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Problem Definition

U.S. ELECTRIC GRID OUTAGE ANALYSIS

DEPI-GIZ1_DAT2_G1e
Group1

22/10/2024

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Problem Definition

Problem:

With the rising demand for energy and increasing climate-related disasters, electricity outages pose a critical challenge to infrastructure resilience. The DOE has accumulated extensive data on power outage incidents but faces difficulties in deriving insights due to severe data quality issues, inconsistencies, and gaps in the dataset. This lack of clarity hinders timely analysis of outage trends, weak points in the grid, and the overall impact on the population.

Key Issues:

- Raw data contains numerous quality and integrity issues (inconsistencies, missing values, and unstructured formats).
- Difficulty in tracking long-term trends or pinpointing significant patterns in outage events.
- Inability to quantify the true impact of outages on demand loss and the affected population.
- Limited visibility into event types, duration, and other critical metrics across the years.

Proposed Solution:

Using Power BI, this project will:

- Clean and consolidate the raw event-level data from multiple files (Systems).
- Build a comprehensive dashboard to visualize trends in outages over time, highlight significant event types, and quantify their impacts.
- Identify and highlight outliers, anomalies, or special events that may skew the analysis.
- Provide clear insights into power grid vulnerabilities, along with any assumptions or alerts related to data quality issues.

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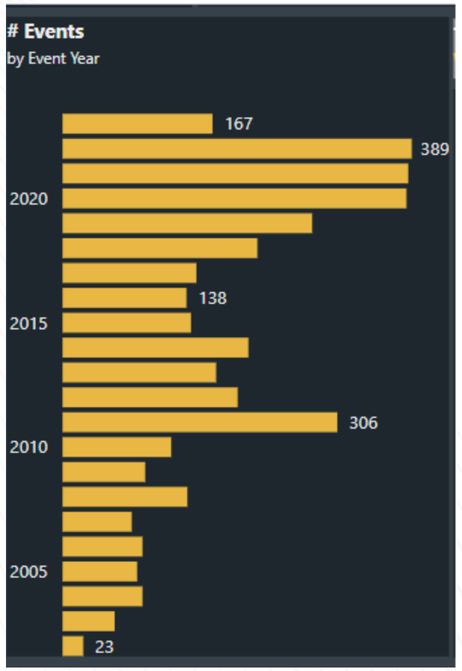
Key Insights from the Analysis

1. Outage Frequency Over Time:

- There has been a noticeable **increase** in the number of power **outages** over the past decade, particularly **since 2020**,.

- From **2014** onwards, the trend shows a consistent **growth** in **outage frequency**. This could be attributed to a variety of factors, including aging infrastructure, rising demand, and climate-related stressors.



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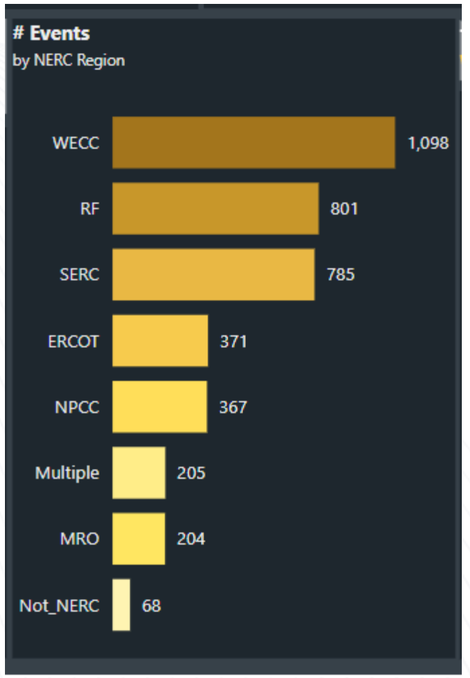
Key Insights from the Analysis

2. Regional Distribution of Outages:

- WECC stands out as the region most affected by power outages, with over 1,000 events recorded. (RF) and the Southeastern United States (SERC) also report a high frequency of events.

- The data suggests that certain regions—especially those with extreme weather variability and complex energy grids—are more prone to outages, signaling potential weaknesses in regional grid resilience.



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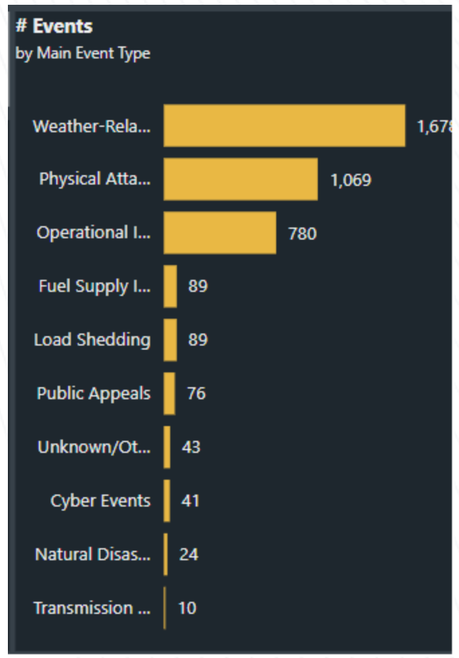
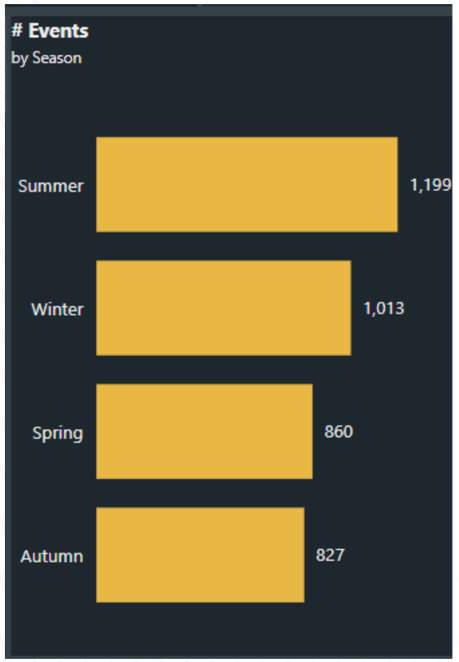
Key Insights from the Analysis

3. Outage Causes:

- Weather-related events (particularly in winter and summer) are the leading cause of power outages, followed by equipment failures and other natural disruptions.

- Outlier outages are driven by severe weather events (hurricanes, ice storms), natural disasters, or major technical failures. These causes are rare but have a far-reaching impact, requiring extensive restoration efforts and preparation for extreme conditions.





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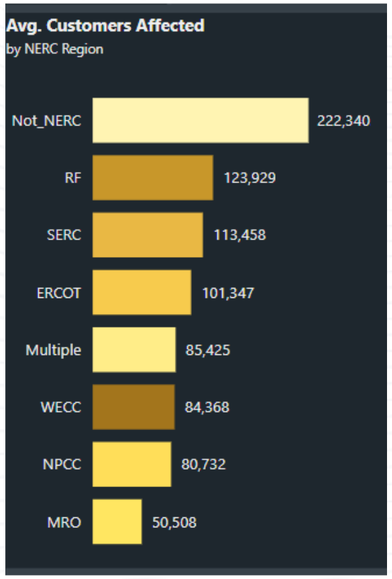

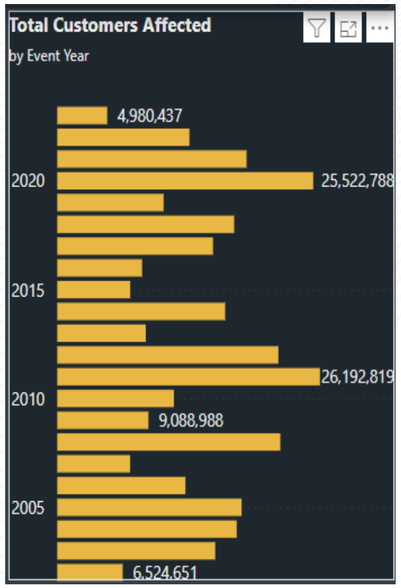

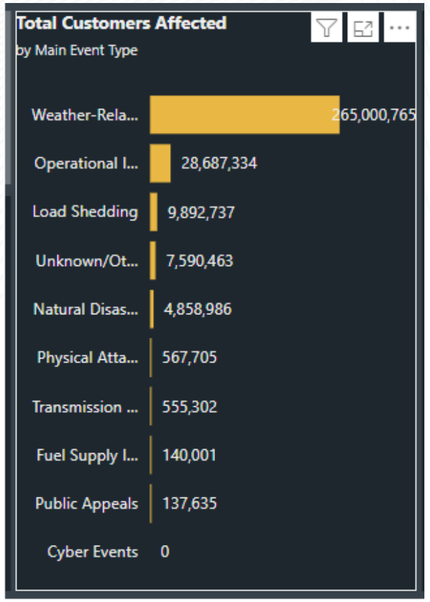

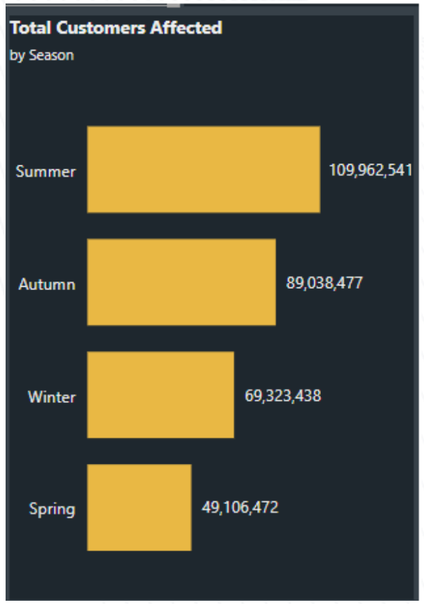

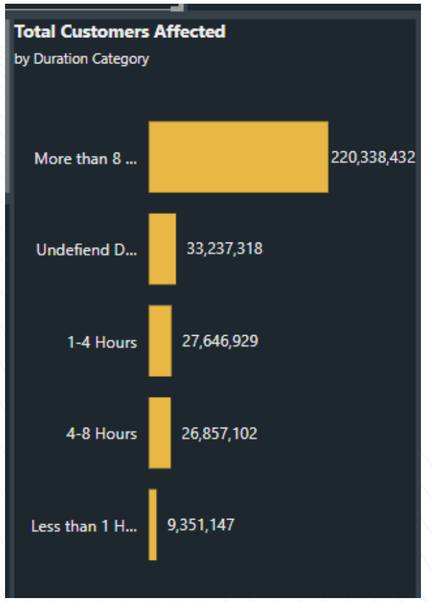

5. Total #Customers Impact:

- Millions of customers are affected by power outages, with ERCOT (Texas), SERC (Southeast), and RF(Midwest and Northeast) experiencing the largest average number of affected customers.
- Some years, particularly 2011, 2012 and 2020 saw high numbers of impacted customers due to large-scale weather events.
- Extreme events such as hurricanes or major operational failures cause massive spikes in affected customers. Outliers indicate rare but highly impactful disruptions requiring emergency interventions.

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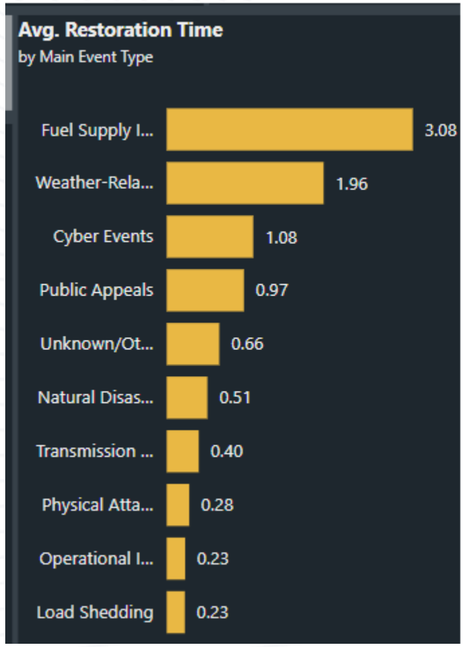
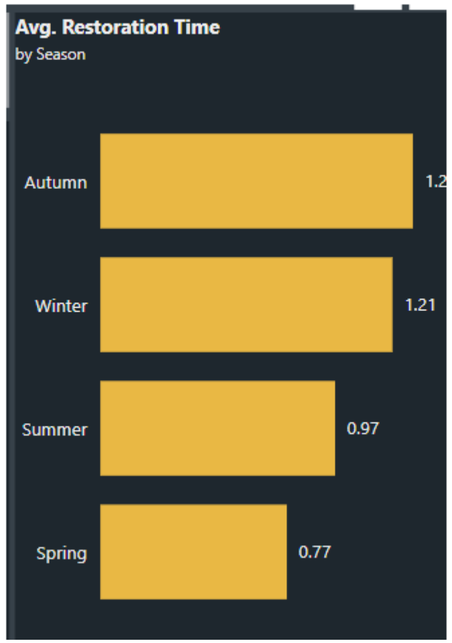
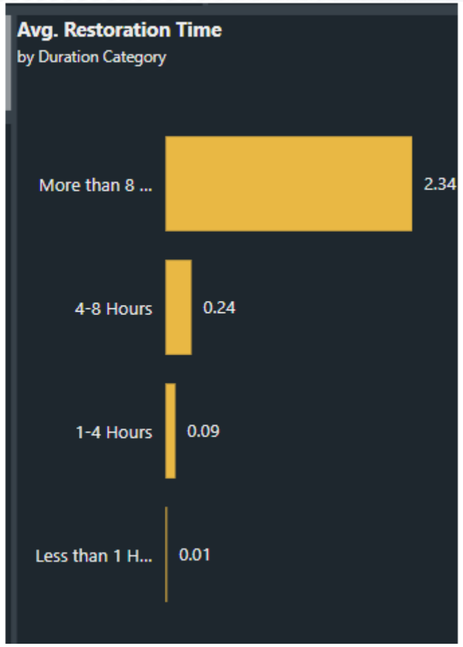
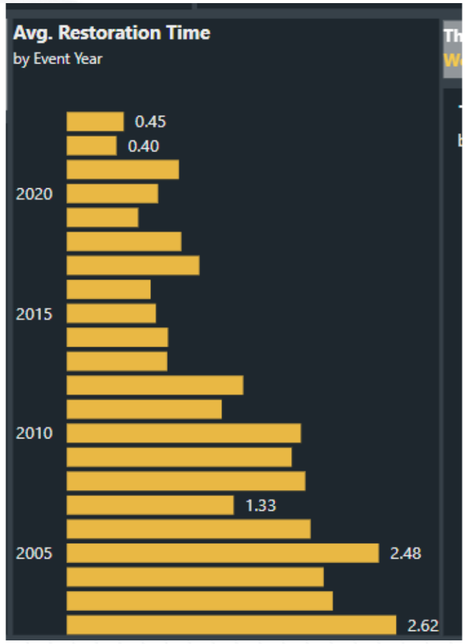
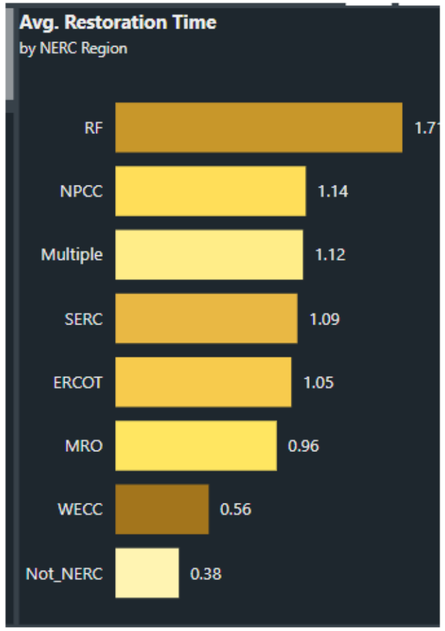
Key Insights from the Analysis











6. AVG. Restoration Time:

- Restoration times differ significantly based on the cause of the outage. For instance, Fuel Supply outages tend to have the longest **AVG**. recovery times, while Load Shedding or physical attacks are typically resolved more quickly.
- The data shows that the complexity and scope of the outage (e.g., large regional weather events versus isolated incidents) strongly influence the time it takes to restore power.
- Restoration times are much longer in outlier events, where response time slows due to the complexity and scale of the incident.

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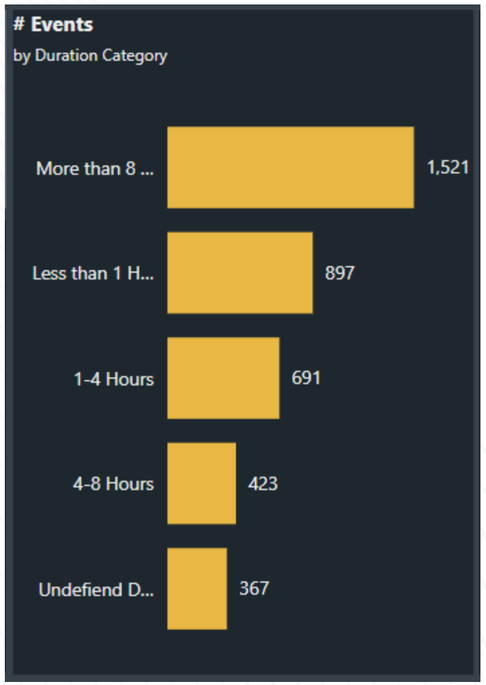
Key Insights from the Analysis

4. Outage Duration:

- Most power outages fall into the category of lasting more than 8 hours, with many even exceeding 24 hours. This is a critical issue for both residential customers and businesses, as longer outages can lead to major economic losses, public health risks.

- Shorter-duration outages (1–4 hours) are less frequent, but their occurrence suggests that many events are quickly resolved, possibly due to less severe underlying causes.

- Outlier events cause significantly longer outages, spanning days or even weeks. Restoration is delayed due to the severity of events, like natural disasters or large-scale technical issues.



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Key Insights from the Analysis

7. Demand Loss:

- Outages lead to substantial demand loss, with significant variations by year and region. The highest losses were reported in 2019-2020.
- Regions such as SERC and WECC report higher total demand loss, which could be indicative of their heavier reliance on electric power in both residential and industrial sectors.
- Demand loss also correlates with the duration of outages, with longer-lasting events having a more profound economic and operational impact on power providers and consumers. The most cause of demand loss is the weather-related events.
- Extreme demand loss occurs during outlier events, disrupting entire regions and severely affecting economic activities due to prolonged power cuts.