An Analysis of How a Fragile Network Ignited California's Deadliest Wildfire

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science University of Virginia • Charlottesville, Virginia

> In Partial Fulfillment of the Requirements for the Degree Bachelor of Science, School of Engineering

> > Johnathan Mirkovich

Spring 2024

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

Advisor

William J Davis, Department of Engineering and Society

Introduction

Wildfires in California have become more frequent and destructive in recent years, fueled by aging infrastructure, inadequate regulatory oversight, and the changing climate. The 2018 Camp Fire was the most devastating wildfire in California's history, claiming 85 lives, burning 153,336 acres, and destroying over 19,000 structures (NOAA, 2020, p. 32). Investigations revealed that Pacific Gas & Electric's (PG&E) transmission lines, which had not been properly maintained despite multiple warnings, sparked the fire (California Public Utilities Commission [CPUC], 2020, p. 24). Facing over \$30 billion in liabilities, PG&E declared bankruptcy, becoming one of the most expensive corporate failures related to wildfires in history.

Although PG&E's faulty infrastructure directly caused the fire, a purely technical explanation is not enough. What led regulatory agencies to fail to enforce stronger safety measures? In what ways did financial and corporate priorities influence PG&E's decisions? Why were local communities unprepared despite previous wildfires (Lareau & Clements, 2021, p. E170)? These questions create a significantly more dynamic sociotechnical failure; one driven by misalignments among key actors rather than a singular flaw. Existing reports often focus on individual technical breakdowns or policy failures, failing to account for the interconnected relationships between infrastructure, regulations, environmental factors, and the complacency that led people to underestimate wildfire risks.

The consequences of the Camp Fire extended well beyond the physical destruction. Tens of thousands of residents were displaced, many struggling to find permanent housing, healthcare, and education (Baroud et al., 2021, p. 24). Smoke exposure created severe health risks across California (Reid et al., 2020, p. 9), and PG&E's bankruptcy completely destabilized California's energy market (Malik, 2019). These effects highlight how wildfire disasters result from systemic disconnects between human and non-human actors rather than singular technical failures.

This paper utilizes Actor-Network Theory (ANT) to analyze how PG&E, regulators, environmental conditions, and local communities contributed to the Camp Fire. In this paper, I argue that the 2018 Camp Fire was not only a technical failure caused by faulty electrical infrastructure but a sociotechnical disaster resulting from misaligned interactions among key actors. Applying ANT, this paper argues that the fire resulted from combined issues from infrastructure maintenance, inadequate regulatory enforcement, and worsening climate conditions, which together created conditions for catastrophic failure. ANT reveals that preventing future wildfire disasters requires restructuring the whole actor network to perfect safety priorities across all actors.

Supporting Argument #1

PG&E has a long history of delaying maintenance, regulatory violations, and prioritizing of financial interests over safety, which directly contributed to several of the deadliest wildfires in the state's history including the Camp and Dixie fires (CPUC, 2020, p. 2). Investigations of the Camp Fire revealed that one of PG&E's transmission lines contained components over 90 years old with signs that the risk had been ignored (CPUC, 2020, p. 83). Reports showed that PG&E executives were aware of these risks but delayed infrastructure improvements because costs were too high.

The financial data recovered from the investigation revealed that PG&E prioritized shareholder interests over infrastructure investments. In 2018 alone, PG&E paid over \$1.1 billion in stock dividends to stockholders while increasing rates from customers to fund overdue infrastructure upgrades (Malik, 2019, p. 226). The implications of PG&E's financial strategy go beyond this single example. The company's repetitive pattern of choosing profits over risk mitigation raises questions regarding how investors' power can worsen these vulnerabilities.

Several studies indicate that privatized utilities are more likely to underinvest in infrastructure maintenance because board members focus on short term stock performance over long-term system safety (Kolhatkar, 2019, p. 20). This leaves the system vulnerable where rising environmental stressors can have devastating consequences.

While some people may argue that PG&E's limited investments as a smart financial move, evidence indicates that many of their issues were self-inflicted. Instead of investing money toward long-term infrastructure improvements, PG&E sent a large amount of money into executive compensation and shareholder payouts. This poor allocation of money along with repeated failures to implement more proactive management plans allowed PG&E to be a large driver for these wildfires.

The California Public Utilities Commission's (CPUC) job is to ensure that utility companies maintain certain safety standards; however, they have repeatedly failed to prevent PG&E's negligent practices. (CPUC, 2020, p. 224). Between 2014 and 2018, CPUC issued 71 safety citations against PG&E, yet none resulted in serious operational changes (Law et al., 2023, p. 378). PG&E instead negotiated settlements and postponed important compliance deadlines with their vast team of lawyers, creating a cycle of no regulatory action. CPUC failed to implement stricter regulations even after PG&E was found guilty of starting the 2017 Wine Country Fires (Kolhatar, 2019, p. 21).

A deeper analysis of CPUC's role shows a common pattern where political pressure that aligned with PG&E's financial interests influenced the agency's decisions instead of prioritizing public safety (Sandoval, 2023, p. 11). All regulatory agencies operate in a political environment where utility corporations exert considerable lobbying influence, oftentimes making it difficult to

fight for a more aggressive regulation. With CPUC mostly relying on fines rather than operational mandates, PG&E has had success in delaying necessary infrastructure investments while paying these fines as a more cost of doing business (Malik, 2019, p. 219).

The legal framework that CPUC falls under also greatly limits it from functioning effectively. CPUC lacks the legal power to make direct changes to failing utility companies unlike federal agencies that have full authority (Sandoval, 2023, p. 5). This situation creates an environment where enforcement efforts become more reactive than proactive, worsening after major disasters. These systematic failures reflect a larger issue around regulations for utility companies. Some scholars argue that CPUC is unable to enforce compliance because the system is designed to balance commercial interest with safety instead of always prioritizing safety. However, this balance has shifted towards corporate stakeholders, leaving residents and local governments to live with the consequences.

Despite the rising danger of wildfires, California's fire prevention policies remain reactive. PG&E's Wildfire Safety Plans (WSPs), designed to outline fire mitigation strategies, primarily focus on removing vegetation around power lines while normally ignoring issues of infrastructure modernization (CPUC, 2020). Studies show electrical failures are the leading cause of utility-related wildfires in California (CPUC, 2020, p. 149). Although vegetation clearing is important, WSPs still prioritize tree trimming over more effective long-term solutions such as equipment upgrades or undergrounding lines (Huang et al., 2023, p. 193). The cost and logistical challenges related to upgrading transmission systems further complicates the process of worthwhile infrastructure modernization. While burying power lines is a much safer fire mitigation strategy, PG&E claimed that it is unfeasible (Law et al., 2023, p. 380). However, strategically burying power lines in high risk fire zones could considerably decrease the chance of wildfires, outweighing the large short term cost (Law et al., 2023).

Another wildfire policy is PG&E's Public Safety Power Shutoff (PSPS) program, which preemptively cuts power during extreme weather. Although it is meant to be proactive, it has proven to be quite controversial and problematic. PSPS does reduce ignition risk but also causes widespread outages (Huang et al., 2023, p. 188), disrupts medical services and emergency communications (Baroud et al., 2021), and creates significant economic losses (Kolhatkar, 2019, p. 18). Critics argue that PSPS is only a temporary solution that does not address the real systemic problems. Instead of improving infrastructure, utility companies shut off power to avoid responsibility while leaving communities exposed to extended outages (Huang et al., 2023, p. 188). Low income and rural communities are disproportionately affected by the PSPS as they have fewer resources to withstand extended power outages.

The Camp Fire occurred in a fire-prone environment of long droughts, extreme heat, and strong winds. Climate research shows California's wildfire season is increasing due to hotter, drier conditions (Lareau & Clements, 2021, p. E159). The years leading up to the Camp Fire also experienced a severe drought that left the vegetation extremely dry, creating an abundance of flammable material (NOAA, 2020, p. 4). These conditions worsened the effects of PG&E's equipment failure, which demonstrates that climate actors actively affect wildfire behavior instead of being passive background factors.

Strong wind gusts over 40 mph blew embers beyond containment zones, accelerating fire spread and overwhelming emergency responses (NOAA, 2020, p. 11). Paradise, CA became a desiccated fire zone with low humidity and dry fuels (Lareau & Clements, 2021, p. E165). This

combination of dry fuel, wind, and low humidity made containment extremely difficult. Climate trends have reshaped California's fire regime, leading to more frequent and intense wildfires. Rising temperatures increase vapor pressure and dry out vegetation faster, extending fire seasons (Lareau & Clements, 2021, p. E166). Shorter, more intense wet seasons followed by long dry periods lead to rapid vegetation growth that becomes fuel (NOAA, 2020, p. 3).

The Camp Fire illustrates how climate interacts with vulnerable infrastructure to create disaster conditions. Without integrated fire mitigation, climate science, and utility reform, California will continue to face devastating wildfires. Policies must evolve to address these risks and ensure prevention strategies account for environmental change. The recurring failures of PG&E, regulatory oversight limitations, and worsening climate suggest technical explanations alone don't capture the complexity of wildfire disasters. To gain a better understanding of the Camp Fire, a sociotechnical approach is needed. The use of Actor-Network Theory (ANT) provides a valuable framework for examining the relationships between PG&E, regulators, and environmental factors, creating a more complete explanation of the Camp Fire.

Supporting Argument #2

Understanding the 2018 Camp Fire requires an approach that examines the interactions between human and non human actors that created the perfect conditions for this disaster instead of just blaming it on a single action. ANT provides a framework for analyzing these interactions by treating technical failures, infrastructure, corporate decisions, environmental conditions, and financial incentives as active components of a network that create outcomes through their relationships (Latour, 2005, p. 14). Unlike traditional analyses that solely focus on technical failures, ANT emphasizes how these elements are interconnected and influence one another. This framework is helpful when studying the Camp Fire as it reveals how aging infrastructure, weak regulatory enforcement, worsening climate conditions, and profit prioritization interacted to create an unstable socio technical network (Sandoval, 2023, p. 3).

When applying ANT to the Camp Fire, the first step is to identify the main actors and to track their interactions. The human actors include PG&E executives, state policymakers, CPUC regulators, and affected community members, all of whom helped shape the wildfire risk while non human actors—including aging electrical infrastructure, environmental conditions, regulations, financial markets, and corporate policies—actively influenced decision making. Recognizing that these actors are active participants makes it clear that no single factor caused this fire. Instead, the Camp Fire was a predictable consequence of failures that culminated over several years (California State Auditor, 2019). For example, PG&E's power lines have been outdated for decades, with the transmission line that started the Camp Fire containing components over 100 years old (CPUC, 2024). Even though PG&E knew of these risks, they prioritized financial success and shareholder returns over long-term safety improvements, a pattern that became commonplace in their company culture (California State Auditor, 2019). This demonstrates how corporate actors are influenced by shareholder expectations and financial pressures, all of which contributed to PG&E's choice to not invest in safety upgrades.

Regulatory oversight also played a significant role in creating vulnerabilities within the network. CPUC must follow strict laws and regulations which limits its ability to enforce reforms other than fines and citations. Unlike other agencies, CPUC is restricted and unable to enforce operational changes, leaving any efforts mostly reactive. The agency uses monetary fines instead of direct intervention, which allows PG&E to treat violations as an extra cost of business. This regulatory design demonstrates how regulators are not external enforcers but internal actors in the network that directly shape what happens through their interactions with large companies.

Between 2012 and 2017, PG&E failed to send in safety verification tickets, however management counted up to tens of thousands of late tickets as completed on time, where subsequently PG&E was fined 110 million dollars for these legal violations (CPUC, 2020, p. 106). CPUC's limited enforcement power and reliance on financial penalties created an environment where PG&E was disincentivized to fix problems and instead delayed important changes. These conditions reinforce the idea that regulatory design and legal limitations are actors that directly shape this outcome.

Changing climate conditions were not passive factors; they actively shaped the environment and interacted with human decisions to increase wildfire risk. The two years before the fire there were record breaking droughts, which greatly decreased moisture left the vegetation extremely flammable (Lareau & Clements, 2021, p. E191). On the day of the fire, wind gusts reached over 40 mph, which carried embers miles in the air (CPUC, 2024). These conditions combined with PG&E's infrastructure delays and CPUC's lack of regulatory action, created the perfect conditions for catastrophe. From an ANT perspective, environmental factors are not just background conditions; they are dynamic actors influencing human actors. For example, wildfire forecasts are often used to justify controversial PSPS policies, which demonstrates how natural actors influence regulation choices. Climate change has also increased both the area and the frequency of high fire conditions, putting greater stress on an already weak network.

A clear example of how corporate decisions directly influence wildfire risk is PG&E's plan to decommission the Potter Valley Project, a hydroelectric facility that the company plans to demolish due to financial losses and aging infrastructure (LaFever, 2024, p. 5). Rather than repair it, PG&E decided to demolish it, despite potential impacts on farmers, ranchers, and wildlife who rely on the reservoir. Some conservationists believe this demolition will support

fish restoration, but PG&E's emphasis on profit instead over ecological restoration goals raises questions about its motives. This debate highlights how utility companies manage infrastructure investments under financial constraints. PG&E's recent increase in rates, which they argued was necessary to fund essential upgrades, highlight how financial pressure greatly shapes certain regulatory policies (LaFever, 2024). This raises ethical concerns whether private companies should be allowed to greatly increase safety costs onto the consumers so they can boost their shareholders' profits. These developments show that wildfire risks are deeply connected to economic and regulatory systems that determine whether infrastructure is maintained or neglected.

These financial and regulatory challenges explain how wildfires are not just a direct result of fire prone environmental conditions or infrastructure failure; instead wildfire risk is a systemic issue that is shaped by corporate policies, poor regulation oversight, and economic constraints. The analysis with ANT highlighted that the interconnected relationships between these factors created a very fragile network that was destined to fail with real world conditions. Examining how these vulnerabilities started during the fire will offer a new perspective that will reveal deeper structural flaws in our current wildlife prevention efforts.

Supporting Argument #3

The collapse of this network was directly linked to PG&E's financial and operational choices. The company consistently prioritized shareholder returns over long-term safety, which created an unstable system where risks built up without oversight. PG&E postponed maintenance for transmission components that exceeded their service life by several decades and justified these actions because of unreasonable financial abilities. While this appears to be corporate misjudgement, further analysis shows that these decisions resulted from deeper systemic

pressures. ANT demonstrates that financial incentives are active components in this network that shape the structure of PG&E's infrastructure management. This is not just an example of poor corporate judgement; it shows that PG&E responded to incentives built into a system that favors cost reduction over safety improvements.

The failure of regulatory agencies to intervene highlights the vulnerabilities of this entire network. CPUC was created to act as a check for private company's risky practices; however, CPUC depended primarily on fines as enforcement tools yet PG&E treated these citations as ordinary business costs. This regulatory framework created an environment where following the rules was incentivized in law but not often practiced. ANT reveals that CPUC was not just a bystander or a separate entity that failed but an active participant whose limited power, legal boundaries, and political pressures made it complicit in PG&E's choices. Instead of trying to address PG&E's neglect, CPUC became an embedded actor in the same system.

These limitations were not just technical issues; the system of relationships was set up in a way that made real accountability nearly impossible. CPUC's oversight was shaped by political actors directly influenced by economic goals and corporate lobbying. Instead of addressing these issues, the system continued to act as if current actions were sufficient. When addressing this from an ANT perspective, this formalism is part of the problem. Without real power, procedural accountability becomes a tool for systemic inaction in the network. This disaster did not occur because CPUC did nothing, but because its role within the system was limited from the start. The Camp Fire was not an unexpected event; it was a direct result of how the system normally functions.

Environmental factors added another layer of complexity to an already fragile system.

Years of rising temperatures, drought, and more destructive wind patterns didn't just create wildfire conditions; they influenced the directions of human actors. ANT argues that natural elements are active forces that overwhelmed an already stressed system and pushed it past its limits. If PG&E had upgraded its infrastructure or if regulators had better accounted for these climate patterns in planning, the outcome could have been different. But without this coordination, these environmental factors didn't cause the fire on their own; they interacted with an unstable system already on the verge of collapse.

PG&E's risk mitigation strategies also reflect the same network pressures that contributed to the fire. Programs like vegetation clearing, PSPS, and rate increases were framed as necessary safety actions. However, ANT would argue that these choices seem more about managing appearances than proactive safety measures. Cutting power during high fire danger scenarios may reduce ignition risk, but it also leaves communities vulnerable without electricity, communication, and access to emergency services. Similarly, increasing rates to fund wildfire safety sounds proactive, but without clear evidence the money is being spent on structural upgrades, it looks like a way to shift attention without doing much change. These actions seem proactive on the surface but end up reinforcing the same weaknesses that made the system vulnerable in the first place.

This complex dynamic of an overstressed system is very evident in the Potter Valley Project. PG&E's claimed financial losses and aging infrastructure as reasons for decommissioning the facility and some environmental grounds supported the move, hoping it would restore fish habitats and river ecosystems. On the other hand, many others opposed it, worried about the loss of a stable water source. This demonstrates that choices that seem unrelated to wildfires exist within the same network of competing pressures. From an ANT

perspective, this isn't a separate issue; it's part of the same pattern where choices made by narrow interests end up affecting the larger system. What might look like a good decision from a financial or ecological perspective, it can quickly create instability across the broader community as they weren't part of the original conversation.

One of the most important takeaways from this analysis is the lack of shared responsibility across the entire network. PG&E acted according to shareholder priorities. CPUC acted within its limited legal authority. Emergency services responded with the resources and information they had. Local communities followed the poor response plans that were made. Each actor behaved in a way that makes sense within their own boundaries, but no actor had full responsibility for the system as a whole. ANT helps explain this kind of fragmentation, where roles that are isolated, makes failure not only possible, but inevitable. The Camp Fire didn't happen because one group failed to act, but because everyone was focused on their personal priorities, while the relationships between each group were ignored. In reality, these groups aren't separated at all. ANT shows that they overlap and directly depend on each other. The Camp Fire is what happens when no one is responsible for seeing the bigger picture, which occurred because the system doesn't have a way to create this picture in the first place.

Moving forward, California needs to restructure the entire network involved with wildfire prevention and response. It is not enough to reform PG&E, expand CPUC's authority, or better invest in fire prevention; while these actions are steps in the right direction, none of them will be enough on their own. Lasting change will require better accountability, communication, and shared responsibility across the entire network. Incentives must shift so safety and long term infrastructure are more important than financial or political goals. This regulatory framework needs to stop treating infrastructure, public safety, and environmental risk as separate issues and

instead treat them as one complex problem. ANT doesn't just help explain what went wrong, it creates a strategy that can help build a stronger, more connected system for the future.

Conclusion

The 2018 Camp Fire was not the result of a single mistake, but the failure of an entire network. By applying Actor-Network Theory, this paper demonstrates how PG&E's financial choices, CPUC's limited regulatory oversight, and worsening climate conditions created a very unstable network. However, none of these issues by themselves are the reason for this disaster. The misalignment of the actors in the network, all acting towards their own goals with no shared responsibility for the entire system's safety ultimately led to the fire.

This analysis reveals that this disaster is much more than a technical failure or natural disaster. Risk was not only created by what actors did, but was the product of an undeveloped network where important connections between these key actors were never created. The broader implication is clear: reducing wildfire risk needs much more than isolated fixes. It will require a system that promotes coordination and accountability across all actors. These solutions must include regulatory reform with real authority, company models that prioritize safety above profit, and fire mitigation efforts that take environmental trends into account.

Still, limitations remain. ANT is not a tool for finding the exact answer to these problems. It breaks down the issue to highlight where these networks are failing and why. While it does not create the perfect solution, it reframes how we interpret complex failures like the Camp Fire. This new perspective is essential if California wants to prevent future disasters and build stronger networks moving forward.

References

- Baroud, H., Camp, J., Stowers, D., & Ghaffarian, S. (2021). Wildfire impacts on education and healthcare: Paradise, California case study. *International Journal of Disaster Risk Reduction*, 57, 102178. <u>https://doi.org/10.1007/s11069-021-05057-1</u>
- Blunt, K. (2024). PG&E is racing to stem increasing fires ignited by its power lines. The Wall Street Journal. <u>https://www.wsj.com/business/energy-oil/pg-e-is-racing-to-stem-increasing-fires-ignited</u> -by-its-power-lines-0228c556
- California Public Utilities Commission (CPUC) (2020). *Root cause analyses 2017-18 wildfires*. <u>https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/safety-policy-division/reports/r</u> oot-cause-analyses-of-the-2017-18-wildfires.pdf
- California Public Utilities Commission (CPUC) (2024). Safety policy division evaluation report: Pacific Gas and Electric (PG&E) risk assessment and mitigation phase (RAMP). California Public Utilities Commission. <u>https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/safety-policy-division/reports/s</u> pd-evaluation-report-2024-pge-ramp-final-with-attachments.pdf
- California State Auditor (2019). *California Public Utilities Commission: Poor oversight of utility* wildfire mitigation plans. <u>https://www.auditor.ca.gov/reports/2019-103/index.html</u>
- Huang, C., et al. (2023). A review of Public Safety Power Shutoffs (PSPS) for wildfire mitigation: Policies, practices, models, and data sources. IEEE Transactions on Energy Markets, Policy and Regulation, 1(3), 187-197. https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=10154121
- Kolhatkar, S. (2019). California Must Take Back Its Power—Literally. *Solar Today*, *33*(4), 18–21. https://search.ebscohost.com/login.aspx?direct=true&db=eih&AN=140948140&site=ehost-live&scope=site.
- LaFever, M. (2025). A California reservoir could disappear if PG&E gets their way. SFGate. <u>https://www.sfgate.com/northcoast/article/potter-valley-project-california-water-battle-2</u> 0192320.php
- Lareau, N. P., & Clements, J. D. (2021). *The synoptic and mesoscale evolution accompanying the* 2018 Camp Fire. Bulletin of the American Meteorological Society, 102(1), E157–E170. https://doi.org/10.1175/BAMS-D-20-0124.1
- Latour, B. (2005). *Reassembling the social: An introduction to actor-network-theory*. Oxford University Press.

- Law, B., Bloemers, R., Colleton, N., & Allen, M. (2023). Redefining the wildfire problem and scaling solutions to meet the challenge. Bulletin of the Atomic Scientists, 79(6), 377–384. <u>https://doi.org/10.1080/00963402.2023.2266941</u>
- Malik, T. (2019). Part II: PG&E's monopoly control boosts profits over ratepayers, 8(3), 217-235. <u>https://www.ewg.org/node/7227</u>
- National Oceanic and Atmospheric Administration (NOAA). (2020). Service Assessment: November 2018 Camp Fire. National Weather Service Western Region Headquarters. https://www.weather.gov/media/publications/assessments/sa1162SignedReport.pdf
- Reid, C. E., Brauer, M., Johnston, F. H., Jerrett, M., Balmes, J. R., & Elliott, C. T. (2020). Critical review of health impacts of wildfire smoke exposure. Environmental Health Perspectives, 124(9), 1334–1343. <u>https://doi.org/10.1289/ehp.1409277</u>
- Sandoval, C. J. K. (2023). Fighting Utility Wildfire with Knowledge Management. Duke Environmental Law & Policy Forum, 33(2), 1–43. <u>https://scholarship.law.duke.edu/delpf/vol33/iss2/1/</u>