Using Battery Energy Storage Systems with Renewable Energy to Strengthen the Texas Power Grid

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Introduction and Objective

February 13-17 2021: the North American winter storm, also known as Winter Storm Uri, affected millions of Texans and more across the country.

2021 Winter Storm Uri: Severity and Damage

- 246 deaths were reported as direct and indirect results of the freeze.
- Water service was disrupted for over 12 million people, leaving 200,000 in completely unoperational areas.
- The outages in the Texas Interconnection power grid averaged about half of their 2021 all-time winter peak load (34,000 of 69,871 MW).

Causes of Power Outages During the 2021 Winter Storm

- 75% of generation unit outages, derates, and failures to start were caused by freezing issues (44%) and fuel issues (31%).
- 14% were caused by wind turbine issues (ice on blades).

Objective: to use GIS mapping to identify vulnerabilities in the Texas power grid and suggest ways to strengthen it using curtailed renewable energy and Battery Energy Storage Systems.

- Terminology
- **Battery Energy Storage System (BESS)**- a type of energy storage that uses a group of batteries connected to the grid.
- **Electric Reliability Council of Texas (ERCOT)**- organization that operates the Texas Interconnection electrical grid, which covers 90% of the state

Energy in Texas

Texas leads the nation in wind-generated electricity and is one of the top solar energy producers in the country. Because ERCOT oversees an independent power grid, the state is vulnerable if Texan power plants are affected by weather or other extreme events.

In 2022, ERCOT curtailed 5% of total available wind generation and 9% of total available solar generation, which is about 7.28 gigawatts (7.28 million kilowatts). By generating this electricity and storing it in BESSs in vulnerable counties, the storage systems can provide electricity when other modes of generation fail.

Energy Nationally and Globally

This research can be applied to other parts of the country and world that may experience extreme weather events or are prone to power outages

Methodology

1. Background research on 2021 Winter Storm Uri

Outage time in Texas	Outage distribution	Causes of outages	Severity and damage

North American Energy Reliability Corporation: comprehensive data about power failures during the 2021 Winter Storm in Texas.

2. Energy distribution and production in ERCOT

Wind and solar locations	BESS locations	Transmission lines	Renewable E production and curtailment

U.S. Energy Information Administration: shows the current state of Texas energy sources. It highlights the major sources of energy and how it compares with the rest of the nation.

USGS Wind Turbine Database and USGS Solar Database: provides the locations of word turbine and solar farms across the United States.

3. Assess risks to Texas energy

Social vulnerability	Areas that lack BESSs	Climate vulnerability	Past storm damage (2021)

FEMA National Risk Index: shows the risks across the United States for different natural disasters and social vulnerability.

CDC Social Vulnerability Index: a database of demographic and socioeconomic factors that adversely affect communities.

4. Locating the best uses of BESSs

Best locations for BESSs	How much E to store	Other recommendations

5. Improving this analysis and applications elsewhere

More small-scale case studies on specific counties and their experiences	Other parts of the country and world vulnerable to extreme events and outages

Results

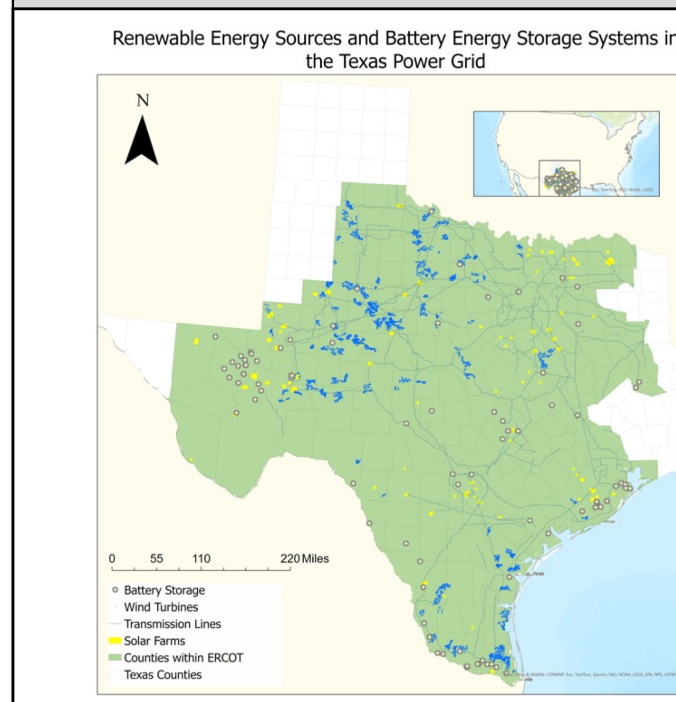

Figure 1. Map of renewable energy sources and batter energy storage systems in the Texas power grid.

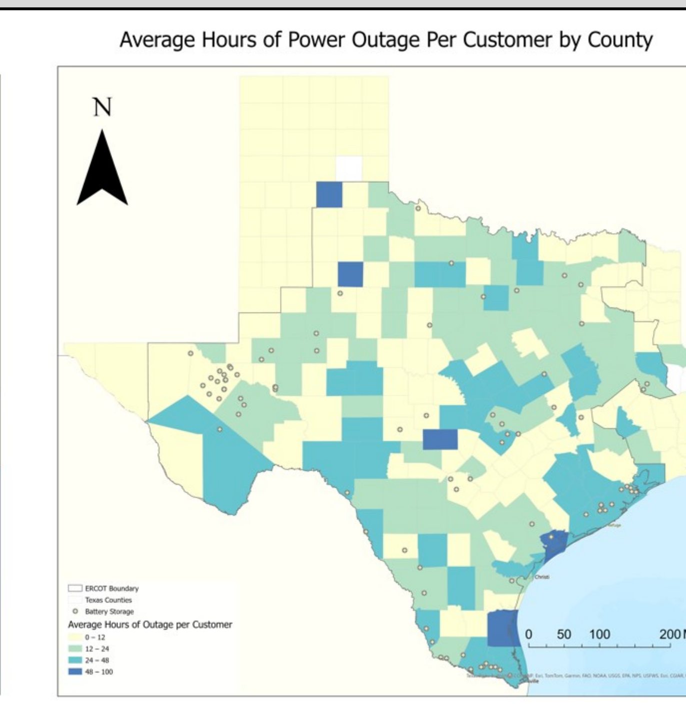

Figure 2. Map of the average hours of power outage/customer/county during Winter Storm Uri.

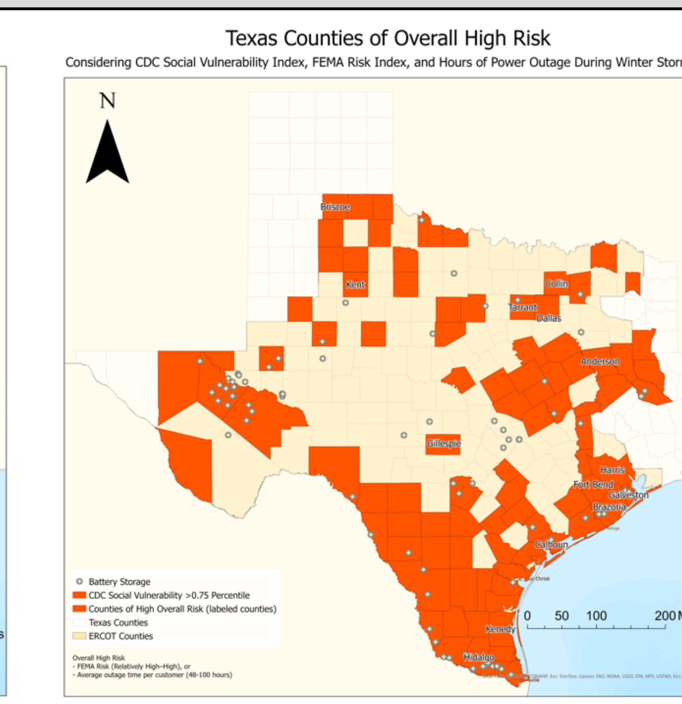

Figure 3. Map of Texas counties of high risk, considering CDC Social Vulnerability, the FEMA Risk Index, and power outages during Uri.

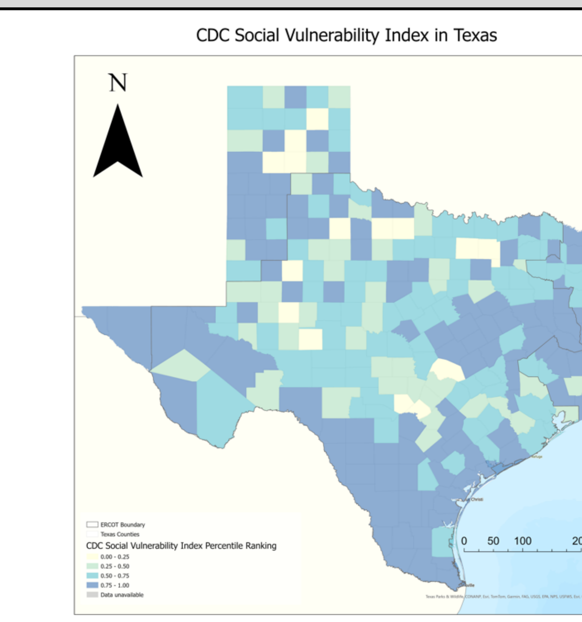

Figure 4. Map of the CDC Social Vulnerability Index in Texas

Maps such as figure 3 help assess the areas that would most benefit from BESSs, as well as areas most feasible for BESSs based on proximity to solar and wind farms. These systems would supplement ERCOT's regular energy production and distribution, especially during extreme weather events.

Figures 2-5 show areas of high risk based on 2021 Winter Storm outages, social and climate vulnerability, and combinations of these factors. The identified counties may need extra support before, during, and after disasters to combat loss.

An example is Duval County, which is ranked high on the social vulnerability index. With 4,432 housing units using about 30 kWh/day, a three-day outage would need 398.9 MWh to power all households. A BESS in San Diego, Texas, would reduce stress on the grid. This can apply to other counties across the state.

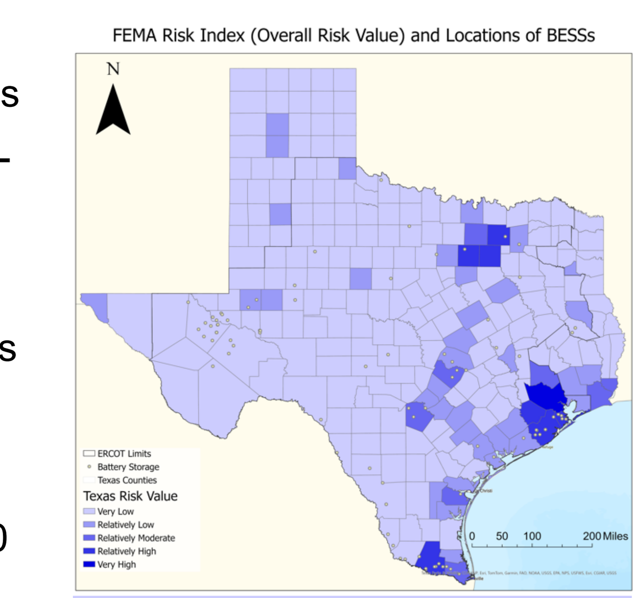

Figure 5. Map of the FEMA Risk Index overall risk value and locations of BESSs.

Discussion and Conclusion

The average household consumes ~40 kilowatt hours (kWh)/day in electricity. Providing communities with a battery storage capacity of 140 MWh and an output of 6 MW, BESSs will provide enough electricity to be independent from ERCOT during outages.

- One full day of energy to a community = # households X 40 kWh/day X # outage days
- A three-day outage in a town of 4,000 houses = 4,000 households X 40 kWh X 3 days = 480,000 kWh (480 MWh ~6.67 MW)

These calculations help inform the amount of battery storage needed to generate for communities whether that be 500 or 20,000 people.

BESSs connect to transmission lines from ERCOT to the consumer. They can attain cheaper electricity when solar and wind output is high or during low-demand/low-price periods. During weather events that cause mass power outages through communities within ERCOT, these BESSs can provide constant electricity when connected to solar or wind plants.

Battery storage facilities in rural communities paired with solar energy can be cheaper than building new transmission lines to reach them This can mediate and reduce social vulnerability within these rural communities.

This research can be built upon by considering the power usage, vulnerabilities, and infrastructure in each county across Texas. Knowledge of individual needs and capabilities would determine feasibility on a case-by-case basis. In addition, analysis in other states and countries could improve energy reliability in areas that are vulnerable to extreme weather or are prone to power outages.