Wildfire Mitigation Data System (WMDS): Motivation and Framework

Alex Evers & Prateek Joshi

Stanford University – Western Interstate Energy Board (WIEB) Internship Project

October 26th, 2020

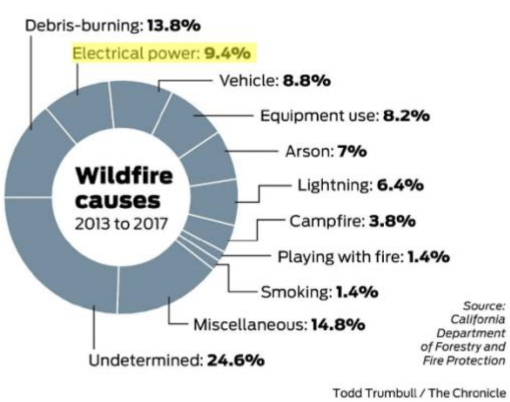
I. Introduction

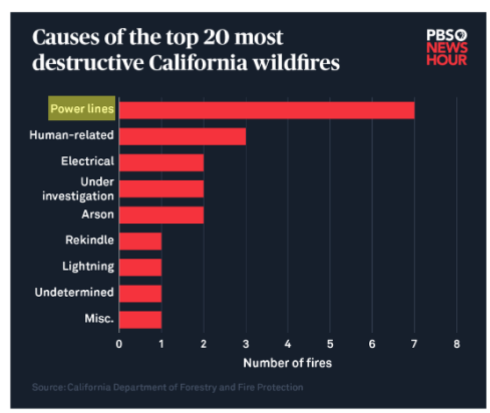
A. Wildfires in the West

Wildfires have been increasing in size and severity due to the expansion of human settlement into the wildland-urban interface (WUI). This trend, coupled with increasing temperatures and prolonged droughts due to climate change, has resulted in extreme wildfires that can both destroy and be caused by electric power infrastructure. This wildfire risk threatens grid reliability, which is only increasing in importance as more end-uses, such as transportation, become electrified.

B. Public Safety Power Shutoffs (PSPS)

To combat the ignition risks involved with electric infrastructure, a strategy called a Public Safety Power Shutoff (PSPS) is sometimes used. These are preemptive de-energizations of specific power lines that run through high-fire risk areas, and the goal is to reduce the chance that ignition will occur during conditions of low humidity, dry vegetation, and high wind speeds. An example of an event that could spark a catastrophic fire is a branch falling on a power line or a conductor dislodging. The three largest utilities in California – Pacific Gas & Electric (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E) – all have PSPS procedures. In 2019, over 2 million customer accounts in the state experienced PSPS events, which can last multiple days and result in significant human and economic impacts. Utilities outside California have also expressed interest in initiating such shutoffs due to the increasing threat of wildfires within their region.





C. Research Overview

In our project, we discovered how data generated from these PSPS events can be used to inform future utility wildfire mitigation efforts for the entire region. Throughout our research, we found that instances of circuit damage were overlooked with respect to data collection and reporting. These are events that happened during the PSPS duration and could have resulted in a wildfire had the power lines been energized. Given this gap, we focused on circuit damage in the distribution system during these shutoffs, in order to extract best practices for wildfire mitigation. We then took the data reporting practices that we recommended for all instances of ignition near misses and combined them into a data system framework. We are proposing a "Wildfire Mitigation Data System" for the Western Interconnection that we believe can help reduce the wildfire risk posed by electric infrastructure.

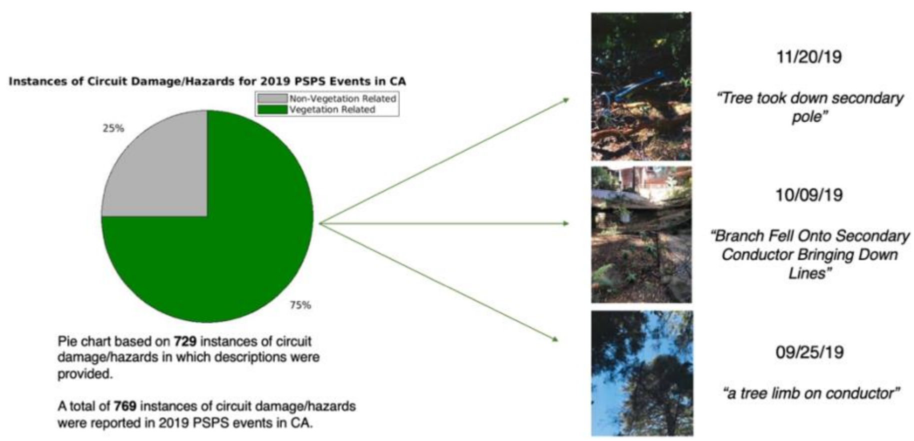
II. Vegetation Management

A. Concept

Vegetation management, which deals with the fuel component of a fire, involves three main activities. "Tree Trimming" is when utilities maintain a radial clearance around lines and remove tree branches above lines. This reduces the risk of vegetation contacting an energized conductor, which can spark a fire. Utilities also conduct frequent inspections. These can be in-person, in which a team is sent to physically patrol power lines to identify vegetation that may damage the infrastructure, or via LiDAR (Light Detection and Ranging), which allows crews to remotely monitor vegetation surrounding lines and identify hazards. Finally, "Fuel Management" is the process of removing ground vegetation that is dead or prone to ignition, as this serves as wildfire fuel. Although the concepts are straightforward, these are labor- and capital-intensive activities, especially given the large territories and difficult terrains covered by utilities throughout the West.

B. 2019 PSPS Data Analysis

During the 2019 PSPS events in California, 75% of instances of circuit damage were vegetation-related, and the figure below shows three specific examples of events that could have started a fire, had the lines been energized.



C. Data Recommendations

The only available information is the name of the damaged circuit and a brief description of the damage. Even this sparse information is inconsistently reported among the utilities, and thus there is room for improvement with regards to data collection and reporting, especially because these examples provide opportunities to learn important wildfire mitigation lessons. Therefore, we present the following recommendations for our data system inputs:

- Information on whether the tree was categorized as a hazard tree or scheduled for removal.
- Information regarding the clearances and the distance between the tree and the distribution lines prior to damage.
- Information on when that section of the circuit was last trimmed, including the time of pruning, amount of vegetation pruned, and next scheduled pruning.

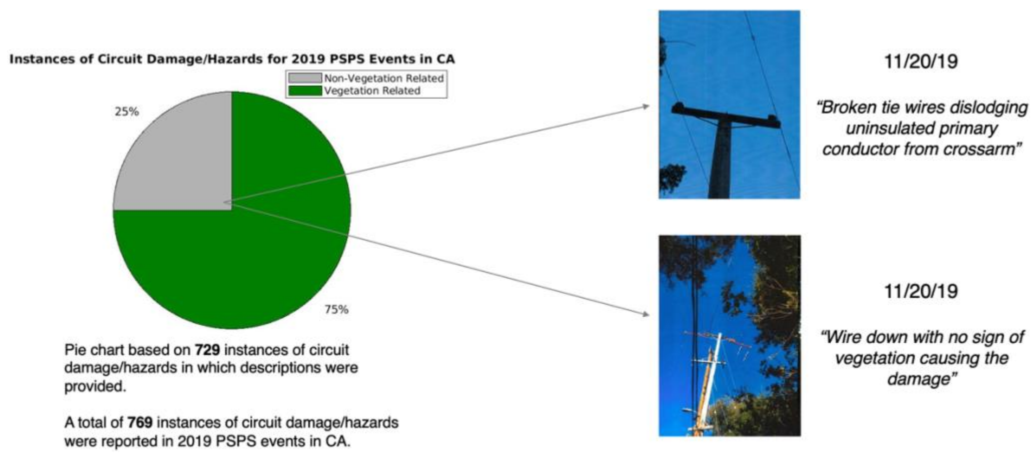
III. Grid Hardening

A. Concept

Grid hardening is the category of actions that deals with the heat source, which is the electrical infrastructure. One method of grid hardening is undergrounding, which is the relocation of overhead distribution lines underground to practically eliminate chances of ignition. This is one of the most effective methods of grid hardening, but also the most expensive and time consuming. Another option is to cover the conductors in an abrasion resistant coating. The coating vastly reduces the chances of ignition if a tree or branch were to contact the energized line, because it would be insulated. Finally, utilities can also replace damaged or old poles with stronger composite ones. These would be less likely to fall over and create sparks in the event of high winds, or if a tree falls on the pole.

B. 2019 PSPS Data Analysis

During 2019, the other 25% of instances of circuit damage during PSPS events were non-vegetation related. An example of non-vegetation related damage is a conductor that dislodged from the pole because of a broken tie wire. Grid hardening can be beneficial for both categories of damage.



C. Data Recommendations

Once again, the current publicly available data on circuit damage does not provide much information that can be used by regulators and other stakeholders to improve wildfire mitigation efforts such as grid hardening. Therefore, we present the following recommendations for our data system inputs:

- Information on whether the conductors were covered or identified for the need to be covered.
- Information on what was done to remediate the circuit and whether the poles were replaced with more resilient ones.
- Information on whether the lines were targeted for undergrounding or whether there is potential for the line segment to be removed entirely.

The goal of this recommended data is to ensure that we are learning as much as we can from these events, in order to better calibrate wildfire mitigation efforts. Even if individual utilities are collecting this information, it should be publicly reported and aggregated in order to maximize the benefits.

IV. Weather Data

A. Concept

Weather data is also relevant for grid hardening and vegetation management efforts, and it is a critical component of this data system proposal. Utility weather stations allow for precise data collection of wind speed, temperature, and humidity, and this information plays a significant role in PSPS and other wildfire mitigation decisions. For example, wind speed data helps determine optimal vegetation management and grid hardening practices for different regions. Weather stations should also be tied to sectionalizing devices during PSPS events.

B. 2019 PSPS Data Analysis

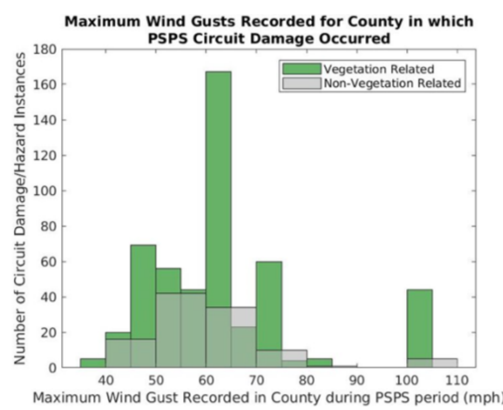
For the 2019 California PSPS events, the only way to associate weather data with circuit damage is to look at the county in which the damage occurred, and to look at the maximum wind gust recorded in that county for the time period. For the example below, we have damage that occurred on a distribution circuit somewhere in Sonoma County. But the only weather data available is the maximum wind gust that occurred in the entire county, and it is unclear if this wind speed was recorded anywhere near the specific location of damage.

Table 3: PSPS Hazards and Damages Found

Issue Type	County	Distribution Circuit
PSPS Hazard	Sonoma	RINCON 1101
PSPS Hazard	Tehama	COTTONWOOD 1103
PSPS Non-Veg Related Damage	Napa	SILVERADO 2105
PSPS Non-Veg Related Damage	Shasta	CEDAR CREEK 1101
PSPS Non-Veg Related Damage	Shasta	CEDAR CREEK 1101
PSPS Non-Veg Related Damage	Sonoma	RINCON ~~1102~~ 1103

Table 6: Maximum wind gusts from November 19 – 20

County	Maximum Wind Gust (mph)	Station ID	Name
Sonoma	75	PG132	Mt. St. Helena West
Kern	63	BIJC1	Bird Springs Pass
Humboldt	60	PTEC1	Cooskie Mountain
Butte	60	PG328	Concow Road



Histogram based on **605** instances of circuit damage/hazards and maximum wind gusts could be tied to the same county.

A total of **769** instances of circuit damage/hazards were reported in 2019 PSPS events in CA.

C. Data Recommendations

The histogram above displays the distribution of maximum wind gusts recorded for the county in which circuit damage occurred. The highest proportion of damage is associated with wind gusts in the 60-70 mph range. Yet, given the county-level reporting, we can't gain any meaningful insights from this data because the location where the wind speed was recorded is only loosely associated with the location of damage. Therefore, we present the following recommended data system input:

- The maximum wind gust at the weather station closest to the point of damage.

This will allow us to more accurately associate a maximum wind gust value with a specific instance of damage.

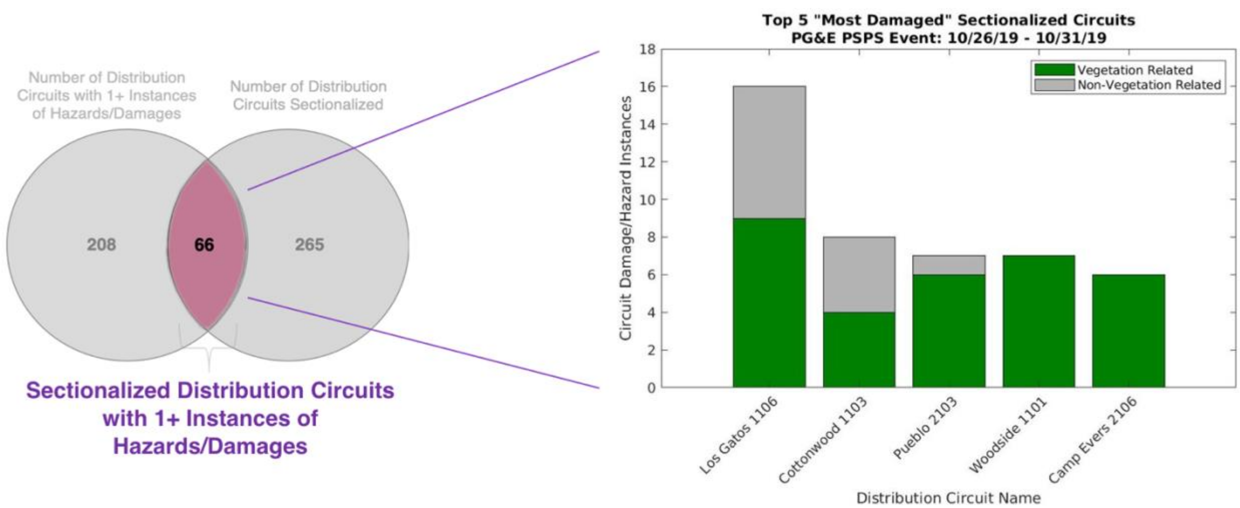
V. Sectionalization

A. Concept

The goal of sectionalization is to divide the distribution circuit into sections through devices that can isolate a fault in the circuit, and thus limit the extent of an outage. A sectionalizer is a self-contained circuit-opening device. These are often used with other protective devices on the line such as circuit breakers and reclosers. Sectionalization limits the scope of all forms of unplanned outages, and is a method used to increase reliability for all utilities, regardless of wildfire threat.

B. 2019 PSPS Data Analysis

During 2019, 2.23 million customer accounts were impacted by California PSPS events. However, 840,000 customers did not lose power specifically because of circuit sectionalization. Out of the 1,988 distribution circuits deenergized across all events last year, 573 were sectionalized. The image below contains data pulled from one specific shutoff last October. In this event, there were 208 unique distribution circuits with 1 or more instances of damage. During this same event, 265 unique distribution circuits were sectionalized. Thus, the overlap represents the number of sectionalized distribution circuits with 1 or more instances of damage. From this intersection, we have identified the 5 "most damaged" sectionalized circuits, in terms of the number of instances of damage. The figure also displays the breakdown between vegetation-related and non-vegetation-related damage.



C. Data Recommendations

Like with grid hardening and vegetation management, these insights are inadequate for systemic change, and we propose the following recommendations for our data system inputs:

- Information on the customer impacts avoided per each individual sectionalized circuit, as opposed to aggregate data on the impacts of sectionalization.
- The Customer Exposure Ratio (CER) for each sectionalized circuit, which is a measure of the "extent of sectionalization" beyond a binary "Yes or No" answer. There is also a need to incorporate wildfire risk into this metric.

VI. Data System Framework

A. Incorporating Near Miss Events

In addition to instances of circuit damage during PSPS events, we also want to include "near misses" into our data system. This will allow us to generate insights from a much larger data pool. Near misses are events that could result in ignition, but these are recorded separately from damages that happen during PSPS events. Each of the utilities reports the number of "near misses" that occurred each year throughout the course of normal operations, broken down into specific categories: contact with foreign object, equipment failure, and other.

B. Current Utility Databases

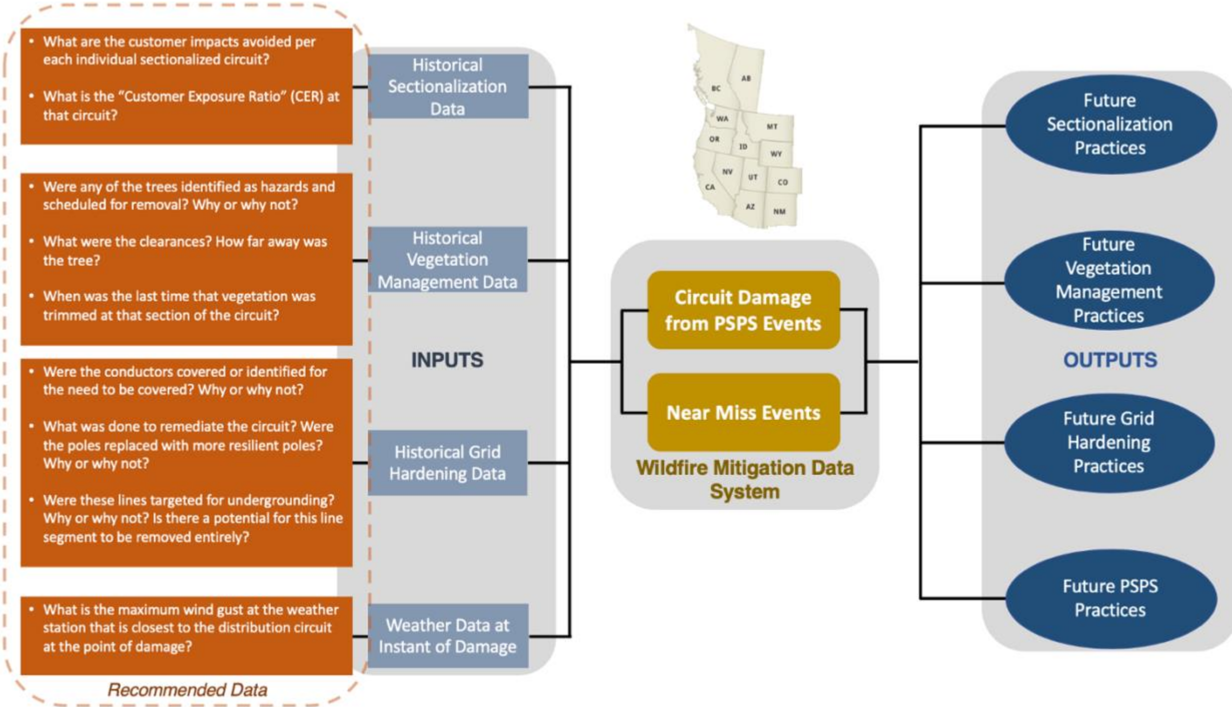
The utilities examined all have various databases in which they potentially collect the information that a regional data system would incorporate. For instance, PG&E has a vegetation inventory system, a pole loading database, and a recloser database. SoCal Edison has a variety of databases that keep track of assets, weather conditions, and outages. Finally, San Diego Gas and Electric maintains a vegetation inventory system and reliability database. Thus, a regional wildfire mitigation data system would likely not burden these utilities with a requirement to collect any additional information beyond what is already contained in their private systems.

C. Data System Precedent

There are some examples of data systems that already aggregate information from a large number of utilities in order to provide useful insights. One of them is NERC's Transmission Availability Data System (TADS), which collects detailed information about individual outage events that, when analyzed at a regional level, will provide data that may be used to improve reliability. Another example is INPO's Consolidated Events Database (ICES), which captures equipment failure data from nuclear power plants in order to communicate best practices throughout the industry.

D. Data System Architecture

The proposed "Wildfire Mitigation Data System" would collect detailed information about individual probable ignition events that, when analyzed at the Western Interconnection level, will provide data that may be used to improve reliability and reduce wildfire occurrences. The data system architecture is shown on the next page. In 2019, across the 3 major California utilities, there were almost 71,000 probable ignition events. Therefore, if data from utilities throughout the Western Interconnection serves as inputs, the outputs can be quite informative. The goal is to create a detailed blueprint for regional cooperation, in which computational power can be used to establish the best wildfire mitigation practices for all utilities throughout the West. Currently, no formal, structured, or scalable data sharing mechanism exists among these utilities. A Wildfire Mitigation Data System can allow utilities to submit their data in exchange for access to a broader dataset that will help them improve their operations, reduce costs, and keep customers safe. The data will help utilities outside California build their models and help the utilities within California further calibrate their models. This system also compliments the efforts and goals of the California Public Utilities Commission (CPUC), who are emphasizing data sharing and transparency in their regulatory role.



E. Opportunity

Potential outputs of the data system are listed below.

- Future sectionalization practices:
  - More effective sectionalization of the most vulnerable circuits
  - Standard comparison of circuit sectionalization using customer exposure ratio
- Future vegetation management practices:
  - Evaluation and potential adjustment to vegetation clearances
  - Informed prioritization of tree trimming and removal
- Future grid hardening practices:
  - Evaluation and adjustments to distribution pole resiliency
  - Standardized information about covered conductor impact
- Future PSPS practices:
  - More informed decisions about when and where to initiate these events
  - A reduction in size and frequency of these events

F. Conclusion

As mentioned before, there would likely be no increased data collection burden for utilities. It would simply be a data sharing opportunity. With regards to data sharing, this system would not require any customer information or other sensitive information. This could be a publicly accessible data set to promote best practices for utility wildfire mitigation. And it could also harness the power of 3rd party research for the benefit of all. This would play a key role in enhancing the energy security, equity, and sustainability of the future electric grid.

VII. References

2018 Annual Electric Reliability Report. Pacific Gas and Electric Company, 15 July 2019, p. 305, https://www.pge.com/pge_global/common/pdfs/outages/planning-and-preparedness/safety-and-preparedness/grid-reliability/electric-reliability-reports/AnnualElectricDistributionReliabilityReport2018.pdf.

2019 Annual Electric Reliability Report. Pacific Gas and Electric Company, 15 July 2020, p. 438, https://www.pge.com/pge_global/common/pdfs/outages/planning-and-preparedness/safety-and-preparedness/grid-reliability/electric-reliability-reports/CPUC-2019-Annual-Electric-Reliability-Report.pdf.

2020 Wildfire Mitigation Plan Report. Pacific Gas and Electric Company, 28 Feb. 2020, p. 494, https://www.pge.com/pge_global/common/pdfs/safety/emergency-preparedness/natural-disaster/wildfires/wildfire-mitigation-plan/2020-Wildfire-Safety-Plan.pdf.

2020-2022 Wildfire Mitigation Plan. Southern California Edison, 7 Feb. 2020, p. 237, https://www.sce.com/sites/default/files/AEM/SCE%202020-2022%20Wildfire%20Mitigation%20Plan.pdf.

Allen, Meredith E. *AMENDED PG&E Public Safety Power Shutoff (PSPS) Report to the CPUC November 20, 2019 De-Energization Event*. Pacific Gas and Electric Company, 9 Dec. 2019, p. 120, https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/News_Room/NewsUpdates/2019/PGE%20Public%20Safety%20Power%20Shutoff%20Nov.%2020-21%202019%20Report.pdf.

---. *AMENDED PG&E Public Safety Power Shutoff (PSPS) Report to the CPUC October 9-12, 2019 De-Energization Event*. Pacific Gas and Electric Company, 8 Nov. 2019, p. 228, https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/News_Room/NewsUpdates/2019/PGE%20Public%20Safety%20Power%20Shutoff%20Oct.%209-12%20Report_Amended.pdf.

---. *AMENDED PG&E Public Safety Power Shutoff (PSPS) Report to the CPUC October 23-25, 2019 De-Energization Event*. Pacific Gas and Electric Company, 8 Nov. 2019, p. 126, https://www.pge.com/pge_global/common/pdfs/safety/emergency-preparedness/natural-disaster/wildfires/PSPS-Report-Letter-10.23.19-amend.pdf.

---. *AMENDED PG&E Public Safety Power Shutoff (PSPS) Report to the CPUC October 26 & 29, 2019 De-Energization Event*. Pacific Gas and Electric Company, 18 Nov. 2019, p. 279, https://www.pge.com/pge_global/common/pdfs/safety/emergency-preparedness/natural-disaster/wildfires/PSPS-Report-Letter-10.26.19.pdf.

"Aluminum Building Wiring." *Wikipedia*, 28 Feb. 2020, https://en.wikipedia.org/w/index.php?title=Aluminum_building_wiring&oldid=943075947.

Joseph H. Eto, et al. "An Examination of Temporal Trends in Electricity Reliability Based on Reports from U.S. Electric Utilities." *Ernest Orlando Lawrence Berkeley National Laboratory*. Accessed 26 June 2020.

San Diego Gas and Electric Company. *2020 Public Safety Power Shutoff Readiness*. https://www.cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/News_Room/NewsUpdates/2020/SDGE%202020%20PSPS%20Readiness%2008-10-2020.pdf. Electric IOU PSPS Public Briefings, California Public Utilities Commission.

Schoennagel, Tania, et al. "Adapt to More Wildfire in Western North American Forests as Climate Changes." *Proceedings of the National Academy of Sciences*, vol. 114, no. 18, May 2017, pp. 4582–90, doi:10.1073/pnas.1617464114.

Annual System Reliability Report For Year 2018. Southern California Edison, p. 110, https://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Electrical_Infrastructure,_Planning,_and_Permitting/Reliability_and_Distribution_Infrastructure/Reliability/SCE.pdf. Accessed 18 Aug. 2020.

Batjer, Marybel, et al. *DECISION ADOPTING PHASE 2 UPDATED AND ADDITIONAL GUIDELINES FOR DE-ENERGIZATION OF ELECTRIC FACILITIES TO MITIGATE WILDFIRE RISK*. Order Instituting Rulemaking to Examine Electric Utility De- Energization of Power Lines in Dangerous Conditions, Rulemaking 18-12-005; Decision 20-05-051, California Public Utilities Commission, 28 May 2020, p. 114, https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M339/K524/339524880.PDF.

Deepak Divan, et al. "Assessing I-Grid(TM) Web-Based Monitoring for Power Quality and Relability Benchmarking." *Lawrence Berkeley National Laboratory*, Apr. 2003, http://escholarship.org/uc/item/5hr918qx.

Electric System Reliability Annual Report 2018. San Diego Gas and Electric Company, 15 July 2002, p. 76, https://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Electrical_Infrastructure,_Planning,_and_Permitting/Reliability_and_Distribution_Infrastructure/Reliability/SDGE.pdf.

Joseph H. Eto, et al. "Distribution System versus Bulk Powersystem: Identifying the Source of Electricservice Interruptions in the US." *The Institution of Engineering and Technology*, doi:10.1049/iet-gtd.2018.6452. Accessed 26 June 2020.

Kim, Ann H., and Kenneth Lee. *CORRECTION TO UPDATED POST-PSPS REPORT FOR OCTOBER 5-6, 2019*. Order Instituting Rulemaking to Examine Electric Utility De-Energization of Power Lines in Dangerous Conditions., Rulemaking 18-12-005, Pacific Gas and Electric Company, 28 Feb. 2020, p. 47, https://www.pge.com/pge_global/common/pdfs/safety/emergency-preparedness/natural-disaster/wildfires/PSPS-Report-Letter-10.05.19-amend-2.pdf.

Kristina H. LaCommare, et al. "Distinguishing Among the Sources of Electric Service Interruptions." *Lawrence Berkeley National Laboratory*, doi:10.1109/PMAPS.2018.8440511. Accessed 27 June 2020.