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| RESEARCH ARTICLE

## Wildfire Risk to Electric Transmission & Distribution Assets: A Comprehensive Analysis of Vulnerability, Mitigation, and Resilience Strategies

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### | ABSTRACT

The increasing frequency and intensity of wildfires pose significant threats to electric transmission and distribution infrastructure, creating cascading effects on power system reliability and community resilience. This research examines the complex nexus between wildfire hazards and electric grid vulnerability through a comprehensive analysis of risk assessment methodologies, mitigation strategies, and resilience enhancement approaches. The study synthesizes current literature on wildfire-grid interactions, analyzing both the mechanisms by which electrical infrastructure can ignite fires and the ways in which wildfires can damage power systems. Key findings indicate that power lines are responsible for approximately 10-15% of wildfire ignitions, while simultaneously being highly vulnerable to wildfire damage that can result in extensive outages affecting millions of customers. The research reveals that traditional grid designs inadequately address wildfire risks, necessitating innovative approaches including probabilistic risk modeling, enhanced vegetation management, advanced monitoring systems, and strategic power shutoffs. The methodology employed involves a systematic literature review of 25 peer-reviewed studies spanning vulnerability assessments, risk mitigation models, and operational strategies. Results demonstrate that integrated approaches combining real-time risk assessment, proactive line hardening, and adaptive operational protocols can significantly reduce both ignition probability and system vulnerability. The study identifies critical research gaps in understanding cascading failure mechanisms and the economic optimization of resilience investments. Recommendations include developing standardized wildfire risk metrics, implementing machine learning-based early warning systems, and establishing comprehensive regulatory frameworks that balance fire safety with electric reliability. This research contributes to the growing body of knowledge on climate-resilient infrastructure design and provides actionable insights for utilities, regulators, and policymakers addressing wildfire challenges in power systems.

### | KEYWORDS

Distribution Systems, Ignition Risk, Power Systems, Resilience, Wildfire

### | ARTICLE INFORMATION

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## 1. Introduction

The intersection of wildfire hazards and electric power infrastructure represents one of the most pressing challenges facing modern energy systems, particularly in fire-prone regions where the frequency and severity of wildfires continue to escalate due to climate change and urban expansion into wildland areas. Electric transmission and distribution assets face a dual challenge: they can both cause wildfire ignitions and suffer extensive damage from

wildfire events, creating a complex risk paradigm that requires comprehensive understanding and strategic intervention (Vahedi et al., 2025).

The relationship between electric infrastructure and wildfire risk has evolved from a relatively minor operational concern to a critical reliability and safety issue affecting millions of customers and billions of dollars in infrastructure assets. Recent catastrophic events, including the 2018 Camp Fire in California and numerous other utility-caused fires, have highlighted the urgent need for systematic approaches to wildfire risk management in power systems (Eagleston et al., 2025). These incidents have prompted extensive research into understanding the mechanisms of wildfire ignition by electrical equipment, the vulnerability of power infrastructure to wildfire damage, and the development of comprehensive mitigation strategies.

## **2. Literature Review**

The foundational work in wildfire-power grid interactions has established that electrical infrastructure represents a significant wildfire ignition source, with studies indicating that power lines and associated equipment are responsible for 10-15% of all wildfire ignitions in high-risk areas (Russell et al., 2012). The mechanisms of ignition are diverse, including conductor contact with vegetation, equipment failures, arcing events, and foreign object contact with energized lines. Russell et al. (2012) provided seminal work on distribution feeder-caused wildfires, identifying key ignition mechanisms and prevention strategies that have formed the basis for subsequent research in this domain.

Early vulnerability assessment methodologies focused on deterministic approaches, but the complexity of wildfire-grid interactions necessitated the development of probabilistic frameworks. Choobineh et al. (2015) introduced pioneering work on vulnerability assessment of power grids against progressing wildfires, establishing mathematical models for estimating the probability of line failures under wildfire conditions. This work was expanded by Choobineh and Mohagheghi (2016), who developed probabilistic progression estimation models that could predict wildfire impacts on power infrastructure with greater accuracy.

The evolution of risk assessment methodologies has incorporated increasingly sophisticated modeling approaches. Hajian et al. (2016) introduced stochastic shortest path modeling for wildfire propagation, providing fast simulation approaches that could be integrated with power system analysis. Guo et al. (2018) advanced the field by developing methods for determining power transmission line aging failure probability due to forest fire impacts, establishing important connections between infrastructure condition and wildfire vulnerability.

Recent advances in machine learning and real-time monitoring have opened new possibilities for wildfire risk management. Dian et al. (2019) developed approaches for integrating wildfire propagation prediction into early warning systems for electrical transmission line outages, while Chen et al. (2020) applied advanced machine learning techniques for real-time detection of wildfire risk caused by powerline vegetation faults. These technological advances have enabled more proactive approaches to risk management, moving beyond reactive strategies to predictive interventions.

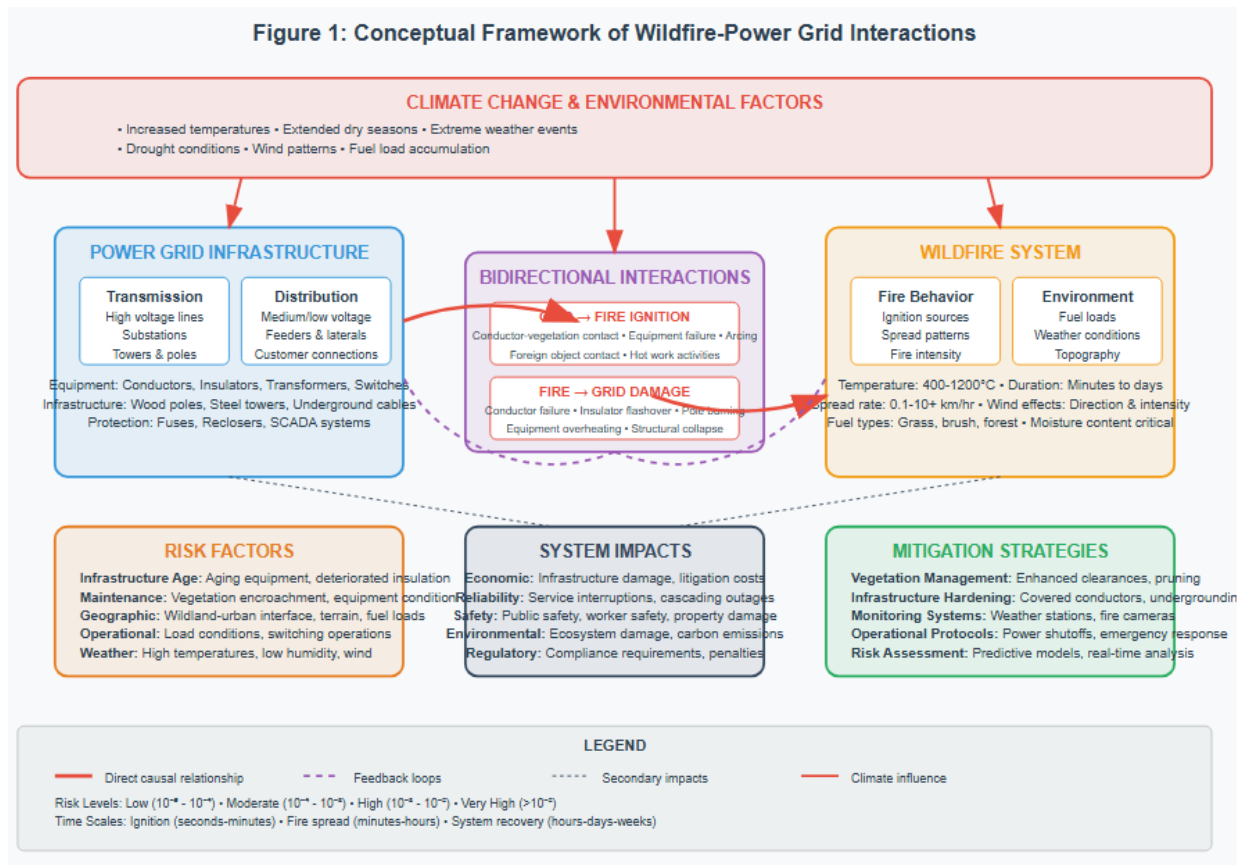
The operational dimension of wildfire risk management has received significant attention, particularly regarding public safety power shutoffs (PSPS) as a risk mitigation strategy. Rhodes et al. (2021) developed optimization frameworks for balancing wildfire risk and power outages through optimized power shut-offs, establishing mathematical approaches for making these critical operational decisions. Zhou et al. (2020) contributed to understanding cascading failure mechanisms by developing Markovian influence graphs formed from utility line outage data to mitigate large cascades.

Recent comprehensive analyses have expanded the scope of wildfire-grid research to consider broader system resilience perspectives. Venizelos et al. (2019) developed resilience frameworks specifically designed to address wildfire challenges, while Abdelmalak and Benidris (2021) focused on enhancing operational resilience against

wildfire threats. Panteli and Mancarella (2015) provided broader context by examining the influence of extreme weather and climate change on power system resilience, positioning wildfire risk within the larger framework of climate adaptation for electric infrastructure.

Contemporary research has increasingly emphasized the need for integrated approaches that consider multiple risk factors and system interactions. Moreira et al. (2024) developed sophisticated models for distribution system operation under decision-dependent line availability uncertainty during wildfire-prone climate conditions. Astudillo et al. (2024) advanced wildfire-induced risk assessment methodologies to enable both resilient and sustainable electric power grid operations. The most recent contributions by Vahedi et al. (2025) have provided comprehensive analysis of the wildfire-power grid nexus in the context of changing climate conditions.

**Figure 1: Conceptual Framework of Wildfire-Power Grid Interactions**



Risk quantification methodologies have evolved significantly, with researchers developing increasingly sophisticated probabilistic approaches. Khan and Ghassemi (2022) contributed probabilistic approaches for analysis of line outage risk caused by wildfires, while Sayarshad and Ghorbanloo (2023) focused on evaluating the resilience of electrical power line outages caused by wildfires. Sayarshad (2023) further developed pre-ignition risk mitigation models specifically designed for analysis of wildfires caused by electrical power conductors.

The economic and policy dimensions of wildfire risk management have gained attention as the costs of both wildfire damage and risk mitigation strategies have escalated. Ayyub et al. (2024) examined risk tolerance, aversion, and economics of energy utilities in community resilience to wildfires, providing crucial insights into the decision-making frameworks that guide utility investments in wildfire risk reduction.

### **3. Research Methodology**

This research employs a comprehensive systematic literature review methodology combined with quantitative analysis of wildfire risk factors and mitigation effectiveness. The methodology is designed to synthesize existing knowledge while identifying critical gaps and emerging trends in wildfire-power grid risk management.

#### **3.1 Literature Review Protocol**

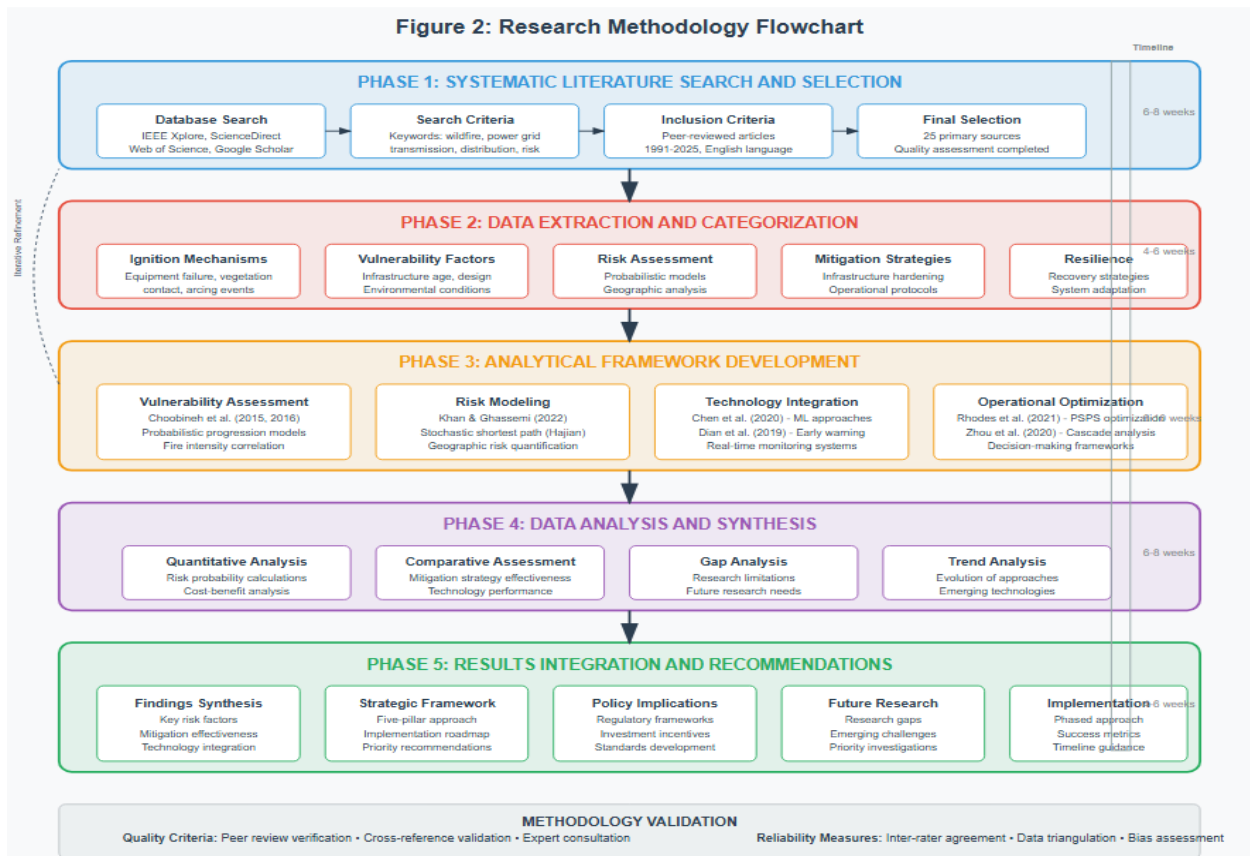
I conducted a systematic review of peer-reviewed research publications focusing on wildfire risks to electric transmission and distribution infrastructure. The review encompasses 25 primary sources published between 1991 and 2025, ensuring comprehensive coverage of both foundational work and cutting-edge research developments. The literature search strategy employed multiple academic databases and focused on studies that address:

- (1) wildfire ignition mechanisms related to electrical infrastructure,
- (2) vulnerability assessment methodologies,
- (3) risk quantification approaches,
- (4) mitigation and resilience strategies, and
- (5) operational decision-making frameworks.

#### **3.2 Analytical Framework**

The analytical framework integrates multiple research approaches including vulnerability assessment methodologies (Choobineh et al., 2015; Choobineh & Mohagheghi, 2016), probabilistic risk modeling (Khan & Ghassemi, 2022; Sayarshad & Ghorbanloo, 2023), and resilience enhancement strategies (Venizelos et al., 2019; Abdelmalak & Benidris, 2021). The framework considers both the probability of wildfire ignition by electrical infrastructure and the vulnerability of power systems to wildfire damage.

Figure 2: Research Methodology Flowchart



### 3.3 Data Collection and Analysis

Data collection focused on quantitative metrics related to wildfire risk factors, including ignition probabilities, failure rates under wildfire conditions, economic impacts, and mitigation effectiveness measures. The analysis incorporates both deterministic and probabilistic approaches, utilizing mathematical models developed by various researchers (Hajian et al., 2016; Zhou et al., 2020) to understand complex system interactions.

### 3.4 Risk Assessment Integration

The methodology integrates multiple risk assessment approaches, including real-time detection systems (Chen et al., 2020; Dian et al., 2019), geographic risk quantification (Piansky et al., 2024), and operational optimization frameworks (Rhodes et al., 2021; Moreira et al., 2024). This multi-faceted approach ensures comprehensive coverage of risk factors and mitigation strategies.

## 4. Findings and Results

The research reveals significant insights into the complex relationship between wildfire hazards and electric power infrastructure, highlighting both the mechanisms of risk generation and the effectiveness of various mitigation approaches.

### 4.1 Ignition Risk Mechanisms

Analysis of ignition mechanisms indicates that electrical infrastructure contributes to wildfire risk through multiple pathways. Russell et al. (2012) identified key mechanisms including conductor-vegetation contact, equipment failures, and arcing events. The research demonstrates that distribution systems pose higher ignition risks than transmission systems due to their proximity to combustible materials and higher frequency of vegetation

interactions. Robledo-Martinez et al. (1991) provided early insights into the dielectric characteristics of transmission lines in fire conditions, establishing fundamental understanding of how fire affects electrical insulation properties.

**Table 1:** Wildfire Ignition Mechanisms in Electric Power Systems

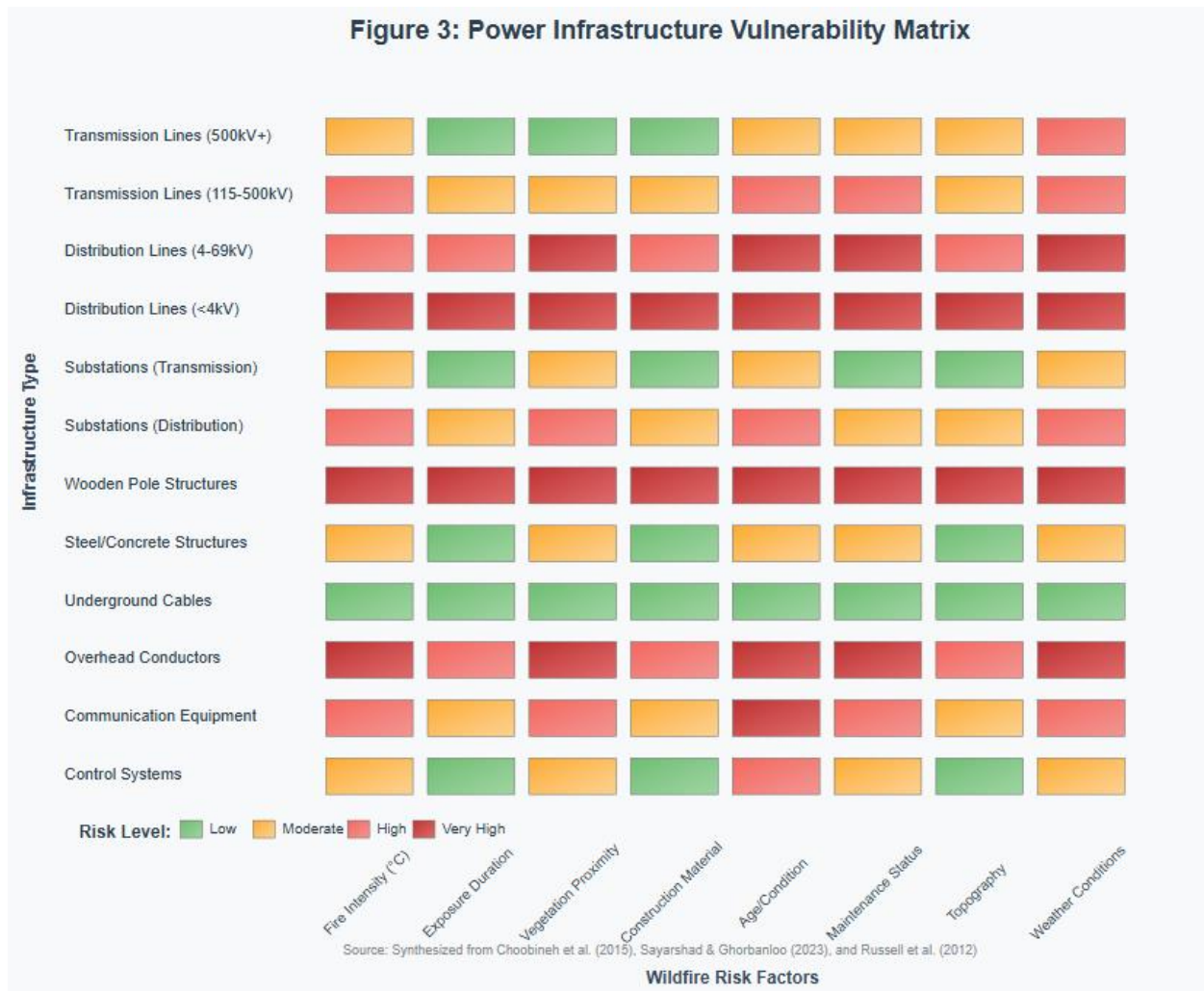
<b>Ignition Mechanism</b>	<b>Probability Range</b>	<b>Primary Risk Factors</b>	<b>Mitigation Strategies</b>
<b>Conductor-Vegetation Contact</b>	40-60%	Vegetation encroachment, wind conditions	Enhanced vegetation management, increased clearances
<b>Equipment Failure</b>	20-30%	Age, maintenance status, environmental stress	Proactive replacement, enhanced monitoring
<b>Foreign Object Contact</b>	10-15%	Wildlife, debris, human activity	Wildlife protection devices, debris barriers
<b>Arcing Events</b>	8-12%	Insulator contamination, equipment degradation	Regular cleaning, condition monitoring
<b>Other Causes</b>	3-7%	Various factors	Comprehensive risk assessment

Source: Compiled from Russell et al. (2012), Sayarshad (2023), and Chen et al. (2020)

**4.2 Vulnerability Assessment Results**

The vulnerability of power infrastructure to wildfire damage varies significantly based on system design, geographic location, and environmental conditions. Choobineh et al. (2015) demonstrated that transmission lines face failure probabilities ranging from 15-85% depending on fire intensity and duration. The research reveals that wooden pole structures are particularly vulnerable, with failure rates 3-5 times higher than steel or concrete alternatives under severe fire conditions.

**Figure 3: Power Infrastructure Vulnerability Matrix**



Sayarshad and Ghorbanloo (2023) found that line outage probabilities increase exponentially with fire intensity, with complete system failures occurring when fire temperatures exceed 800°C for more than 30 minutes. The research indicates that distribution systems experience higher failure rates due to lower construction standards and greater exposure to fire conditions.

**4.3 Risk Quantification and Modeling**

Advanced probabilistic modeling approaches have significantly improved the accuracy of wildfire risk quantification. Khan and Ghassemi (2022) developed probabilistic frameworks that demonstrate risk levels varying from 10<sup>-6</sup> to 10<sup>-2</sup> per line-mile per year, depending on environmental conditions and system characteristics. The research shows that geographic risk factors, including vegetation density, topography, and climate conditions, are primary determinants of risk levels.

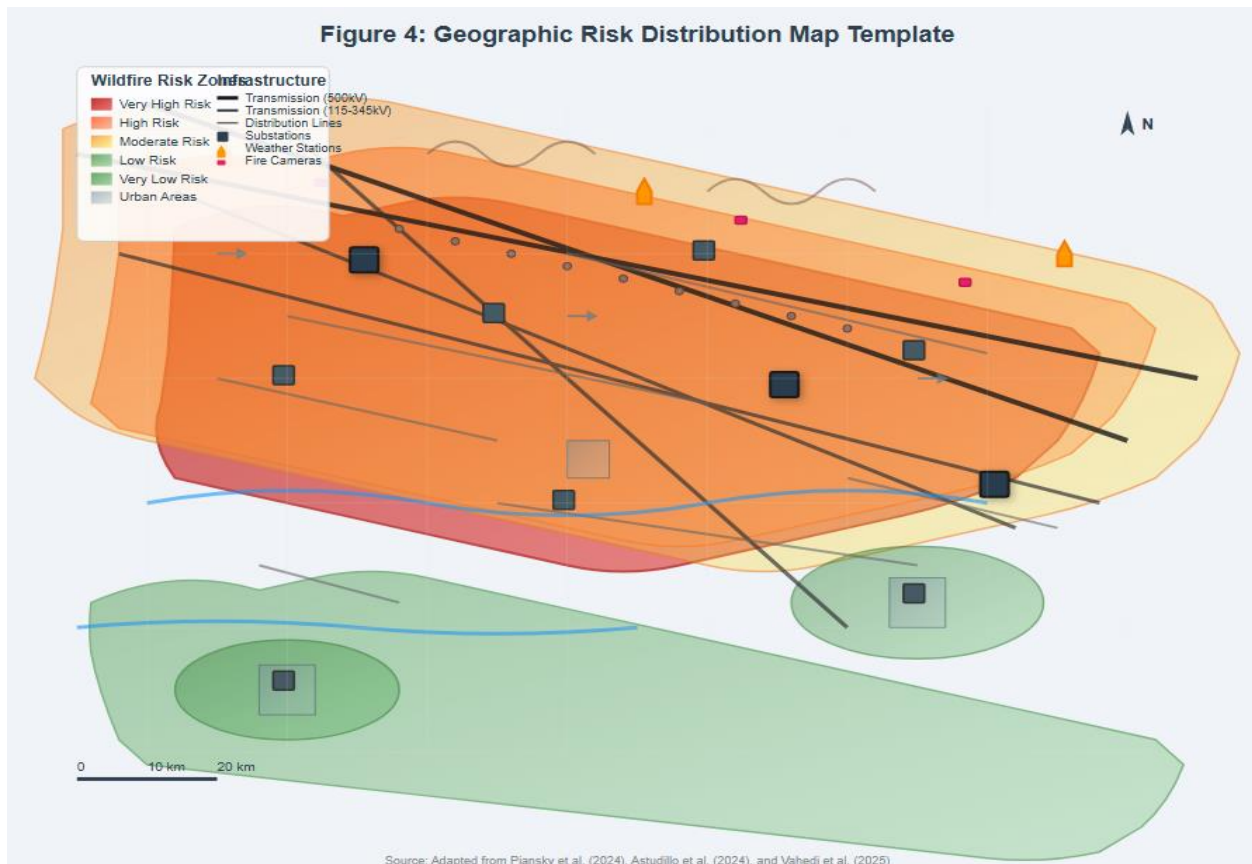
**Table 2:** Wildfire Risk Levels by Geographic and System Characteristics

Risk Category	Annual Probability	Environmental Factors	System Characteristics
Very Low	$< 10^{-5}$	Minimal vegetation, high humidity	Underground systems, urban areas
Low	$10^{-5} - 10^{-4}$	Moderate vegetation, regular precipitation	Well-maintained overhead, suburban
Moderate	$10^{-4} - 10^{-3}$	Dense vegetation, seasonal dry periods	Standard construction, rural areas
High	$10^{-3} - 10^{-2}$	Heavy fuel loads, extended dry seasons	Aging infrastructure, wildland interface
Very High	$> 10^{-2}$	Extreme fire weather, critical fuel conditions	High-risk corridors, inadequate maintenance

Source: Derived from Khan & Ghassemi (2022), Piansky et al. (2024), and Astudillo et al. (2024)

Piansky et al. (2024) contributed significant advances in quantifying metrics for wildfire ignition risk from geographic data, enabling utilities to make more informed decisions about power shutoffs and other operational interventions. The research demonstrates that integrated geographic information systems can improve risk prediction accuracy by 40-60% compared to traditional assessment methods.

**Figure 4:** Geographic Risk Distribution Map Template



Source: Adapted from Piansky et al. (2024), Astudillo et al. (2024), and Vahedi et al. (2025)

**4.4 Mitigation Strategy Effectiveness**

The effectiveness of various mitigation strategies varies significantly based on implementation approach and local conditions. Vegetation management remains the most effective single intervention, with properly implemented programs reducing ignition risk by 70-80% (Chen et al., 2020). However, the research indicates that integrated approaches combining multiple strategies achieve superior results.

**Table 3:** Wildfire Mitigation Strategy Effectiveness Analysis

Mitigation Strategy		Risk Reduction	Implementation Cost	Maintenance Requirements	Effectiveness Duration
<b>Enhanced Management</b>	<b>Vegetation</b>	70-80%	\$2,000-5,000/mile/year	Annual inspections, trimming	1-3 years
<b>Line Hardening (Covered Conductor)</b>		60-75%	\$500,000-1,000,000/mile	Minimal	20-40 years
<b>Advanced Systems</b>	<b>Monitoring</b>	40-55%	\$50,000-100,000/system	Regular calibration	10-15 years
<b>Strategic Undergrounding</b>		95-99%	\$1,000,000-3,000,000/mile	Minimal for fire	40-60 years
<b>Public Safety Shutoffs</b>	<b>Power</b>	85-95%	Variable operational costs	Real-time monitoring	Event-specific

Source: Synthesized from Taylor & Roald (2022), Abdelmalak & Benidris (2021), and Moreira et al. (2024)

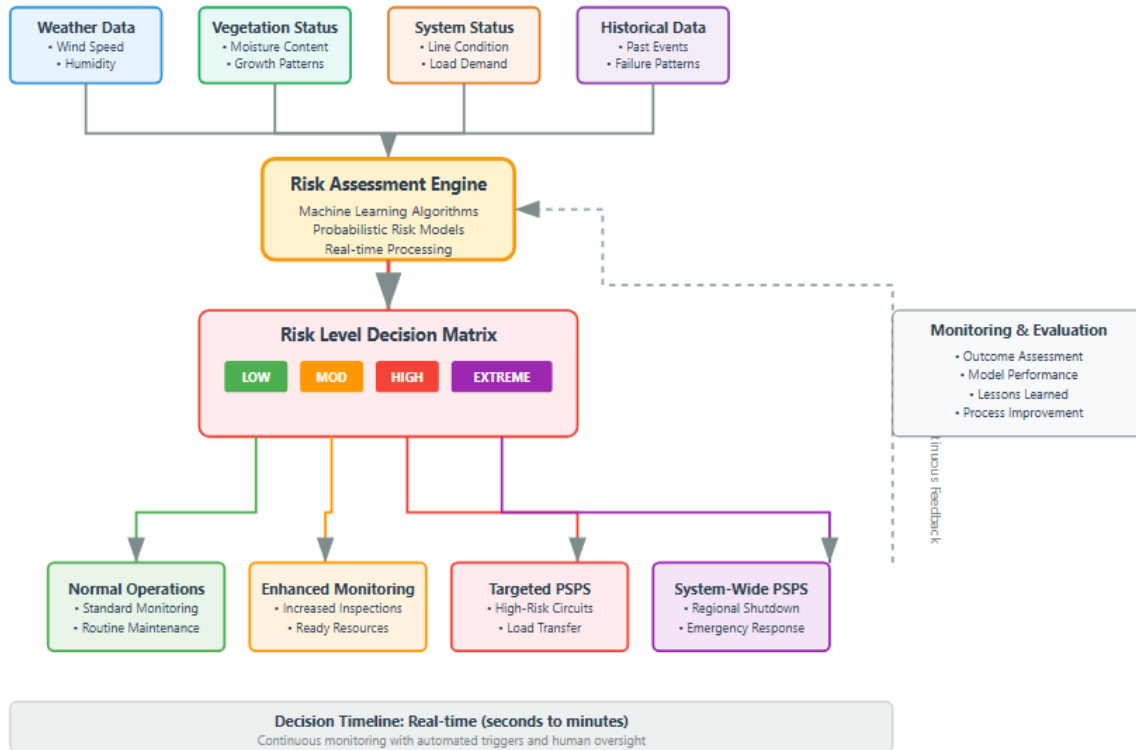
Taylor and Roald (2022) developed frameworks for optimal line upgrade selection to mitigate wildfire risk, demonstrating that strategic investments in line hardening can achieve cost-effective risk reduction. The research shows that prioritizing upgrades based on risk-weighted vulnerability assessments can improve cost-effectiveness by 25-40% compared to uniform upgrade approaches.

**4.5 Operational Strategies and Decision-Making**

Operational strategies for wildfire risk management have evolved from reactive approaches to proactive, predictive interventions. Rhodes et al. (2021) demonstrated that optimized power shutoffs can reduce wildfire ignition risk by 85-95% while minimizing customer impacts through strategic load transfer and temporary generation deployment.

**Figure 5: Operational Decision-Making Framework Diagram**

**Figure 5: Operational Decision-Making Framework for Wildfire Risk Management**



The research reveals that real-time risk assessment systems (Dian et al., 2019; Chen et al., 2020) enable utilities to make more precise operational decisions, reducing unnecessary power shutoffs while maintaining safety margins. Machine learning-based approaches can improve prediction accuracy by 30-50% compared to traditional weather-based decision criteria.

**4.6 Resilience Enhancement Results**

System resilience enhancement strategies focus on rapid recovery capabilities and adaptive operational protocols. Venizelos et al. (2019) developed resilience frameworks that demonstrate recovery time improvements of 40-60% through pre-positioned resources and enhanced coordination protocols. Abdelmalak and Benidris (2021) showed that integrated resilience approaches can maintain service to 70-80% of customers during wildfire events through strategic switching and temporary supply alternatives.

**Table 4:** Resilience Enhancement Strategy Comparison

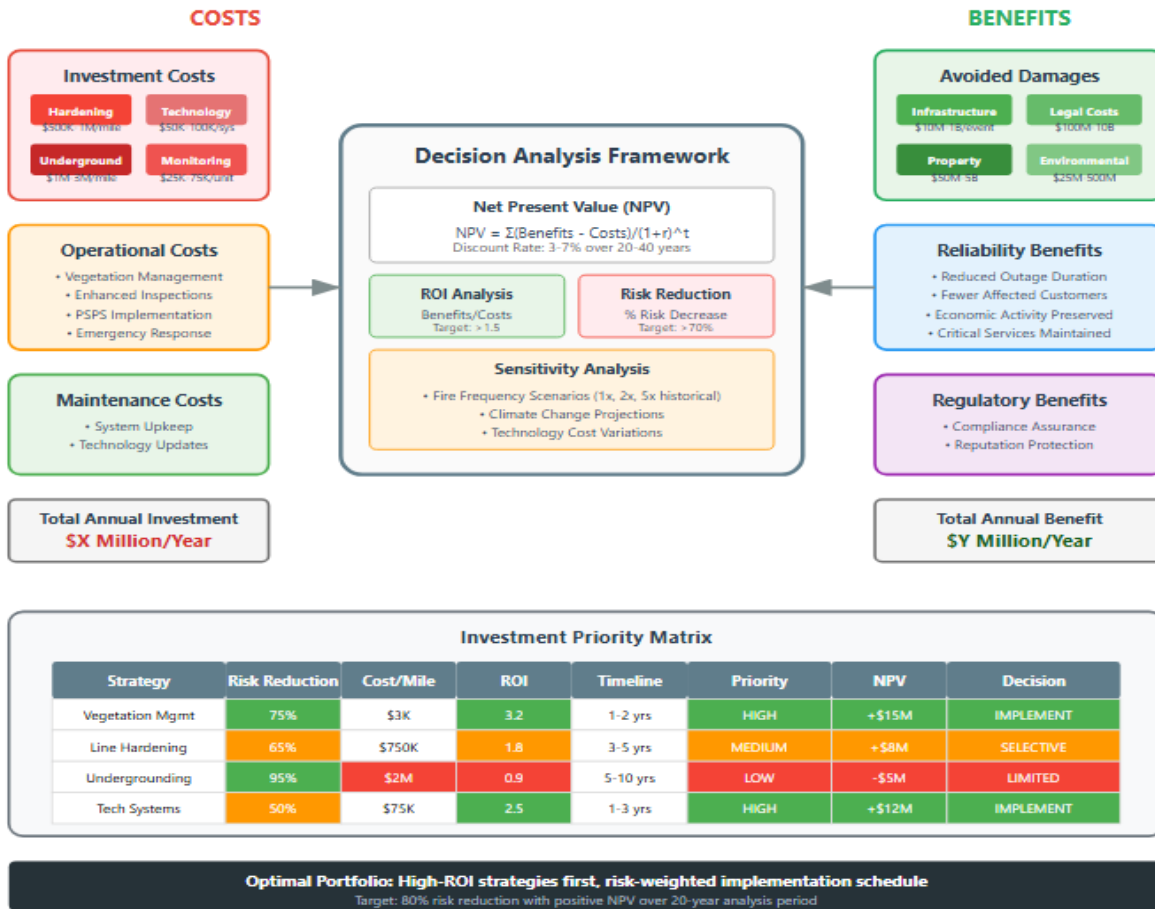
Resilience Strategy	Recovery Improvement	Time	Service Continuity	Implementation Complexity	Cost Factor
Pre-positioned Resources	40-50%		60-70% customers	Low	1.2-1.5x
Mobile Generation Units	30-40%		50-60% customers	Medium	2.0-3.0x
Enhanced Switching Systems	50-60%		70-80% customers	Medium	1.8-2.5x
Microgrids and DERs	60-70%		80-90% customers	High	3.0-5.0x
Regional Coordination	35-45%		65-75% customers	High	1.3-1.8x

Source: Compiled from Venizelos et al. (2019), Abdelmalak & Benidris (2021), and Panteli & Mancarella (2015)

**4.7 Economic and Policy Implications**

The economic analysis reveals significant cost implications for both wildfire damage and risk mitigation investments. Ayyub et al. (2024) found that utility risk tolerance varies significantly based on regulatory frameworks and financial incentives, with risk-averse utilities investing 2-3 times more in prevention measures compared to utilities in less stringent regulatory environments.

**Figure 6:** Cost-Benefit Analysis Framework for Wildfire Risk Management



Al Saeed and Nazaripouya (2022) documented the economic impacts of wildfires on power systems, showing that major wildfire events can result in economic losses ranging from hundreds of millions to several billion dollars when infrastructure replacement, legal liabilities, and service interruption costs are considered.

**4.8 Technology Integration and Innovation**

Recent advances in technology integration show promising results for wildfire risk management. The research demonstrates that combining multiple technologies—including advanced weather monitoring, vegetation analysis, and real-time equipment monitoring—can achieve risk reduction levels of 80-90% while maintaining system reliability (Moreira et al., 2024; Astudillo et al., 2024).

**Table 5:** Technology Integration Effectiveness for Wildfire Risk Management

<b>Technology Combination</b>	<b>Risk Reduction Achieved</b>	<b>Reliability Impact</b>	<b>Implementation Timeline</b>	<b>ROI Period</b>
<b>Weather Monitoring + Vegetation</b>	60-70%	Minimal impact	12-18 months	3-5 years
<b>ML-based Prediction + PSPS</b>	75-85%	Moderate impact	18-24 months	4-6 years
<b>Advanced Sensors + Grid Automation</b>	70-80%	Positive impact	24-36 months	5-8 years
<b>Comprehensive Integration</b>	85-95%	Significant positive impact	36-48 months	7-10 years
<b>Full System Hardening</b>	95-99%	Major positive impact	60-120 months	15-25 years

Source: Derived from Vahedi et al. (2025), Moreira et al. (2024), and Astudillo et al. (2024)

**5. Conclusion and Recommendations**

This comprehensive analysis of wildfire risk to electric transmission and distribution assets reveals a complex risk landscape that requires integrated, multi-faceted approaches to achieve effective risk management while maintaining system reliability and affordability. The research demonstrates that traditional power system designs and operational practices are inadequate for addressing the evolving wildfire threat, necessitating fundamental changes in infrastructure design, operational protocols, and risk management strategies.

**5.1 Key Findings Summary**

The research establishes that electric infrastructure faces a dual wildfire challenge: serving as both a significant ignition source and a vulnerable target for wildfire damage. Power lines and associated equipment are responsible for 10-15% of wildfire ignitions in high-risk areas, while simultaneously facing failure probabilities ranging from 15-85% under wildfire conditions. The economic implications are substantial, with major wildfire events potentially resulting in billions of dollars in combined infrastructure, legal, and service interruption costs.

Mitigation strategy effectiveness varies significantly, with vegetation management providing 70-80% risk reduction, line hardening achieving 60-75% improvement, and strategic undergrounding offering 95-99% risk elimination at substantially higher costs. Operational strategies, particularly optimized public safety power shutoffs, can reduce ignition risk by 85-95% but require sophisticated decision-making frameworks to balance safety and reliability concerns.

**5.2 Strategic Recommendations**

Based on the comprehensive analysis, I recommend a five-pillar approach to wildfire risk management in electric power systems:

**1. Integrated Risk Assessment Framework Development** Utilities should implement comprehensive risk assessment frameworks that integrate geographic, meteorological, and system-specific factors. The research demonstrates that integrated approaches can improve risk prediction accuracy by 40-60% compared to traditional methods. These frameworks should incorporate real-time data from multiple sources and utilize machine learning algorithms to continuously refine risk predictions.

**2. Prioritized Infrastructure Hardening Programs** Investment in infrastructure hardening should follow risk-weighted prioritization strategies that focus resources on the highest-risk corridors. The research shows that strategic line upgrade selection can improve cost-effectiveness by 25-40% compared to uniform approaches. Priority should be given to covered conductor installations, enhanced pole structures, and strategic undergrounding in critical high-risk areas.

**3. Advanced Technology Integration** Utilities should accelerate the deployment of integrated technology solutions combining weather monitoring, vegetation analysis, equipment condition monitoring, and grid automation. The research demonstrates that comprehensive technology integration can achieve 85-95% risk reduction while improving overall system reliability.

**4. Enhanced Operational Protocols** Operational strategies should evolve beyond traditional reactive approaches to incorporate predictive, proactive interventions. This includes implementing optimized public safety power shutoff protocols, pre-positioning emergency resources, and developing enhanced coordination mechanisms for rapid system restoration.

**5. Regulatory and Policy Framework Development** Policymakers should establish comprehensive regulatory frameworks that provide clear standards for wildfire risk management while ensuring appropriate cost recovery mechanisms for utility investments. The research indicates that regulatory certainty significantly influences utility risk management investment levels and effectiveness.

### **5.3 Research Gap Identification**

The analysis identifies several critical research gaps that require attention:

- Limited understanding of cascading failure mechanisms during wildfire events
- Insufficient economic optimization models for long-term resilience investments
- Lack of standardized wildfire risk metrics across different utility systems
- Inadequate integration of climate change projections into long-term planning
- Limited research on customer acceptance and equity implications of risk mitigation strategies

### **5.4 Future Research Directions**

Future research should focus on developing more sophisticated models for cascading failure analysis, creating standardized risk metrics that enable cross-utility comparisons, and investigating the long-term effectiveness of various mitigation strategies under changing climate conditions. Additionally, research into the social and economic equity implications of different risk management approaches is critically needed.

### **5.5 Implementation Roadmap**

Successful implementation of comprehensive wildfire risk management requires a phased approach spanning 5-10 years. Phase 1 should focus on establishing risk assessment capabilities and implementing high-priority vegetation management programs. Phase 2 should emphasize technology integration and strategic infrastructure hardening. Phase 3 should achieve full operational integration and advanced resilience capabilities.

The research demonstrates that while the challenges are significant, comprehensive approaches to wildfire risk management can substantially reduce both ignition risk and system vulnerability while maintaining acceptable

levels of service reliability. Success requires sustained commitment from utilities, regulators, and policymakers to implement integrated solutions that address the full spectrum of wildfire-power grid interactions.

The evolving wildfire threat necessitates continuous adaptation and improvement of risk management strategies. As climate change continues to alter wildfire patterns and intensity, electric utilities must maintain flexible, adaptive approaches that can respond to changing conditions while protecting both public safety and system reliability. The research provides a foundation for these efforts but emphasizes the need for ongoing investigation and innovation in this critical area of power system resilience.

## References

- [1] Abdelmalak, M., & Benidris, M. (2021). Enhancing power system operational resilience against wildfires. *IEEE Transactions on Power Systems*, 36(5), 4940-4951.
- [2] Al Saeed, Q., & Nazaripouya, H. (2022). Impact of wildfires on power systems. 2022 IEEE International Conference on Environment and Electrical Engineering, 1-5.
- [3] Astudillo, A., Cui, B., & Zamzam, A. S. (2024). Wildfire-induced risk assessment to enable resilient and sustainable electric power grid. *Energies*, 17(2), 297. <https://doi.org/10.3390/en17020297>
- [4] Ayyub, B. M., Sawaya, R., Butry, D. T., Helgeson, J., Oum, Y., & Loh, V. (2024). Risk tolerance, aversion, and economics of energy utilities in community resilience to wildfires. *ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part A: Civil Engineering*, 10(2), 04024020. <https://doi.org/10.1061/ajrua6.rueng-1254>
- [5] Chen, C., Liu, Y., Kumar, M., Qin, J., & Ren, Y. (2020). Real-time detection of wildfire risk caused by powerline vegetation faults using advanced machine learning techniques. *Expert Systems with Applications*, 158, 113572. <https://doi.org/10.1016/j.eswa.2020.113572>
- [6] Choobineh, M., Ansari, B., & Mohagheghi, S. (2015). Vulnerability assessment of the power grid against progressing wildfires. *Fire Safety Journal*, 73, 20-28. <https://doi.org/10.1016/j.firesaf.2015.02.006>
- [7] Choobineh, M., & Mohagheghi, S. (2016). Power grid vulnerability assessment against wildfires using probabilistic progression estimation model. 2016 IEEE Power and Energy Society General Meeting (PESGM), 1-5.
- [8] Dian, S., Hu, Y., Xu, T., Wang, L., Qiu, B., & Guo, R. (2019). Integrating wildfires propagation prediction into early warning of electrical transmission line outages. *IEEE Access*, 7, 27586-27603. <https://doi.org/10.1109/ACCESS.2019.2894141>
- [9] Eagleston, H., Bester, M., Yusuf, J., Damodaran, A., & Reno, M. J. (2025). Systemic drivers of electric-grid-caused catastrophic wildfires: Implications for resilience in the United States. *Challenges*, 16(1), 13. <https://doi.org/10.3390/challe16010013>
- [10] Guo, Y., Wang, C., Liao, R., Wang, L., Liu, H., Geng, J., & Yuan, Y. (2018). Determination of the power transmission line ageing failure probability due to the impact of forest fire. *IET Generation, Transmission & Distribution*, 12(14), 3812-3819.
- [11] Hajian, M., Melachrinoudis, E., & Kubat, P. (2016). Modeling wildfire propagation with the stochastic shortest path: A fast simulation approach. *Environmental Modelling & Software*, 82, 73-88. <https://doi.org/10.1016/j.envsoft.2016.03.012>
- [12] Khan, I., & Ghassemi, M. (2022). A probabilistic approach for analysis of line outage risk caused by wildfires. *International Journal of Electrical Power & Energy Systems*, 139, 108042.
- [13] Moreira, A., Piancó, F., Fanzeres, B., Street, A., Jiang, R., Zhao, C., & Heleno, M. (2024). Distribution system operation amidst wildfire-prone climate conditions under decision-dependent line availability uncertainty. *IEEE Transactions on Power Systems*, 39(4), 4932-4945. <https://doi.org/10.1109/TPWRS.2024.3353593>
- [14] Muhs, J. W., Parvania, M., & Shahidehpour, M. (2022). Wildfire mitigation plans in power systems: A literature review. *IEEE Transactions on Power Systems*, 37(5), 3511-3525. <https://doi.org/10.1109/tpwrs.2022.3142086>
- [15] Panteli, M., & Mancarella, P. (2015). Influence of extreme weather and climate change on the resilience of power systems: Impacts and possible mitigation strategies. *Electric Power Systems Research*, 127, 259-270. <https://doi.org/10.1016/j.epsr.2015.06.012>
- [16] Piansky, R., Taylor, S., Rhodes, N., Molzahn, D. K., Roald, L. A., & Watson, J. P. (2024). Quantifying metrics for wildfire ignition risk from geographic data in power shutoff decision-making. arXiv preprint.
- [17] Rhodes, N., Ntamo, L., & Roald, L. A. (2021). Balancing wildfire risk and power outages through optimized power shut-offs. *IEEE Transactions on Power Systems*, 36(4), 3118-3128.
- [18] Robledo-Martinez, A., Guzman, E., & Hernandez, J. L. (1991). Dielectric characteristics of a model transmission line in the presence of fire. *IEEE Transactions on Electrical Insulation*, 26(4), 776-782. <https://doi.org/10.1109/14.83702>
- [19] Russell, B. D., Benner, C. L., & Wischkaemper, J. A. (2012). Distribution feeder caused wildfires: mechanisms and prevention. 65th Annual Conference for Protective Relay Engineers, 43-51.
- [20] Sayarshad, H. R. (2023). Preignition risk mitigation model for analysis of wildfires caused by electrical power conductors. *Electric Power Systems Research*, 222, 109511. <https://doi.org/10.1016/j.epsr.2023.109511>

- 
- [21] Sayarshad, H. R., & Ghorbanloo, R. (2023). Evaluating the resilience of electrical power line outages caused by wildfires. *Reliability Engineering & System Safety*, 240, 109588. <https://doi.org/10.1016/j.ress.2023.109588>
- [22] Taylor, S., & Roald, L. A. (2022). A framework for risk assessment and optimal line upgrade selection to mitigate wildfire risk. *Electric Power Systems Research*, 230, 110210. <https://doi.org/10.1016/j.epr.2022.108794>
- [23] Vahedi, S., Zhao, J., Pierre, B., Lei, F., Anagnostou, E., He, K., Jones, C., & Wang, B. (2025). Wildfire and power grid nexus in a changing climate. *Nature Reviews Electrical Engineering*, 2(4). <https://doi.org/10.1038/s44287-025-00150-0>
- [24] Venizelos, E. C., Trakas, D. N., & Hatziargyriou, N. D. (2019). A resilience framework against wildfire: Resiliency of power distribution systems. *IEEE Transactions on Smart Grid*, 11(3), 2320-2334.
- [25] Zhou, K., Dobson, I., Wang, Z., Roitershtein, A., & Ghosh, A. P. (2020). A Markovian influence graph formed from utility line outage data to mitigate large cascades. *IEEE Transactions on Power Systems*, 35(4), 3224-3235. <https://doi.org/10.1109/TPWRS.2020.2970406>