SMART FOREST MANAGEMENT SYSTEM

EXAMINING PACIFIC GAS AND ELECTRIC'S CULTURE OF NEGLIGENCE AS A CAUSE OF DEVASTATING WILDFIRE

A Thesis Prospectus
In STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Computer Engineering

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November 8, 2024

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

In California, 10% of wildfires from 2016-2020 were caused by electrical power distribution or transmission equipment (California State Auditor, 2022). These wildfires kill dozens of people, erase towns, and devastate forests. Reducing the number and intensity of wildfires caused by Pacific Gas and Electric's (PG&E) electrical systems is a complex socio-technical challenge that must be solved to protect communities and the environment.

In 2021, the Dixie fire burned 963,309 acres in Northern California (Safety and Enforcement Division, 2023). PG&E was aware of a downed power line, but was not aware of the presence of fire. One technician was deployed to repair the line but was overwhelmed by a fire he was not expecting (Safety and Enforcement Division, 2023). Because PG&E did not have a full picture of the situation, the technician was completely overwhelmed by the small fire. To accomplish the goal of reducing wildfire risk, by preventing a similar situation to the Dixie fire, I will develop and test an early warning fire-detection system. The Smart Forest Management (SFM) will use an infrared sensor to detect fire and notify an operator if detected.

Early detection is not always enough to prevent a devastating wildfire, the Butte County Camp Fire, also stemming from PG&E electrical equipment, was reported within 10 minutes, yet continued to kill 85 people and burn 153,336 acres (Butte County District Attorney, 2020). PG&E failed to properly maintain its electrical equipment and as a result, pleaded guilty to 84 counts of involuntary manslaughter (Romo, 2020). I will draw on the framework of technological momentum to investigate the culture of complacency at PG&E and our society's willingness to accept this negligence because of our dependence on electricity.

Without understanding PG&E's internal culture of complacency and our society's complete dependence on electricity, the fire detection system may reduce the risk of wildfire, but

will fail to eliminate the key factors contributing to utility company caused wildfires. Because reducing the risk of fires caused by electrical equipment is sociotechnical in nature, it requires attending to both its technical and social aspects to accomplish successfully. In what follows, I set out two related research proposals: a technical project proposal for developing an early-warning fire detection system and an STS project proposal examining PG&E's culture of complacency at the time of the Butte County Camp Fire.

Technical Project Proposal

The Dixie Fire grew out of control because PG&E technicians were not aware of a fire ignited by a power line; they only knew of a service fault in the area. Had the response crew and operators known of a fire, an appropriate response could have been mounted, preventing one of the largest wildfires in California history. To prevent a similar situation, PG&E has deployed a state of the art grid monitoring system that pinpoints areas experiencing voltage drops caused by grid disturbances (Currents, 2021). This grid monitoring system allows for quicker and more efficient response to dangerous conditions, reducing the risk of fire ignition. The implementation of the new system allows the electrical company to directly monitor power line conditions, without needing customer reports of loss of power. However, the new system still provides no information on fire ignition and spread. The new system allows for quicker response, but still fails to provide enough information for an appropriate response.

Thinking back to the Dixie Fire, a single technician arrived after 10 hours, only to find a fire they were unable to extinguish. PG&E's new system would notify that technician much quicker, and yet, if a fire had already begun, the outcome would be the same – another devastating wildfire. More available information allows for a more informed and prepared

emergency response. Knowledge of the presence of fire is a key piece of information in a high risk area. To provide the critical information on the existence of a fire, I propose the usage of a fire monitoring system in addition to the electrical monitoring system already in place. The addition of this fire monitoring system will allow operators to monitor for the presence of fire in locations that have been flagged by the electrical monitoring system, so if fire is detected, an electrical and fire response can be organized by PG&E technicians and local responders. The combination of these two systems will allow for a prepared response and prevent a situation like the Dixie Fire from recurring.

I propose the design of a sensor network to be deployed on every electrical pole in high risk or remote areas. High risk electrical poles will have a Smart Forest Management node (SFM) that uses sensors to detect fire and then notify PG&E technicians of any detected fire. The SFM node will have an infrared sensor positioned so it is 'looking' down the electrical line for fire. The infrared sensor will be configured to detect the wavelengths of radiation that are emitted by fire. If these wavelengths are detected, the SFM node will notify PG&E's operators. In conjunction with the infrared sensor, a temperature sensor will be used to monitor for unusually high temperatures. These two sensors, together, will be able to recognize many common fire situations, including fire caused by debris contact and transformer failure. If a fire is detected, the SFM node needs to communicate with a human operator so that appropriate resources can be deployed. Each SFM node will use LoRa, a radio modulation technique, to communicate with a computer in the closest electrical substation, where an operator will be able to see the fire alert (The Things Network). Each SFM node will require the development of a printed circuit board (PCB) with an infrared and temperature sensor, along with a microcontroller and battery. The development of this system will require a custom PCB, microcontroller programming for

handling the sensor data and LoRa communication in C++, and a user interface implemented in Angular.

The reliability of the Smart Forest Management system makes or breaks its viability as a product – false positives are expensive and false negatives burn down forests and towns. To test the SFM node's fire detection ability, I will set fires of different sizes in a fire pit and see from what angles and distances the SFM is able to detect from. Along with sensor testing, I will test the reliability of signal transmission to determine the level of data corruption and add redundant data accordingly.

STS Project Proposal

The Butte County Camp Fire, which killed 85 people and burned 153,336 acres of forest in California, was caused by PG&E's negligent failure to maintain its electrical equipment. A live wire broke from a nearly century old, unmaintained power line, and became the source of the Camp Fire (Penn et al, 2020). The Butte County investigation concluded that the "reckless actions of PG&E created the risk of a catastrophic fire in the Feather River Canyon, that PG&E knew of that risk and PG&E ignored the risk by not taking any action to mitigate the risk" (Butte County District Attorney, 2020). I will be using the Camp Fire case and PG&E's negligence to explore how the grid's incredible technological momentum insulates PG&E from the consequences of its negligence.

There are many factors that influence PG&E's culture of negligence, including its natural monopoly over utilities in California, legislation, and our society's reliance on electricity. Current discourse primarily focuses on the natural monopolization of utilities providing companies insulation from the consequences of their negligence. In the aftermath of the Camp

Fire, PG&E was convicted of 85 felonies. A “felony conviction can deal a mortal blow” to a company, PG&E’s “customers cannot switch to another provider of electricity and gas” (Penn et al, 2020). Customers are unable to easily or cheaply switch to alternative sources of power, which protects utility companies. The lack of competition allows PG&E leeway for negligence because the corporation’s future is guaranteed. Previous writers have concluded that utility company negligence stems from monopolization and lack of competition, but they fail to consider the impact of society’s reliance on widely-available electricity. Monopolies in the past have been split through legislation, yet the government still supports utility monopolization, meaning that the issue is more complex than just busting monopolies.

Today, electricity is the foundation of modern life. Our machines and technology cannot function without constant access to electricity. Many people, including myself, find it difficult to imagine life without limitless energy at our fingertips. Our society tears down mountains, splits atoms, and fracks the remains of dinosaurs to feed our hunger for electricity. PG&E has 125,147 miles of electrical line to service 16 million people in the Western United States (Pacific Gas and Electric). I propose that PG&E’s culture of negligence stems from our societal dependence on electricity and our inability to imagine a different system of utility management.

For my analysis of PG&E’s culture of negligence, I will be using the framework of technological momentum. Developed by Thomas Hughes, technological momentum claims that technologies are shaped by society to fulfill a need, but over time, as society becomes more reliant on that technology, the technology begins to shape society instead. Hughes argues that as a technological system matures, social and institutional components continue to give the system momentum through infrastructure, economic interests, bureaucracy, and specialization (Hughes, 1994). This increase in momentum makes change increasingly difficult as many aspects of

society have adapted to the current PG&E grid system. Businesses, schools and homes are all dependent on PG&E's continued electrical service, making transitioning or widespread maintenance extremely difficult. As a result, PG&E is allowed to continue with its track record of negligence because of California's dependence on the power it distributes. PG&E's culture of negligence stems from the fact that society has grown to be so dependent on PG&E's infrastructure that there is very little opportunity for the exploration of other technological solutions. The evidence I will draw on will be primarily based on lawsuits against PG&E for service outages, showing the depth of society's dependence on electricity. Additionally, I will analyze PG&E's bankruptcy bailout to determine the value the government places on continued widespread electrical service.

Conclusion

The Dixie Fire grew out of control because PG&E operators were unaware of and unprepared to extinguish the transformer fire they discovered. My technical project, the Smart Forest Management system, will detect fire stemming from electrical equipment and notify operators so a prepared response can be deployed. My STS project will use the framework of technological momentum to develop an understanding of how a societal reliance on electricity protects PG&E and contributes to a corporate culture of negligence. Understanding PG&E's corporate culture will allow me to design around PG&E's direct involvement with the SFM system. For example, repairs and testing on the SFM system may become a third party service if PG&E's unreliability continues. Combining new technology with societal analysis will allow for a future where wildfires caused by electrical equipment are less frequent and less devastating.

Word Count: 1774

References

California State Auditor. (2022, March 24). *Electrical System Safety.* https://information.auditor.ca.gov/pdfs/reports/2021-117.pdf

Safety and Enforcement Division. (2023, October 9). *Dixie Fire Investigation Report*. California Public Utilities Commission. https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/safety-and-enforcement-division/investigations-wildfires/dixie-fire-investigation-report.pdf

Butte County District Attorney. (2020, June 16). *The Camp Fire Public Report.* https://www.buttecounty.net/DocumentCenter/View/1881/Camp-Fire-Public-Report---Summary-of-the-Camp-Fire-Investigation-PDF

Romo, V. (2020, June 17). *PG&E pleads guilty on 2018 California Camp Fire: "our equipment started that fire."* NPR. https://www.npr.org/2020/06/16/879008760/pg-e-pleads-guilty-on-2018-california-camp-fire-our-equipment-started-that-fire

Currents. (2021, December 4). *PG&E Deploys Enhanced Wires Down Detection System To Reeduce Wildfire Riskduce* . PG&E Currents. https://www.pgecurrents.com/articles/3239-pg-e-deploys-enhanced-wires-detection-system-reduce-wildfire-risk

The Things Network. (n.d.) *What are Lora and Lorawan?*. The Things Network. https://www.thethingsnetwork.org/docs/lorawan/what-is-lorawan/

Penn, I., & Eavis, P. (2019, December 4). *Report detailing PG&E's failures raises new hurdles for utility*. The New York Times. https://www.nytimes.com/2019/12/03/business/energy-environment/pge-camp-fire-report.html

Penn, I., & Eavis, P. (2020, June 16). *PG&E pleads guilty to 84 counts of manslaughter in Camp Fire Case*. The New York Times. https://www.nytimes.com/2020/06/16/business/energy-environment/pge-camp-fire-california-wildfires.html

Pacific Gas and Electric. (n.d.). *PG&E Company profile*. Company Profile. https://www.pge.com/en/about/company-information/company-profile.html

Hughes, T. (1994). *Technological Momentum.*