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ORNL Technical Assistance for Georgia

ORNL Team:

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U.S. DEPARTMENT OF ENERGY

Purpose/Objective

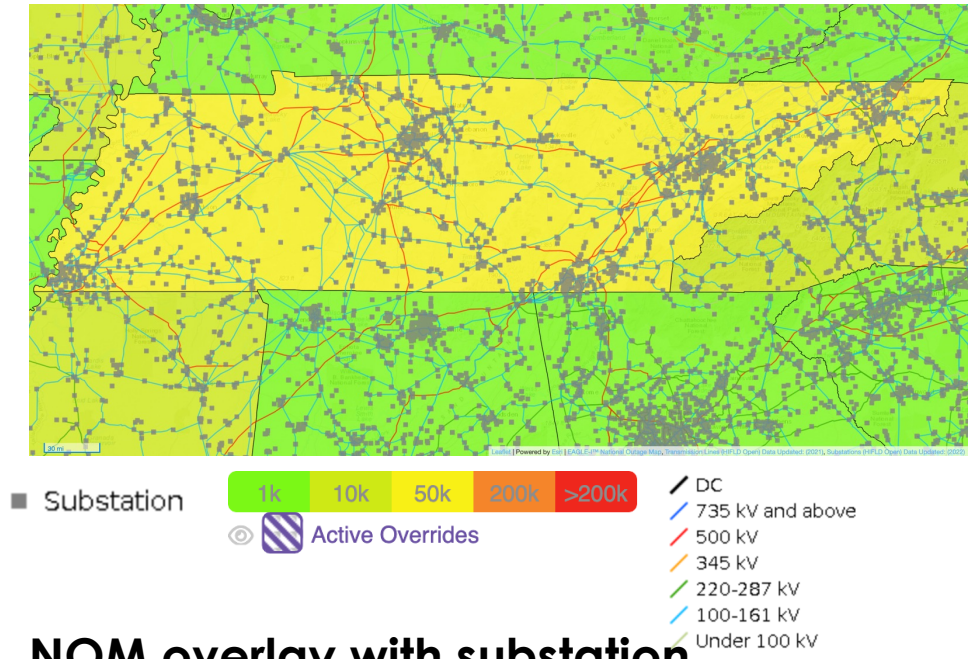
To deliver technical assistance to **evaluate the resilience potential of infrastructure investments**

- technical assistance (TA) for Tennessee, Mississippi, and Georgia by leveraging existing systems like **EAGLE-I and Outage Data initiative Nationwide (ODIN)**
- offer capabilities that include **outage data analysis**, **community footprint report** for utilities, and other **EIA-861 based summary reports** capturing automated metering infrastructure, net metering, distribution systems and reliability metrics data etc.

ORNL has unique capabilities in

1. Grid resilience modeling for distribution and transmission
2. Data for electricity customer outages and
3. Infrastructure interdependency analysis (URBAN-NET)

EAGLE-I™



NOM overlay with substation and transmission lines

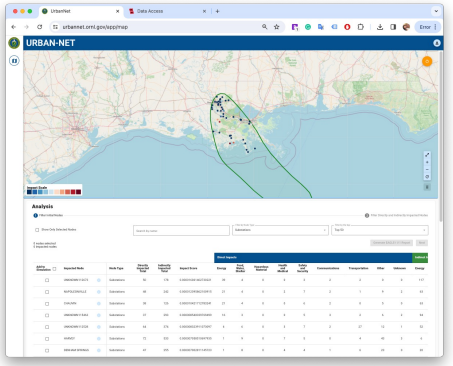
Key to evaluate quantitatively the impact of investments into **selected states** regional energy system through the IIJA.

ORNL Grid Capabilities

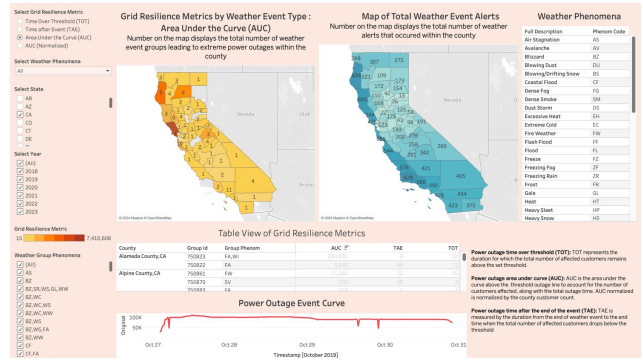
- Oak Ridge National Laboratory (ORNL) has been working on numerous projects centered on grid and energy resilience, cultivating robust capabilities in:
  - Data Collection and Analysis
  - Standardization
  - In-Depth Resilience Analysis
  - Visual Dashboards
  - Interdependency Analysis
- Following projects will be briefly introduced:
  - EAGLE-I, ODIN, TASTI-GRID, URBAN-NET

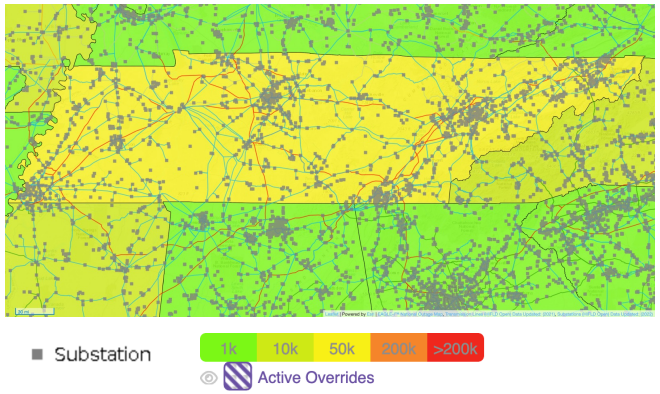
ODIN

URBAN-NET



TASTI-GRID





EAGLE-I™

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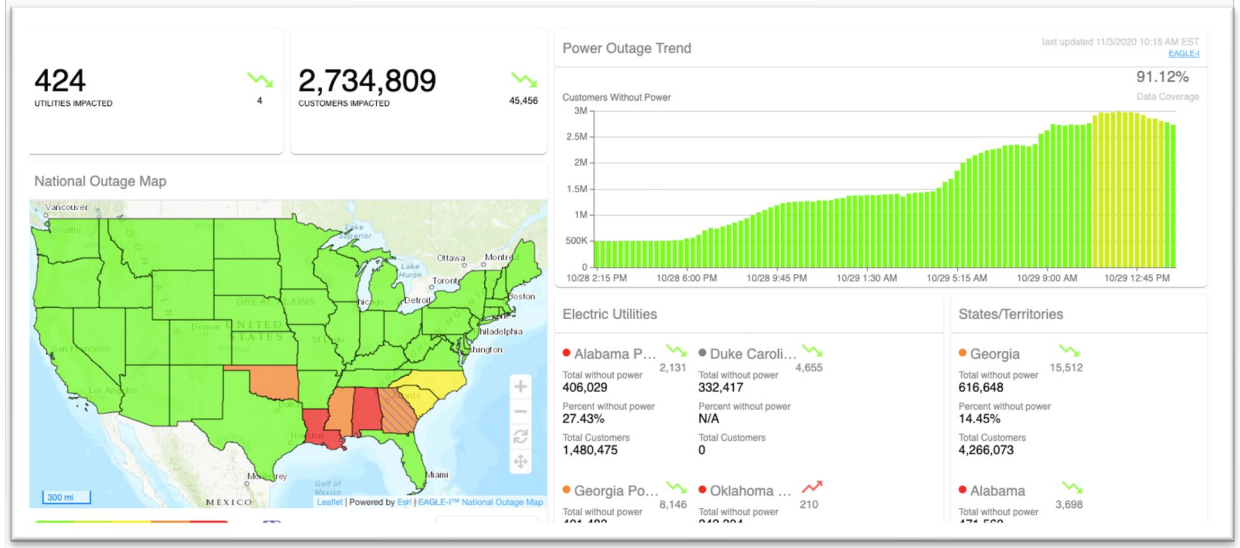
EAGLE-I™: Environment for Analysis of Geo-Located Energy Information

Utility Outage Data

- Collects utility outage data every 15 minutes
- Provided mission critical function to DOE (ESF12)
  - 92% electricity customers
  - 99% availability in FY21
  - 990 active users (~2,500 total)

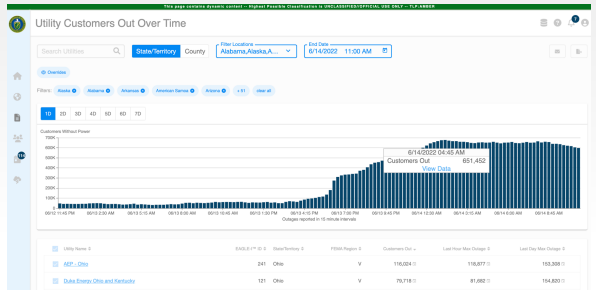


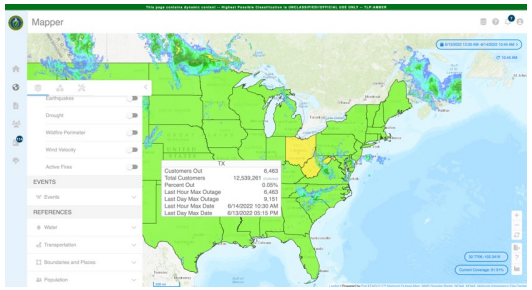
EAGLE-I login link

Mission Impact and Features

- Presidential Emergency Declaration during winter storm Uri and FEMA support/Colonial pipeline disruption

Mapper: Features spatial distribution of real-time power outages, able to be overlayed with **61 other mapper reference** or real time layers





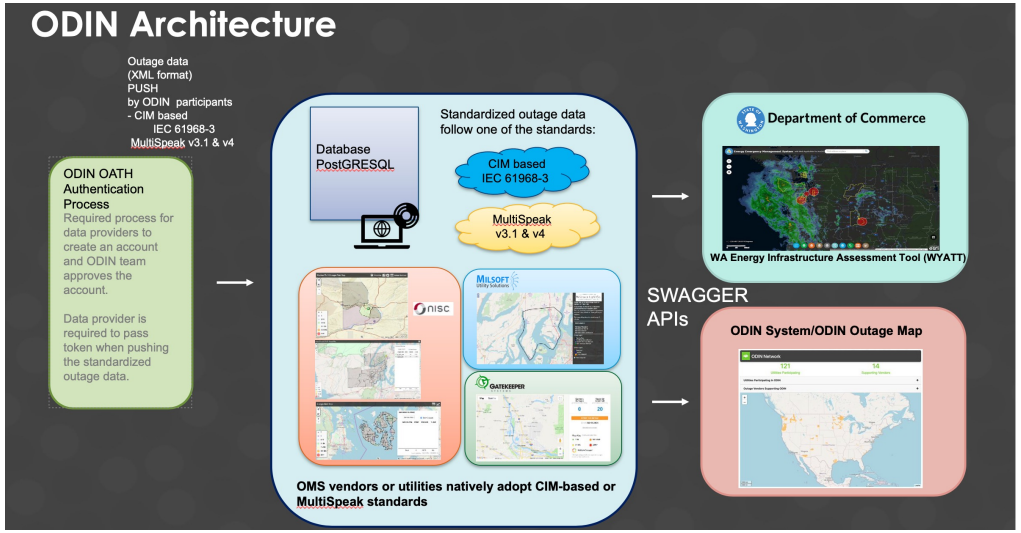
Reports: Customizable by geographic region and time period, these reports visually display power outages for the user-specified selections

Source: From EAGLE-I™

Outage Data Initiative Nationwide (ODIN)

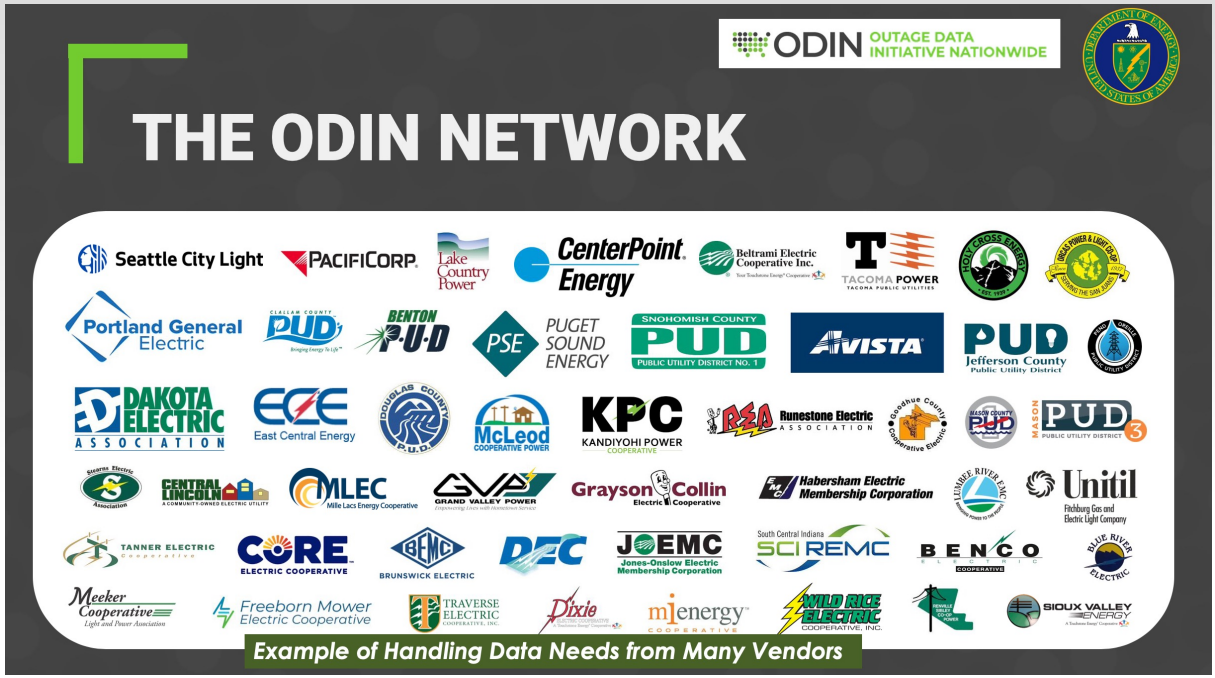
What is ODIN?

- ODIN is a network of leading electric service providers who are committed to providing comprehensive interoperable power outage data that enables utilities and others to exchange data freely with designated stakeholders at all levels — helping restoration, reliability, risk mitigation, emergency response, and more.



Source: https://odin.ornl.gov

ODIN Network of Utilities and Vendors



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- Tableau Dashboards Demo

1. Statistical Summaries of Historical EAGLE-I Outage Information for All States – Narayan Bhusal
2. Restoration Curves/ Linking CEJST with Utility Service Territories and EAGLE-I Coverage data- Nasir Ahmad
3. Weather Baselined Outage Data – Sangkeun Matt Lee
4. Coverage Dashboard

State

- [ ] Oregon
- [ ] Pennsylvania
- [ ] Rhode Island
- [ ] South Carolina
- [ ] South Dakota
- [x] Tennessee
- [ ] Texas
- [ ] Utah
- [ ] Vermont

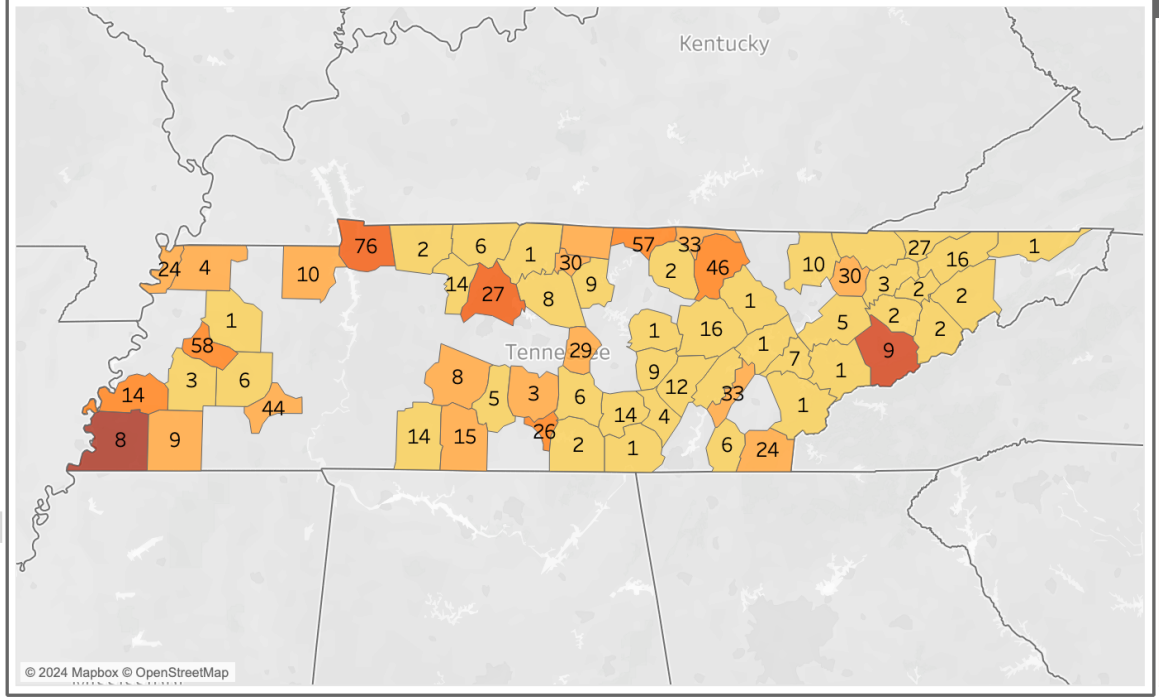
Select Metric 1

- ( ) Impact Rate
- ( ) Impact Level
- ( ) Recovery Duration
- ( ) Recovery Rate
- ( ) Recovery Impact Ratio
- (•) Event Duration

Year of Year

- [x] (All)
- [x] 2018
- [x] 2019
- [x] 2020
- [x] 2021
- [x] 2022

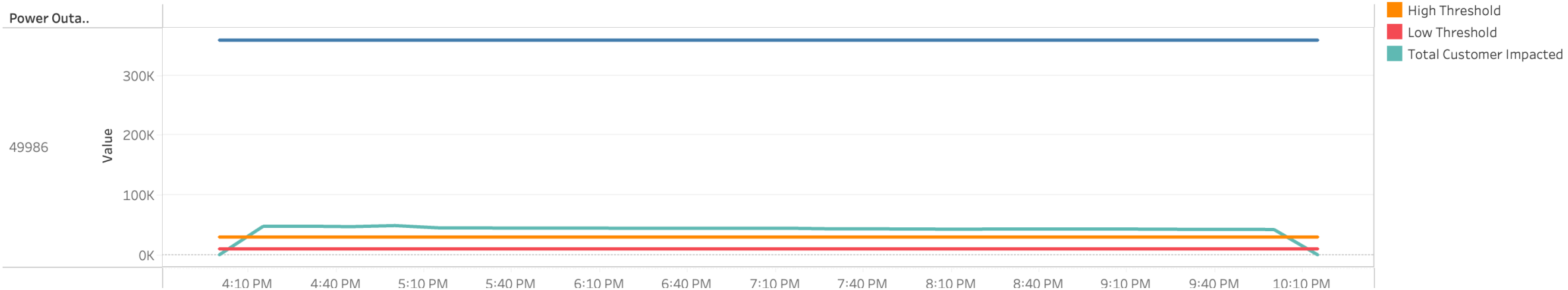
County Level Metric - Color represents Event Duration
Number of outage events are displayed on the map



Power Outage Event Details

County	Week of Run Start Time	Power Outage Event	Total Customer Impacted	Customers
Davidson	June 16, 2019	43255	73,488	1,436,208
		43257	863,791	13,643,976
	March 1, 2020	49980	696,664	8,258,196
		49982	335,384	3,231,468
		49984	289,849	2,872,416
		49986	1,069,479	9,335,352
		49988	204,700	2,513,364
		49990	580,309	6,462,936
		49992	35,739	1,077,156
		49994	35,725	1,077,156
		49996	212,603	2,872,416
		49998	69,713	1,436,208
		50000	383,266	4,667,676
		50002	3,805,838	53,498,748
	May 3, 2020	50006	3,779,784	12,566,820
		50008	849,278	3,590,520
		50010	748,220	3,590,520
		50012	833,614	3,949,572
		50014	4,187,042	18,670,704

Power Outage Event Visualization



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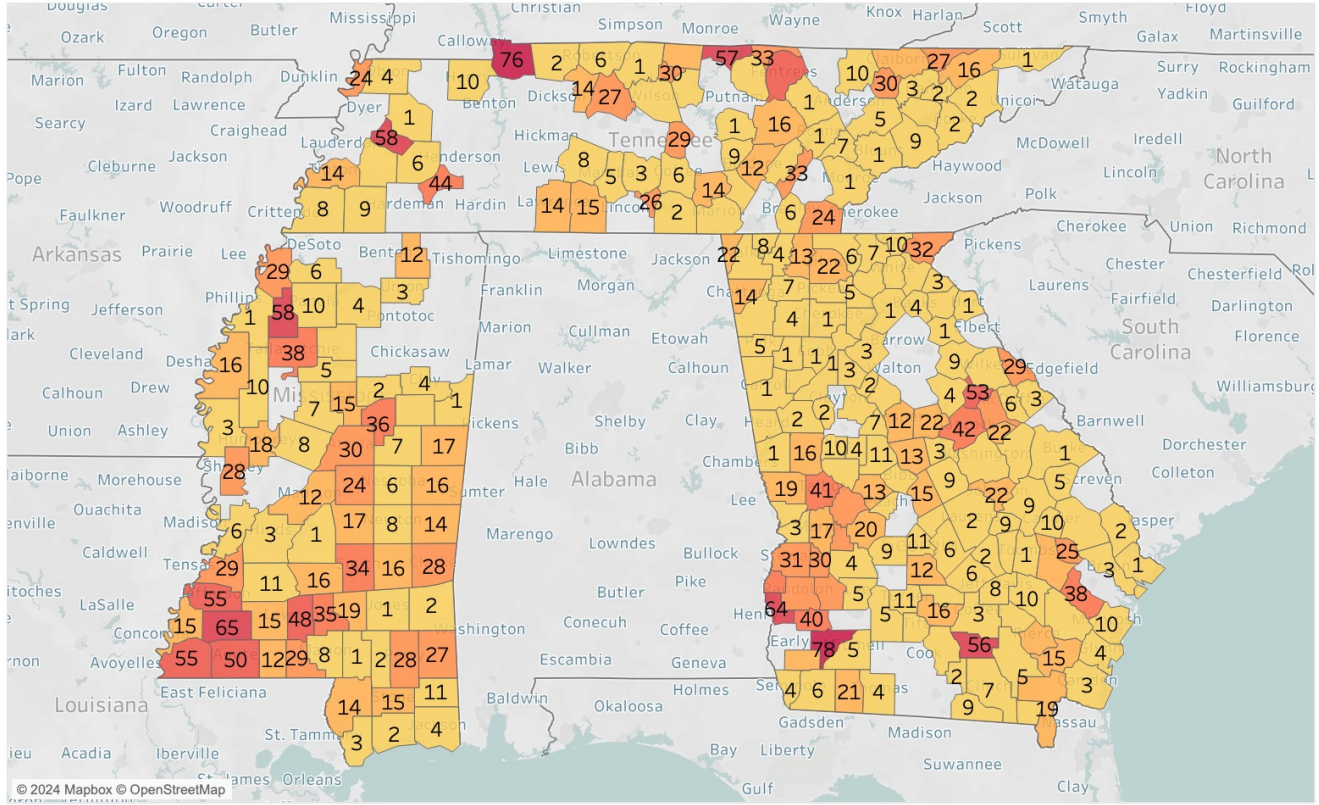
State

- [ ] District of Columbia
- [ ] Florida
- [x] Georgia
- [ ] Hawaii
- [ ] Idaho
- [ ] Illinois
- [ ] Indiana
- [ ] Iowa
- [ ] Kansas
- [ ] Kentucky
- [ ] Louisiana
- [ ] Maine
- [ ] Maryland
- [ ] Massachusetts
- [ ] Michigan
- [ ] Minnesota
- [x] Mississippi

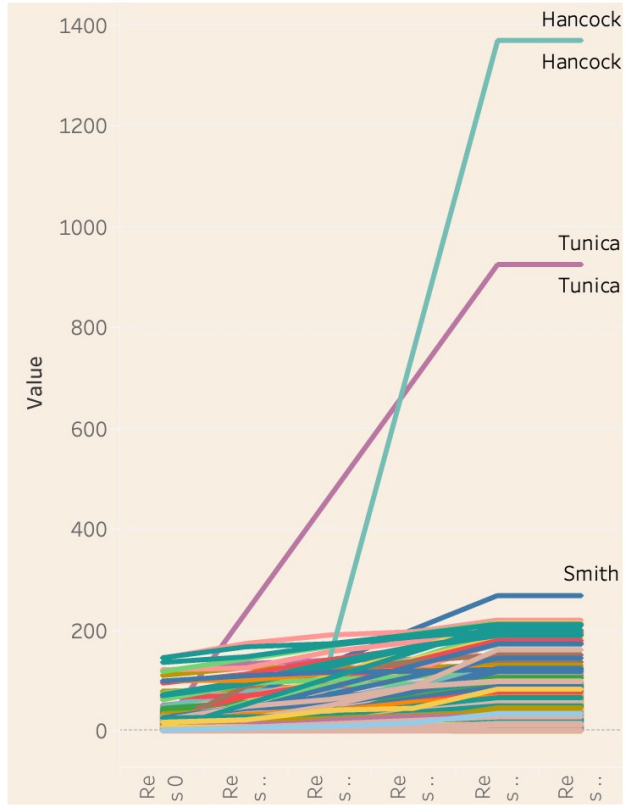
Year

- [x] (All)
- [x] 2018
- [x] 2019
- [x] 2020
- [x] 2021
- [x] 2022

Total Number of Power Outage Events - County Level



Restoration Curves for All



Number of Outage Events

1 — 78

County

(All)

County

- Douglas
- Campbell
- Jackson
- Jones
- Lake
- Lawrence
- Lincoln
- Marshall
- Turner
- Union
- Adams
- Amite
- Appling
- Atkinson
- Attala
- Bacon
- Baker
- Baldwin
- Banks

Group

- 5959
- 6026
- 6028
- 6043
- 6053
- 6141
- 6151
- 6182
- 6244
- 6246
- 6248
- 6250
- 6371
- 6556
- 6559

>12 hour outage events

State	County
Mississippi	Jefferson
	Wilkinson
	Franklin
	Jefferson Davis
	Walthall
	Quitman
	Pike
	Tallahatchie
	Adams
	Attala
	Amite
	Claiborne

>24 hour outage events

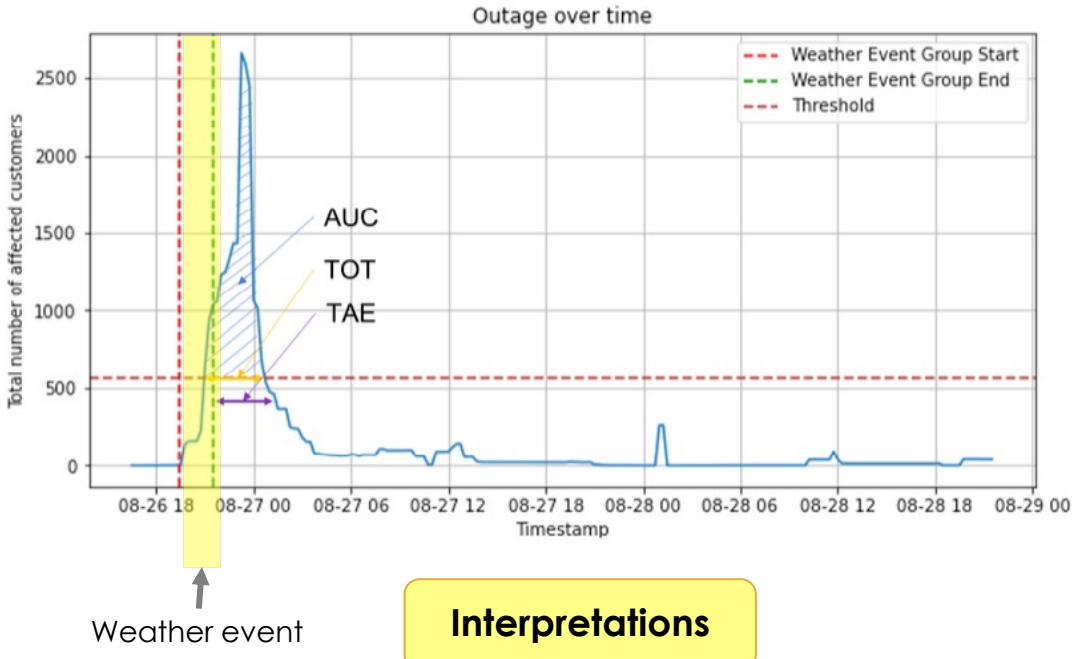
State	County
Mississippi	Jefferson Davis
	Wilkinson
	Jefferson
	Pike
	Franklin
	Quitman
	Adams
	Walthall
	Tallahatchie
	Amite
	Sunflower
	Lincoln

>48 hours outage events

State	County
Mississippi	Quitman
	Franklin
	Tallahatchie
	Jefferson Davis
	Pike
	Jefferson
	Walthall
	Wilkinson
	Adams
	Sunflower
	Warren
	Panola

Resilience Metrics

- **Power outage Time Over Threshold (TOT)**
  - TOT represents the time between an outage curve crossing the threshold line (duration of power outages experienced by customers due to extreme events)
- **Power outage Area Under Curve (AUC)**
  - To account for the number of customers affected, along with the total outage time, we calculated the area under the curve as another quantification metric.
  - AUC is the area under the curve above the dotted threshold outage line
- **Power outage Time After the End of the event (TAE)**
  - TAE is calculated to determine how long a power outage event continues after the end of an extreme weather event
  - Physically weak and aging infrastructures have more probability of failure resulting longer response time due to repair and installation requirement



Interpretations

(1) Low TOT and low AUC signify that very few customers were impacted and that they experienced shorter power outage durations

(2) Low TOT and high AUC signify that many customers were impacted for a shorter duration of time;

(3) High TOT and low AUC signify that a few customers experienced prolonged power outages

(4) High TOT and high AUC signify that a large number (wide spread) of customers experienced prolonged outages (this indicates a less/poor resilient power system)

Select Grid Resilience Metric

- Time Over Threshold (TOT)
- Time after Event (TAE)
- Area Under the Curve (AUC)
- AUC (Normalized)

Select Weather Phenomena

All

Select State

- [ ] AR
- [ ] AZ
- [x] CA
- [ ] CO
- [ ] CT
- [ ] DE

Select Year

- [x] (All)
- [x] 2018
- [x] 2019
- [x] 2020
- [x] 2021
- [x] 2022
- [x] 2023

Grid Resilience Metric

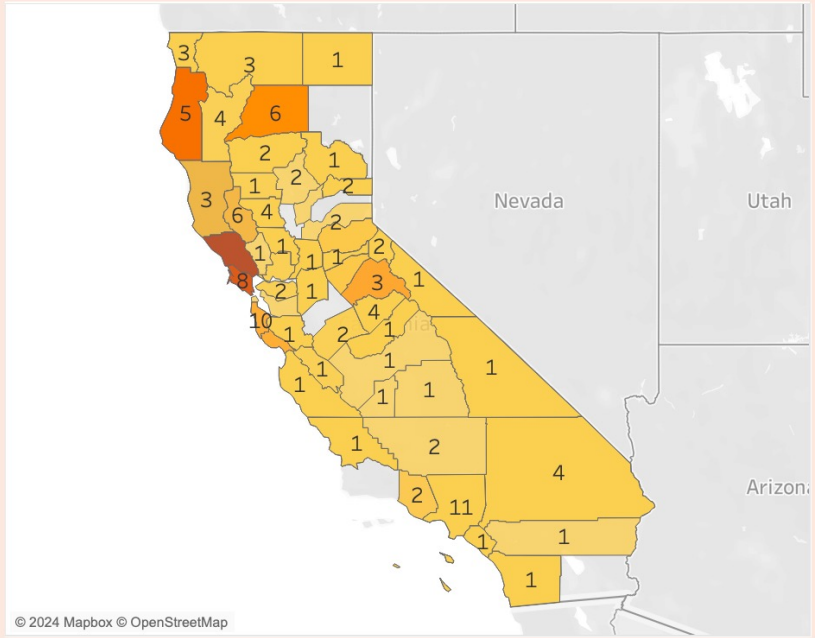
15 7,410,608

Weather Group Phenomena

- [x] (All)
- [x] AS
- [x] BZ
- [x] BZ,SR,WS,GL,WW
- [x] BZ,WC
- [x] BZ,WC,WS
- [x] BZ,WC,WW
- [x] BZ,WS
- [x] BZ,WS,FA
- [x] BZ,WW
- [x] CF
- [x] CF,FA

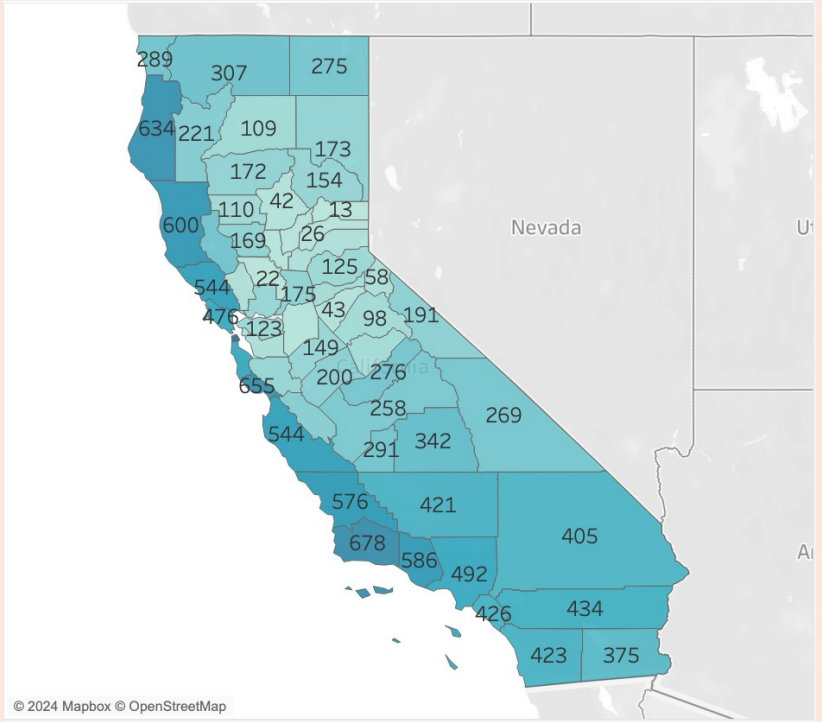
Grid Resilience Metrics by Weather Event Type : Area Under the Curve (AUC)

Number on the map displays the total number of weather event groups leading to extreme power outages within the county



Map of Total Weather Event Alerts

Number on the map displays the total number of weather alerts that occured within the county



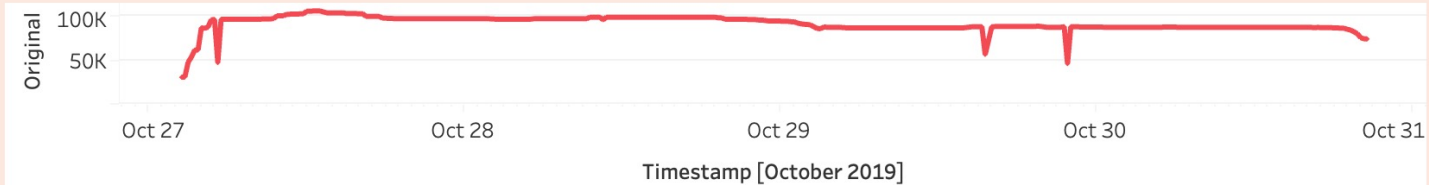
Weather Phenomena

Full Description	Phenom Code
Air Stagnation	AS
Avalanche	AV
Blizzard	BZ
Blowing Dust	DU
Blowing/Drifting Snow	BS
Coastal Flood	CF
Dense Fog	FG
Dense Smoke	SM
Dust Storm	DS
Excessive Heat	EH
Extreme Cold	EC
Fire Weather	FW
Flash Flood	FF
Flood	FL
Freeze	FZ
Freezing Fog	ZF
Freezing Rain	ZR
Frost	FR
Gale	GL
Heat	HT
Heavy Sleet	HP
Heavy Snow	HS

Table View of Grid Resilience Metrics

County	Group Id	Group Phenom	AUC	TAE	TOT
Alameda County,CA	750823	FA,WI	234,081	3	22
	750822	FA	5,543	45	2
Alpine County,CA	750861	FW	15,260	22	29
	750870	SV	593	48	3
	750883	FA	558	0	4

Power Outage Event Curve



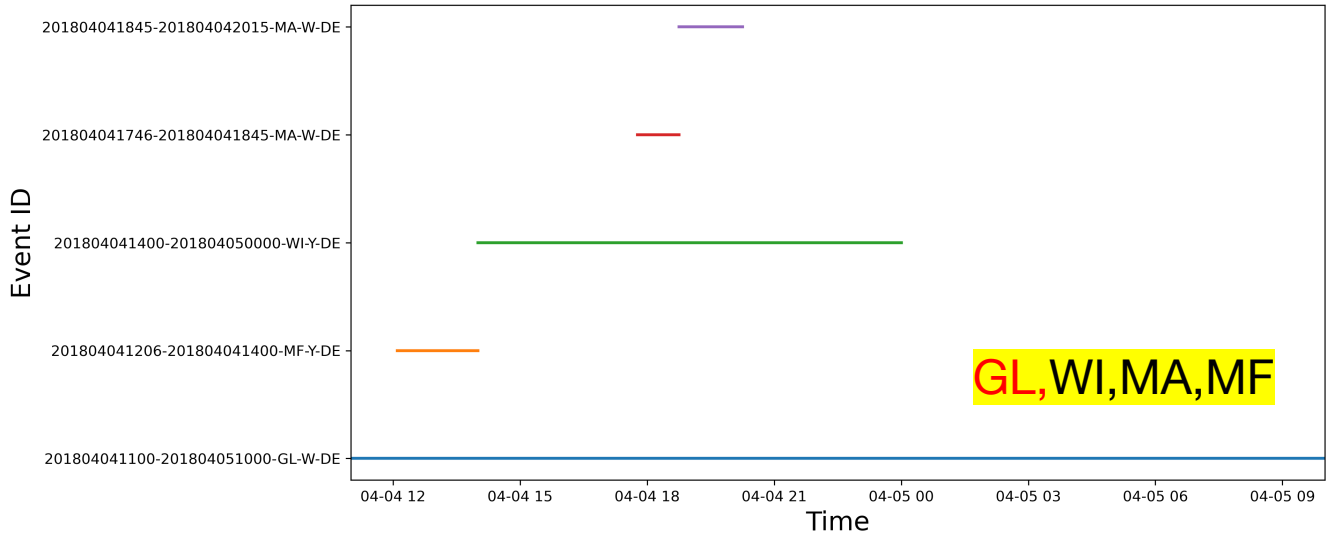
Power outage time over threshold (TOT): TOT represents the duration for which the total number of affected customers remains above the set threshold.

Power outage area under curve (AUC): AUC is the area under the curve above the threshold outage line to account for the number of customers affected, along with the total outage time. AUC normalized is normalized by the county customer count.

Power outage time after the end of the event (TAE): TAE is measured by the duration from the end of weather event to the end time when the total number of affected customers drops below the threshold

https://www.weather.gov/media/vtec/VTEC_explanation2-23.pdf

Weather Event Group Type – Combinational Effect

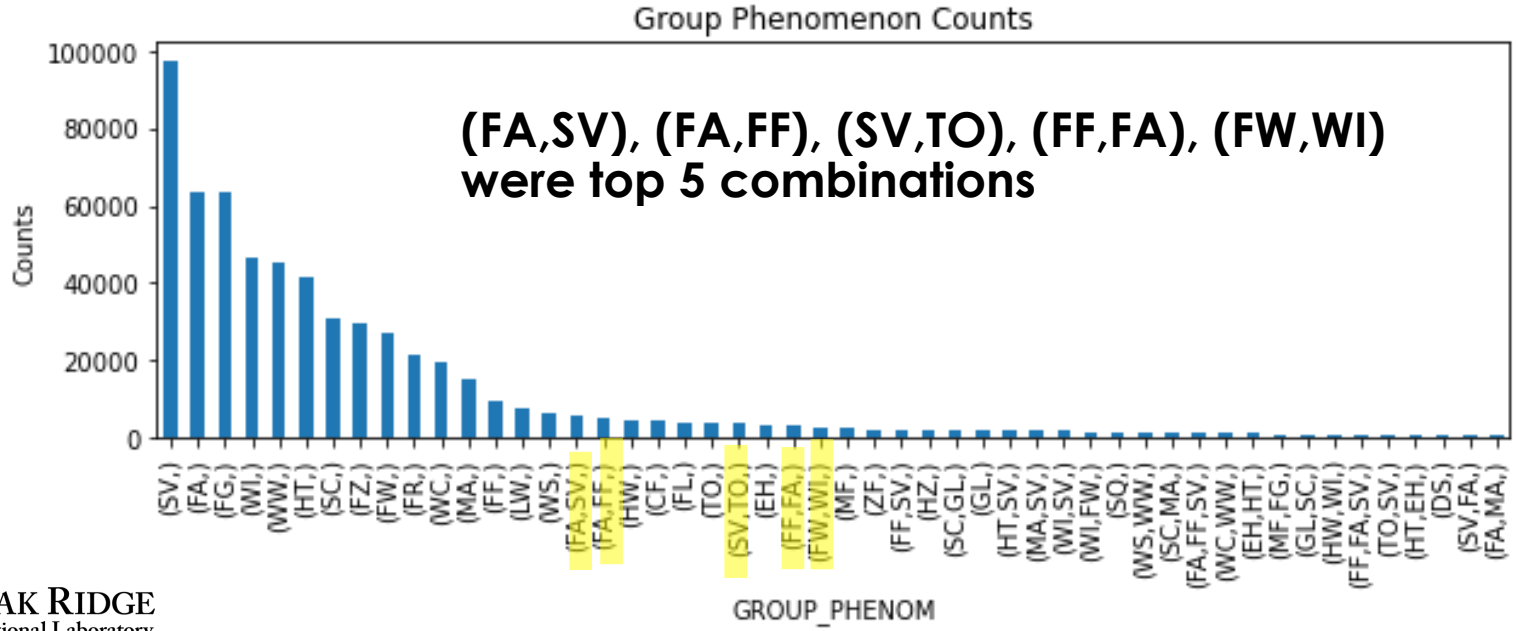


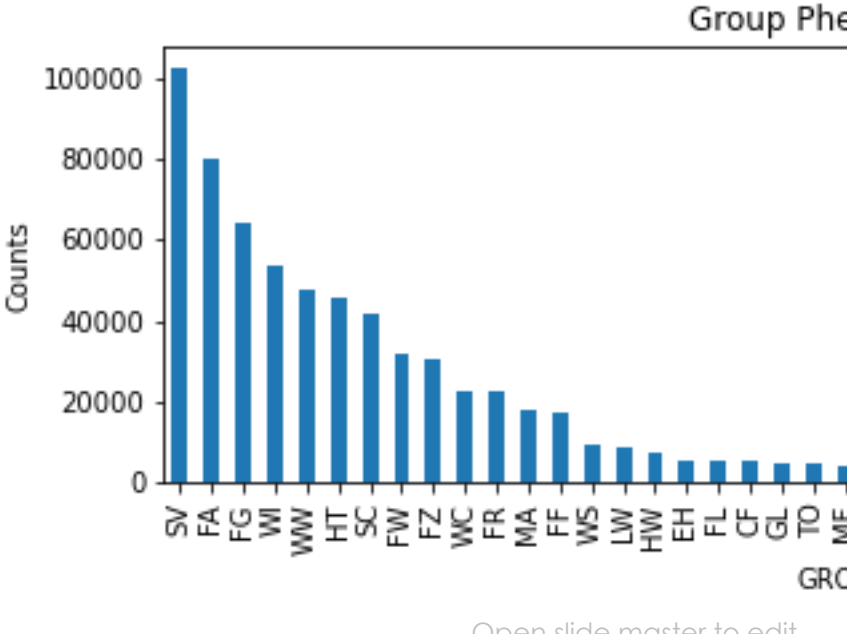
The combined effect of various weather conditions on power outage resilience is important.

- **GL** - Gale Warning: Indicates that gale force winds
- **WI** - Wind
- **MA** - Marine
- **MF** - Dense Fog (Marine Fog)

The first one 'GL' may be used to simplify the analysis

Combining all types
Sorted by the duration





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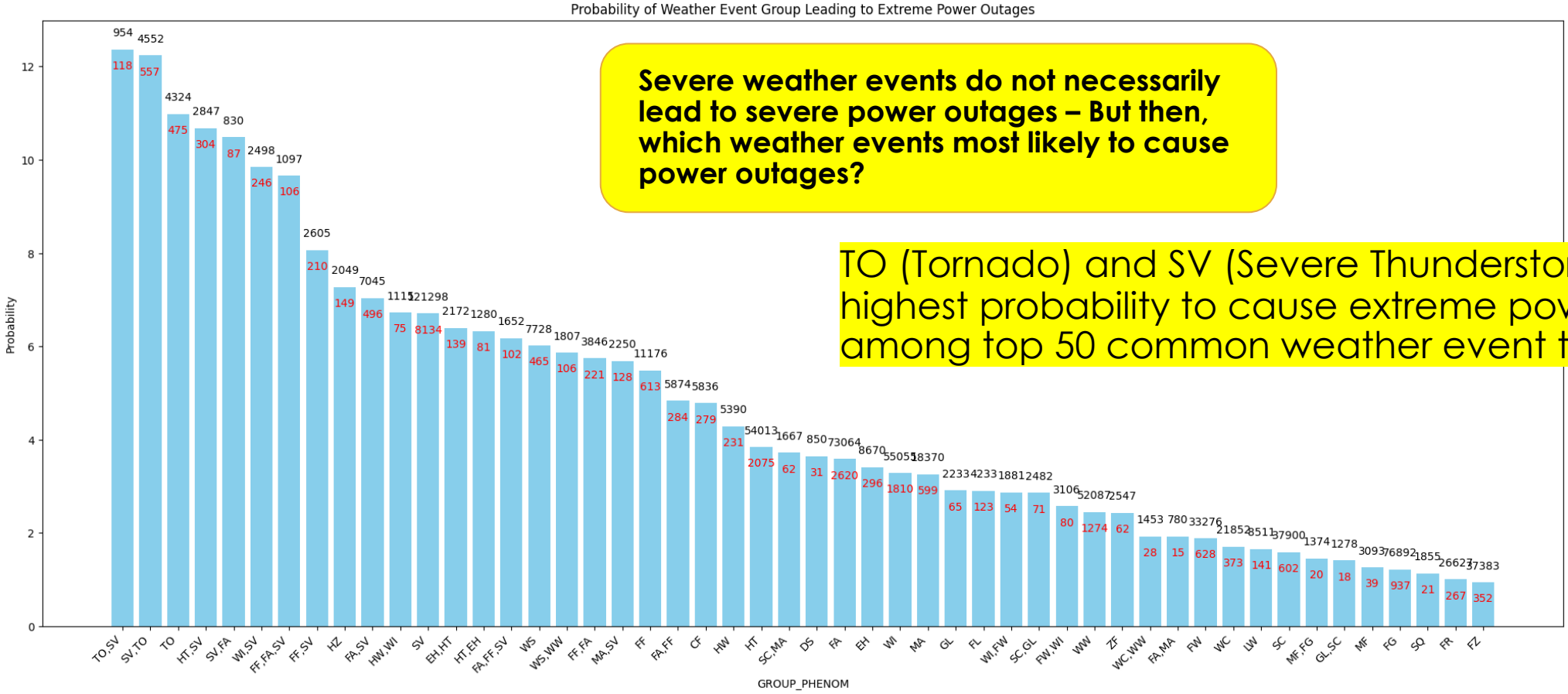
Open slide master to edit

What weather type (and their combinations) has more chance to cause extreme power outages?



Severe weather events do not necessarily lead to severe power outages – But then, which weather events most likely to cause power outages?

TO (Tornado) and SV (Severe Thunderstorm) has the highest probability to cause extreme power outages among top 50 common weather event types(12%)

Top 50 common weather event types

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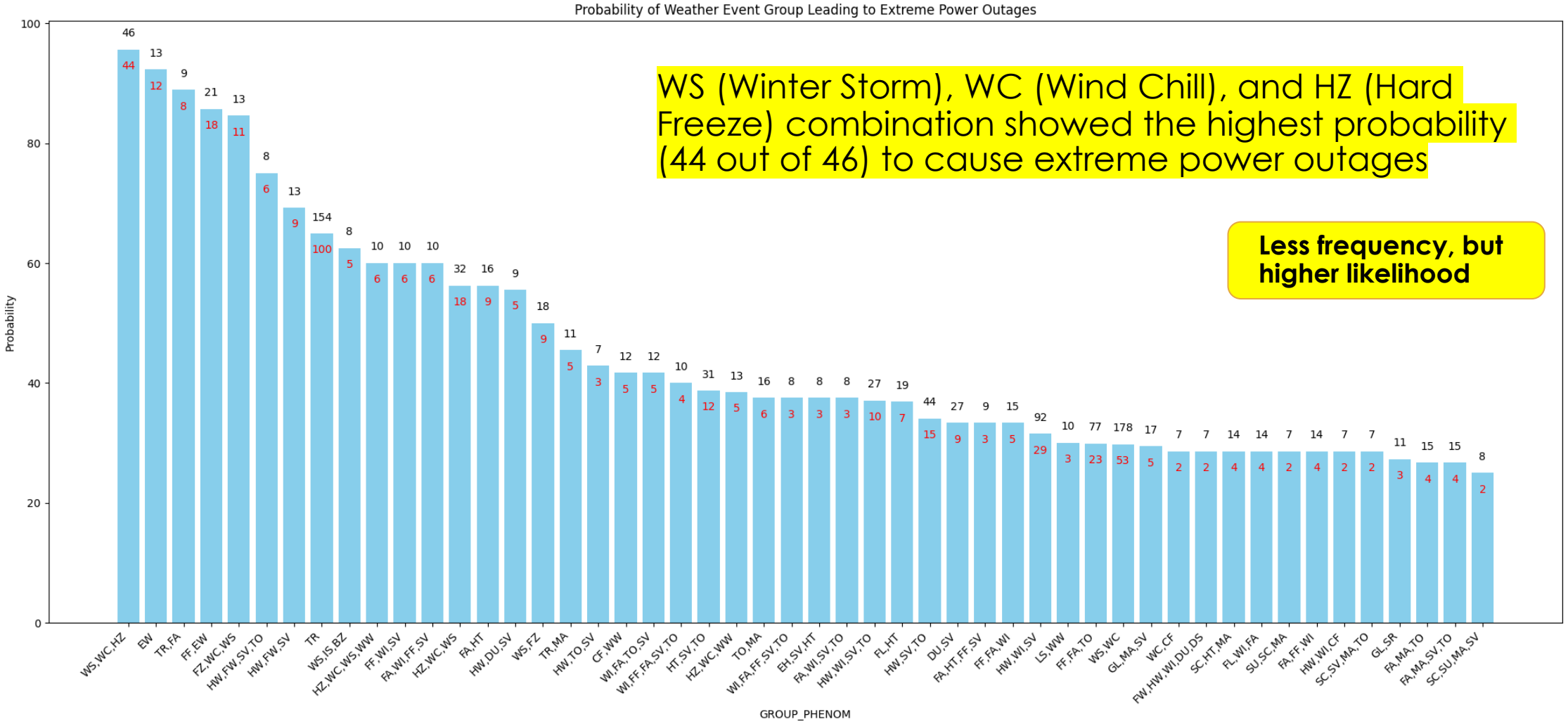
What weather type (and their combinations) has more chance to cause extreme power outages? – Less common weather types



WS (Winter Storm), WC (Wind Chill), and HZ (Hard Freeze) combination showed the highest probability (44 out of 46) to cause extreme power outages

Less frequency, but higher likelihood

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Disadvantaged Communities Assessment using CEJST Data

- Filter 32 key indicators from the reported 124 indicators by CEJST.
- Categorize 32 indicators into 8 categories (e.g., climate change).
- Overlay the CEJST data with HIFLD electric retail service territories to identify and analyze service territories' disadvantaged communities.

Climate change

Are at or above the 90th percentile for expected agriculture loss rate OR expected building loss rate OR expected population loss rate OR projected future flood risk OR projected future wildfire risk

AND are at or above the 65th percentile for low income

Energy

Are at or above the 90th percentile for energy cost OR PM 2.5 in the air

AND are at or above the 65th percentile for low income

Health

Are at or above the 90th percentile for asthma OR diabetes OR heart disease OR low life expectancy

AND are at or above the 65th percentile for low income

Housing

Experienced historic underinvestment OR at or above the 90th percentile for housing cost OR lack of green space OR lack of indoor plumbing OR lead paint

AND are at or above the 65th percentile for low income

Legacy pollution

Have at least one abandoned mine land OR Formerly Used Defense Sites (FUDS) OR are at or above the 90th percentile for proximity to hazardous waste facilities OR proximity to Superfund (National Priorities List (NPL)) sites OR proximity to Risk Management Plan (RMP) facilities

AND are at or above the 65th percentile for low income

Transportation

Are at or above the 90th percentile for diesel particulate matter exposure OR transportation barriers OR traffic proximity and volume

AND are at or above the 65th percentile for low income

Water and wastewater

Are at or above the 90th percentile for underground storage tanks and releases OR wastewater discharge

AND are at or above the 65th percentile for low income

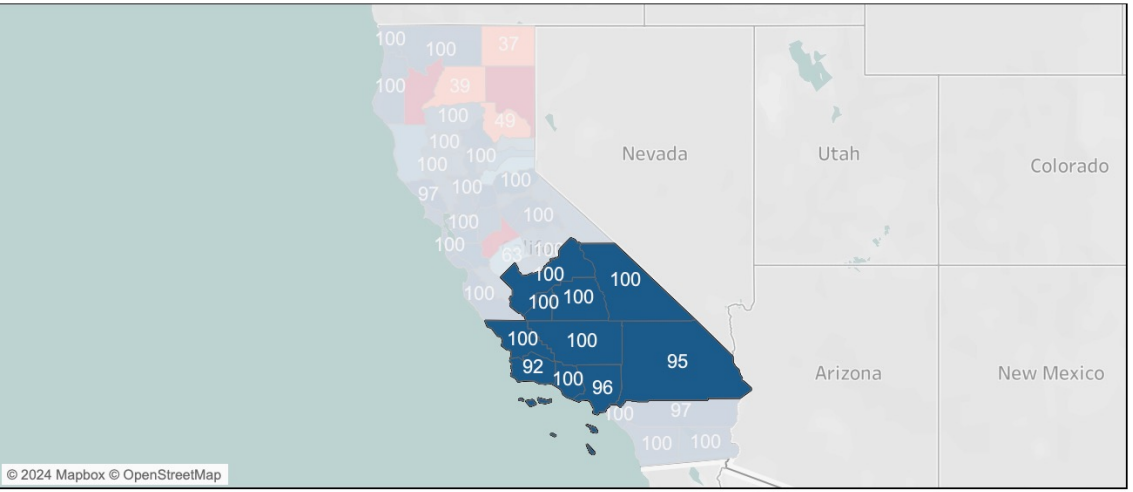
Workforce development

Are at or above the 90th percentile for linguistic isolation OR low median income OR poverty OR unemployment

AND fewer than 10% of people ages 25 or older have a high school education (i.e. graduated with a high school diploma)

California

Disadvantaged Communities with Power Outage Data Coverage



County Coverage
2.78 100.00

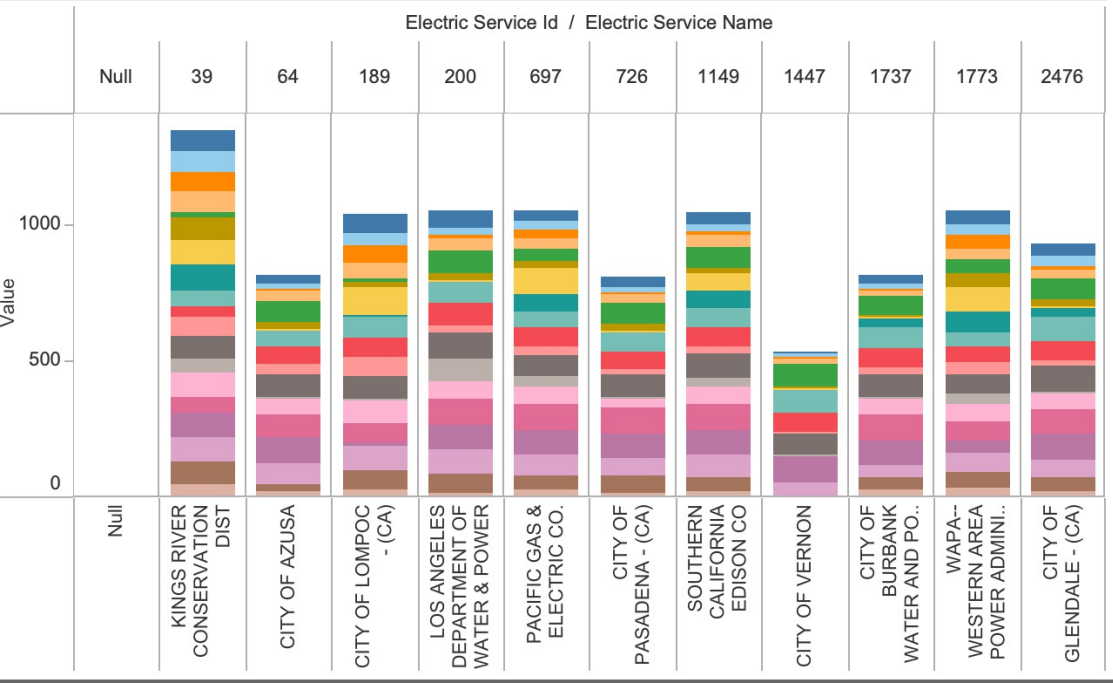
Disadvantaged Communities with Power Outage Data Coverage

State	County	Avg. County Coverage	Avg. Health	Avg. Energy	Avg. Climate	Avg. Workforce Development
California	Santa Barbara County	92	0.0	0.0	0.1	0.2
	San Bernardino County	95	0.1	0.3	0.2	0.3
	Los Angeles County	96	0.0	0.3	0.1	0.4
	Fresno County	100	0.2	0.6	0.3	0.5
	Inyo County	100	0.0	0.0	0.2	0.0
	Kern County	100	0.2	0.5	0.3	0.5
	Kings County	100	0.1	0.6	0.4	0.6
	San Luis Obispo County	100	0.0	0.0	0.0	0.0
	Tulare County	100	0.1	0.7	0.4	0.6
	Ventura County	100	0.0	0.0	0.1	0.2

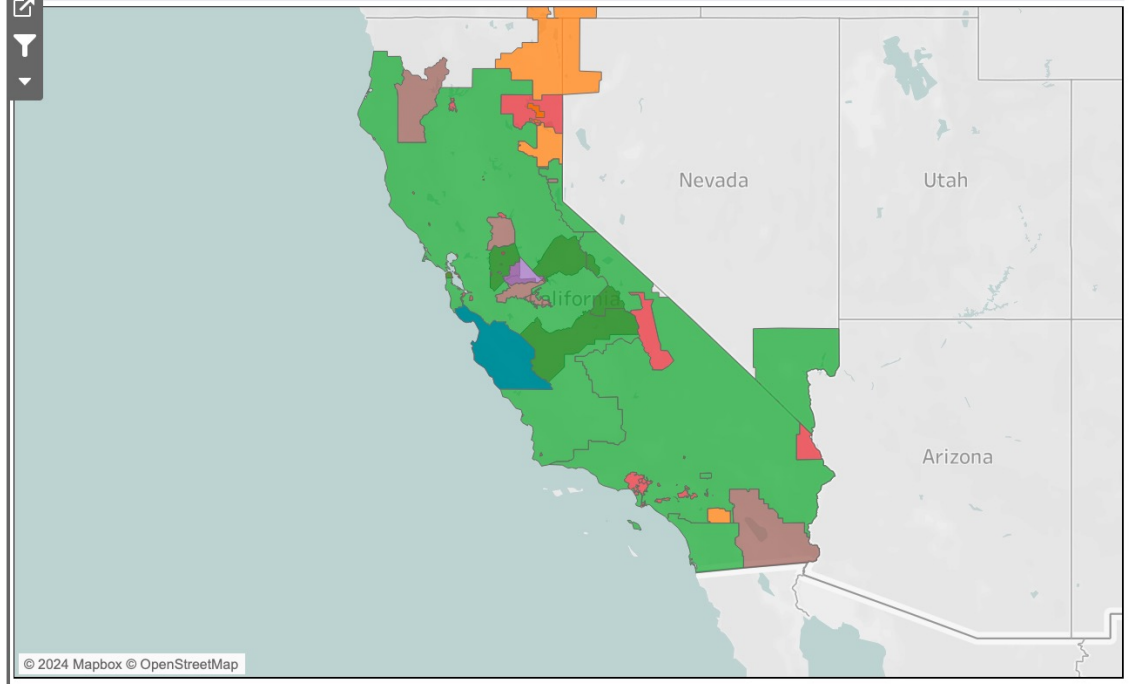
Measure Names
- Adjusted percent of indiv..
- Coronary heart disease ..
- Current asthma among a..
- Diagnosed diabetes amo..
- Diesel particulate matter ..
- Energy burden
- Expected agricultural los..
- Expected building loss r..
- Housing burden (percent)
- Leaky underground stor..
- Life expectancy (years)
- Linguistic isolation (perc..
- Median household inco..
- Unemployment (percent)
- Median value ($) of own..
- PM2.5 in the air
- Percent individuals age ..

State
Type COMMU..

Disadvantaged Electric Utility Service

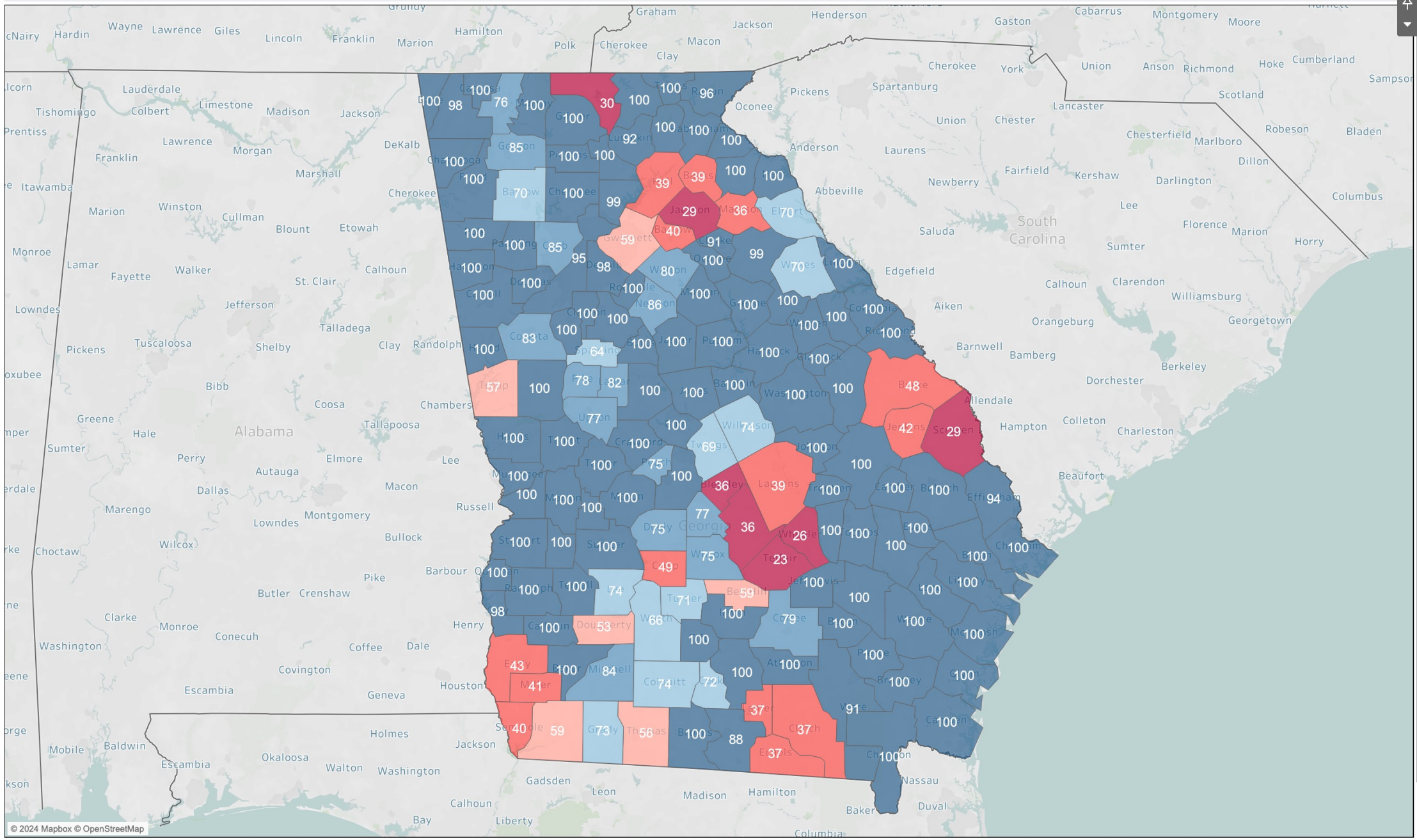


UtilityServiceMap



State
- (All)
- Null
- Alabama
- Alaska
- American Samoa
- Arizona
- Arkansas
- California
- Colorado
- Connecticut
- Delaware
- District of Columbia
- Florida
- Georgia
- Guam
- Hawaii
- Idaho
- Illinois
- Indiana
- Iowa
- Kansas
- Kentucky

Customer Coverage for Power Outage Data for Georgia



- (All)
- Alabama
- Alaska
- Arizona
- Arkansas
- California
- Colorado
- Connecticut
- Delaware
- District of Columbia
- Florida
- ☑ Georgia
- Hawaii
- Idaho
- Illinois
- Indiana
- Iowa
- Kansas
- Kentucky
- Louisiana
- Maine
- Maryland
- Massachusetts
- Michigan
- Minnesota
- Mississippi
- Missouri
- Montana
- Nebraska
- Nevada
- New Hampshire
- New Jersey
- New Mexico
- New York
- North Carolina
- North Dakota
- Ohio
- Oklahoma
- Oregon
- Pennsylvania

County Coverage

23 — 100

Source: EAGLE-I

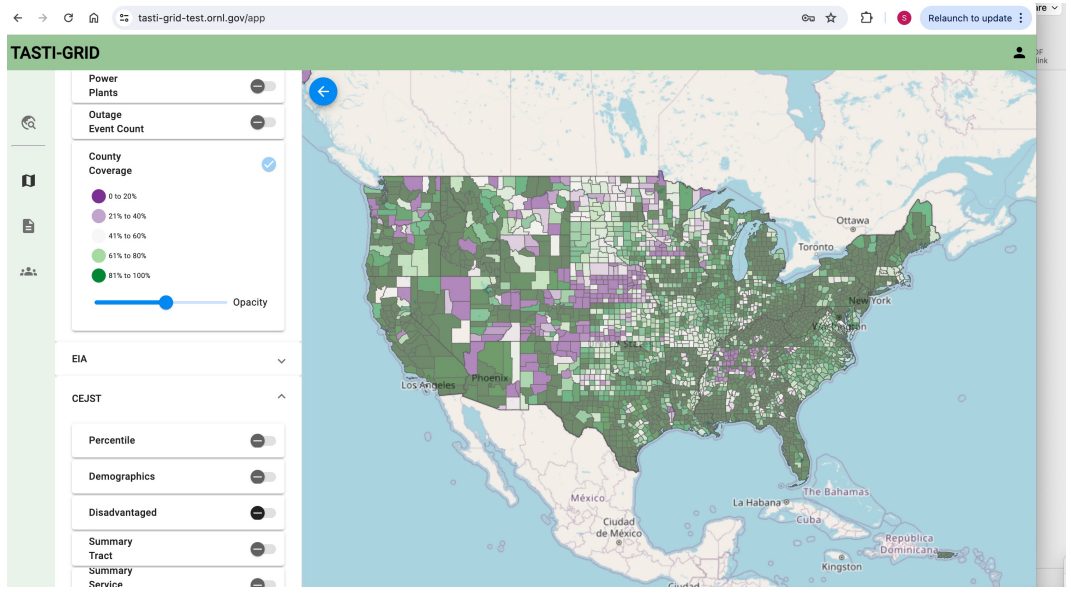
Dashboard | Layout

Data Source | Area Under the Curve Dashb... | Significant Weather Events C... | CountyCoverage_CEJST | **CountyCoverage Dashboard** | TableView | Map Simultaneous weather event | Weather Events ca

TASTI-GRID: EAGLE-I like Interface

Datasets

- J40 datasets indicating disadvantaged communities at the census tract level – OCED source
- Resilience Dashboard
- Power Outage Events/Restoration Dashboard
- Weather specific power outage event Dashboard
- Critical infrastructure data (e.g., hospitals,police stations, firestations, banks, credit from HIFLD)
  - Utility service territories
  - Relevant EIA-861 datasets
    - Reliability Indices
    - VVO optimization



Communities Feature

- Secure Data sharing with specific utilities/GDO/ORNL/States
- Role based access control

Questions to discuss with states

- Who can upload files?
- Will there be roles within the community?
- What happens when a file is uploaded?
- Can users request access to a community?
- Are some users auto added to a community?
  - if so, how do we determine that?

Source: From EAGLE-I™

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URBAN-NET Demo

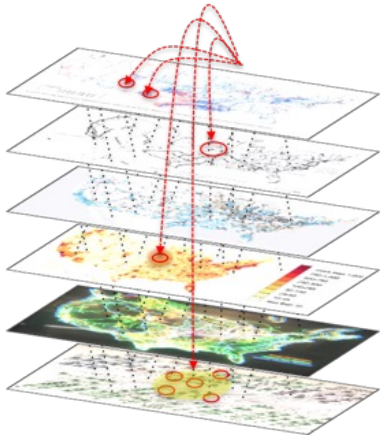
- Sangkuen Matt Lee

URBAN-NET: Project Overview

Project Overview

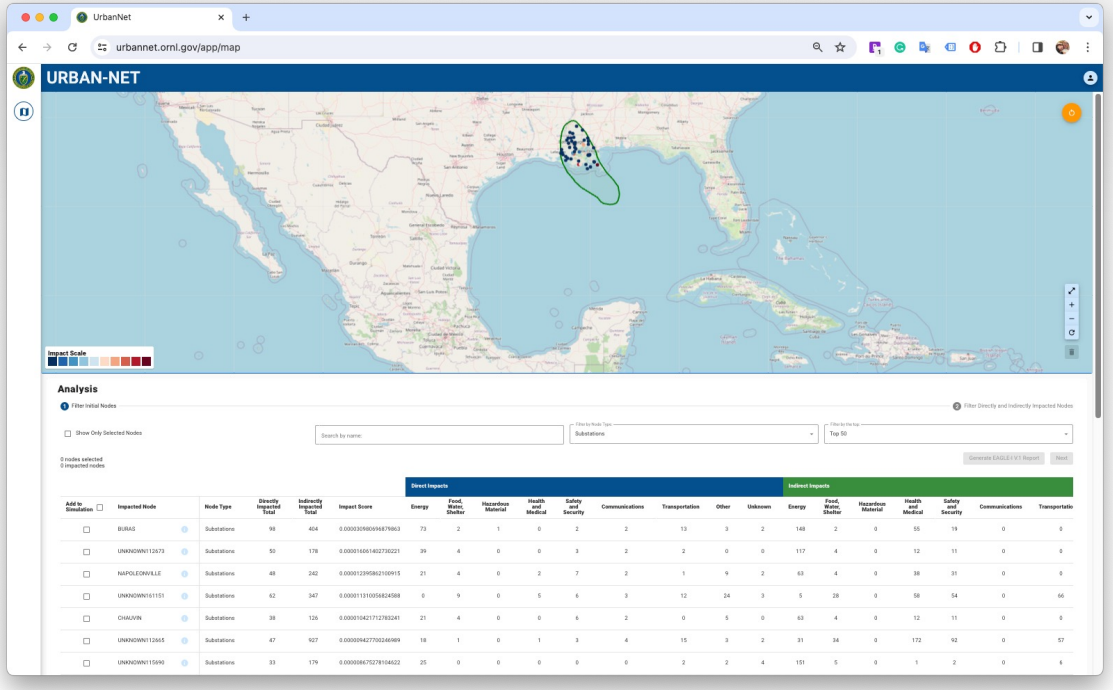
- The URBAN-NET system **evaluates the significance of components within critical infrastructure networks** by analyzing the cascading effects of their interactions.
- URBAN-NET **offers a web-based interface for users to simulate "what-if" scenarios**, enabling strategic planning and response.
- In the event of a disaster, URBAN-NET reports provide invaluable insights for assessing impacts and guiding the prioritization of mitigation efforts.
- URBAN-NET has been successfully integrated with the EAGLE-I framework to enhance situational awareness and decision-making capabilities.

Total of 31 HIFLD layers have been used to construct the URBAN-NET large-scale critical infrastructure networks using the URBAN-NET graph builder



Project Technology

- Construction of large-scale integrated CIS network from HIFLD* Open Data layers
- Quantification of criticality of CIS components
- EAGLE-I integration via API

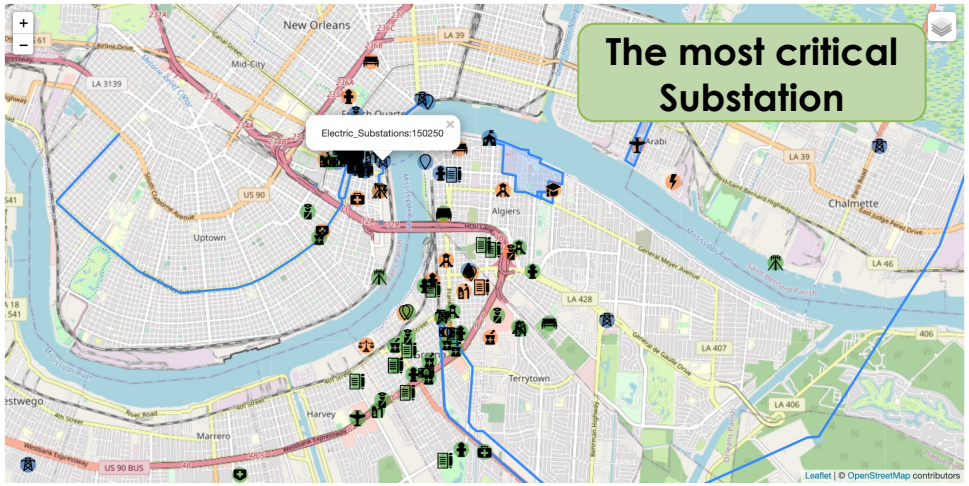


URBAN-NET.ORNL.GOV

Interdependency Analysis with URBAN-NET

- **Identifying critical infrastructure components** (e.g., electrical substations, power generation plants, transmission lines etc.) that potentially have high downstream impact
- **Identifying downstream impacted CIS components based on a what-if scenario** (e.g., *hurricane landfall with high wind speed*)

Identification of Critical Infrastructure Components



Cascade impact estimation – Hurricane Ida (approx. 84 hours before the landfall)

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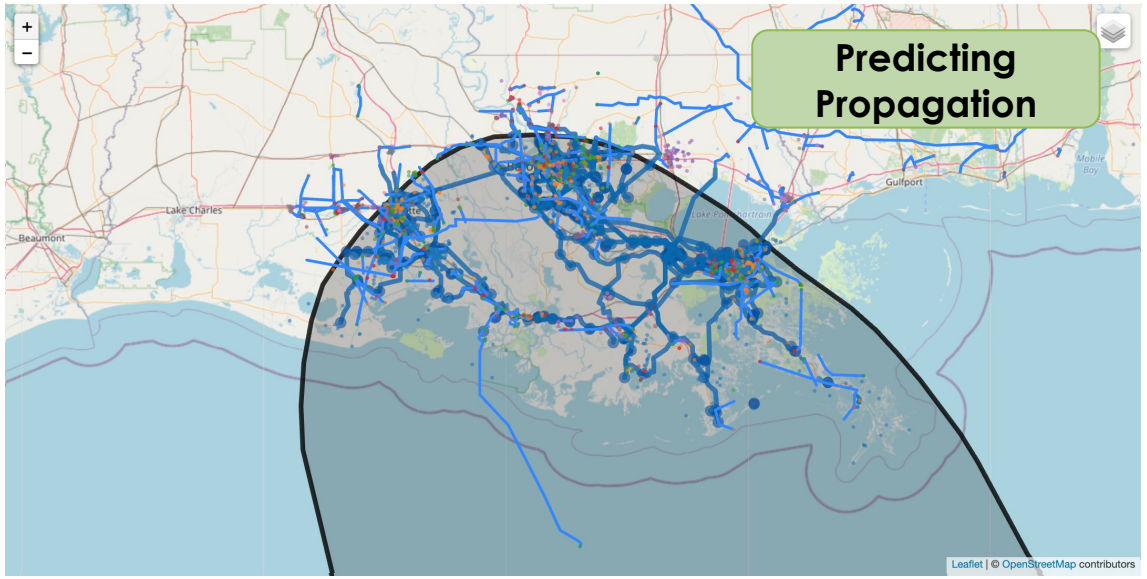

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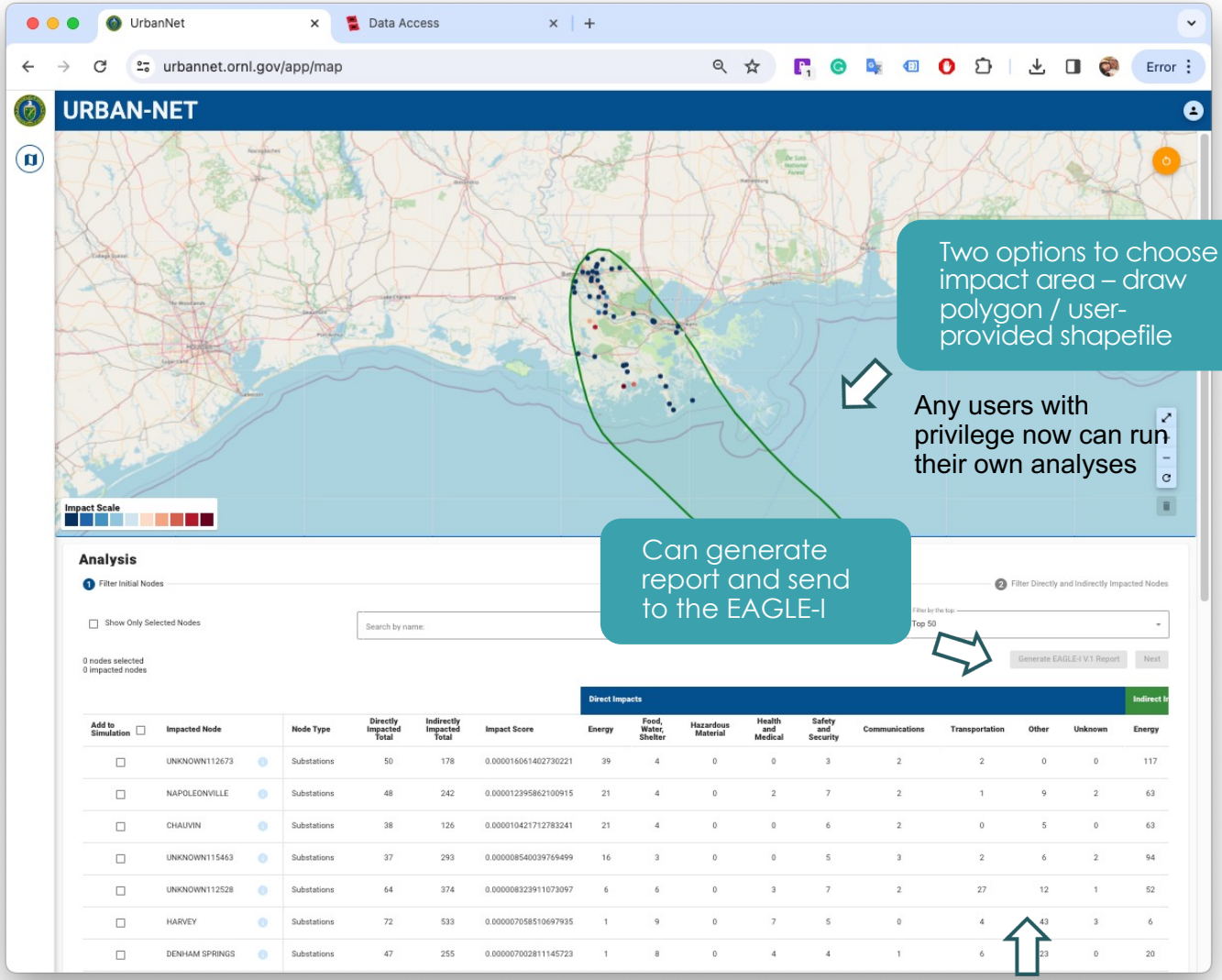
URBAN-NET Analysis Example



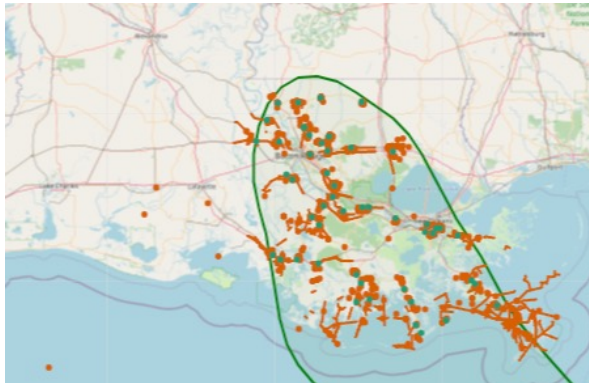
Two options to choose impact area – draw polygon / user-provided shapefile

Any users with privilege now can run their own analyses

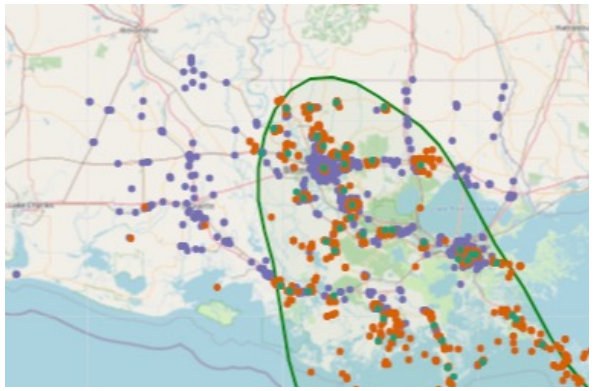
Can generate report and send to the EAGLE-I

Search, filtering and ranking of critical infrastructure via various criteria

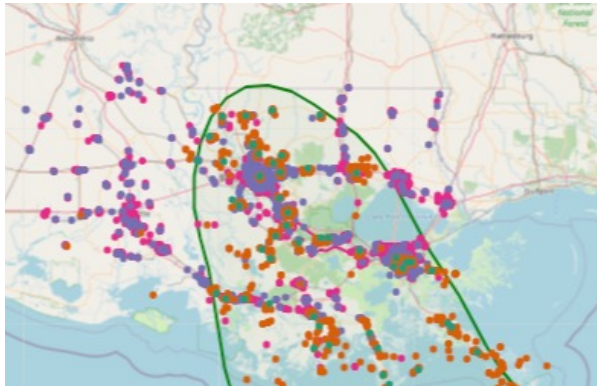
Show me the ranking of ”Substations” by the number of potential downstream impact in terms of “Medical”



1 hop propagation from the initial disruption



2 hop



3 hop

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Questions?