Sandia National Laboratories

Exceptional service in the national interest

An Overview of Sandia's Resilient Node Cluster Analysis Tool (ReNCAT) and the Social Burden Metric

Hawaii Public Utilities Commission Energy Storage Systems Workshop Series

Session 4: Energy Storage Valuation Modeling

Presented by Olga Hart, PhD, PE

February 7, 2024

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

SAND2024-02531O

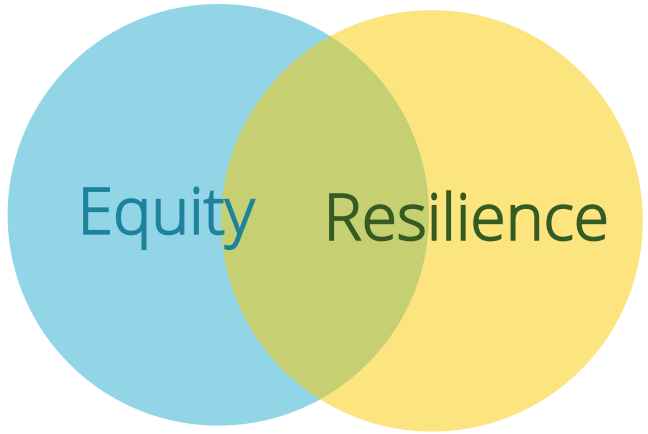
Equity and resilience are interdependent

Resilience is a component of equity

- Cannot have a truly equitable energy system if some communities are more resilient than others

However, equity is also a component of resilience

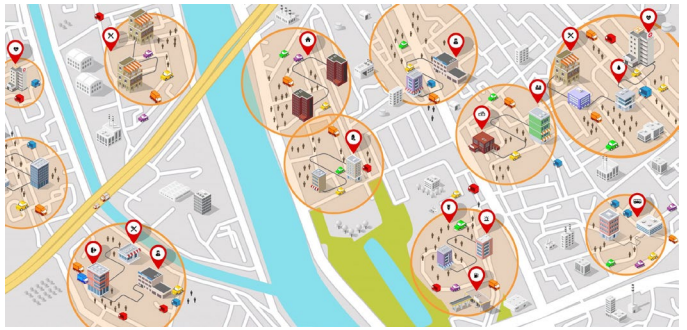
- Energy system is embedded in communities (social) and within other (physical) infrastructures
  - Embedded social inequalities independent of the energy system also impact equity
- Inequities are vulnerabilities
- Vulnerabilities reduce resilience
- Can escalate events from local concern to national security priority
  - e.g., New Orleans, Puerto Rico



Social Burden: measuring critical service availability and accessibility and prioritizing resilience investments to mitigate disproportionate harm from outages

Social Burden is a measure of: **equity** in service availability vs baseline capacity; **resilience** to disruption in service access

"Blue Sky" Scenario: Grid Powered, All Available Facilities "ONLINE"

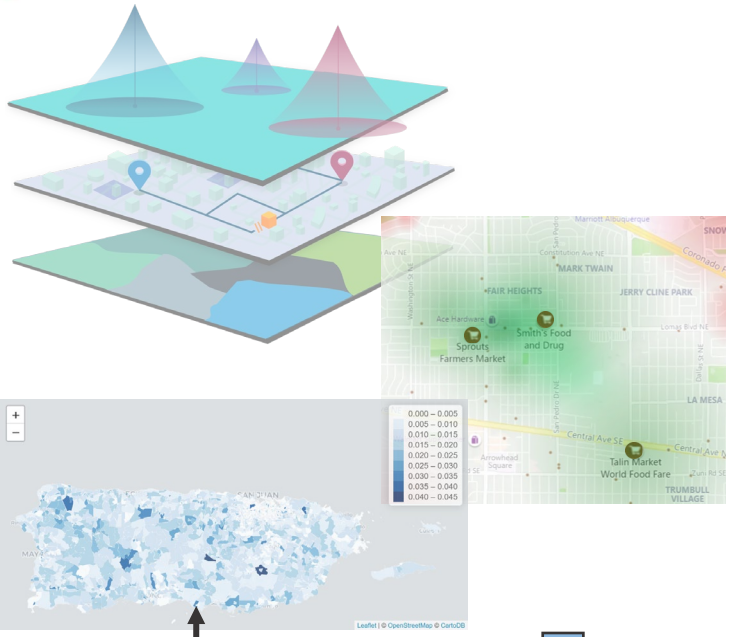


"Black Sky" Scenario: Grid Outage, Some/All Facilities "OFFLINE"

$$Social\ Burden = Effort/Ability \cong$$

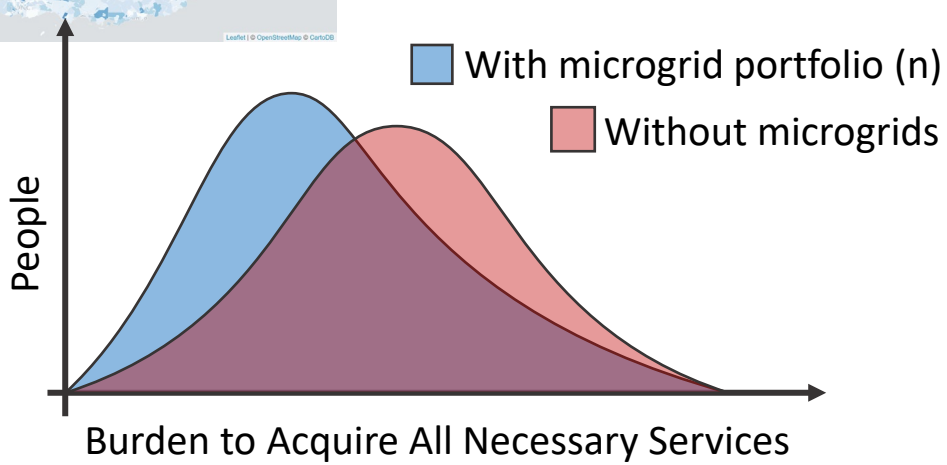
$$\frac{Effort\ to\ Obtain\ Service_{people,services}}{Service\ Levels_{facilities,services} \times Baseline\ Capacity_{people}}$$

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!



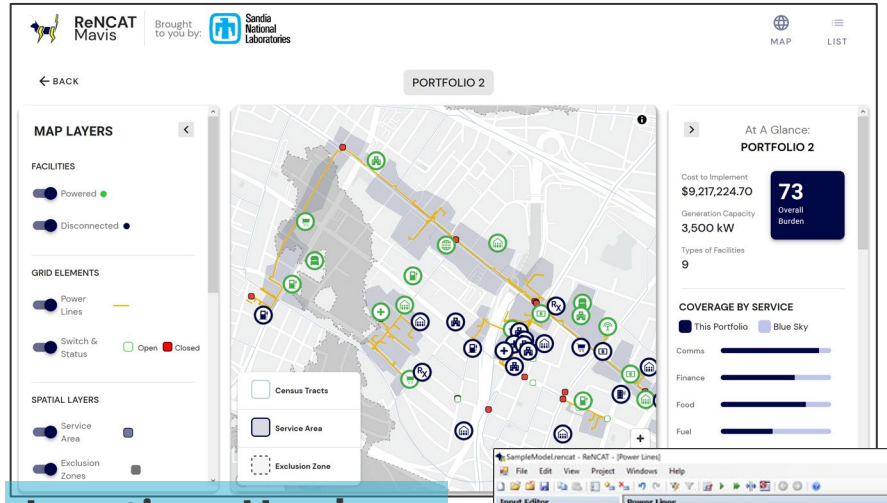
Need a tool to help with:

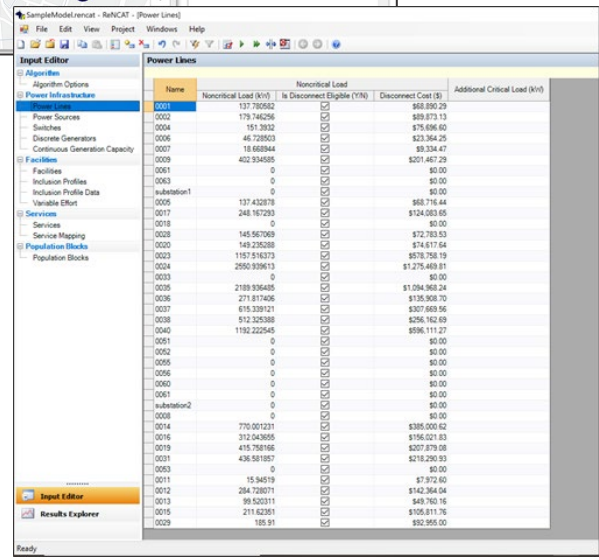
- Siting infrastructure investments
- Evaluating alternative projects
- Understanding public safety power shutoff plan (PSPS) impacts
- Mitigation measures

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



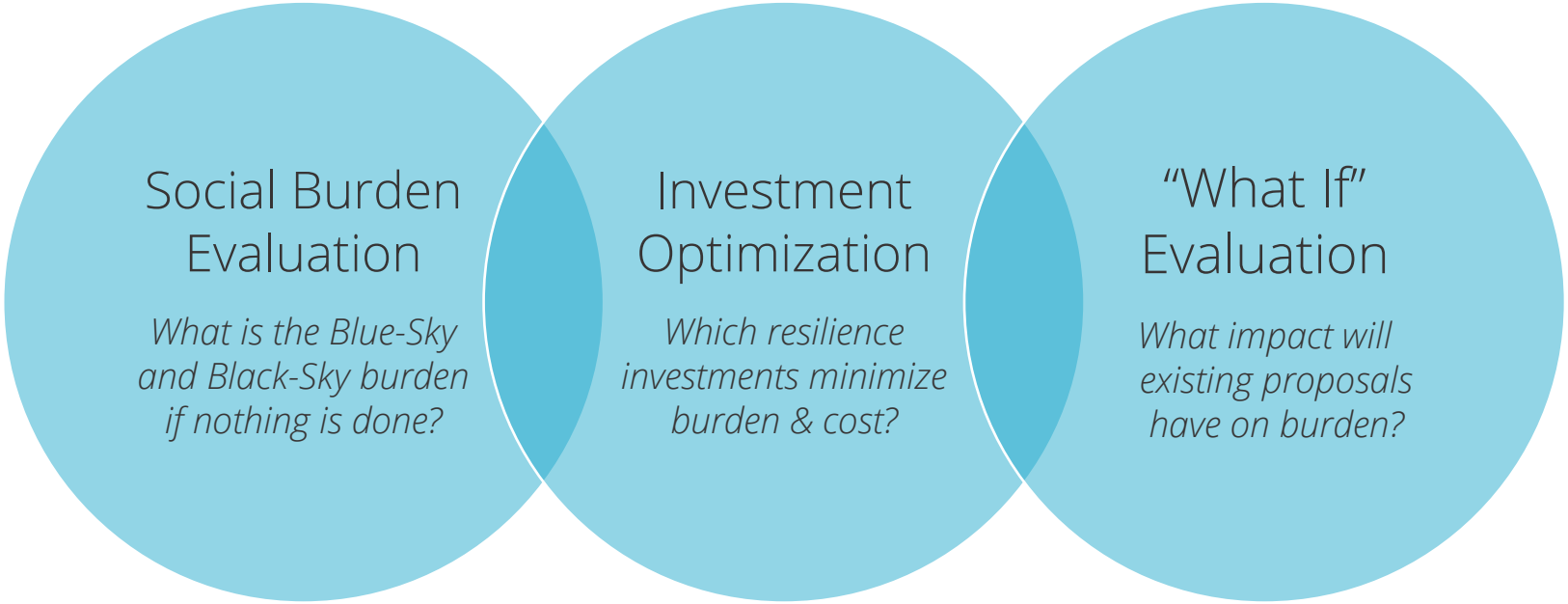


Locations Used:

- Southern California Edison
- New Orleans
- Puerto Rico
- Pittsburgh
- Nags Head, NC
- Colorado Springs
- Bakersfield
- and more

Applications of ReNCAT

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



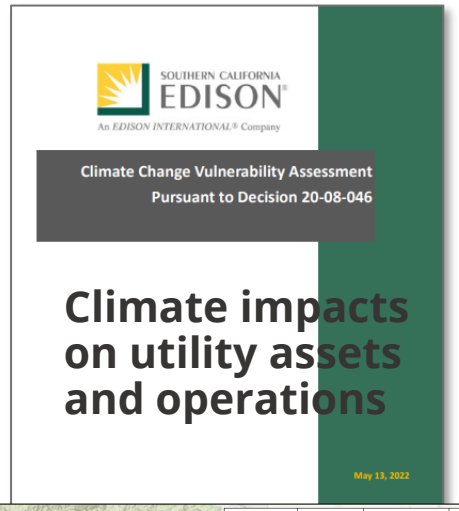
Can be mixed and matched depending on data availability, study questions, and project needs.

Supporting development of climate-informed equitable resiliency evaluation and planning processes

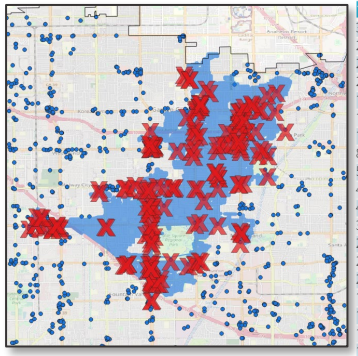
CALIFORNIA Public Utilities Commission

EDISON INTERNATIONAL®

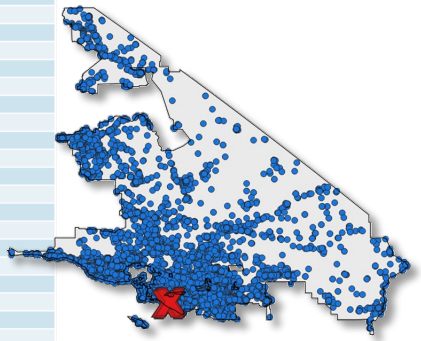
Sandia National Laboratories



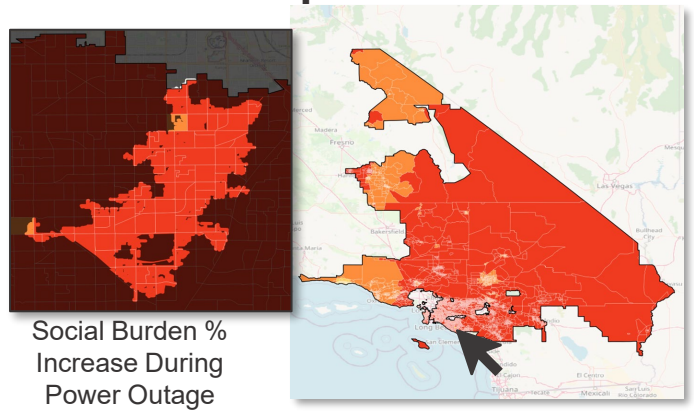
What is lost (facilities x services)?

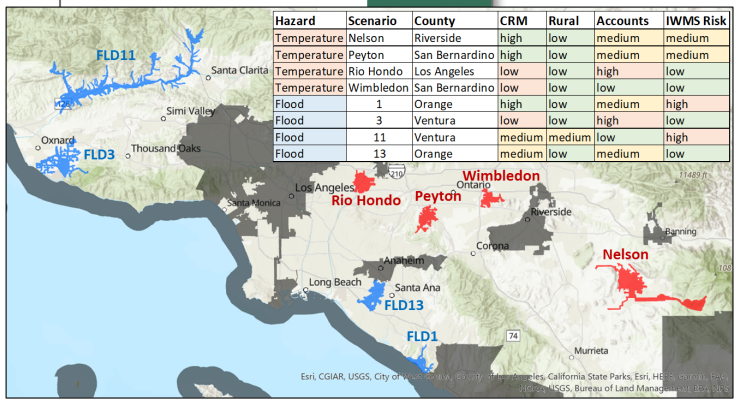


181 total facilities (~0.51% of total)
36 Gas Stations (1.2%)
26 Pharmacies (1.4%)
25 Microwave Towers (0.3%)
20 Bank Branches (0.9%)
15 Fast Food Sites (0.6%)
12 EV Charging Sites (0.3%)
10 Official Shelters (0.5%)
8 Convenience Stores (1.2%)
5 Supermarkets (0.9%)
4 Retail Superstores (1.0%)
4 EMS Sites (0.5%)
3 Fire Stations (0.4%)
2 EOC Sites (2.3%)
2 Landfills (0.2%)
2 Local Law Enforcement (0.7%)
1 Hospital (0.5%)
1 ATM (0.3%)
1 Bus Station (2.0%)
1 Money Transfer site (6.7%)
1 PSAP site (0.2%)
1 Urgent Care (0.4%)
1 Cooling Center (0.4%)



What is the impact?

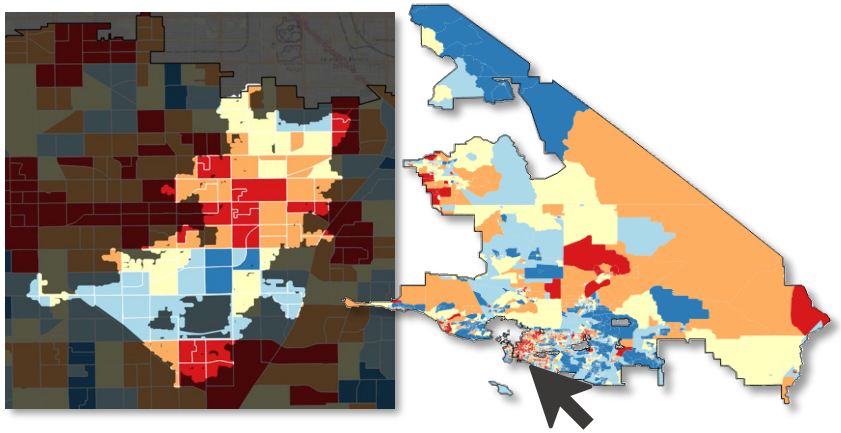




Hazard	Scenario	County	CRM	Rural	Accounts	IWMS Risk
Temperature	Nelson	Riverside	high	low	medium	medium
Temperature	Peyton	San Bernardino	high	low	medium	medium
Temperature	Rio Hondo	Los Angeles	low	low	high	low
Temperature	Wimbledon	San Bernardino	low	low	low	low
Flood	1	Orange	high	low	medium	high
Flood	3	Ventura	low	low	high	low
Flood	11	Ventura	medium	medium	low	high
Flood	13	Orange	medium	low	medium	low

How do climate threats translate to hypothetical grid outages?

Who is impacted (people)?



How to prioritize mitigations?

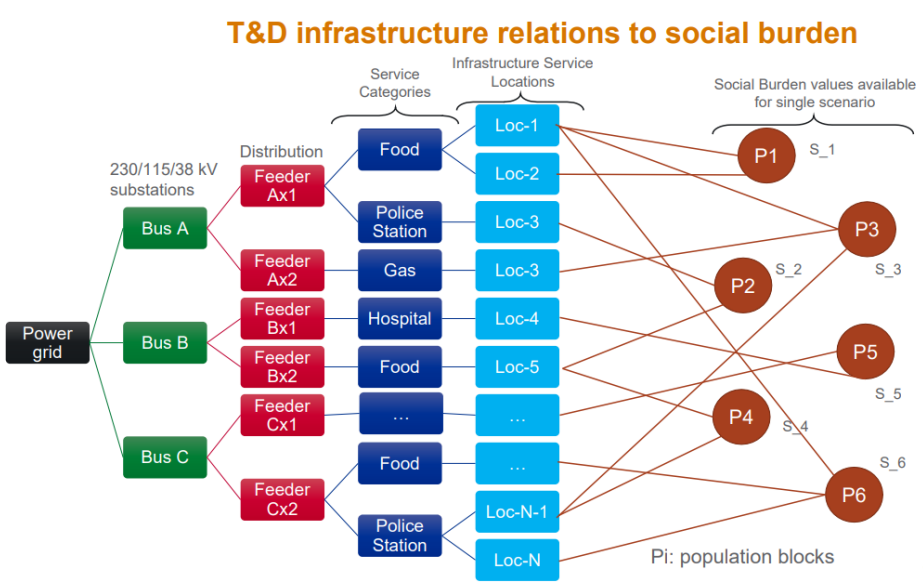
Hazard	Scenario	County	CRM	Social Burden Differential[a]
Temperature	Nelson	Riverside	High	+0.72%
Temperature	Peyton	San Bernardino	High	+0.78%
Temperature	Rio Hondo	Los Angeles	Low	+1.12%
Temperature	Wimbledon	San Bernardino	Low	+0.10%
Flood	1	Orange	High	+0.55%
Flood	3	Ventura	Low	+0.29%
Flood	11	Ventura	Medium	+0.44%
Flood	13	Orange	Medium	+1.23%

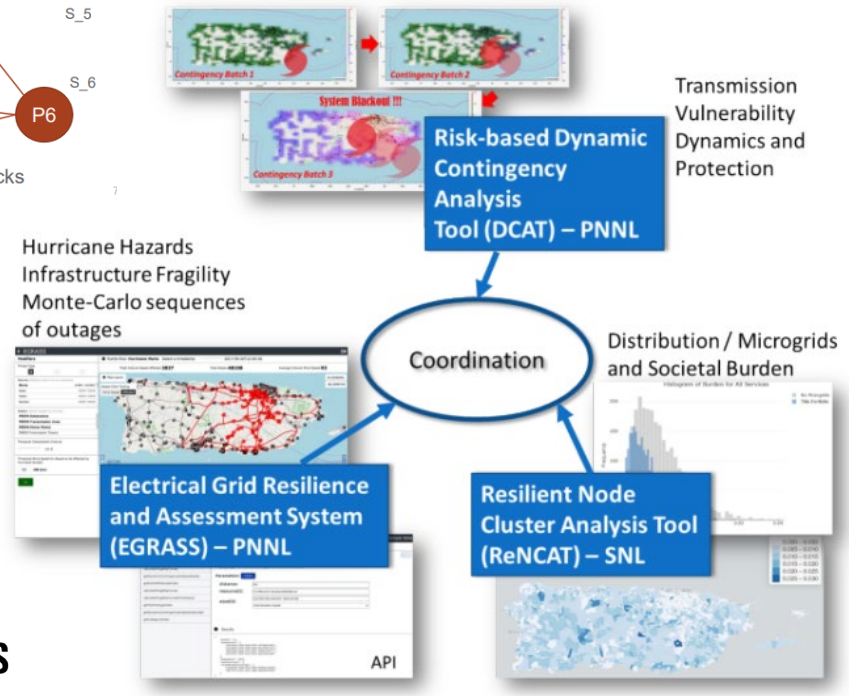
Informing equitable resilience in connected T&D systems

Sandia and PNNL developing tools to improve integrated T&D resilience planning and post-event restoration.

The EGRASS-DCAT-ReNCAT "trifecta" tools model resilience assessment of proposed transmission and distribution projects, like:

- transmission line upgrades, new generation, proposed substation relocation, distribution system hardening, distribution automation, and microgrids





Pacific Northwest NATIONAL LABORATORY

Sandia National Laboratories

Source: https://www.osti.gov/servlets/purl/1891186

Can be coupled with economic impact models to capture the diverse impacts of long duration outages

Power outages have severe consequences:

Productivity
- Damage to equipment
- Loss of perishables
- Lost computing time
- Unsafe work conditions

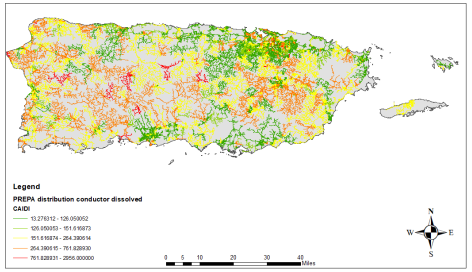
Daily life
- Communications challenges
- Cooking difficult
- Entertainment unavailable

Health
- Loss of heating/cooling
- Medication spoilage

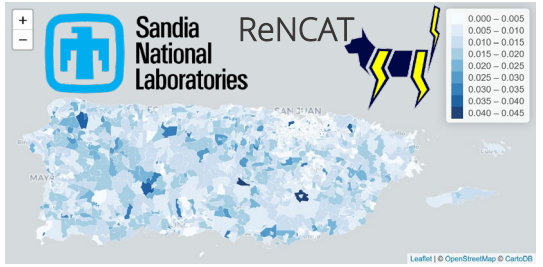
Power System Performance

Impacts

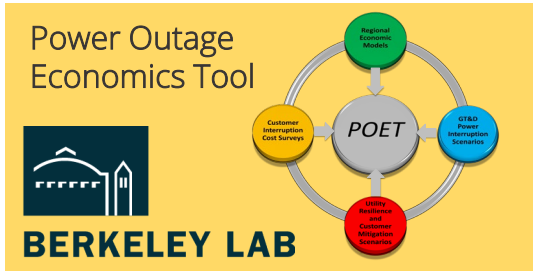
MWh not served
Total energy not served over the duration of a disruptive event (or all disruptive events)



Social burden
Human effort expended to achieve a basic level of lifeline services



Power interruption cost
Direct and indirect costs resulting from power interruptions



Additional Resources

Download ReNCAT:

https://energy.sandia.gov/news/download-sandias-resilient-node-cluster-analysis-tool-rencat/

Further Reading:

- Wachtel, A., Melander, D., & Jeffers, R. (2022). *Measuring Societal Infrastructure Service Burden* (No. SAND2022-2029R). Sandia National Lab.(SNL-NM), Albuquerque, NM (United States).
- Wachtel, A., Melander, D., & Hart, O. (2022). *ReNCAT: The Resilient Node Cluster Analysis Tool* (No. SAND2022-10888R). Sandia National Lab.(SNL-NM), Albuquerque, NM (United States).
- Gunda, T., Wachtel, A., Khadka Mishra, S., & Moog, E. (2023). Quantitative approaches for including equity in risk and resilience infrastructure planning analyses. *Risk Analysis*.

California PUC case study, public webinar recordings:

- Hart, O., Wachtel, A., Melander, D., and Bresloff, C. (July 2022) *Resilience Node Cluster Analysis Tool (ReNCAT).* CPUC Microgrid Proceeding – Track 5 Value of Resiliency: Economic and Equity Impacts of Large Disruptions – Social Burden Index. *https://www.youtube.com/watch?v=QKM_L9YcHmg*
- Hart, O., Wachtel, A., Melander, D., Brockway, A., and Blagaich, M. (July 2023). *Sandia's Social Burden and Southern California Edison's Community Resilience Metric*. CPUC Microgrid Proceeding – Track 5 Value of Resiliency: Economic and Equity Impacts of Large Disruptions – Social Burden Index. *https://www.youtube.com/watch?v=6eD-dUGaWXk&t=588s*
- Hart, O., Wachtel, A., Melander, D., Brockway, A., and Torres, S. (November 2023). *Evaluating Social Burden in California: Final Results*. CPUC Microgrid Proceeding – Track 5 Value of Resiliency: Economic and Equity Impacts of Large Disruptions – Social Burden Index. *https://www.youtube.com/watch?v=e0ZXqXuCLyg*