

# FROM BLACKOUTS TO BREAKTHROUGHS



x



Itty-Bitty  
ELECTRIC COMPANY

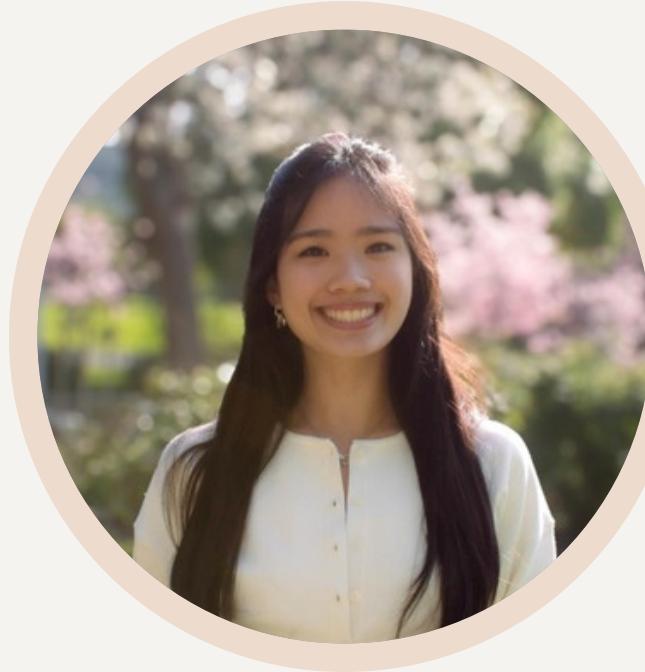
# Our Team



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**01**

**Executive Overview**

**02**

**Our Process**

**03**

**Data Visualization**

**04**

**Machine Learning**

**05**

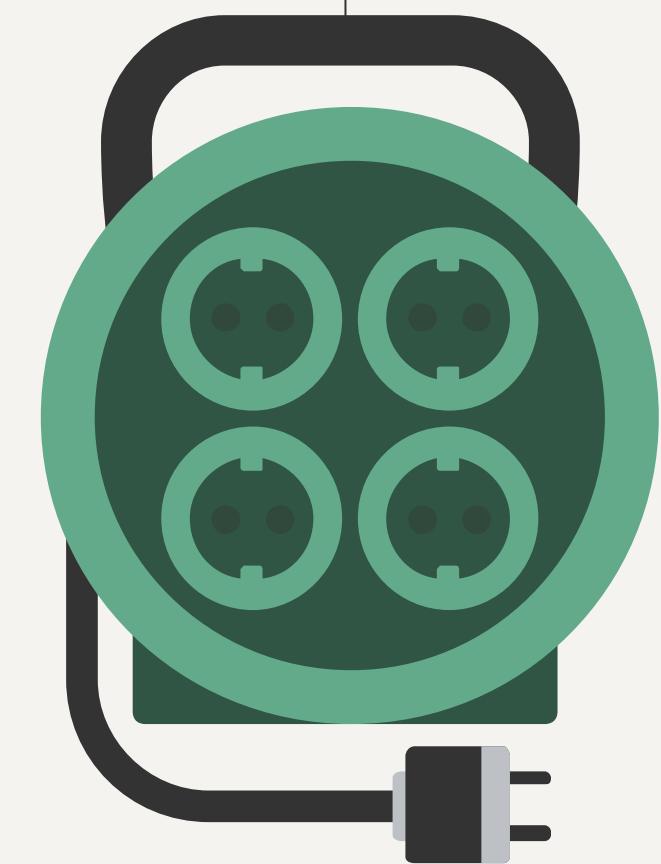
**Recommendations**

**06**

**Implementation Plan**

# Executive Overview

01



# Current Standing

## Strengths

- IBEC tracks outage durations and affected circuits
- Stable customer base in Southern California
- Regulatory awareness for spending and system upgrades

## Weaknesses

- Limited analytical capabilities and expertise
- Reactive maintenance approach
- Lack of data integration

## Opportunities

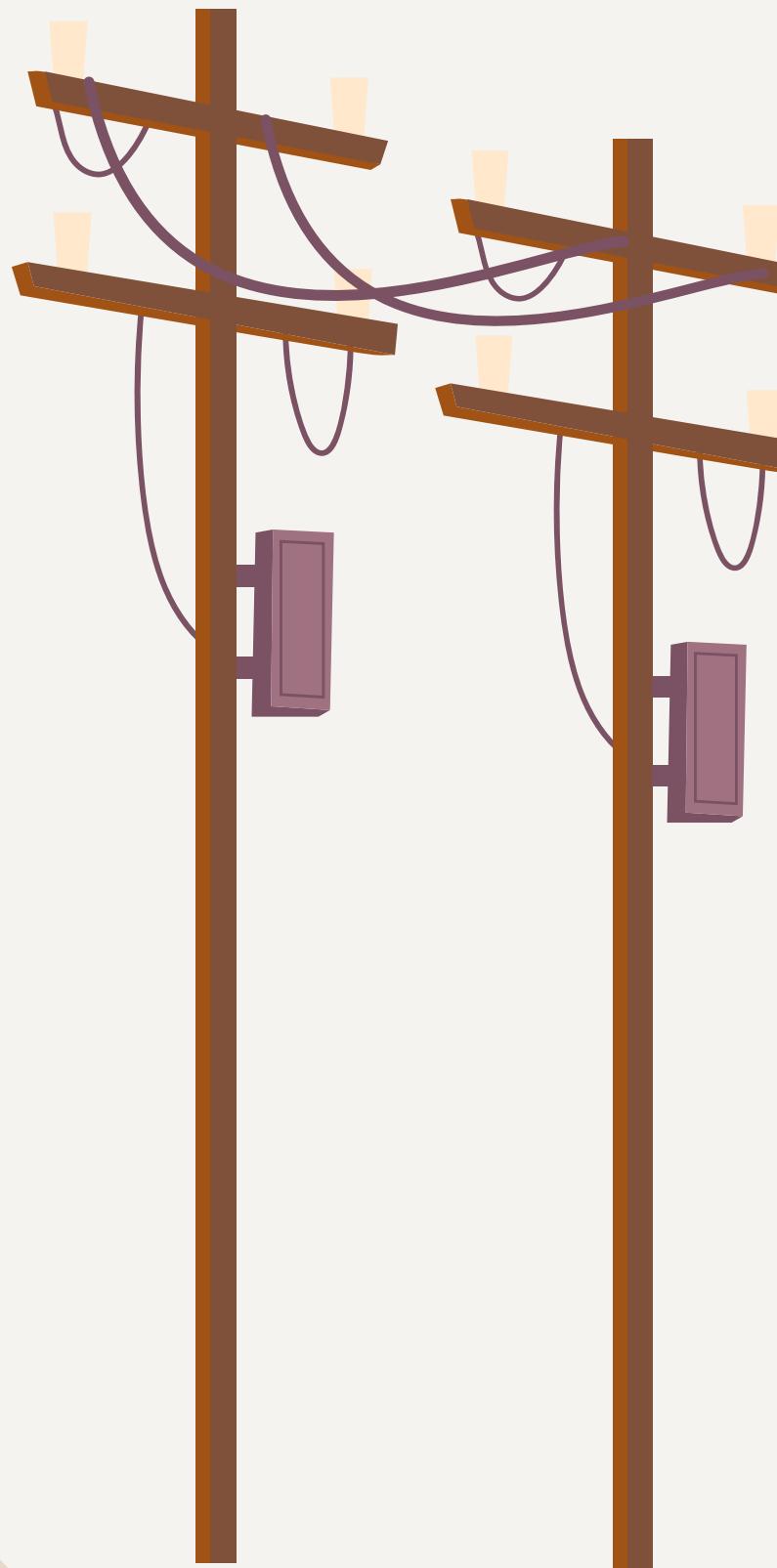
- Adoption of predictive analysis
- Guide capital improvement to the impacted circuits
- Improve service reliability and brand loyalty

## Threats

- Fines or difficulty securing rate approvals if issues continue
- Frequent outages can decrease customer trust
- Older equipment increases outage risk



# Our Goals

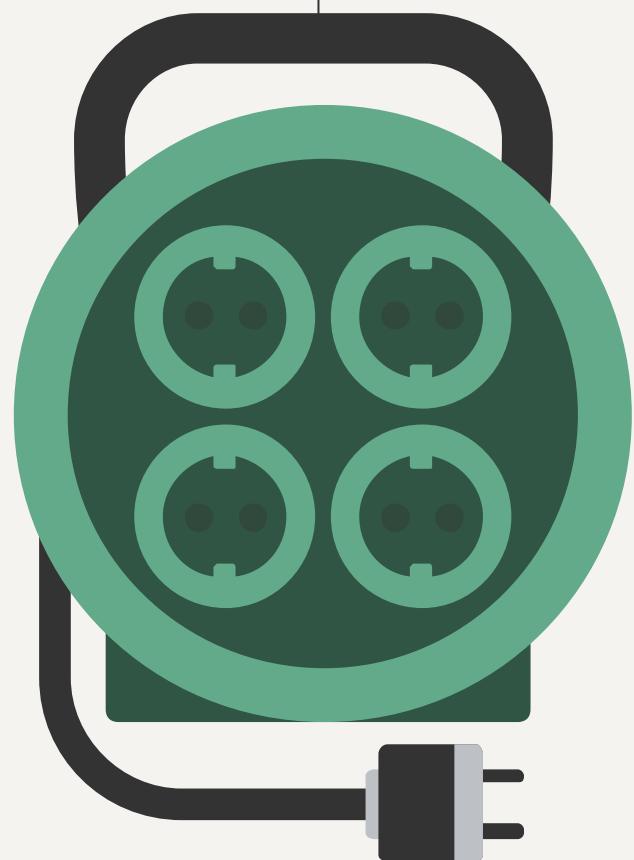


- 1 **Focus on high CMI areas** to reduce overall frequency and duration of outages
- 2 **Implement predictive modeling** to determine cause of outage duration and customers affected
- 3 **Increase system reliability** by effectively allocating IBEC's budget toward system maintenance and upgrades

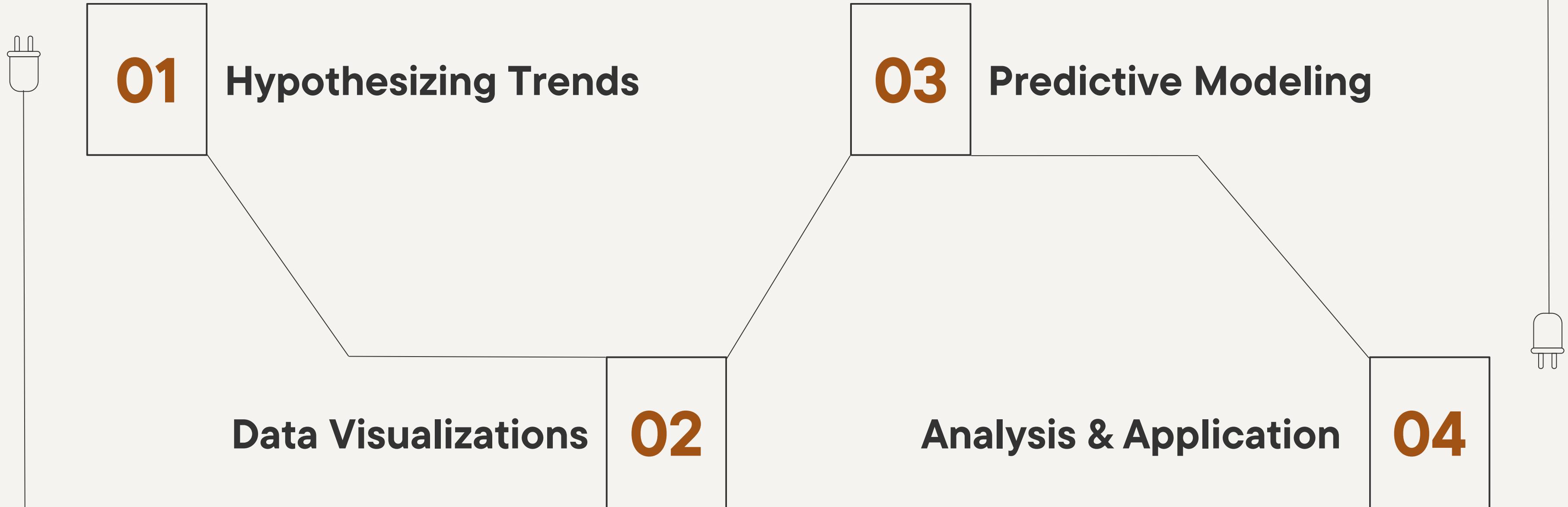


# Our Process

02



# Our Process



# Hypothesizing Trends

To create effective visualizations, we first need to understand what information we want to convey. We achieved this by:



**Creating Relevant Questions**



**Selecting Key Factors for Comparison**





## Creating Relevant Questions

- Which circuits have the highest total CMI?*
- How does CMI vary across different regions?*
- What is the most common cause of outages?*
- What is the average CMI per outage by region?*



## Selecting Key Factors for Comparison

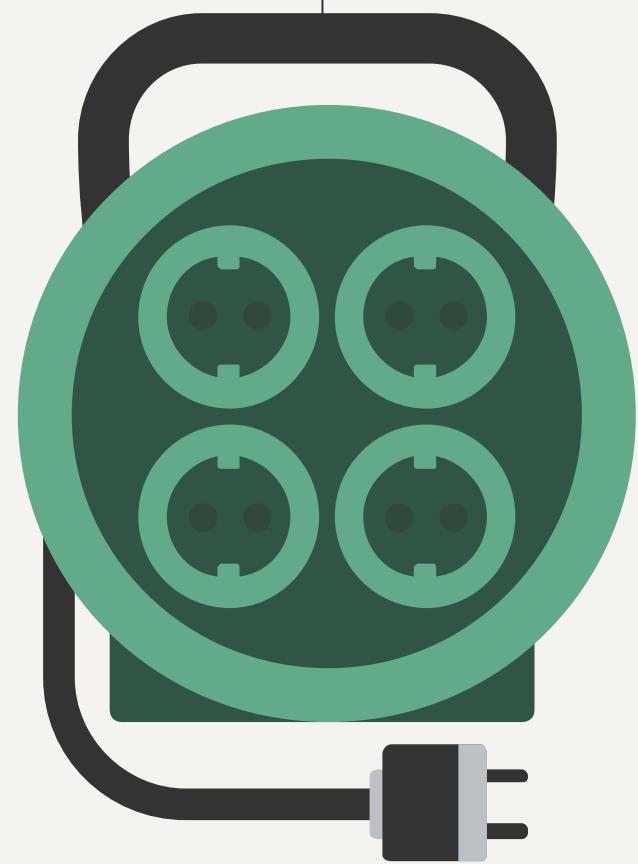
- CMI vs. Month*
- Outage Cause vs. Frequency*
- Region vs. Outage Cause*
- Outage Cause vs. Average CMI*

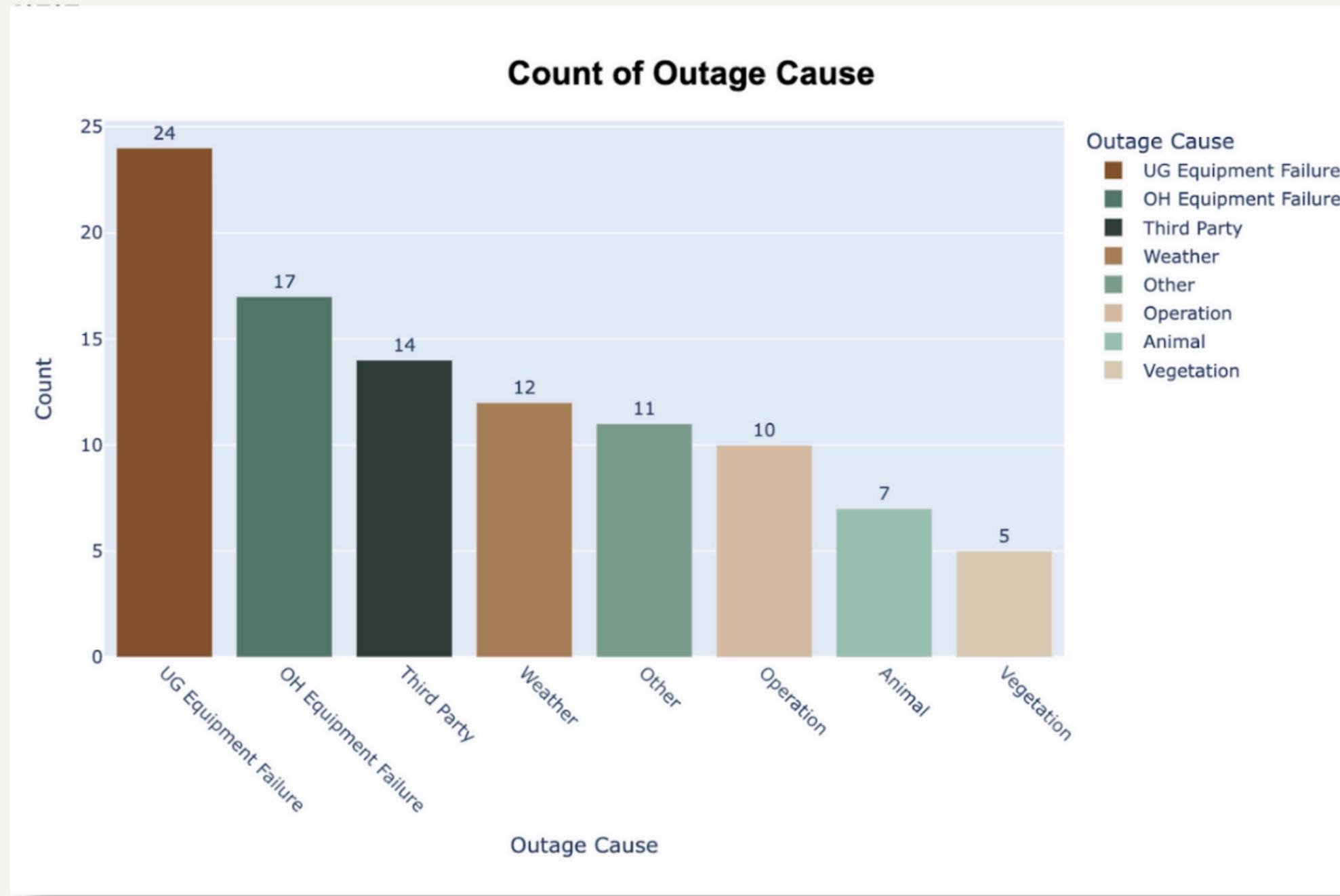
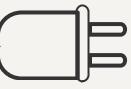
These questions and comparisons help tell a data-driven story, revealing key patterns and outage impacts.



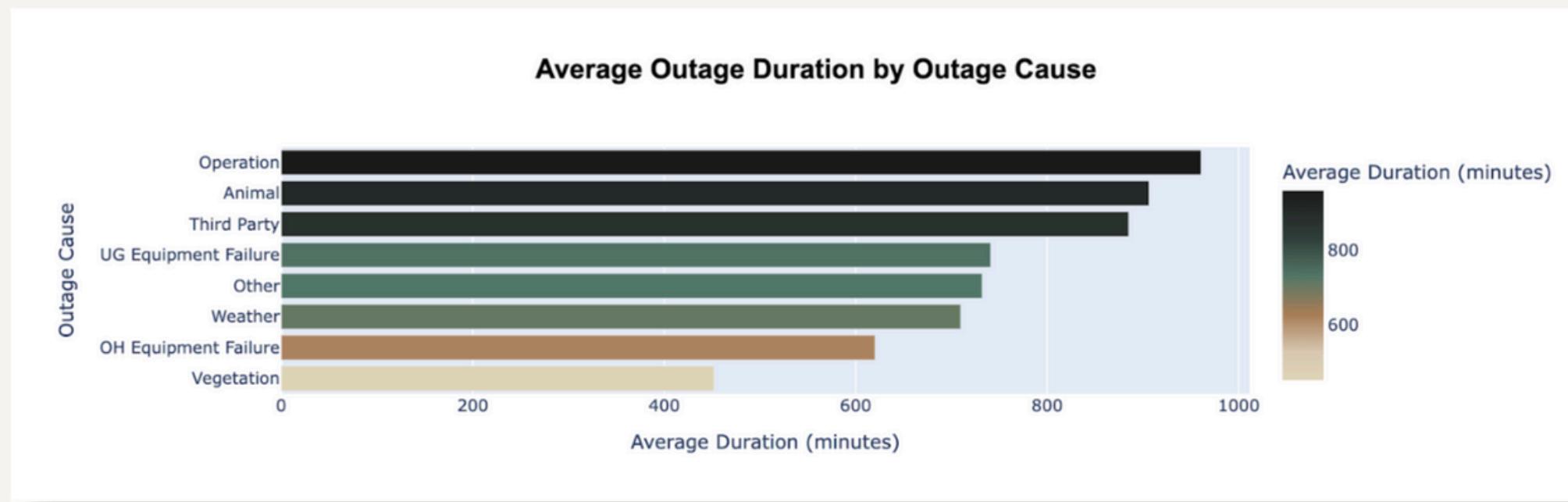
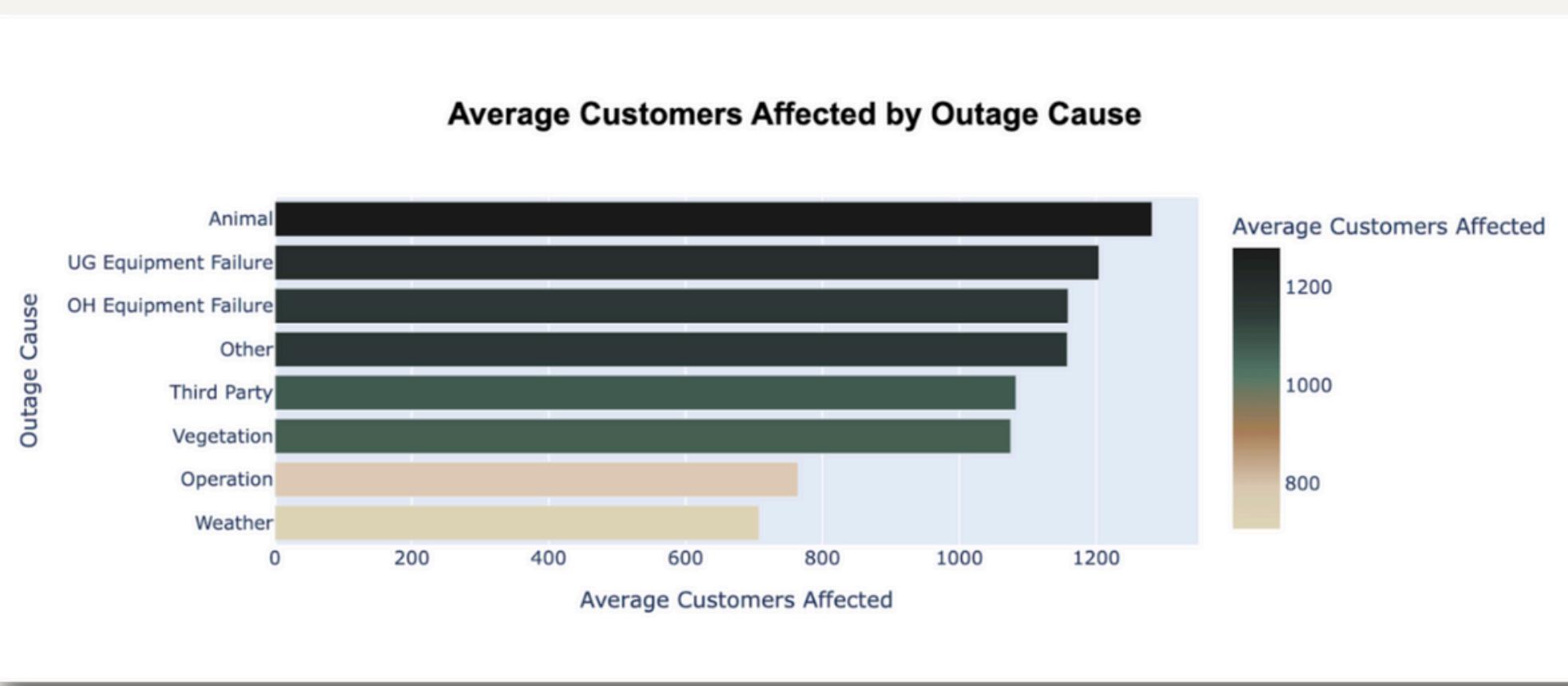
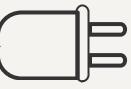
# Data Visualization

03





Most common reported outage causes are  
**Underground and Overhead Equipment Failure.**



## Main Focus

Customers affected &  
Outage Duration

## Insights

Inconsistencies when  
comparing by outage cause  
and difficult to gauge which  
metrics to prioritize

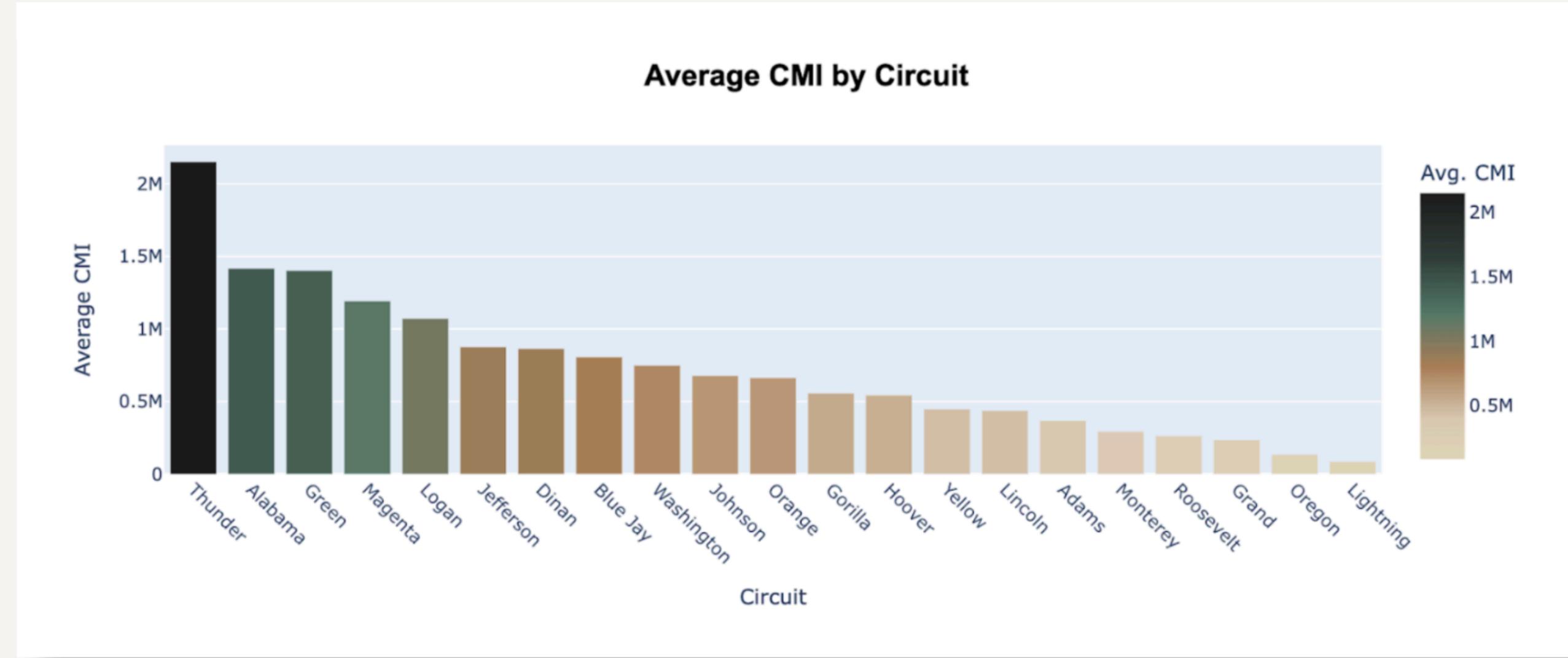
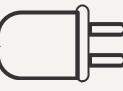


# What is CMI?

## **Customer Minutes of Interruption:**

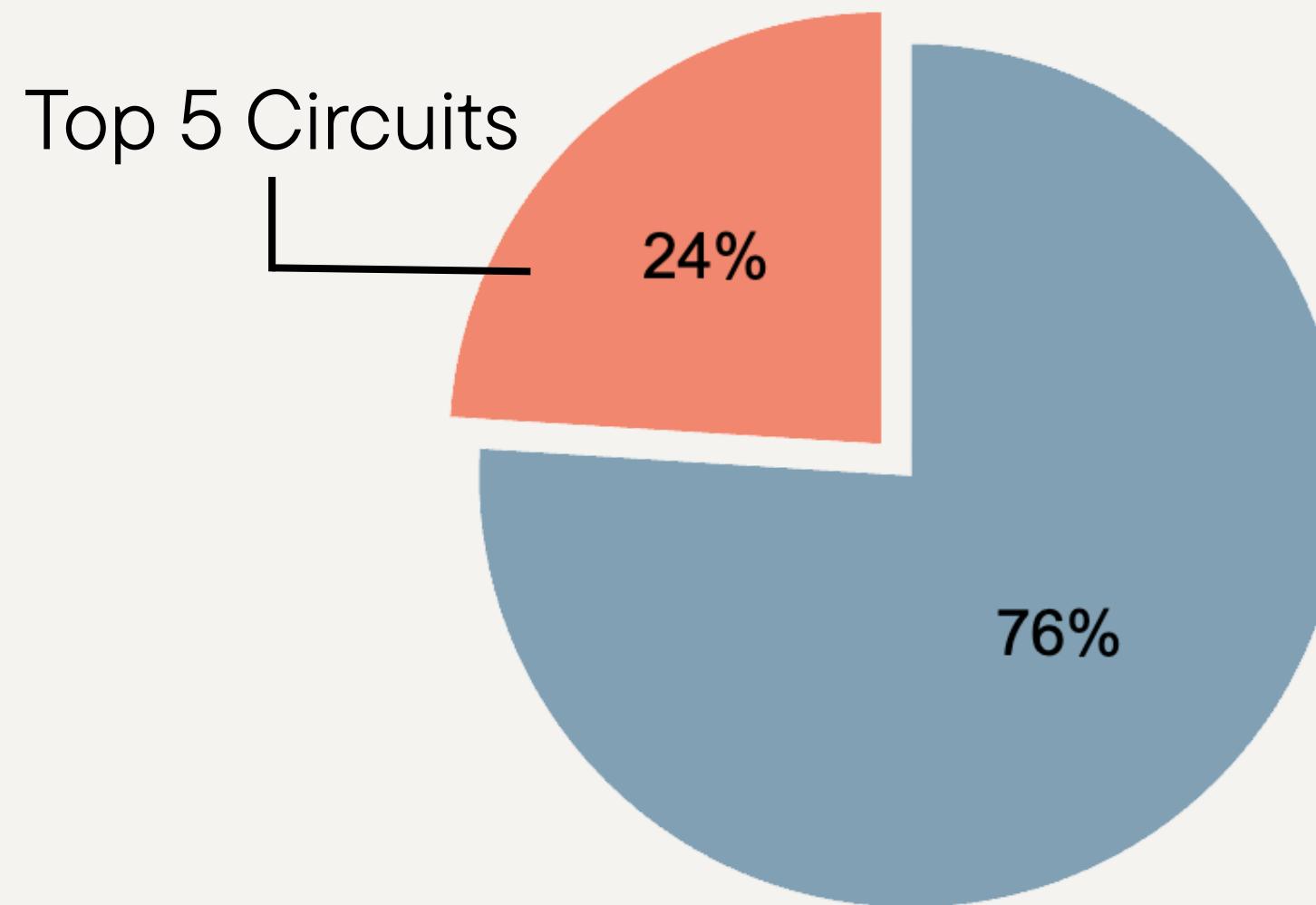
How many customers are affected by power outages and for what duration?

**CMI = Outage Duration x Customers Affected**

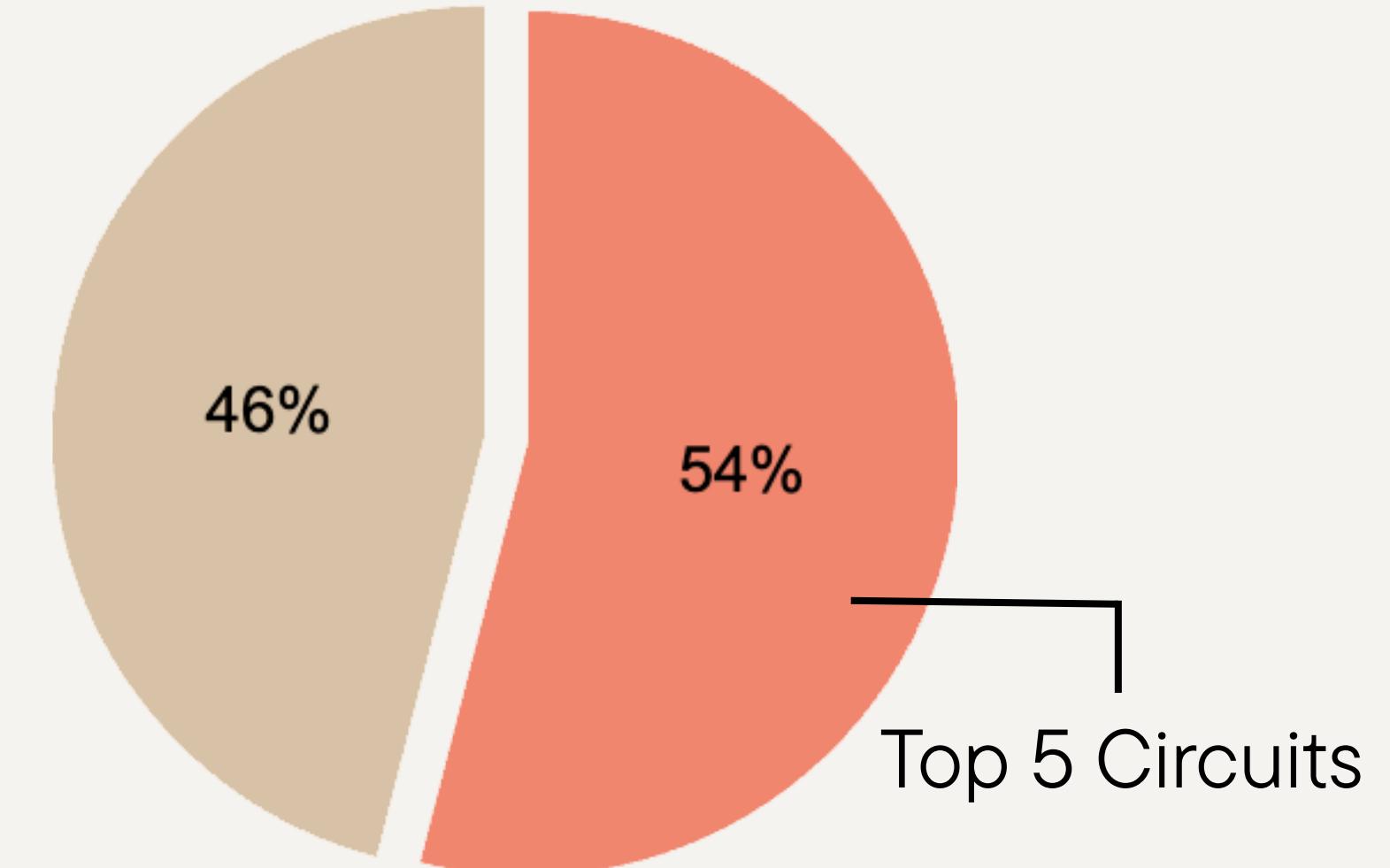


**Thunder, Alabama, and Green** have highest average CMI, while Lightning, Oregon, and Grand were least.

## Total Circuits

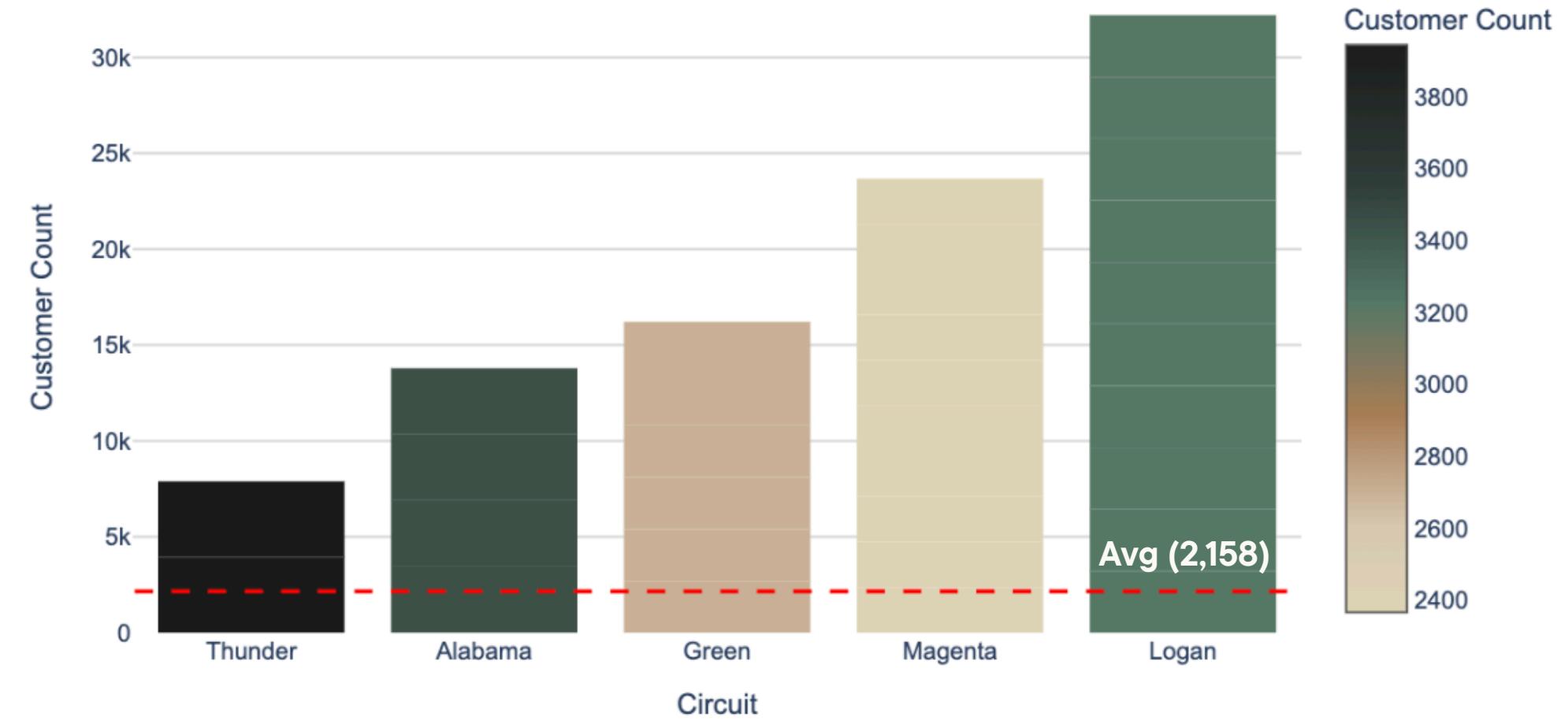


## Total CMI



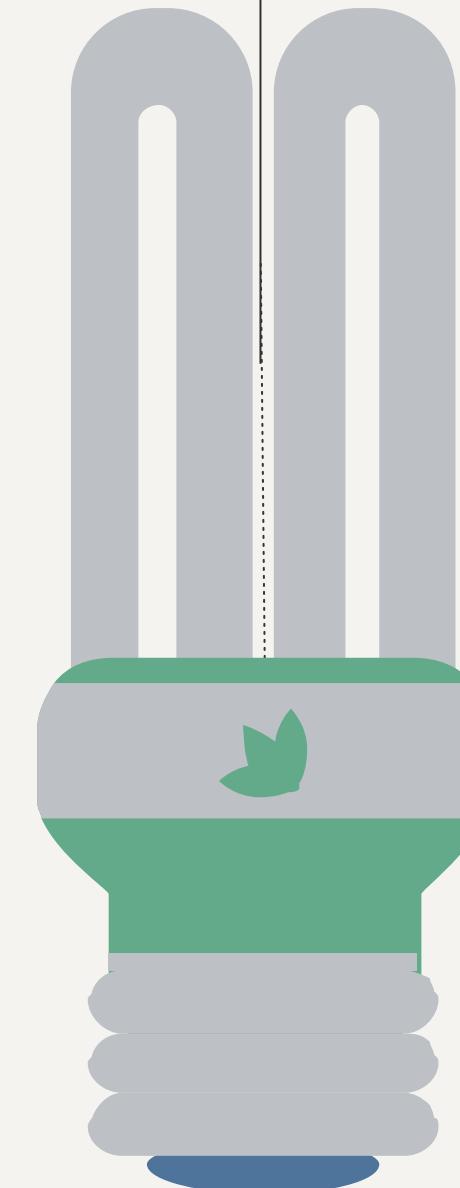
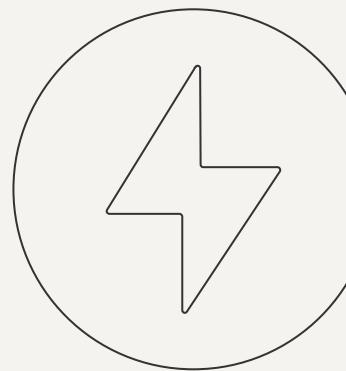
The **top five circuits**, while representing just **24% of all circuits**, were responsible for **54% of the total CMI**. A small number of circuits are causing more than half of the problems.

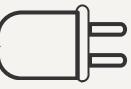
### Top 5 Circuits - Customer Count



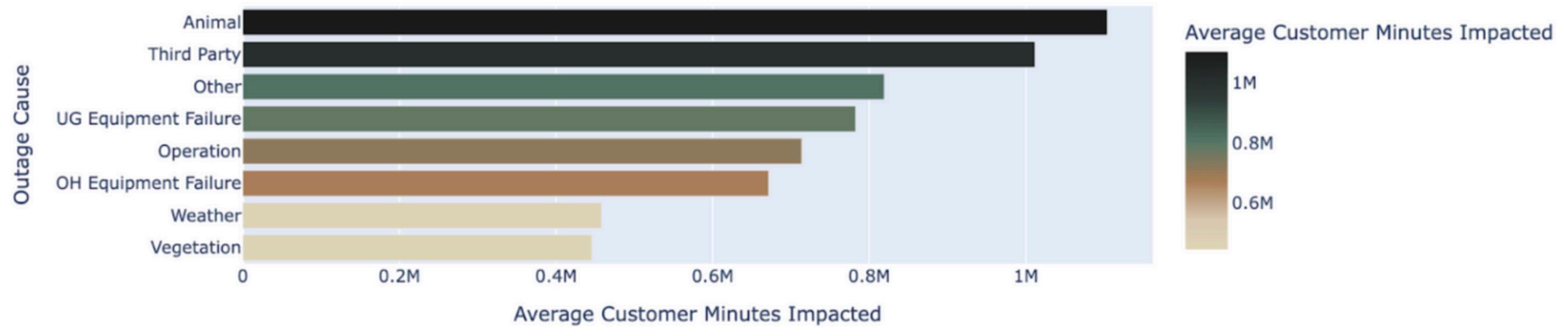
The Top 5 Circuits have customer counts **above**  
**the average**, 2,158 customers.

# What causes high CMI?

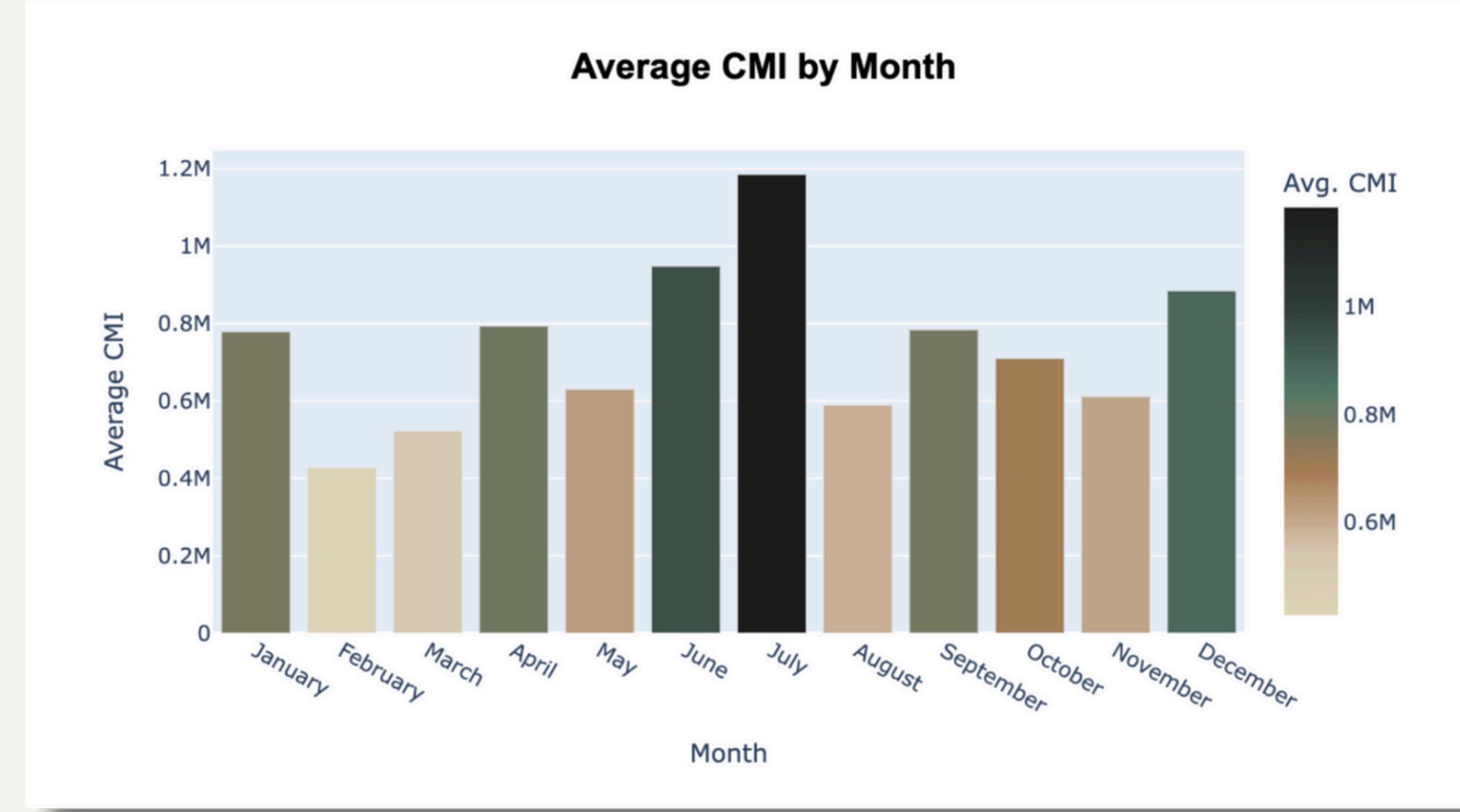
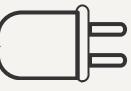




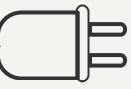
### Average CMI by Outage Cause



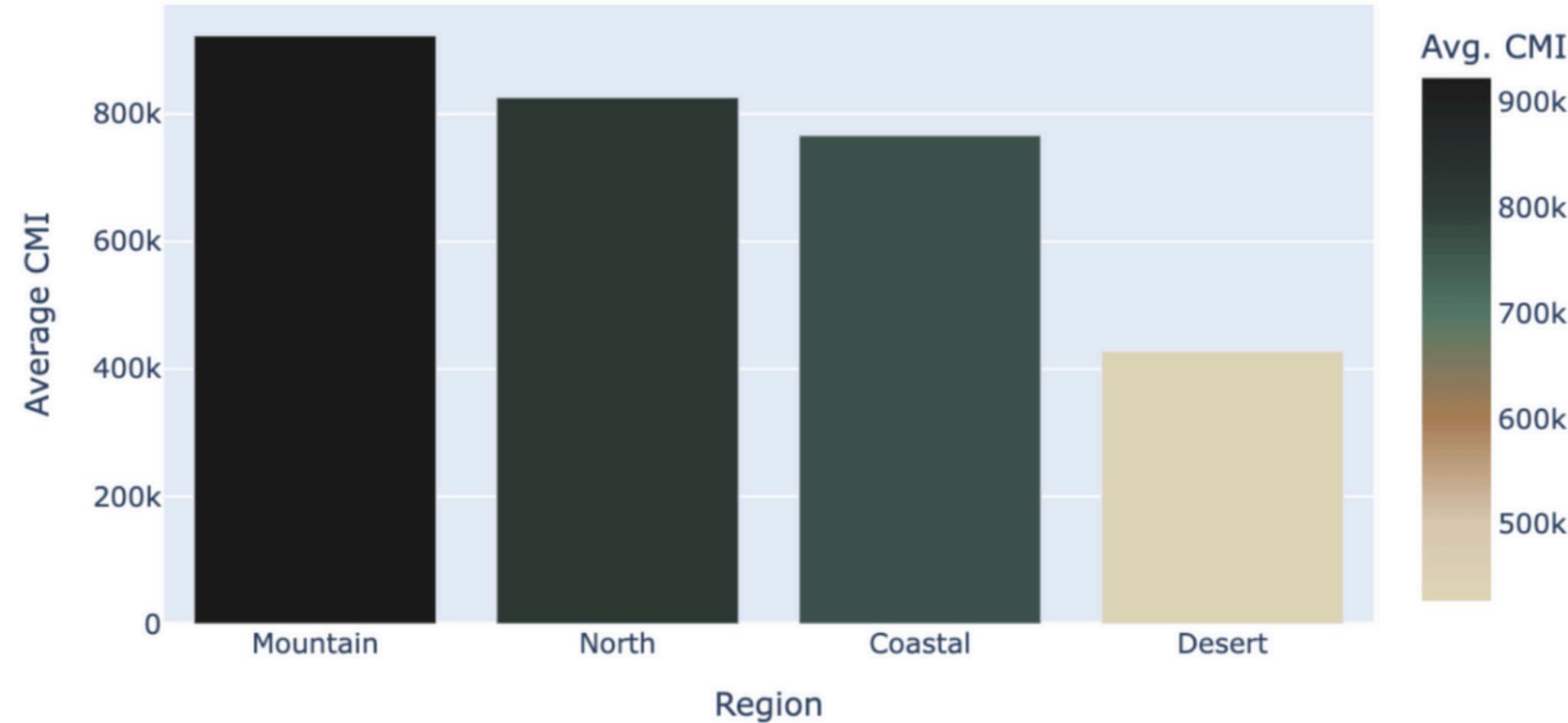
The highest average CMI was observed for **Animal, Third Party, and Other** outage causes.



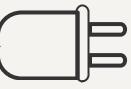
**June, July, and December** have the highest CMI and February, March, and August have the lowest CMI. Also, CMI increases and decreases in a cyclical pattern, with the peaks in July and December.



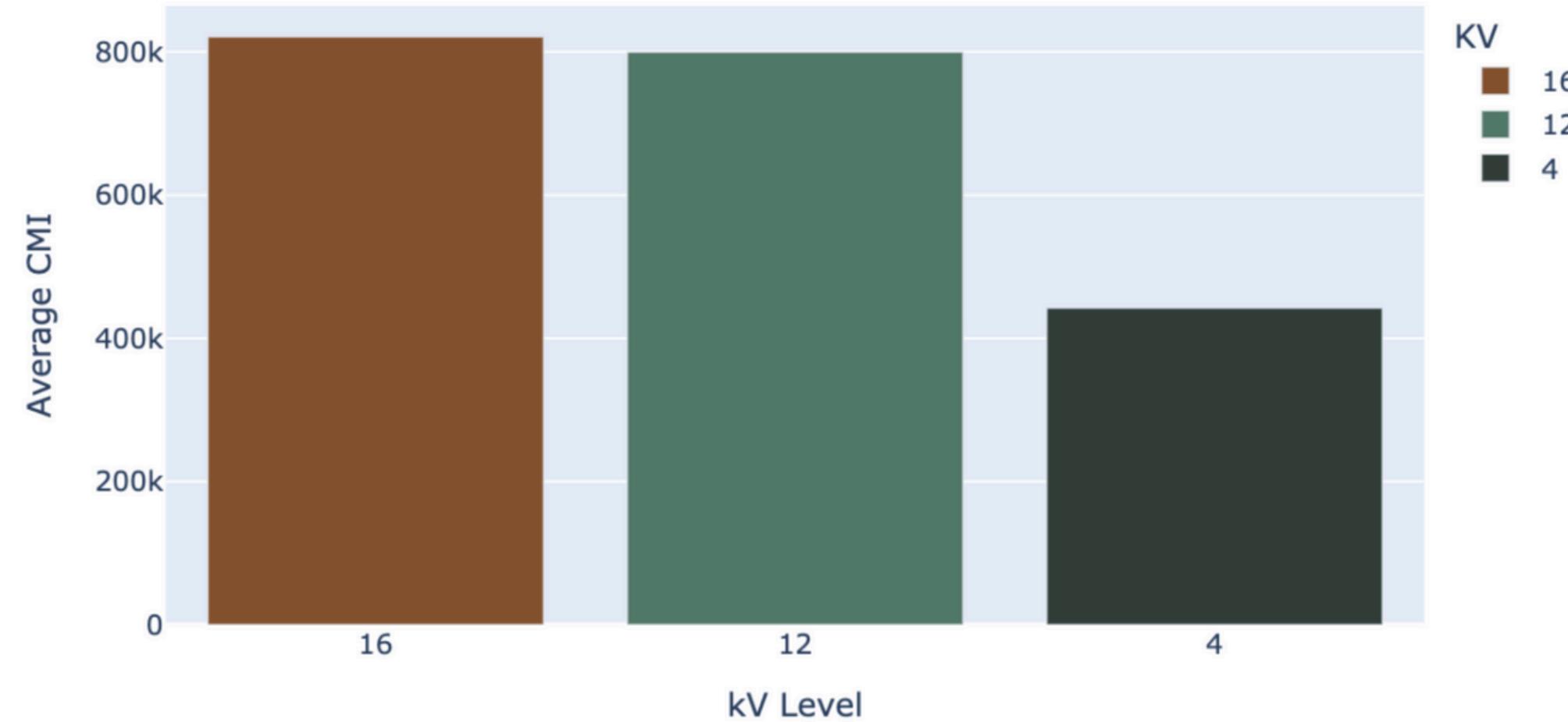
## Average CMI by Region



The highest CMI occurs in the **Mountain and North** regions and the lowest occurs in the Desert Region.



### Average CMI by kV



The highest average CMI by kV levels were **16 and 12**, whereas the lowest was recorded at 4 kV, highlighting a difference in impact based on voltage levels.

# Summary Data Insights

1

**Top Circuits:** Thunder, Alabama, Green, Magenta, and Logan make up 54% of CMI, but only 24% of circuits

2

**Main Causes:** UG and OH equipment failures are most common; animals and vegetation are less frequent but impactful

3

**Regional Trends:** Mountain and North has the highest average CMI; Desert the lowest

4

**Voltage Impact:** 16 kV and 12 kV circuits have the highest average CMI

5

**Seasonal Peaks:** CMI is highest in June, July, and December

6

**Customer Impact:** Animal, Third-Party, and Equipment Failures cause the most prolonged and widespread outages

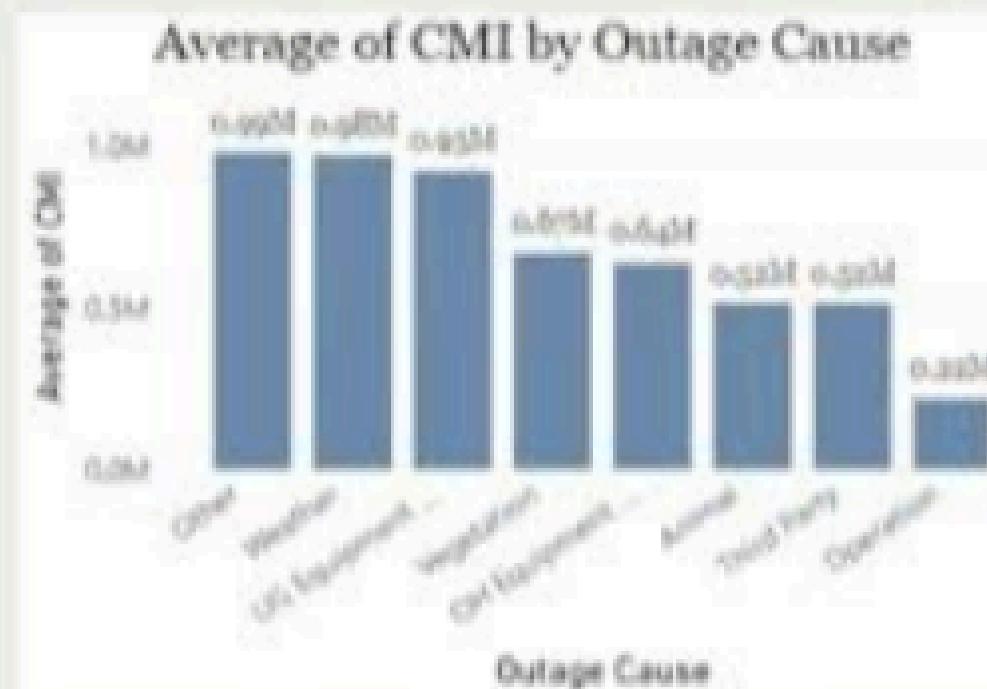




Total CMI  
**26M**

Average CMI  
**774.63K**

Total Outages  
**33**



Watch on YouTube

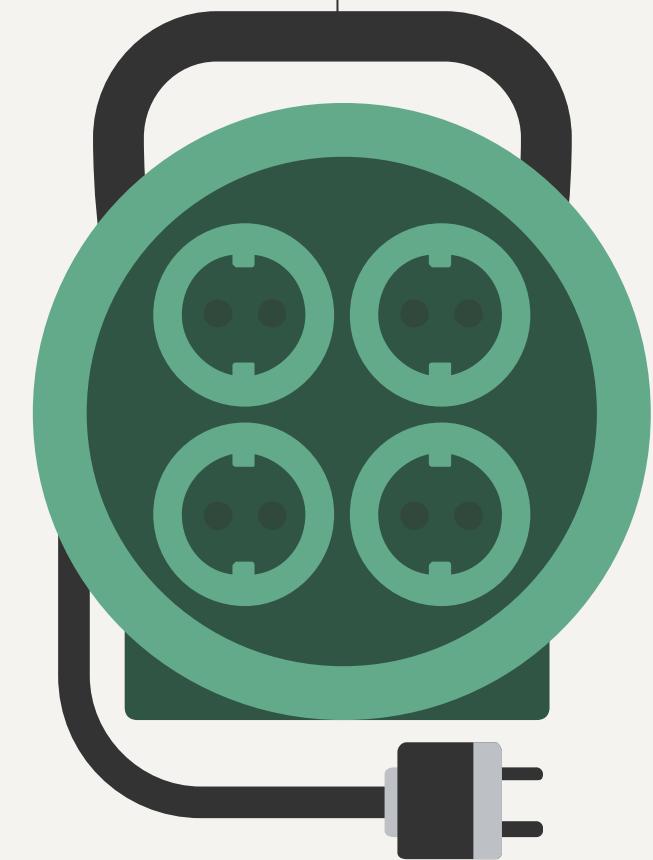


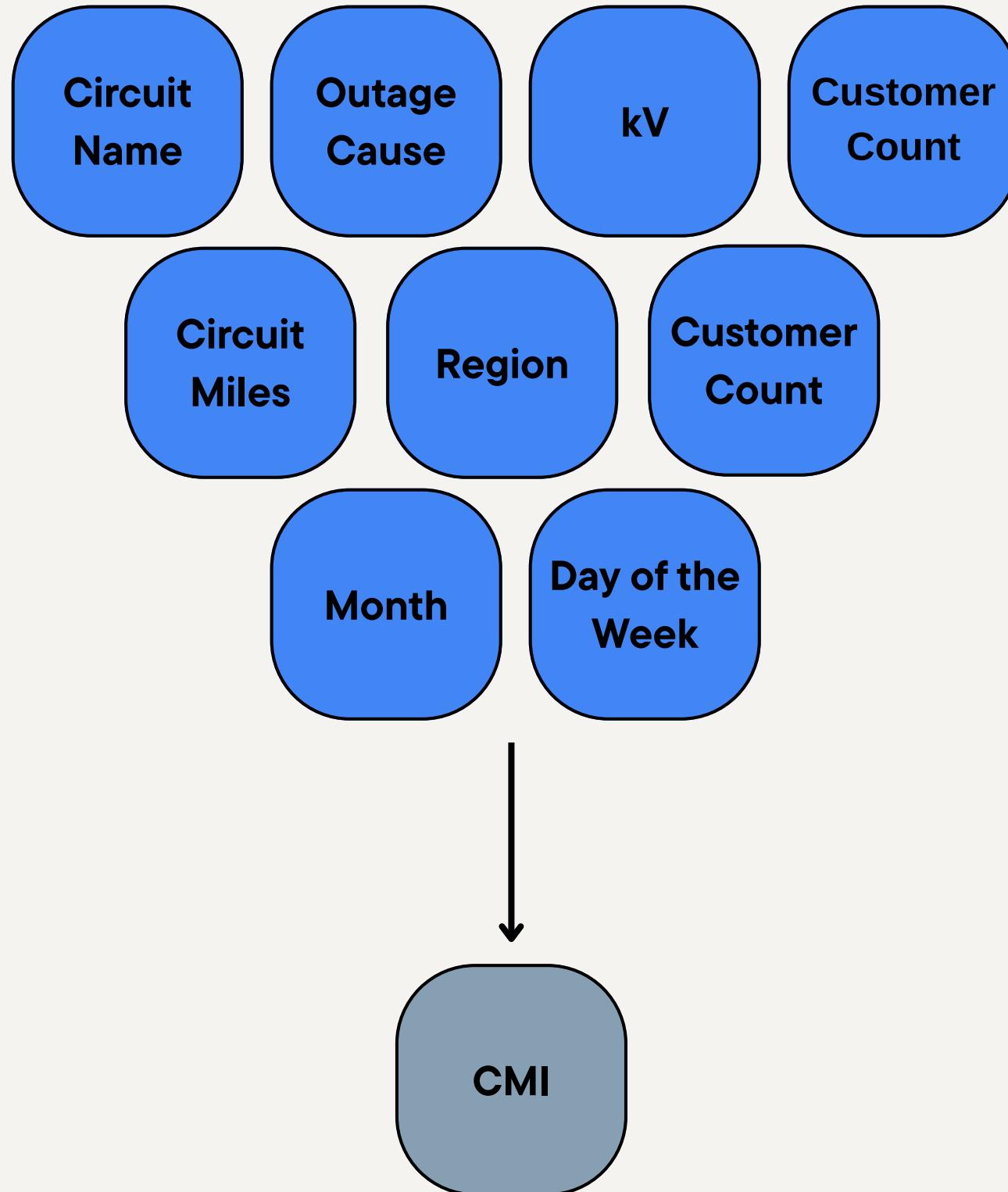
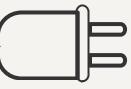
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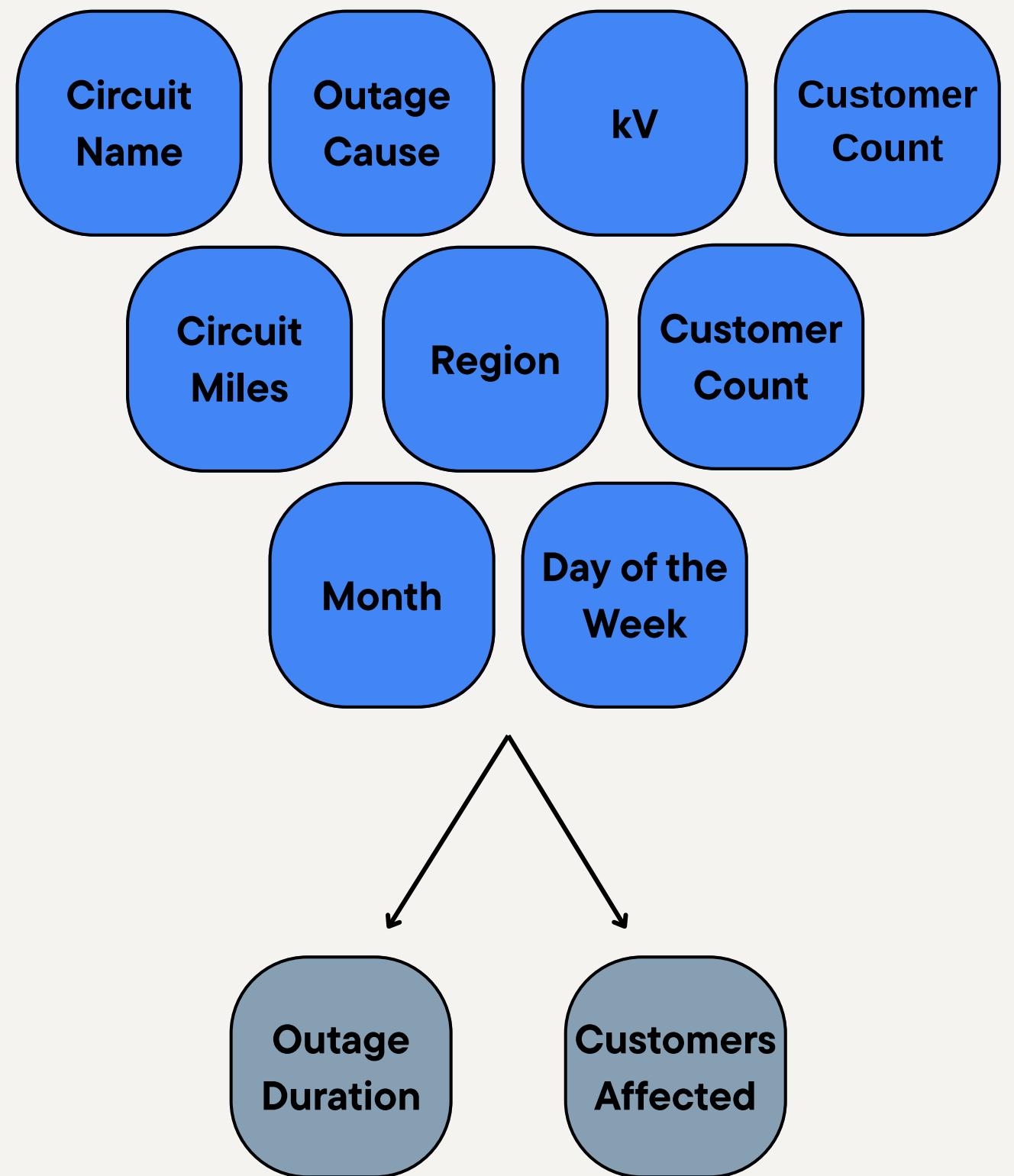
# Machine Learning

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*Our initial idea was to develop a machine learning model to **predict Customer Minutes Interrupted (CMI)**. The goal was to analyze historical outage data and identify key factors contributing to service disruptions.*



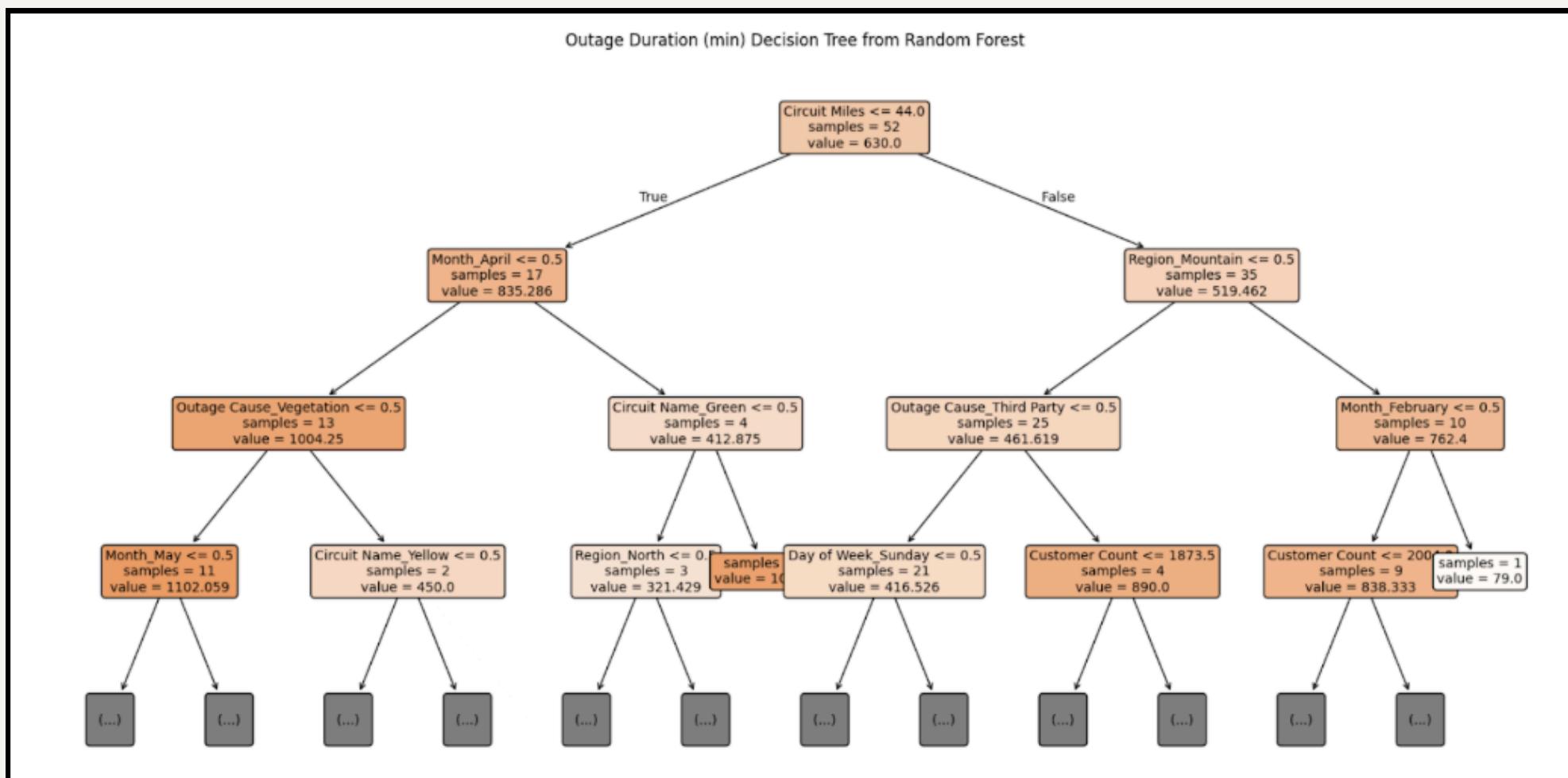
## Why Use Two Separate Models Instead of Predicting CMI Directly?

**CMI** = **Customers Affected**  $\times$  **Outage Duration**

Customers Affected	Outage Duration	CMI Level
Low	Low	Low
Low	High	Medium/High
High	Low	Medium/High
High	High	High

Similar CMI values can stem from different causes; separate models reveal the distinct drivers behind each

# How Random Forest Works?



## Random Forest

Decision trees split data into smaller groups using features that best improve prediction accuracy. At each step, the model selects the optimal variable and threshold to minimize error.

Each path from root to leaf forms clear rules, offering intuitive insights into key predictors and decision-making (shown on the left).

Outperformed Multiple Linear Regression

Customers Affected Top contributing features:		
	Feature	Importance
0	Customer Count	0.293010
1	Circuit Miles	0.093252
19	Circuit Name_Roosevelt	0.054191
3	Circuit Name_Alabama	0.051882
26	Outage Cause_Other	0.034137
55	Day of Week_Tuesday	0.025864
43	Month_July	0.022959
52	Day of Week_Saturday	0.022792
36	Region_Mountain	0.022743
37	Region_North	0.022233

Outage Duration Top contributing features:		
	Feature	Importance
0	Customer Count	0.149201
1	Circuit Miles	0.116304
34	Region_Coastal	0.092914
31	KV_12	0.085854
24	Outage Cause_OH	0.078077
28	Outage Cause_UG	0.045612
45	Month_March	0.043158
6	Circuit Name_Gorilla	0.042693
32	KV_16	0.040034
19	Circuit Name_Roosevelt	0.029039

1

2

3

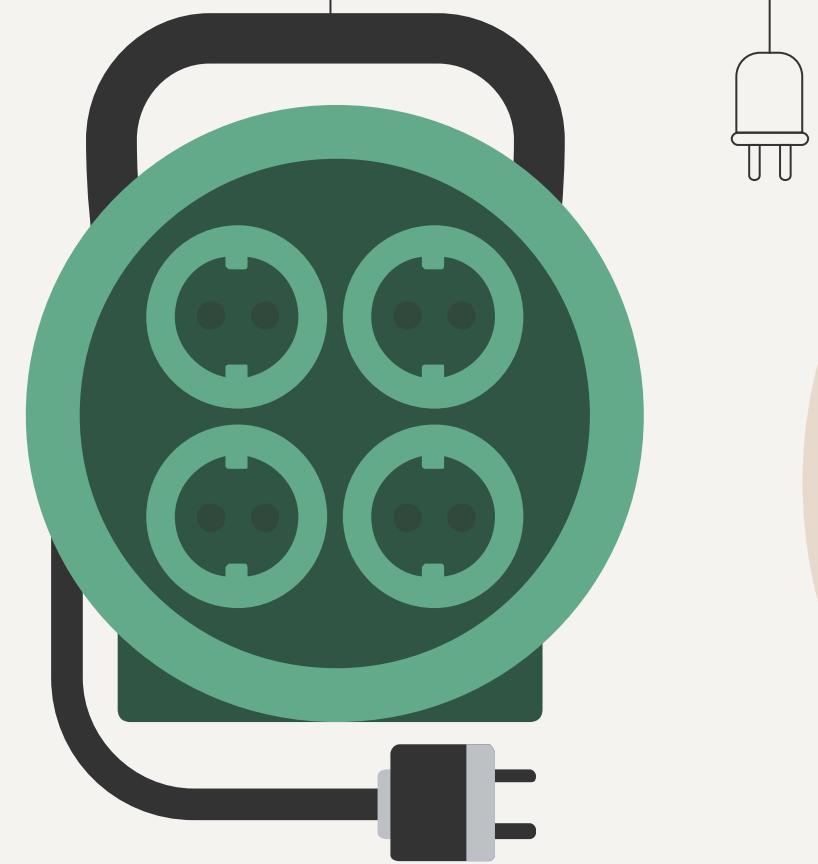
**Customer Count** and **Circuit Miles** were the top predictors for both Outage Duration and Customers Affected.

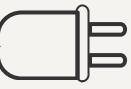
Larger customer bases and longer circuits are key factors influencing outage impact.

Top 10 predictors include KV 12 and 16, Mountain North region, and outage cause: OH UG, which align with visuals.

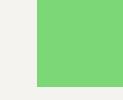
# Recommendations

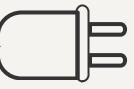
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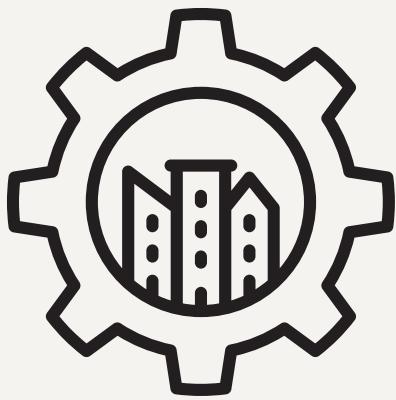


# Top 5 Circuits with Highest CMI

Circuit Name	kV	Region	Outage Cause
Thunder 	16	Mountain	Third Party, UG Equipment Failure
Alabama 	12	North	UG Equipment Failure (3), Third Party
Green 	12	Coastal	UG Equipment Failure (4), Other, Weather
Magenta 	16	Mountain	OH Equipment Failure (3), Weather (3), Other, Third Party, Operation, Animal
Logan 	16	North	OH Equipment Failure (4), Operation (2), Weather, Third Party, Animal, Vegetation



# Infrastructure (OH & UG)



## Overhead Equipment

Overhead inspections  
with drones

Overhead pole modernizations

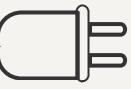


## Underground Equipment

Underground predictive  
maintenance with thermal sensors

Underground cable replacement





# Vegetation & Wildlife

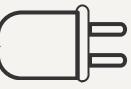


**Animal guards and diverters** to fend off animals.

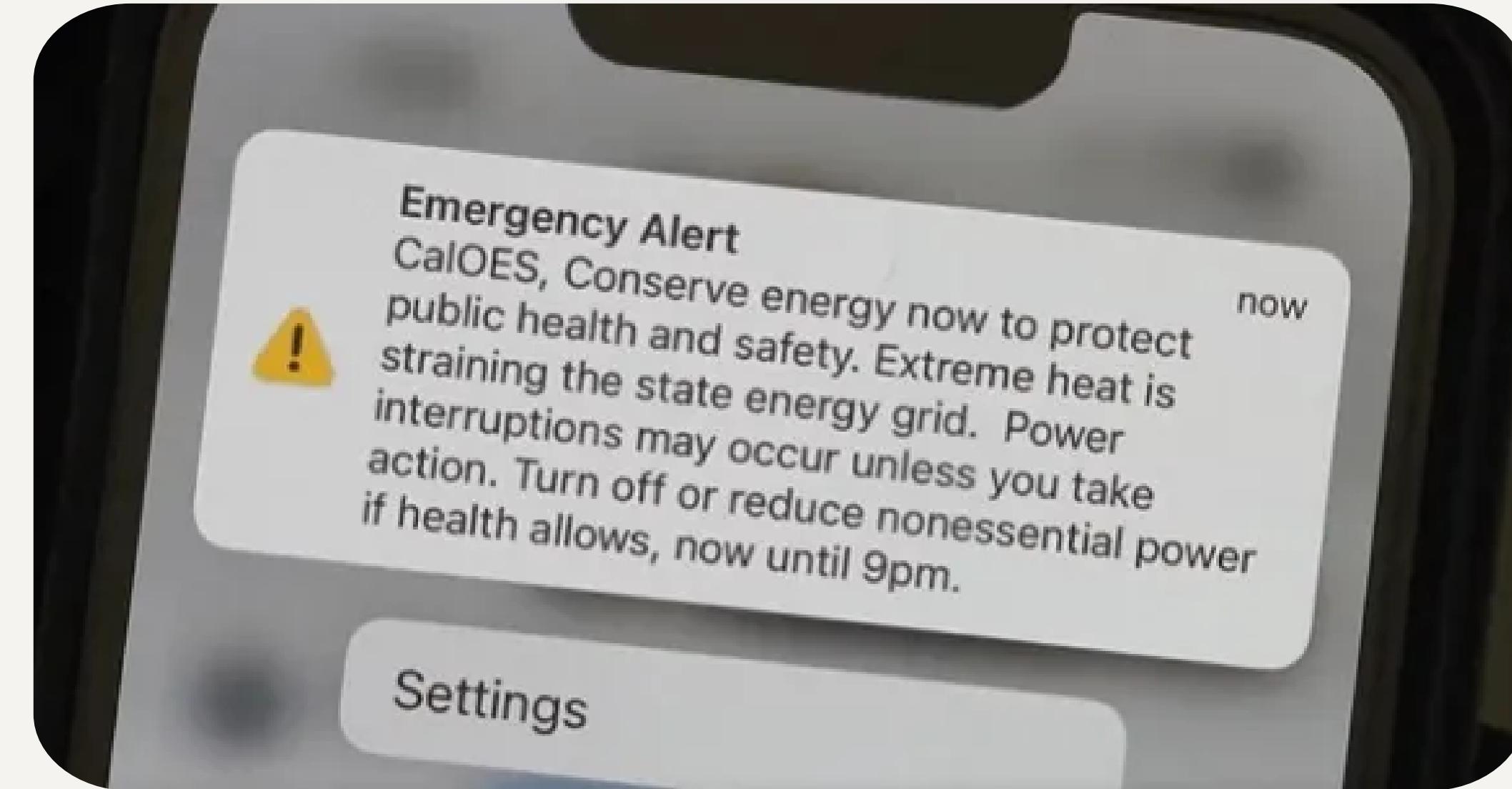


**Expand tree-trimming** around high-risk circuits.

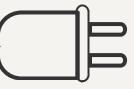




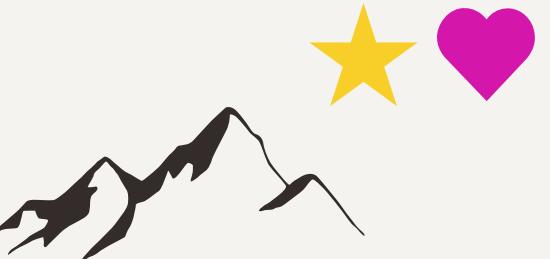
# Third-Party Incident Reduction

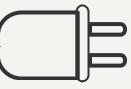


Implement digital permit and alert systems to ensure customers are aware of potential critical situations and help reduce the intensity of outages



# Region-Specific Solutions

 <b>Mountain</b>	<b>Weather-Hardened Equipment</b> <ul style="list-style-type: none"><li>• Insulated power lines, fire-resistant poles, and flood-protected substations</li></ul>	<b>Microgrids and Sectionalizers</b> <ul style="list-style-type: none"><li>• Isolate outages and maintain power to critical areas</li></ul>
 <b>Coastal</b>	<b>Underground Flood Protection</b> <ul style="list-style-type: none"><li>• Sealed vaults and pump systems to prevent water damage</li></ul>	

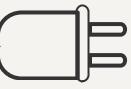


# Operational Enhancements



## **Solutions**

- 1 Perform Supervisory Control and Data Audit (SCADA) to evaluate the cable monitoring systems.
- 2 Field staff training to make sure workers are ready for any potential circumstances.



# Strategy Cost Estimation

1

Sheet contains estimate costs for each strategy and circuits applicable

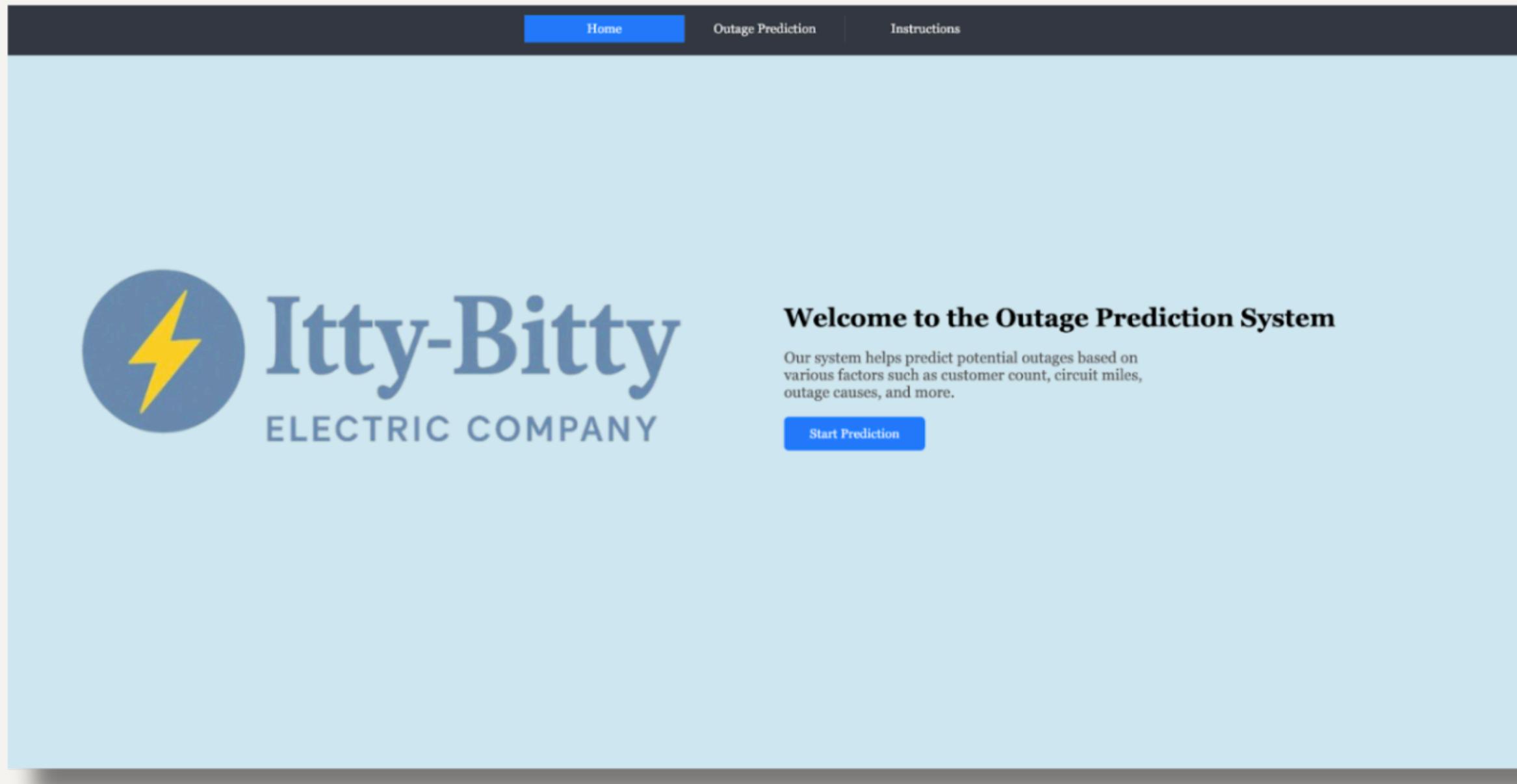
2

Costs account for **OH/UG percentage** and **circuits' total miles**

3

Calculated cost per mile and cost range to build a **comprehensive financial model**

# Outage Prediction Website



The screenshot shows the homepage of the Outage Prediction website. At the top, there is a dark navigation bar with three items: "Home" (highlighted in blue), "Outage Prediction", and "Instructions". Below the navigation bar, on the left, is the logo for "Itty-Bitty ELECTRIC COMPANY", which includes a blue circle with a yellow lightning bolt icon. To the right of the logo, the text "Welcome to the Outage Prediction System" is displayed in bold. Underneath this, a smaller text block explains: "Our system helps predict potential outages based on various factors such as customer count, circuit miles, outage causes, and more." At the bottom of this section is a blue button labeled "Start Prediction".

We utilized **Machine Learning** and **Flask** to build an interactive website.

The site allows users to input outage-related features and receive predictions for both **outage duration** and **number of customers affected**.

[Home](#)[Outage Prediction](#)[Instructions](#)

# ITC 2025 - Circuit Outage Prediction Website Demo

**Customer Count:****Circuit Miles:****Circuit Name:****Outage Cause:****KV Level:****Region:****Month:****Day of Week:****Predict****Watch on** **YouTube**

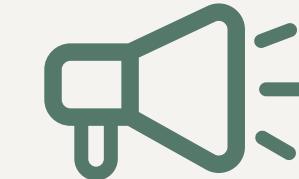
# Key Website Features



## Real-Time Outage Impact Assessment

The website offers **real-time updates and predictions** on current and upcoming outages, including estimated duration and impacted customers.

Enables proactive response, efficient resource allocation, and reduced service disruptions.



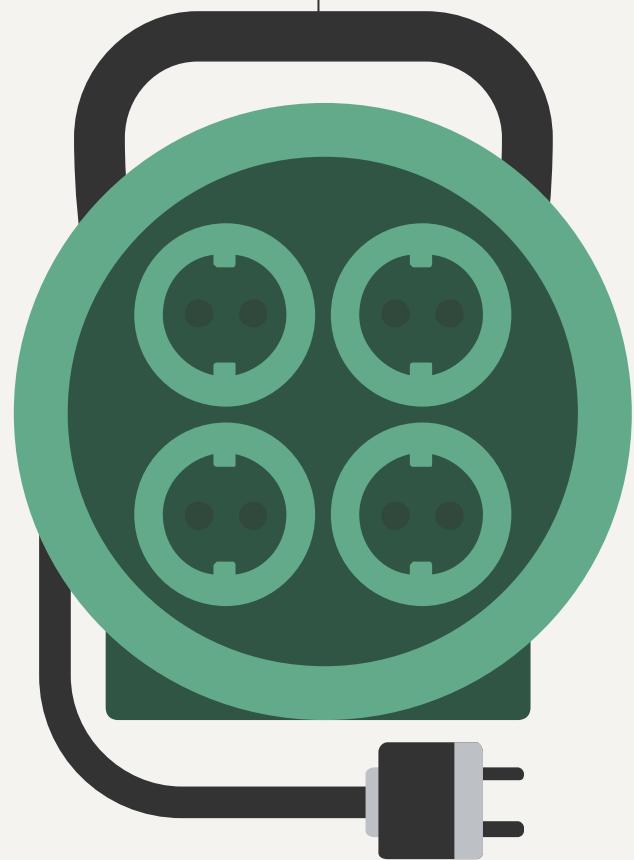
## Customer Alerts & Updates

The website would **notify customers** about ongoing outages through automated alerts via email, SMS, or mobile app.

Keeps customers informed with restoration estimates and updates, improving satisfaction and managing expectations.

# Implementation Plan

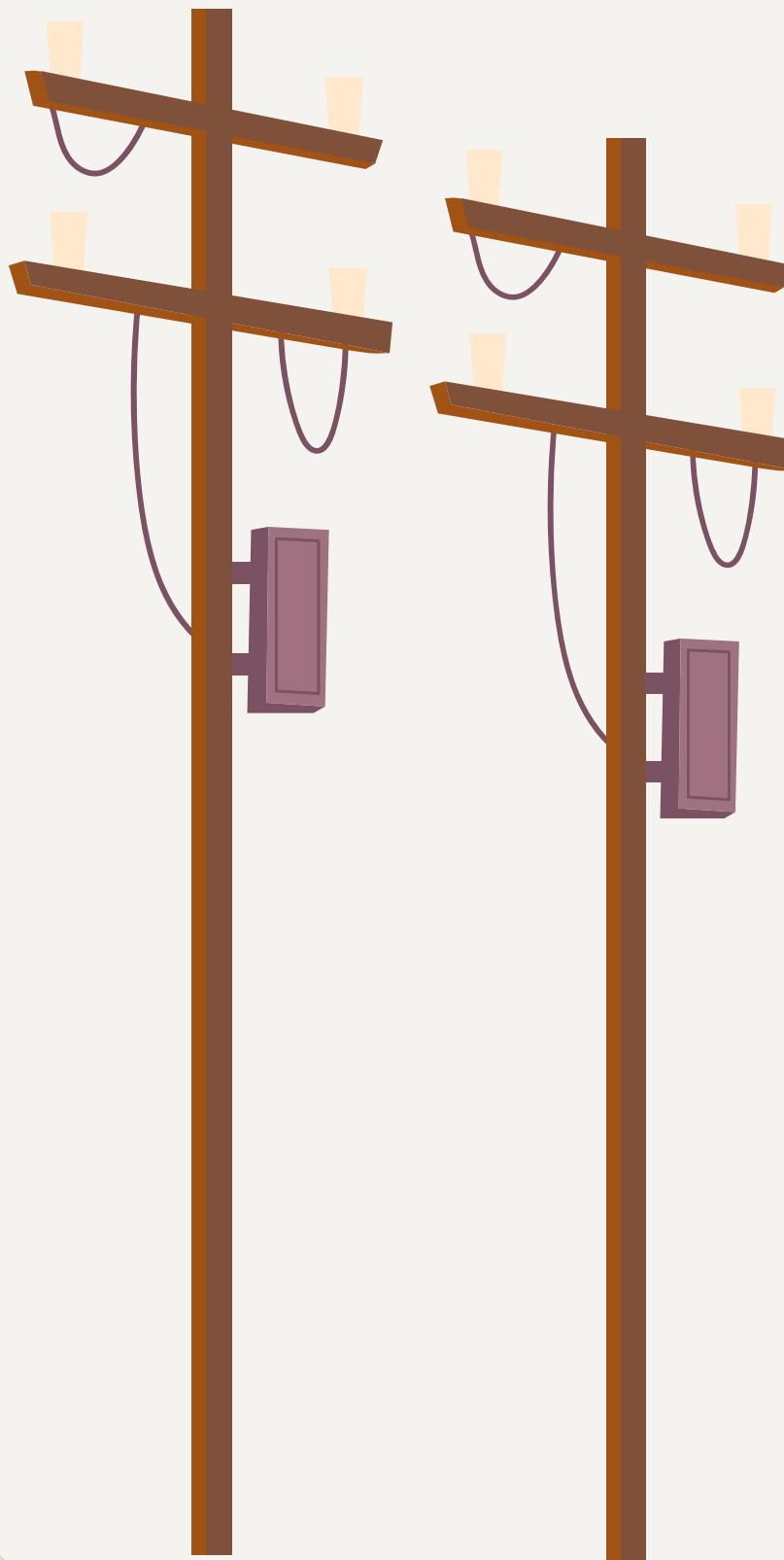
06



# Short-Term Plan (Year 1)

	Q1 (May - July)	Q2 (Aug - Oct)	Q3 (Nov - Jan)	Q4 (Feb - April)
Thunder Circuit	Conduct UG cable inspection using fault indicators Audit 3rd party damage locations	UG cable replacements in highest-failure zones	Install UG cable monitoring devices & pilot community alert system	Evaluate updated UG cable performance Review third-party incidents and adjust outreach program
Alabama Circuit	Conduct UG cable inspections & replace most vulnerable UG segments Start root-cause investigation for frequent failures	Being quarterly coordination meetings with city planning & contractors	Implement QR-coded asset tagging for quicker diagnostics	Review outage metrics & expand preventative maintenance
Green Circuit	Inspect water damage on UG systems & collect data on storm-related outage patterns	Replace compromised UG systems Apply corrosion-restraint treatments & clear vegetation ahead of storm season		Test enclosures for reliability & monitor post-storm metrics
Magenta Circuit	Audit OH poles for age/damage & identify animal hotspots	Install animal guard and weather-resistant gear Replace damaged OH equipment & implement drone inspections pre/post weather events	Roll-out third party alert system during construction	Evaluate post-weather performance
Logan Circuit	Map vegetation risk zones & operator error logs Begin vegetation trimming along critical lines	Replace aging OH equipment & insert smart reclosers and fault indicators Launch animal guard installations		Conduct full audit of CMI improvements & refine SOPs

# Data-Driven Intelligence



1

**Expand Data Collection:** Integrate outage data from newly activated circuits to uncover deeper performance insights

2

**Continuous Model Evolution:** Automatically retrain models with fresh data for smarter, faster adaptation

3

**Strategic Impact:** Unlock sharper predictions and enable precision-targeted maintenance and response strategies

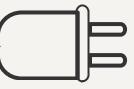
# Long-Term Plan

Circuit Name	KVs	Region	Outage Cause	Priority (Year)
Thunder	16	Mountain	Third Party, UG Equipment Failure	1
Alabama	12	North	UG Equipment Failure (3), Third Party	1
Green	12	Coastal	UG Equipment Failure (4), Other, Weather	1
Magenta	16	Mountain	OH Equipment Failure (3), Weather (3), Other, Third Party, Operation, Animal	1
Logan	16	North	OH Equipment Failure (4), Operation (2), Weather, Third Party, Animal, Vegetation	1
Jefferson	12	Coastal	UG Equipment Failure, Vegetation, Third Party	2-3
Dinan	12	Coastal	Other, UG Equipment Failure, OH Equipment Failure, Third Party, Animal	2-3
Blue Jay	16	Desert	Animal	2-3
Washington	12	North	Weather, Animal, Third Party	2-3
Johnson	16	Mountain	OH Equipment Failure, Third Party, Vegetation	2-3
Orange	4	Coastal	Other, Weather, Third Party	4-5
Gorilla	16	Desert	OH Equipment Failure (3), Third Party, Other, Weather, UG Equipment Failure	4-5
Hoover	12	North	Operation, UG Equipment Failure (3), Other, Animal	4-5
Yellow	4	North	Vegetation, Other, OH Equipment Failure (2), Operation, Weather	4-5
Lincoln	16	Mountain	Third Party, UG Equipment Failure (3), Operation	4-5
Adams	4	Desert	Operation, Vegetation	
Monterey	16	Desert	Other, UG Equipment Failure	
Roosevelt	12	Coastal	UG Equipment Failure (4), Weather, Operation (2), Animal, Other	
Grand	4	Mountain	OH Equipment Failure	
Oregon	16	Desert	Weather, OH Equipment Failure, Third Party	
Lightning	4	Mountain	Other	

In years 2-3, upgrade the next set 5 circuits, followed by the next 5 in years 4-5 to enhance reliability and customer satisfaction.



# Thank You!



# References

1. "Depth Requirements for Buried Electrical Cable." TGC Company, <https://www.tgccompany.com/depth-requirements-for-buried-electrical-cable/>. Accessed 25 Apr. 2025.
2. "The 9 Real Benefits of Conducting Asset Condition Monitoring Using Drones & AI." RocketDNA, <https://www.rocketdna.com/blog/the-9-real-benefits-of-conducting-asset-condition-monitoring-using-drones-ai>. Accessed 25 Apr. 2025.
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