

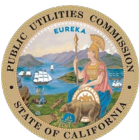
# Microgrids Proceeding R.19-09-009

## Track 5 Value of Resiliency

### Economic and Equity Impacts of Large Disruptions: Resilience Node Cluster Analysis Tool (ReNCAT) and the Social Burden Index

Grid Resiliency and Microgrids Team, Energy Division

July 7, 2022



California Public  
Utilities Commission

# WebEx and Call-In Information

## Join by Computer:

<https://cpuc.webex.com/cpuc/onstage/g.php?MTID=ef4eeaf4299941849d9dea5af13ce0503>

Event Password: GRMG (case sensitive)

Meeting Number: 2482 667 5651

## 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>.
- This meeting will be recorded and a Staff Summary Report will be sent to the Service List summarizing the discussion.
- While one or more Commissioners and/or their staff may be present, no decisions will be made at this meeting.

# 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

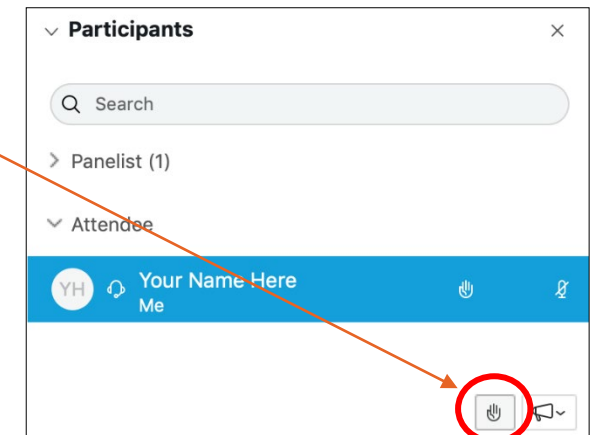
**1. Click here to access the attendee list to raise and lower your hand.**

**Access the written Q&A panel here**

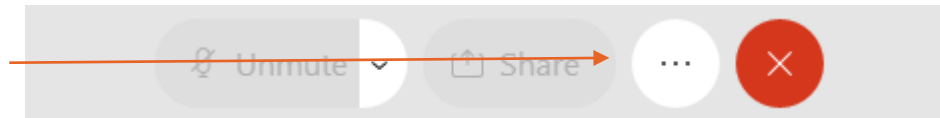


**2. Raise your hand by clicking the hand icon.**

**3. Lower it by clicking again.**



**Access your meeting audio settings here**



# WebEx Event Materials

## Event Information: Resiliency and Microgrids Working Group Meeting


Registration is required to join this event. If you have not registered, please do so now. [English](#) : [San Francisco Time](#)

**Event status:** Not started ([Register](#))

**Date and time:** Tuesday, March 2, 2021 9:30 am  
Pacific Standard Time (San Francisco, GMT-08:00)  
[Change time zone](#)

**Duration:** 1 hour

**Description:**



**Event material:** [RMWG Meeting Material\\_EXAMPLE.docx](#) (31.7 KB)

By joining this event, you are accepting the Cisco Webex [Terms of Service](#) and [Privacy Statement](#).

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**Email address:**

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# Microgrids R.19-09-009 Track 5 Workshop Schedule

## Track 5 Schedule

Event	Date
Economic & Equity Impacts of Large Disruptions, public workshop(s)	Quarter 2, 2022
Definitions, Metrics, Tools, and Methods, public workshop(s)	Quarter3, 2022
Informing Grid Planning, public workshops	Quarter 4, 2022
Staff Proposal	Quarter 1, 2023
ALJ Ruling Establishing 2023 Scheduling & Activities	Quarter 1, 2023

# Agenda

- |   |                        |
|---|------------------------|
| <b>I. Introduction</b> <i>(CPUC Staff)</i>  | <b>10:00a – 10:05a</b> |
| <ul style="list-style-type: none"><li>• WebEx logistics, agenda review</li></ul>  |                        |
| <b>II. Opening Remarks by Commissioner Shiroma</b>  | <b>10:05a – 10:10a</b> |
| <b>III. Resiliency Node Cluster Analysis Tool (ReNCAT), Sandia National Laboratories</b>  | <b>10:10a – 11:55a</b> |
| <ul style="list-style-type: none"><li>• The Social Burden Index</li><li>• Q &amp; A and Discussion</li><li>• ReNCAT Overview</li><li>• Q &amp; A and Discussion</li></ul> |                        |
| <b>IV. Closing Remarks, Adjourn</b>   | <b>11:55p – 12:00p</b> |



Exceptional service in the national interest

# Resilience Analysis

Microgrids Proceeding – Track 5  
Impacts of Large Disruptions

Olga Hart, Amanda V...  
Cynthia Bresloff

July 7, 2022 10:00 AM – 11:00 AM

## Microgrids Proceeding R.19-09-009 Track 5 Value of Resiliency

Economic and Equity Impacts of Large Disruptions:  
Interruption Cost Estimate (ICE) Calculator and Power Outage Economic Tool (POET)

Grid Resiliency and Microgrids Team, Energy Division  
May 10, 2022



# AGENDA

## **Introductions**

Grid Modernization at Sandia

Project Team

Project Overview

## **ReNCAT/Equity Metrics Workshop**

**Social Infrastructure Service Burden**

### **ReNCAT**

Overview

Data Needs, Inputs, and Workflow

Results and Outputs

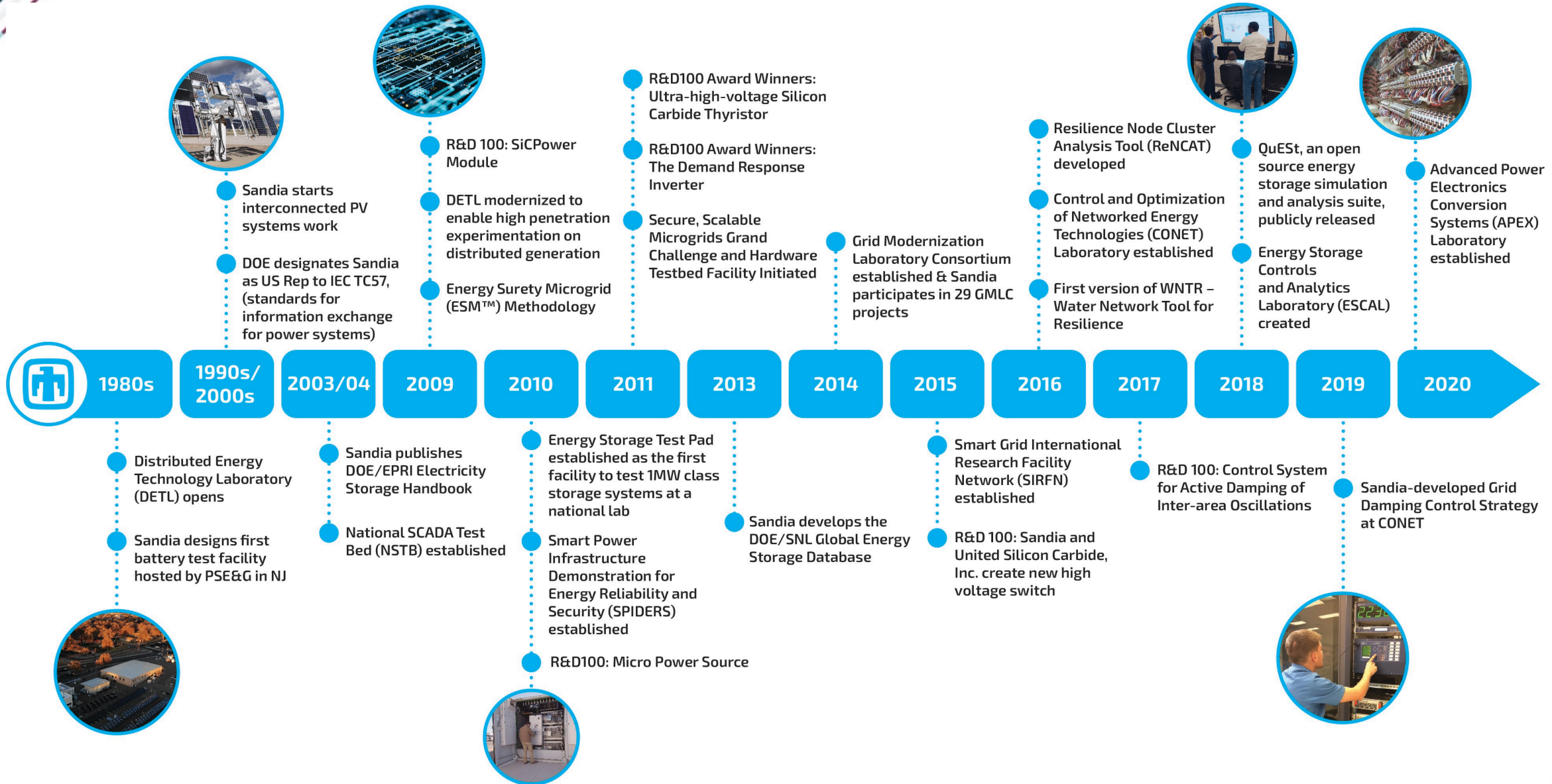
## **Discussion and Next Steps**



# Introductions



# History of Grid Modernization at Sandia







# Renewable and Distributed Systems Integration

Multi-disciplinary research and development to enable grid modernization and large-scale deployment of renewable and distributed energy resources.

## RESEARCH AREAS



Distributed Energy Resource Technology

Power Electronics and Controls

Electric Vehicle Charging

Standardization

Grid Security

Advanced Modeling and Simulation



## CAPABILITIES

- Advanced modeling and simulation
- Power electronics and controls
- Microgrid design and validation
- Grid performance evaluations and compatibility
- Distributed energy technology validation and demonstration
- Integrated systems optimization, distributed controls, communications, interoperability, and cybersecurity
- Vehicle charging infrastructure grid integration and threat modeling





# Sandia Project Team

**Olga Hart**



Project Lead

**Amanda Wachtel**



Resilience and  
Equity Research  
Analyst

**Darryl Melander**



Lead ReNCAT  
Software  
Developer

**Cynthia Bresloff**



GIS and Scientific  
Visualization  
Specialist





# Project Phases

## Phase 1 – Baseline Evaluation


- Collect data
- Evaluate the current state of one IOU territory
- Educate stakeholders on tools and metrics
- Scope data needs for Phase 2

## Phase 2—Mitigation Measure Optimization

- Collect data
- Build optimization model for one IOU territory
- Provide analysis of targeted locations for resilience investments

## Phase 3—Options Evaluation

- Refine model for use in evaluating proposed projects
- Work with stakeholders to integrate tool into workflow

The image features a central dark blue diamond shape with the text "ReNCAT Workshop" in white serif font. This diamond is surrounded by a white border and is set against a background of two diagonal lines that meet at the center. These lines are composed of several colored segments: teal, purple, orange, green, and dark blue. The overall design is clean and modern.

ReNCAT  
Workshop

# The Social Burden Metric





# Introduction to Energy Justice

- Energy justice refers to the concepts of equity, affordability, accessibility and participation in the energy system and energy transition regardless of race, nationality, income or geographic location.
- Energy justice can be achieved by:
  - Reducing energy costs and burdens on low-income customers
  - Avoiding disproportionate impacts and ensuring equitable benefits
  - Ensuring access to reliable and clean energy
  - Inviting community participation in energy sector decision-making and development
- **Access to services** is a primary **measure** of energy justice.

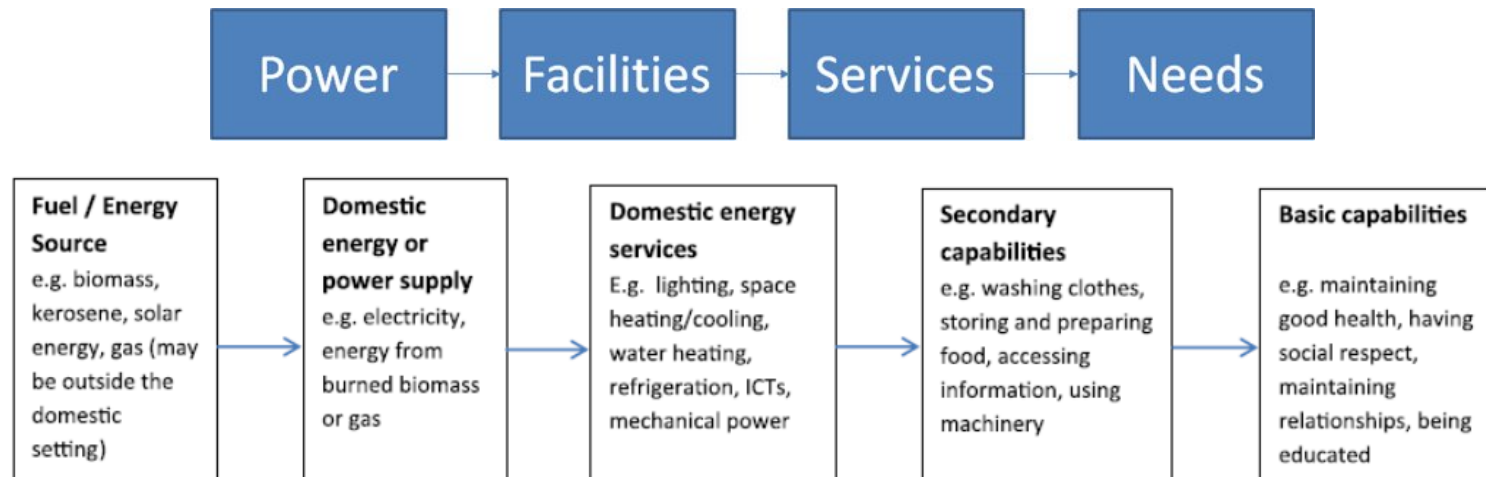


Fig. 1. Conceptualising the relationship between energy, services and outcomes.



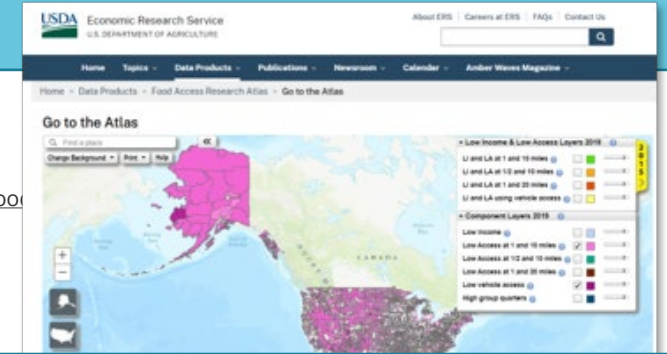
# Introduction to Burden Estimation

- Where you live has an impact on quality of life; resources and threats are not evenly distributed across the landscape.
- Other commonly known types of burden analyses have been used in the past to understand issues related to:
  - disparities in food access [1]
  - environmental risk [2]
  - natural hazards [3]

1

## USDA Food Access Research Atlas

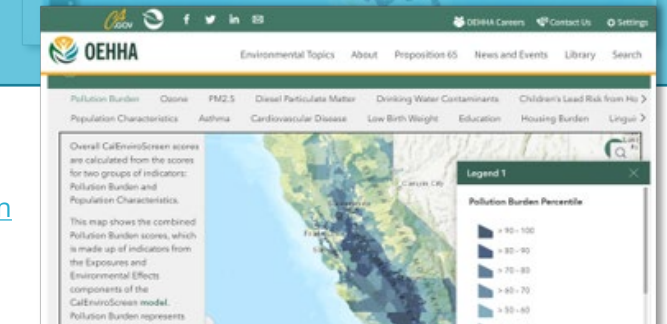
<https://www.ers.usda.gov/data-products/food-access-research-atlas/go-to-the-atlas/>



2

## CalEnviroScreen Pollution Burden

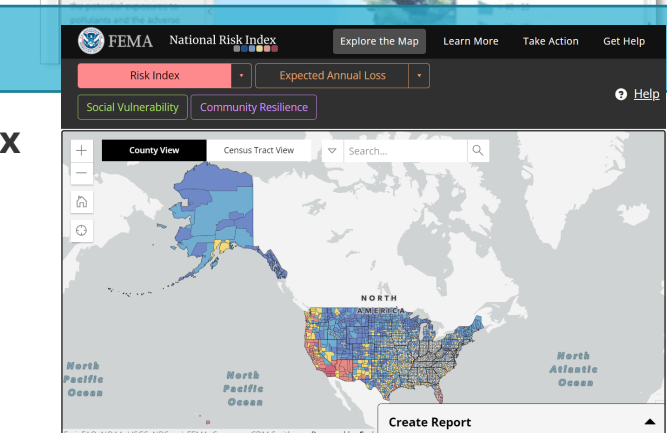
<https://oehha.ca.gov/calenviroscreen>



3

## FEMA National Risk Index

<https://hazards.fema.gov/nri/map>





# Societal Infrastructure Service Burden (“Social Burden”)





# Sandia's Social Burden Metric: a Function of Effort and Ability

## Social Burden Metric

We can begin to estimate burden by comparing effort to ability:

### Effort

~Distance

*Q: How far must I travel to reach nearest supply point?*

**vs.**

### Ability

~Service Availability

*Q: What amount/quality is available?*

~ Resources

*Q: How equipped am I to spend money, time, and energy in search of the service?*

Sandia's Social Burden metric goes beyond one service (e.g., USDA food deserts):

- Looks at the full suite of critical services
- However, total burden can be combined or disaggregated spatially or by category

The metric provides a way to quantify, compare, and make decisions.





# Infrastructure Provides Critical Services

**Critical services\*** are services that people need to survive on a daily basis such as:

- Food
- Water
- Shelter
- Medical Care
- Financial Services
- Communications
- Etc.



FEMA Lifelines, Source: FEMA 2019

*\*Sandia's definition of Critical Services is similar to FEMA lifeline services, but with greater emphasis on acute individual needs than on restoration*



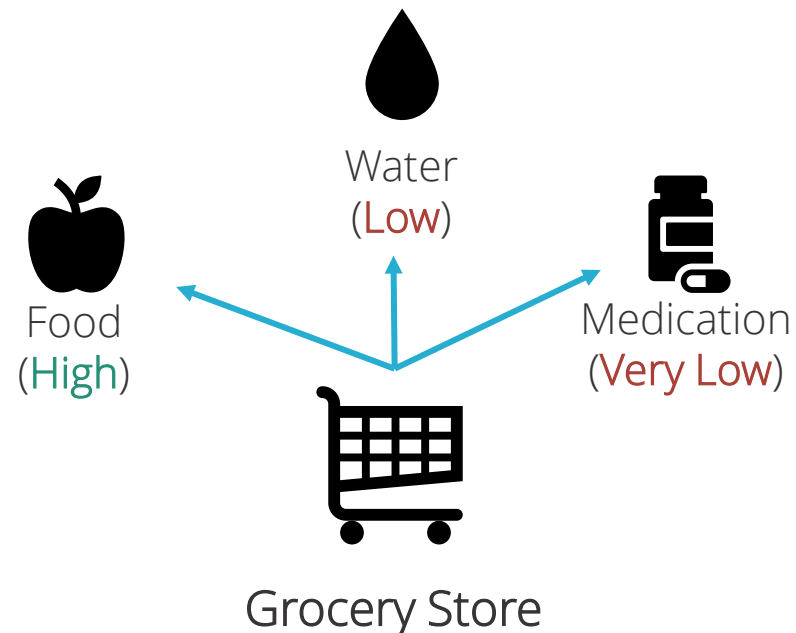


## Mapping Infrastructure to Services

After defining critical services, we also need to map infrastructure sectors (e.g., grocery stores, banks, hospitals) to the services they provide

One infrastructure sector may provide multiple critical services at different levels

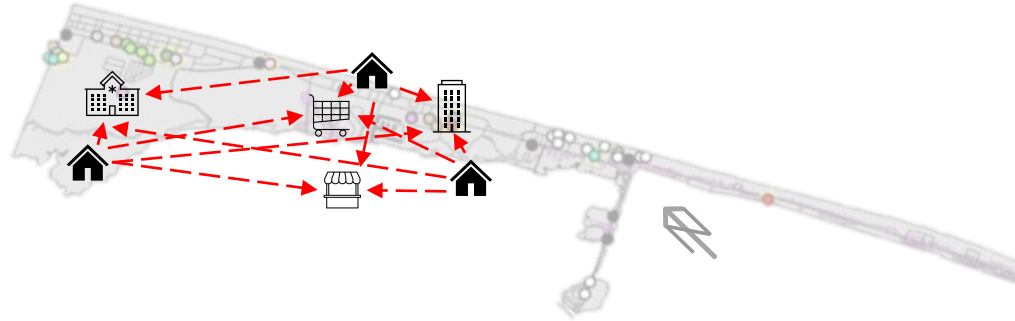
- Create a mapping between services and sectors



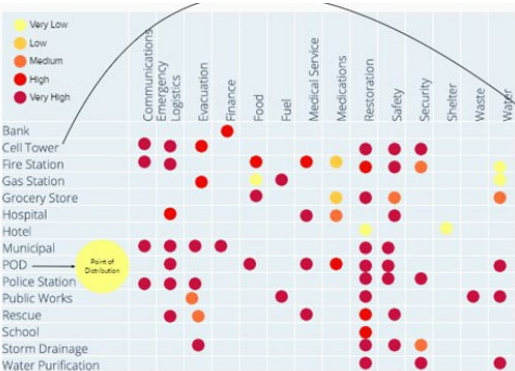
	Service 1	Service 2	Service 3
Sector 1	High		Low
Sector 2		Low	
Sector 3	Medium		
Sector 4			Very High



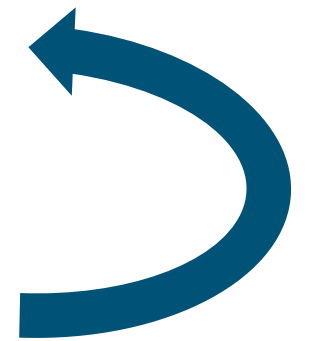
# Measuring Societal Infrastructure Service Burden



$$SB = \frac{\text{Distances to Services}_{\text{people, services}}}{\text{Service Levels}_{\text{facilities, services}} \times \text{Median Household Income}_{\text{people}}}$$



\$172k  
 \$57k  
 \$228k  
 \$43k  
 ...



ReNCAT uses the distance from the centroid of census blocks to calculate effort, and the median income of census blocks to scale ability. These proxies can be tailored when needed.



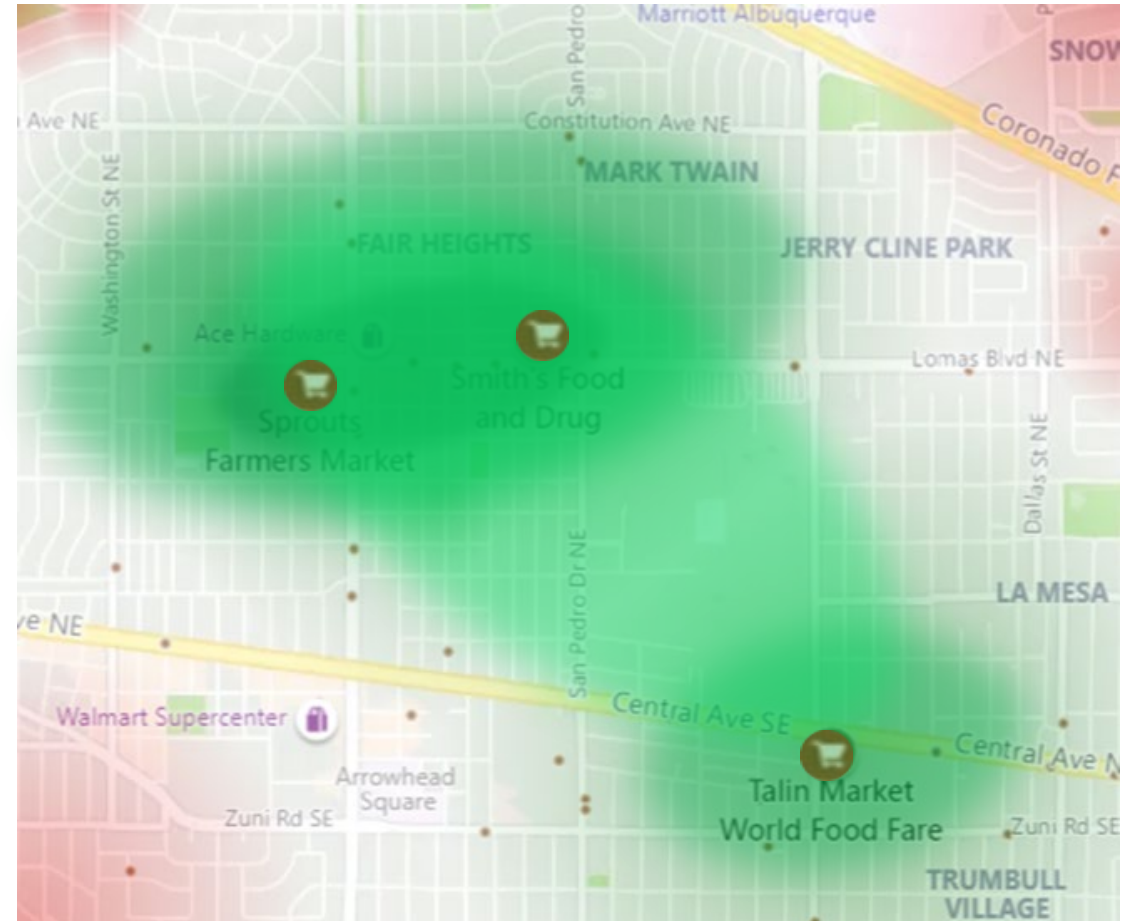
## Social Burden Explained

Burden to acquire a service:

- Increases with distance to facilities
- Decreases with additional facilities (diminishing returns, non-linear)
- Decreases with ability (typically average household income)

Burden aggregation:

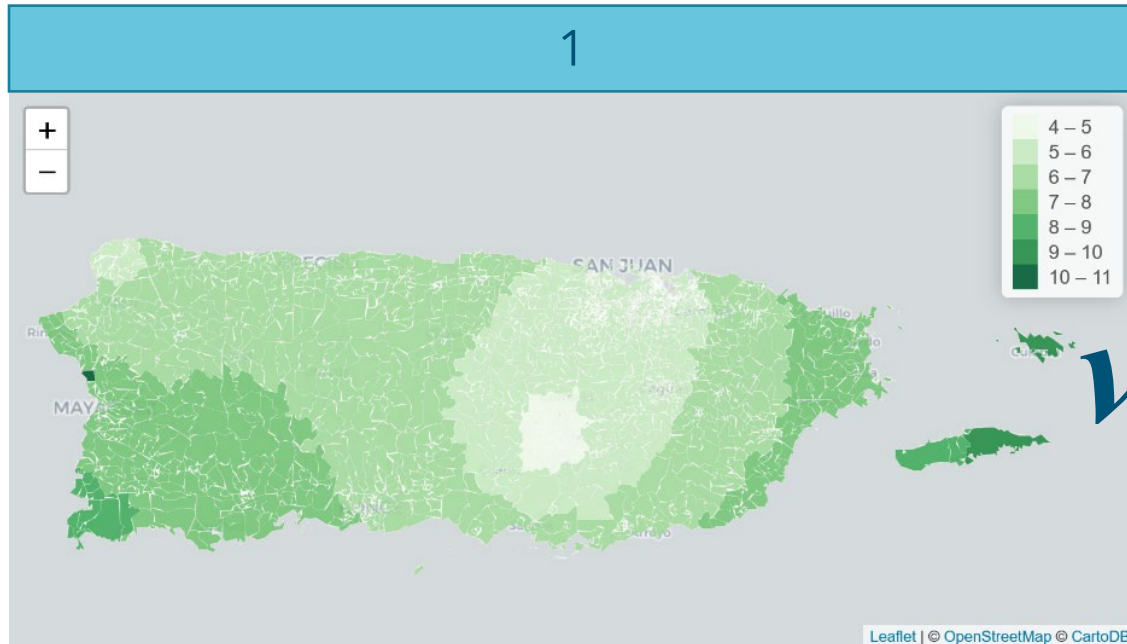
- Per-service burden calculated for each population block
- Burden summed across blocks
- Total burden summed across services



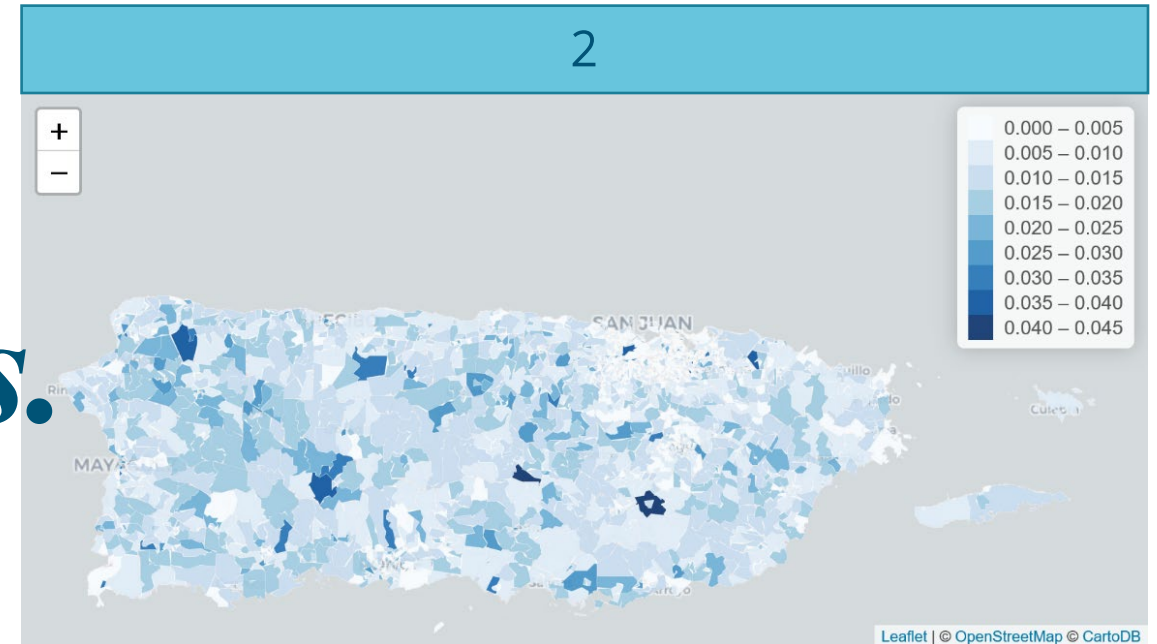


# The Impact of Including Social Burden in Planning for Equitable Distribution of Infrastructure Services

By considering the population's ability to acquire services and the available infrastructure's ability to provide those services, Social Burden uncovers a much more complex map of need [2] than looking at distance alone might suggest [1]. *See example application in Puerto Rico:*



**Effort (Distance) by Census Block Group for Randomly Selected Portfolio of Microgrids**




**Societal Burden by Census Block Group for Randomly Selected Portfolio of Microgrids**



## Key Attributes of the Social Burden Metric

Attributes of Sandia's Social Burden Metric implementation:

- Spatially-explicit;
- Consistent;
- Adaptable;
- Community-input oriented;
- Scalable.



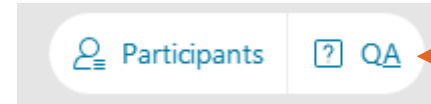
Break for  
Discussion and  
Questions



# Discussion and Q&A

## WebEx Tip

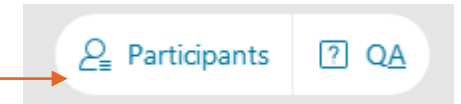
Option 1:



Access the written Q&A panel here

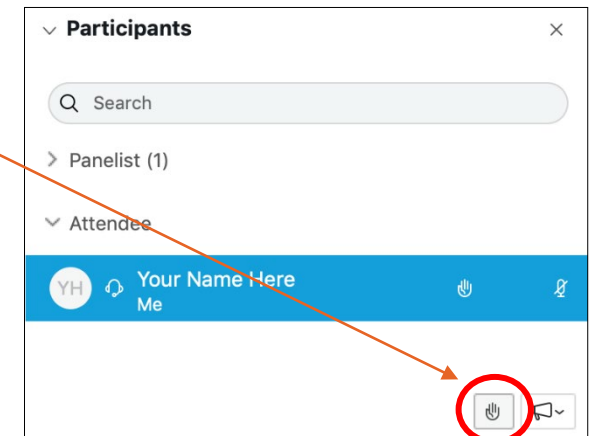
Option 2:

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.



# ReNCAT: 1) Overview



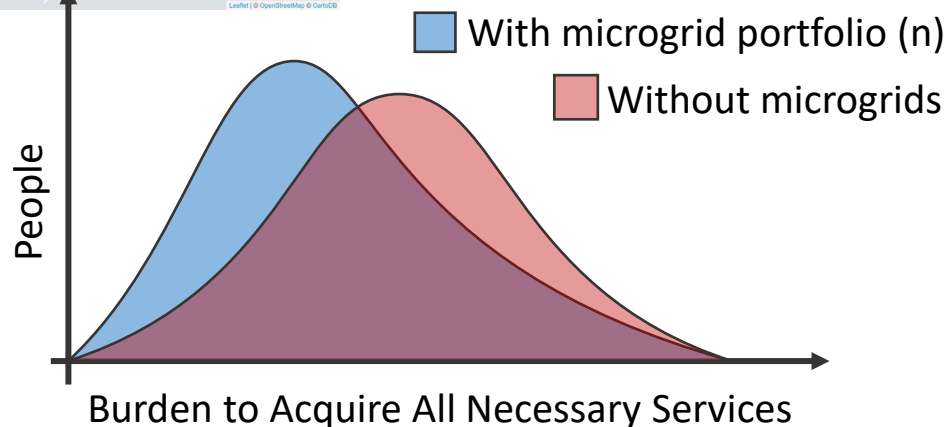
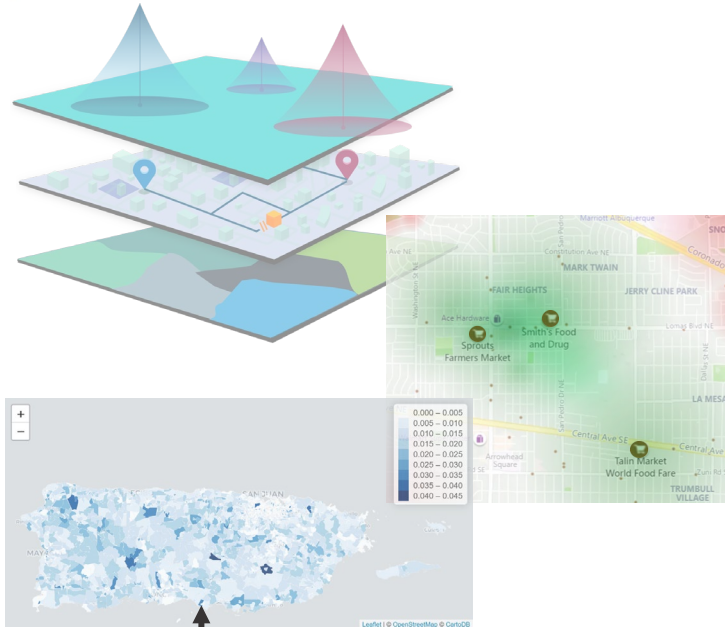




# A Need to Act on the Social Burden Metric to Make Optimal and Equitable Power Infrastructure Decisions

Want to make sure that people within communities have critical needs met during emergency situations?

Knowing that burden exists still doesn't tell us how we can best minimize its impact on people using limited resources and constrained by legacy infrastructure investments!



## Need a tool to help with:

- Siting infrastructure investments
- Evaluating alternative projects
- Understanding public safety power shutoff plan (PSPS) impacts
- Mitigation measures



# What is ReNCAT?

ReNCAT stands for the Resilient Node Cluster Analysis Tool created by Sandia National Laboratories



- Desktop application
  - Active development since 2016
- Optimization tool
  - Uses genetic algorithm to site and size resilience solutions across a broad landscape
- Grid and other critical infrastructure explicitly modeled
  - Uses distribution system layout and identifies which sub feeders to energize based on critical infrastructure locations and services
- Identifies portfolios of resilience solutions that optimize for social burden vs cost
  - Calculated burden to residents to obtain critical services
  - Balances against cost of generation needed to power microgrids
- Can also be used for social burden evaluation

**ReNCAT Mavis** Brought to you by: **Sandia National Laboratories**

PORTFOLIO 2

At A Glance: **PORTFOLIO 2**

Cost to Implement: **\$9,217,224.70**

Generation Capacity: **3,500 kW**

Types of Facilities: **9**

Overall Burden: **73**

COVERAGE BY SERVICE

■ This Portfolio ■ Blue Sky

Comms:

Finance:

Name	Noncritical Load (kW)	In Disconnect Eligible (Y/N)	Disconnect Cost (\$)	Additional Critical Load (kW)
0001	137.70562		\$68,890.29	
0002	179.746296		\$89,873.13	
0004	191.3932		\$76,096.60	
0006	46.728503		\$23,364.25	
0007	18.668944		\$9,334.47	
0009	402.934005		\$201,467.29	
0001	0		\$0.00	
0063	0		\$0.00	
0009	0		\$0.00	
0005	137.432878		\$68,716.44	
0017	248.167293		\$124,083.65	
0018	0		\$0.00	
0028	145.567069		\$72,783.53	
0000	149.230289		\$74,617.64	
0023	110.916373		\$55,788.19	
0024	250.939613		\$1,275,468.81	
0013	0		\$0.00	
0026	2189.936405		\$1,094,968.24	
0036	271.817406		\$135,908.70	
0017	619.339121		\$307,689.56	
0028	613.220388		\$306,612.69	
0040	1192.222545		\$596,111.27	
0061	0		\$0.00	
0062	0		\$0.00	
0065	0		\$0.00	
0066	0		\$0.00	
0060	0		\$0.00	
0061	0		\$0.00	
0008	0		\$0.00	
0014	770.001231		\$385,000.62	
0016	312.043695		\$156,021.83	
0019	435.789166		\$217,894.58	
0031	436.581887		\$218,290.93	
0063	0		\$0.00	
0011	15.54819		\$7,774.09	
0012	284.728071		\$142,364.04	
0013	99.520311		\$49,760.16	
0016	211.62061		\$105,811.76	
0029	185.91		\$92,955.00	

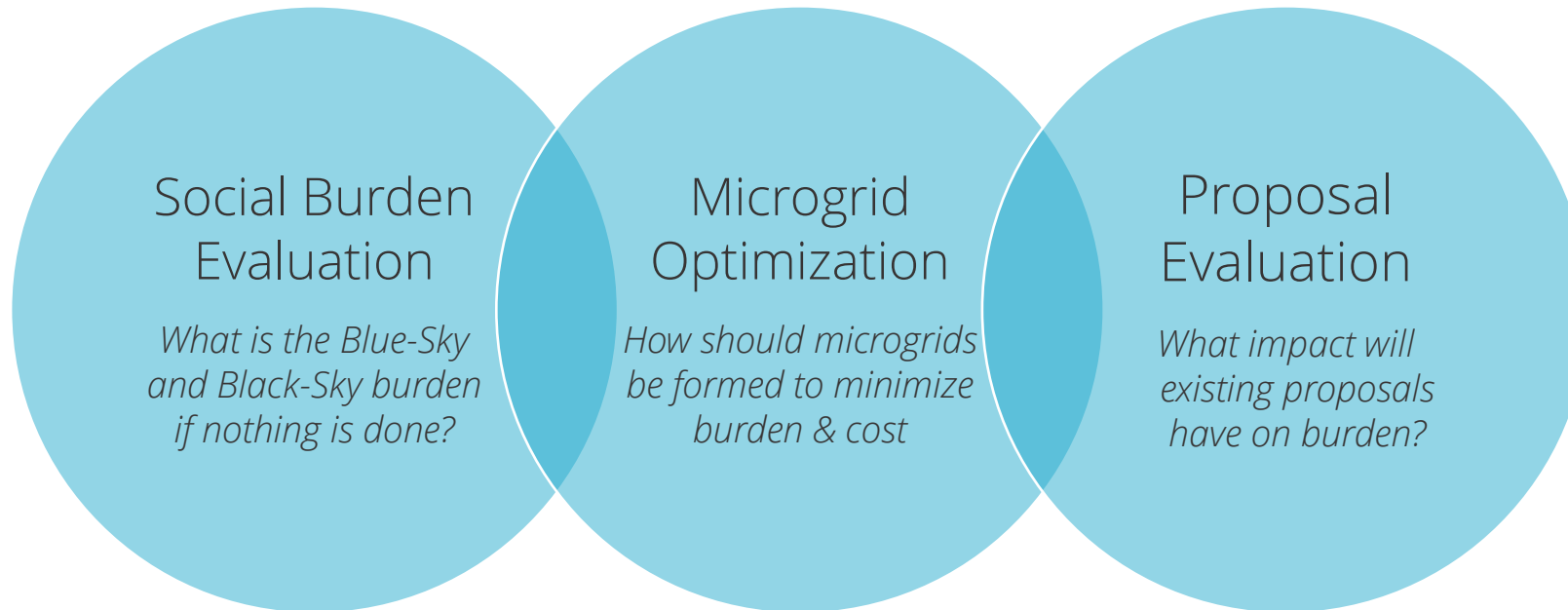
## Locations Used:

- New Orleans
- Puerto Rico
- Pittsburgh
- Nags Head, NC
- Colorado Springs



## Applications of ReNCAT

**one** tool x **two** capabilities x **three** applications:



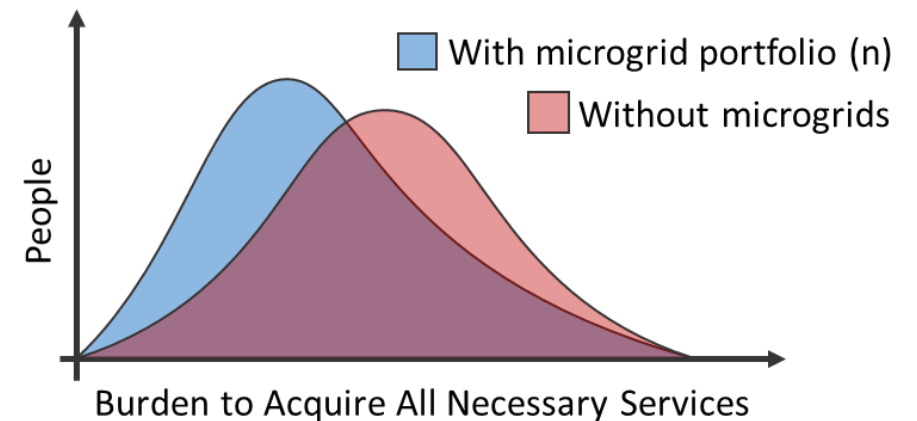
Can be mixed and matched depending on data availability, study questions, and project needs.



# ReNCAT Optimization Reduces Burden at Least Cost

- The ReNCAT optimization is striving to minimize both burden and cost
  - Each optimal portfolio of microgrids balances these two metrics
- **ReNCAT** identifies least cost-option for each burden level (*decision-support*)
- **Decision-makers** judge desirable/acceptable level of cost and burden

## ReNCAT Optimization



Enables Maximum Burden Reduction at Least Cost

ReNCAT:  
2) Data Needs,  
Inputs, and Workflow

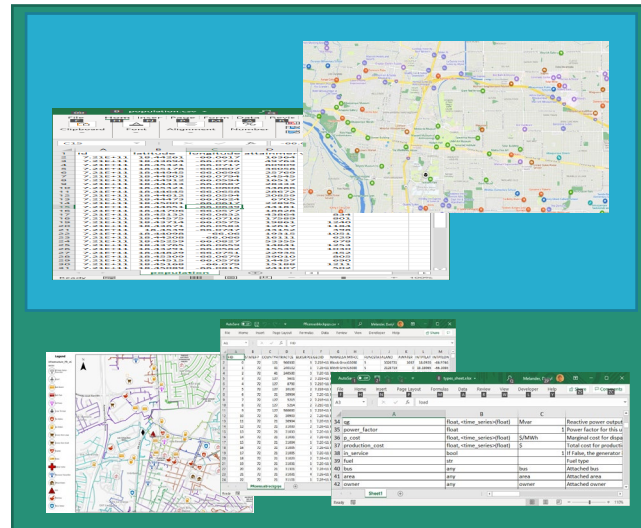




# ReNCAT Data Requirements

- Data gathering is one of the most demanding steps to use ReNCAT
- Data requirements depend on which capability is being used
  - Burden assessment (Phases 1 and 3)
  - Optimization of microgrid placement (Phase 2)
- Burden assessment uses a *subset* of data required for microgrid optimization

Burden  
Assessment  
Data



Microgrid  
Placement  
Optimization  
Data





# Data Requirements for Burden Assessment



## Basic Facility Data

- *Location*
- *Sector*

## Population Data

- *Census Blocks*
- *Median Income*

## Burden Parameters

- *Service levels*
- *Effort parameters*

## Power Scenario

- *Which facilities have power*

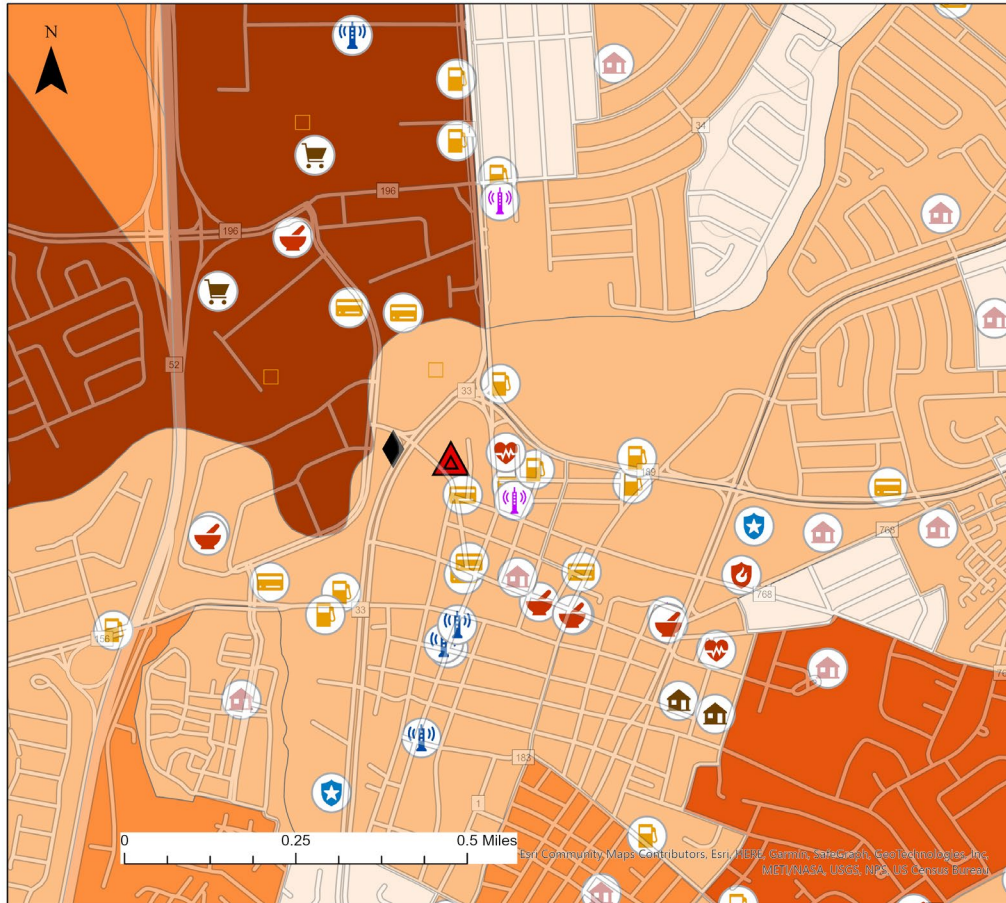
Burden Values



# Required Data Example : Census Data Mapping

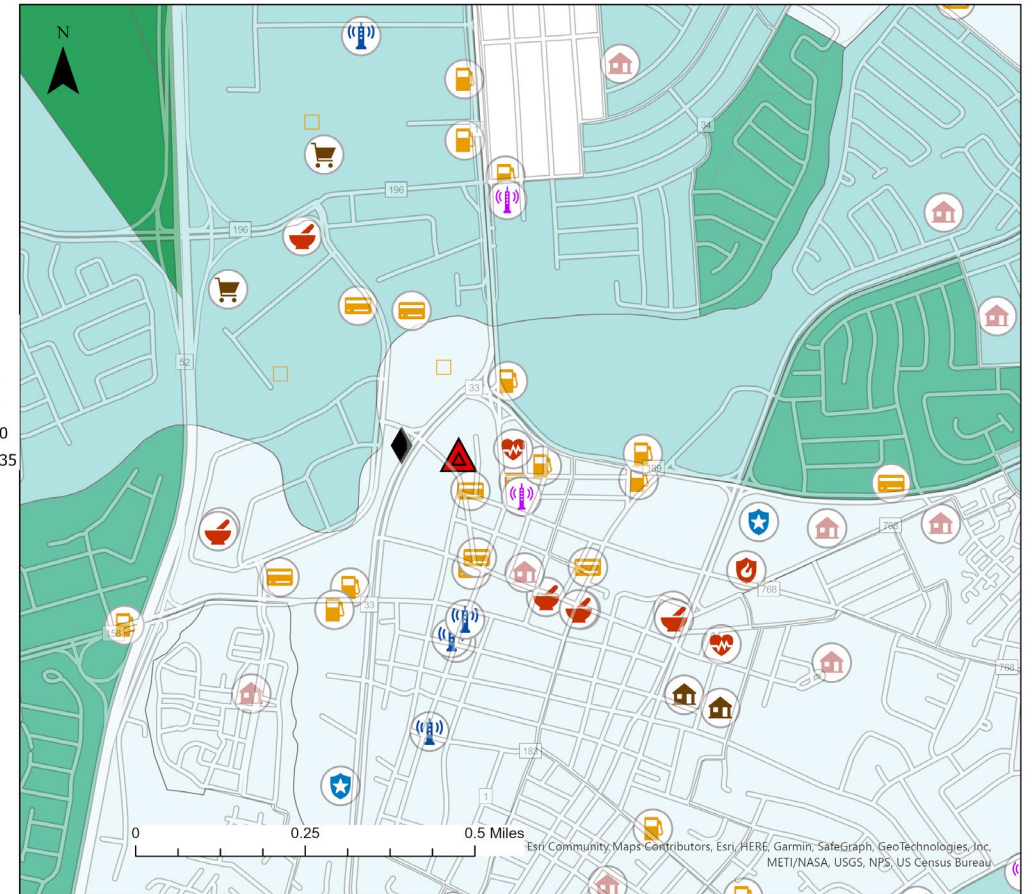
POPULATION

- 0 - 751
- 752 - 1261
- 1262 - 1812
- 1813 - 2488
- 2489 - 4995



MEDIAN INCOME

- 2500 - 18233
- 18234 - 30551
- 30552 - 51139
- 51140 - 105960
- 105961 - 244735



*Population and Median Income for a region of Puerto Rico*





# Data Requirements for Burden Assessment



Expert  
Judgement

## Basic Facility Data

- *Location*
- *Sector*

## Population Data

- *Census Blocks*
- *Median Income*

## Burden Parameters

- *Service levels*
- *Effort parameters*

## Power Scenario

- *Which facilities have power*

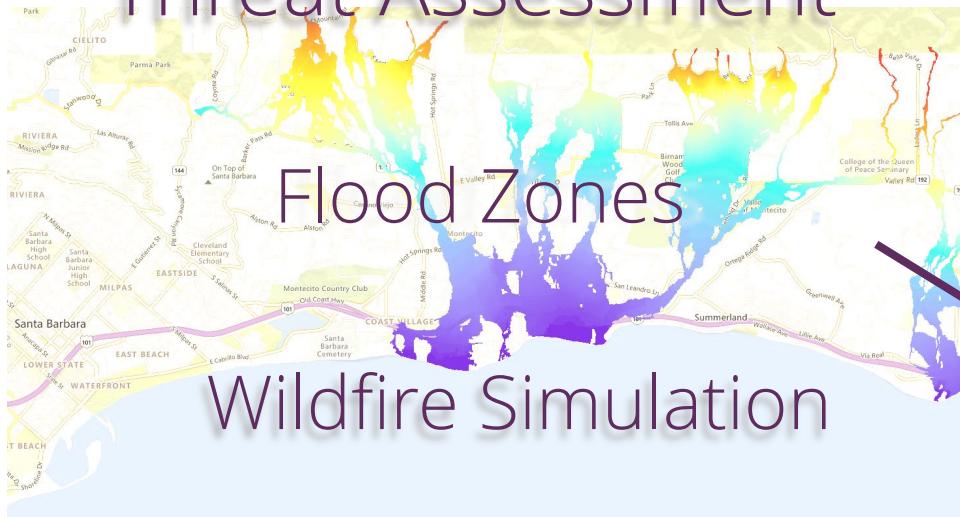
Burden Values



# Data Requirements for Burden Assessment

Normal "Blue Sky" State

Threat Assessment



Flood Zones

Wildfire Simulation

Basic Facility Data

- *Location*
- *Sector*

Population Data

- *Census Blocks*
- *Median Income*

Burden Parameters

- *Service levels*
- *Effort parameters*

Power Scenario

- *Which facilities have power?*

Burden Values



# Data Requirements for Microgrid Placement

- ReNCAT's microgrid placement capability requires additional types of data

## Basic Facility Data

- *Location*
- *Sector*

## Population Data

- *Census Blocks*
- *Median Income*

## Burden Parameters

- *Service levels*
- *Effort parameters*

## Power Scenario

- *Which facilities have power?*

Burden Values

## Idealized Power Grid Topology

- *Where are distribution lines connected*
- *Where are facilities connected to the distribution network*

## Load Data

- *Loads imposed by facilities*
- *Other "non-critical" loads*

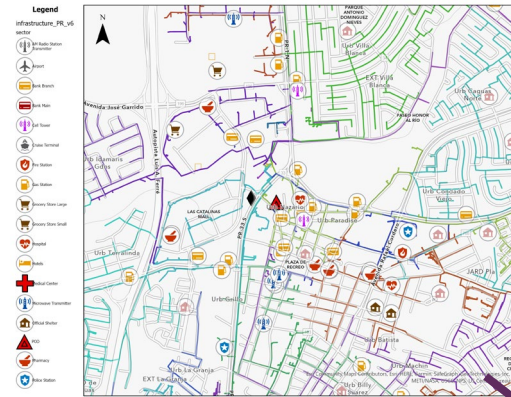
## Cost Data

- *Cost to isolate sections*
- *Cost to increase generation capacity*
- *Cost to disconnect loads*



# Data Requirements for Microgrid Placement

- Simplified view of the distribution network
  - Distribution network split into sections
  - Sections divided at potential microgrid boundaries
- Identify the grid section that powers each facility



Basic Facility Data

- Location
- Sector

Population Data

- Census Blocks
- Median Income

Burden Parameters

- Service levels
- Effort parameters

Power Scenario

- Which facilities have power?

Burden Values

**Idealized Power Grid Topology**

- Where are facilities connected to the distribution network
- How can the topology be altered?

Load Data

- Loads imposed by facilities
- Other "non-critical" loads

Cost Data

- Cost to isolate sections
- Cost to increase generation capacity
- Cost to disconnect loads



GIS Systems

Grid Operators

Subject Experts





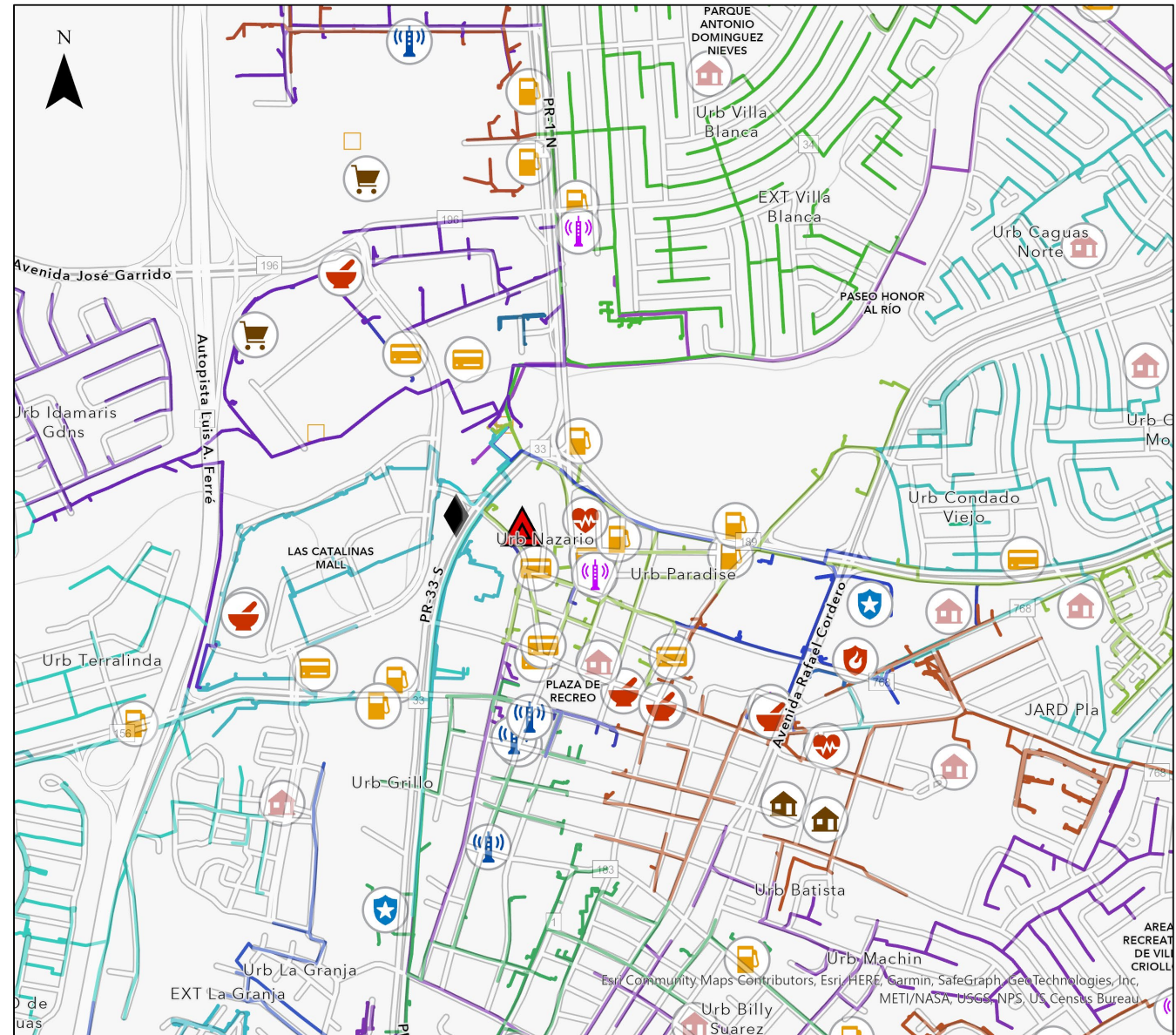
# Required Data Example : Facilities and Power Line Segments

- Colored lines represent segments of the distribution network (typically feeders)
- Each facility is mapped to a power line segment

**Legend**

infrastructure\_PR\_v6  
sector

- AM Radio Station Transmitter
- Airport
- Bank Branch
- Bank Main
- Cell Tower
- Cruise Terminal
- Fire Station
- Gas Station
- Grocery Store Large
- Grocery Store Small
- Hospital
- Hotels
- Medical Center
- Microwave Transmitter
- Official Shelter
- POD
- Pharmacy
- Police Station





# Data Requirements for Microgrid Placement

- Load Data
  - Load from each facility
  - Aggregate load from everything else on each grid segment

## Basic Facility Data

- *Location*
- *Sector*

## Population Data

- *Census Blocks*
- *Median Income*

## Burden Parameters

- *Service levels*
- *Effort parameters*

## Power Scenario

- *Which facilities have power?*

Burden Values

## Idealized Power Grid Topology

- *Where are facilities connected to the distribution network*
- *How can the topology be altered?*

## Load Data

- *Loads imposed by facilities*
- *Other "non-critical" loads*

## Cost Data

- *Cost to isolate sections*
- *Cost to increase generation capacity*
- *Cost to disconnect loads*





# Data Requirements for Microgrid Placement

- Costs to create microgrids
  - Cost to connect or isolate grid sections (switches)
  - Cost to disconnect facilities and aggregate non-critical loads
  - Cost to increase generation capacity (generator investments)

## Basic Facility Data

- *Location*
- *Sector*

## Population Data

- *Census Blocks*
- *Median Income*

## Burden Parameters

- *Service levels*
- *Effort parameters*

## Power Scenario

- *Which facilities have power?*

Burden Values

## Idealized Power Grid Topology

- *Where are facilities connected to the distribution network*
- *How can the topology be altered?*

## Load Data

- *Loads imposed by facilities*
- *Other "non critical" loads*

## Cost Data

- *Cost to isolate sections*
- *Cost to increase generation capacity*
- *Cost to disconnect loads*







# Data Requirements for Microgrid Placement

- Power scenario data requirements may be reduced compared to burden assessment
  - Identify where power is available to the grid, not the powered state of each facility
  - As ReNCAT explores microgrid placement options, it will use grid topology to identify which facilities have power

## Basic Facility Data

- *Location*
- *Sector*

## Population Data

- *Census Blocks*
- *Median Income*

## Burden Parameters

- *Service levels*
- *Effort parameters*

## Power Scenario

- *Which facilities have power?*

Burden Values

## Idealized Power Grid Topology

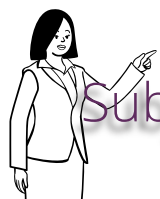
- *Where are facilities connected to the distribution network*
- *How can the topology be altered?*

## Load Data

- *Loads imposed by facilities*
- *Other "non-critical" loads*

## Cost Data

- *Cost to isolate sections*
- *Cost to increase generation capacity*
- *Cost to disconnect loads*



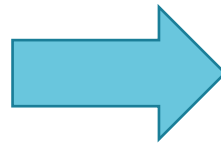
Subject Experts



# Where Can We Get Data for ReNCAT?

Data is gathered from a variety of sources, entered into the ReNCAT application

- Google/Google Maps
- Open Street Map
- US Census Bureau
- American Community Survey
- HIFLD Open
- Hazus (FEMA)
- Utility data
- City data
- Local government data
- Propriety databases



SampleModel.rencat - ReNCAT - [Population Blocks]

File Edit View Project Windows Help

**Input Editor**

- Algorithm
- Algorithm Options
- Power Infrastructure
  - Power Lines
  - Power Sources
  - Switches
  - Discrete Generators
  - Continuous Generation Capacity
- Facilities
  - Facilities
  - Inclusion Profiles
  - Inclusion Profile Data
  - Variable Effort
- Services
  - Services
  - Service Mapping
- Population Blocks
  - Population Blocks

**Population Blocks**

Name	Centroid		Attainment Factor	Population
	Latitude	Longitude		
721270024001	18.44261	-66.061682	16364	1141
721270105002	18.436941	-66.073624	49763	1236
721270009004	18.453214	-66.071676	60909	735
721270011001	18.451778	-66.060705	36058	762
721270018001	18.449446	-66.069591	25769	1210
721270020021	18.449026	-66.079409	14545	661
721270015001	18.449121	-66.059408	16517	1061
721270023001	18.444326	-66.068703	28333	224
721270019002	18.453205	-66.080808	34886	1066
721270016003	18.446446	-66.065844	28672	595
721270025001	18.446115	-66.05939	20859	751
721270025003	18.444732	-66.062363	6705	101
721270015002	18.450014	-66.061668	22895	899
721270016002	18.44651	-66.063939	44181	819
721270026001	18.44706	-66.057683	18828	259
721270019004	18.451322	-66.083244	43864	834
721270022001	18.445747	-66.071553	17589	801
721270038001	18.437138	-66.057472	19861	1240
721270038002	18.436707	-66.058318	12617	1184
721270009003	18.453899	-66.07469	43152	398
721270024002	18.440983	-66.06	19315	1051
721270023003	18.442082	-66.065999	16111	629
721270019003	18.452588	-66.082687	53355	678
721270039023	18.43765	-66.065864	14841	1253
721270044003	18.432914	-66.05821	15539	1030
721270021002	18.448286	-66.075094	22935	452
721270010005	18.453092	-66.06789	39010	805
721270026004	18.445148	-66.057802	14457	690
721270021001	18.451682	-66.078956	15188	1211
721270020022	18.450892	-66.081519	24107	502
721270042003	18.446697	-66.079205	23788	1211
721270010004	18.451602	-66.067319	28550	1380
721270010003	18.452855	-66.065054	51167	291
721270016001	18.450322	-66.064088	49318	480
721270025002	18.446683	-66.061341	20060	884
721270039021	18.437172	-66.059287	15881	1524
721270042002	18.445983	-66.08098	17434	1164
721270023002	18.441855	-66.069147	14231	522
721270037005	18.434882	-66.058218	11964	594
721270010002	18.45251	-66.062388	55078	1487
721270042001	18.447815	-66.083312	27083	238

Input Editor

Results Explorer

Ready



## Data Needs for ReNCAT

Things to know about data:

- **Sources**

Data will come from multiple sources and sometimes from a mix of open sources and propriety sources

- **Formats**

Data will likely be in the form of GIS files that will need to be processed

- **People**

You'll need to work with people who can access and manipulate data

- Someone with expertise in programs like ArcGIS or QGIS
- Someone who can identify potential modifications to the electrical distribution system



## Required Data Summary

### Required Data to build a ReNCAT model:

- GIS representation of the electrical distribution system
  - Feeders, candidate microgrid boundaries, non-grid generation assets, non-critical load
- Power generation investment options
  - Continuous and discrete options, costs
- Facilities
  - Geographic location, feeder connection information, load, cost to disconnect
- Threat profiles
  - Relevant threat profiles and their impact on facilities
- Services
  - Mapping of facility sectors to services
- Census block group data
  - Geographic centroid of each block group, median income, population

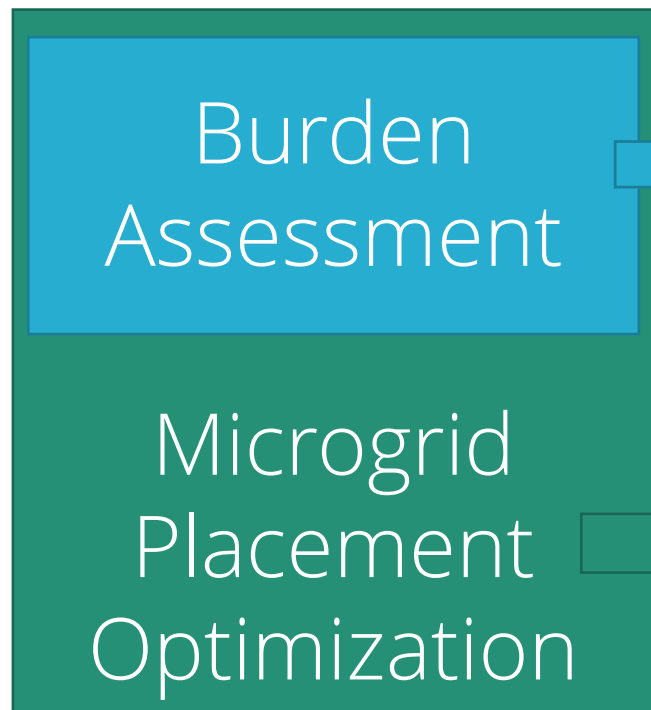
ReNCAT:  
3) Results & Outputs





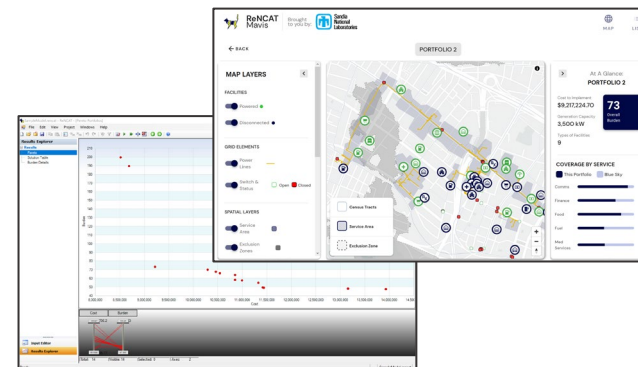
# ReNCAT Results

ReNCAT results will depend on whether we're running a ReNCAT evaluation or a ReNCAT optimization



Burden Distribution Maps

- Total and Per-Service



Recommended Microgrid Portfolios

- Portfolios at various cost-to-burden ratios
- Microgrid layout details



## Results of a Burden Evaluation

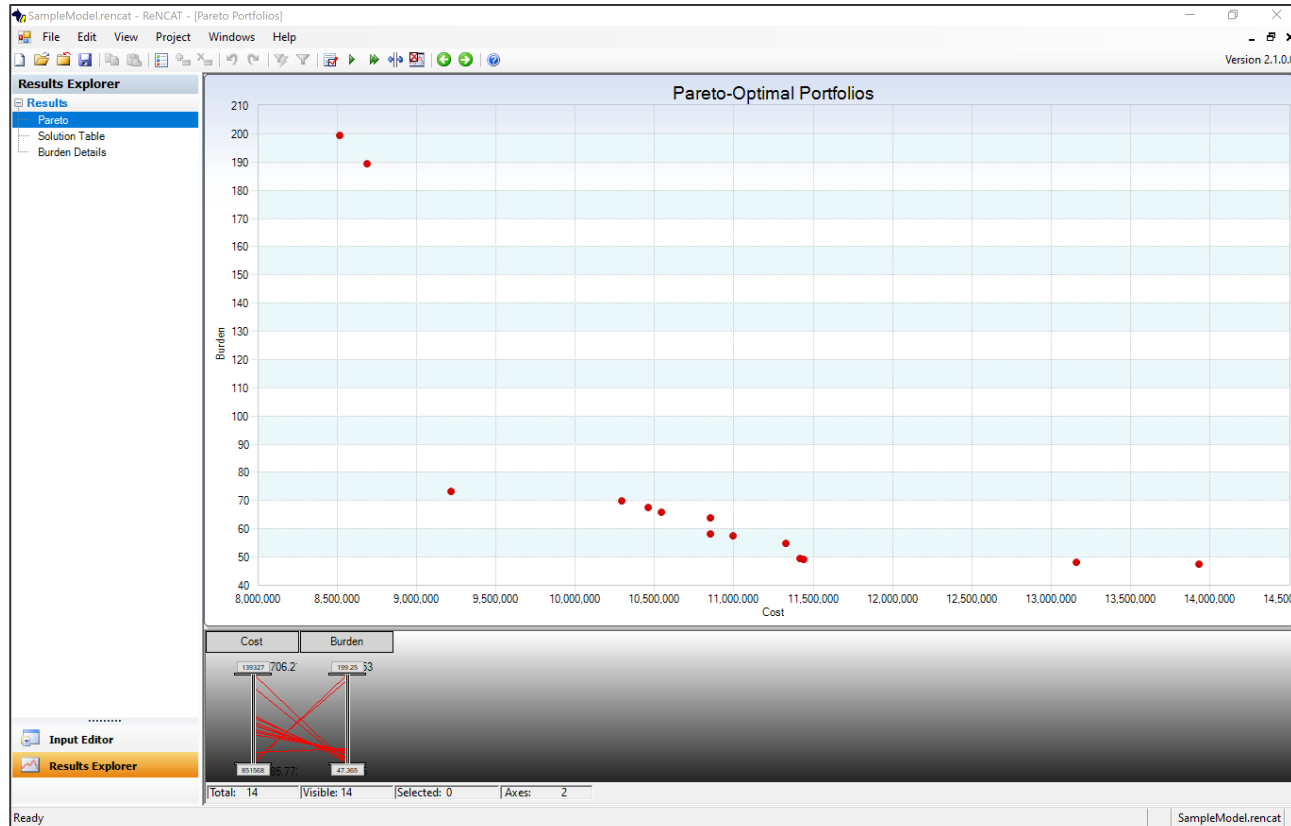


- A social burden evaluation (blue sky or black sky) results in a map of social burden by census block group
- Maps can be customized to look at overall burden or at burden for a specific service type
- Applies to Phase 1 and Phase 3 of the project





# Results of a Microgrid Placement Optimization



- A microgrid optimization generates multiple recommended microgrid portfolios
- Each recommended portfolio has one or more microgrids
- Each recommended portfolio has a different balance of cost and burden
- The “sweet spot” is determined by human judgement



# Results of a Microgrid Placement Optimization

Candidate Grid	# Subgrids	Objectives		Switches																
		Burden	Cost	0	1	10	11	12	13	14	15	16								
Solution 0	2	199	\$8,515,686	Open	\$500,000	Closed	\$0	Open	\$0	Open	\$100,000	Open	\$100,000	Closed	\$0	Closed	\$0	Open	\$0	Open
Solution 1	3	189	\$8,688,238	Open	\$500,000	Closed	\$0	Open	\$0	Open	\$0	Closed	\$0	Closed	\$0	Closed	\$0	Open	\$100,000	Open
Solution 2	3	73	\$9,217,225	Closed	\$0	Open	\$100,000	Open	\$0	Closed	\$0	Closed	\$0	Closed	\$0	Closed	\$0	Open	\$0	Closed
Solution 3	2	70	\$10,297,898	Closed	\$0	Closed	\$0	Open	\$0	Open	\$0	Closed	\$0	Closed	\$0	Closed	\$0	Open	\$0	Closed
Solution 4	4	68	\$10,464,187	Closed	\$0	Open	\$100,000	Open	\$0	Closed	\$0	Closed	\$0	Closed	\$0	Closed	\$0	Open	\$0	Closed
Solution 5	4	66	\$10,544,255	Closed	\$0	Closed	\$0	Open	\$0	Open	\$0	Open	\$100,000	Open	\$500,000	Closed	\$0	Open	\$0	Closed
Solution 6	4	64	\$10,852,002	Closed	\$0	Closed	\$0	Closed	\$100,000	Open	\$100,000	Closed	\$0	Closed	\$0	Closed	\$0	Open	\$0	Closed
Solution 7	4	58	\$10,853,225	Closed	\$0	Closed	\$0	Closed	\$100,000	Closed	\$0	Closed	\$0	Closed	\$0	Closed	\$0	Open	\$0	Closed
Solution 8	2	57	\$10,997,223	Closed	\$0	Open	\$100,000	Closed	\$0	Open	\$100,000	Closed	\$0	Closed	\$0	Closed	\$0	Open	\$0	Open
Solution 9	4	55	\$11,332,661	Closed	\$0	Closed	\$0	Closed	\$100,000	Open	\$100,000	Closed	\$0	Closed	\$0	Open	\$500,000	Closed	\$100,000	Closed
Solution 10	3	49	\$11,421,069	Closed	\$0	Closed	\$0	Open	\$0	Open	\$0	Closed	\$0	Closed	\$0	Open	\$500,000	Open	\$0	Closed
Solution 11	3	49	\$11,445,286	Closed	\$0	Closed	\$0	Open	\$0	Open	\$0	Closed	\$0	Closed	\$0	Open	\$500,000	Open	\$0	Closed
Solution 12	4	48	\$13,159,911	Closed	\$0	Closed	\$0	Closed	\$0	Open	\$100,000	Closed	\$0	Closed	\$0	Closed	\$0	Open	\$100,000	Closed
Solution 13	5	47	\$13,932,706	Open	\$500,000	Closed	\$0	Open	\$0	Closed	\$0	Closed	\$0	Closed	\$0	Closed	\$0	Open	\$100,000	Open

Solution	Total	Total Burden	Service Category	Service Burden	Population
Solution 0			Population Block	Block Service Burden	Attainment Factor
Solution 1			Facility Category	Service Level	Distance
Solution 2			Overall Burden	199.25264317046251	
Solution 3			Communications	18.983730883744503	
Solution 4			Finance	18.326483796563206	
Solution 5			72127009003	0.0003012691432679606	43152
Solution 6			Bank Branch	High	
Solution 7			1912	0.002111273572855158	1815.9673544316913
Solution 8			1933	0.0028078670261775063	2417.3015582722351
Solution 9			72127009004	0.0001725265967438349	6909
Solution 10			72127001002	0.000162369540345017	55078
Solution 11			72127001003	0.00018206979176580275	51167
Solution 12			72127001004	0.0002645666847479238	28550
Solution 13			72127001005	0.00023766031975470023	39010
			72127001101	0.00028835617733936897	36058
			72127001901	0.00057154689033148428	16517
			72127001502	0.00036017509322445611	22895
			72127001601	0.00014301862577647073	49318
			72127001602	8.76888103002137E-05	44181
			72127001603	9.8017400094412753E-05	28672
			72127001801	0.00021188343667731454	25769
			72127001802	0.0004239654346136401	27933
			72127001901	0.0002731657167682339	59074
			72127001902	0.0005038734584930762	34886
			72127001903	0.0003668788341267749	53355
			72127001904	0.0004283957857691865	43864
			72127002001	0.0009720298784302647	14545
			72127002002	0.0007075387385888319	24107
			72127002101	0.00098325834540287566	15188
			72127002102	0.000407174421131722	22935
			72127002201	0.00026639743214196645	17589
			72127002202	0.0003994964546174643	14355
			72127002301	8.99710132495169E-05	28333
			72127002302	0.0003392909825245881	14231
			72127002303	0.00020251693009640796	16111
			72127002401	0.00034600177968745622	16364
			72127002402	0.00043025518072737165	19315
			72127002501	0.0003827436676299374	20864

- Details of each portfolio are also available:
  - Burden
  - Overall Cost
  - Microgrid layout details
  - Which facilities have power
  - Cost components
  - Detailed burden components
- Details can be used to generate maps of microgrid portfolios (outside of ReNCAT)



## Insights Gained from a ReNCAT Analysis

### Takeaways from social burden evaluation:

- Identify areas that lack services, even during normal operations
- Identify which services are provided at adequate levels and which services are not
  - Influencing factors: location of critical infrastructure, expected impact of threats, etc.
- Customized look at equity, based on services that stakeholders have prioritized

### Takeaways from microgrid location optimization:

- Understanding of where microgrid portfolios are located
- Identification of any areas that don't have good coverage
- Clear representation of how coverage changes as social burden decreases and cost increases
- Ability for decision makers to identify portfolios that meet budget requirements and still meet the needs of the community


Next Steps





## Next Steps

- Identify an IOU partner
- Begin data collection for an IOU territory
  - Infrastructure assets and locations, census block group data
- Work with stakeholders to map infrastructure sectors to critical services



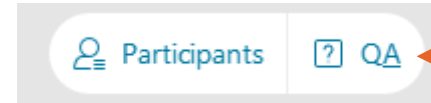
Break for  
Discussion and  
Questions



# Discussion and Q&A

## WebEx Tip

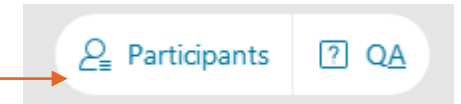
Option 1:



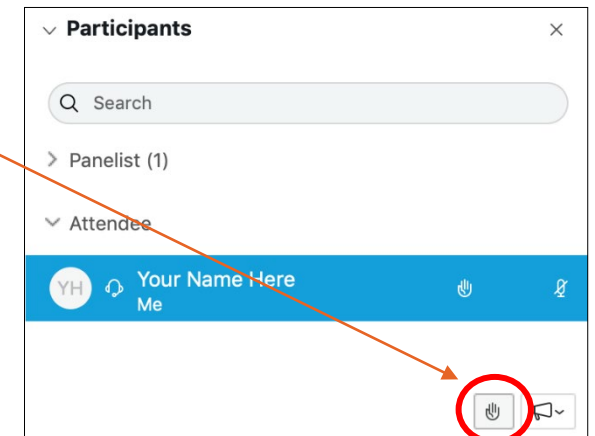
**Access the written Q&A panel here**

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.**

## For more information:

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**Julian Enis**  
**Julian.Enis@cpuc.ca.gov**

**<https://www.cpuc.ca.gov/resiliencyandmicrogrids/>**

