Resiliency & Microgrids Working Group

Value of Resiliency – 4 Pillar Methodology:
Pillar 3 Resiliency Scorecard and
presentation by Sandia National Labs on Resiliency Node Cluster Analysis Tool (ReNCAT)

Resiliency and Microgrids Team, Energy Division

June 17, 2021

California Public
Utilities Commission

WebEx and Call-In Information

Join by Computer:

https://cpuc.webex.com/cpuc/onstage/g.php?MTID=ecff7a9546195b403e7f1ac49c2881f65

Event Password: RMWG (case sensitive)

Meeting Number: 187 221 4091

Join by Phone:

- Please register using WebEx link to view phone number.

(Staff recommends using your computer's audio if possible.)

Notes:

- Today's presentations are available in the meeting invite (follow link above) and will be available shortly after the meeting on https://www.cpuc.ca.gov/resiliencyandmicrogrids.

- The meeting presentations by Sandia and Lawrence Berkeley National Labs will be recorded. There will not be meeting minutes.

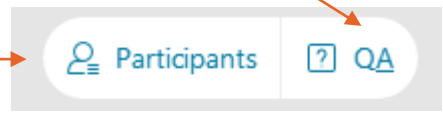
WebEx Logistics

- All attendees are muted on entry by default.
- Questions can be asked verbally during Q&A segments using the "raise hand" function.
  - The host will unmute you during Q&A portions [and you will have a maximum of 2 minutes to ask your question].
  - Please lower your hand after you've asked your question by clicking on the "raise hand" again.
  - If you have another question, please "re-raise your hand" by clicking on the "raise hand" button twice.
- Questions can also be written in the Q&A box and will be answered verbally during Q&A segments.

WebEx Tip

Access the written Q&A panel here

1. Click here to access the attendee list to raise and lower your hand.



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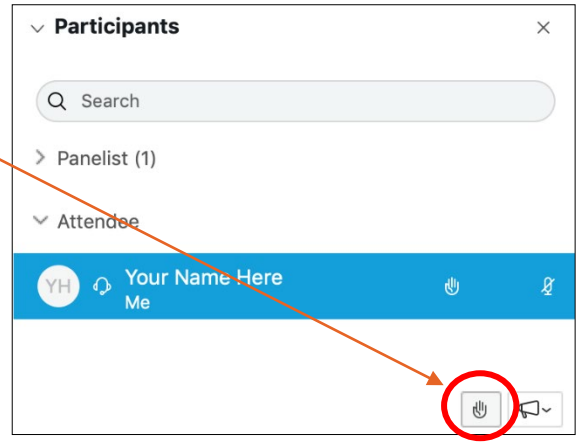
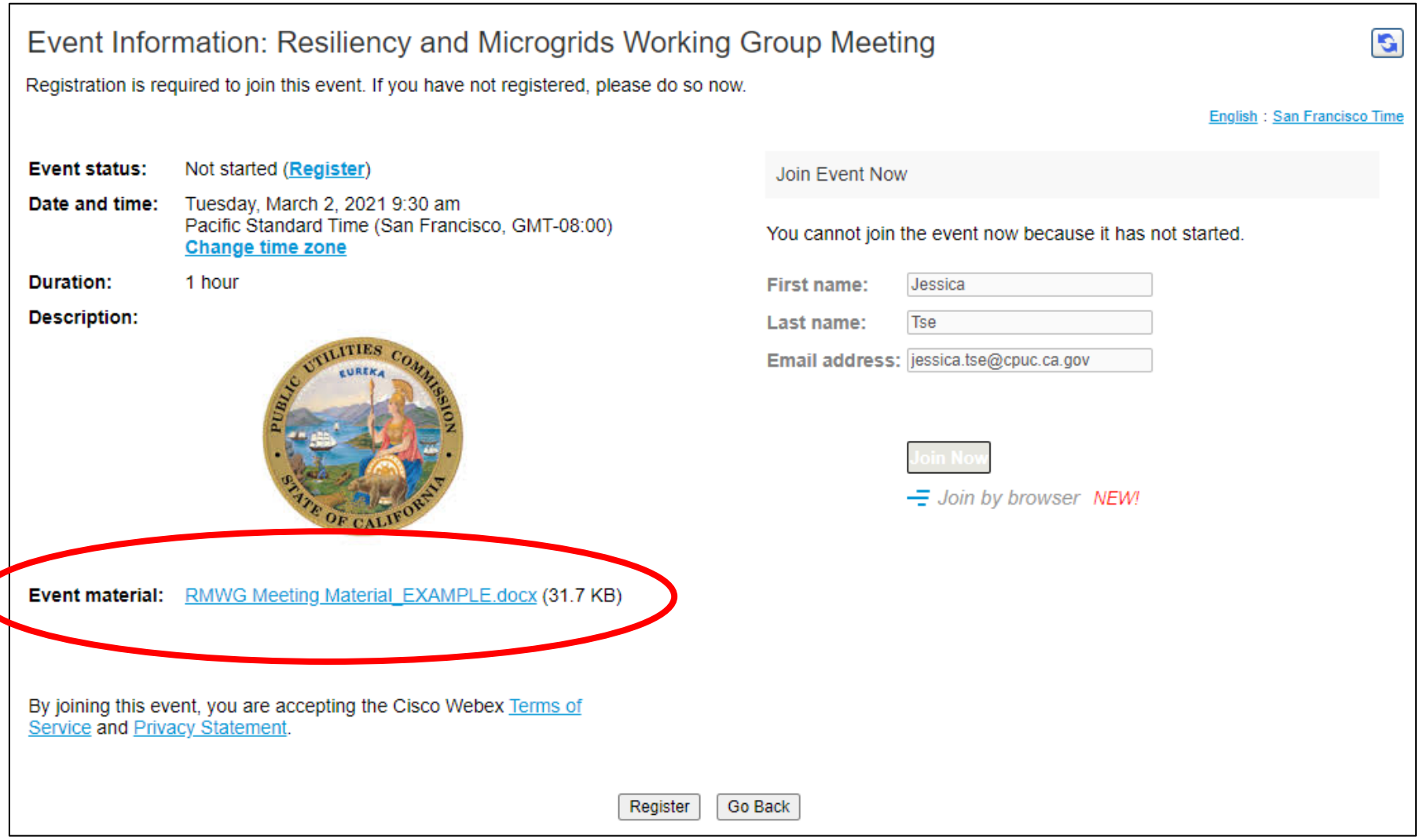
3. Lower it by clicking again.



Access your meeting audio settings here

WebEx Event Materials



Preliminary Resiliency & Microgrids Working Group Schedule

Month	Resiliency and Microgrids Working Group Topics			
February	Standby Charges	Multi-Property Microgrid Tariff		
March				
April				
May			Value of Resiliency	
June				
July				
August				Microgrid Interconnection
September				
October				
November	Customer-Facing Microgrid Tariff Revisit			
December				
January				
February				

Value of Resiliency: Working group participants to discuss resiliency valuation through an all-hazard approach to disruptions and mitigations by examining metrics, methodologies, and policy applications.

Agenda

I. Introduction *(CPUC Staff)* **2:00p – 2:05p**
- WebEx logistics, agenda review

II. Value of Resiliency – Pillar 3 – Resiliency Scorecard **2:05p – 2:35p**
- A tool to compare mitigation measure resiliency configuration characteristics
- **Q & A and Discussion** **2:35p – 2:45p**

III. Resilience Node Cluster Analysis Tool (ReNCAT)
- Bobby Jeffers – Sandia Labs **2:45p – 3:30p**
- **Q&A and Discussion** **3:30p – 3:45p**

IV. Additional Q&A and Discussion **3:45p – 3:55p**

V. Closing Remarks, Adjourn **3:55p – 4:00p**
- Provide information on the next meeting

The Problem to Solve: How can we optimize grid investments to maximize resiliency?

4 Pillars of Resiliency Valuation

I. Baseline Assessment

I. What do we want to protect and where is it?
II. What threatens it?
III. How well are we doing now to protect it?

II. Mitigation Measure Assessment

II. What protection options do we have?
III. What does the best job at protecting the most?
IV. What does it cost?

III. Resiliency Scorecard – scoring resiliency configuration characteristics

IV. Resiliency Response Assessment (post-disruption or modeling) –

II. How well did the investments do in reaching resiliency targets?
III. Did the investments reduce impacts on the community?

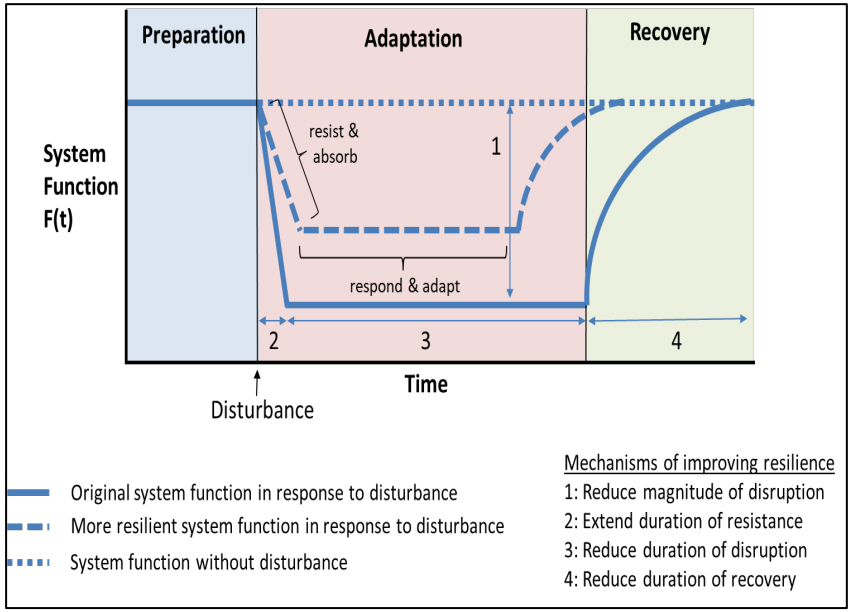
All-Hazard Approach to Assess Resiliency Measures

Mitigation measures to achieve the minimum resilience level for the geographic area defined would be compared in terms of cost, effectiveness (based on the effect on the resiliency trapezoid and/or meeting resiliency targets), and the degree to which the measure would mitigate various hazards (risk-assessment based on weighted all-hazard probability and impact analysis). This type of mitigation measure comparison may reveal vulnerabilities and benefits previously unrealized.

As an example:

i. Measure A mitigates Hazard Z by taking preparatory measures, which may affect another stage.
ii. Measure B mitigates Hazard Z & Y increasing preparation and decreasing magnitude.
iii. Measure C mitigates Hazard X reducing adaptation and recovery stages.
iv. Measure D mitigates Z, Y & X, but different stages depending on the hazard.
v. Measure D offers highest level of resilience -- at what cost?
vi. Compare with costs of either Meas. A + Meas B. + Meas. C OR Meas B + Meas. C
vii. Compare with Resilience Measure Characteristics (notification, crossover, duration, fuel type, load capacity, emissions, geographical impact)

Measure	Mitigates Hazard	Ranking	Cost *	Resiliency Trapezoid
A	Z	1	$40,000	Preparation
B	Z, Y	2	$100,000	Preparation/Magnitude
C	X	1	$400,000	Adaptation/Recovery
D	Z, Y, X	3	$520,000	Preparation (Z, Y), Magnitude (Y), Adaptation (X), Recovery (X)



*Cost figures are arbitrary and for illustration purposes only

All-Hazard Approach to Assess Resiliency Measures

Portfolio	Measure	Cost *	Modeled Recovery Costs *	Total Costs *	Outage Magnitude (cumulative customer days w/o power)
0 (Do nothing)			$1,600,000	$1,600,000	58,000
1	A, B, C	$540,000	$350,000	$890,000	33,000
2	B, C	$500,000	$475,000	$975,000	40,000
3	D	$520,000	$250,000	$770,000	34,000

*Cost figures are arbitrary and for illustration purposes only

Resilience Mitigation Measure Characteristics

Mitigation Measure Characteristic	Metric
Start-up or islanding crossover transition time (intermittent downtime before specified backup is available)	Time – minutes, hrs
Notification time/Advanced notice needed for backup available at specified load/duration	Time – minutes, hrs
Duration of backup – with no other inputs	Time – minutes, hrs
Load Capacity (which loads are backed up and how much load (Critical, Priority, Discretionary)	kWh, MWh or % of load
Fuel Type/Fuel Availability	Unit of fuel, availability before/during islanding
Emissions level – GHG and particulates	MMCO2, PPM
Geographic boundary	Location on geographic map, sq ft, sq mi
Blue Sky participation	kWh, kW

Resiliency Valuation Methodology
III. Resiliency Scorecard

Resiliency "Scorecard"

1) Resiliency Scorecard is a tool that aims to provide a mechanism for comparing resiliency solution configurations that recognizes a basic benchmark of achievement and provides for improvement.

2) Scoring system provides for different areas of (potentially ongoing) improvement (e.g. 100% resilience targets are met, but configuration uses 70% fossil fuel resources to meet those targets. Improvement would be to decrease fossil fuel resources while maintaining targets which would result in a higher "score").

3) Areas to be scored and scoring mechanisms could be determined by a Resiliency Scorecard Working Group. Review and updates of the Scorecard could happen periodically (e.g. every 3 yrs) to capture acknowledgement of Scorecard effectiveness, changing technologies and a changing energy environment.

Resiliency Valuation Methodology
III. Resiliency Scorecard (draft)

Resiliency Scorecard: Mitigation Measure Characteristics	Points	Score
Duration of backup – with no other inputs		
4 hrs	1	
8 hrs	2	
24 hrs	3	
48 hrs (2 days)	4	
96 hrs (4 days)	5	
Indefinite	6	
Load Capacity (which loads are backed up and how much load (Critical, Priority, Discretionary)		
Critical		
90 - 100%	9	
50 - 90%	8	
0 – 50%	7	
Priority		
90 - 100%	6	
50 - 90%	5	
0 – 50%	4	
Discretionary		
90 - 100%	3	
50 - 90%	2	
0 – 50%	1	

Resiliency Scorecard: Mitigation Measure Characteristics	Points	Score
Fuel Availability		
Onsite, intermittent	2	
Onsite, produced	3	
Piped infrastructure	2	
Wires infrastructure	2	
Transport	1	
Emissions level – GHG and particulates		
Non-GHG emitting	4	
Meets CARB emission standards	3	
GHG emissions < xxx	2	
Cap n Trade	1	

Resiliency Scorecard: Mitigation Measure Characteristics	Points	Score
Start-up/ islanding /isolation/ crossover transition time (intermittent downtime before specified backup is available)		
0 - 1 min	5	
2 - 5 min	4	
5 - 30 min	3	
30 - 120 min	2	
< 120 min	1	
Notification time/Advanced notice needed for backup available at specified load/duration		
0 - 1 min	5	
2 - 5 min	4	
5 - 30 min	3	
30 - 120 min	2	
< 120 min	1	
Blue Sky Services		
Demand Response	2	
Voltage/Frequency	1	
Wholesale participation	1	
NEM participation	1	

Resiliency Valuation Methodology
II. Mitigation Measure Assessment w/Resiliency Scorecard

Hypothetical Example: County

	Critical	Priority	Discretionary
Resiliency Targets	100%/24 hrs	60%/24 hrs	50%/24hrs
Current system performance against Hazards:			
Hazard #1 Wildfire	0%	0%	0%
Hazard #2 High Winds	70%/Indefinite	75%/Indefinite	80%/Indefinite
Hazard #3 High heat events	50%/Indefinite	30%/Indefinite	30%/Indefinite

Resiliency Valuation Methodology
III. Resiliency Scorecard (draft)
For Hypothetical Example 4: County, Mitigation Measure Option 1, Hazard 1

Resiliency Scorecard: Mitigation Measure Characteristics	Points	Score
Duration of backup – with no other inputs		
4 hrs	1	
8 hrs	2	
24 hrs	3	
48 hrs (2 days)	4	
96 hrs (4 days)	5	
Indefinite	6	6
Load Capacity (which loads are backed up and how much load (Critical, Priority, Discretionary)		
Critical		
90 - 100%	9	
50 - 90%	8	
0 – 50%	7	7
Priority		
90 - 100%	6	
50 - 90%	5	
0 – 50%	4	4
Discretionary		
90 - 100%	3	
50 - 90%	2	
0 – 50%	1	1

Resiliency Scorecard: Mitigation Measure Characteristics	Points	Score
Fuel Availability		
Onsite, intermittent	2	
Onsite, produced	3	
Piped infrastructure	2	
Wires infrastructure	2	2
Transport	1	
Emissions level – GHG and particulates		
Non-GHG emitting	4	
Meets CARB emission standards	3	
GHG emissions < xxx	2	
Cap n Trade	1	1

Resiliency Scorecard: Mitigation Measure Characteristics	Points	Score
Start-up/ islanding /isolation/ crossover transition time (intermittent downtime before specified backup is available)		
0 - 1 min	5	
2 - 5 min	4	4
5 - 30 min	3	
30 - 120 min	2	
< 120 min	1	
Notification time/Advanced notice needed for backup available at specified load/duration		
0 - 1 min	5	
2 - 5 min	4	
5 - 30 min	3	3
30 - 120 min	2	
< 120 min	1	
Blue Sky Services		
Demand Response	2	2
Voltage/Frequency	1	1
Wholesale participation	1	1
NEM participation	1	

Resiliency Valuation Methodology
II. Mitigation Measure Assessment w/Resiliency Scorecard

Hypothetical Example: County

	Critical	Priority	Discretionary
Resiliency Targets	100%/24 hrs	60%/24 hrs	50%/24hrs
Current system performance against Hazards:			
Hazard #1 Wildfire	0%	0%	0%
Hazard #2 High Winds	70%/Indefinite	75%/Indefinite	80%/Indefinite
Hazard #3 High heat events	50%/Indefinite	30%/Indefinite	30%/Indefinite

Mitigation Measure	Option 1: Covered Conductors, undergrounding, new feeders and reclosers, sectionalizers			Resiliency Scorecard
	Critical	Priority	Discretionary	
Hazard #1 Wildfire	75%/Indefinite	20%/Indefinite	0%/Indefinite	31
Hazard #2 High Winds	60%/Indefinite	20%/Indefinite	40%/Indefinite	31
Hazard #3 High heat events	50%/Indefinite	20%/Indefinite	20%/Indefinite	30

Resiliency Valuation Methodology
II. Mitigation Measure Assessment w/Resiliency Scorecard
Hypothetical Example 4: County

	Option 1	Option 2	Option 3
Mitigation Measure	Covered Conductors, undergrounding, new feeders and reclosers, sectionalizers	IFOM MGs with dispatchable BTM DERs	IFOM MG, PV, Batt
Hazard 3: High Heat Events	**Option 1**	**Option 2**	**Option 3**
Effect of Mitigation on Target	50% CL; 20% PL; 20% DL	100% CL, 50% PL, 30% DL	50% CL; 20% PL; 20% DL
Resilience Enhancement cost	$5.65M	$4.1M	$ 2.5M
Resiliency Scorecard	**30**	**31**	**30**

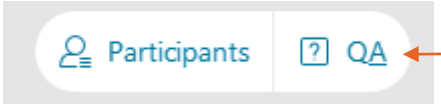
Resiliency Valuation Methodology
II. Mitigation Measure Assessment w/Resiliency Scorecard
Hypothetical Example 4: County

Hazard 1: Wildfire	Option 1	Option 2	Option 3
Mitigation Measure	Covered Conductors, undergrounding, new feeders and reclosers, sectionalizers	IFOM MGs with dispatchable BTM DERs	IFOM MG, PV, Batt
Effect of Mitigation on Target	75% CL; 20% PL; 0% DL	60% CL; 35 % PL; 30% DL	50% CL; 20% PL; 0% DL
Resiliency Scorecard	**31**	**36**	**34**
Hazard 2: High Winds	**Option 1**	**Option 2**	**Option 3**
Effect of Mitigation on Target	60% CL; 20% PL; 40% DL	100% CL, 40% PL, 10% DL	50% CL; 20% PL; 20% DL
Resiliency Scorecard	**31**	**37**	**34**
Hazard 3: High Heat Events	**Option 1**	**Option 2**	**Option 3**
Effect of Mitigation on Target	50% CL; 20% PL; 20% DL	100% CL, 50% PL, 30% DL	50% CL; 20% PL; 20% DL
Resilience Enhancement cost	$5.65M	$4.1M	$ 2.5M
Resiliency Scorecard	**30**	**31**	**30**

Discussion and Q&A

WebEx Tip

Option 1:



Access the written Q&A panel here

Option 2:

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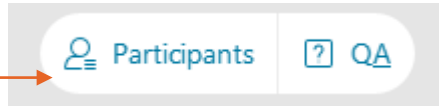

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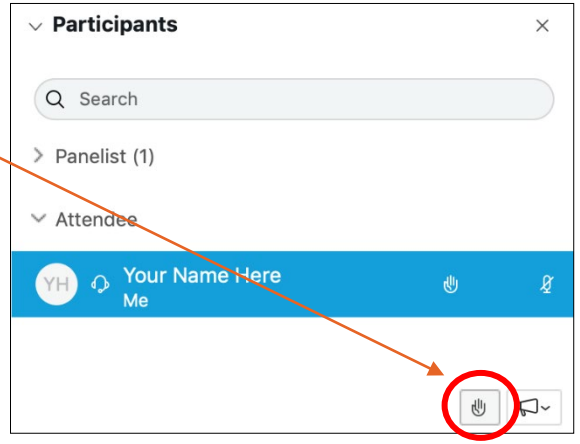
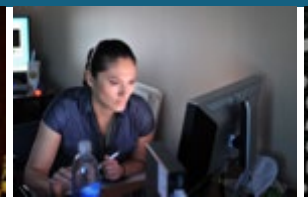
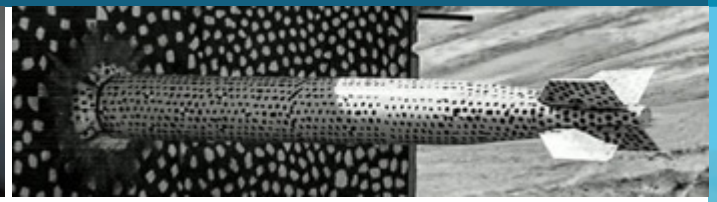


Discussion Questions

- For a given jurisdiction (e.g., a city government), what characteristics should be considered in a resiliency scorecard?
- How might the characteristics relevant to include in a resiliency scorecard differ by jurisdiction, if at all?
- How could equity be better represented in a resiliency scorecard to reflect a particular jurisdiction's priorities?
- How might a jurisdiction customize the weights assigned to different metrics to reflect their own priorities?

Quantifying Community Resilience:
Social Burden and the Resilience Node Cluster Analysis Tool (ReNCAT)





Bobby Jeffers, Amanda Wachtel, Darryl Melander, Brooke Garcia, Adam Pierson

Sandia National Laboratories

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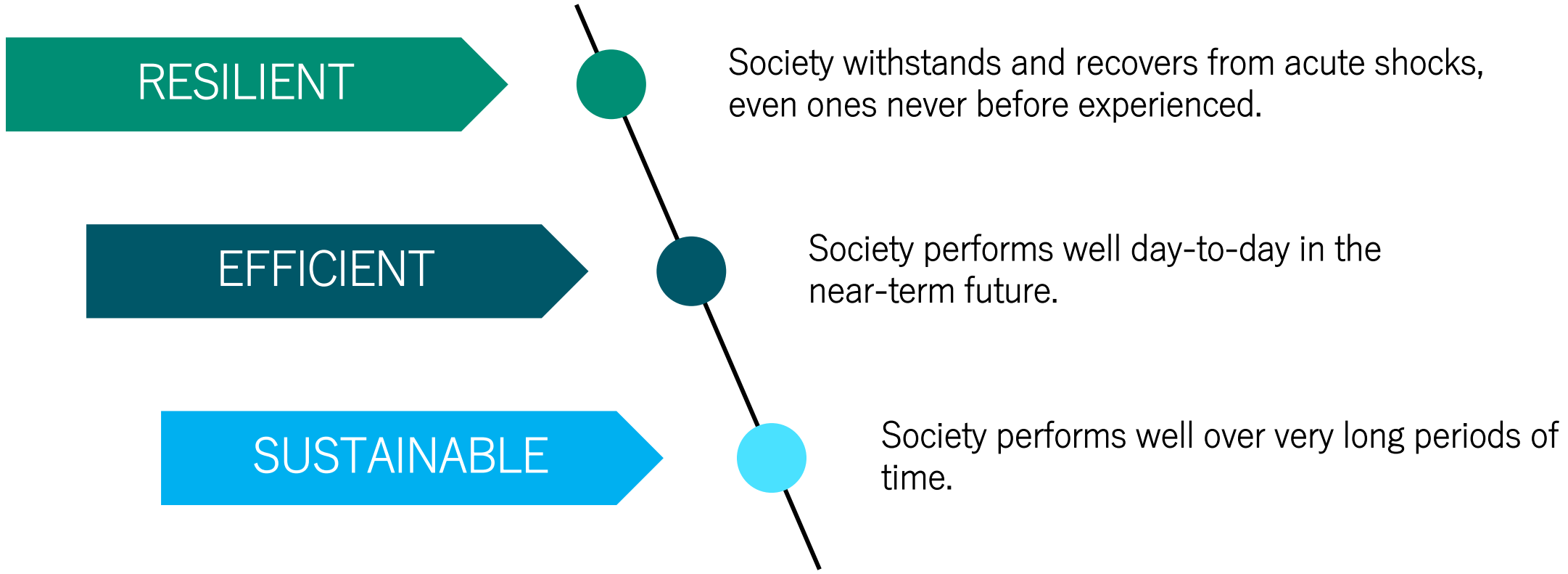
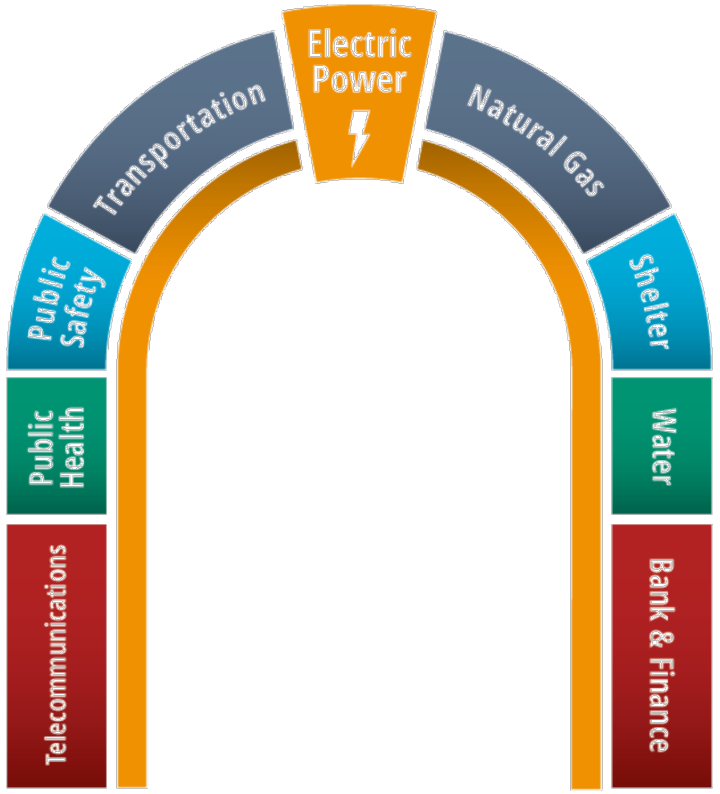


At all scales (T, D, Buildings), there are very real tradeoffs between performance in these dimensions.

Motivation

- The grid is the keystone infrastructure – central to the web of interconnected systems that support life as we know it.
- During extreme events, prices do not reflect the value of all the services (food, water, shelter, etc.) that electricity provides
  - Consequence-focused **resilience is an externality** in power markets
  - The performance of the economy, military, and **society as a whole** are all important consequences



9 months after Hurricane Maria, thousands of Puerto Ricans still don't have power

The grid is in worse shape than it was before Hurricane Maria.

By Umair Irfan | Updated Jun 20, 2018, 8:06am EDT

"It took Cardona 11 days to find a working phone and a cellular signal to let her mother in Florida know that she was okay. In the weeks following the storm, she woke up at 2 am to get in line for diesel fuel to run the generator at her father's home in Sabana Grande on the southwest coast of the island. After waiting for 13 hours, she went home empty-handed. She stood in lines that stretched blocks to get cash, since no electricity meant credit card readers weren't running."

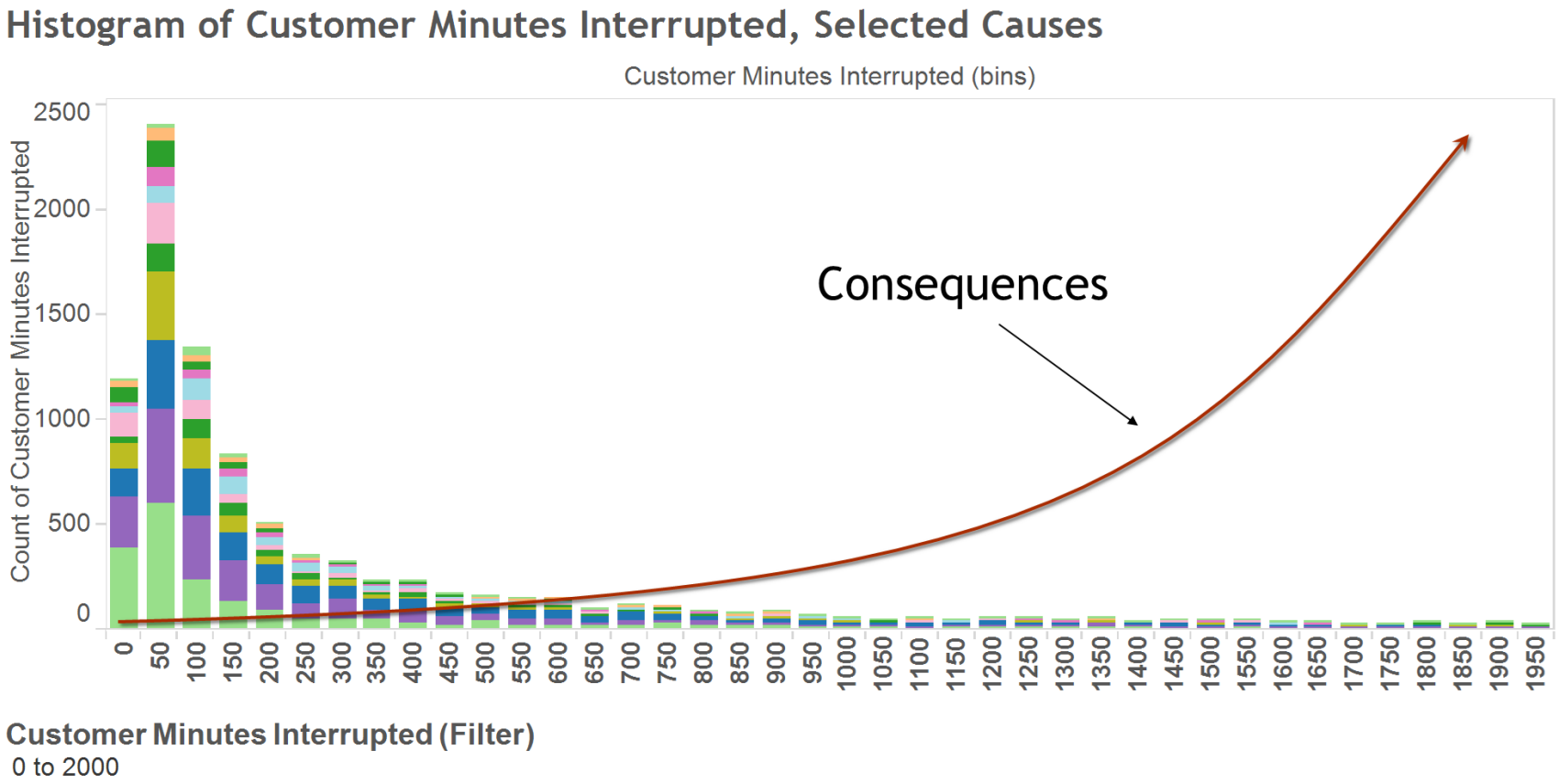
Image credit: Wikimedia Commons user "Mdf"





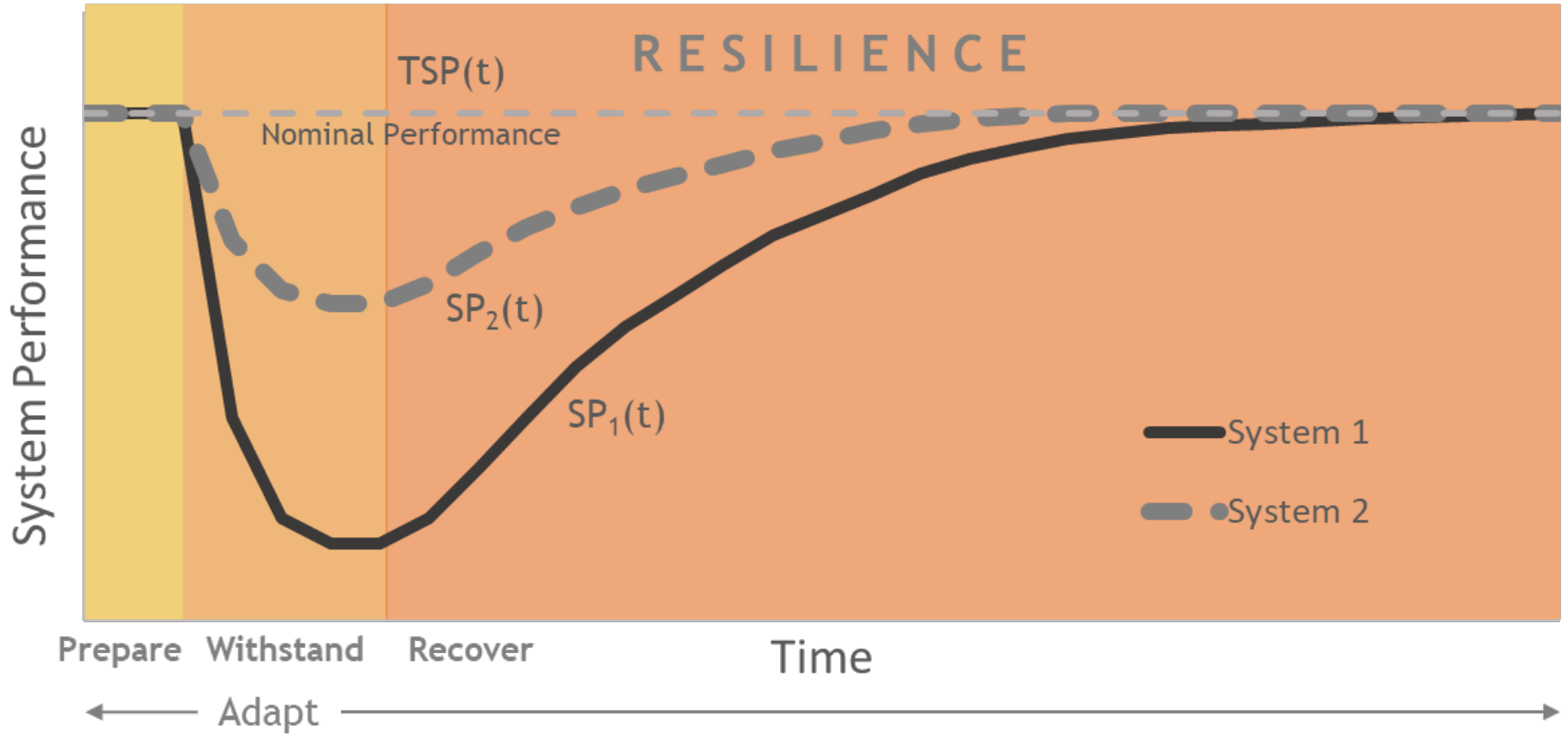
Motivation, cont.

NATIONAL ACADEMIES (2017), RECOMMENDATION #1 TO DOE: "IMPROVE UNDERSTANDING OF CUSTOMER AND SOCIETAL VALUE ASSOCIATED WITH INCREASED RESILIENCE AND REVIEW AND OPERATIONALIZE METRICS FOR RESILIENCE…"



National Academies Press (2017) Enhancing the Resilience of the Nation's Electricity System
https://www.naesb.org/misc/nas_report.pdf

Measuring and forecasting resilience



Resilience metrics should:

- Convey the wide variance among outages in terms of size, duration, and impact on customers
- Capture the context of the threat environment
- Translate system performance into consequence, where the severity of consequences can change nonlinearly over time

Resilience Metrics

Attribute-based:

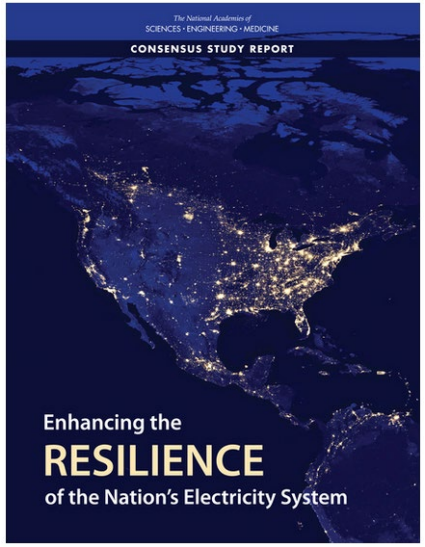
- What makes the system more/less resilient?
- Things you can count now (on a blue-sky day)
- Often grouped into categories that describe some aspect of resilience
  - Robustness, adaptivity, recoverability, etc.
- Often populated via surveys or checklists
  - Relatively simple to populate

Performance-based:

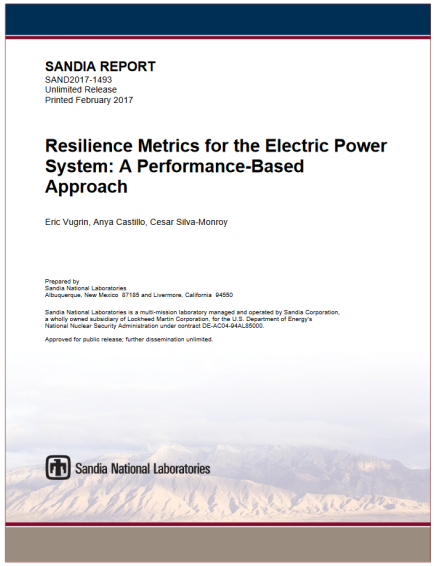
- How resilient is/was the system?
- Things you can measure only during disruption
- Often uses data from an event or a model of an event
  - Can be difficult to populate for planning
- Useful to weigh resilience against other goals
  - (e.g. within benefit cost analysis)

Either approach can be:

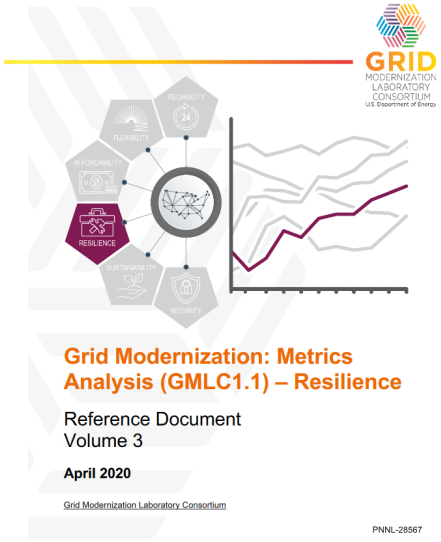
- Retrospective or forward-looking
- Infrastructure-focused or consequence-focused
- Threat-informed or threat-agnostic



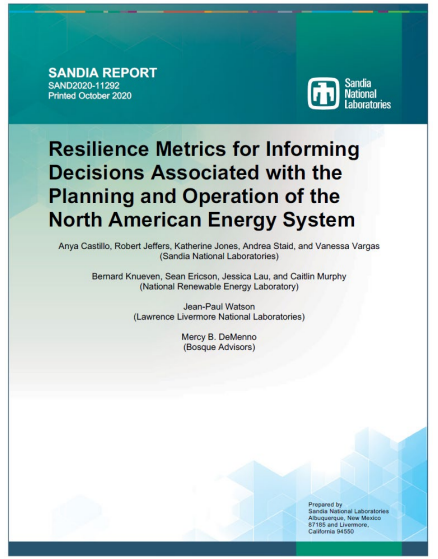
National Academies (2017), Recommendation #1 to DOE: "Improve understanding of customer and societal value associated with increased resilience and review and operationalize metrics for resilience…"



Vugrin et al. (2017) under GMLC 1.1 Foundational Metrics: First power-focused discussion of attribute-based and performance-based resilience metrics.



GMLC 1.1 Final Report (2020): Begins to clarify how attribute and performance-based approaches can complement.

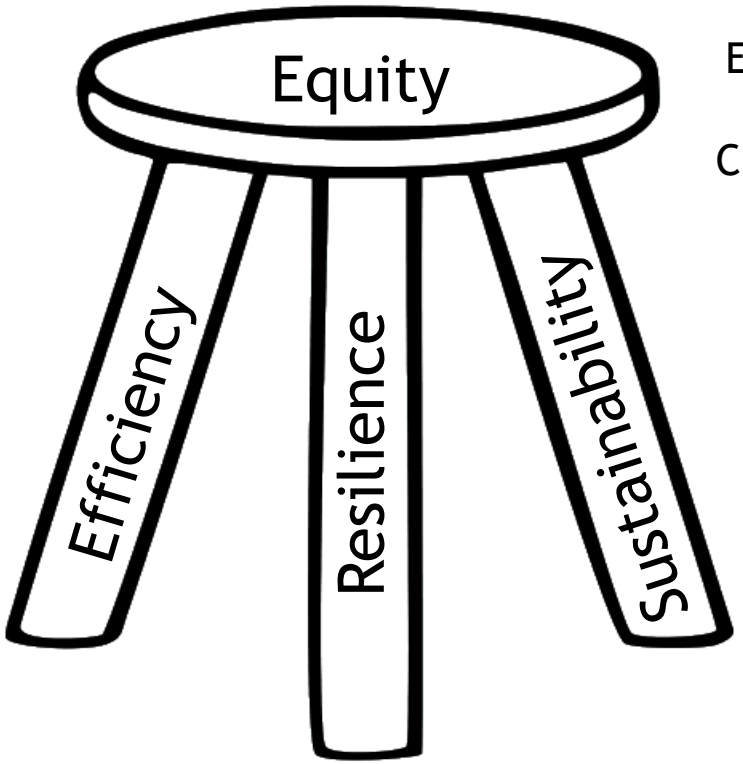


NAERM Metrics Report (2020): Describes consequence dimensions and metric formulation

Metrics and Equity

Acute Social Burden

Energy Burden,
Chronic Social Burden,
…



Equitable access to clean energy solutions,
Chronic environmental injustices,
…

Cost of Service,
Customer Bills
…

GHG Emissions,
Land Use
…

Loss of Load Expectation
MWh not served
…

Consequence-focused Resilience Projects

Society

- 2015-16 GMLC: New Orleans Grid Resilience
- 2017-present GMLC: Designing Resilient Communities
- 2018-present SETO and OE: Puerto Rico Recovery

Economy

- 2014 Internal: Norfolk and 100 Resil Cities
- 2015-17 GMLC: Valuation
- 2017-present GMLC: Lab Valuation Analysis Team

National Security

- 2017-18 ESTCP: Resilient Energy Master Planning
- 2019-present OE: Energy Assurance for Critical Infrastructure
- 2020-present GMLC: Energy Resilience for Mission Assurance

Cross-cutting:

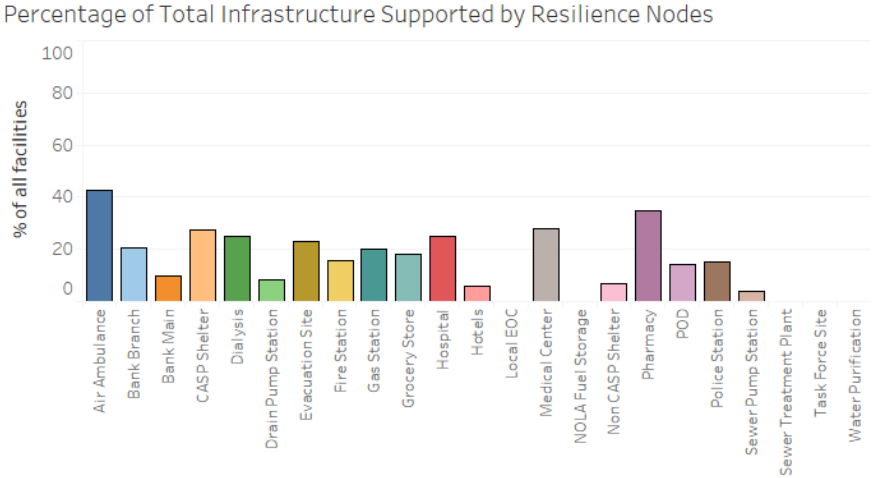
- 2013-14 DOE Quadrennial Energy Review
- 2015-17 GMLC: Foundational Metrics
- 2019-21 OE: North American Energy Resilience Model

Outcome of GMLC New Orleans 2016

We have moved from "worst case" to "worst consequence" planning.

We need a metric for social resilience. Simply serving "critical" load is misleading.

The needs of multiple offices within local and state government are not adequately represented within power system planning.



Quantifying Social Resilience

Capabilities framework, based on Sen and Nussbaum, applied to energy by Day et al.

University at Buffalo
The State University of New York

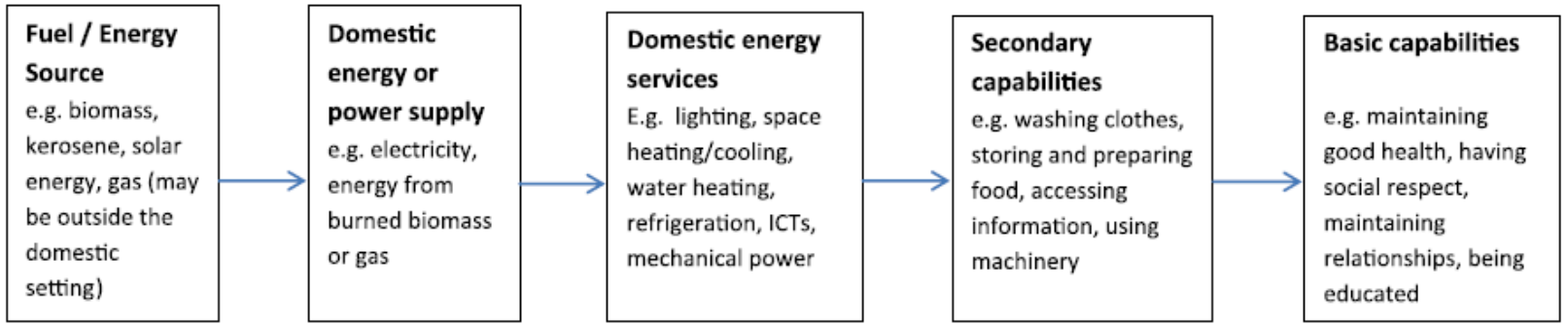


Fig. 1. Conceptualising the relationship between energy, services and outcomes.

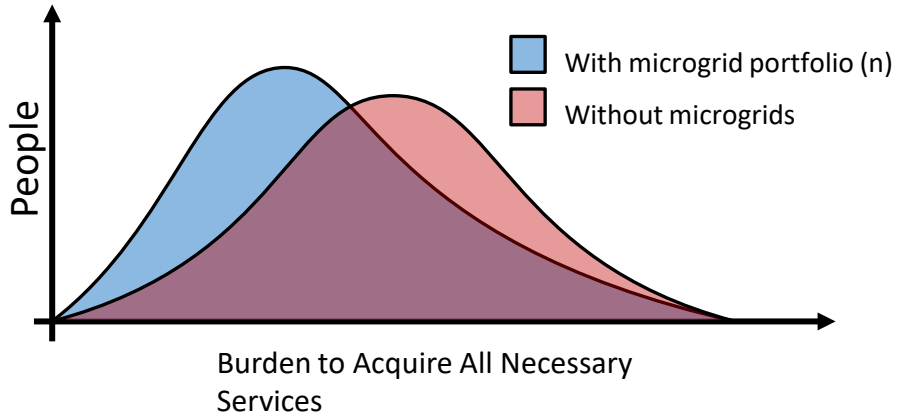
We are utilizing this theory, but advancing/extending in two ways:

- **Chronic vs. Acute**: we are applying the capabilities framework to acute, post disaster scenarios, whereas previous literature focuses on chronic "blue sky" capabilities
- **Rigorous Quantification**: we are the first to apply a mathematical formulation to the theory

Nussbaum, Capabilities as fundamental entitlements: Sen and social justice. 2003; Sen, Human Rights and Capabilities. 2005;
Day, R., Walker, G., Simocck, N. Conceptualising energy use and energy poverty using a capabilities framework. Energy Policy. 2016.

Performance Based Metric: Social Burden

The **social burden metric** calculates how hard society is working to achieve their basic human needs.



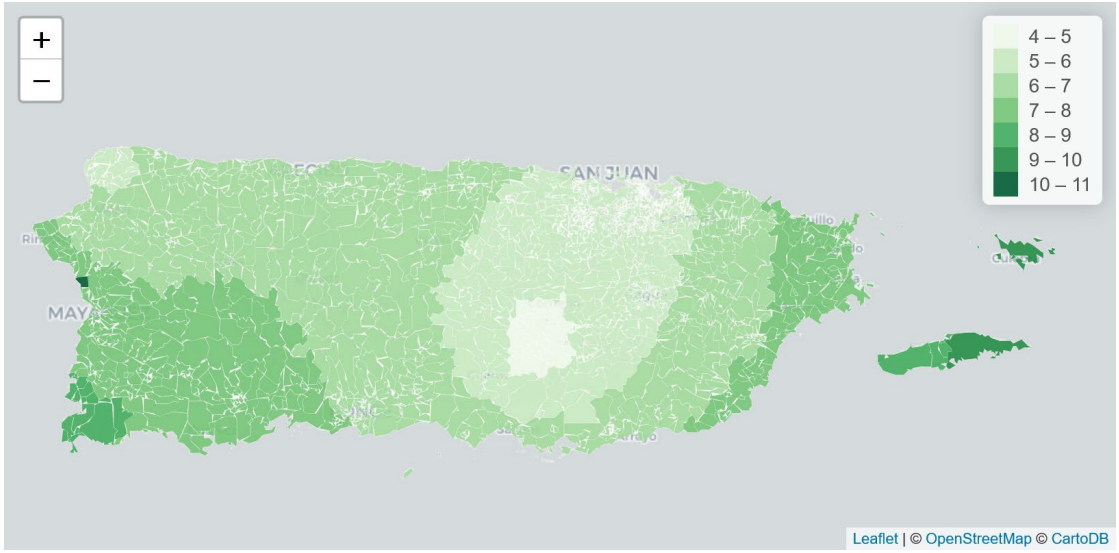
Effort
Time + money spent to achieve basic level of human needs

Ability
Median household income
Additional predictors

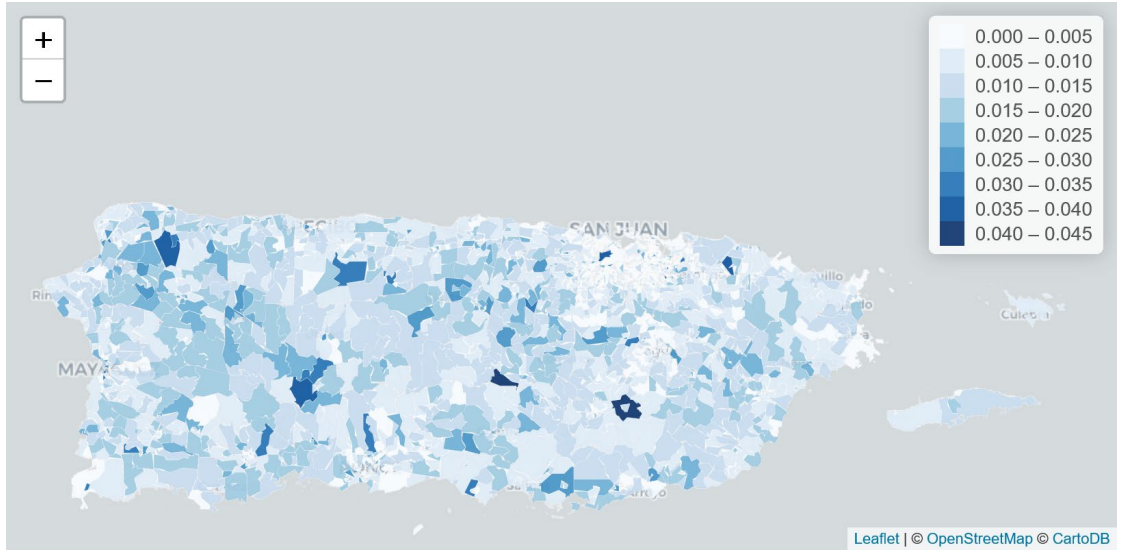
Burden

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

Effort for a portfolio of 80 microgrids



Social Burden for the same portfolio

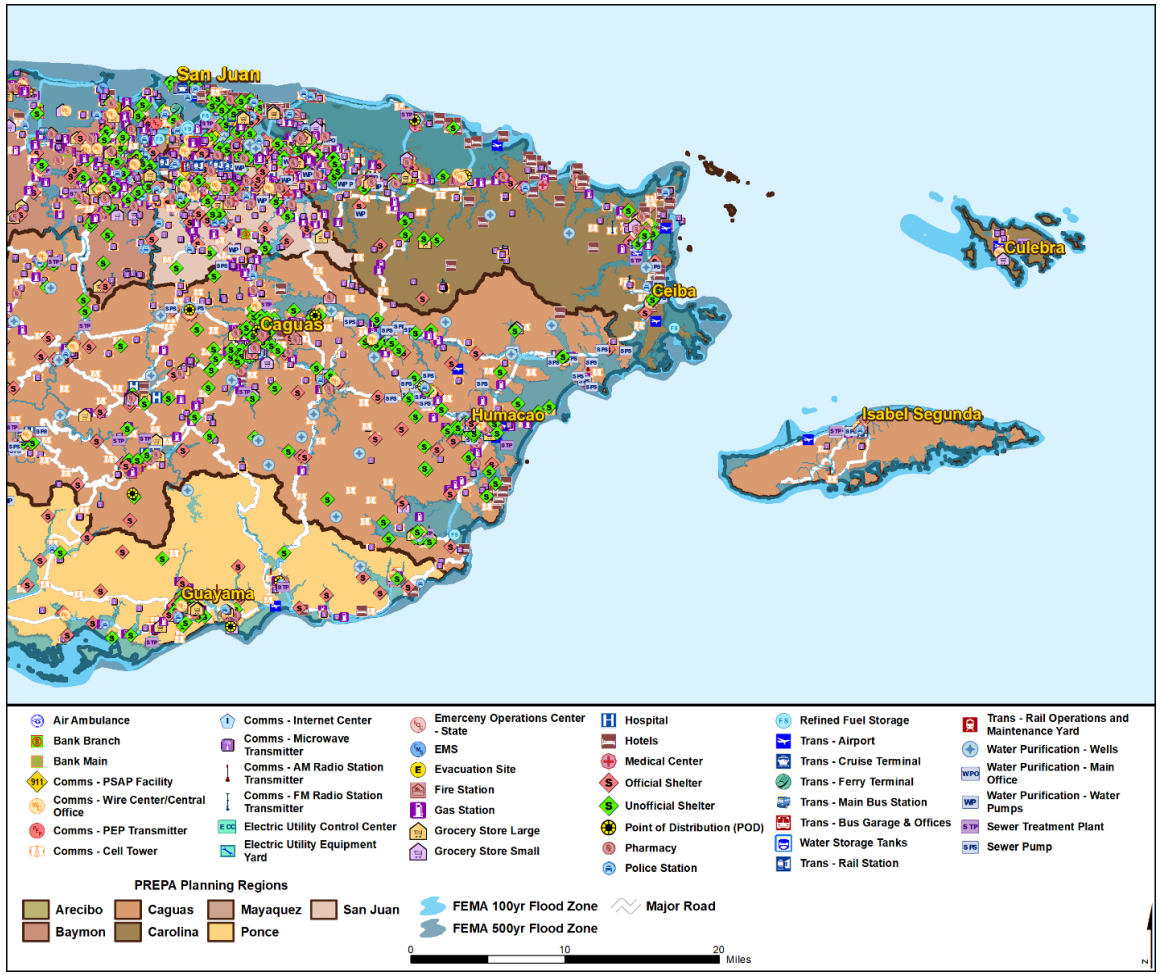


Social Burden Explained

$$Social\ Burden_{S,f} = \int_{t0}^{tf} \frac{{}^{1}/_{\sum_{inf} {}^{Svc_{inf}}/_{E_{inf}}}}{Ability}$$

Units:
Hours of effort per dollar of ability

Using Social Burden for Distribution System Planning



Motivation: How do we take critical infrastructure locations in an area and figure out optimal locations for microgrids or other resilience investments?

Goal: Choose distributed resilience investments that keep critical community services online during emergency events when the grid is down

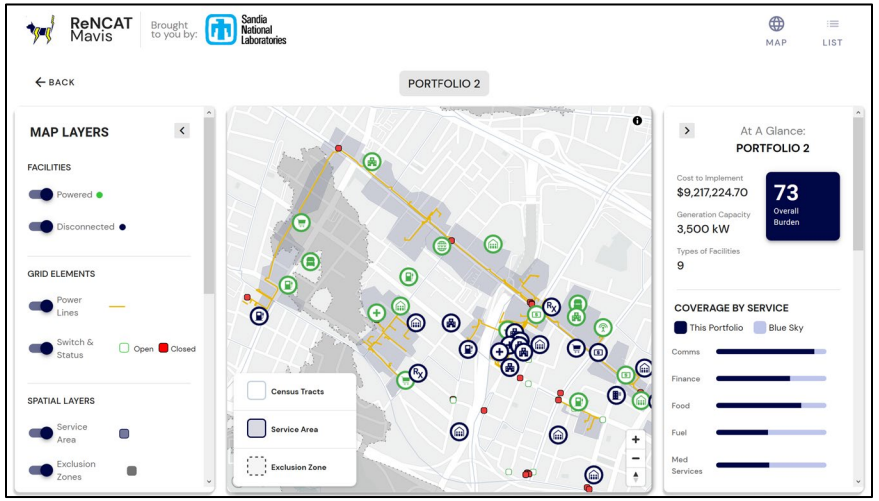
Community: Ensure microgrids are distributed so residents have access based on both location and economic means

ReNCAT

- Resilient Node Cluster Analysis Tool
  - Developed at Sandia National Laboratories under DOE funding

Version 1

- Calculation-based tool
- Divides area into grid and sums up service points in each cell to determine potential microgrid locations
- Only considers locations of critical infrastructure and provided services



★ Version 2

- Optimization tool
- Uses distribution system layout and identifies which sub feeders to energize based on critical infrastructure locations and services
- Calculates burden to residents to obtain critical services

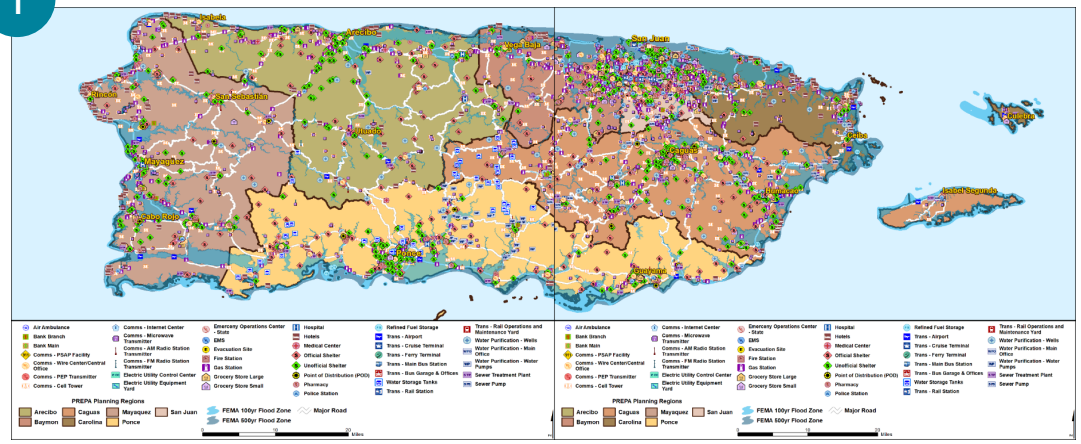
ReNCAT in Puerto Rico

- During the **phase 1 PR recovery effort** in 2018, Sandia developed and demonstrated a process for siting and roughly sizing/costing microgrids with a focus on **social burden**.

- The phase 1 work furthered development of and utilized **ReNCAT 1.2** – an open-use tool that suggests clusters of assets that provides these services.

- In 2020, Sandia developed **ReNCAT 2.0**, which is intended to become an open-source environment for optimal distribution system investment planning

1



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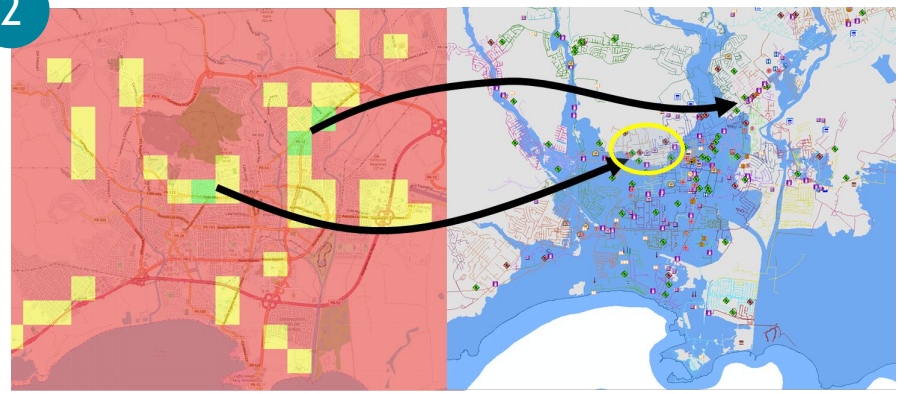

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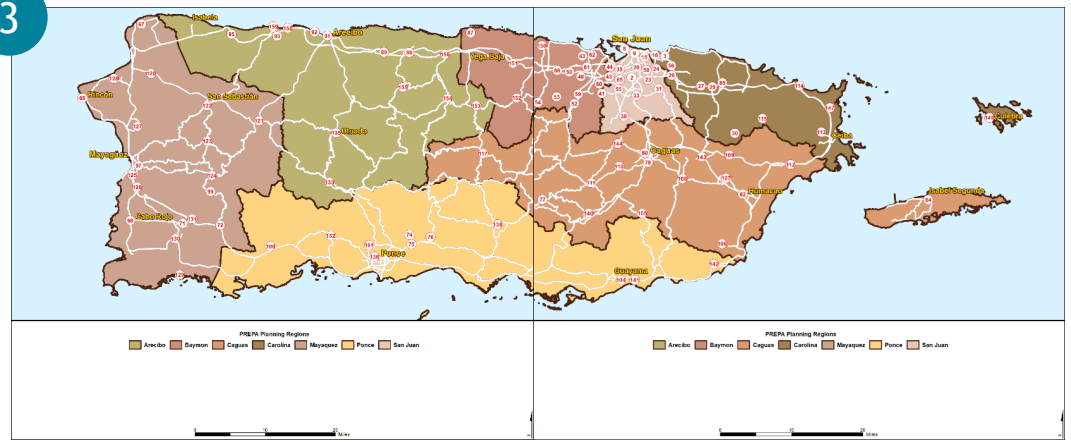
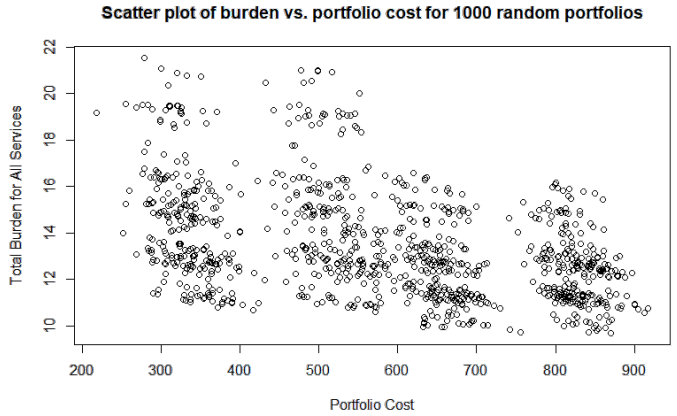


4

Social Burden

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

inf = infrastructure service categories
pop = population groupings (census block groups)



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

Process (ReNCAT 1.2 to 2.0)

- ReNCAT 1.2 was released "open use" after the 2018 Puerto Rico Phase 1 work. The ReNCAT 1.2 workflow involved a heavy amount of manual effort to develop smart/cost-effective portfolios for social burden. It also became difficult to explicitly consider how existing grid topology would impact the design and siting of microgrids.

1. Data acquisition

1. Raw distribution infrastructure
2. Raw critical infrastructure assets
3. Raw buildings data
4. Raw census and American Community Survey data
5. Raw threat/hazard data

2. Data manipulation

1. "Subcircuit" layer, includes non-critical load
2. Switch layer, includes switch CapEx
3. Critical Infrastructure layer, includes critical load
4. Census Block Group layer, includes population and household income

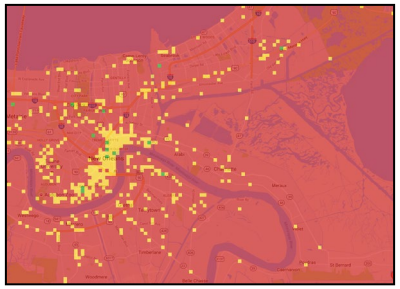
3. ReNCAT 1.2

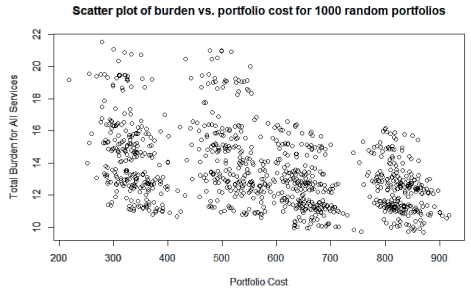
4. Site and size all microgrids

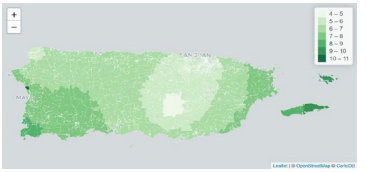
5. Social burden evaluation

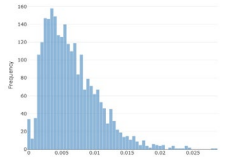
6. Microgrid portfolio development

7. Results visualization









3. ReNCAT 2.0

Design and run optimization (ReNCAT core)

Explore results and generate insight (ReNCAT MAVIS)

Algorithms

- ReNCAT 1.2 used simple linear algebra to suggest microgrid locations
- ReNCAT 2.0 **uses a genetic algorithm** (JEGA) wrapping a heuristic-driven model that utilizes the social burden calculation as a core evaluator
- Each candidate solution is defined by the **status of all switches in the system** during outage conditions
- Heuristics to look at all resulting "potential islands" and decide whether to add generation (thereby forming a microgrid)
- Can give the optimizer an option to disconnect non-critical and critical loads (often at a cost)
- Each candidate solution evaluated in two dimensions: **cost and social burden**

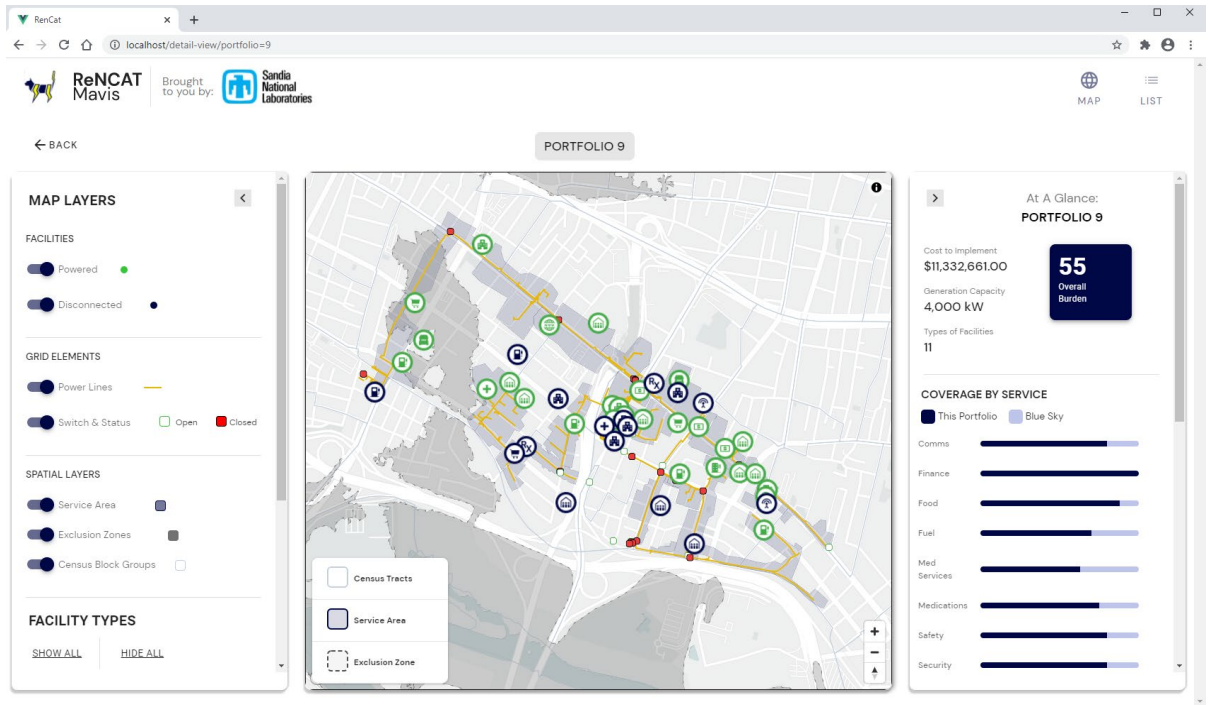
Effort
Time and money applied to acquiring services

Ability
Median population statistics for census block group

Social Burden

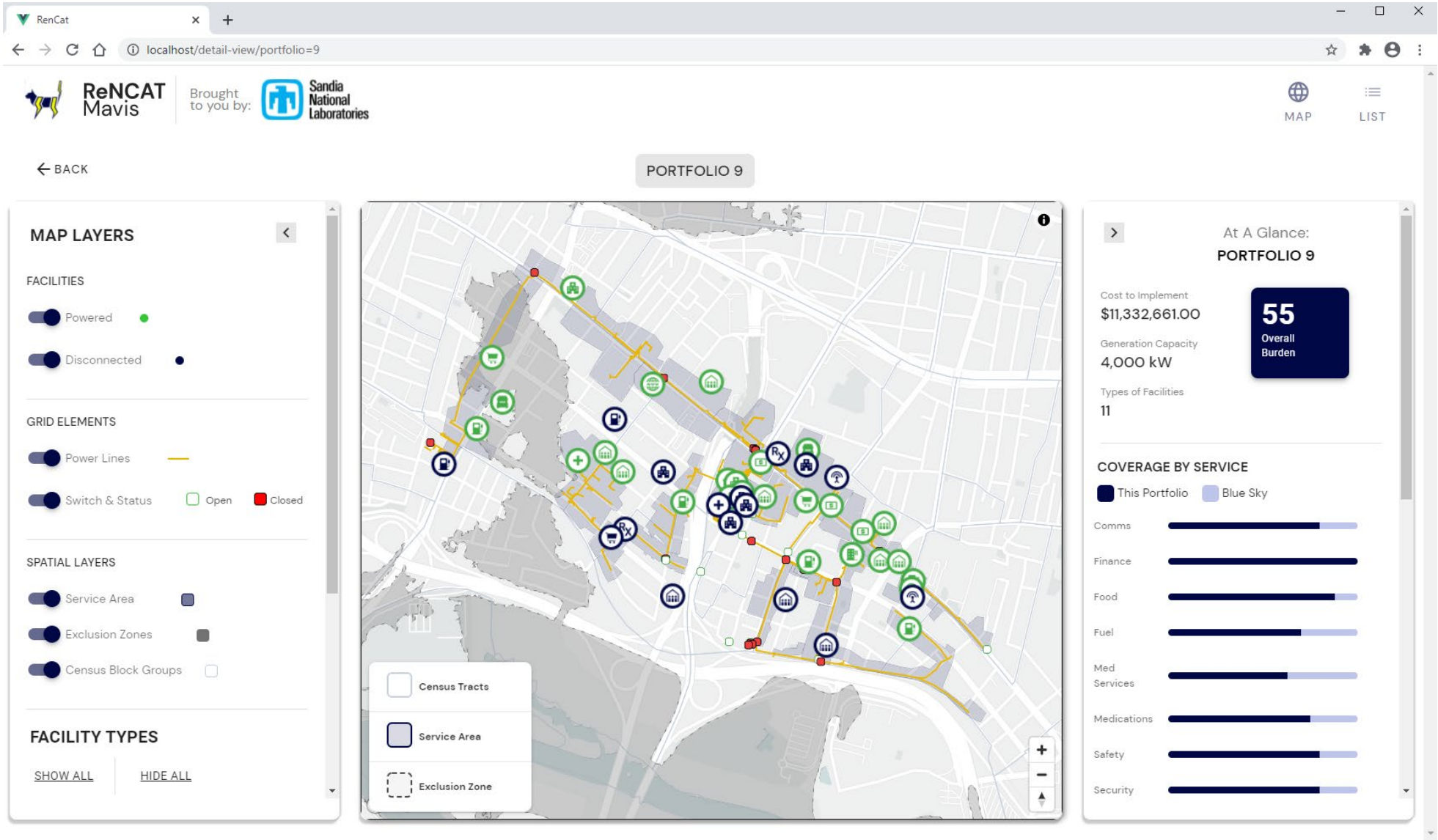
$$B_C = \sum_{inf} \sum_{pop} \frac{E_{inf,pop}}{A_{pop}}$$

inf = infrastructure service categories
pop = population groupings (census block groups)



Interactive Results

- The solution viewer shows the details of each portfolio including:
  - Social Burden
  - Cost
  - Number of microgrids
  - Position of every switch and any associated costs for that configuration
  - Facilities supported and not supported

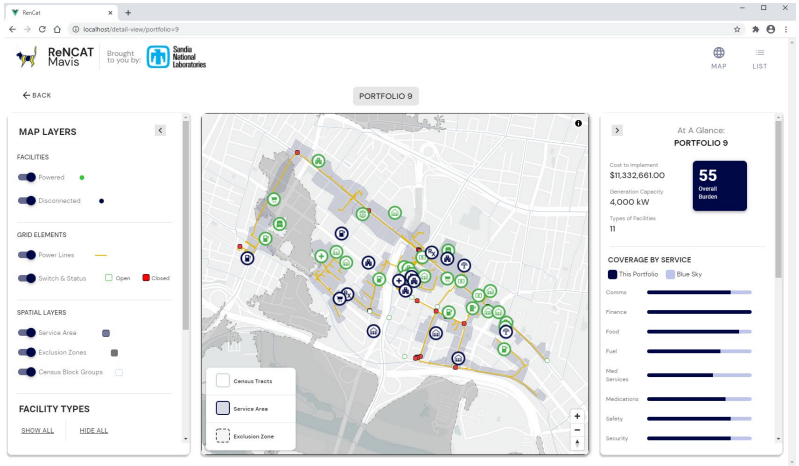


Validating, Applying, Socializing

Validate

1. **Data**: Do we have the data to calculate social burden ex post?
2. **Surveying**: What data can we receive directly from those impacted?
3. **Mod/Sim**: Improve connection between theory and calculation

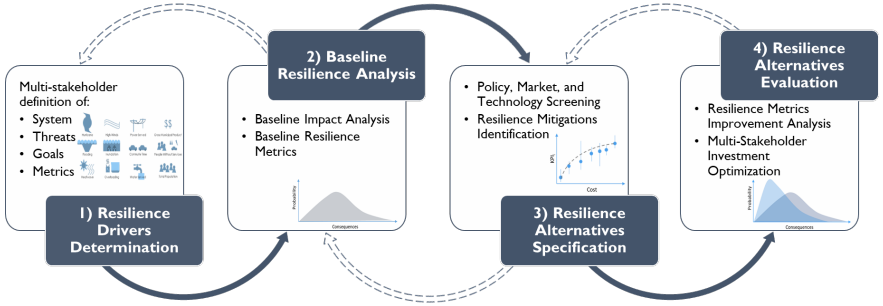
Apply



Current:
Puerto Rico (3 x)
San Antonio

Future:
Texas
New Mexico

Socialize



DRC Stakeholder Advisory Group:

- New York + ConEd
- Los Angeles + LADWP
- Norfolk + Dominion Energy
- Boston + Eversource
- Honolulu + HECO
- San Antonio + CPS Energy
- National Association of Utility Regulatory Commissioners (NARUC)

Thank you!

Questions?

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Backup Material

Next Steps and Discussion

ReNCAT 2.0 provides a unique capability to design distribution systems for optimal community resilience benefit, but we are just scratching the surface

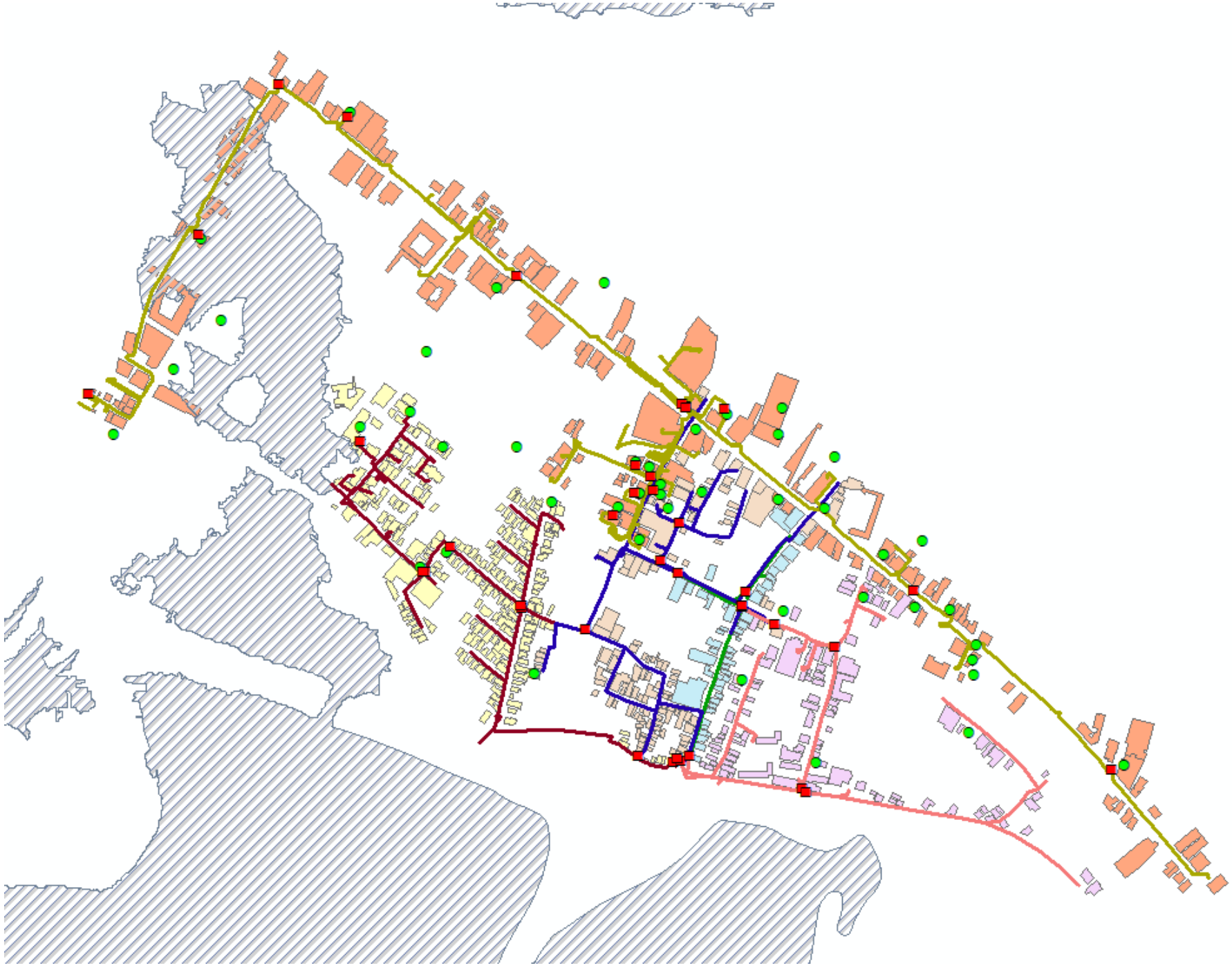
- Efficiency of work flow: streamline the input and model setup
- Efficiency of algorithms: scalability requires more testing
- From "tool" to software: several avenues (CRADA, university partners, etc.)
- Continue to refine the social burden calculation
- Incorporate additional resilience metrics (e.g. using ReAcct, future GMLC-ERMA product, etc.)
- Incorporate blue sky optimization
- Integrate with power flow solvers
- Improve ease of handoff to MDT

Long-term, we see the need for a suite of tools to co-optimize and cover a broad range of distribution system planning challenges:

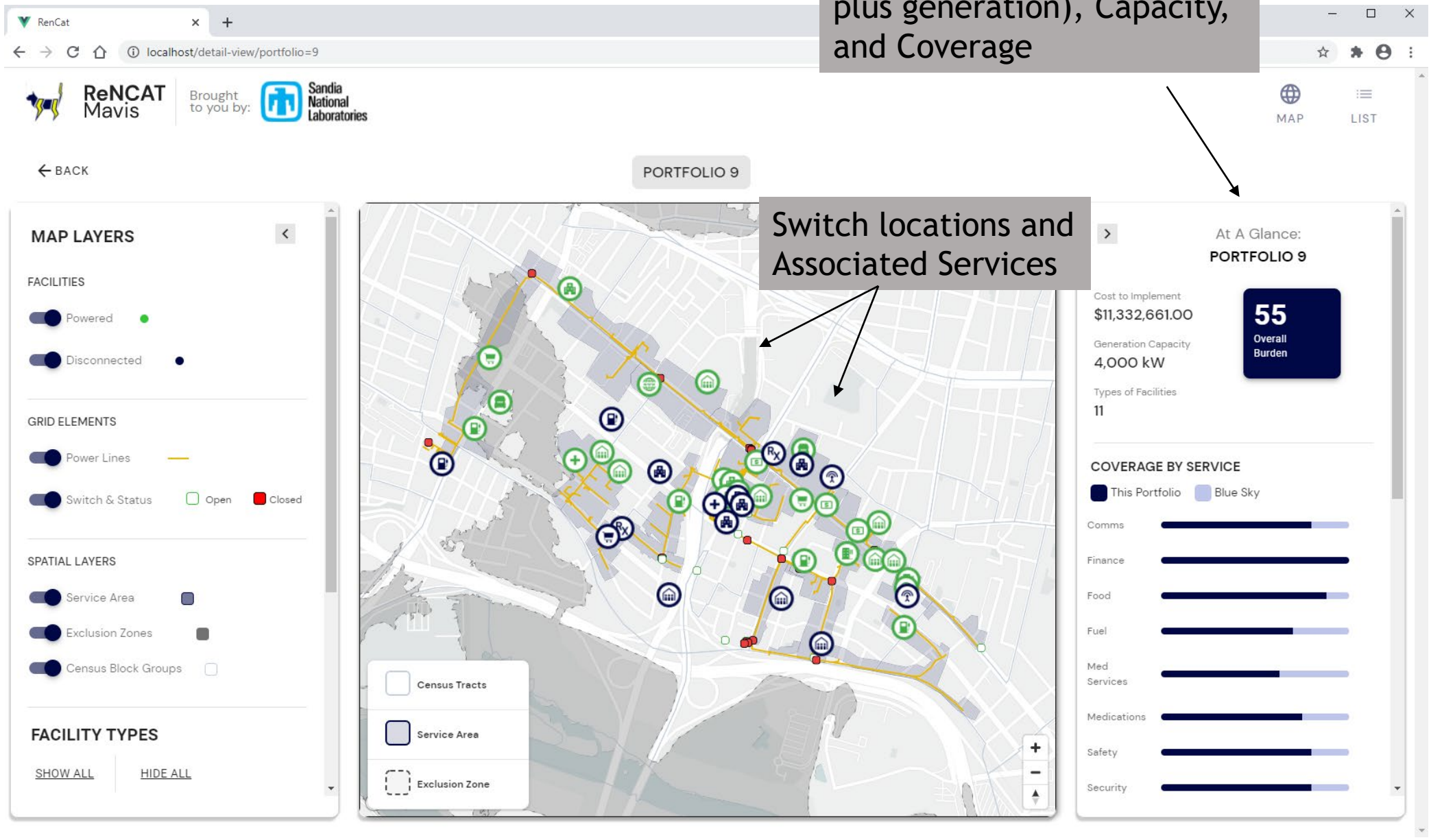
- Integration of resilience with other goals (affordability, renewable penetration, etc.)
- Expansion of resilience evaluations in other consequence categories
- Integration of reliability-focused planning and historic grid data (e.g. OMS data)
- Thermal systems (e.g. district heating and cooling, inclusion of simple building models)
- Building technologies (e.g. BEMS)

Demo problem

- Five feeders in central San Juan, PR (four on one substation, one on another)
- Flooding hazard along the west edge of the study area
- Mix of residential and commercial buildings
- Two main clusters of buildings with services, but some services more scattered



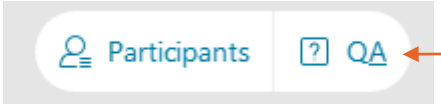
ReNCAT Portfolio Viewer



Discussion and Q&A

WebEx Tip

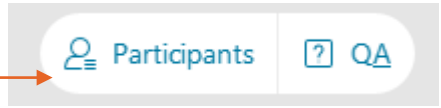
Option 1:



Access the written Q&A panel here

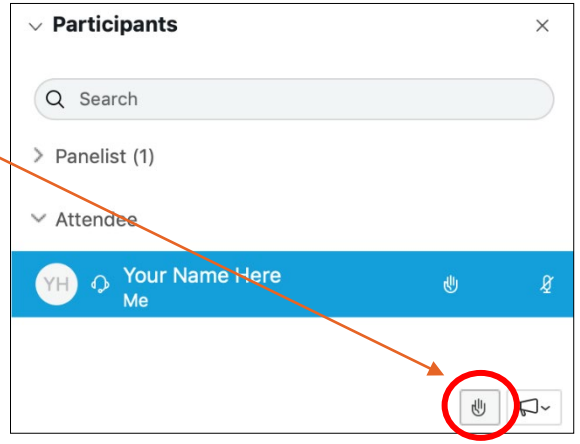
Option 2:

1. Click here to access the attendee list to raise and lower your hand.



2. Raise your hand by clicking the hand icon.

3. Lower it by clicking again.



Upcoming Meetings

- **Thursday, July 1, 2021, 2-4PM**
  Topic: Value of Resiliency – Pillar 4: Resiliency Assessment Post-disruption; additional presentations TBD

- **Thursday, July 15, 2021, 2-4PM**
  Topic: Value of Resiliency – Pillar 4: Resiliency Assessment Post-disruption; additional presentations TBD

California Public Utilities Commission

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https://www.cpuc.ca.gov/resiliencyandmicrogrids/