Master of Science in
Computational Analysis and Public Policy
AT THE UNIVERSITY OF CHICAGO

GridX
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Project Summary

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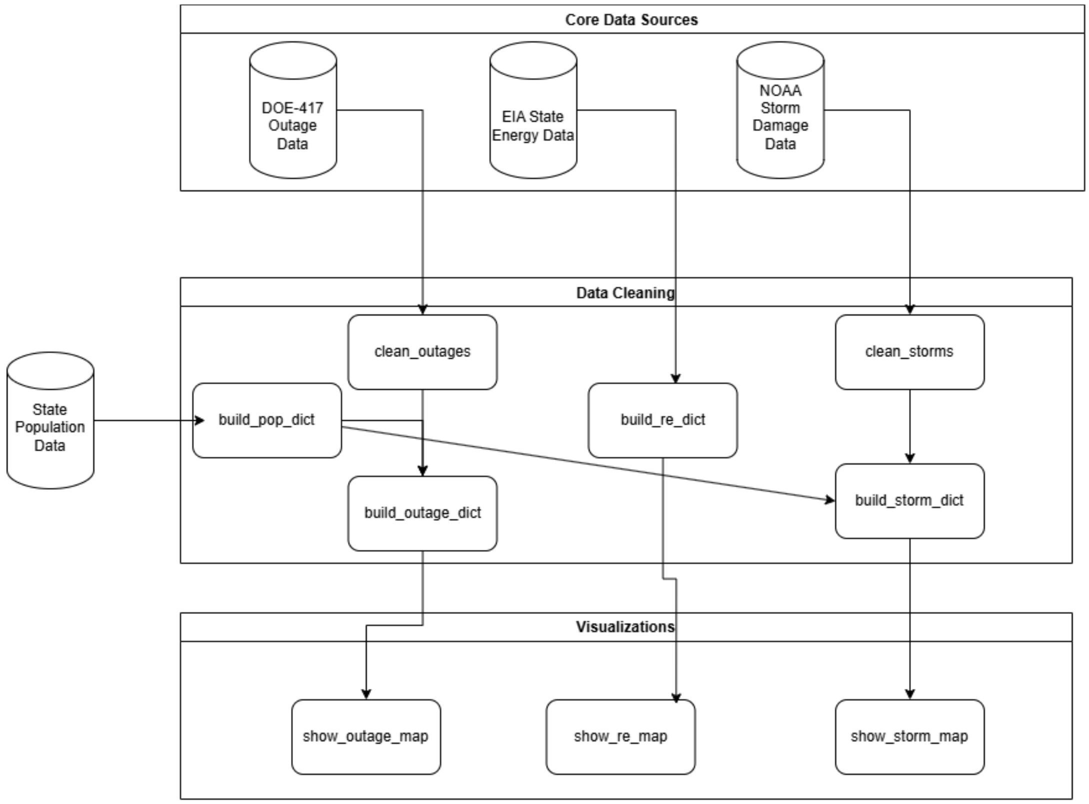
Project Abstract

Our project examines the relationship between renewable energy adoption and power outage severity in the U.S. using data from three primary sources. The Department of Energy's DOE-417 reports provide outage data by region, the National Oceanic and Atmospheric Administration tracks storm-related property and crop damage, and the Energy Information Administration's State Energy Data System offers state-level renewable energy production percentages. We linked these datasets by U.S. state region. Our scope was limited by the availability of public data, particularly archival outage data predating 2016.

We developed three visualizations to illustrate trends in renewable energy production, storm damage, and power outages from 2016 to 2022. While renewable energy adoption showed a general upward trend, storm damage and outages varied by state. By analyzing these patterns, our model highlights anomalies in state energy grids and serves as a foundation for further research and case studies.

Project Structure

- **data/** – Contains project datasets, including outage Excel data, renewable energy Excel data, population CSV data, state shapefiles, and abbreviated storm damage CSV's.
- **exploration/** – Archive of old code, including API pulls, geospatial functions, and data cleaning for NERC and power plant files.
- **gridx/** – Core project functions
    - **__main__.py** – Launches the browser with visualizations
    - **app.py** – Integrates visualizations into web browser
    - **clean.py** – Cleans and prepares large data files as needed
    - **recon.py** – Generates standardized state-specific analysis for each data source
    - **utils.py** – Provides functionality for data reconciliation
    - **viz.py** – Creates dataframes and visualizations
- **milestones/** – Contains written project updates
- **tests/** – Python files for testing data handling and cleaning functions



Code Contributions

Ethan Evans
- Came up with project topic and designed project structure
- Wrote recursive spatial join*, built pipeline for outage and storm data
- Assigned tasks, edited code/documentation as needed, and managed GitHub repo

Ganon Evans
- Wrote cleaning functions for power plant* and renewable energy data
- Built pytests for all data handling and cleaning functions
- Wrote initial drafts of project documentation

Euijin Kim
- Wrote functions to spatially join NERC regions with generation plants*
- Built functions to visualize the data as interactive maps using plotly and dash

Callie Leone
- Wrote original API call for OE-417 data*
- Wrote function to load in relevant Census data, __main__.py
- Facilitated notes, scheduling, and other administrative responsibilities

*Some code was necessary to the project but did not end up in the final build, so we put it in an "exploration" folder.

Analysis

Between 2016 and 2022, some states increased their renewable energy output more than others. Within the scope of our project, it appeared that these states with a higher renewables profile had energy grids that were more outage-resistant. Further, some states with a lower renewables profile appeared to be less outage-resistant. These trends appeared across states with similar extreme weather severity. Deeper statistical analysis is needed in order to make causal claims.

Project Evolution

Initially, we aimed to use EIA-860M reports to map every U.S. power plant by energy type and NERC region, but decided that NERC regions were too large (and would change from year to year), and chose to use U.S. states instead.

For weather damage, we considered FEMA's National Risk Index but ultimately used raw storm data from NOAA. Additionally, while we first attempted to retrieve OE-417 outage data via API, the bulk data alternative proved more complete. Notably, our renewables dataset dates back to 1960, allowing for potential long-term analyses of renewable adoption and grid resilience trends.

Reflections

A key motivation for this project was understanding whether states most vulnerable to extreme weather were proactively adopting renewables in response to climate change. We also explored whether states with high renewable adoption and frequent storm damage were effectively "footing the bill" for others failing to transition their energy systems.

Interpreting our data requires considering external factors like climate, weather patterns, and geography. The Midwest frequently faces billion-dollar losses from derechos and tornadoes, while hurricanes have battered the Gulf Coast for centuries. These regions will always be high-risk zones. Storm damage extends beyond the electrical grid, making a more refined analysis—such as a regression on renewables over time—valuable for future research.

On a practical level, our tool can inform infrastructure policy. In extreme weather events, renewable sources like solar and wind can function on microgrids and battery storage, maintaining power during blackouts. Even non-storm events, such as droughts or heat waves, can shut down natural gas plants, highlighting the importance of energy diversification.

Climate change is a global issue, making it impossible to perfectly isolate the factors that exacerbate disaster risk and damage. However, our interactive model allows users to compare regions, assess weather-related risks, and evaluate state-level renewable energy efforts in the broader push for energy sustainability.