REQUEST FOR PROPOSAL

ITTY BITTY ELECTRIC CO.

2022

Prepared By:
DATA IN MOTION

BRYCE MANDAP
DATA ANALYST

JEAN MILLAN
DATA SPECIALIST

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JOSE ORTIZ
UTILITY SME

ROSE ROLDAN
CRM SPECIALIST

Cover Letter

March 19, 2022

Mr. Jim Horstman
Director of T&D and CTO
Itty-Bitty Electric Company
3801 W Temple Ave.
Pomona, CA 91768

Dear Mr. Horstman:

On Saturday, March 19, Data In Motion received an invite from Itty-Bitty Electric Company (IBEC) to submit a Data Analytics Project proposal to address issues and improve the company's system reliability.

By partnering with Data In Motion on this project, IBEC will benefit from Data In Motion's 26+ years of analytical solutions service specialized in business operations and analytics in the U.S. Energy and Utility Industry. For this Request for Proposal, we assigned this project to a team of talented consultants highly skilled in data analytics.

Data In Motion has acknowledged all issues and requirements of this RFP and confirms our proposal submission. A detailed report will be submitted on April 2, 2022, and a presentation will be given on April 9, 2022.

Sincerely,

Data In Motion

Executive Summary

Background

On March 19, 2022, the Director of Transmission and Distribution (T&D) and CTO for Itty-Bitty Electric Company put forward a request for proposal to integrate data analytics into IBEC's operations. The request comes at a time when the occurrence of environmental events such as wildfires have increased and pose a significant risk to IBEC's distribution grid and negatively impacting reliability metrics.

Request for Proposal

IBEC has requested to propose ideal strategies, recommendations, and directions using analytical methodologies to fulfill their business troubles. Subjects of concern include:

- System Hardening Activities
- Vegetation Management
- Public Safety Power Shut Off
- Situational Awareness

Summarized Options

Summary of Data In Motion's solutions to improve IBEC's operations will include the following:

- System Hardening
    - Survey and document IBEC's existing data resources.
    - Improve data quality: data consolidation, cleaning, transformation, reduction on existing resources.
    - Perform a detailed descriptive analysis of historical records for context and understanding of infrastructure and behavior.
    - Engineering to implement new sources of data acquisition including IIoT devices, field equipment, and drones.
    - Perform determined system hardening practices, upgrading equipment and facilities.
    - Implement novel predictive analytic models to forecast investment opportunities.
- Vegetation Management
    - Utilize database to record previous and future vegetation management for descriptive & predictive analytics.
    - Integrate Light Detection and Ranging equipment for modeling of vegetation surrounding electrical equipment.
    - Integrate publicly available datasets from organizations such as California Department of Fish & Wildlife and organizations such as California Native Plant society for more efficient and environment friendly trimming, pruning, and cutting of vegetation.

- Public Safety Power Shutoff
    - Executing descriptive analytics to identify customer and governmental complaints.
    - Creating and establishing weather data sources and databases.
    - Enhancing forecasting proficiency with machine learning.
    - Applying machine learning to different aspects of PSPS such as circuit thresholds.
- Situational Awareness
    - Evaluate strategic plans and processes in IBEC's outage management and practices following Lean Six Sigma methods.
    - Implement and deploy support and resource services to remote locations during outages to consumers.
    - Survey and document consumers' feedback through customer research.
    - Have clear, accurate, and direct communication with consumers, media, government, and public via multiple communication channels.

About Our Consultants

DATA IN MOTION DATA ANALYST

BRYCE MANDAP is experienced with numerous analysis techniques. Capable with machine learning, data mining, descriptive and predictive analytics. Targets the issues IBEC has in regards to their Public Safety Power Shut Off. Bryce is currently scheduled to receive his Bachelors in Business with an emphasis in Computer Information Systems and Business Intelligence from California Polytechnic University Pomona in 2022.

DATA IN MOTION DATA SPECIALIST

JEAN MILLAN Supplies knowledge from a combination of work experience and academic knowledge learned through Cal Poly's learn by doing approach. Capable of providing transformed data for use in machine learning algorithms for actionable insights. His skills will be applied in improving IBEC's vegetation management. Jean will be graduating with a Bachelors in Business Administration emphasizing Computer Information Systems in May of 2022.

DATA IN MOTION OPERATIONS ANALYST

JENNY LAM specializes in operations and analytics processes. Her role will assist IBEC in implementing and executing processes to improve IBEC's operations, specifically increasing situational awareness to reduce the duration of outages while also supporting other service and system integrations. Jenny currently holds an executive position as Scheduler in the non-profit organization at Cal Poly's Operations Management Society club. She also supports Niagara Bottling under the Engineering Department as an Asset Management Intern, analyzing warranty data and providing plant support. Jenny will be recognized with the award of Bachelor of Science Degree in Business with an emphasis in Technology and Operations Management from California State Polytechnic University at Pomona in Spring 2022. Her award includes a minor in Computer Information Systems.

About Our Consultants (con't.)

DATA IN MOTION UTILITY SME

JOSE ORTIZ, having previously worked at various local light and power utilities as a designer, estimator, and project manager, he brings his subject matter expertise to help interpret and develop the ideal solutions. He will oversee System Harding and its corresponding activities, such as identifying existing facilities that may be compromising system integrity, opportunities where the infrastructure can be improved, and advantages which system engineers and designers can benefit from. With a background in Computer Information Systems, specializing in Business Intelligence, he will be a robust and integral resource to deploying a solution which IBEC will benefit from.

DATA IN MOTION CRM SPECIALIST

ROSE ROLDAN specializes in customer relationship management. Her role will assist IBEC in implementing ways in which IBEC can better communicate with their consumers and partners to improve response time. Rose currently holds the positions of Vice President of Marketing in Collegiate Entrepreneurs' Organization (CEO) and Secretary in Alpha Phi Omega (APO). Rose will be recognized with the award of Bachelor of Arts Degree in Psychology from California State Polytechnic University at Pomona in Spring 2022. Her award includes a minor in Computer Information Systems.

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System Hardening Activities

System Hardening

Grid and System Hardening refers to measures which minimize Public Safety Power Shutoffs (PSPS), a temporary safety related event. Measures implemented focus on increasing the resilience of the grid to improve reliability and reduce wildfire risk. Hardening is a holistic approach including facilities, communication, and documentation to better shield the infrastructure and deliver better service during extreme environmental events. There isn't a single approach to system harding, rather it is a custom solution determined by the utility's needs, system, and budget. A mix of carefully chosen options to address hardening and resilience must be made to counter wildfire events and mitigate potential vulnerabilities (Richard, 2017).

Typical versus Natural Disaster Outages

TABLE 1 | Types of outages

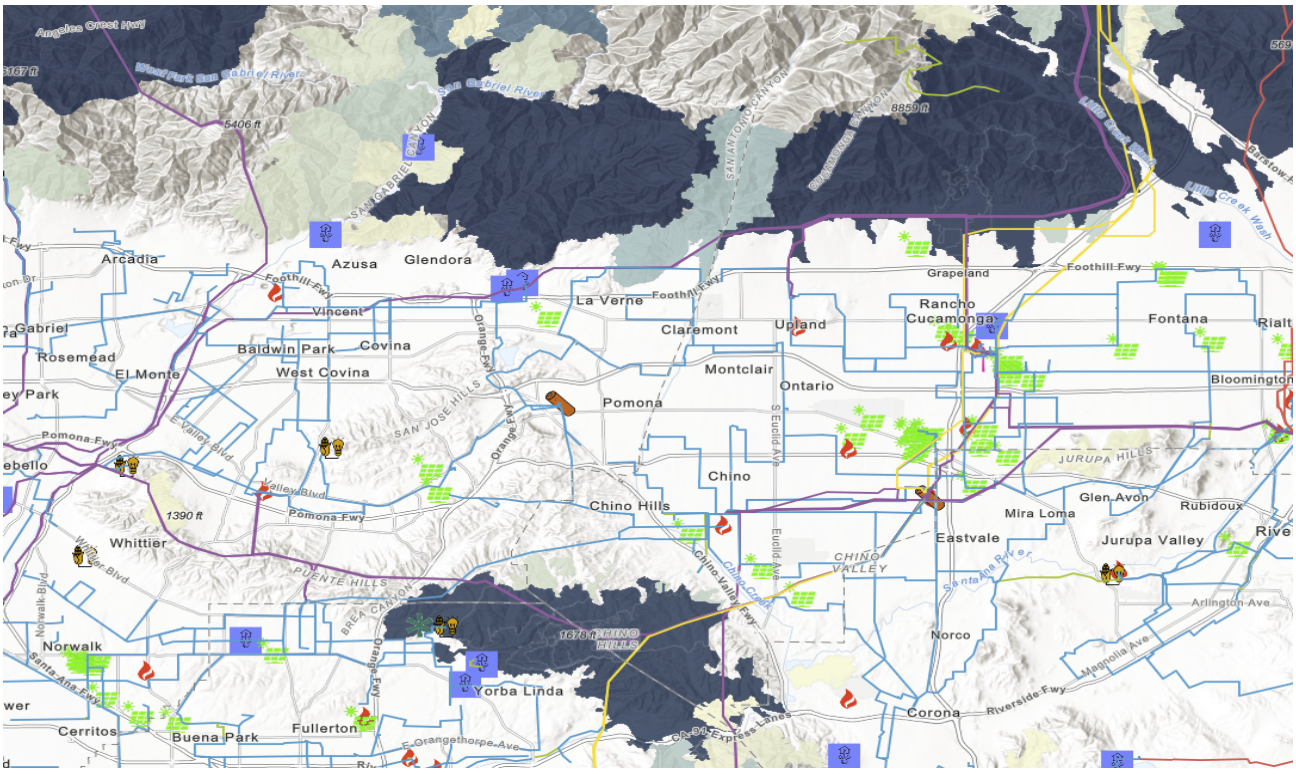
Typical Outages	Outages due to Natural Disasters
● Single fault due to one component failure. ● No stochastic feature involved in general analysis. ● No spatiotemporal correlation for the fault; fault happens randomly. ● Most power generation units are working and stay connected. ● Transmission & distribution net-work remain intact. ● Only involves the power grid's infrastructure. ● Quickly repair and restore.	● Multiple faults due to catastrophic damage. ● Uncertainty & stochasticity with the process of natural disasters. ● Spatiotemporal correlation for the faults due to natural disasters. ● Power generation units may be out of service. ● Transmission & distribution net-work are damaged and incomplete. ● Have interdependence with other infrastructures. ● Difficult to repair and restore, e.g., debris after the disaster.

(Wang et al., 2015, 5)

Priorities and Target Options

To determine investment priorities, target options and decision making descriptive analytics would first be utilized to become familiar with what has happened. Presented below is a visualization of various data sets related to wildfires in the Southern California Area. This has enabled a base understanding of the historical impact to the area and the facilities within it. With historical and in-house data and modern IIoT (Industrial Internet of Things) devices as inputs, predictive analytics can be applied to help understand current and potential threats so outcomes can be quickly addressed and resolved.

FIGURE 1 | Typical area map with burned regions, various transmission lines, and power facilities.



Hardening and Resilience Activities

Hardening Activities

Wind Protection

The wind is a major cause for system failures. However, several mitigation practices are available. Pole replacement programs which focus on the upgrading of damaged poles and structures are necessary to improve grid hardening. Installing a mix of composite poles or fire-resistant wrap around wooden poles are also effective mitigation efforts in the event a wildfire is wind driven. Bare conductors should be replaced with insulated wires where vegetation is known to be a complex variable, reducing the chances of arcing or sparking as a result of a dry branch or metallic balloons coming in contact with the bare wire, creating an arc, spark, and eventually a fault. Strengthening poles with guy wires, and possibly even burying the lines should the overhead solutions prove to be more of an impact.

FIGURE 2 | System Hardening objects

Modernization

Protective devices such as fast acting fuses, remote-controlled sectionalizers, fast-curve trip settings on circuit breakers during events. New technologies like Rapid Earth Fault Current Limiters (REFCLs) which limit the amount of current flowing through a line upon sensing a disturbance, which combined with other mitigation measures can potentially provide results

similar to undergrounding. Also, deploying sensors, control technology, and the Industrial Internet of Things. Finally, installing asset databases and tools.

Resilience Activities

General Readiness

A utility's general readiness activities should include improving communications and preparedness training, planning, and activities. Also, complying with inspections protocols, maintenance, and vegetation management by field crews and aerial devices such as drones or by helicopter will further improve system resilience. Participating with general assistance groups. Purchasing/leasing mobile transformers and substations. Procure spare transmission and distribution equipment.

Storm-Specific Readiness

Alternatively, storm-related readiness involves bolstering emergency measures and having them ready to deploy in the immediate aftermath of a storm. These activities include pre-staging materials and developing a plan for crew response (Leidos, 2017). Facilitate employee evacuation and reentry. Securing emergency fuel contracts. And supplying logistics to staging areas.

Innovative Measures

Due to the complexity of the issue, it involves interdisciplinary techniques such as statistics, meteorology, power engineering, optimization, communication and control, as well as policies and regulations (Wang et al., 2015, 7). However, creative solutions may nevertheless be implemented for example, by uncovering the need for the utility to move overhead lines underground to reduce the impact, while increasing operational readiness through fire

management efforts like replacing wood poles for composite ones. Another example of implementing these measures is the need to focus on pole line location and design. Specifically, the utility may look at optimizing structure poles and line design to improve line access to minimize a storm's impact (Richard, 2017).

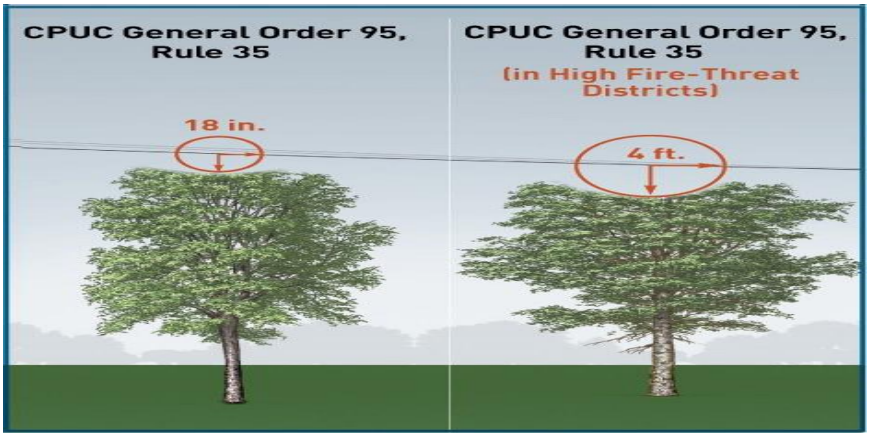
FIGURE 3 | Drone in flight

Vegetation Management

Vegetation Management Overview

Vegetation Management is an essential task that must be completed to ensure the continual distribution of electricity that provides power to cities, workplaces, and homes enabling residents to conduct their daily lives, without interruption. Vegetation management consists of maintenance tasks such as trimming, pruning, and cutting of trees or shrubs in order to create and maintain a clearance zone around electrical equipment. The trimming, pruning, and cutting of trees as well as shrubs that are in close proximity to components of an electrical grid is a necessity. It is also important to note that federal regulations require areas that are inside of a designated High Fire Risk Area to maintain a larger clearance zone(Federal Energy Regulatory Commission, 2020).

FIGURE 4 | Reliability Standard FAC-003-4



The lack of vegetation management can have devastating effects on a community and its members. As one example highlights, the 2021 Dixie Fire devastated Northern California burning over 900,000 acres of land and over 1300 structures when a tree came into contact with a

power line that is owned and operated by Pacific Gas & Electric company (Reardon, 2022). To underscore the importance of maintaining the clearance zone around electrical equipment. Before the Dixie Fire broke out in 2021,one of the worst fires in California history (Cal Fire, 2022), PG&E reached a settlement for over $13 billion for lawsuits involving numerous wildfires where equipment from the utility company was found to be a significant factor stemming back to 2017 (CBS/Reuters, 2019).

FIGURE 5 | Photo of Dixie Fire Raging Through Vegetation

Traditional Approach to Vegetation Management

Vegetation management has historically involved manually completed inspections by maintenance crews that are required to conduct individual inspections of power lines located along right-of-way easements for encroaching vegetation. The duties may be outsourced to third party contractors that conduct the clearance of encroaching vegetation. Crews performing maintenance would be required to drive for hours and miles upon miles to complete their inspections of power lines(Divis & Guide, n.d.). Requiring crews to drive to each power line for inspection was necessary but inefficient due to the size of the geographical region such as Southern California that may require years to complete an inspection. (Divis & Guide, n.d.) In addition, Subject matter experts such as environmental biologists are consulted to identify

different species of trees and other vegetation to understand the risks imposed on the electrical equipment by trees that may grow too tall and come in contact with power lines or trees that are unhealthy and may fall on to the power lines (Taylor, 2013). Having a clear and accessible path for maintenance crews to reach power lines is also an important factor (Taylor, 2013). Approaching vegetation management in this way is time consuming and resource intensive that requires the repetition of crude methods in an insufficient manner.

Innovative Approach to Vegetation Management

Utilizing data analytics methods to accommodate vegetation management is a necessary step to increase its overall effectiveness by providing maintenance crews with information on which areas require their attention. Combining expertise of crews and analytics tools that identify which local vegetation can lead to issues facilitates approaching the task in a manner least impactful on the environment.

Data Storage

For no existing database available in house, there are external providers of databases that can be brought in to facilitate storage from companies such as Trimble, Accenture, or Pacific Data Integrators that have products available to facilitate IBEC's evolving analytical capabilities. Data analytics will enable IBEC to store any new incoming data and input past records to provide insight on future vegetation management plans. With analytics guiding IBEC's vegetation management their resources will be applied by developing a better understanding of different species vegetation and how it might impact equipment.

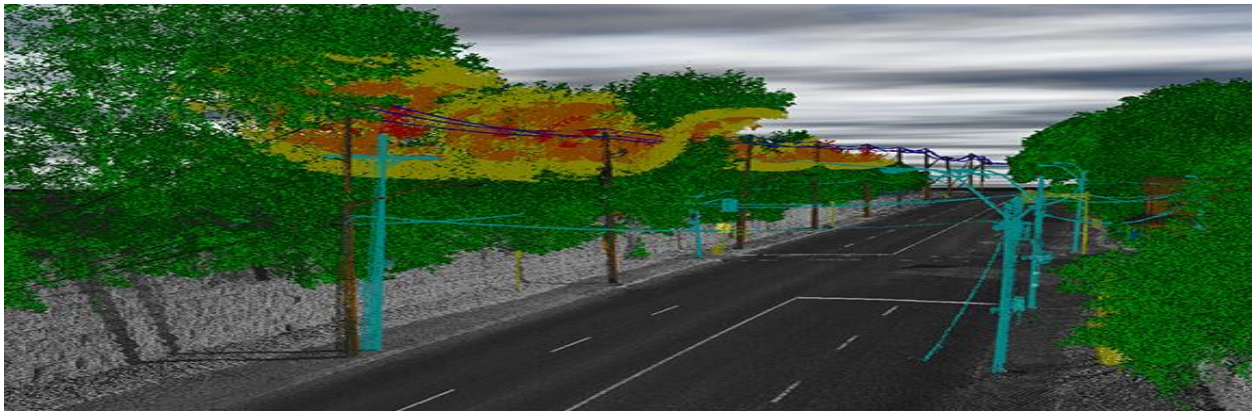
Data Collection

There are a number of ways technology can be leveraged to create actionable insights on developing strategies to execute and monitor vegetation management without the need to send maintenance crews on surveys to each pole without foreknowledge of what to trim, prune, cut or remove.

LiDAR (Light Detection and Ranging) has penetrated the industry of vegetation management with its capability to create high resolution models of ground elevation with an accuracy of 10 centimeters (U.S.G.S, n.d.). LiDAR is typically attached to small aircrafts that include unmanned air vehicles such as drones that uses GPS (Global positioning system), which comprises satellites along with devices that receive data used to determine the location of something on earth (Warren, 2011), INS (Inertial Navigation System), that determines where the device is in relation to where it started (Oxford Technical Solutions, n.d.), and a laser scanner that sends pulses of light to the ground to determine the distances between the scanner and the ground by calculating the travel time of the pulse reflections back to the LiDAR system. The benefit LiDAR offers is the capability to create digital models of IBEC electrical equipment and surrounding vegetation with precision in creating a profile of individual trees that can later be used in analysis to identify unhealthy trees. Using LiDAR will keep crews out of harm's way by minimizing the amount of inspections crews are required to complete for vegetation management protocols by sending out crews to locations where trimming, pruning, or cutting of trees is necessary. LiDAR does have factors that limit its effectiveness in certain areas. Factors that can affect LiDAR are alignment of the coordinate system, quality of point data, point density, vegetation height thresholds, vegetation density in the canopy, wind that affects the leaves, leaf-on and leaf-off seasons, forest cover effects, complex vegetation cover, size of individual

trees, undergrowth of herbs, shrubs' areas, wood quality, birds in the vicinity, slope and elevation of the terrain, terrains with high and low reliefs, data recruitment times and dates, aircraft fluctuations, the distance between LiDAR sensor and trees, pulse mode, site conditions, weather, interpolation of points, stitching accuracy, and the LiDAR sensor itself (Alam, 2016). In the cases where LiDAR is ineffective, maintenance crews will be required to conduct inspections on location.

FIGURE 6 | A sample of LiDAR data used to create high-resolution model

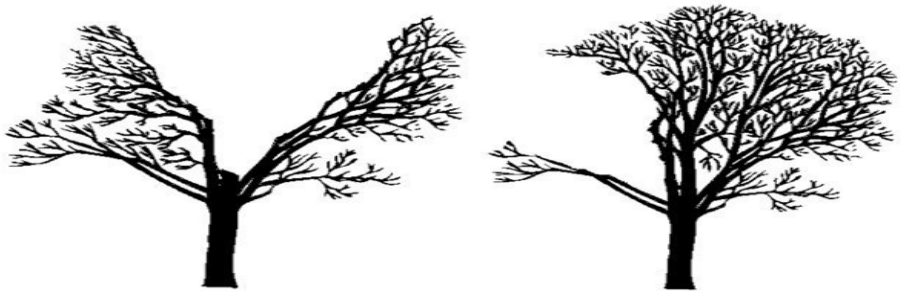


Connecting subject matter experts with IBEC's internal team will improve the understanding of the species of vegetation in regions where IBEC equipment is located. Pulling from available data sources provided by government agencies such as the California Department of Fish & Wildlife and organizations such as California Native Plant society. With subject matter experts advising on different species of vegetation present, consideration for a particular tree's characteristics such as rate of growth for one species versus another species may be accounted for when developing action plans (Dhanesha, 2021) and limiting the damage done to local vegetation.

Gaining Information from Data

Once the method for storing data is determined, utilizing the information gathered from analysis of data from machine learning will enable tailor made strategies as mentioned previously that account for species of trees and brush and the different rates of growth given the conditions such as climate, elevation, and proximity to equipment. Consulting with subject matter experts when conducting analysis will increase the effectiveness of categorizing vegetation into risk categories and will greatly increase the ability to prioritize locations that require greater vegetation management monitoring. Trees that may be unhealthy and pose potential hazards to power lines can be identified through analysis of LiDAR models to be designated for removal to prevent contact with IBEC equipment and to prevent spread of disease to nearby vegetation. It is important when maintaining a clearance zone to minimize the damage done to the tree when trimming or pruning to limit the need for the task in the future by directing the regrowth of the tree and reducing internal decay and keep the structural integrity of the tree (Divis & Guide, n.d.).

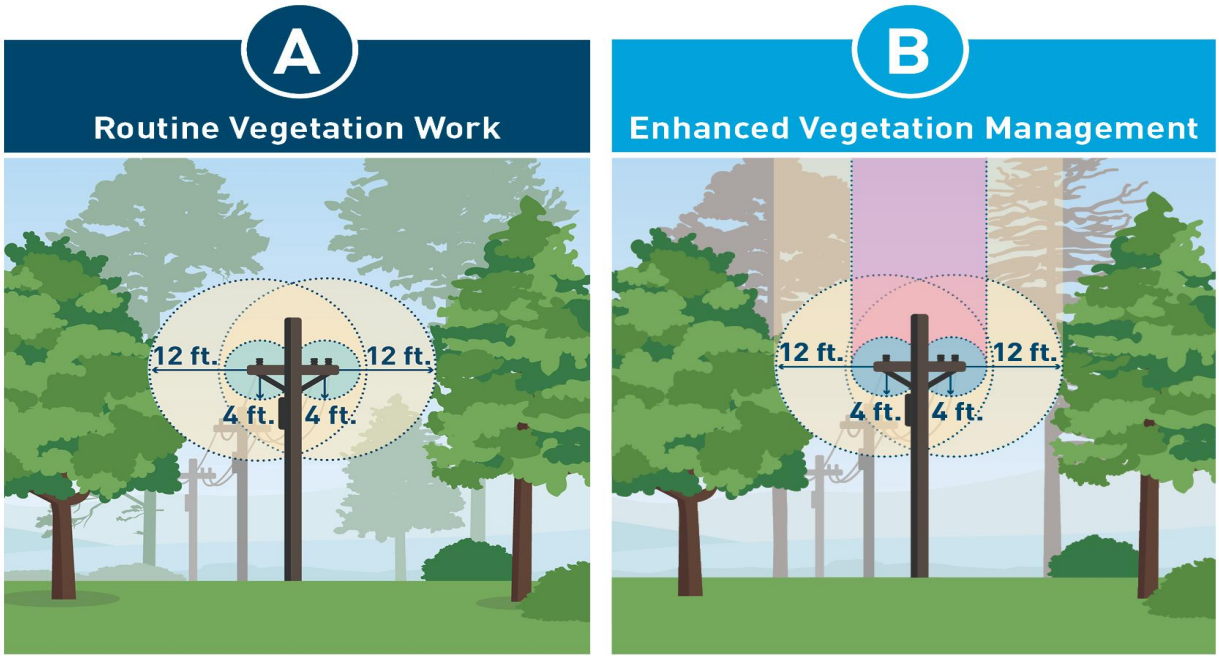
FIGURE 7 | Directional Pruning



Outcomes of Innovative Measures

The benefits of having databases will provide a valuable resource tool to store information regarding vegetation management for analysis. LiDAR will provide digital models of vegetation and electrical equipment for visualization and analysis to determine the health of present vegetation and verification of clearance zones. Publicly available datasets in conjunction with subject matter experts will improve use of resources and decrease damage to the environment when performing vegetation management. By improving vegetation management there will be a reduction of a wildfire and blackout occurring where IBEC would be held liable and suffer monetary and reputation damages.

FIGURE 8 | Comparison of traditional vegetation management and a modernized approach



Public Safety Power Shut Off, PSPS

While the previously mentioned system hardening and vegetation management capabilities can help IBEC with wildfire mitigations, emergencies do happen. Due to the unfortunate wildfires that have destroyed over thousands of miles of land, the CPUC (California Public Utilities Commission) has required electric utility companies to acquire a last resort protocol to further mitigate weather damages. This protocol is referred to as PSPS (Public Safety Power Shut Off). A PSPS protocol proactively initiates temporary de-energization to circuits that meet a specific criteria of potential danger from weather conditions. By shutting off dangerous circuits, it reduces the chance of fallen power lines that cause public damage and ignites wildfires. While this protocol is appreciated for its mitigation intent, its de-energization immediately impacts customers that are reliant on the circuits. Due to the early stage of this mitigation protocol, we realize IBEC can receiving criticisms regarding its overall effectiveness.

Processing and Analyzing Customer Criticisms

Due to the large-scale impact PSPS can have on IBEC's customers, there can be a multitude of criticisms on its successfulness. To determine where IBEC should focus their resources to improve their PSPS program, they need to proficiently categorize and analyze their customer and governmental criticisms. Our team will provide enhanced descriptive analysis techniques along with statistical measurements to identify and specifically target the most demanded improvements.

Implementation

The first step to execute this process requires IBEC to have an internal customer /governmental complaint database. This database requires certain attributes in order to maximize potential business insights. The data attributes needed can include customer demographics, complaint descriptions, and the time of complaint. An example of a customer database that is proficient can be seen in *Figure 9*. If IBEC does not have the resources to internalize their complaints, we can offer suggestions in-house. We will then offer our data analysis and visualization tools to be implemented with your internal database.

The software needed to project these results can simply include Excel and R-Studio. These are cost effective tools that are easily acquired. The softwares mentioned will be introduced and/or further implemented with your current PSPS team and customer service department. It is important that these two operations work in synergy to acquire the best results for improving PSPS.

Projected Results

While we currently don't have access to your internal customer data, we applied these techniques to PG&E's (Pacific Gas and Electric Company) customer complaint database. Examples of such analytical products can be seen in *Figures 10-12* . The methods used in reference to PG&E will be performed in IBEC's customer database when received.

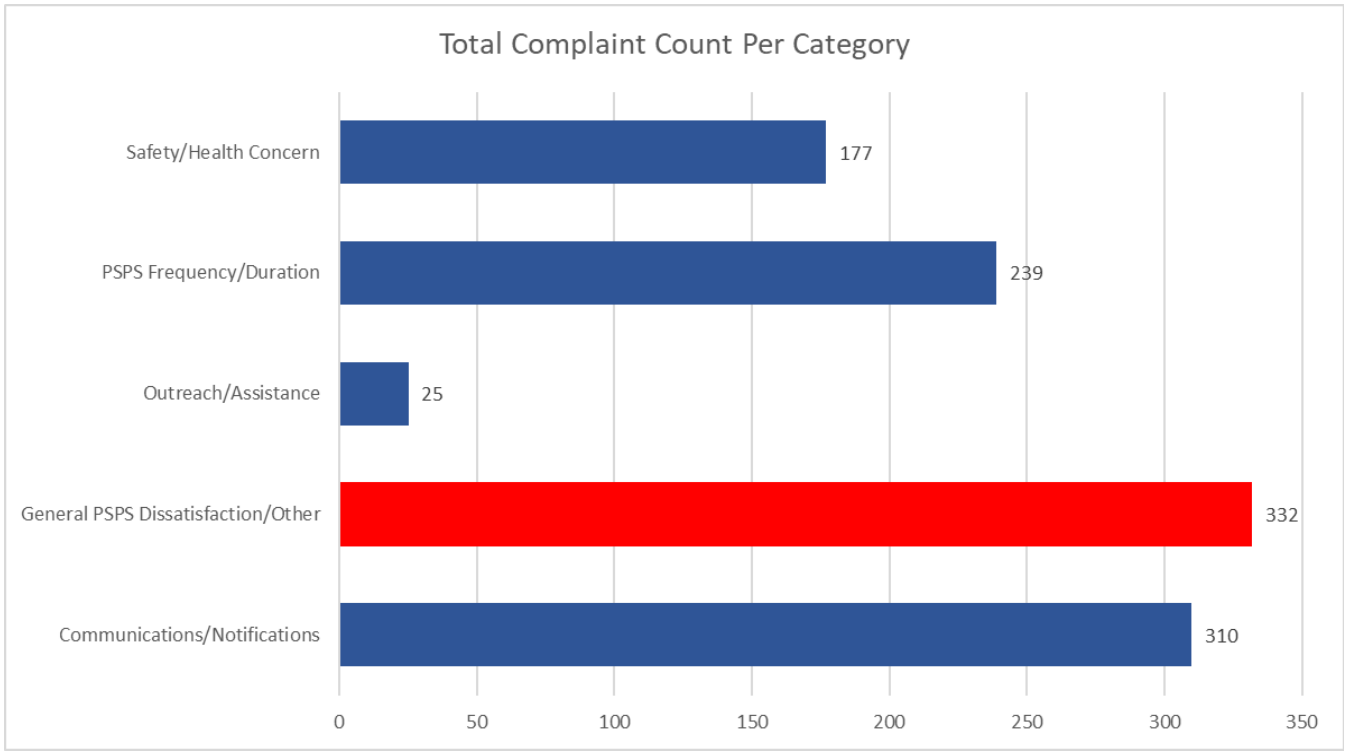
FIGURE 9 | Example of PG&E Customer Complaint Records

Source:https://www.pge.com/en_US/residential/outages/public-safety-power-shuttoff/psps-reports.page

Complaint Number [1]	Complaint Received Date	Complaint Avenue	Resolution [2]	Location (City, County, Zip) [3]	PSPS Event Date Range	Complaint Category	Complaint Category Definition
1	8/16/2021	CC&B	N	MAGALIA,CA	August 17 - 19, 2021	Communications/Notifications	Communications/Notifications = Including, but not limited to complaints regarding lack confusing notice, false alarm notice, problems with getting up-to-date information, inacc being able to get information in the prevalent languages and/or information accessibility, Safety Partner Portal, REST/DAM sites (as applicable)
2	8/16/2021	CC&B	N	ANDERSON, CA	August 17 - 19, 2021	Communications/Notifications	Communications/Notifications = Including, but not limited to complaints regarding lack confusing notice, false alarm notice, problems with getting up-to-date information, inacc being able to get information in the prevalent languages and/or information accessibility, Safety Partner Portal, REST/DAM sites (as applicable)
3	8/16/2021	CC&B	N	Unknown	August 17 - 19, 2021	Communications/Notifications	Communications/Notifications = Including, but not limited to complaints regarding lack confusing notice, false alarm notice, problems with getting up-to-date information, inacc being able to get information in the prevalent languages and/or information accessibility, Safety Partner Portal, REST/DAM sites (as applicable)
4	8/16/2021	CC&B	N	COTTONWOOD, CA 96022	August 17 - 19, 2021	Communications/Notifications	Communications/Notifications = Including, but not limited to complaints regarding lack confusing notice, false alarm notice, problems with getting up-to-date information, inacc being able to get information in the prevalent languages and/or information accessibility, Safety Partner Portal, REST/DAM sites (as applicable)
5	8/16/2021	CC&B	Y	NAPA, CA, 94558	August 17 - 19, 2021	Communications/Notifications	Communications/Notifications = Including, but not limited to complaints regarding lack confusing notice, false alarm notice, problems with getting up-to-date information, inacc being able to get information in the prevalent languages and/or information accessibility, Safety Partner Portal, REST/DAM sites (as applicable)
6	8/16/2021	CC&B	N	REDDING, CA, 96003	August 17 - 19, 2021	Communications/Notifications	Communications/Notifications = Including, but not limited to complaints regarding lack confusing notice, false alarm notice, problems with getting up-to-date information, inacc being able to get information in the prevalent languages and/or information accessibility, Safety Partner Portal, REST/DAM sites (as applicable)
7	8/17/2021	CC&B	N/A	Unknown	August 17 - 19, 2021	Safety/Health Concern	Safety/Health Concern = Including, but not limited to complaints regarding difficulties e populations, traffic accidents due to non-operating traffic lights, inability to get medical water, inability to keep property cool/warm during outage raising health concern
8	8/17/2021	CC&B	N	Unknown	August 17 - 19, 2021	General PSPS Dissatisfaction/Other	General PSPS Dissatisfaction/Other = Including, but not limited to complaints about bei event and related hardships such as food loss, income loss, inability to work/attend scho complaints that do not fall into any other category
9	8/17/2021	CC&B	Y	PARADISE, CA 95969	August 17 - 19, 2021	Communications/Notifications	Communications/Notifications = Including, but not limited to complaints regarding lack confusing notice, false alarm notice, problems with getting up-to-date information, inacc being able to get information in the prevalent languages and/or information accessibility, Safety Partner Portal, REST/DAM sites (as applicable)
10	8/17/2021	CC&B	N	Unknown	August 17 - 19, 2021	Safety/Health Concern	Safety/Health Concern = Including, but not limited to complaints regarding difficulties e populations, traffic accidents due to non-operating traffic lights, inability to get medical water, inability to keep property cool/warm during outage raising health concern
11	8/17/2021	CC&B	N	94567	August 17 - 19, 2021	General PSPS Dissatisfaction/Other	General PSPS Dissatisfaction/Other = Including, but not limited to complaints about bei event and related hardships such as food loss, income loss, inability to work/attend scho complaints that do not fall into any other category

Attributes included in PG&E's database contains: Complaint Number, Complaint Received Date, Resolution, Location, PSPS Event Date Range, Complaint Category, and Complaint Category Definition. These are attributes that are similarly needed within IBEC's internal customer database.

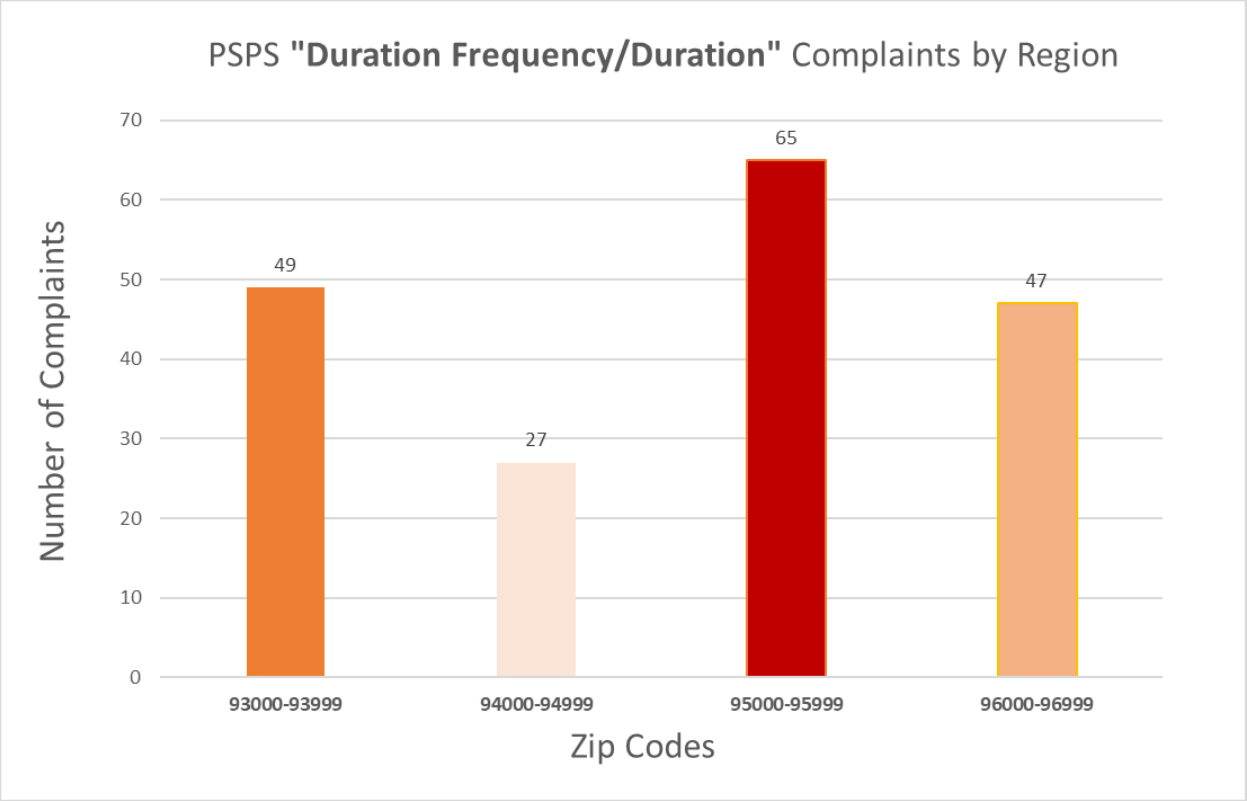
FIGURE 10 | Frequency Chart created from PG&E Database



Frequency chart made in-house. X-axis represents the no of complaints , y-axis represents the categorized customer complaint.

This bar chart can identify which concerns are least/most frequent. This can offer IBEC insight on priority in regards to which section of PSPS to improve first. For instance, PG&E appears to be succeeding in customer assistance. However, they lack in areas of Communication Capabilities. The "General PSPS Dissatisfaction/Other" section contains complaints that are more broad/random miscellaneous that could not be categorized in other sections.

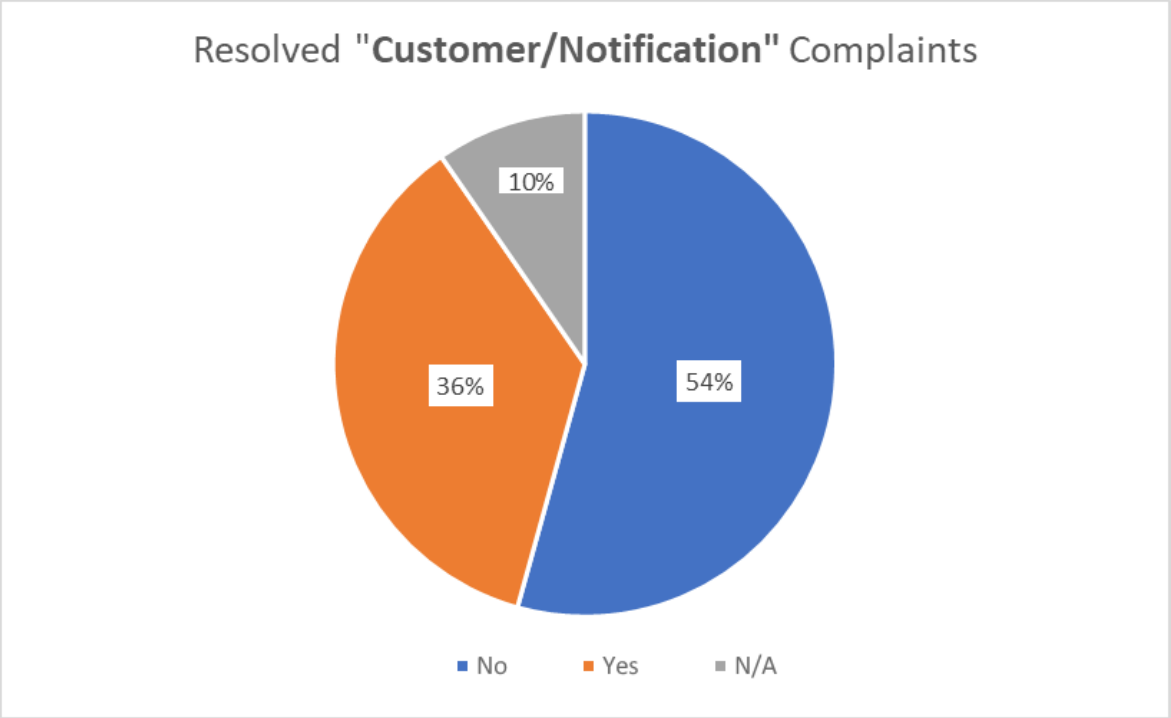
FIGURE 11 | Number of Complaints per Region (zip code) created from PG&E Database



This frequency chart visualizes the amount of "Duration Frequency/Duration" criticisms per geographic region (specified by zip codes).

This chart can identify the areas that have the most complaints. For instance, the zipcodes from 95000-95999 have had the most complaints about durations. Therefore, it is probable that these areas need more improvement regarding PG&E's response time.

FIGURE 12 | Pie Chart from PG&E Complaints



PG&E inputed data on whether or not their team disputed each complaint respectively. This pie chart diagram focuses attention on complaints that have and have not been addressed. This can help PG&E understand if they have attempted to improve certain complaints.

These diagrams are most effective when analyzed in parallel. For instance, PG&E can cross reference the pie chart information with the frequency chart to determine if their methodologies for resolution are working efficiently.

PSPS Preparedness and Effectiveness

We understand that customer safety is the company's main priority when accounting for the effectiveness of a PSPS program. To help maximize the safety of your consumers, we want to improve your weather forecasting abilities by enhancing your PSPS preparedness. Forecasting weather can be an extremely difficult task to do, especially with precise accuracy. However, this

does not make us stray away from the possibilities it can hold for providing safety towards your patrons.

Establishing Additional Weather Data Sources

Before we recommend and implement analytical strategies to enhance your forecasting systems, we need to establish your weather data sources. It is crucial to have readily available weather data to have a successful forecasting ability.

Assumptions from IBEC in regards to weather related assets:

1. IBEC has an established weather department with assets such as meteorologists, weather reporting technologies, and etc.
2. IBEC communicates with multiple different weather stations throughout California to receive weather data.

The open source data services we are planning to use in conjunction with IBEC's internal weather data can be found below in *Table 2*.

TABLE 2 | External Weather Data Sources

Services:	Available Data
SAWTI - Santa Ana Wildfire Threat Index	● Forecasts Wildfire Potential in southern California zones. ● Categorizes fire threats, wind strengths, and fuel moistures.
Alert Wildfire	● Real time videos of California Regions ● Monitor and Observe HFRA (High Fire Risk Areas)
CAL FIRE - California Department of Forestry and Fire protection	● Real time weather data throughout California with NWS (National Weather Service) ● Historical Wildfire Information/data ● Red Flag Warnings and Fire Weather Watches
Synoptic	● Provides locations of weather stations used for electric utility companies. ● Includes thorough real-time weather variables

These sources offer additional value to your internal weather team to help communicate potential threats to your PSPS system. While this data can be useful for IBEC's internal weather team, we also plan on collaborating with our weather analytic partners that work with us to provide advanced weather analytical services.

Improving Weather Forecasting Capabilities

A PSPS event starts with the level of granularity and accuracy their forecasting models can offer. To focus attention on enhancing your forecasting abilities, IBEC needs to implement a machine learning algorithm that can work in accordance with your established weather team. A machine learning model is a computational algorithm that can learn from historical data to help predict and uncover unknown relationships. In this case, our recommended machine learning model will make advanced predictions on weather events based on historical weather data. This model will not only help predict wildfire occurrences, but other concerning variables including temperatures, wind speeds, wind directions, and humidity levels that can be of equal danger to IBEC's customers and infrastructure. It can also be used in assistance to determine PSPS events; this will be further mentioned in detail in section *Machine Learning Applicability*.

Implementation

Successful implementation requires multiple resources to be provided. First, IBEC's internal historical weather databases and external weather sources mentioned above must be readily available. This allows the model to input consistent and reliable weather data to increase its performance. If IBEC does not currently have an established internal weather database, we recommend starting with the provided data sources, previously listed in *Table 2*. Specifically SAWTI and CAL FIRE since they provide weather data in an excel format that can be easily

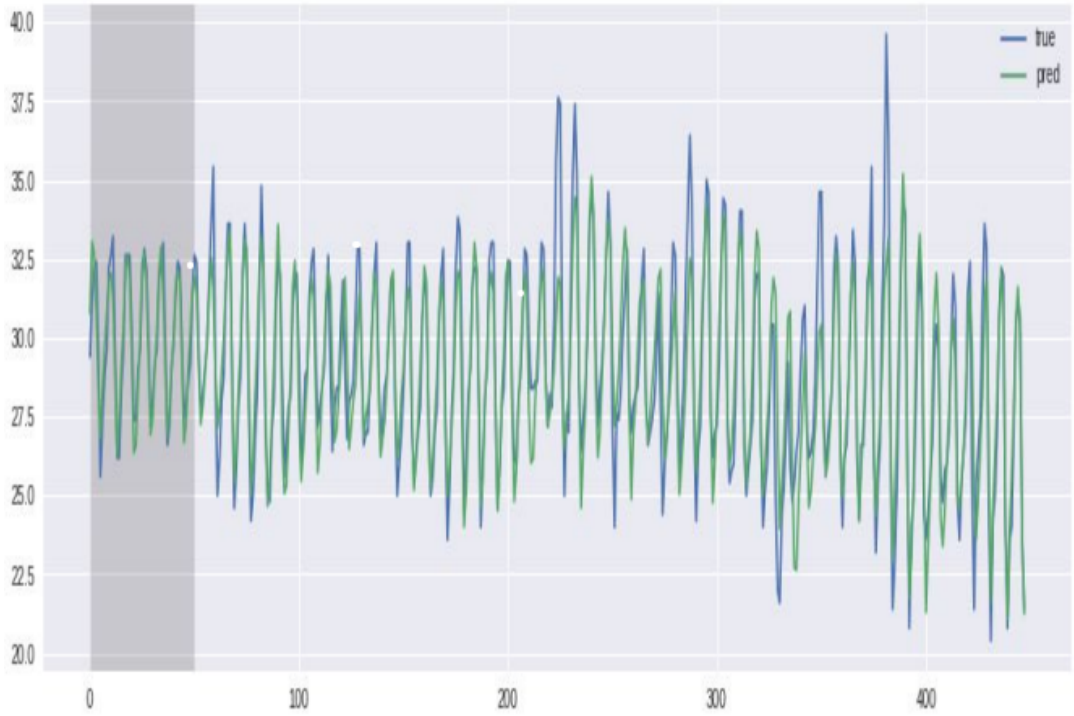
transferable to your team. While this data is useful, we would advise IBEC to establish an internal database in the future to use in-house assets for more granular data.

Python will be our main programming language for our machine learning purposes. However, we recognize that the expertise and skills required to work with a machine learning model may require a learning process. Therefore, we will deploy a team to regularly teach and audit this tool until IBEC can maintain it independently.

The software used for this model can include TensorFlow and Shogun. After meeting with your weather department we will reference and discuss the intended software that best works for your team. An example of machine learning predicting weather variables can be seen in *Figure 13*.

FIGURE 13 | Actual v. Predicted Temperature with RNN (Recurrent Neural Network)

Source:https://deliverypdf.ssrn.com/delivery.php?ID=730022068104123006113065121127114094125005035067064043105082099027064120011088081109059117052062000025007006022092127119093101050010068062039005094005022069015004076007010015004115099095117074118072016104109066087083098116113030112121087014121006117069&EXT=pdf&INDEX=TRUE



The temperature predicted is the green line, and the actual temperature is the blue line. The x-axis shows the sequence number of test data, and the y-axis is the temperature.

This graph is an example of the predictive capabilities in machine learning. It is showing the tested/predictive data against real weather data. To reemphasize, the predictive line is computed from historical weather data. Based on the visuals, it performed extremely well. This model will then continue to project predictive weather data. To maintain its performance, the model needs to be regularly examined against real data.

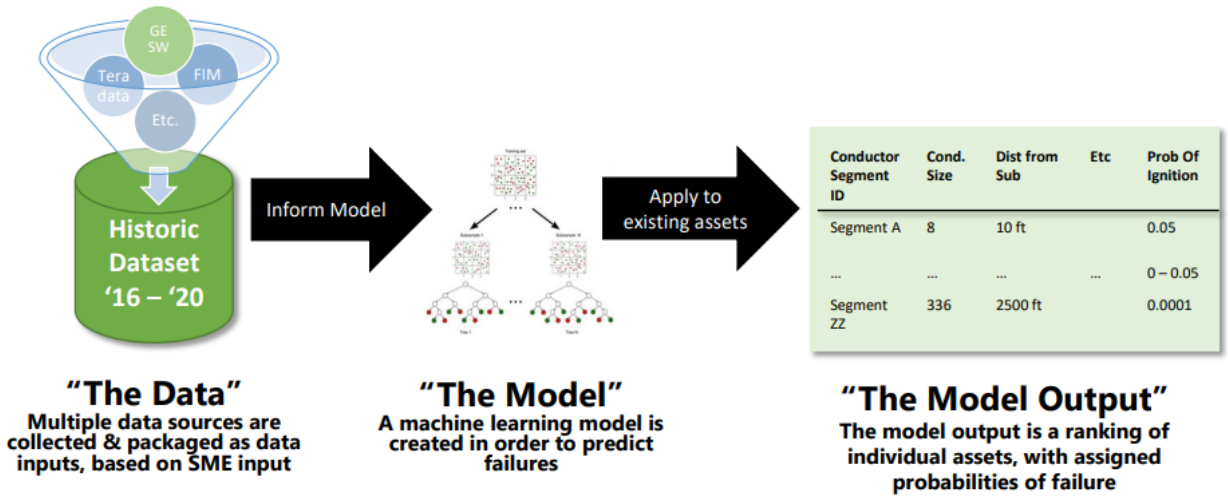
Machine Learning Applicability - Circuit De-energization Thresholds

Deciding to activate a PSPS requires several factors to be considered. One of these factors can include de-energization thresholds. At the distribution level, each electrical circuit has a specific threshold at which the provided electric utility company establishes and monitors

to determine when they must be de-energized for public safety. This threshold is typically determined by the level of FPI (Fire Potential Index) and IPW (Ignition Probability Weather). Since FPI and IPW are determined and calculated with weather variables such as moisture levels, wind speed, etc. our machine learning model can work hand-in-hand with your threshold decision criterias. The model can help improve the accuracy of forecasting which in return can allow your weather department to be aware of certain circuits, meeting the thresholds in advance. This can give IBEC a faster response time to potential dangerous weather events. References to how these models will work can be seen below:

FIGURE 14 | Process of Machine Learning

Source: https://efiling.energysafety.ca.gov/eFiling/Getfile.aspx?fileid=51785&shareable=true



This figure represents the flow of Machine Learning. The first step of this process is to collect historical data. It is important to have these datasets precise and consistent. Given the provided data, the model will be created based on the analysis algorithm best suited for the business need. After the model is created, we will run the model to predict the desired results. In this diagram specifically, SCE (Southern California Edison) is attempting to predict which assets will fail "Prob of Ignition". They used the decision tree machine learning algorithm for their model. Their model ranked the assets in descending order with the highest probability of failure.

Situational Awareness

Overview

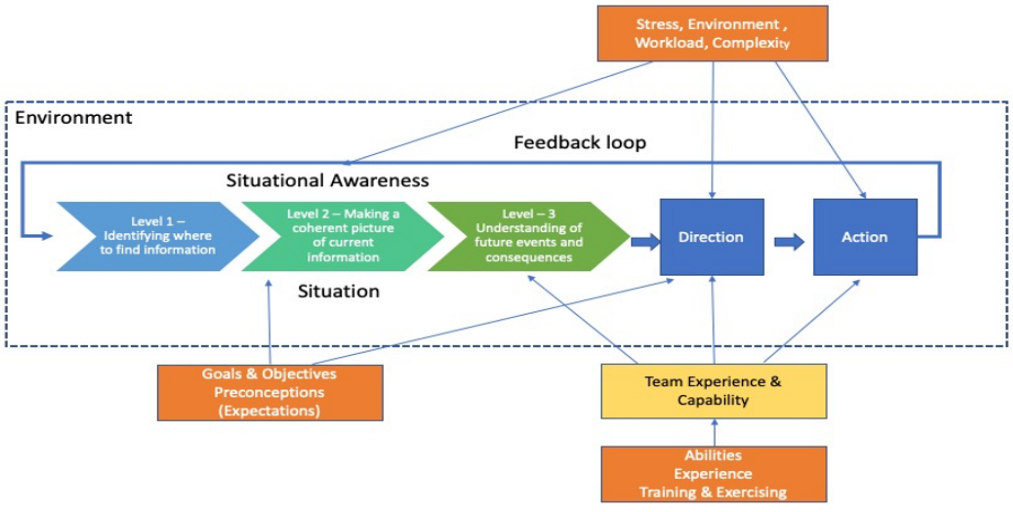
Electricity is essential in operating all types of appliances to support consumers in businesses and homes. All aspects considered in situational awareness play a major role in IBEC's overall performance in events of outages and fieldwork. It is crucial for IBEC to maintain a high level of situational awareness to ensure a high level of safety, productivity, and quality. For IBEC to maintain high consumers' satisfaction, it is important to operate a service with fast response and restoration time. To successfully improve response and reduce the duration of outages, several factors are considered to improve IBEC's operations.

Reducing Duration of Outage

With the recent negative impact on the reliability of IBEC's system, a comprehensive review and redesign of the company's strategic plans and processes will help achieve operational excellence.

FIGURE 14 | Model for Situational Awareness

Source: https://www.b-c-training.com/bulletin/a-model-for-situational-awareness



A successful execution will always require effective planning, readiness, and communication. The most important step to managing events is having a defined event scope that outlines all activities, resources, timelines, and goals. Operations to restore outages will require a wide range of tasks. IBEC must determine the order of tasks to be executed and how those tasks must be approached. Organizing the tasks will be determined by the level of importance and urgency. Many utility companies such as SCE give immediate attention to their pain points, such as frequently impacted circuits, and saw a 70% reduction in duration. This does not mean IBEC will disregard other affected areas. Optimizing productivity processes and minimizing its bottlenecks will help reduce the duration of outages. To help maximize efficiency, IBEC must also consider the number of distributed workers and equipment to precise locations. Having high activity in the wrong areas will result in the company incurring high expenses (Rubinetti, 2019). This can be prevented by having a strong understanding of the utility team's strengths and weaknesses in skillset, level of experience, and familiarity with the environment. Workers assigned to a specific location must be capable of supporting and completing the tasks on site. They should also be comfortable and skilled in functioning the necessary equipment used to restore power. All workers should be aware and knowledgeable about the surrounding architectural elements of power lines and the environment, in general, to avoid compromising health and safety risks to the team and nearby consumers.

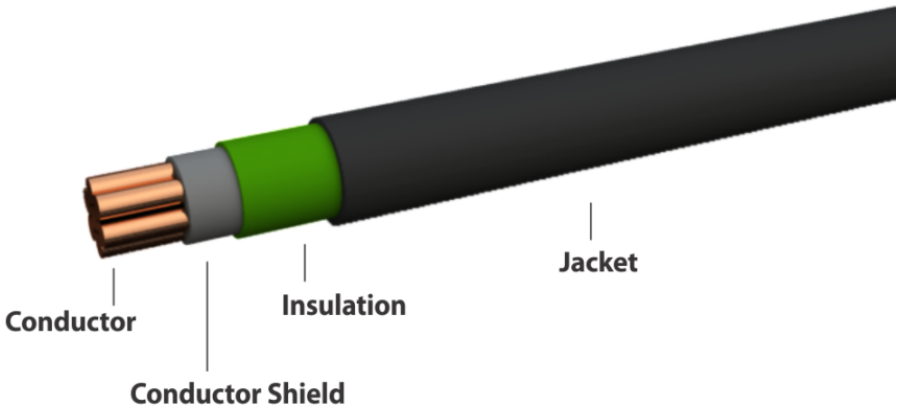
With respect to technical skills, communication within the company also plays a vital role during outages in coordinating and sharing information, especially when time is a critical factor. These shared information and details discussed during outages should be included in a post event

report[1] that will be made transparent to consumers addressing the plans of processes and practices to improve IBEC's operations for future events and decision-making (SCE, 2021). Reviewing feedback and the evaluation of performance of both the service and equipment from this report will allow IBEC to constantly make adjustments to where it is needed to provide a stable, reliable service (See Figure 15). Practicing continuous improvement following Lean Six Sigma[2] standards will help IBEC align the company's overall strategy and design an empowering environment for employees to solve problems and make process improvements as part of their regular activities[3] (SCE, n.d.).

While making plans to upgrade business processes, it is also important to consider upgrading the technology and equipment installed by IBEC. This past February, consumers of Edison have experienced shorter power outages during weather events because of the new installments. These upgrades included thousands of miles of covered conductors to wires in high fire risk areas with the addition of more automated remote switches

FIGURE 15 | Structure of Covered Conductors on Wires

Source: https://axis-india.com/2020/08/covered-conductors-electrical-distribution/



[1] CPUC Utility Post Event Reports and Template: https://www.cpuc.ca.gov/consumer-support/psps/utility-company-psps-post-event-reports
[2] Basics of Lean Six Sigma: https://goleansixsigma.com/what-is-lean-six-sigma/
[3] Lean Six Sigma Trainings and Certifications for Organizations: https://leansixsigmainstitute.org/

that help reenergize power lines and substations (The Repository, 2022). These upgrades have proved to be effective in preventing dangerous events and outages. In 2020, a large tree fell onto an insulated line in Malibu, but no outage nor electrical damages were present (SCE, 2021). This is one of the many events that prove new equipment allows for faster restoration and reduces the number of interruptions. With all these approaches, IBEC can effectively improve their reliability system including metrics of SAIDI and SAIFI (See Table 3).

TABLE 3 | Reliability Metrics: SAIDI and SAIFI

Source: https://blog.hexstream.com/guide-to-utility-reliability-metrics

Reliability Metric	Definition
SAIDI (System Average Interruption Duration Index)	Total average duration of the consumer interruption; measured in unit of time. $\frac{\sum \textit{Customer Interruption Durations}}{\sum \textit{Customers Served}}$
SAIFI (System Average Interruption Frequency Index)	Total average frequency of consumers experiencing an interruption. $\frac{\sum \textit{Customer Interruptions}}{\sum \textit{Customers Served}}$

Measures of SAIDI and SAIFI are indicators of utility performance reliability. Note: Lower value indices are considered more reliable service–must also consider other factors of company's operations.

Providing Resources to Consumers during Outages

Prolonged outages create tensions in communities and even in our [United States] economy. Our lives revolve around the use of electricity and technology, so it is common for consumers to feel insecure during extended periods without power. Many of the consumers' worries during outages consist of delayed production, spoiled and accessibility of food, damaged equipment, and many

other inconveniences. To ease the impact of outage-related stress, IBEC can improve their program by providing resources to their consumers before, during, and after outages. With review to PGE and other utility companies' complaint records (See Figure 9), we found that implemented support and resource services available during emergencies and outage events were highly valued by consumers. Through these services they connect consumers to various

FIGURE 16 | SCE Providing Consumers with Support and Resource Services

Source: https://www.sce.com/wildfire/customer-resources-and-support

SCE deploys Community Crew Vehicles (CCV) to several remote locations to answer consumers' questions and reduce impact of outages on consumers.

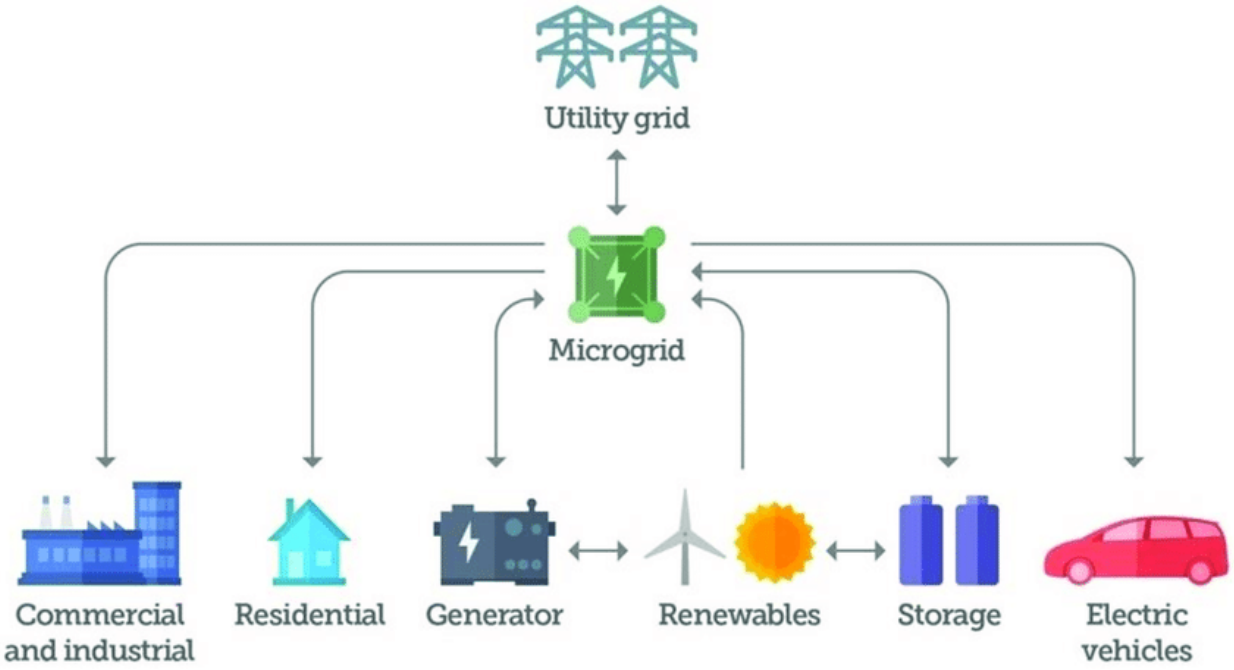
community assistance programs for education and necessities including emergency preparedness, food services, transportation, housing, medical baseline, public assistance, and many other assistance services (PGE, n.d.). Regarding electricity, a variety of backup power supplies are used to reduce the duration of outages. While the primary source of power is down, common backup power supplies used are microgrids and resiliency zones to provide temporary power generation for essential services such as grocery stores and healthcare services. Consumers local to high fire risk areas and or dependent on life sustaining medical equipment are eligible for portable battery at no cost through programs such as the Critical Care Backup Battery Program

(SCE, n.d.). These are approaches and resources that should be considered to improve IBEC's situational awareness among consumers.

FIGURE 17 | Model of Microgrid Distribution

Source:

https://www.pewtrusts.org/en/research-and-analysis/issue-briefs/2016/02/why-and-how-microgrid-technology-is-a-good-power-source



"Microgrids are small groupings of interconnected power generation and control technologies that can operate within or independent of a central grid, mitigating disturbances and increasing system reliability. By enabling the integration of distributed resources such as wind and solar, these systems can be more flexible than traditional grids" (PEW, 2016).

Improving Response with Consumers and Partners

Communication with consumers and business partners before and during outages is important. There are various methods IBEC can go about communication. Many utility companies such as SCE have implemented notification systems and outreach programs to contact consumers through phone calls, text, and emails with details and updates of outages. It is highly

encouraged for consumers to subscribe to these communication channels to get updates and alerts. When implementing these communication channels, IBEC should have an easy application process for consumers to subscribe. To increase awareness in communities about outages and emergencies events, IBEC should create advertisements on wildfire and PSPS mitigation practices. Electricity could be a vital use for some consumers, especially those reliant on medical equipment.

FIGURE 18 | SCE Outage Prevention Billboard Advertisement

Source:https://workingnotworking.com/projects/248216-southern-california-edison-mylar-balloon-safety

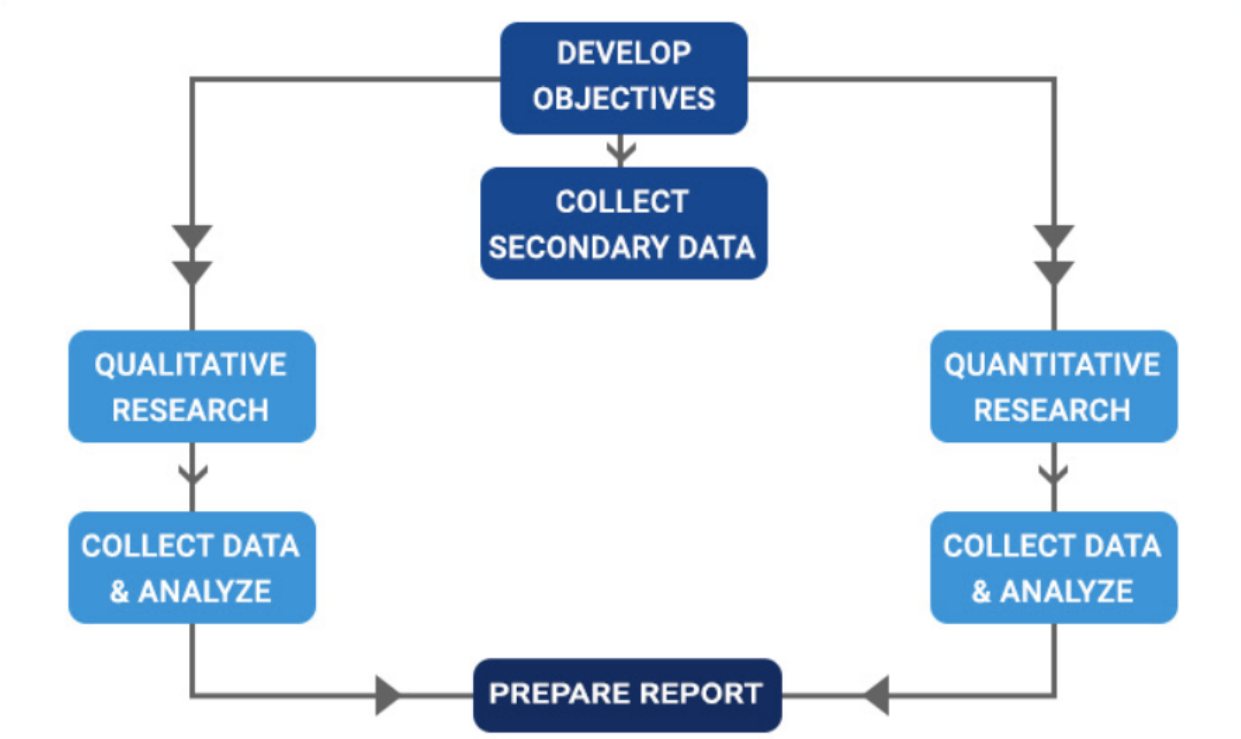
Having IBEC quickly dispatch resource and support services such as a Medical Baseline Program to remote locations is important. The Medical Baseline Program can include additional energy monthly at a low rate with active notifications about outages (PGE, n.d.). Additional marketing of these programs and services can increase users to apply. With sending notifications to consumers, it is also important to consider quickly responding to questions and concerns from them. Having consumers be aware of events like outages, they can react safely and prepare for these events. Workers should be ready in handling emergencies regarding consumers' safety. A

common method utility companies do is visiting consumers nearby the origination of the outage. This is also known as “doorbell rings”. When consumers are not present at home, a note such as a door hanger, will be left to notify the consumers they have been visited. In a severe, life-threatening emergency, workers should be ready and quick to assist the consumer by calling 911 (PGE, n.d.).

Another approach IBEC can practice to improve their response is through holding community meetings that can take place virtually and in person to directly engage with communities and address any questions and concerns about outage events. To track IBEC’s response time performance and consumer satisfaction, it is highly suggested to conduct customer research to identify and accommodate consumers’ needs (See Figure 20). When conducting this research, it is recommended to include consumers under the Access and Functional Needs group.

FIGURE 19 | Model of Customer Research Process

Source: https://www.questionpro.com/blog/consumer-research/

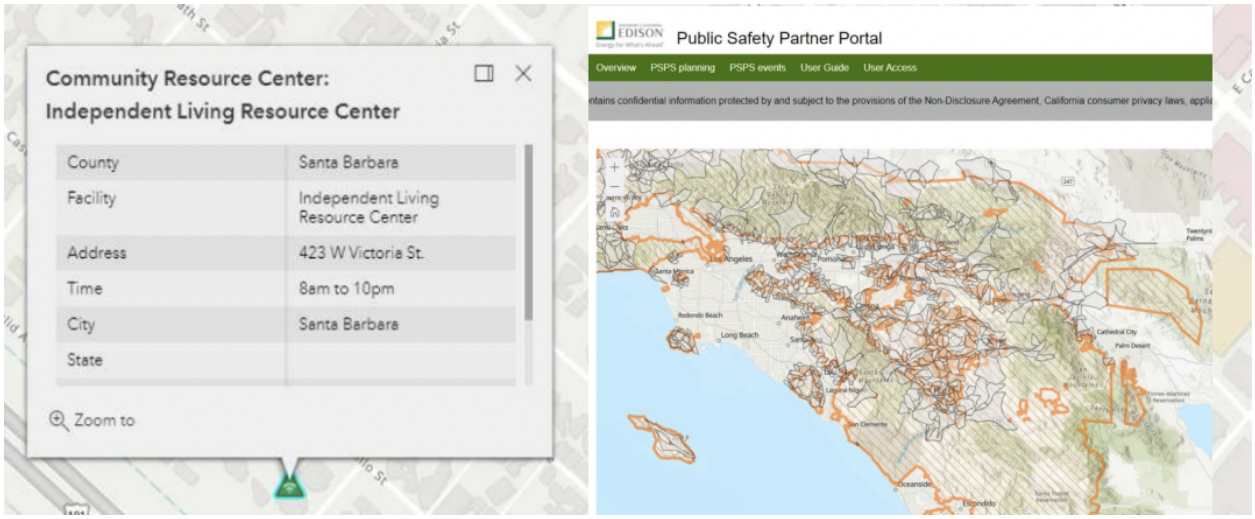


Receiving feedback from consumers can help IBEC further understand what resources and services should be added to ease the impact on consumers during outages. Close communication with stakeholders, governments and public safety partners is important to share information and receive feedback on improvements (SCE, 2021). Creating an internal resource and communication line, such as a Public Safety Partner Portal, with IBEC's public safety partners can allow for faster information updates about outages that may not be available to the public (SCE, n.d.) With these communication practices, IBEC will deliver a fast response time to consumers and partners to be aware and prepared for future outages.

FIGURE 20 | SCE Public Safety Portal

Source:

https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/safety-and-enforcement-division/meeting-documents/psps-briefings-february-2022/sce-psps-briefing-feb-2022.pdf

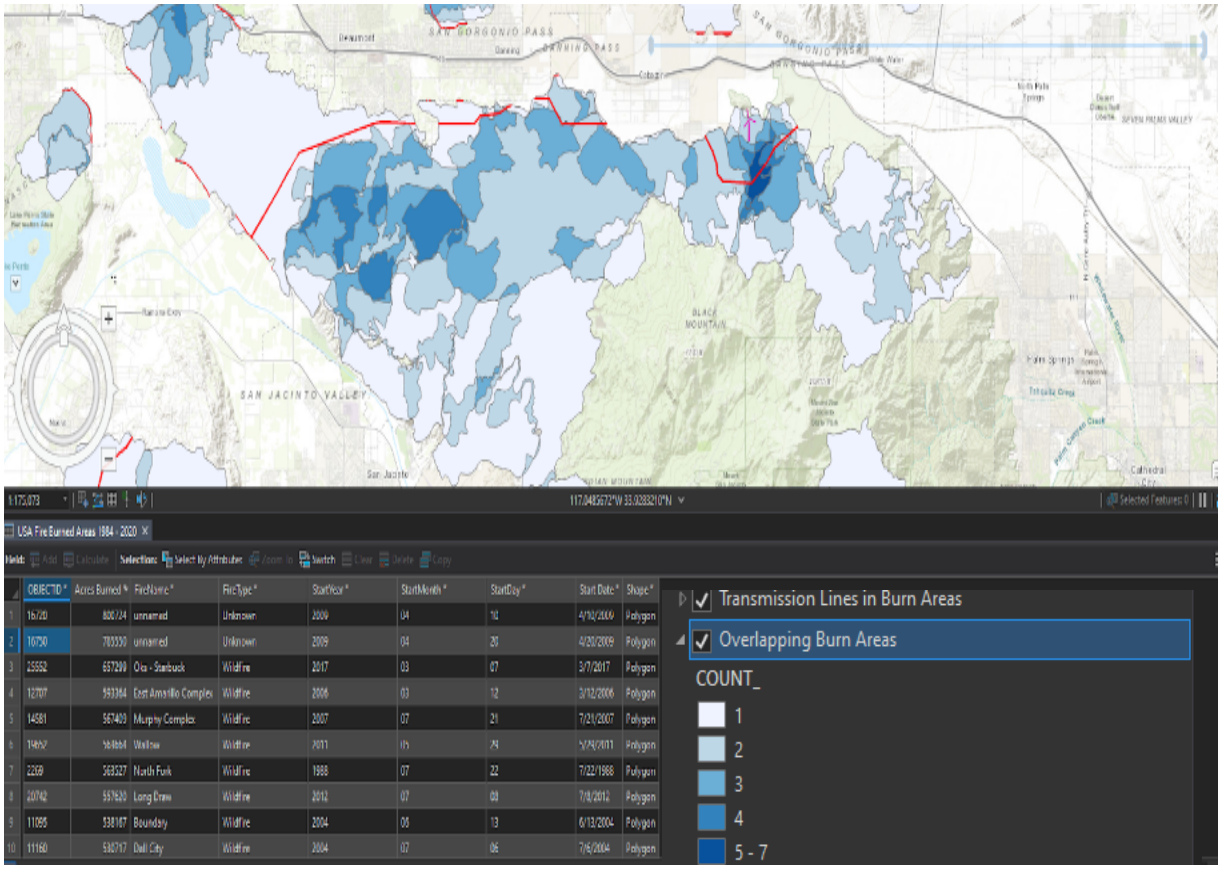


The Public Safety Partner Portal allows for consumers to look up power outage status by their address.

Conclusion

Data analysis is an essential tool to have in any industry. In the figure below is visualization of historical data of wildfires in the Black Mountain region of southern California along with transmission lines that run through areas prone to wildfires. Integrating data analytics into IBEC's operations will provide confidence and reassurance in decisions they make to enrich their business with actionable insight to combat future damages and limit liability.

FIGURE 21 | Southern California High Fire Risk Areas (for demonstration purposes only)



Recommendations

To improve reliability metrics and the overall durability of electrical equipment and vegetation management, IBEC is recommended to implement data storage to facilitate data analytics through machine learning algorithms to identify weak points based on historical records, public data sets, and LiDAR models. Data In Motion suggests implementing descriptive and predictive analytical tools in PSPS operations for cases such as customer complaint identification and weather forecasting. Data In Motion also suggests developing structured models and processes while incorporating Lean Six Sigma approaches to improve performance by reducing variation.

IBEC's Benefits

By following our recommendations IBEC can gain value in the following:

- Durable hardening systems capable of withstanding the environment.
- Enhance and environmentally friendly vegetation management.
- Gain the ability to measure and identify customer needs for business insight.
- Enrich forecasting capabilities to aid the PSPS preparedness.
- Improve reliability metrics: SAIDI and SAIFI.
- Reduce duration of outage events.
- Improve communication time and satisfaction with consumers.

Appendix A

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Appendix B

List of Tables

List of Figures