Utility Disconnection
Project Report Fall 2024

1. OVERVIEW

The Utility Disconnection Dashboard project was undertaken in collaboration with our sponsor, Jason Gumaer and the Energy Justice Lab, to explore trends and patterns in utility disconnections. Our primary goal was to perform exploratory data analysis (EDA) on datasets provided by the sponsor to uncover meaningful insights. Unlike traditional dashboard-building projects, this effort focused on analyzing existing data to better understand the dynamics of utility disconnections, particularly during the COVID-19 pandemic.

We started by examining various datasets to identify state-level trends, followed by conducting significance testing to evaluate changes in disconnection rates before and after COVID. The findings aim to support stakeholders in identifying inequities and designing policies that promote energy justice.

2. PURPOSE

The project addressed a significant issue in energy equity: understanding the factors contributing to utility disconnections, which disproportionately affect vulnerable populations. Disconnections can lead to severe consequences, such as health risks, housing instability, and financial hardship, making this a critical area for analysis. By uncovering trends and identifying disparities, this project helps shine a light on systemic challenges and provides data-driven insights for change.

The work directly benefits stakeholders like the Energy Justice Lab, policymakers, utility providers, and advocacy groups working toward equitable energy access. The communities impacted by this work include low-income households and marginalized groups who face high risk of utility disconnections. This analysis is a step toward enabling these stakeholders to implement fairer policies and targeted interventions, promoting better outcomes for affected populations.

3. METHODOLOGY

To address the problem of understanding utility disconnection trends and their underlying causes, we adopted a structured approach divided into several phases. Below is an outline of our methodology, including data sources, technologies, and the analytical techniques employed to uncover meaningful insights.

3.1 DATA OVERVIEW

The datasets provided by our sponsor, Jason Gumaer, formed the foundation for our analysis. These datasets contained rich information on utility disconnections across states, utility provider types, and zip codes, along with details about protections and policies in place. Below is a brief summary of the key datasets we worked with:

- **Service Territory Data**
  This was our primary dataset, providing detailed information about disconnections and reconnections by state and utility providers. It included variables such as disconnection rates, total residential accounts, and utility types (e.g., municipal or investor-owned utilities). Spanning a timeline from 1996 to 2024, this dataset allowed us to analyze trends, seasonal variations, and provider-specific patterns.

- **Protections Data**
  This dataset highlighted state-level utility disconnection protections, including weather-based and temperature-

specific rules, legal frameworks, and targeted groups (e.g., low-income families or elderly populations). It provided crucial context for understanding how policies influence disconnection rates.

- **Zip Code Level Data**
  Data for specific zip codes across various states offered granular insights into disconnection patterns. It included information on disconnections by year, month, and customer category (e.g., residential or low-income). This dataset was useful for visualizing regional disparities and exploring trends across smaller geographic areas.

- **SP Territory Data**
  Extracted from the SP_Territory.dbf file, this dataset contained over 3,000 records with utility-specific details, such as average revenue per customer and total retail data.

While most of our analysis centered on the Service Territory Data, we utilized the other datasets to validate insights and further explore specific questions. For a comprehensive dataset overview, including feature descriptions and initial findings, please refer to the document hosted on Basecamp.

Additionally, the datasets can be accessed directly on Basecamp.

This layered approach to data ensured an overall understanding of utility disconnections while allowing us to explore various dimensions and contexts.

3.2 TECHNOLOGIES USED

We primarily used Excel and Python for data analysis, visualization, and statistical testing. Excel was utilized for quick data exploration and summary statistics, while Python allowed for more advanced analysis and the creation of visualizations to present our findings. Libraries like Pandas, Matplotlib, and SciPy were integral to our work.

3.3 ANALYTICAL METHODS

1. **State Wise Trend Analysis (Link)**

- **Method**: We analyzed state-level disconnection data using Excel and Python to identify year-over-year trends. We referred to the existing dashboard provided by the sponsor and complemented it with our own visualizations.
- **Why**: Understanding state-level trends is critical for identifying which regions experienced the most significant changes in utility disconnections, pinpointing areas for targeted policy intervention and understanding the underlying reasons.
- **Outcome**: The analysis revealed a few key disparities among states, highlighting specific areas that require attention.

2. **Nationwide Statistical Significance Testing (Link)**

- **Method**: Using Python, we performed ANOVA, Kruskal Wallis H test and Dunn's Test which is commonly used for post-hoc pairwise comparisons after Kruskal-Wallis, to determine whether the disconnection rates before, during and after COVID were statistically different.
- **Why**: This method allowed us to quantify the impact of COVID-19 on utility disconnections at a national level.
- **Outcome**: The results showed clear patterns of increased disconnections in certain periods. This comprehensive analysis suggests that national disconnection rates significantly decreased during the COVID period (possibly due

to moratoriums and financial aid) and increased again post-COVID, though not reaching Pre-COVID levels.

3. **State-Level Statistical Significance Testing (Link)**

- **Method**: State-specific disconnection data was analyzed using statistical tests, including T-test, ANOVA and the Kruskal-Wallis H-test, to compare disconnection rates across three periods: Pre-COVID, COVID, and Post-COVID. These tests identified significant differences in mean and median disconnection rates, with follow-up pairwise comparisons (Dunn's Test) pinpointing where differences occurred.
- **Why**: State-level analysis provided a localized perspective on disconnection trends, helping policymakers and stakeholders identify disparities and focus efforts effectively. Understanding these differences highlights the impact of state-specific policies and practices during crises like the COVID pandemic.
- **Outcome**: The analysis revealed significant state-level differences in disconnection rates across the three periods. States like California, New York, Michigan, and Maryland experienced substantial changes, particularly during the COVID period, while states such as Texas, Idaho, and Utah showed consistent rates across all periods. Dunn's Test highlighted notable pairwise differences, especially between the COVID and Pre-COVID periods in states like California and Michigan, reflecting the impact of pandemic-related disruptions and policies. The T-Test results between Pre-COVID and Post-COVID periods showed significant decreases in utility disconnection rates in states like California, Florida, Maryland, Michigan, and New Jersey, reflecting effective pandemic protections. However, increases were observed in North Dakota, Texas, and Utah, indicating weaker measures, while states like Hawaii and Idaho showed no significant changes. These findings underscore the need for state-specific interventions to promote equitable energy access, particularly during crises.

4. **State, Period, Utility_Provider Specific Statistical Significance Testing (Link)**

- **Method**: The analysis involved filtering state-level utility disconnection data by period (Pre-COVID, COVID, and Post-COVID) and selecting only utility providers with consistent and complete disconnection rate data across these periods. The periods were defined differently for each state, based on the trends observed in the dashboard to align with state-specific disconnection rate patterns. Statistical tests, including ANOVA, Kruskal-Wallis H-test, and pairwise Dunn's Test, were conducted to identify significant differences in disconnection rates across periods for each utility provider. This state-specific tailoring ensured meaningful and contextually relevant comparisons, capturing unique impacts and policy responses at the state level.
- **Why:** This tailored, data-driven approach enabled a granular understanding of utility disconnection trends across distinct pandemic periods. By including only providers with complete data, the analysis ensured statistical robustness and relevance. The insights help policymakers, utility companies, and stakeholders evaluate the effectiveness of state-specific interventions during the pandemic, identify areas needing improvement, and craft strategies for equitable energy access in future crises.
- **Outcome**: Disconnection rates varied across states and providers. California showed reductions during COVID with partial rebounds, Utah experienced increases during COVID, and Missouri and North Carolina displayed mixed trends with some recovery post-COVID. These results emphasize the need for tailored, data-driven policies to enhance utility resilience during crises.

5. **Utility Type Statistical Significance Testing (Link)**

- **Method**: Disconnection data was segmented by utility type (e.g., Investor Owned, Municipal) to explore whether provider characteristics influenced disconnection rates. Statistical testing and comparative visualizations were employed.
- **Why**: Analyzing by provider type offered insights into systemic disparities and the role of different providers in

ensuring equitable energy access.

- **Outcome**: All utility types showed significant changes in disconnection rates over the three periods, with the COVID period experiencing higher rates compared to Pre-COVID and Post-COVID periods. Investor-Owned Utilities exhibited the largest statistical differences, potentially reflecting varying policies or practices regarding customer support during crises. Municipal utilities and cooperatives also showed significant, though smaller, disparities.

6. **Analysis on Raw Disconnection Numbers (Link)**

- **Method**: We conducted statistical analyses using Python to evaluate raw disconnection data across pre-COVID, COVID, and post-COVID periods, focusing on utility types. Statistical tests included T-tests for mean comparisons and Kruskal-Wallis tests for non-parametric data.
- **Why**: The objective was to assess the pandemic's impact on utility disconnections and understand how regulatory measures influenced these trends. This approach aimed to highlight how different utility types and regulatory environments influenced disconnection rates, providing a nuanced understanding that could inform future regulatory strategies.
- **Outcome**:Our findings indicated significant variations in disconnections by utility type and period. Disconnections decreased notably during COVID due to moratoriums but increased post-COVID, not returning to pre-pandemic levels. This suggests the need for continued regulatory scrutiny and potential policy adaptations to address ongoing economic challenges.

3.4 REFLECTION ON FAILURES AND REEVALUATION

Initially, our approach of analyzing datasets in isolation without consulting the dashboard and sponsor feedback proved inefficient. This lack of direction led to fragmented insights. Reevaluating our approach after discussing with the sponsor enabled us to focus on pre-COVID and post-COVID trends, significantly improving the relevance and depth of our analysis.

4. RESULTS

Below is the summary of results for the tasks we performed on the disconnection data.

1. State Wise Trend Analysis

In our analysis of utility disconnection trends across states, Florida Power & Light (FPL) and the City of Fort Collins stood out as important examples. They show different challenges and approaches to handling disconnections after the COVID-19 moratoriums ended. These examples provide useful lessons for creating better rules and strategies to manage utility disconnections in the future:

a. **Florida Power & Light (FPL):**

- **Impact of Large Customer Base:** FPL's significant spike in disconnections reflects the challenges faced by large utilities in managing economic recoveries. As noted by Jason, this scale effect underscores the need for tailored customer support programs that can address the widespread impact of financial hardships on a large customer base.

- **Strategic Recommendations:** Regulatory bodies might consider mandating more robust consumer protection measures for utilities like FPL, ensuring they provide adequate support such as extended payment relief or financial assistance programs during economic downturns.

b. **City of Fort Collins, Colorado:**

- **Backlog Challenges:** The sharp spikes in disconnections in Fort Collins likely resulted from a backlog of undocumented disconnections. This situation highlights the need for improved procedural policies to manage backlogs transparently, ensuring customers are adequately prepared for resumed enforcement.

- **Policy Adjustments Suggested by Jason:** Enhancing communication and documentation practices is essential for municipal utilities like Fort Collins, where policy adjustments could significantly ease customer burdens during post-crisis periods.

c. **Broader Implications and Policy Considerations:**

- **Diverse Management Practices**: FPL quickly resumed disconnections, while Fort Collins faced spikes due to a backlog. These differences show how utility policies and customer needs can lead to very different outcomes. Jason pointed out that understanding these contrasts is key to creating fair policies that balance the needs of both utility companies and customers.

- **Regulatory Enhancements**: Strengthening rules to include crisis management plans and better communication with customers can help utilities handle challenges after moratoriums end. Jason's suggestion of a balanced approach enforcing rules while offering support to customers could be a helpful guideline for utilities across the country.

2. Nationwide Statistical Significance Testing

Years Included in the 3 periods were:
Pre COVID - 2018 and 2019
COVID - 2020
Post COVID - 2021, 2022

Below are the results that we achieved

<u>Mean and Median Disconnection Rates by Period:</u>
Pre-COVID - Mean: 0.005912319891193181, Median: 0.002996159
COVID - Mean: 0.0025795621475121094, Median: 0.0
Post-COVID- Mean: 0.003663976373019466, Median: 0.00100901

<u>Statistical Test Results:</u>
F-statistic: 126.0037
P-value: 0.0000

<u>Kruskal-Wallis Test Results:</u>
H-statistic: 1264.8274
P-value: 0.0000

Data counts per period:
Pre-COVID: 3520
COVID: 2271
Post-COVID: 4418

Dunn's Post-hoc Test Results (p-values):

	COVID	Post-COVID	Pre-COVID
COVID	1.000000e+00	1.001653e-71	7.113813e-270
Post-COVID	1.001653e-71	1.000000e+00	2.560229e-100
Pre-COVID	7.113813e-270	2.560229e-100	1.000000e+00

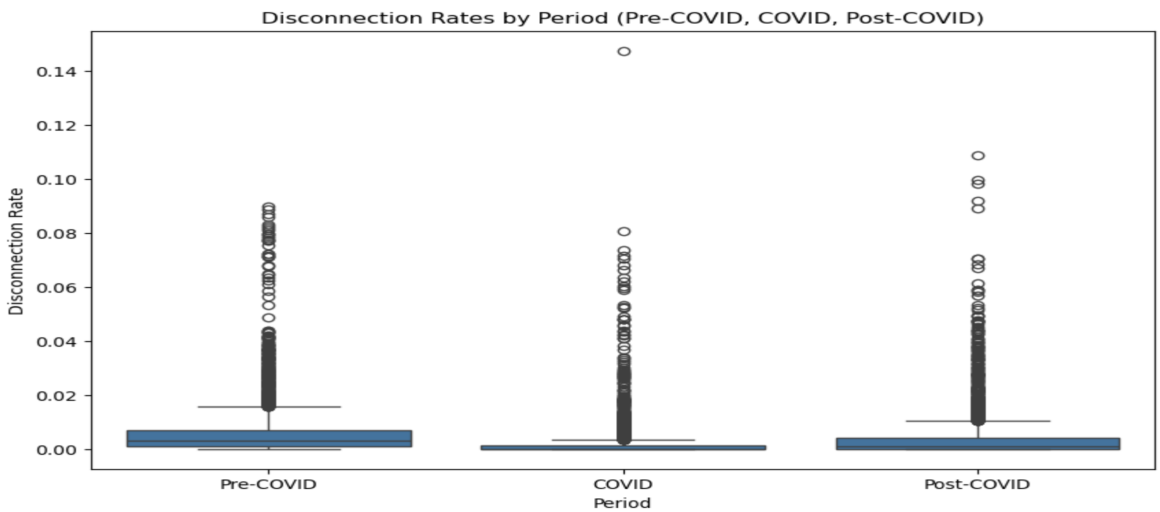

Figure 1- Nationwide disconnection rates by Period(Pre-COVID, COVID, Post-COVID)

The analysis of disconnection rates across pre-COVID (2018-2019), COVID (2020), and post-COVID (2021-2022) periods reveals several significant findings -

The extremely low p-values from both the ANOVA test and Kruskal-Wallis test demonstrate that there are statistically significant differences in disconnection rates between the three periods:

Pre-COVID Period

- Highest mean disconnection rate (0.0059)
- Shows more variability in rates
- Contains several high-value outliers reaching up to 0.09

COVID Period

- Lowest mean disconnection rate (0.0026)
- Most concentrated distribution
- Notable outlier at approximately 0.14

Post-COVID Period

- Intermediate mean rate (0.0037)
- Distribution pattern similar to pre-COVID
- Multiple outliers above 0.10

Dunn's post-hoc test results show extremely small p-values for comparisons between periods, confirming that the differences between all periods are statistically significant.

The data suggests that disconnection rates:
- Decreased substantially during COVID
- Partially rebounded in the post-COVID period but remained lower than pre-COVID levels
- Show consistent presence of outliers across all periods

This pattern might reflect policy changes and intervention measures implemented during the COVID period that may have affected disconnection practices, with some lasting effects visible in the post-COVID period.

3. State-Level Statistical Significance Testing

State	F-statistic	P-value	Significant Difference	Pre-COVID Mean Disconnection Rate	COVID Mean Disconnection Rate	Post-COVID Mean Disconnection Rate	Change COVID vs Pre-COVID	Change Post-COVID vs COVID	Change Post-COVID vs Pre-COVID
Alabama	20.8994	2.96E-07	Yes	7.50%	5.22%	5.26%	Decrease (2.2829%)	Increase (0.0433%)	Decrease (2.2396%)
California	21.562746	1.45E-09	Yes	0.64%	0.15%	0.00%	Decrease (0.4906%)	Decrease (0.1445%)	Decrease (0.6351%)
Colorado	19.99492	8.09E-09	Yes	0.51%	0.15%	0.22%	Decrease (0.3645%)	Increase (0.0793%)	Decrease (0.2852%)
Connecticut	20.035947	1.35E-08	Yes	0.98%	0.20%	0.34%	Decrease (0.7801%)	Increase (0.1413%)	Decrease (0.6388%)
Florida	41.526804	3.87E-17	Yes	2.29%	0.79%	1.37%	Decrease (1.4935%)	Increase (0.5814%)	Decrease (0.9121%)
Idaho	2.0235921	0.14403	No	1.91%	0.87%	1.40%	Decrease (1.0407%)	Increase (0.5278%)	Decrease (0.5129%)
Illinois	18.550385	1.93E-08	Yes	0.21%	0.11%	0.34%	Decrease (0.1022%)	Increase (0.2324%)	Increase (0.1302%)
Indiana	11.949935	9.91E-06	Yes	0.69%	0.38%	0.52%	Decrease (0.3132%)	Increase (0.1429%)	Decrease (0.1703%)
Iowa	7.976987	0.00041	Yes	0.39%	0.10%	0.29%	Decrease (0.2855%)	Increase (0.1863%)	Decrease (0.0992%)
Maine	27.286522	3.31E-12	Yes	0.18%	0.00%	0.17%	Decrease (0.1807%)	Increase (0.1676%)	Decrease (0.0132%)
Maryland	45.59224	5.03E-19	Yes	0.39%	0.05%	0.17%	Decrease (0.3431%)	Increase (0.1221%)	Decrease (0.2210%)
Michigan	53.146239	3.49E-21	Yes	1.04%	0.19%	0.41%	Decrease (0.8493%)	Increase (0.2195%)	Decrease (0.6297%)
Minnesota	39.728433	9.86E-17	Yes	0.46%	0.05%	0.25%	Decrease (0.4151%)	Increase (0.2051%)	Decrease (0.2100%)
Missouri	3.0720038	0.04776	Yes	1.37%	0.72%	1.11%	Decrease (0.6439%)	Increase (0.3842%)	Decrease (0.2597%)
New Hampshire	13.82055	2.28E-06	Yes	0.23%	0.01%	0.23%	Decrease (0.2167%)	Increase (0.2155%)	Decrease (0.0012%)
New Jersey	35.716942	5.55E-09	Yes	2.23%	1.74%	0.09%	Decrease (0.4837%)	Decrease (1.6531%)	Decrease (2.1368%)
New York	93.314321	9.61E-36	Yes	0.20%	0.02%	0.05%	Decrease (0.1812%)	Increase (0.0256%)	Decrease (0.1556%)
North Carolina	2.0539814	0.12935	No	0.44%	0.43%	0.57%	Decrease (0.0121%)	Increase (0.1423%)	Increase (0.1302%)
North Dakota	40.685537	2.27E-15	Yes	0.02%	0.04%	0.21%	Increase (0.0188%)	Increase (0.1662%)	Increase (0.1850%)
Ohio	41.50322	3.34E-18	Yes	0.46%	0.19%	0.29%	Decrease (0.2700%)	Increase (0.0980%)	Decrease (0.1720%)
Oklahoma	1.2394342	0.29865	No	0.79%	0.53%	1.58%	Decrease (0.2638%)	Increase (1.0487%)	Increase (0.7849%)
Oregon	57.098758	9.05E-22	Yes	0.26%	0.06%	0.10%	Decrease (0.1971%)	Increase (0.0445%)	Decrease (0.1527%)
South Carolina	13.305877	2.94E-06	Yes	0.85%	0.47%	0.68%	Decrease (0.3836%)	Increase (0.2121%)	Decrease (0.1714%)
Texas	0.7595993	0.47023	No	1.84%	1.62%	1.96%	Decrease (0.2244%)	Increase (0.3369%)	Increase (0.1124%)
Utah	8.8269562	0.00034	Yes	0.02%	0.32%	0.19%	Increase (0.3008%)	Decrease (0.1331%)	Increase (0.1678%)
Vermont	5.0393504	0.00678	Yes	0.33%	0.17%	0.13%	Decrease (0.1633%)	Decrease (0.0365%)	Decrease (0.1998%)
Virginia	37.122077	1.13E-15	Yes	0.65%	0.10%	0.37%	Decrease (0.5560%)	Increase (0.2714%)	Decrease (0.2845%)
Washington	30.924749	6.31E-13	Yes	0.47%	0.09%	0.07%	Decrease (0.3784%)	Decrease (0.0238%)	Decrease (0.4021%)
Washington, D.C.	15.994342	7.23E-07	Yes	0.25%	0.05%	0.08%	Decrease (0.1993%)	Increase (0.0328%)	Decrease (0.1665%)
Wisconsin	4.3600136	0.01859	Yes	0.18%	0.00%	0.19%	Decrease (0.1772%)	Increase (0.1905%)	Increase (0.0133%)

Figure 2 - State-level ANOVA test result

State	H-statistic	P-value	Significant Difference	Pre-COVID Median Disconnection Rate	COVID Median Disconnection Rate	Post-COVID Median Disconnection Rate	Change COVID vs Pre-COVID	Change Post-COVID vs COVID	Change Post-COVID vs Pre-COVID
Alabama	31.85	1.21E-07	Yes	7.63%	5.99%	4.94%	Decrease (1.6430%)	Decrease (1.0457%)	Decrease (2.6887%)
California	236.95	3.52E-52	Yes	0.28%	0.00%	0.00%	Decrease (0.2840%)	Decrease (0.0000%)	Decrease (0.2840%)
Colorado	90.991	1.74E-20	Yes	0.37%	0.00%	0.06%	Decrease (0.3701%)	Increase (0.0570%)	Decrease (0.3131%)
Connecticut	39.2252	3.04E-09	Yes	1.09%	0.00%	0.13%	Decrease (1.0934%)	Increase (0.1347%)	Decrease (0.9587%)
Florida	96.2108	1.28E-21	Yes	2.30%	0.11%	1.05%	Decrease (2.1824%)	Increase (0.9316%)	Decrease (1.2508%)
Idaho	3.7482	0.1534928	No	1.70%	0.16%	1.77%	Decrease (1.5410%)	Increase (1.6042%)	Increase (0.0632%)
Illinois	50.5151	1.07E-11	Yes	0.14%	0.00%	0.21%	Decrease (0.1401%)	Increase (0.2084%)	Increase (0.0683%)
Indiana	29.2818	4.38E-07	Yes	0.63%	0.27%	0.30%	Decrease (0.3588%)	Increase (0.0286%)	Decrease (0.3301%)
Iowa	47.2825	5.40E-11	Yes	0.20%	0.01%	0.13%	Decrease (0.1809%)	Increase (0.1137%)	Decrease (0.0672%)
Maine	104.443	2.09E-23	Yes	0.02%	0.00%	0.00%	Decrease (0.0190%)	Decrease (0.0000%)	Decrease (0.0190%)
Maryland	146.703	1.39E-32	Yes	0.32%	0.00%	0.02%	Decrease (0.3212%)	Increase (0.0226%)	Decrease (0.2986%)
Michigan	74.7779	5.78E-17	Yes	1.13%	0.01%	0.27%	Decrease (1.1265%)	Increase (0.2691%)	Decrease (0.8574%)
Minnesota	136.538	2.24E-30	Yes	0.35%	0.00%	0.10%	Decrease (0.3547%)	Increase (0.0990%)	Decrease (0.2557%)
Missouri	23.2002	9.17E-06	Yes	1.08%	0.21%	0.50%	Decrease (0.8683%)	Increase (0.2823%)	Decrease (0.5859%)
New Hampshire	68.8218	1.14E-15	Yes	0.16%	0.00%	0.15%	Decrease (0.1559%)	Increase (0.1487%)	Decrease (0.0071%)
New Jersey	20.2832	3.94E-05	Yes	2.38%	1.51%	0.06%	Decrease (0.8682%)	Decrease (1.4598%)	Decrease (2.3280%)
New York	288.439	2.32E-63	Yes	0.17%	0.00%	0.00%	Decrease (0.1665%)	Decrease (0.0000%)	Decrease (0.1665%)
North Carolina	30.1956	2.77E-07	Yes	0.39%	0.00%	0.25%	Decrease (0.3907%)	Increase (0.2542%)	Decrease (0.1364%)
North Dakota	63.7532	1.43E-14	Yes	0.02%	0.00%	0.17%	Decrease (0.0166%)	Increase (0.1620%)	Increase (0.1454%)
Ohio	114.262	1.54E-25	Yes	0.32%	0.01%	0.16%	Decrease (0.3031%)	Increase (0.1496%)	Decrease (0.1535%)
Oklahoma	6.38796	0.0410084	Yes	0.81%	0.66%	0.03%	Decrease (0.1569%)	Decrease (0.6322%)	Decrease (0.7891%)
Oregon	92.2395	9.34E-21	Yes	0.24%	0.00%	0.09%	Decrease (0.2433%)	Increase (0.0854%)	Decrease (0.1579%)
South Carolina	28.8766	5.36E-07	Yes	0.84%	0.17%	0.70%	Decrease (0.6646%)	Increase (0.5307%)	Decrease (0.1339%)
Texas	1.10995	0.5740857	No	1.73%	1.73%	2.18%	Increase (0.0040%)	Increase (0.4466%)	Increase (0.4506%)
Utah	4.22813	0.1207463	No	0.02%	0.03%	0.03%	Increase (0.0037%)	Increase (0.0017%)	Increase (0.0055%)
Vermont	137.514	1.38E-30	Yes	0.22%	0.00%	0.00%	Decrease (0.2225%)	Decrease (0.0000%)	Decrease (0.2225%)
Virginia	127.149	2.45E-28	Yes	0.47%	0.00%	0.02%	Decrease (0.4707%)	Increase (0.0221%)	Decrease (0.4486%)
Washington	77.1331	1.78E-17	Yes	0.31%	0.00%	0.00%	Decrease (0.3058%)	Decrease (0.0000%)	Decrease (0.3058%)
Washington, D.C.	39.7643	2.32E-09	Yes	0.20%	0.00%	0.00%	Decrease (0.2015%)	Decrease (0.0000%)	Decrease (0.2015%)
Wisconsin	8.65095	0.0132272	Yes	0.13%	0.00%	0.08%	Decrease (0.1310%)	Increase (0.0777%)	Decrease (0.0532%)

Figure 3 - State-level Kruskal test result

State	T-statistic	P-value	Significant Difference	Pre-COVID Mean Disconnection Rate	Post-COVID Mean Disconnection Rate	Change Post-COVID vs Pre-COVID
Alabama	8.79431	2.74E-10	Yes	7.50%	5.26%	Decrease (2.2396%)
California	7.134	3.31E-11	Yes	0.64%	0.00%	Decrease (0.6351%)
Colorado	4.83161	2.71E-06	Yes	0.51%	0.22%	Decrease (0.2852%)
Connecticut	4.14809	0.000293	Yes	0.98%	0.34%	Decrease (0.6388%)
Florida	5.69721	3.26E-08	Yes	2.29%	1.37%	Decrease (0.9121%)
Hawaii	-1.24786	0.243104	No	0.11%	0.14%	Increase (0.0299%)
Idaho	1.1675	0.250688	No	1.91%	1.40%	Decrease (0.5129%)
Illinois	-4.26196	2.64E-05	Yes	0.21%	0.34%	Increase (0.1302%)
Indiana	2.89787	0.004132	Yes	0.69%	0.52%	Decrease (0.1703%)
Iowa	1.62754	0.104729	No	0.39%	0.29%	Decrease (0.0992%)
Maine	0.55974	0.575848	No	0.18%	0.17%	Decrease (0.0132%)
Maryland	6.37692	4.79E-10	Yes	0.39%	0.17%	Decrease (0.2210%)
Michigan	6.0202	1.37E-07	Yes	1.04%	0.41%	Decrease (0.6297%)
Minnesota	4.58385	1.10E-05	Yes	0.46%	0.25%	Decrease (0.2100%)
Missouri	0.94435	0.347196	No	1.37%	1.11%	Decrease (0.2597%)
New Hampshire	0.02432	0.98065	No	0.23%	0.23%	Decrease (0.0012%)
New Jersey	14.0042	2.78E-13	Yes	2.23%	0.09%	Decrease (2.1368%)
New York	10.5996	2.11E-23	Yes	0.20%	0.05%	Decrease (0.1556%)
North Carolina	-1.98898	0.047781	Yes	0.44%	0.57%	Increase (0.1302%)
North Dakota	-10.2538	4.20E-17	Yes	0.02%	0.21%	Increase (0.1850%)
Ohio	6.28161	5.22E-10	Yes	0.46%	0.29%	Decrease (0.1720%)
Oklahoma	-0.8863	0.390336	No	0.79%	1.58%	Increase (0.7849%)
Oregon	8.0805	1.65E-13	Yes	0.26%	0.10%	Decrease (0.1527%)
South Carolina	3.01069	0.002899	Yes	0.85%	0.68%	Decrease (0.1714%)
Texas	-0.52997	0.597699	No	1.84%	1.96%	Increase (0.1124%)
Utah	-4.12032	0.000211	Yes	0.02%	0.19%	Increase (0.1678%)
Vermont	6.52089	2.48E-10	Yes	0.33%	0.13%	Decrease (0.1998%)
Virginia	4.70831	3.55E-06	Yes	0.65%	0.37%	Decrease (0.2845%)
Washington	6.43489	1.92E-09	Yes	0.47%	0.07%	Decrease (0.4021%)
Washington, D.C.	4.50415	1.99E-05	Yes	0.25%	0.08%	Decrease (0.1665%)
Wisconsin	-0.1744	0.863211	No	0.18%	0.19%	Increase (0.0133%)

Figure 4 - State-level T-test result (Post Covid vs Pre Covid)

```
Dunn's Test Results for California:
                   COVID    Post-COVID     Pre-COVID
COVID       1.000000e+00  8.200807e-02  1.194004e-23
Post-COVID  8.200807e-02  1.000000e+00  2.001470e-47
Pre-COVID   1.194004e-23  2.001470e-47  1.000000e+00

Dunn's Test Results for Colorado:
                   COVID    Post-COVID     Pre-COVID
COVID       1.000000e+00  3.758817e-03  1.728064e-19
Post-COVID  3.758817e-03  1.000000e+00  2.489778e-11
Pre-COVID   1.728064e-19  2.489778e-11  1.000000e+00

Dunn's Test Results for Connecticut:
                   COVID  Post-COVID     Pre-COVID
COVID       1.000000e+00    0.003707  1.163413e-09
Post-COVID  3.707018e-03    1.000000  2.115444e-05
Pre-COVID   1.163413e-09    0.000021  1.000000e+00
```

Figure 5a

```
Dunn's Test Results for New York:
                  COVID    Post-COVID     Pre-COVID
COVID       1.000000e+00  9.741380e-01  8.842589e-41
Post-COVID  9.741380e-01  1.000000e+00  1.092734e-51
Pre-COVID   8.842589e-41  1.092734e-51  1.000000e+00

Dunn's Test Results for North Carolina:
                  COVID  Post-COVID     Pre-COVID
COVID       1.000000e+00    0.000102  1.598675e-07
Post-COVID  1.018318e-04    1.000000  3.440671e-01
Pre-COVID   1.598675e-07    0.344067  1.000000e+00

Dunn's Test Results for North Dakota:
                  COVID    Post-COVID     Pre-COVID
COVID       1.000000e+00  2.344490e-12  7.675873e-01
Post-COVID  2.344490e-12  1.000000e+00  4.701026e-08
Pre-COVID   7.675873e-01  4.701026e-08  1.000000e+00
```

Figure 5b

```
Dunn's Test Results for Texas:
               COVID  Post-COVID  Pre-COVID
COVID       1.000000    0.903296        1.0
Post-COVID  0.903296    1.000000        1.0
Pre-COVID   1.000000    1.000000        1.0

Dunn's Test Results for Utah:
               COVID  Post-COVID  Pre-COVID
COVID       1.000000    1.000000   0.177227
Post-COVID  1.000000    1.000000   0.260566
Pre-COVID   0.177227    0.260566   1.000000

Dunn's Test Results for Vermont:
                   COVID    Post-COVID     Pre-COVID
COVID       1.000000e+00  1.652973e-03  2.021457e-26
Post-COVID  1.652973e-03  1.000000e+00  5.657390e-19
Pre-COVID   2.021457e-26  5.657390e-19  1.000000e+00

Dunn's Test Results for Virginia:
                   COVID    Post-COVID     Pre-COVID
COVID       1.000000e+00  2.110038e-05  1.747584e-26
Post-COVID  2.110038e-05  1.000000e+00  2.704853e-13
Pre-COVID   1.747584e-26  2.704853e-13  1.000000e+00
```

Figure 5c

Figure 5a, 5b, 5c - State level Dunn's test result

The statistical significance testing, that includes ANOVA, Kruskal-Wallis, T-test, and Dunn's Test, revealed diverse patterns in disconnection rates across states during pre-COVID, COVID, and post-COVID periods.

Key insights:

- States like California, Michigan, Maryland, New York, and Florida exhibited significant differences across periods, indicating effective pandemic protections. Conversely, states such as Texas, Idaho, North Carolina, and Oklahoma showed no significant differences, suggesting consistent rates or weaker interventions.

- Significant decreases were observed during COVID in states like California and Michigan. Post-COVID rates in some states rebounded, such as Idaho, highlighting the rollback of protections.

- States like California, Michigan, Maryland, and New York saw significant decreases in Post-COVID disconnection rates compared to Pre-COVID, demonstrating lasting benefits of pandemic interventions. However, states like

North Dakota, Utah, and Texas experienced increases or insignificant changes, signaling the need for more robust recovery measures.

- Dunn's Test results emphasized stark contrasts between pre-COVID and COVID periods in states such as California and Michigan, reflecting pandemic-related policy impacts.
- Pairwise comparisons for states like Colorado, Florida, and Virginia demonstrated substantial increases in disconnection rates during the pandemic, suggesting the inadequacy of crisis response mechanisms in specific utility structures.
- The variability in results underlines the necessity for state-specific interventions and policies tailored to utility structures (e.g., investor-owned, municipal).
- States with consistent rates (e.g., Texas, Utah) may serve as benchmarks for sustainable disconnection practices, while states with sharp variations need to address systemic disparities.
- Most states experienced statistically significant differences in disconnection rates, supporting the hypothesis that pandemic interventions played a critical role in shaping utility practices.
- These findings suggest an ongoing need for equitable energy access strategies, particularly during crises, to mitigate disparities across different demographic and geographical segments.

4. State, Period, Utility_Provider Specific Statistical Significance Testing

```
Dunn's Test Results for Pacific Gas & Electric Co:
                   COVID  Post-COVID     Pre-COVID
COVID       1.000000e+00    0.000063  5.426162e-12
Post-COVID  6.343806e-05    1.000000  2.647923e-01
Pre-COVID   5.426162e-12    0.264792  1.000000e+00

Dunn's Test Results for San Diego Gas & Electric Co:
                   COVID  Post-COVID     Pre-COVID
COVID       1.000000e+00    0.730651  1.063025e-12
Post-COVID  7.306510e-01    1.000000  1.466914e-06
Pre-COVID   1.063025e-12    0.000001  1.000000e+00

Dunn's Test Results for Southern California Edison Co:
                   COVID  Post-COVID     Pre-COVID
COVID       1.000000e+00    0.037303  4.702233e-14
Post-COVID  3.730306e-02    1.000000  1.958745e-04
Pre-COVID   4.702233e-14    0.000196  1.000000e+00

Dunn's Test Results for Southern California Gas Company:
                   COVID  Post-COVID     Pre-COVID
COVID       1.000000e+00    0.464651  8.278111e-12
Post-COVID  4.646511e-01    1.000000  5.438418e-06
Pre-COVID   8.278111e-12    0.000005  1.000000e+00

Aggregated Dunn's Test Results for California (All Selected Providers):
                   COVID    Post-COVID     Pre-COVID
COVID       1.000000e+00  1.712718e-06  1.094655e-45
Post-COVID  1.712718e-06  1.000000e+00  1.465082e-12
Pre-COVID   1.094655e-45  1.465082e-12  1.000000e+00
```

Figure 6a

```
Dunn's Test Results for Rocky Mountain Power in Utah:
               COVID  Post-COVID  Pre-COVID
COVID       1.000000    0.039669   0.004019
Post-COVID  0.039669    1.000000   1.000000
Pre-COVID   0.004019    1.000000   1.000000
```

Figure 6b

```
Dunn's Test Results for Ameren Missouri:
               COVID  Post-COVID  Pre-COVID
COVID       1.000000    0.017178   0.028342
Post-COVID  0.017178    1.000000   1.000000
Pre-COVID   0.028342    1.000000   1.000000

Dunn's Test Results for City Utilities of Springfield:
               COVID  Post-COVID  Pre-COVID
COVID       1.000000    0.010808   0.088324
Post-COVID  0.010808    1.000000   1.000000
Pre-COVID   0.088324    1.000000   1.000000

Dunn's Test Results for Empire:
               COVID  Post-COVID  Pre-COVID
COVID       1.000000    0.009422   0.231647
Post-COVID  0.009422    1.000000   0.400791
Pre-COVID   0.231647    0.400791   1.000000

Dunn's Test Results for Evergy Metro:
               COVID  Post-COVID  Pre-COVID
COVID       1.000000    0.035218   0.128276
Post-COVID  0.035218    1.000000   1.000000
Pre-COVID   0.128276    1.000000   1.000000

Dunn's Test Results for Evergy West:
               COVID  Post-COVID  Pre-COVID
COVID       1.000000    0.040171   0.094029
Post-COVID  0.040171    1.000000   1.000000
Pre-COVID   0.094029    1.000000   1.000000

Dunn's Test Results for Liberty Utilities:
               COVID  Post-COVID  Pre-COVID
COVID       1.000000    0.010944   0.174956
Post-COVID  0.010944    1.000000   0.666276
Pre-COVID   0.174956    0.666276   1.000000

Dunn's Test Results for Spire:
               COVID  Post-COVID  Pre-COVID
COVID       1.000000    0.014882   0.040618
Post-COVID  0.014882    1.000000   1.000000
Pre-COVID   0.040618    1.000000   1.000000

Dunn's Test Results for Summit:
               COVID  Post-COVID  Pre-COVID
COVID       1.000000    0.022009   0.036594
Post-COVID  0.022009    1.000000   1.000000
Pre-COVID   0.036594    1.000000   1.000000

Aggregated Dunn's Test Results for Missouri (All Selected Providers):
                   COVID    Post-COVID     Pre-COVID
COVID       1.000000e+00  2.060442e-14  1.963893e-10
Post-COVID  2.060442e-14  1.000000e+00  1.000000e+00
Pre-COVID   1.963893e-10  1.000000e+00  1.000000e+00
```

Figure 6c

Dunn's Test Results for City of New Bern:

	COVID	Post-COVID	Pre-COVID
COVID	1.000000	1.000000	0.012607
Post-COVID	1.000000	1.000000	0.000048
Pre-COVID	0.012607	0.000048	1.000000

Dunn's Test Results for Dominion Energy North Carolina:

	COVID	Post-COVID	Pre-COVID
COVID	1.000000	0.039191	0.000417
Post-COVID	0.039191	1.000000	0.224078
Pre-COVID	0.000417	0.224078	1.000000

Dunn's Test Results for Duke Energy Carolinas:

	COVID	Post-COVID	Pre-COVID
COVID	1.000000e+00	0.262968	7.347616e-07
Post-COVID	2.629678e-01	1.000000	3.210913e-06
Pre-COVID	7.347616e-07	0.000003	1.000000e+00

Dunn's Test Results for Duke Energy Progress:

	COVID	Post-COVID	Pre-COVID
COVID	1.000000	0.020619	0.000033
Post-COVID	0.020619	1.000000	0.064282
Pre-COVID	0.000033	0.064282	1.000000

Dunn's Test Results for Frontier Natural Gas:

	COVID	Post-COVID	Pre-COVID
COVID	1.000000	0.118346	0.008069
Post-COVID	0.118346	1.000000	0.635031
Pre-COVID	0.008069	0.635031	1.000000

Dunn's Test Results for New River Light & Power:

	COVID	Post-COVID	Pre-COVID
COVID	1.000000	0.000264	0.004704
Post-COVID	0.000264	1.000000	0.568262
Pre-COVID	0.004704	0.568262	1.000000

Dunn's Test Results for Piedmont Natural Gas:

	COVID	Post-COVID	Pre-COVID
COVID	1.000000	0.035865	0.000011
Post-COVID	0.035865	1.000000	0.013798
Pre-COVID	0.000011	0.013798	1.000000

Dunn's Test Results for Toccoa Natural Gas:

	COVID	Post-COVID	Pre-COVID
COVID	1.000000	0.143448	0.454722
Post-COVID	0.143448	1.000000	1.000000
Pre-COVID	0.454722	1.000000	1.000000

Aggregated Dunn's Test Results for North Carolina (All Selected Providers):

	COVID	Post-COVID	Pre-COVID
COVID	1.000000e+00	2.527307e-07	2.264709e-14
Post-COVID	2.527307e-07	1.000000e+00	4.542054e-03
Pre-COVID	2.264709e-14	4.542054e-03	1.000000e+00

Figure 6d

Figure 6a, 6b, 6c,6d - State, Period, Utility_Provider Specific Dunn's test results

The analysis of utility disconnection rates revealed state-specific and provider-specific trends across Pre-COVID, COVID, and Post-COVID periods.

Key Insights:

- California's utility providers demonstrated significant reductions in disconnection rates during the pandemic, reflecting effective protective measures. Post-COVID, disconnection rates partially rebounded but remained significantly lower compared to pre-pandemic levels for most providers. However, stability in rates during and after the pandemic was observed for some providers, like Southern California Gas Company. These results highlight varying levels of pandemic intervention effectiveness and recovery trends across providers.

- Rocky Mountain Power in Utah exhibited significant changes in disconnection rates between the pandemic and other periods. While rates decreased significantly during COVID (compared to Pre-COVID), they increased post-pandemic, returning to pre-pandemic levels. This indicates temporary effectiveness of pandemic-related interventions, followed by a reversal post-COVID.

- In Missouri, only a few providers, such as Ameren Missouri and City Utilities of Springfield, exhibited significant changes in disconnection rates between pre-pandemic, pandemic, and post-pandemic periods. Rates for most providers remained consistent, particularly between pre- and post-pandemic, indicating limited policy impacts or changes in utility practices across these periods.
- In North Carolina, significant differences were observed between Pre-COVID and COVID periods for most providers, reflecting reductions in disconnection rates during the pandemic. Comparisons between Pre-COVID and Post-COVID showed that some providers, such as Duke Energy Carolinas and Piedmont Natural Gas, experienced sustained changes post-pandemic, while others normalized. COVID vs Post-COVID comparisons indicated that a few providers, such as Dominion Energy North Carolina, exhibited significant differences, highlighting adjustments post-pandemic. These results underscore the varied impacts of pandemic measures across utility providers.
- These findings highlight the need for targeted policies to address disparities and strengthen utility resilience during crises.

5. Utility Type Statistical Significance Testing

Years Included in the 3 periods were:
Pre COVID - 2018 and 2019
COVID - 2020
Post COVID - 2021 and 2022

<u>Analysis for Utility Type - **Investor Owned Utility**</u>

Data counts per period - Pre-COVID: 2292, COVID: 1621, Post-COVID: 3228
Mean and Median Disconnection Rates:
Pre-COVID - Mean: 0.0040, Median: 0.0026
COVID - Mean: 0.0016, Median: 0.0000
Post-COVID - Mean: 0.0028, Median: 0.0009

ANOVA Results - F-statistic: 80.48489188051792, P-value: 2.717414988890475e-35

Kruskal-Wallis Results - H-statistic: 959.0546077273299, P-value: 5.545465529434084e-209

Dunn's Post-hoc Test Results (p-values):

	COVID	Post-COVID	Pre-COVID
COVID	1.000000e+00	5.567142e-62	8.921777e-208
Post-COVID	5.567142e-62	1.000000e+00	5.784990e-72
Pre-COVID	8.921777e-208	5.784990e-72	1.000000e+00

<u>Analysis for Utility Type: **Municipal Utility**</u>

Data counts per period - Pre-COVID: 977, COVID: 524, Post-COVID: 920

Mean and Median Disconnection Rates:
Pre-COVID - Mean: 0.0112, Median: 0.0052
COVID - Mean: 0.0060, Median: 0.0000
Post-COVID - Mean: 0.0073, Median: 0.0023

ANOVA Results - F-statistic: 34.958132739356735, P-value: 1.0795166314969995e-15

Kruskal-Wallis Results - H-statistic: 202.9754197581504, P-value: 8.403256469446487e-45

Dunn's Post-hoc Test Results (p-values):

	COVID	Post-COVID	Pre-COVID
COVID	1.000000e+00	5.745947e-10	3.762214e-43
Post-COVID	5.745947e-10	1.000000e+00	7.045703e-18
Pre-COVID	3.762214e-43	7.045703e-18	1.000000e+00

Analysis for Utility Type: **Utility Cooperative**

Data counts per period - Pre-COVID: 251, COVID: 126, Post-COVID: 270

Mean and Median Disconnection Rates:
Pre-COVID - Mean: 0.0030, Median: 0.0021
COVID - Mean: 0.0005, Median: 0.0000
Post-COVID - Mean: 0.0020, Median: 0.0005

ANOVA Results - F-statistic: 31.645802410024647, P-value: 7.771972197529143e-14

Kruskal-Wallis Results - H-statistic: 116.31425241079997, P-value: 5.529438163460271e-26

Dunn's Post-hoc Test Results (p-values):

	COVID	Post-COVID	Pre-COVID
COVID	1.000000e+00	1.214980e-08	5.639593e-26
Post-COVID	1.214980e-08	1.000000e+00	5.396950e-09
Pre-COVID	5.639593e-26	5.396950e-09	1.000000e+00

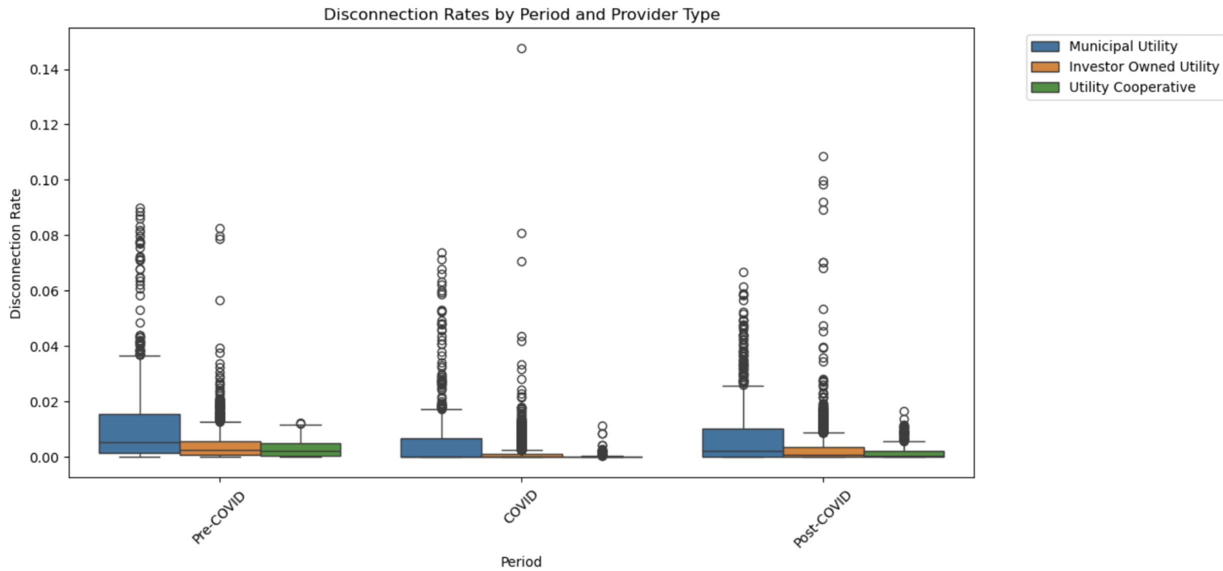

Figure 7 - Disconnection rates by Period and Provider type

The analysis reveals significant differences in disconnection rates across utility types and COVID-19 periods, with several key findings:

<u>Temporal Patterns</u>

Pre-COVID Period

- Municipal utilities showed the highest disconnection rates (mean: 0.0112, median: 0.0052)
- Investor-owned utilities and cooperatives had similar, lower rates (means of 0.0040 and 0.0030 respectively)

During COVID

- All utility types showed substantial decreases in disconnection rates
- Many providers reduced disconnections to zero (median: 0.0000 across all types)
- The sharpest decline was observed in utility cooperatives (mean dropping to 0.0005)

Post-COVID Period

- Partial rebound in disconnection rates, but not returning to pre-COVID levels
- Municipal utilities maintained the highest rates (mean: 0.0073)
- Investor-owned utilities and cooperatives showed moderate increases from COVID period

<u>Statistical Significance</u>

- ANOVA and Kruskal-Wallis tests show highly significant differences ($p < 0.001$) across periods for all utility types
- Dunn's post-hoc tests confirm significant differences between all period pairs
- The strongest statistical differences were observed in investor-owned utilities (F-statistic: 80.48, H-statistic: 959.05)

The data demonstrates that COVID-19 had a profound impact on utility disconnection practices, with all providers significantly reducing disconnections during the pandemic period.

6. Analysis on Raw Disconnection Numbers

The analysis assessed raw disconnection numbers across pre-COVID (2018-2019), COVID (2020), and post-COVID (2021-2022) periods using ANOVA for normally distributed data and the Kruskal-Wallis test for non-parametric data.

Statistical Test Results:

- **Mean Disconnection Numbers by Period:**
  - Pre-COVID: Mean: 175.56
  - COVID: Mean: 93.27
  - Post-COVID: Mean: 123.74

- **Median Disconnection Numbers by Period:**
  - Pre-COVID: Median: 158
  - COVID: Median: 90
  - Post-COVID: Median: 120

- **F-statistic (ANOVA):** 84.232

- **P-value (ANOVA):** <0.0001

- **Kruskal-Wallis Test Results:**
  - H-statistic: 857.16
  - P-value: <0.0001

- **Data Counts per Period:**
  - Pre-COVID: 3185
  - COVID: 2048
  - Post-COVID: 3694

- **Dunn's Post-hoc Test Results (p-values):**
  - **Comparisons:**
    - COVID to Post-COVID: 2.452e-59
    - Pre-COVID to Post-COVID: 1.012e-45
    - Pre-COVID to COVID: 3.214e-84

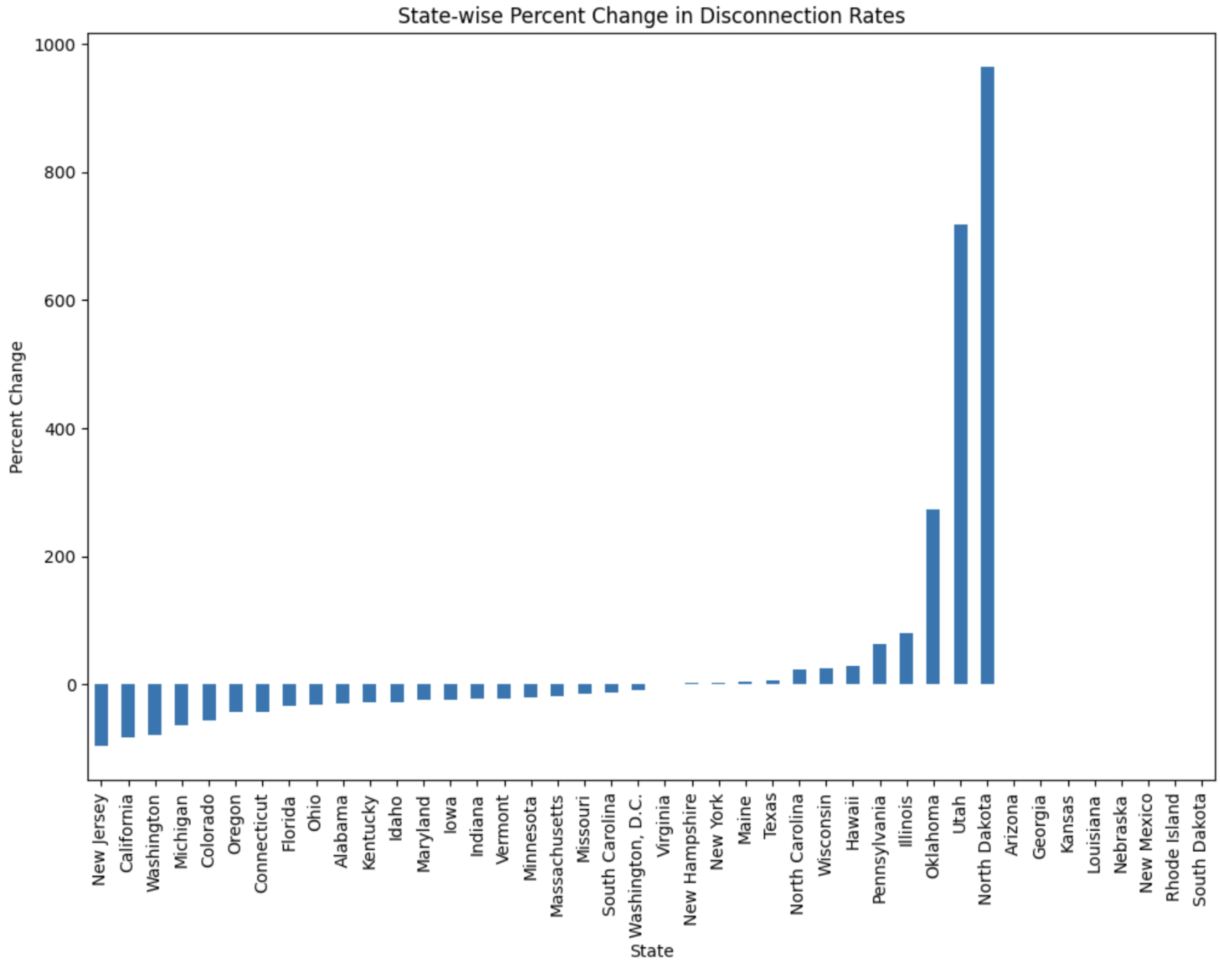

Figure 8 - State-wise percent change in disconnection rates

The graph showing state-wise percentage changes in disconnection rates highlights large differences between states. North Dakota stands out with a sharp increase, likely due to the lack of a statewide moratorium during the pandemic. This may have led to a backlog of disconnections that were processed all at once after restrictions were lifted. To understand these unusual cases better, it was suggested to analyze data at the utility provider level instead of just aggregating by state. This refined approach can pinpoint specific factors influencing disconnection rates, especially in cases like North Dakota, where individual utility actions may have driven the trend.

Analysis of Null Values: Jason pointed out that missing values, especially in the COVID-era data, could be due to incomplete reporting or changes in how utilities reported data. These gaps might also reflect operational pauses or adjustments made during the pandemic, but such instances were not consistently documented across regions or providers.

Refined Approach: Taking Jason's advice, the analysis shifted to focus on utility-level data rather than broad state-level trends. This allowed for a deeper understanding of how specific utility companies managed disconnections during the pandemic. The results showed that utilities responded differently depending on local regulations and company policies, offering more insight into the challenges they faced.

To sum up, the analysis vividly illustrates significant variations in raw disconnection numbers during the observed periods. There was a notable decline during the COVID period, influenced by moratoriums and economic aid, followed by a partial rebound post-COVID, remaining lower than pre-pandemic levels. This enduring effect of the COVID interventions suggests changes in consumer behavior and utility policies that continue to impact disconnection practices.

Utilizing utility-specific data as Jason advised showed distinct responses to the pandemic, reflecting the diverse impact across providers depending on their adherence to moratoriums and the regional policies in place. These insights underscore the importance of adopting utility-specific management strategies and flexible policy-making to navigate the post-pandemic recovery effectively, ensuring utilities are prepared for similar future challenges. The detailed statistical analysis, supported by Dunn's post-hoc tests, firmly establishes the significant differences in disconnection rates across all periods, highlighting the necessity for adaptive utility operations in a changing economic and regulatory environment.

5. CONCLUSION

In this project, we explored utility disconnection data to uncover trends and provide insights that can guide the Energy Justice Lab in its future efforts. By analyzing disconnection rates before, during and after COVID, studying state-wise protections, and comparing utility providers, we have gained a deeper understanding of how disconnections vary across states and under different conditions. This helps highlight areas where policies or support systems could be improved to protect vulnerable communities.

Our statistical significance testing revealed notable trends. Nationally, disconnection rates significantly decreased during COVID compared to pre-COVID levels, likely due to protective measures implemented during the pandemic. However, these rates rose again post-COVID, though they remained lower than pre-COVID levels. A similar trend was observed in the utility provider type analysis. When analyzing state-level and utility provider-specific data, the results varied by state. For example, California showed reductions during COVID with partial rebounds post-COVID, Utah experienced increases during COVID, and Missouri and North Carolina displayed mixed trends with some recovery post-COVID. These state-specific findings highlight the need for tailored, data-driven policies to address unique regional challenges and improve resilience during crises.

We believe we have addressed the problem by providing meaningful insights into disconnection patterns and the factors influencing them. These findings can be used by the sponsor to advocate for better protections, support policy changes, or inform future research. Our work also sets a foundation for future teams, with clear documentation and recommendations to build on what we have accomplished. This ensures that the project remains valuable and continues to make a positive impact.

6. RECOMMENDATIONS FOR FUTURE WORK

To continue and expand upon this project, we recommend the following specific actions:

a. **Deep Dive into Policy Data**
   Future teams could work on analyzing the policy data in greater detail. By focusing on state policies that show

significant changes in disconnection numbers, teams can gain a better understanding of why these spikes or decreases occurred. This could involve examining factors like the timing of policy implementations, their scope, and their enforcement mechanisms. Such analysis would provide valuable insights to the Energy Justice Lab.

b. **Update the Analysis with New Data**
Once data post-2022/2023 becomes available, rerunning the analysis to identify new trends or confirm existing ones will be crucial. This updated analysis can help track the effectiveness of recent policies and protections and identify emerging issues in utility disconnections.

c. **Developing Comparative Analyses**
Future teams could perform comparative analyses of disconnection patterns between states with similar demographics/geographics but different policy frameworks. This could provide valuable insights into which protections are most effective and inspire better practices across states. This could also include doing a comparative analysis of states in the same region (i.e. States in Eastern US, States in Western US etc).

d. Incorporating Additional Data
To enhance the analysis, future teams could join the existing data with external datasets, such as state-level population, gross annual income, or other socioeconomic indicators. This would help account for confounding factors and provide a deeper understanding of the drivers behind disconnection rates. For example, states with higher income levels might have lower disconnection rates, regardless of their policies, which could add context to the findings.

e. **State, Period, Utility_Provider Specific Statistical Significance Testing**
Future teams could extend the analysis to all other states by customizing the periods according to state-specific disconnection trends and selecting utility providers with complete and consistent data. Refining period definitions based on actual disconnection trends will ensure relevant and meaningful comparisons. The same statistical methodology can be applied to compare disconnection rates across periods, enabling the identification of significant patterns and disparities across states. This broader analysis will enhance understanding of state-level variations and support the development of equitable, data-driven policies to improve utility resilience and address disparities during crises.

By focusing on these areas, future teams can build on our work, contributing to a deeper understanding of utility disconnections. These efforts will ensure the project remains impactful and relevant in addressing energy justice issues.