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.

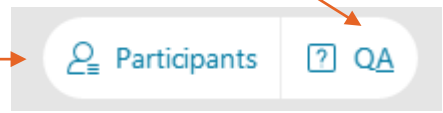
WebEx Logistics

- 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

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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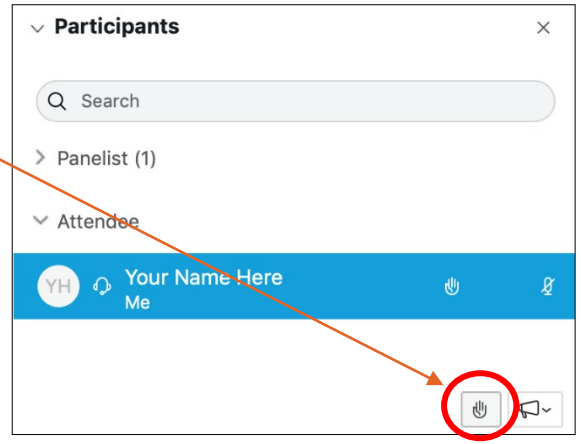
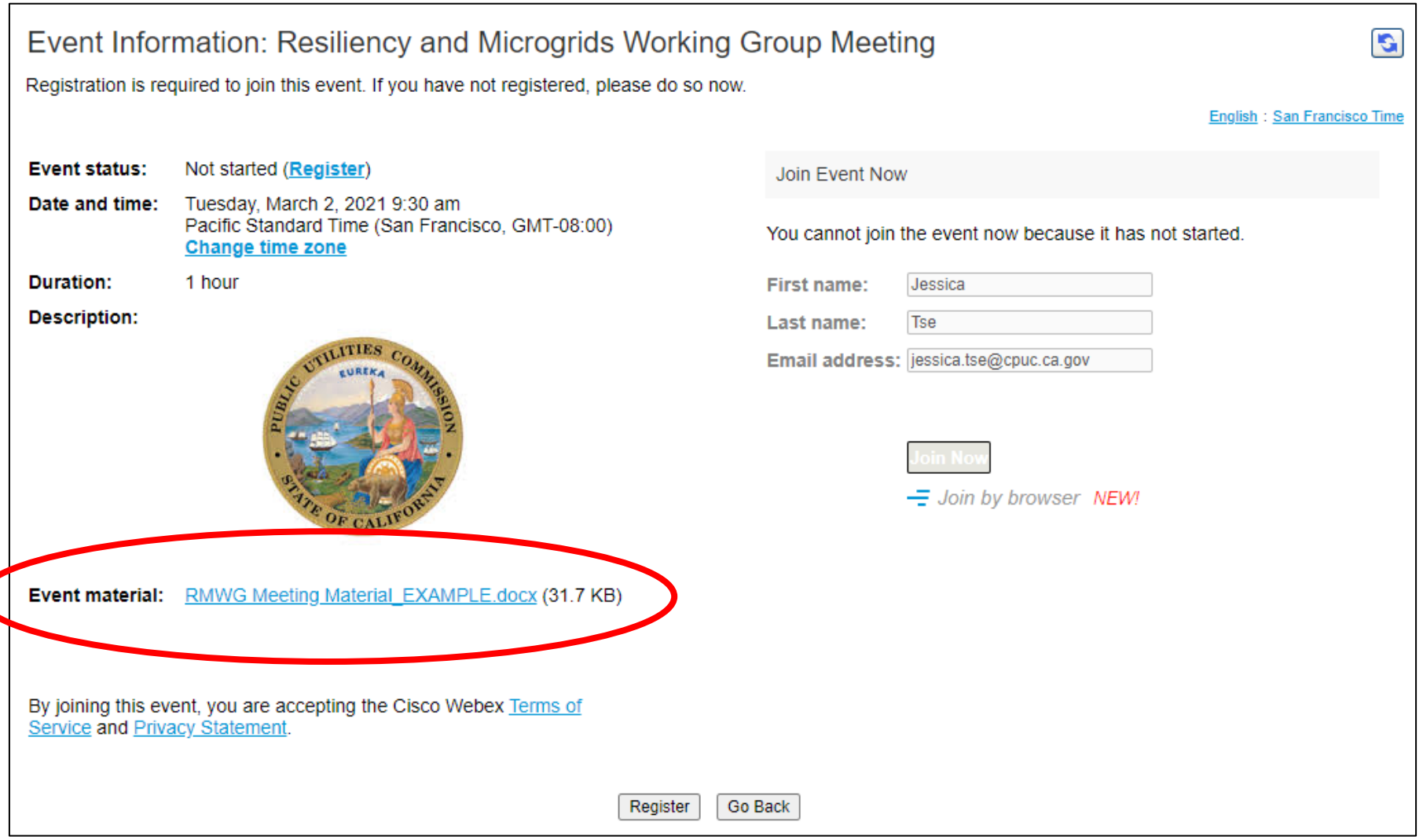


Access your meeting audio settings here

WebEx Event Materials



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

I. Introduction *(CPUC Staff)* **10:00a – 10:05a**

- WebEx logistics, agenda review

II. Opening Remarks by Commissioner Shiroma **10:05a – 10:10a**

III. Resiliency Node Cluster Analysis Tool (ReNCAT), Sandia National Laboratories **10:10a – 11:55a**

- **The Social Burden Index**
- **Q & A and Discussion**
- **ReNCAT Overview**
- **Q & A and Discussion**

IV. Closing Remarks, Adjourn **11:55p – 12:00p**

Sandia National Laboratories

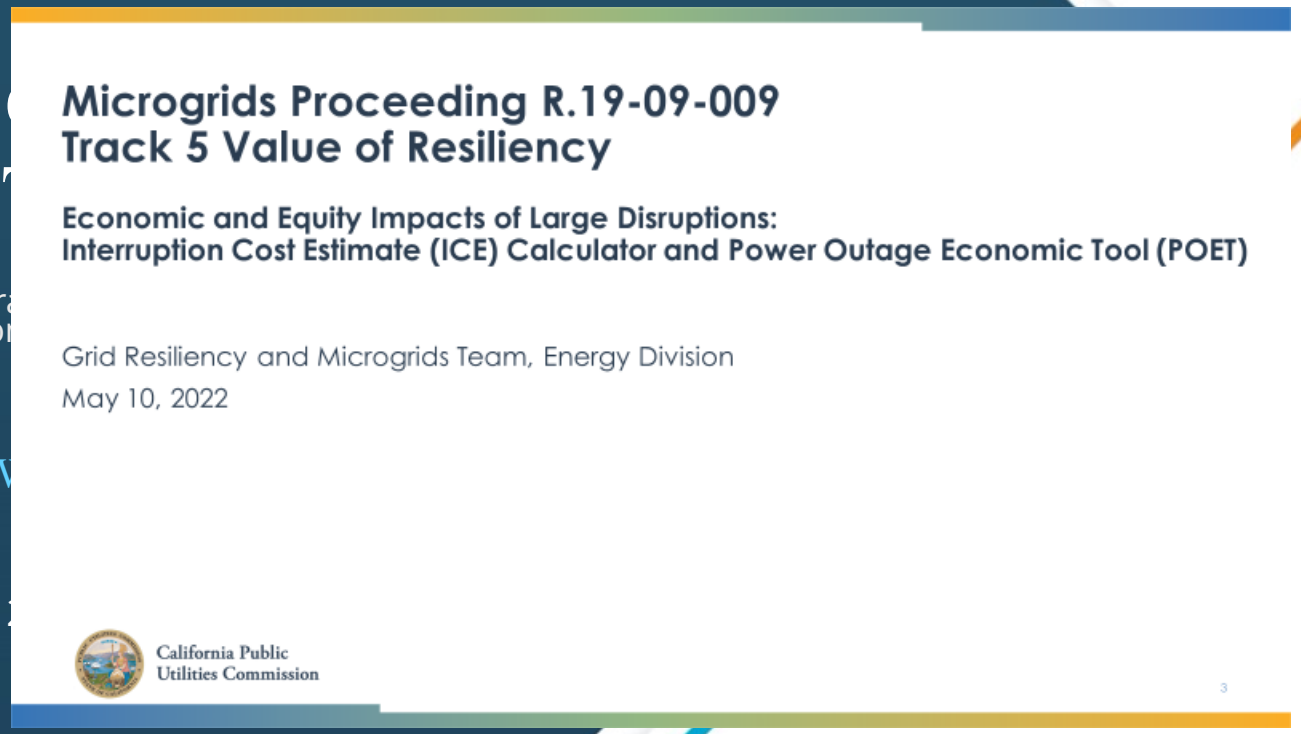
Exceptional service in the national interest

Resilienc
Analysis

Microgrids Proceeding – Tr
Impacts of Large Disruptio

Olga Hart, Amanda V
Cynthia Bresloff

July 7, 2022 10:00 AM – 1



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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

1980s

- Distributed Energy Technology Laboratory (DETL) opens
- Sandia designs first battery test facility hosted by PSE&G in NJ

1990s/ 2000s

- Sandia starts interconnected PV systems work
- DOE designates Sandia as US Rep to IEC TC57, (standards for information exchange for power systems)

2003/04

- Sandia publishes DOE/EPRI Electricity Storage Handbook
- National SCADA Test Bed (NSTB) established

2009

- R&D 100: SiCPower Module
- DETL modernized to enable high penetration experimentation on distributed generation
- Energy Surety Microgrid (ESM™) Methodology

2010

- Energy Storage Test Pad established as the first facility to test 1MW class storage systems at a national lab
- Smart Power Infrastructure Demonstration for Energy Reliability and Security (SPIDERS) established
- R&D100: Micro Power Source

2011

- R&D100 Award Winners: Ultra-high-voltage Silicon Carbide Thyristor
- R&D100 Award Winners: The Demand Response Inverter
- Secure, Scalable Microgrids Grand Challenge and Hardware Testbed Facility Initiated

2013

- Sandia develops the DOE/SNL Global Energy Storage Database

2014

- Grid Modernization Laboratory Consortium established & Sandia participates in 29 GMLC projects

2015

- Smart Grid International Research Facility Network (SIRFN) established
- R&D 100: Sandia and United Silicon Carbide, Inc. create new high voltage switch

2016

- Resilience Node Cluster Analysis Tool (ReNCAT) developed
- Control and Optimization of Networked Energy Technologies (CONET) Laboratory established
- First version of WNTR – Water Network Tool for Resilience

2017

- R&D 100: Control System for Active Damping of Inter-area Oscillations

2018

- QuESt, an open source energy storage simulation and analysis suite, publicly released
- Energy Storage Controls and Analytics Laboratory (ESCAL) created

2019

- Sandia-developed Grid Damping Control Strategy at CONET

2020

- Advanced Power Electronics Conversion Systems (APEX) Laboratory established

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

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.

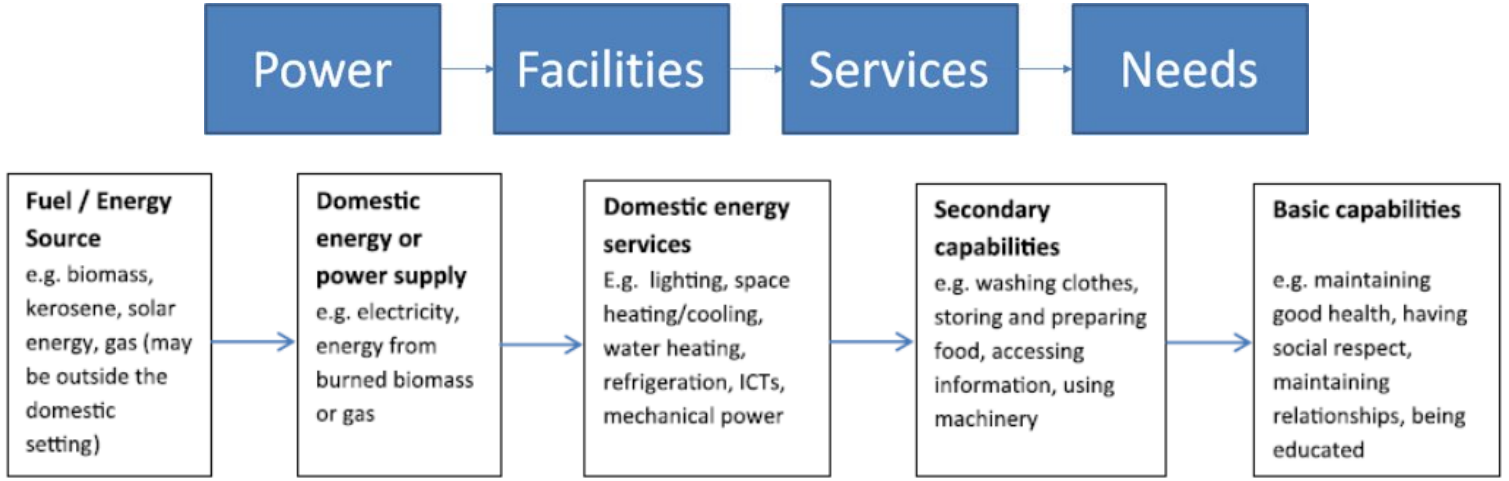


Fig. 1. Conceptualising the relationship between energy, services and outcomes.

Source: Day, R., Walker, G., & Simcock, N. (2016). Conceptualizing energy use and energy poverty using a capabilities framework. *Energy Policy*, *93*, 255-264.

Introduction to Burden Estimation

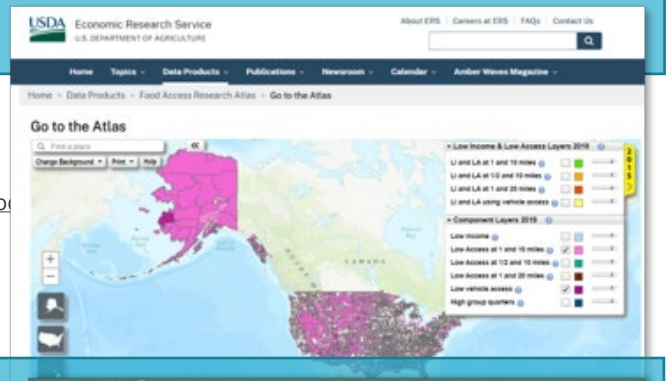
- Where you live has an impact on quality of life; resources and threats are not evenly distributed across the landscape.

- 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

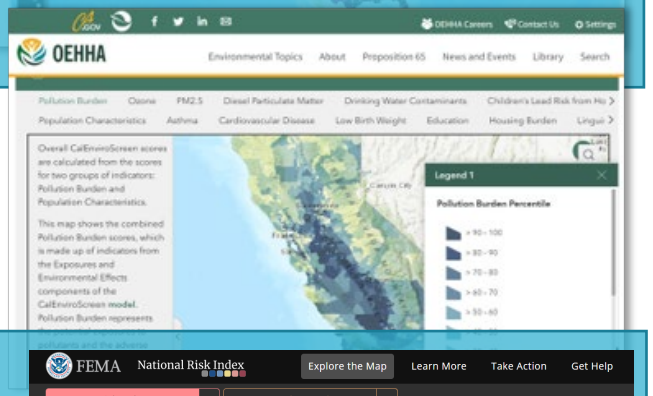
https://www.ers.usda.gov/data-products/foo
access-research-atlas/go-to-the-atlas/



2

CalEnviroScreen Pollution Burden

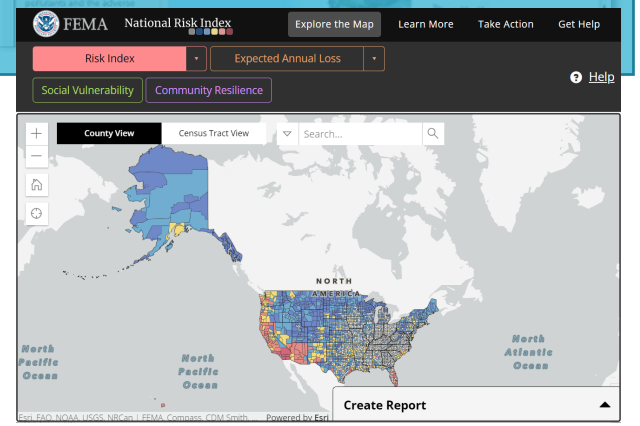
https://oehha.ca.gov/calenviroscreen



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

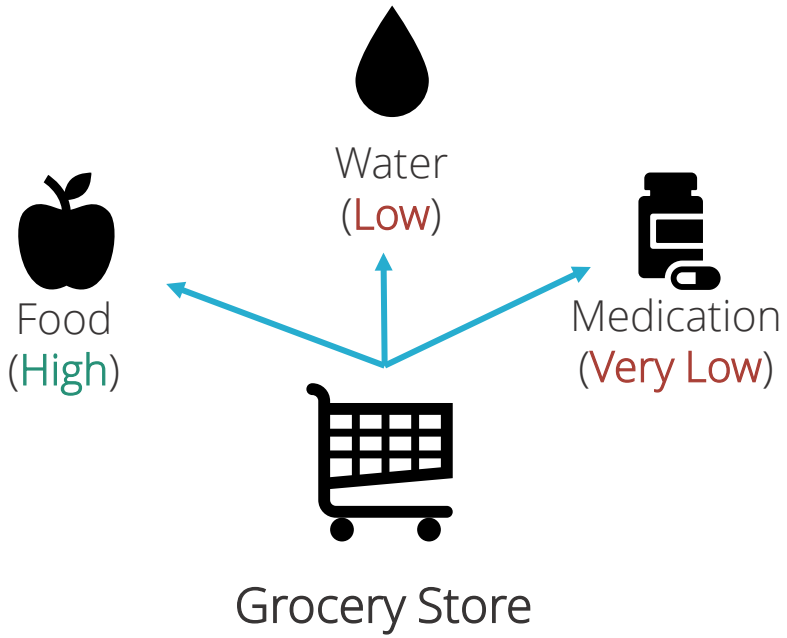
**Sandia's definition of Critical Services is similar to FEMA lifeline services, but with greater emphasis on acute individual needs than on restoration*

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

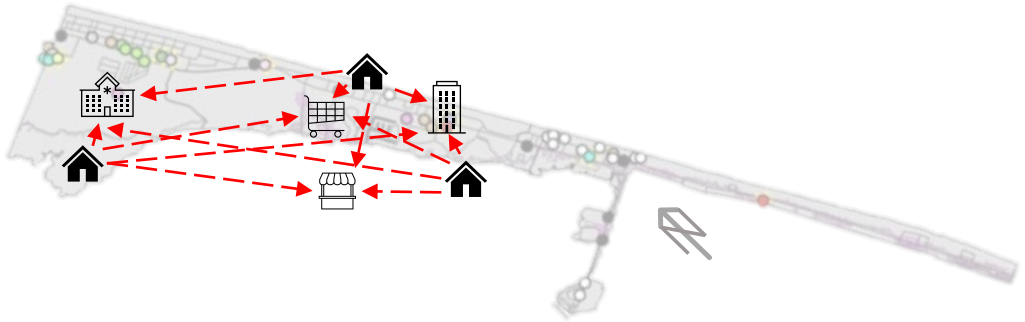
One infrastructure sector may provide multiple critical services at different levels

- Create a mapping between services and sectors

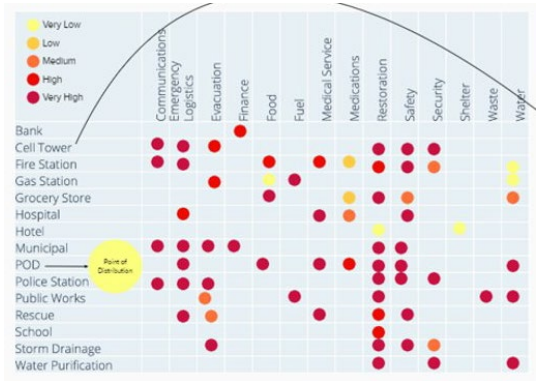


	Service 1	Service 2	Service 3
Sector 1	High		Low
Sector 2		Low	
Sector 3	Medium		
Sector 4			Very High

Measuring Societal Infrastructure Service Burden



$$SB = \frac{Distances\ to\ Services_{people,services}}{Service\ Levels_{facilities,services} \times Median\ Household\ Income_{people}}$$



$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.

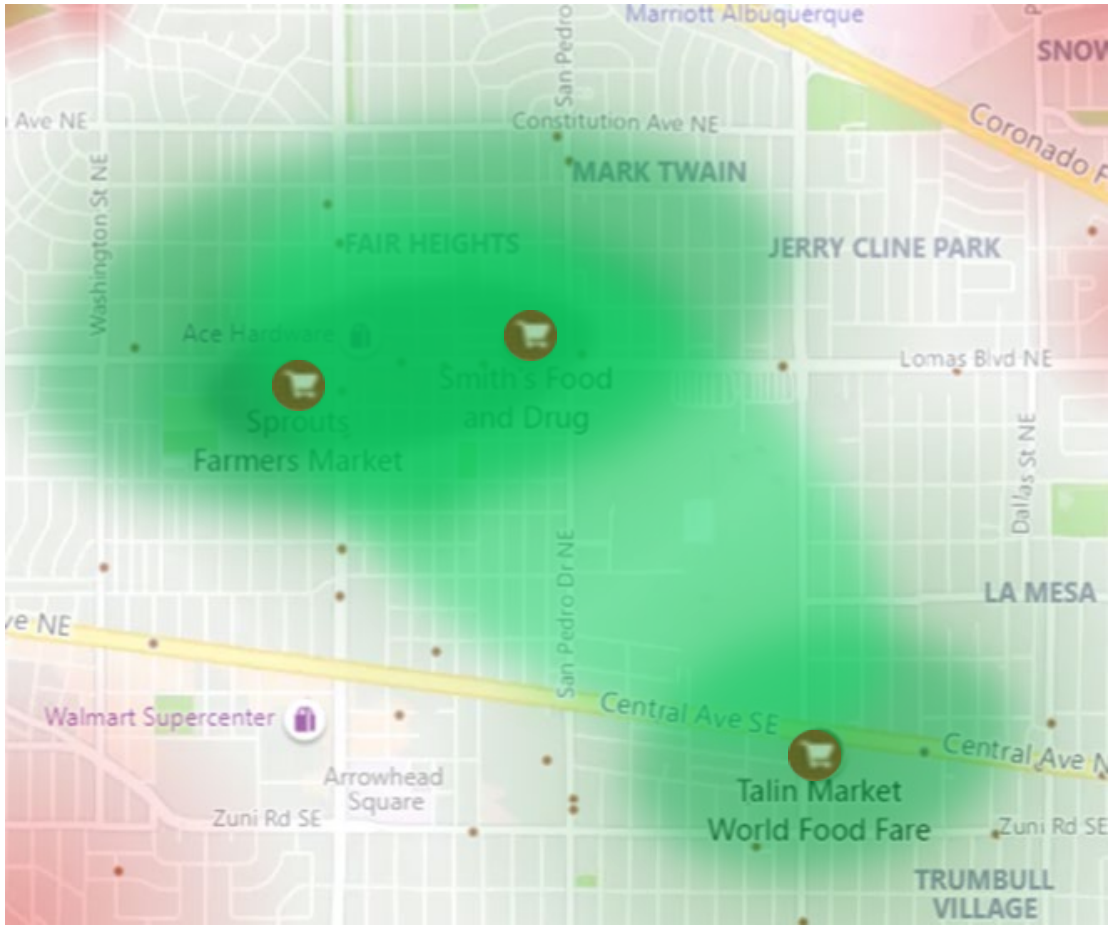
Social Burden Explained

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:

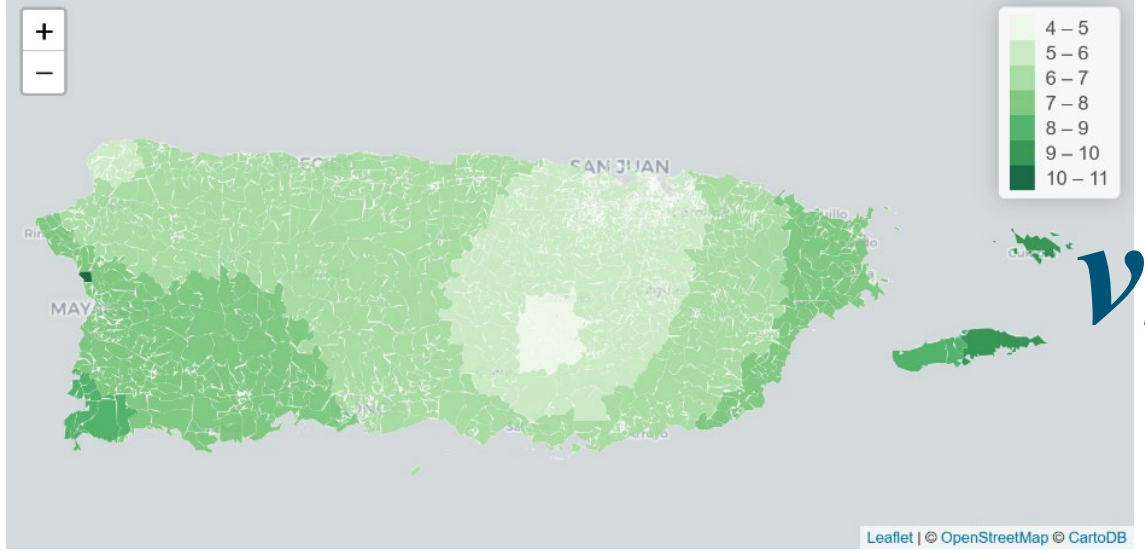
- Per-service burden calculated for each population block
- Burden summed across blocks
- Total burden summed across services



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:*

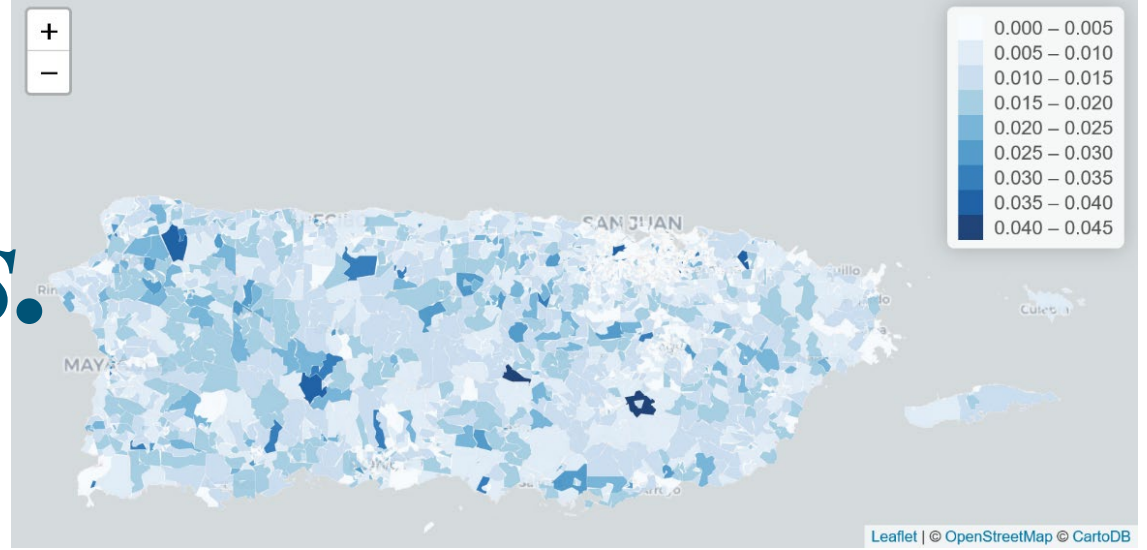
1



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

vs.

2



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:

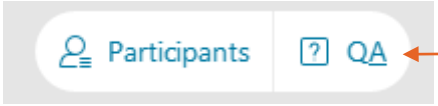
- Spatially-explicit;
- Consistent;
- Adaptable;
- Community-input oriented;
- Scalable.

Break for Discussion and Questions

Discussion and Q&A

WebEx Tip

Option 1:



Access the written Q&A panel here

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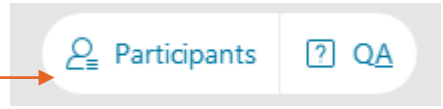

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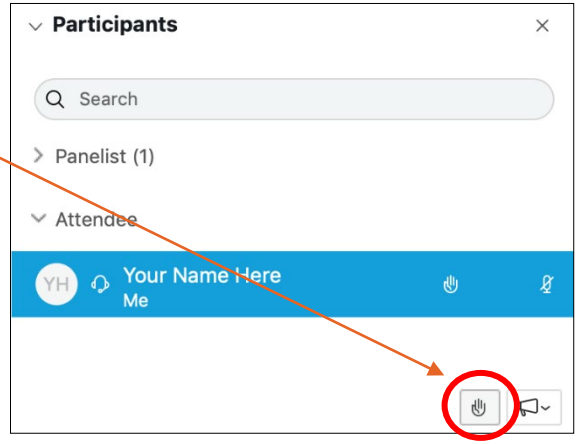
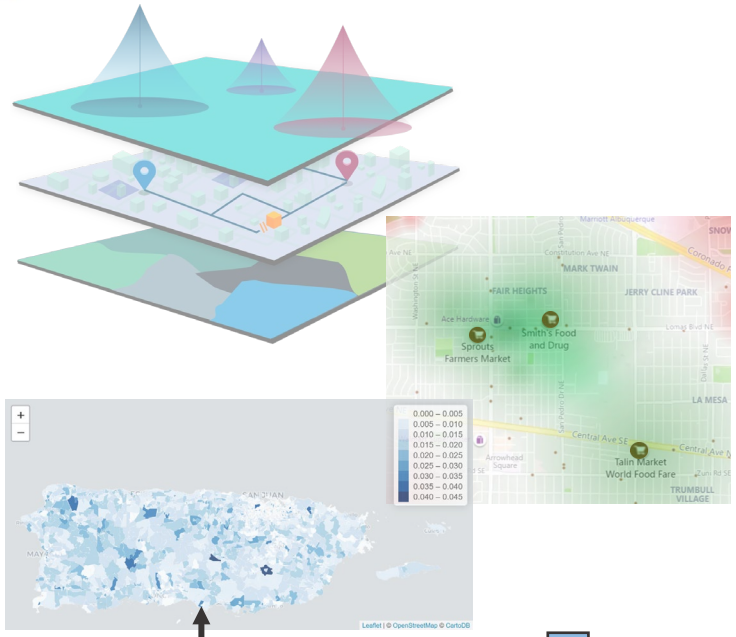


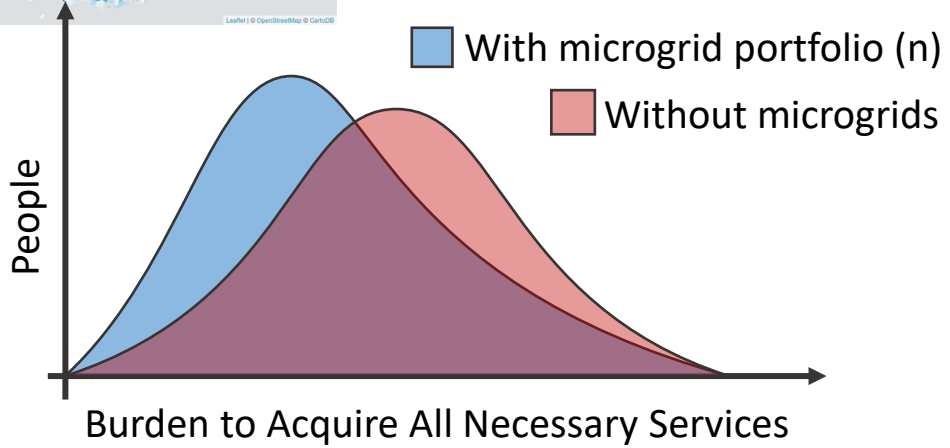
ReNCAT:
1) Overview

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!



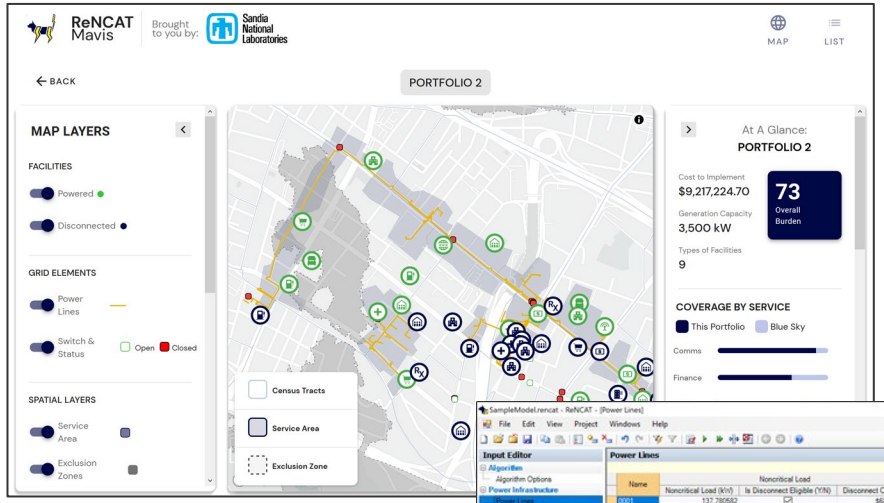
Need a tool to help with:

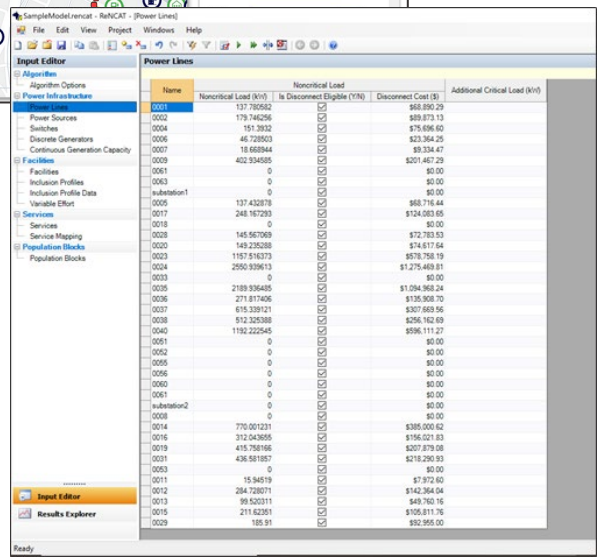
- Siting infrastructure investments
- Evaluating alternative projects
- Understanding public safety power shutoff plan (PSPS) impacts
- Mitigation measures

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



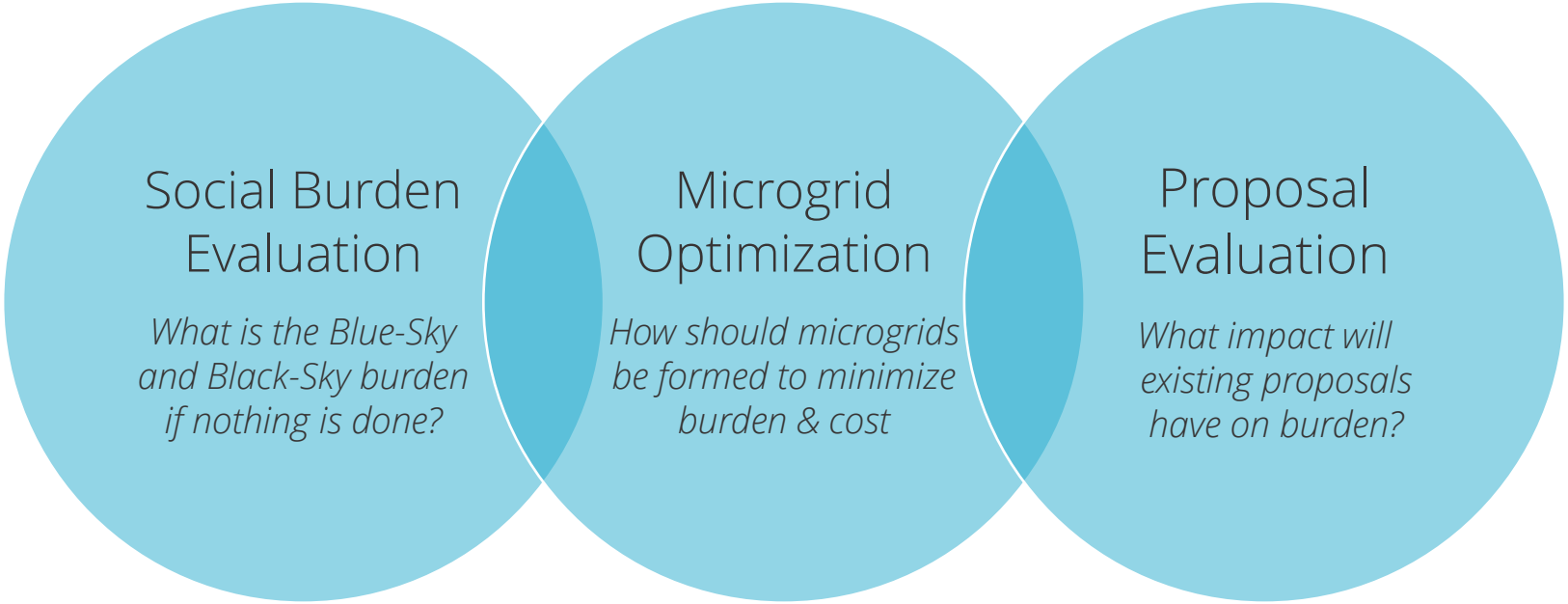


Locations Used:

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

Applications of ReNCAT

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



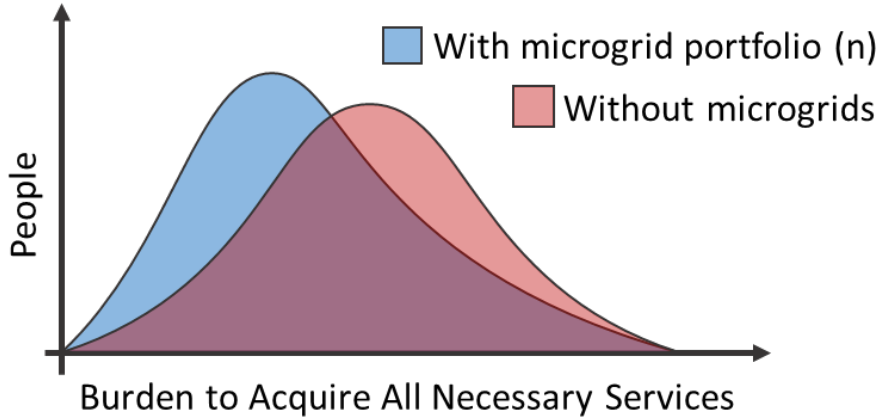
Can be mixed and matched depending on data availability, study questions, and project needs.

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



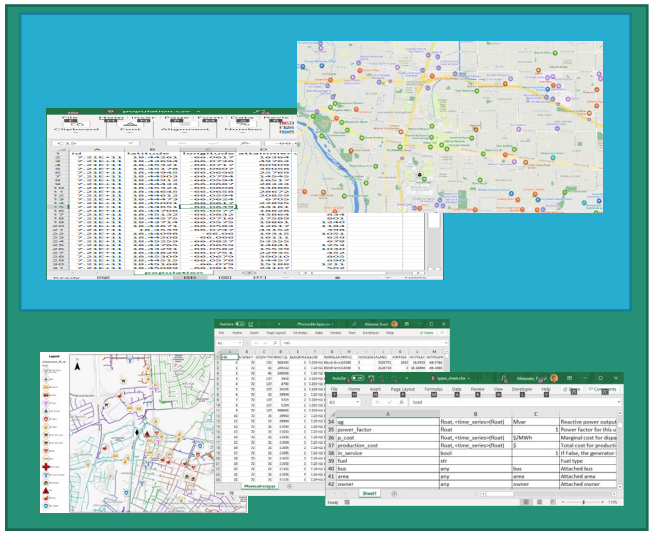
Enables Maximum Burden Reduction at Least Cost

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*

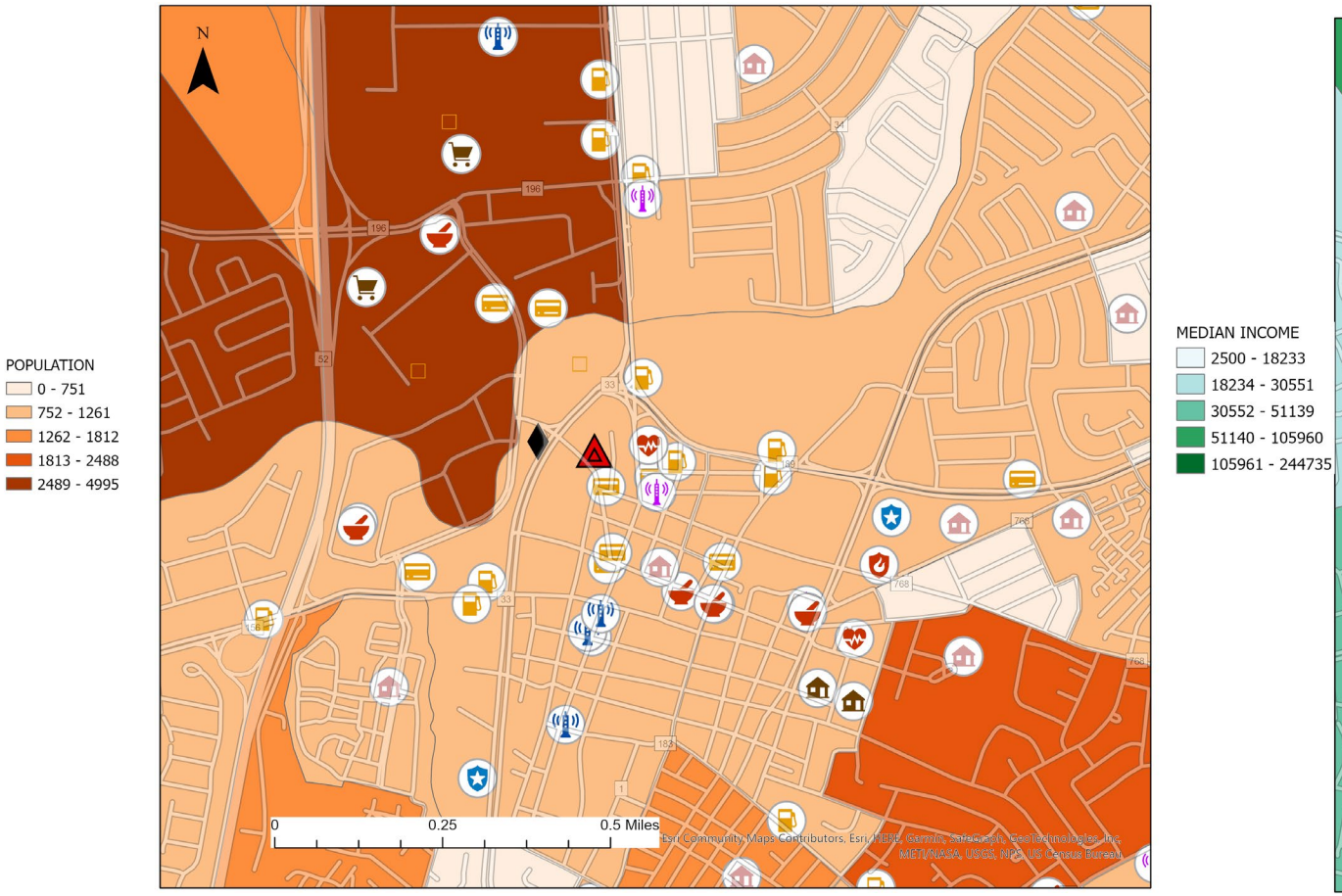
Population Data
- *Census Blocks*
- *Median Income*

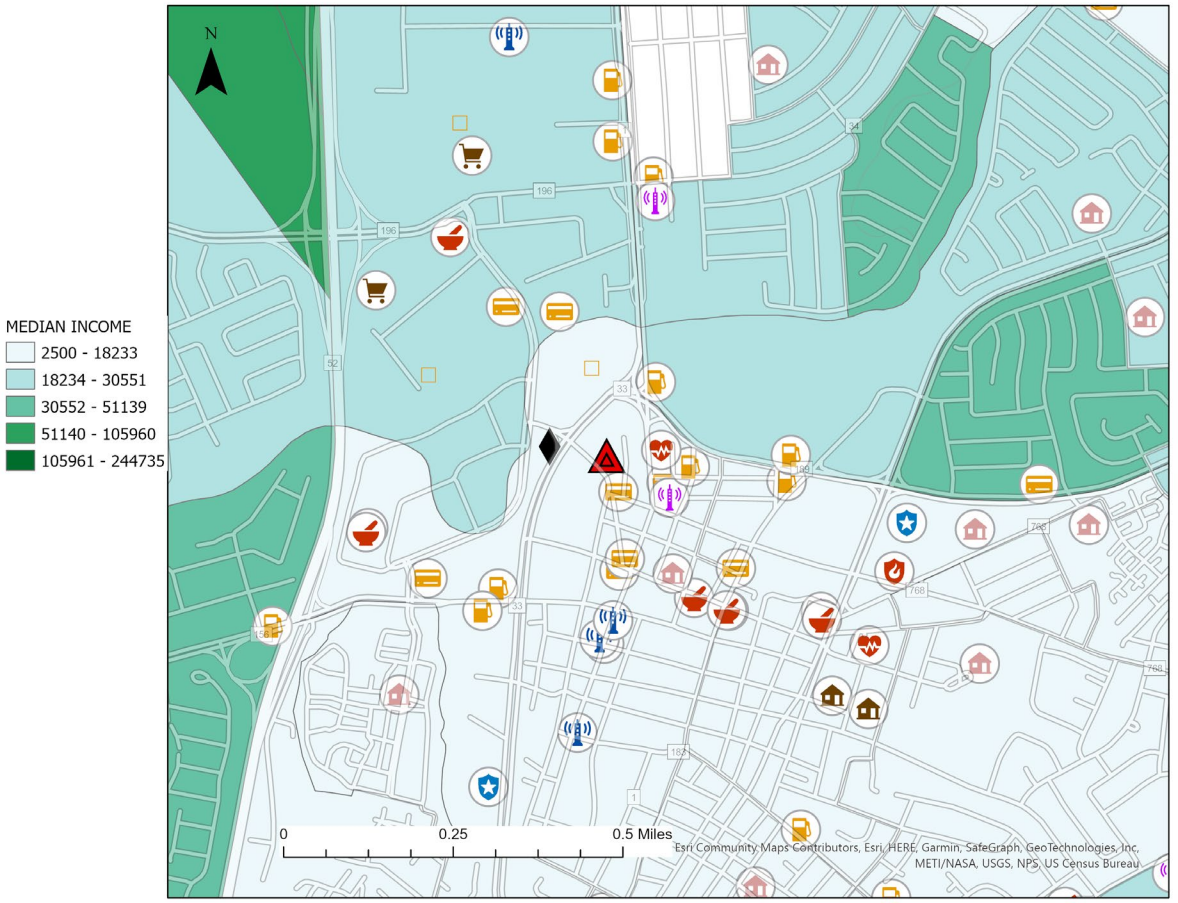
Burden Parameters
- *Service levels*
- *Effort parameters*

Power Scenario
- *Which facilities have power*

Burden Values

Required Data Example : Census Data Mapping





Population 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

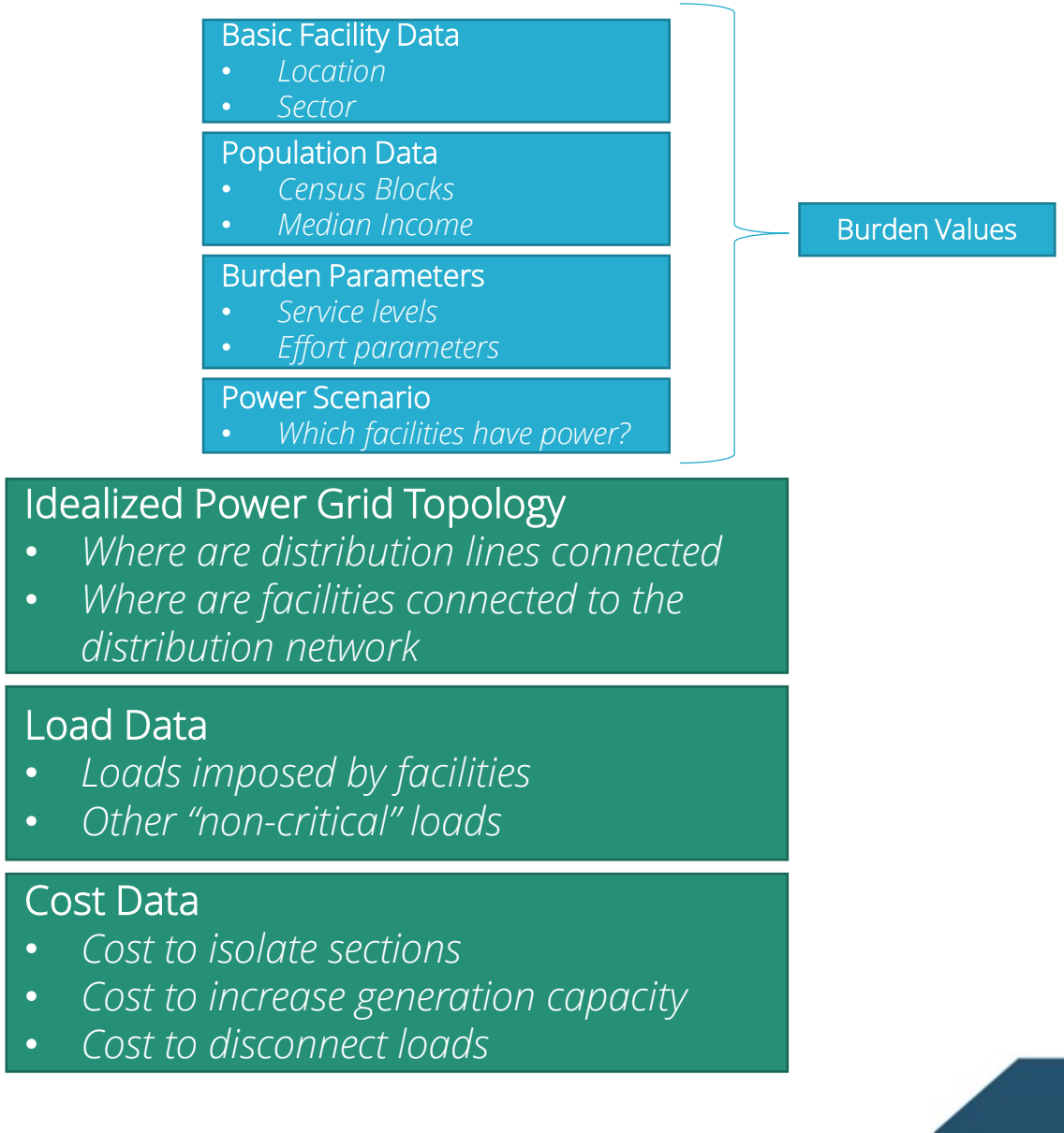
Threat Assessment

- **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**

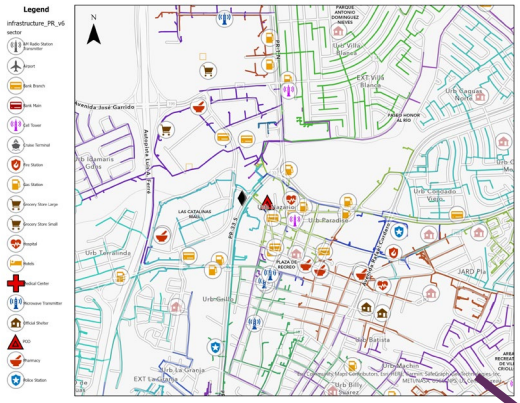
Data Requirements for Microgrid Placement

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



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

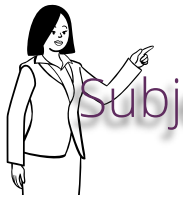
Idealized Power Grid Topology
- *Where are facilities connected to the distribution network*
- *How can the topology be altered?*

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

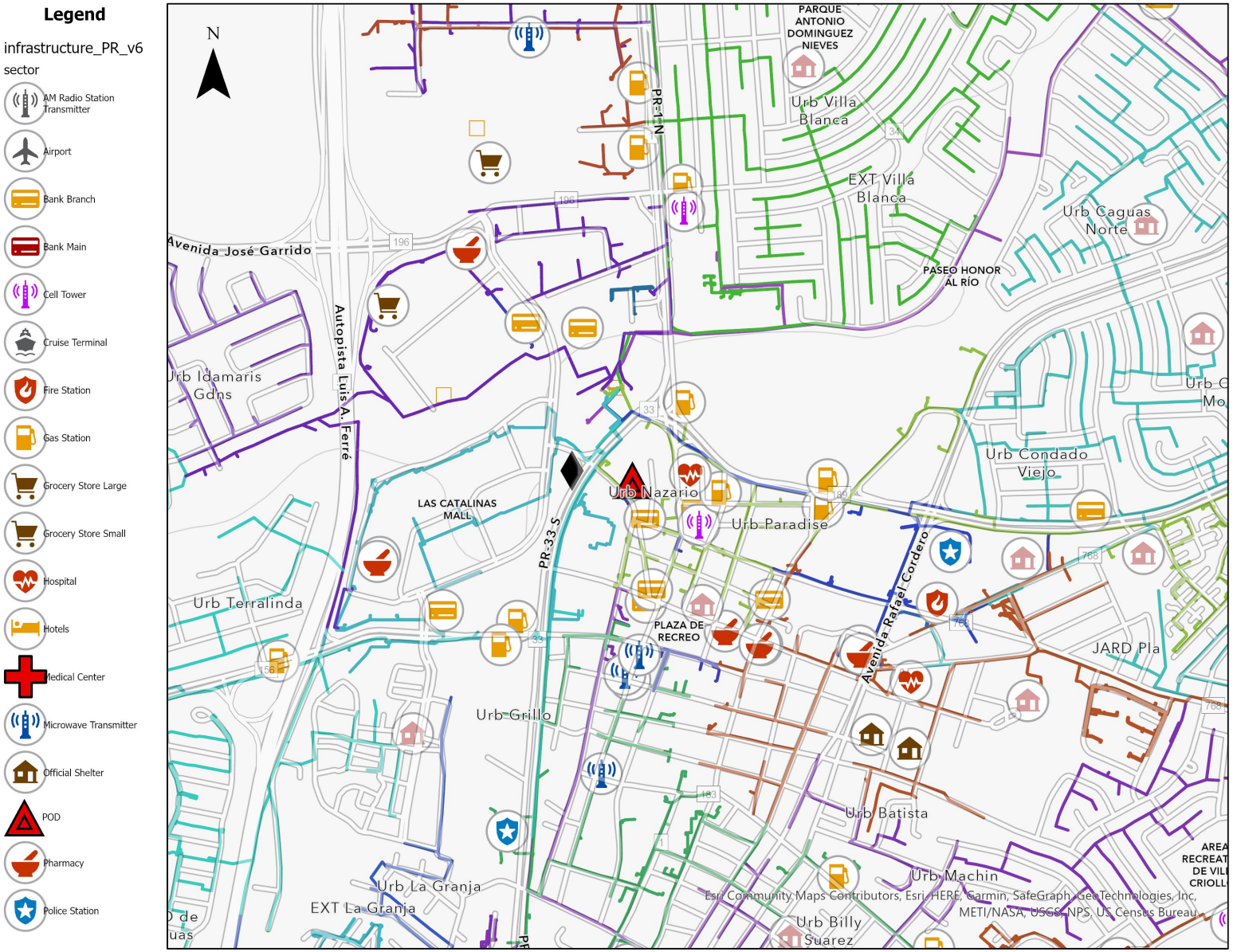
Grid Operators



Subject Experts

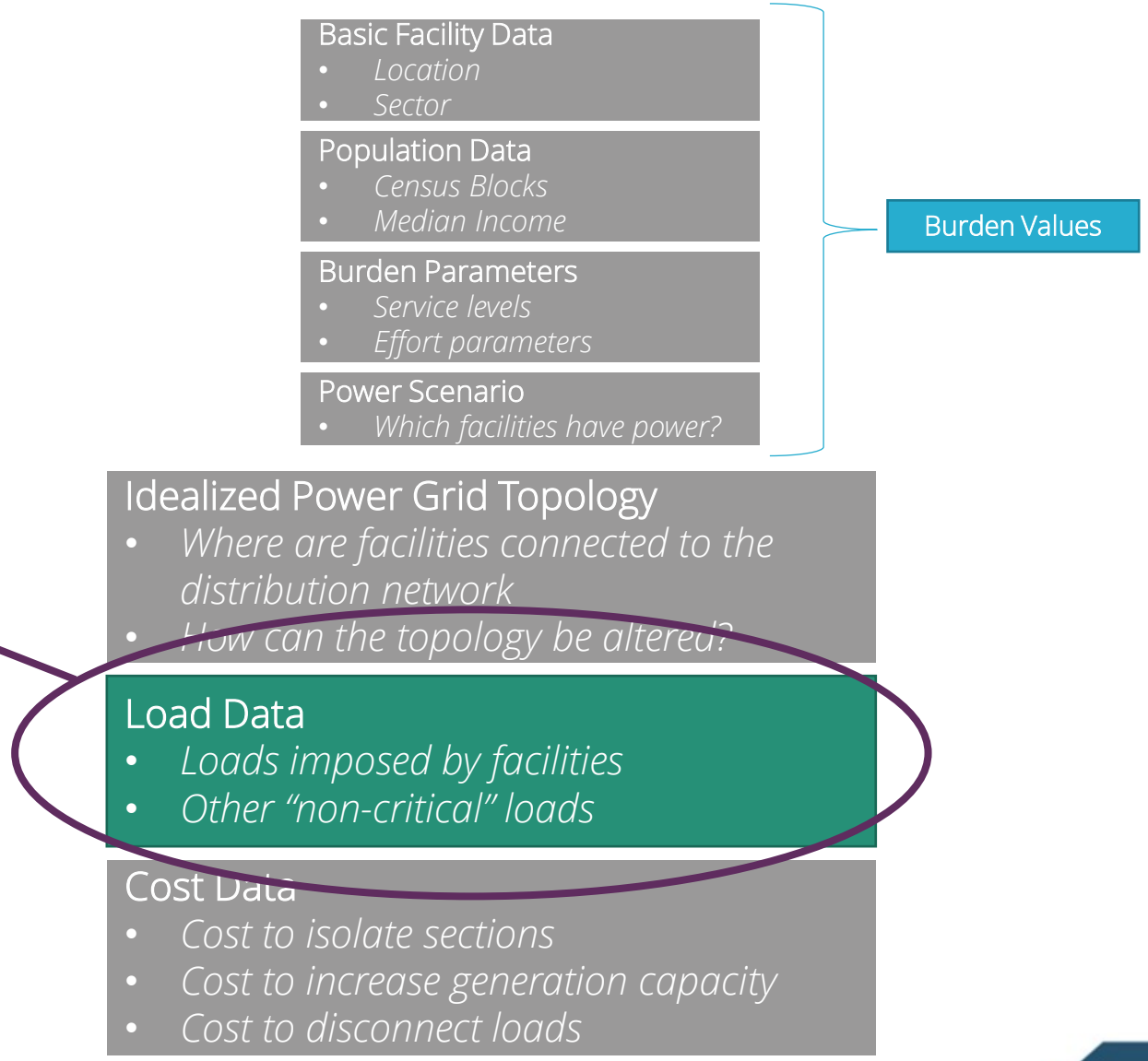
Required Data Example : Facilities and Power Line Segments

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



Data Requirements for Microgrid Placement

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



Grid Operators

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)

Grid Operators

Subject Experts

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

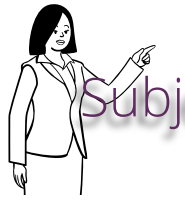
Idealized Power Grid Topology
- *Where are facilities connected to the distribution network*
- *How can the topology be altered?*

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

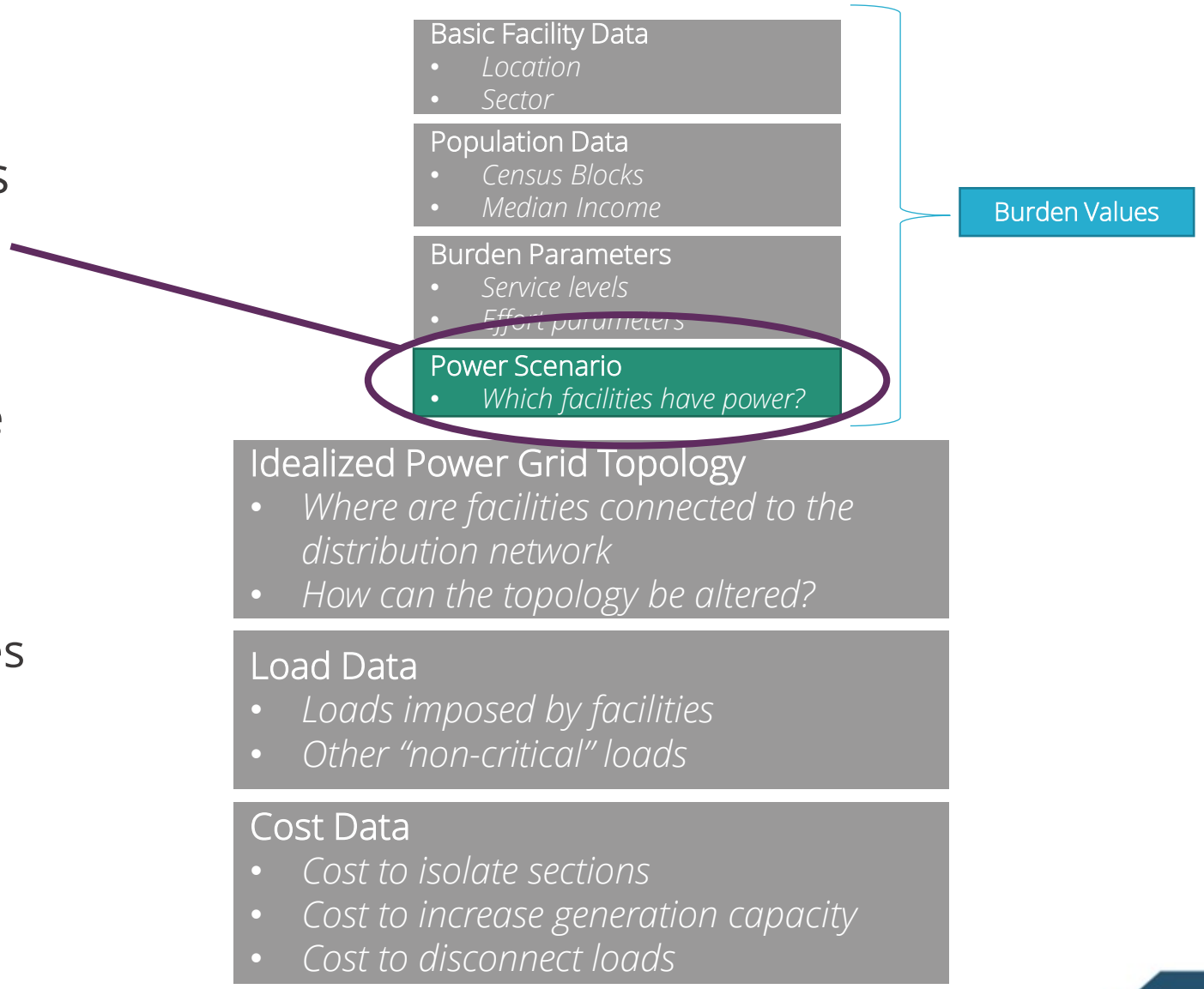
Cost Data
- *Cost to isolate sections*
- *Cost to increase generation capacity*
- *Cost to disconnect loads*

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



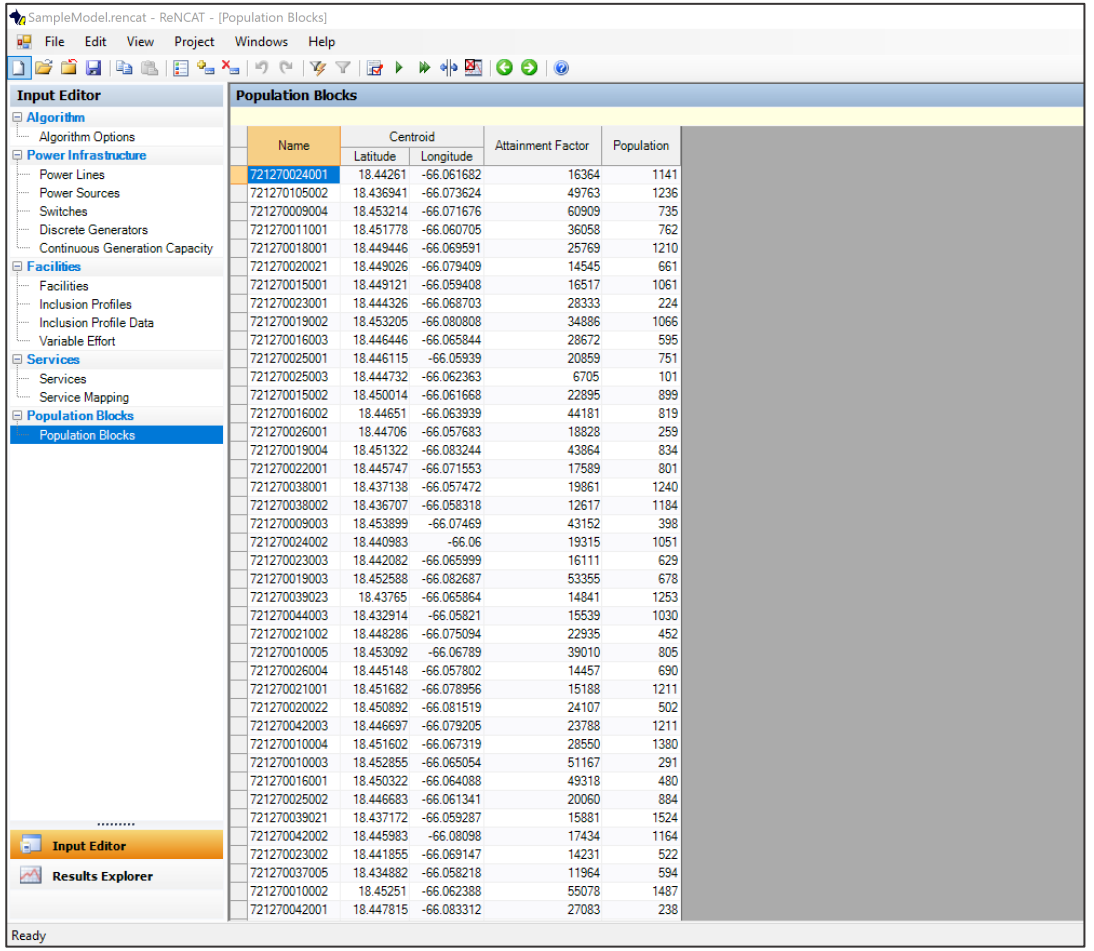
Subject Experts



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



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

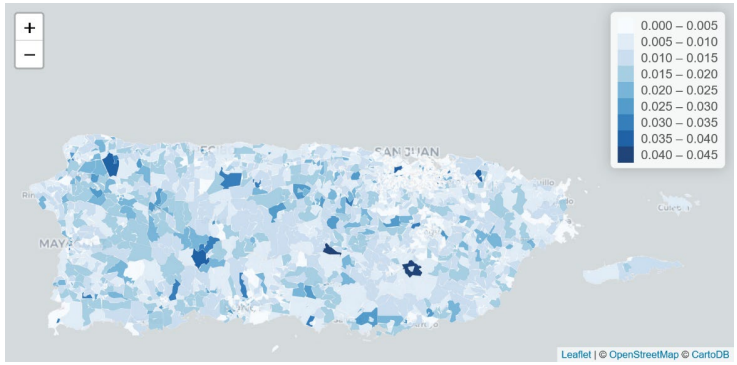
ReNCAT:
3) Results & Outputs

ReNCAT Results

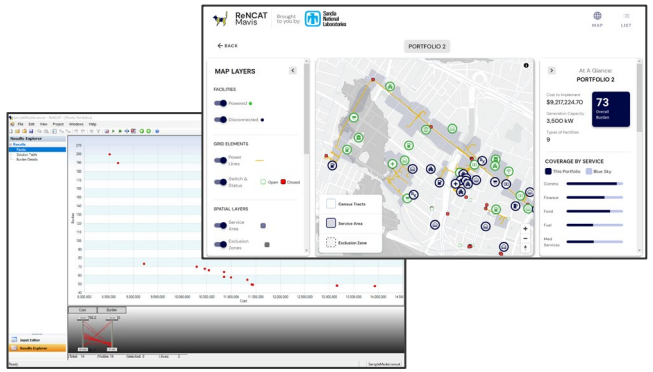
ReNCAT results will depend on whether we're running a ReNCAT evaluation or a ReNCAT optimization

Burden Assessment

Microgrid Placement Optimization

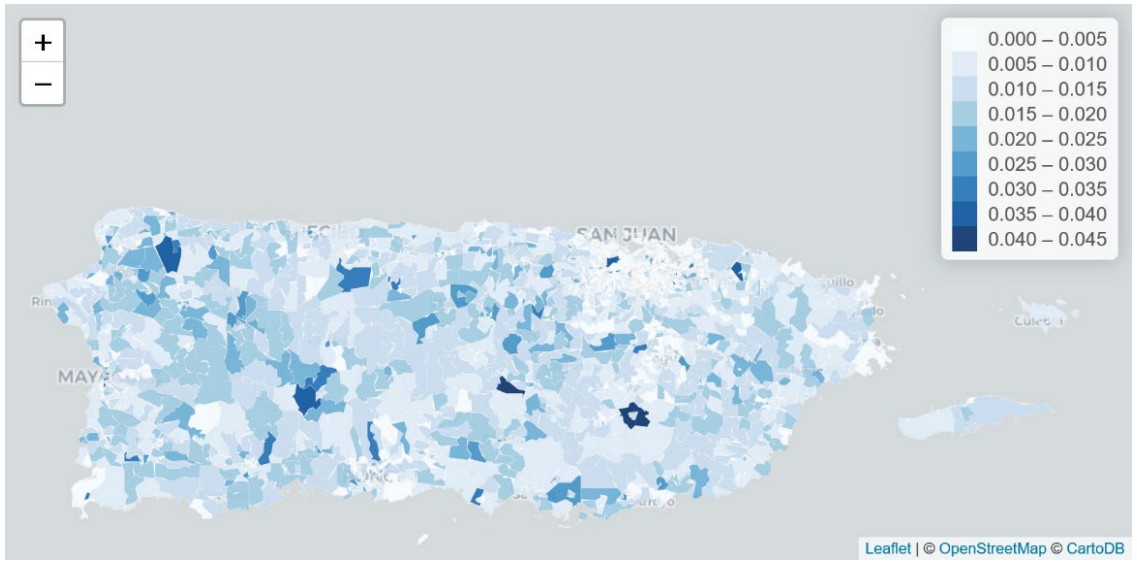


Burden Distribution Maps
- Total and Per-Service



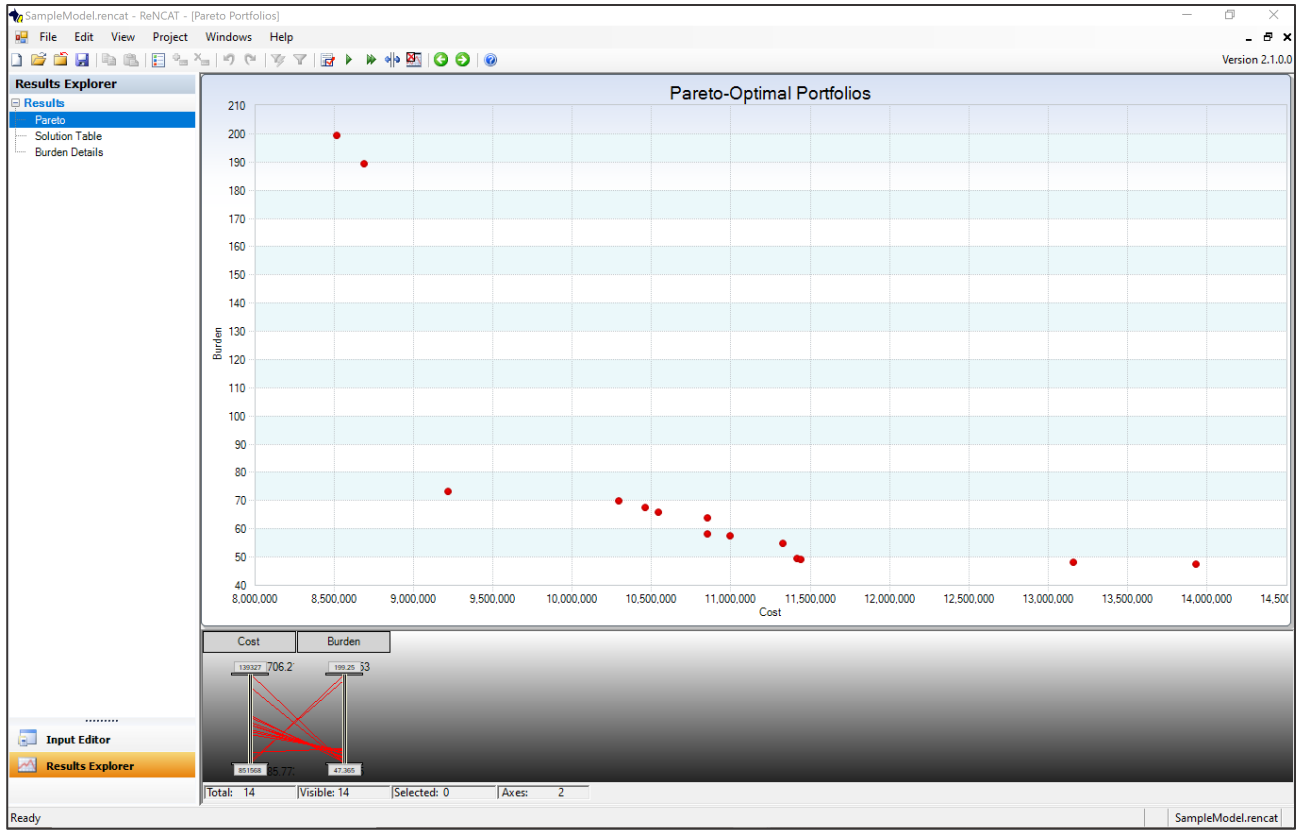
Recommended Microgrid Portfolios
- Portfolios at various cost-to-burden ratios
- Microgrid layout details

Results of a Burden Evaluation



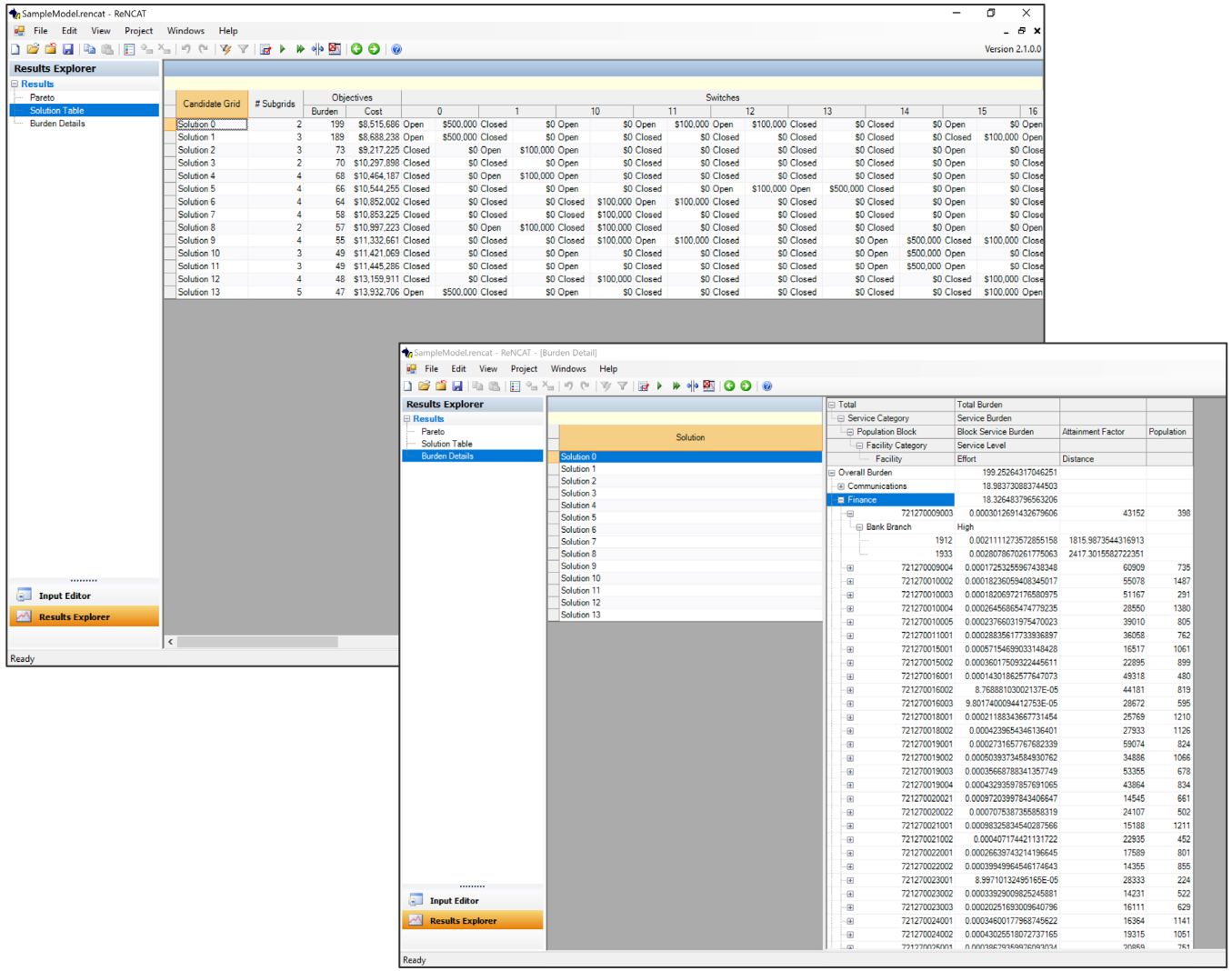
- A social burden evaluation (blue sky or black sky) results in a map of social burden by census block group
- Maps can be customized to look at overall burden or at burden for a specific service type
- Applies to Phase 1 and Phase 3 of the project

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



- 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

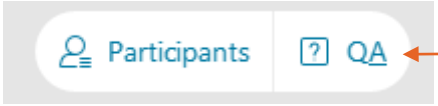
- Identify an IOU partner
- Begin data collection for an IOU territory
  - Infrastructure assets and locations, census block group data
- Work with stakeholders to map infrastructure sectors to critical services

Break for Discussion and Questions

Discussion and Q&A

WebEx Tip

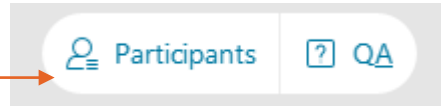
Option 1:



Access the written Q&A panel here

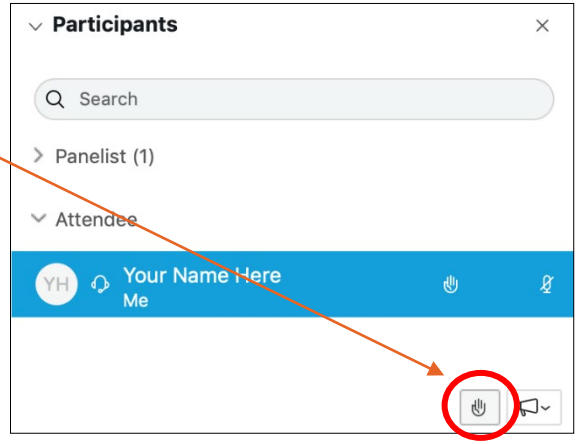
Option 2:

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.



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