each jurisdiction chooses the metric that works for them
- Within a jurisdiction, the metric is consistent and agreed upon

Electric Utility

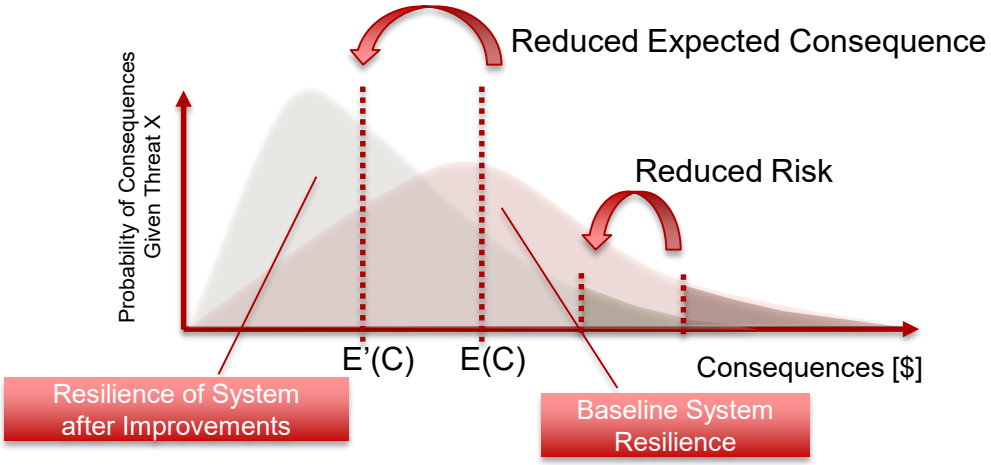
- Integrated Resource Planning and Capacity Expansion
- Integrated Distribution Planning
- Alternative Business Models and Retail Services

City Government

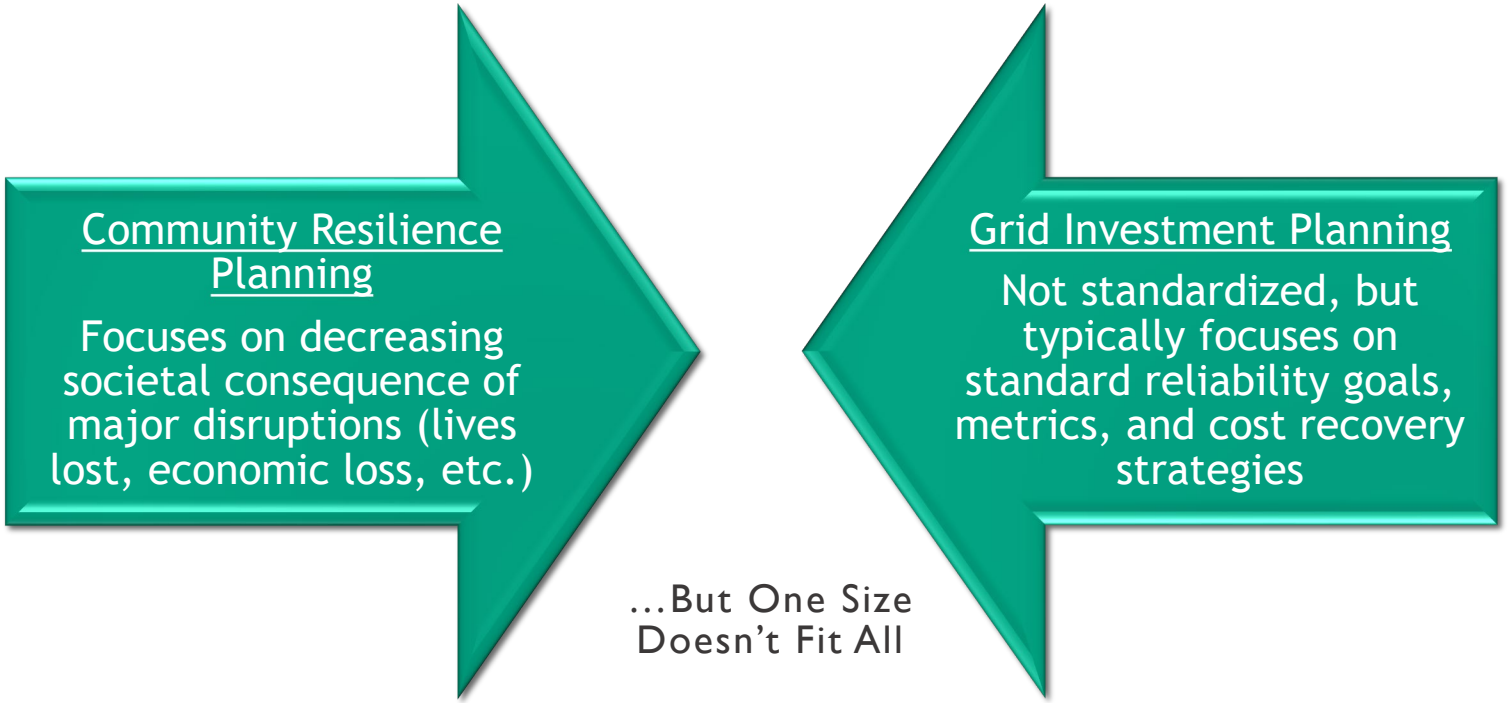
- Resilience and Mitigation
- Emergency Operations
- Sustainability
- Transportation
- Water/Wastewater
- Economic Development

Utilities Regulator

- Individual investment approval
- Rate Cases
- Integrated Resource Planning
- Alternative Regulatory Frameworks



Energy Resilience Supports Community Resilience…



Resilience shocks and stresses (regional differences in hazards, economic, political)

Electric utility configuration (municipal, investor-owned, cooperative) and horizontal/vertical integration

Resilience Metrics in Action

Supporting microgrid investment in Puerto Rico

Microgrid Benefit

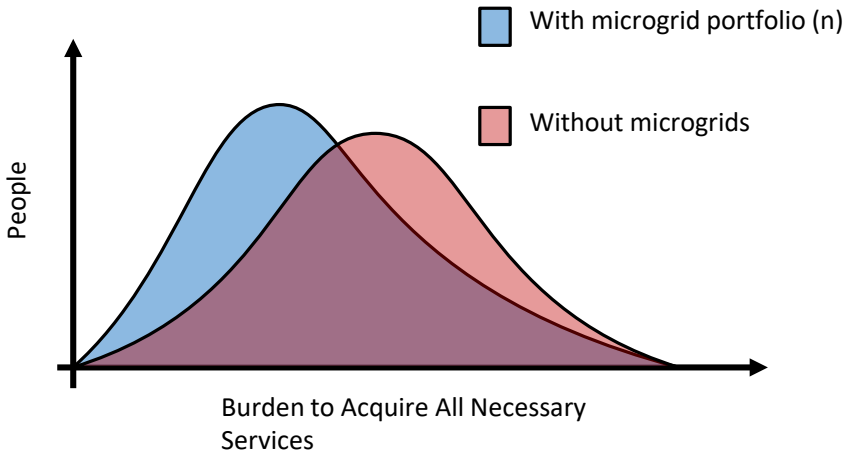
Goal is to:

- Assess microgrid impact resilience
- Choose optimal portfolio given all potential options

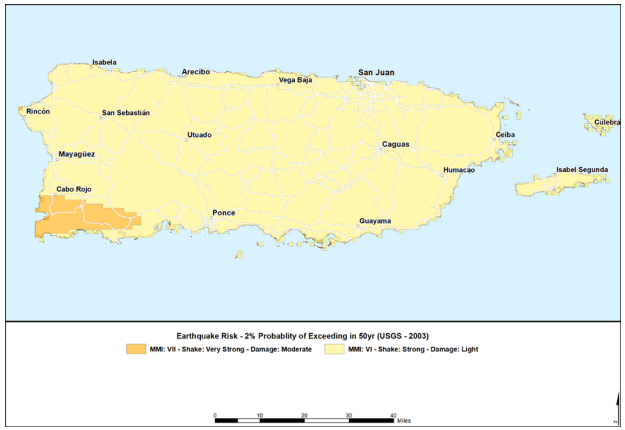
Effort
Average distance traveled to acquire service

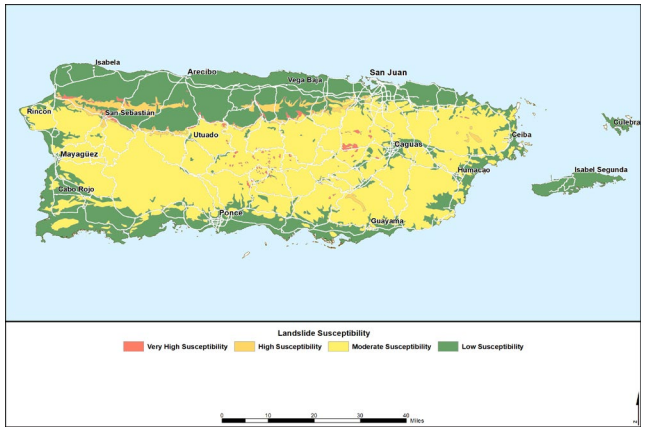
Ability
Median household income for census block group

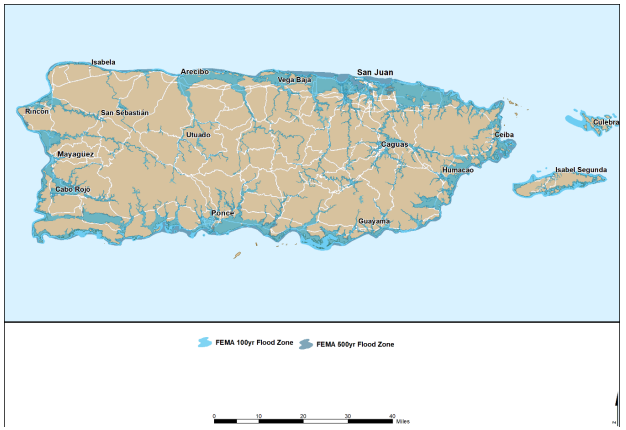
→ **Burden**



Threat Characterization

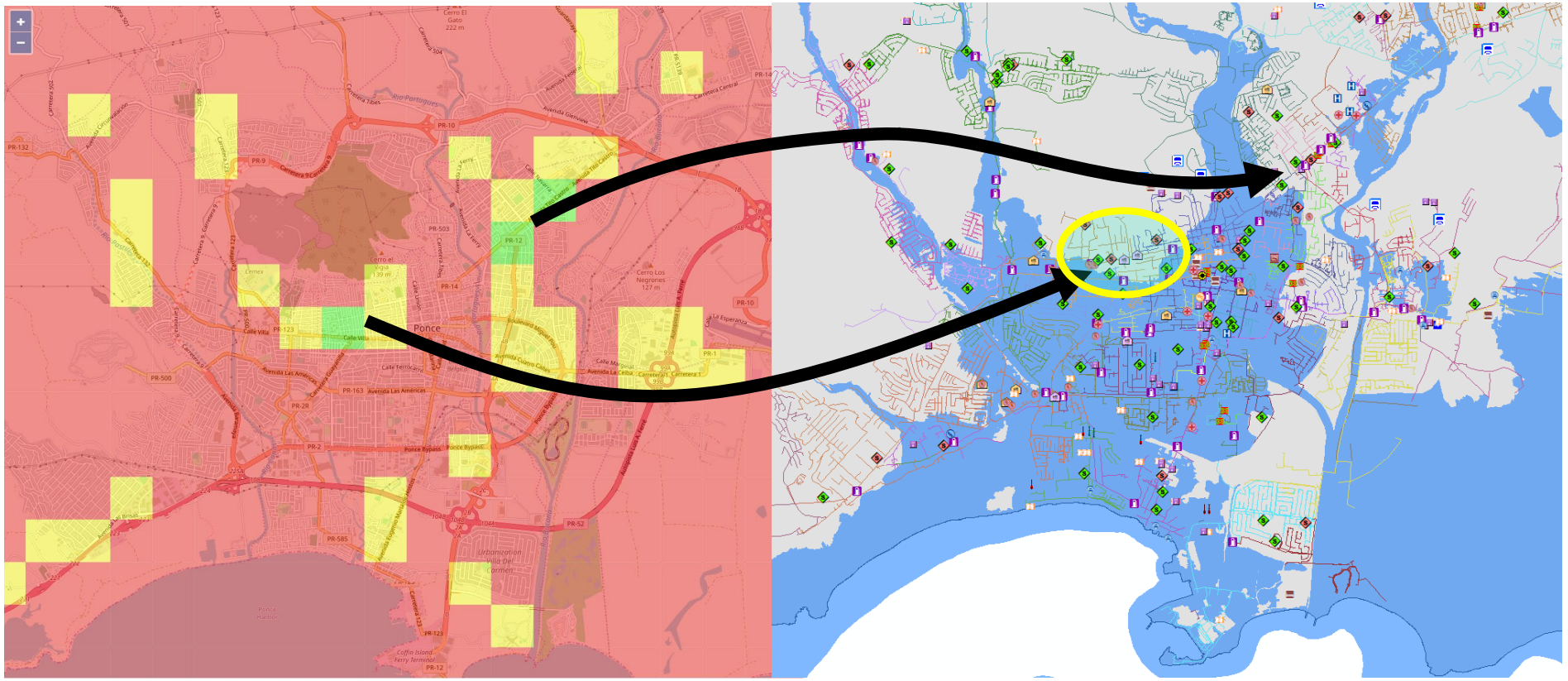




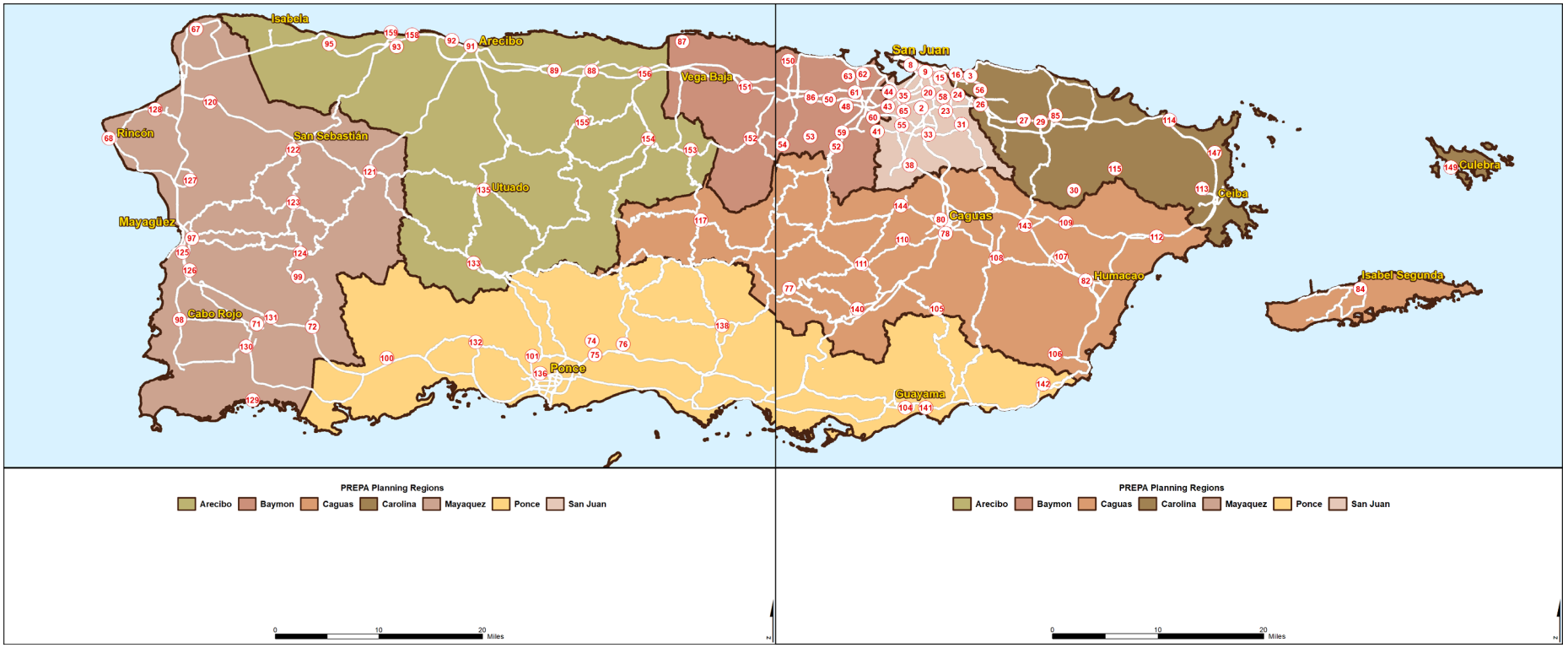


Hazard	Source	Threat Profile Used	50-yr Probability of Exceedance	Link
Flooding	FEMA FIRM	100-yr and 500-yr (return period)	39% (100-yr) 9.5% (500-yr)	www.fema.gov/flood-mapping-products
Wind	ASCE	100-yr and 700-yr (return period)	39% (100-yr) 6.9% (700-yr)	windspeed.atcouncil.org/
Landslide	USGS	Susceptibility: 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

Filtering of Highest-Value Microgrids



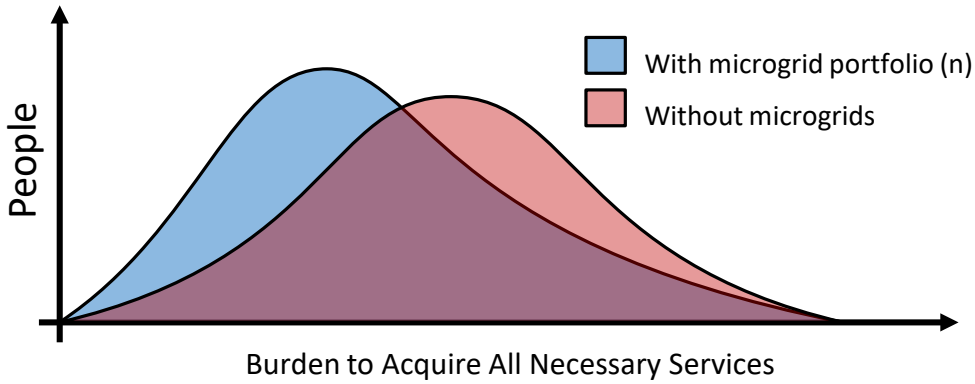
Design of Microgrid Alternatives



159 locations in total

Infrastructure Performance -> Societal Consequence

Advancing metric calculation for grid investment portfolio evaluation

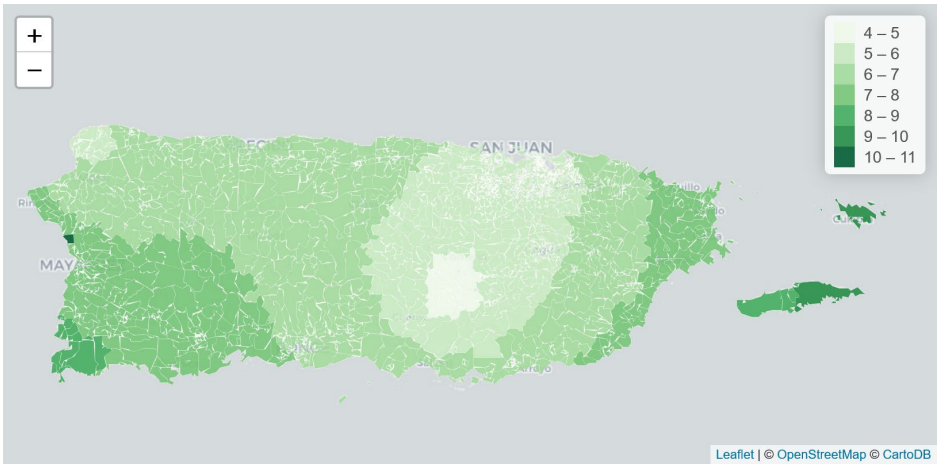


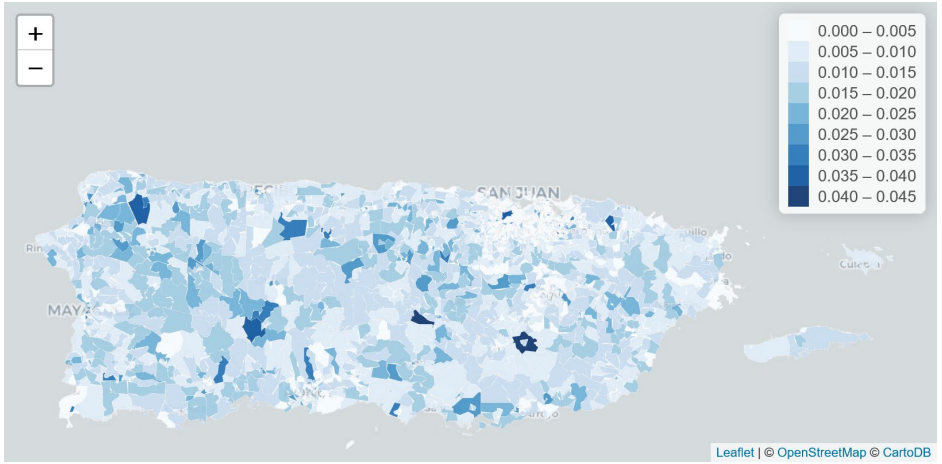
$$B_C = \sum_{inf} \sum_{pop} \frac{E_{inf,pop}}{A_{pop}}$$

Effort
Average distance traveled to acquire service

Ability
Median household income for census block group

→ **Burden**

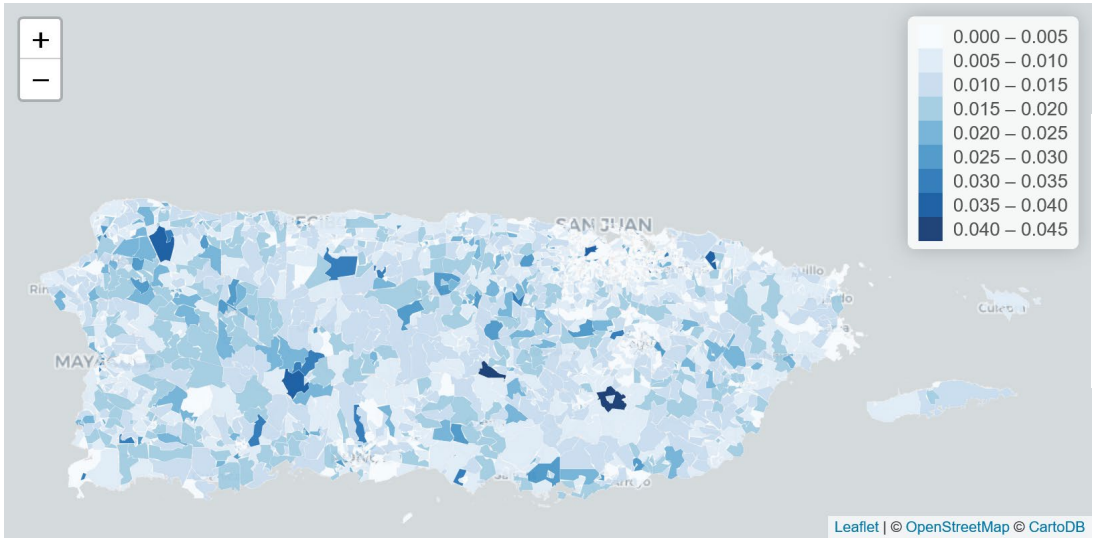




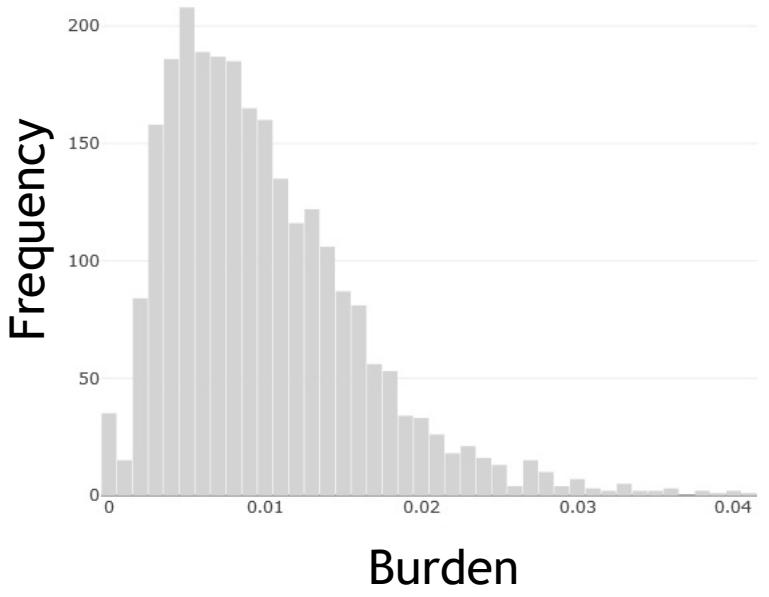
Jeffers et al. (2018) Analysis of Microgrid Locations Benefitting Community Resilience for Puerto Rico. SAND2018-11145

Baseline Resilience

Map of Total Burden to Acquire All Services in the Baseline Scenario (No Microgrids Built)



Histogram of Burden to Acquire All Services in the Baseline Scenario



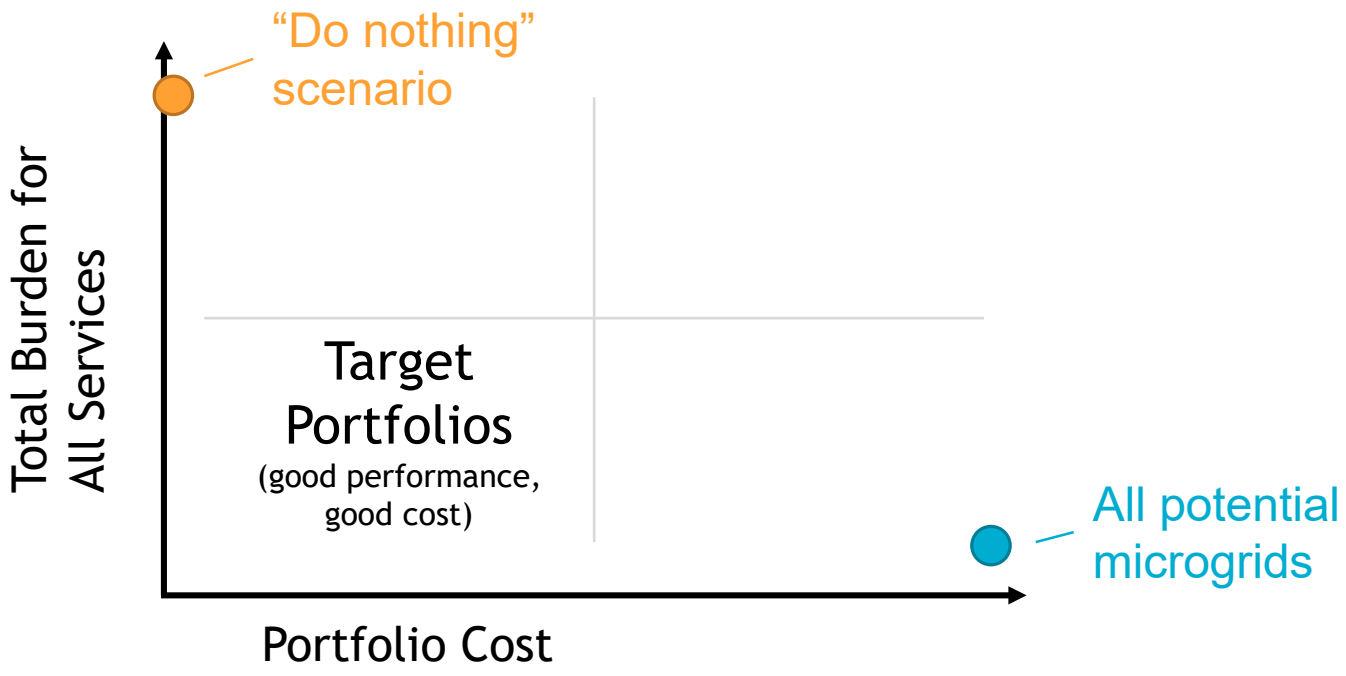
Assumptions

- City-wide blackout
- No infrastructure considered as reliable backup power

Evaluating Burden for Microgrid Portfolios

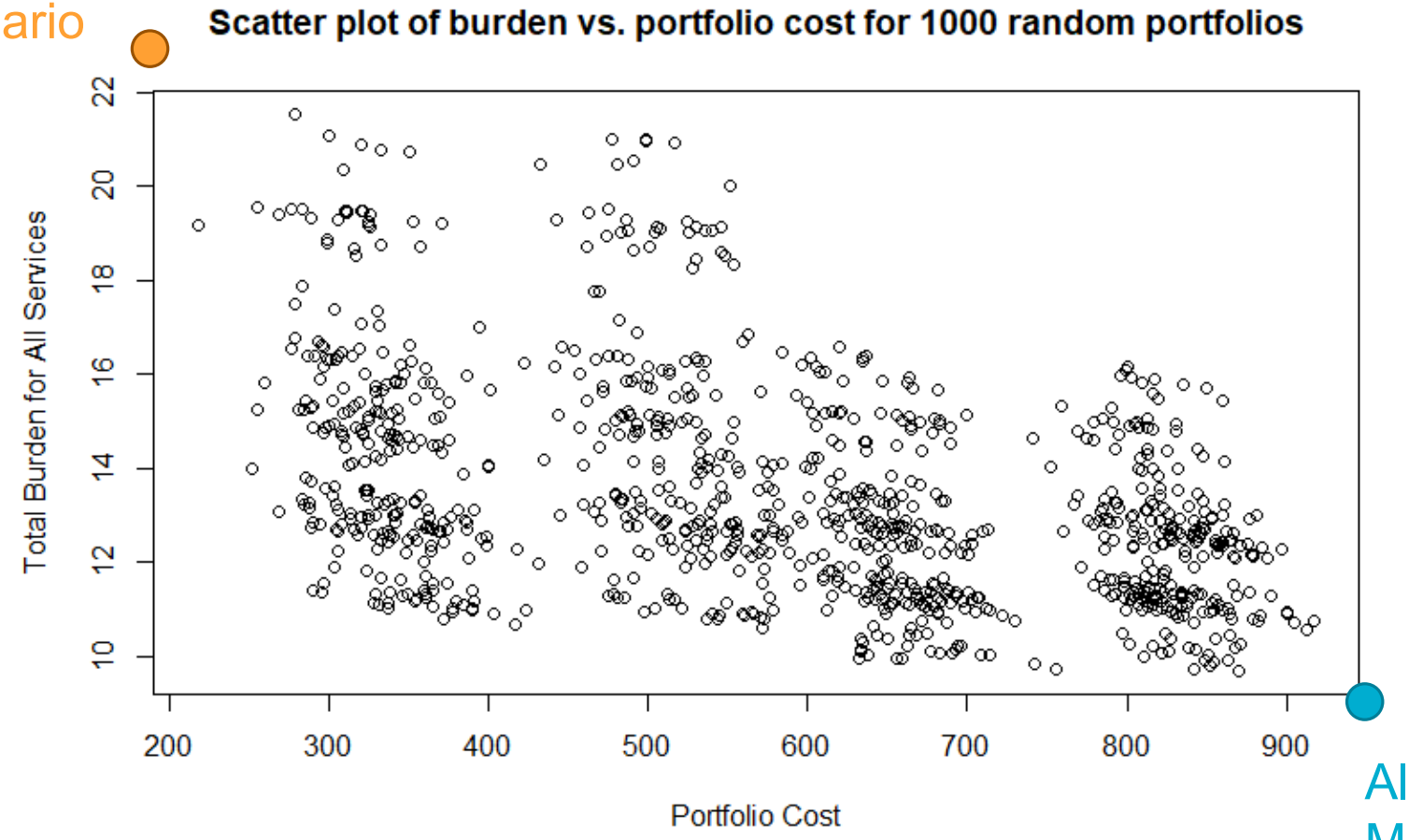
Recognize complementary nature of certain microgrids

Goal is to design a system of microgrids to decrease overall burden



Portfolio evaluation

"Do nothing" scenario



All Microgrids

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

Additional Info on Metrics

Familiar Territory: Reliability Metrics

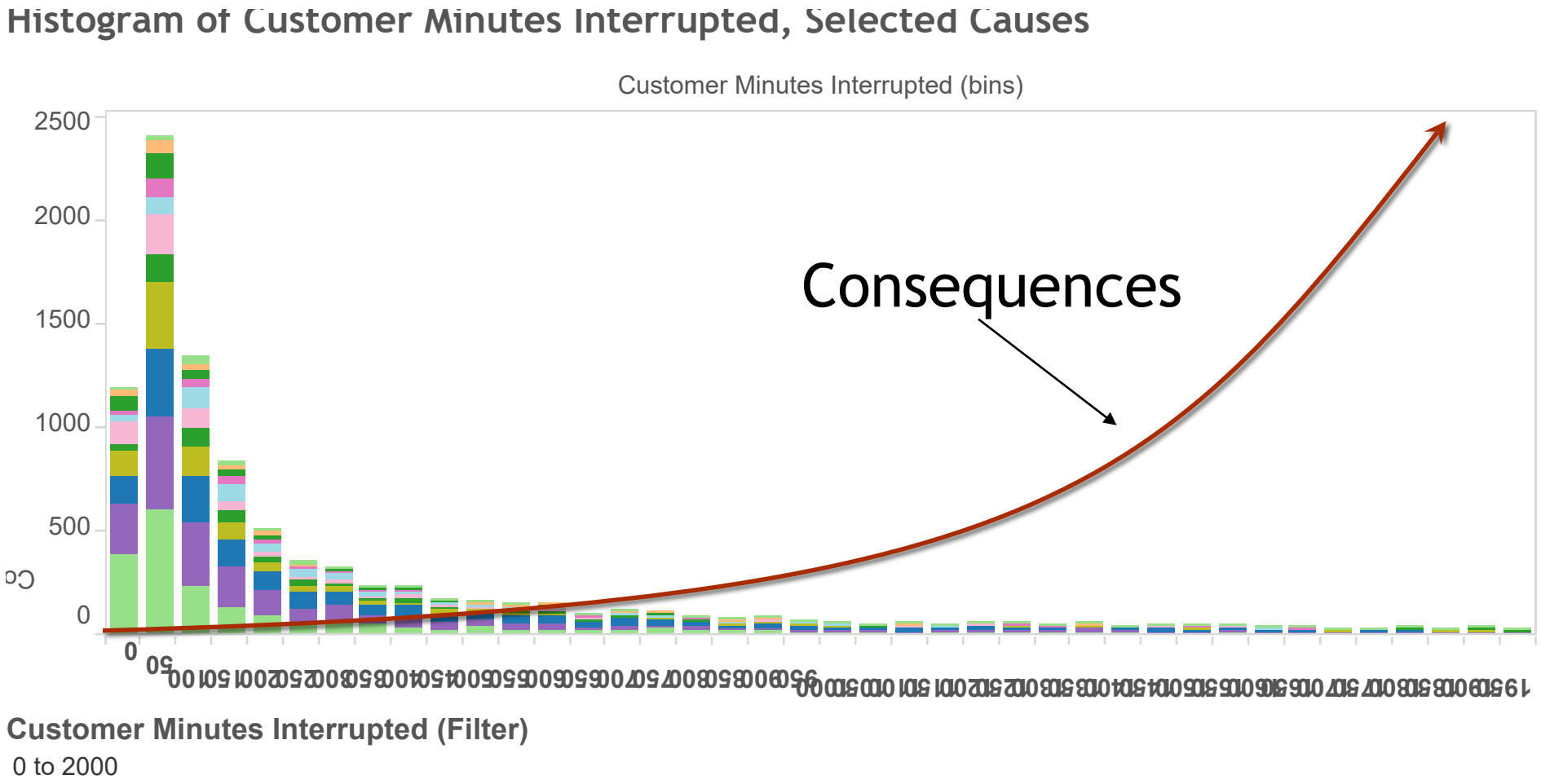
$$SAIDI = \frac{Total\ Duration\ of\ Customer\ Interruptions}{Total\ Number\ of\ Customers\ Served}$$

$$SAIFI = \frac{Total\ Number\ of\ Customer\ Interruptions}{Total\ Number\ of\ Customers\ Served}$$

$$CAIDI = \frac{Total\ Duration\ of\ Customer\ Interruptions}{Total\ Number\ of\ Customer\ Interuptions}$$

Standard measures of reliability have been used to evaluate investment effectiveness

Reliability Metrics Do Not Capture Consequence



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

Metrics that Focus on 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 Loss
	Change in Capital Wealth
	Business Interruption Costs

Urban planners can be using **metrics of consequence** to their communities to define and plan for resilience

Examples of Utility Roles in Societal Consequences

Waste Disposal

Hurricane Florence floodwaters breach coal ash basin (September 2018)

https://www.pbs.org/newshour/nation/hurricane-florence-breaches-manure-lagoon-coal-ash-pit-in-north-carolina

https://slate.com/business/2019/01/pge-bankruptcy-fire-victims-corporate-responsibility-solar-energy.html

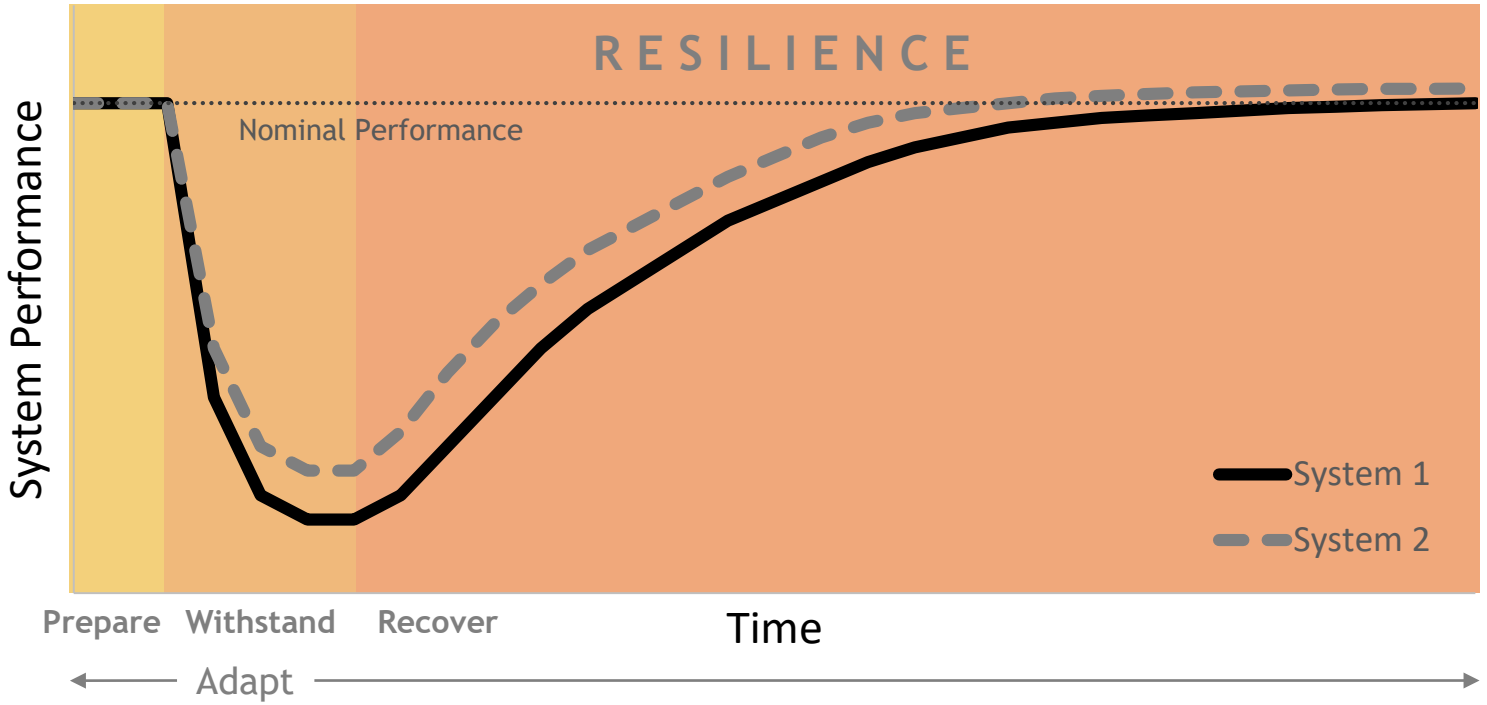
Electric Asset-Caused Wildfire Ignitions

PG&E had 486 fire ignitions associated with PG&E facilities in 2015-2016

Drivers:

- Vegetation contact with conductors
- Equipment failure
- Third-party contact
- Animal contact
- Fuse operation

Performance-Based Framework for Resilience Metrics



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 community functions by preparing for, withstanding, adapting to, and recovering from disruptions

NIST: Categories of Resilience Metrics (Hybrid)

Recovery Times

Estimated based on combination of simplified modeling, past experience, and/or expert opinion

Consider:

- Original design criteria
- Distribution of physical damage
- Availability of resources
- Critical interdependencies

Economic Vitality

Economic development concerns include:

- Attracting/retaining businesses/jobs
- Tax base
- Poverty and income distribution
- Local services and amenities
- Sustainability
- Debt ratios

Social Well-Being

Address the hierarchy of human needs:

- Survival
- Safety and security
- Sense of belonging
- Growth and achievement

Measure Improvements

Proactive planning and implementation to produce a faster and more robust recovery

NIST Disaster Resilience Framework, 75% Draft, February 11, 2015