EPRI

2024 White Paper

EPRI Wildfire Mitigation Research

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BACKGROUND

Wildfires threaten electric companies' ability to provide reliable and affordable electricity to the customers and communities they serve. With climate change and the emergence of increased extreme weather events, the power delivery systems of the future must be more prepared for wildfire threats and other weather-related dangers. Electric companies, in an effort to mitigate these threats, continue to play a pivotal role to raise awareness of and to invest in solutions because wildfires, regardless of ignition source, present a significant threat to electric infrastructure and public safety.

These investment actions have revealed that reduction in ignition incidents is a key risk management focus for electric service providers globally. Technology developers, research organizations, and electric companies continue to dedicate significant resources to exploring innovations aimed at reducing this risk.

This portfolio aims to provide stakeholders with the technical basis with which to select and apply technologies and approaches to mitigate wildfire risk.

EPRI WILDFIRE R&D PORTFOLIO

Fire-hardened electric power system infrastructure and state-of-the-art smart grid technologies are intended to reduce the risk of ignition and increase resiliency. In addition, electric service providers need access to situational awareness technologies and to alerts that identify dynamic fire risk and recommend the actions necessary to minimize those risks.

While other organizations are focused on developing new technologies and sharing industry practices, EPRI's main roles are evaluating the effectiveness of new technologies and their ability to de-risk wildfire areas. In addition, EPRI investigates prudent practices and mitigation methods, understanding of the impact on the full asset lifecycles.

The following table maps some of the EPRI support roles to relevant wildfire risk reduction categories:

RESEARCH CATEGORIES Identified by EEI	EPRI'S EFFORTS
All Categories	Identifying, testing, and verifying new emerging technologies.
1. Wildfire Risk Assessment	Cataloging and assessing wildfire hazard assessment tools and informing planning methods to evaluate grid impacts and prioritizing mitigation options.
2. Situational Awareness	Evaluating and piloting the use of situational awareness methods including sensors, asset monitoring, cameras, and satellites.
3. Vegetation Management	Evaluation and piloting of advanced vegetation management inspection approaches.
4. Protection & Control	Laboratory testing and field evaluation of advanced relay protection, downed conductor detection, and fault interrupting and current limiting devices and technologies.
5. Operational Practices & Training	Creating awareness of any advanced Public Safety Power Shutoff (PSPS) approaches and technologies being used.
6. Community Outreach	Making utilities aware of any advanced approaches and technologies being utilized.
7. Grid Hardening	Evaluation of grid hardening technologies and understanding the full asset life cycle.
8. Utility Practices Capability Models	Monitoring and contributing as requested.

EPRI Wildfire Related Projects

For more than a decade, EPRI has conducted industry-leading research on wildfires. EPRI has a deep and diverse portfolio of applied research results, ranging from seasonal readiness guides, fuel studies, and vegetation management to the recently launched Wildfire Advisory Group, which brings together experts for analysis and best practices. EPRI's breadth of expertise on these topics and state-of-the-art lab testing facilities provide members with a unique advantage as they navigate complex, emerging, and highly specific needs.

EPRI must understand the practices and technologies electric companies are adopting on a global scale. Therefore, EPRI engages with many of the other collaborative entities addressing wildfire risk, including the U.S. Department of Energy (DOE), International Wildfire Risk Mitigation Consortium (IWRMC), Electricity Subsector Coordinating Council (ESCC), and North American Transmission Forum (NATF). Plus, EPRI draws on the knowledge and insights from countries like Australia and South Africa to accelerate the deployment of wildfire risk mitigation technologies.

The following sections summarize the past contributions, ongoing research, and future areas of work that the EPRI team is undertaking. The work is diverse and cuts across many EPRI transmission, distribution, and energy systems R&D areas.

EPRI'S EFFORTS	RESEARCH CATEGORIES Identified by EEI							
	1	2	3	4	5	6	7	8
Wildfire Consideration in Bulk System Planning	X							
Inventory and Assessment of Wildfire Hazard Data Products	X							
Identification and Piloting of Wildfire Detection & Monitoring Technologies		X						
Fuel Removal for Wildfire Management			X					
Vegetation Management Efficacy Database			X					
Testing of Protection and Downed Conductor Detection Systems				X				
Public Safety Power Shutoffs (PSPS) as a Last Resort for Extreme Fire Risk Conditions					X			
Wildfire Impacts on Air Quality and Human Health and Safety						X		
Normalized Difference Vegetation Indices (NDVI) Health Analytics						X		
Evaluation of Insulation and Fault Protective Coverings and Components							X	
Full Scale Overhead System Design Testing							X	
Conductor Slap Modeling and Data Mining for Incident Identification and Avoidance							X	
Undergrounding to Reduce Ignition Incident Risk							X	

Research Category 1

Inventory and Assessment of Wildfire Hazard Data Products

As extreme weather events increase in frequency and society's dependence on electricity grows, EPRI launched Climate READi (REsilience and ADaptation Initiative) to deliver a comprehensive, consistent, and collaborative approach to mitigate physical climate risk, ensure resilient energy, and enable robust planning. This includes a look at wildfire's impact to the energy system and mitigation efforts.

EPRI's Ongoing Efforts:

EPRI is currently developing an inventory and assessment of available wildfire hazard datasets, models, tools, and services as part of Climate READi. The goal of this work is to conduct an objective evaluation of existing wildfire risk assessment and wildfire smoke products based on a set of evaluation criteria to guide electric companies and other organizations towards the optimal products for specific applications. The wildfire risk and wildfire smoke data products being reviewed vary widely in their purpose and functionality, complexity (including the types of data used), their definition of risk, spatial and temporal extent and resolution, and accessibility (e.g., methodological transparency, cost, ease of use). The outcomes will provide stakeholders, including utilities, communities, and emergency response organizations, with options on how to ingest more actionable and up-to-date data layers into their risk analysis tools and information systems.

EPRI's Future Plans:

As more and more utilities across the globe begin to leverage wildfire hazard assessment tools, EPRI intends to continue maintaining its catalog of available risk assessment and smoke data products. This work also helps to inform a climate data gap analysis being conducted in Climate READi that identifies critical climate data needs for physical risk assessments in the power sector. EPRI is also developing a subsequent RFP that will fund the development of climate data to fill these gaps.

Research Category 1

Wildfire Consideration in Bulk System Planning

From a bulk system planning perspective, EPRI has worked on two aspects related to consideration of wildfires: consideration of wildfires in long-term system expansion planning and assessing impact of wildfires on transmission system resilience to make investment decisions.

EPRI's Past Contributions:

EPRI recently completed a study for Australian Energy Market Operator (AEMO) to develop a formulation to include hazard-driven load changes, deratings and shutdowns of generation and transmission assets, the risk of damage costs to grid components or outside parties, hardening options to mitigate those disruptions and damages, and the costs and operational implications of those hardening investments.

To better plan against potential extreme events, a California utility worked with EPRI to conduct a synthetic climate assessment (SCA) to assess existing and future climate conditions and extreme weather events in the Los Angeles basin to identify vulnerabilities to their bulk power system.

EPRI's Ongoing Efforts:

Further work on both topics is being performed and focuses on improving the methodologies and integrating them in EPRI's Climate READi framework to assess system impacts and adaption options for climate change and extreme weather events.

Research Category 2

Identification and Piloting of Wildfire Detection & Monitoring Technologies

One of EPRI's important roles in the detection and monitoring space is the early vetting of emergent technologies that may inform improved wildfire situational awareness. This includes developing test protocols and unique test configurations, creating evaluation performance metrics, and working directly with vendors to insure they are developing technologies that have a viable operationalization pathway.

EPRI's Past Contribution:

EPRI has evaluated the effectiveness and technology readiness of several different detection and monitoring systems that have wildfire related aspirations including the IND.T Early Fault Detection system, the Pano AI smoke detection system, the Dryad smoke sensor network, the Gridware Inc. downed wire and environmental sensor for overhead line applications, and the EPRI Distribution Fault Anticipator DFA technology that was jointly developed with a collaborative of EPRI Advisors and with Texas A&M University.

EPRI's Ongoing Efforts:

As members prioritize and invest in these and other new technologies it is important to ensure that success cases are rapidly turned around, so the industry can learn and succeed quickly. Each of the previously described technologies are emergent for wildfire applications and require continued evaluation and continued iteration to keep electric companies apprised of the relevance of each of these tools and resources.

EPRI's Future Plans:

EPRI intends to continue testing new technology as it is identified and aims to work with U.S. National Labs and other industry stakeholders to develop new detection and monitoring technologies. This space is broad but one tangible and beneficial opportunity is the curation of a Fault Signature repository. This activity would collaborate with EPRI members and the U.S. DOE to create a repository aspiring to contain 1000 or more fault incidents with known cause, relevant electrical waveforms, and any other signatures of value. Given that a comprehensive fault repository is available to any researchers or monitoring technology developers interested in testing their algorithms or concepts, the entire industry benefits from this (training and testing) data resource.

Research Category 3

Fuel Removal for Wildfire Management

There are many different options for vegetation management, depending on regulations, ecosystem aspects, precipitation, fire regimes, proximity to communities, and other factors. Enhanced clearing can serve as an important type of more aggressive vegetation management.

EPRI's Past Contribution:

EPRI worked with a California utility to document current fuel removal practices across the company's rights of way located within U.S. Forest Service (USFS) land, explore the scientific background and regional applicability of several additional options for addressing, and provide a focused analysis of selected options. The general categories of practices reviewed included debris management, removal (including consideration of secondary use) and mechanical treatment, herbicides and growth inhibitors, fuel breaks, targeted grazing, and enhancing integrated vegetation management efforts. Additionally, EPRI developed a cost-benefit tool to evaluate the economic impacts related to wildfire risk mitigation in forested watersheds around utilities.

EPRI's Ongoing Efforts:

An analysis of watershed activities and forest management practices is ongoing in the Ecosystem Risk and Resilience program, developing a set of management practices to reduce risk and avoid damages associated with wildfire, and other landscape hazards. In addition, the cost-benefit tool developed to review scenarios of catastrophic fire is being augmented to include other risk factors related to reducing wildfire risk. Understanding these practices and risk factors will help companies link the various activities underway across their organizations to incorporate wildfire mitigation priorities and enable stakeholder and agency engagement using scientific and economic impact analyses.

EPRI's Future Plans:

EPRI will perform cost-benefit analyses, document practices, create frameworks, and design roadmaps for utilities to evaluate their forested areas and different fuel management options, and to decrease wildfire risk from dead and dying trees in their service territories and around their rights of way. These will revolve around helping companies document and evaluate their options for fuel management given the company's specific regional concerns, creating frameworks to measure company-wide and company-specific wildfire management performance, developing metrics to track and communicate progress to stakeholders, as well as more targeted research to help companies create a tailored roadmap to manage wildfire risk.

Research Category 3

Vegetation Management Efficacy Database

Utilities must often meet regulatory requirements related to wildfire risk, which can include compliance with public utility general orders and statutory obligations concerning vegetation management and additional requirements regarding rights of way (ROW). One key area of practical research is vegetation management and how it may affect outages and associated ignition incidents. An important type of more aggressive vegetation management is enhanced clearing. EPRI focuses on analyzing the efficacy of enhanced clearing through database development and data analysis.

EPRI's Past Contribution:

EPRI completed a study on distribution grid resiliency and vegetation management, which included industry interviews and modeling to provide important types of data needed to prioritize vegetation management resiliency improvements. The EPRI team assessed the key issue of debris management and fuel removal, tested different types of branches and vegetation, and created real faults to understand the arc energy and wire burndown concerns associated with such faults. The team also developed demonstration projects to analyze segments of utility distribution networks to assess vegetation hazards along segments.

EPRI's Ongoing Efforts:

The current research effort centers around the effectiveness of enhanced vegetation clearing and its potential effects on ignition risk and outages. The three investor-owned energy companies in California are supporting a joint study to examine the effectiveness of enhanced clearances across their diverse territories. The research aims to create a joint database across the three utilities which would be able to establish uniform data collection standards, focus on tree-caused risk events, incorporate both biotic and abiotic factors, and assess the effectiveness of enhanced clearances. The joint database provides opportunity for both utility SMEs and researchers to gain deep insight on the causes of ignition events and the potential vegetation management options to mitigate some of them.

EPRI's Future Plans:

The study in California has the potential to address short and long-term research needs in California and around the world, where wildfire risk is not expected to decrease in the coming decades. EPRI is implementing a phased approach which will first look at a set of common variables between the utilities. In subsequent phases, EPRI will conduct an extended analysis, which includes a granularity assessment of common variables and analysis of individual investor-owned utility (IOU) data to evaluate and provide ideas for future utility data collection efforts.

Research Category 4

Testing of Protection and Downed Conductor Detection Systems

Protection and downed conductor detection systems can automatically detect, report, and deenergize circuits which may be a fire and ignition risk. This same system can function in non-fire threat areas to avoid electric shock risks to the public. The effectiveness and ease of implementation of these technologies remains largely unquantified.

EPRI's Past Contribution:

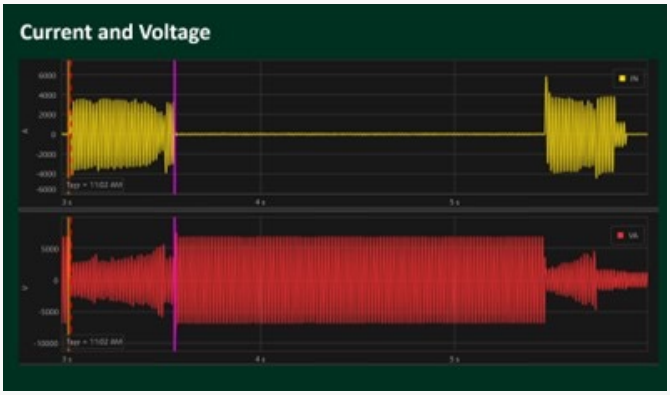
EPRI built a broken conductor and live downed conductor test site at the EPRI Lenox, MA test facility. To date, EPRI has tested seven different monitoring or combination monitoring/protection systems and has evaluated several types of overhead power line geometries. For the algorithm-based protection systems, EPRI found that while the systems can detect many unsafe conditions, users will have to tolerate some false positives and therefore must make risk informed decisions about how and where to apply these detection systems.

EPRI's Ongoing Efforts:

EPRI continues to use its test infrastructure to evaluate advanced detection technologies and protection schemes to determine their ability to reduce arc and fault energy. This work may help vendors better optimize their algorithms and can assist utilities with tuning their systems for optimal field performance.

EPRI's Future Plans:

EPRI is developing a detailed specification for utilities to procure ultra-fast current limiting protection systems that may enable reduced Public Safety Power Shutoff (PSPS) durations by allowing a circuit to continue operating normally right up until storm conditions become extreme and unsafe. EPRI is also facilitating the development of the next generation of distribution automation devices leveraging advanced edge computing to monitor local environmental conditions and to adapt protective settings.



Research Category 5

Public Safety Power Shutoffs (PSPS) as a Last Resort for Extreme Fire Risk Conditions

According to the California Public Utilities Commission website: "With the continuing threat of wildfire, the electric investor-owned utilities (IOUs) may proactively cut power to electrical lines as a measure of last resort if the utility reasonably believes that there is an imminent and significant risk that strong winds may topple power lines or cause major vegetation-related issues leading to increased risk of wildfires. This effort is called a PSPS or Public Safety Power Shutoff."

EPRI's Past Contribution:

In 2021, EPRI published a document that highlights wildfire risks and the challenges to electric power and societal resilience, experienced and addressed at the levels of individuals, businesses, governments, and electric utilities. The document includes details on the value of electricity resilience to customers and society during PSPS events, and drivers and alternatives for emerging and equitable technology solutions for electricity resilience. Plus, it includes impediments to the adoption of advanced distributed energy resource (DER) and microgrid solutions.

EPRI's Ongoing Efforts:

EPRI is investigating and testing fault current limiting technology that has the potential to either reduce the footprint or the total duration of a power shutoff event.

EPRI's Future Plans:

Since PSPS events are an emergent and unfamiliar tool for many utilities around the globe, EPRI intends to support members with forums to curate leading practice around the decision making and the communications aspects of operating a wildfire risk reduction program that involves the option to use power shutoffs as an ignition mitigation tool.

Research Category 6

Wildfire Impacts on Air Quality and Human Health and Safety

With the increasing frequency of wildfires in recent years, smoke emissions are boosting air pollution concentrations, leading to record breaking numbers of days impacted by wildfire smoke. An ongoing challenge is that areas of the U.S. that would otherwise achieve National Ambient Air Quality Standards (NAAQS) from the U.S. Environmental Protection Agency (EPA) must prove that uncontrollable wildfire smoke exceeded these standards due to an "exceptional event."

EPRI's Past Contribution:

EPRI supported academic research on air and the measurement and chemistry of wildfire emissions because exposure to pollutants from wildfire events, including fine particulate matter (PM2.5) and ozone, can cause both acute and long-term health impacts. EPRI also supports research on air quality, the health impacts of wildfires, and modeling of wildfire events and air quality related simulations.

EPRI's Ongoing Efforts:

EPRI is developing a nationwide screening methodology for PM2.5 and ozone enhancements due to wildfire smoke emissions. The screening methodology combines widely used wildfire tools, including the National Oceanic and Atmospheric Administration's (NOAA) Hazard Mapping System (HMS) smoke maps, observations from PM2.5 and ozone monitors, smoke specific PM2.5 model results, and Generalized Additive Modeling (GAM) results. Results from this research will be directly applicable policy-relevant information on possible NAAQS attainment or nonattainment for many areas across the U.S.

EPRI's Future Plans:

As wildfires increase in frequency and broaden their impact across many geographic areas, EPRI has initiated a supplemental project on Wildfire Smoke Health and Safety Hazards. The results from this research should directly support electric utility companies in identifying, monitoring, and mitigating wildfire-related health and safety risks to utility staff. In other efforts specific to air quality, EPRI will also continue to improve the representation of the chemistry of wildfire emissions in air quality models to help the development of effective air quality management strategies. Overall, these planned activities are expected to inform the development of sound safety management practices, supporting the health of the workforce and, by extension, the communities in which workers live.

Research Category 6

Normalized Difference Vegetation Indices (NDVI) Health Analytics:

Normalized Difference Vegetation Indices (NDVI) may be used as a key input variable for modeling and simulation tools to understand the relative greenness or dryness and corresponding health of different species of trees, plants, grasses, and crops. Having a real time understanding of local vegetation dryness contributes immeasurably to both wildfire hazard potential and to fire spread risk modeling. A common industry challenge is the lack of consistency between different data sources and the derivation of the real time geospatial representation of fire hazard conditions.

EPRI's Past Contribution:

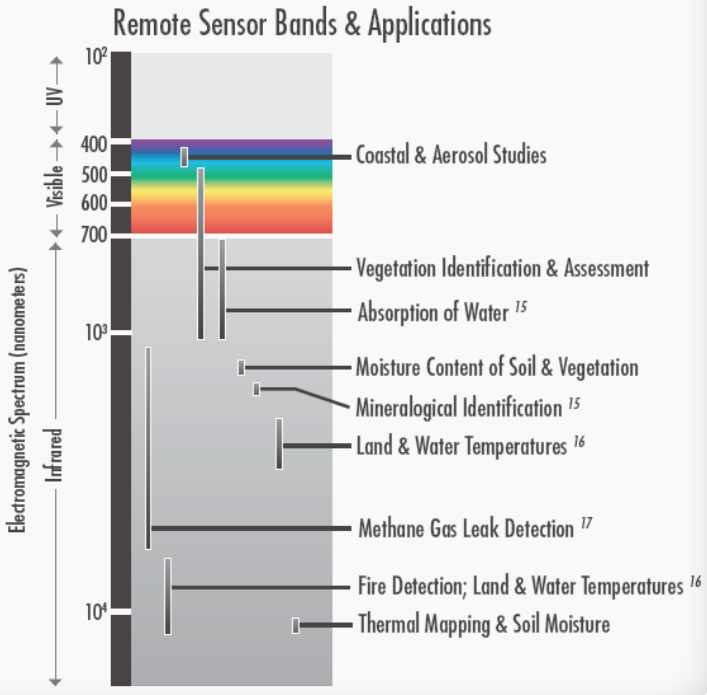
EPRI has conducted several studies with both NDVI and with Synthetic Aperture Radar (SAR) from satellite imagery to better guide the industry to understand how this emergent data could shape the future of vegetation analytics. One such effort provides a 2020 snapshot in time of how NDVI analytics can identify distressed trees outside of a utility right-of-way that are of the greatest risk of falling into the lines during a future high wind event. The follow-on 2022 research sponsored by EPRI's AI initiative found that the same NDVI approaches along with some enrichment data sets performs well in fire ravaged areas where some of the remaining standing trees may need to be removed before they result in a line contact or in an access roadway blockage.

EPRI's Ongoing Efforts:

EPRI continues to evaluate the use of aerial lidar and multi-spectral imagery for vegetation management purposes, this includes a research effort leveraging substation drones to fly planned and unplanned missions. In addition, EPRI has a supplemental project offering designed to understand the possibilities afforded with satellite acquired SAR.

EPRI's Future Efforts:

EPRI plans to work with Pacific Northwest National Labs (PNNL) and interested members to leverage the roughly two-meter-wide tree canopy change discernment capabilities available with SAR. The premise being that SAR holds promise for finding trees that have fallen in a utility right of way after the high winds have subsided and when those lines need to be inspected after a PSPS event.



Evaluation of Insulation and Fault Protective Coverings and Components

One method for ignition incident reduction is to insulate or to apply coverings to energized components. For example, the practice of using covered conductors is common in areas with significant tree and vegetation density and in areas where wildlife related faults are of concern. These retrofits resulted in several questions such as the lifecycle aging performance, moisture ingress, added weight of the coverings, ice buildup, wind vibration concerns, and installation best practices.

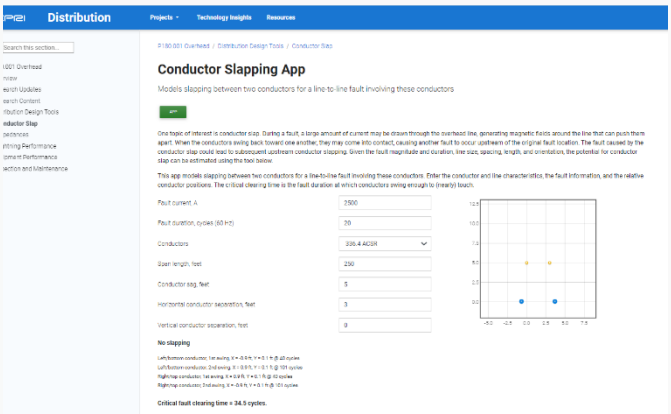
EPRI's Past Contribution:

EPRI conducted lifecycle and flammability testing on multiple overhead distribution assets, including wildlife guards, fiberglass crossarms, pole materials, and covered conductor and their accessories. These tests generally evaluate components as they would be applied in the field, as opposed to material tests commonly prescribed by standards. For example, components at EPRI labs are exposed to arcing flashover events like those that might occur due to a wildlife contact.

- *Wildlife guards* - EPRI developed a wildlife guard database including EPRI flammability and arc flash resiliency testing. The database enables utilities to select wildfire hardened designs. The results also prompted some manufacturers to reconfigure their products to improve performance. Utilities also used the results as a basis for selecting wildlife guards in areas with elevated wildfire risk.
- *Structural components* – EPRI tested the flammability of fiberglass reinforced polymer (FRP) poles and crossarms. EPRI also examined the electrical tracking performance of these materials to better determine their ability to resist dry-band arcing. Finally, EPRI conducted testing on chemically treated wood poles to better understand pole performance when exposed to wildfire, e.g., CCA-treated poles tend to continue burning internally even though the exterior may appear extinguished.
- *Lifecycle Performance* – EPRI developed and executed tests to evaluate covered conductor and accessory performance. One such test evaluated insulation degradation by exposing conductor coverings to high electrical stresses over a period of two years. Other tests placed accessories in an energized salt-fog chamber to learn more about their corrosion and electrical tracking characteristics. For example, one piercing connector experienced significant corrosion damage that could potentially lead to heating and subsequent failure. EPRI also replicated conditions that caused ground wire covering to ignite, demonstrating the importance of conducting combustibility testing of certain components while they operate at high temperatures, such as those experienced during a wildfire.

EPRI's Ongoing Efforts:

New to market insulations and component coverings are actively being tested to determine if they provide enhanced performance over those developed decades ago. As new designs and materials become available, EPRI develops and refines design and product qualification tests. One example of a need going forward is for full scale evaluations on complete covered conductor systems, as materials are currently tested individually.



EPRI's Future Plans:

EPRI intends to develop tests to optimize covered conductor weight-to-insulation thickness and material thermal design criteria. In addition, EPRI aims to work with U.S. National Labs and other industry stakeholders to develop improved protective coverings and connectors to ensure that some of the remaining fault concerns with system coverings are adequately resolved. This includes materials science R&D as well as work creating ice buildup inhibiting designs and combustion resistant designs. Additional materials research is needed to identify polymers better suited for use on a wide range of components for 'wildfire resistant infrastructure.'

Full Scale Overhead System Design Testing

Overhead distribution structures exhibit complicated dynamics when subjected to mechanical and electrical stresses. While these dynamics are difficult to accurately model, full-scale testing can fill some knowledge gaps. To optimize structure performance, EPRI performs mechanical force stress tests on structure designs specified by utilities to improve their ability to resist and recover from damage.

EPRI's Past Contribution:

EPRI investigates structure performance in terms of expected failure modes, subsequent restoration expectations, and opportunities to prevent damage from occurring at all. Examples include:

- *Branch retention* – EPRI works with utilities to select optimal designs that reduce the likelihood of branches getting caught in overhead infrastructure and causing a subsequent outage. This research is performed in the context of the voltage gradients required to ignite a branch and start fires.
- *Risk of tree ignition during line contact* – EPRI conducts tests to evaluate the spacing between conductors if a tree falls into the line. If the spacing between conductors is small enough, the voltage gradient could be high enough to ignite the vegetation. Overhead structures may be designed in ways that mitigate this risk.
- *Ability of structures to avoid downed conductors* – EPRI conducts simulated tree strike tests on numerous overhead structure designs. The tests aim to limit the damage and prevent pole breakage to result in a lower number of downed conductors. Designs are revised and retested to optimize performance. Numerous utilities have adopted the revised designs.

EPRI's Ongoing Efforts:

EPRI continues to test overhead structure designs at the EPRI Lenox, MA test facility. Multiple utilities participate in testing each year to refine structure designs to mitigate damage and reduce restorations times. EPRI also works with utilities to test covered conductor designs.

EPRI's Future Plans:

EPRI plans to conduct additional research, including full-scale testing, into approaches to prevent cascading overhead structure failures. EPRI is also developing test structures and capabilities to better understand the performance of various pole materials exposed to wildfire conditions. A test fixture capable of simulating wildfire conditions has been constructed and testing is expected to begin soon. Pole materials to be tested include fiberglass reinforced polymers, ductile iron, wood, and others.

Conductor Slap Modeling and Data Mining for Incident Identification and Avoidance

Wind induced conductor to conductor contact from lines swinging together at the mid-point between supports is a source of system faults and the field inspection more often than-not yields a "no problem found" result. Sparks and molten materials from the contact may ignite vegetation beneath the contact point and if it occurs multiple times it may result in a line break and a downed conductor.

EPRI's Past Contribution:

EPRI developed software tools to model conductor slap and understand physical modifications that may be made to avoid the slap in different scenarios. EPRI guided utilities that have experienced conductor slap due to increase distribution automation on approaches to mine distributed sensor, power analyzer, and smart meter data to identify slap locations and to model and then modify line designs.

EPRI's Ongoing Efforts:

EPRI continues to conduct demonstrations on the fault induced conductor slap at the EPRI Lenox, MA test facility to educate members on this phenomenon and to demonstrate ways to avoid it. The web-based analytics tools are available at https://distribution.epri.com

EPRI's Future Plans:

EPRI will update conductor slap analysis tools applicable to both downstream faults. Furthermore, EPRI will conduct ignition propensity tests to understand the probability of molten particles resulting in ignition of different types of vegetation.

Research Category 7

Undergrounding to Reduce Ignition Incident Risk

Undergrounding to address wildfires is an expensive but well accepted approach. Hybrid undergrounding where the lines are neither left in the air nor trenched and buried underground is a compelling concept. The goal of hybrid undergrounding is to require minimal or no excavation and to simultaneously eliminate weather and tree exposure.

EPRI's Past Contribution:

EPRI conducted a three-year system hardening research effort referred to as the Distribution Grid Resiliency project to support electric service providers with storm hardening research. The undergrounding outcomes from the project have been used by utilities across North America as supporting material for their grid resilience initiatives.

EPRI's Ongoing Efforts:

EPRI facilitates the UDIG interest group, whose charter is to identify leading and innovative undergrounding approaches and programs and share the insights amongst members. UDIG offers advisors regular web meetings designed to share the latest best practices, new technologies, and concepts. The information is curated on the Distribution Resource Center website.

EPRI's Future Plans:

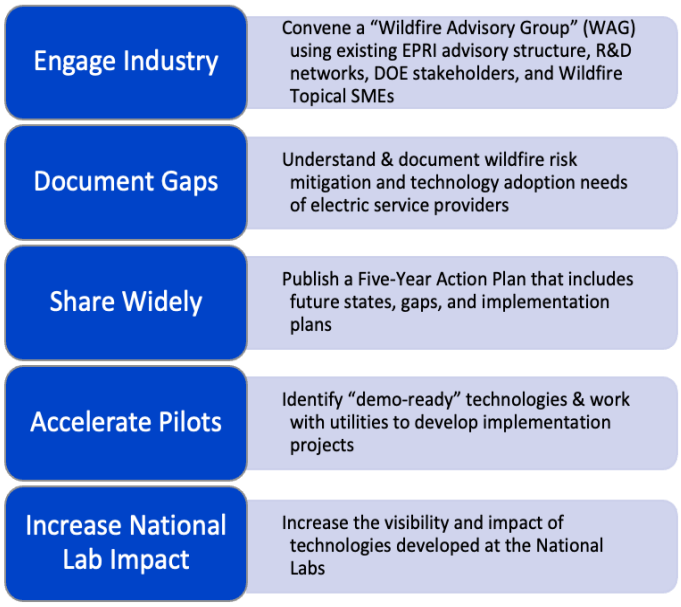
EPRI is building the test structures necessary to conduct mechanical and thermal performance tests on emerging hybrid underground prototypes and intends to initiate testing in 2024. The testing is designed to provide early insights into questions associated with safety, robustness, fire immunity, ampacity, thermal performance, and fault protection.

COLLABORATING WITH THE U.S. DEPARTMENT OF ENERGY (DOE)

In addition to the R&D EPRI is doing directly with utilities, EPRI is engaged with the U.S. DOE to identify technology gaps in the wildfire risk reduction arena, create a five-year wildfire risk mitigation action plan, and propose new technology demonstrations. EPRI, U.S. National Labs, and the electric utility industry will then collaborate to advance the application understanding and risk reduction benefits of technology in this space.

This unique collaboration enables emerging technology developers and researchers from industry and from the U.S. National Labs to engage with electric utilities and to accelerate new technology adoption and deployment. The model also enables greater industry visibility of ongoing R&D projects and creates new opportunities to implement emerging technologies with documentable and measurable success criteria.

As part of this Wildfire Advisory Group, EPRI has engaged more than 100 industry experts, along with the International Wildfire Risk Mitigation Consortium (IWRMC) and four of the leading U.S. National Labs. The project has facilitated 14 advisory webcasts, five unique surveys on specific wildfire risk reduction topics, and four face-to-face roadmapping sessions.



Overall, the input and feedback from such a diverse set of stakeholders provide an opportunity to make advancements in five specific areas that are helpful toward wildfire risk reduction:

- *Fault Count Reduction* – Unintended power line contacts result in faults and arcs that may ignite vegetation. Consequently, methods to reduce the total number of faults is expected to reduce the total number of actual ignition incidents.
- *Fault Energy Reduction* – The total amount of arc energy injected into vegetation dictates the likelihood of igniting that vegetation. Historical power system protection strategies consider reliability over fault energy reduction and there are many coordinated energy limiting approaches and concepts to be vetted.
- *Improved Situational Awareness* – Continuous monitoring of assets, power flow anomalies, weather, and vegetation condition each contribute to ignition risk reduction and to faster emergency response.
- *Modeling and Simulation* – Advanced tools that enable scenario analysis such as impinging weather predictions, fire spread forecasting, and spatially relevant fire threat indices are important innovations. As they become more mainstream, they help the industry more comprehensively understand and reduce wildfire risks.
- *Fire Protective Materials* – Understanding how systems and components may be designed and specified in the future to be less susceptible to fire damage and to simultaneously be less prone to combust in ways that might promote ignitions.

A technology catalog, developed as part of the project, provides all electric utilities with a useful snapshot of available wildfire risk reduction options. The catalog entries can be found at the following weblink. https://distribution.epri.com/wildfire/public/wildfire-tech-database

MEMBER SUCCESS STORIES

Salt River Project (SRP) – Forensic Analysis and New Installation Criteria for Insulated Pole Ground Wire

In 2021, the SRP experienced a third fire incident that resulted the insulation on a ground wire to burn upward to the top of a wood pole. The response crews took photos and video – confirming that only the covering on the wire (and not the pole) was aflame as the fire moved up the pole. After obtaining samples of both the burned and unburned insulated ground wire material from SRP, EPRI conducted Gas Chromatography and Mass Spectroscopy (GC/MS) materials analysis and combustibility tests.

The tests revealed that the insulated ground wire was only combustible if it was preheated to unusually high temperatures typical of summer desert conditions. To avoid future incidents, SRP determined they could have crews go to similar pole configurations and remove a few feet of the existing wire insulation to create a vertical gap that the flames could not bridge. For new installations, the options include either the same approach to remove a few feet of insulation or to identify and pre-test ground wire coverings (that burn and char) but will not sustain a flame.

Southern California Edison – Identification and Mitigation of Conductor Slap and Molten Particles Spray on Ground Fuel

At the EPRI Lenox, MA test facility, EPRI staff replicated a magnetically induced conductor slap, which occurs when fault currents flowing in opposite directions on a source and a return conductor develop a magnetic repulsion that move the two conductors away from one another in a pendulum arc motion.

When the fault is removed, the conductors complete the pendulum motion by swinging back down and toward one another. Heated and elongated wires (from the fault currents) intensify the swing by adding additional sag to the conductors. In addition, new distribution automation devices with faster fault clearing and reclosing ability can exacerbate the swinging of the conductor, thereby creating a second or a third arcing and sparking fault like the photo shown here.

After learning about EPRI's research at a 2022 wildfire tech transfer session, Southern California Edison (SCE) investigated their custom variations using EPRI's conductor slap calculation tool. SCE's implementation resulted in several mitigation options being identified that reduced the risks associated arcing and molten particles from conductor slap.

Portland General Electric, Pacific Gas and Electric, and Xcel Energy –AI Enabled Smoke Detection Cameras for Early Warning

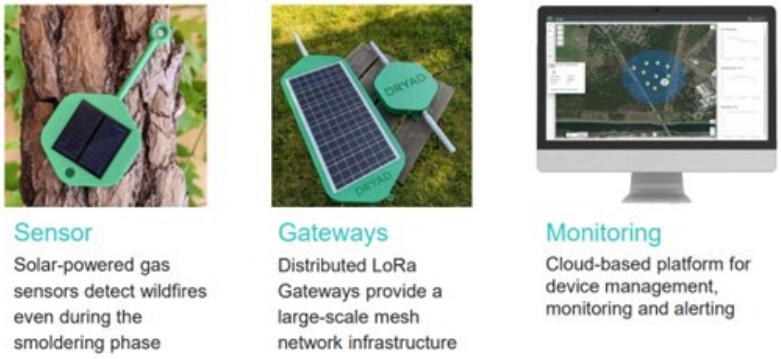
In 2021, EPRI and Pano collaborated with several EPRI Incubatenergy utility sponsors to answer the question: How can computer vision be better leveraged in the early detection and response to wildfires? The Pano AI project was designed to demonstrate how their web portal and alert center could automatically detect and provide geospatial logistics on fire ignition incidents.

The Pano AI project was one of the first to use strategically located 360-degree view cameras and AI to filter out many of the nuisance non-smoke detections such as fog and clouds. The effort examined ways to improve net fire detection time, how the simultaneous use of multiple cameras reduces false-positive rates, and how to expand existing imagery capabilities to provide 24/7 detection during various weather and light conditions.

Pacific Gas and Electric (PG&E) – Evaluation of (Ultra-Low-Cost) AI Enabled Fire and Gas Sensors

In 2022, EPRI and Dryad collaborated with Incubate Energy partner PG&E to learn if Dryad's AI enabled smoke sensing units could learn how to detect an impinging fire, and to discern between different kinds of smoke. Dryad sensors can detect seven different gases, and can measure temperature, humidity, and barometric pressure. Powered by an integrated solar panel with supercapacitor storage Dryad sensors communicate to a gateway using LoRaWAN for low bandwidth long-range communications.

The project showed that the sensor can distinguish between different kinds of fires in the lab, but it becomes difficult to detect smoke in the outdoor environment unless it is of sufficient density, which could be an issue for smaller fires. However, the Dryad communication modules may be able to hop signals and data for many miles if the line of sight between sensors is not impeded. Going forward, the researchers hope to enable both fire sensing in high fire threat areas and innovative ways to get data back from areas where communication has been historically challenging.



About EPRI

Founded in 1972, EPRI is the world's preeminent independent, non-profit energy research and development organization, with offices around the world. EPRI's trusted experts collaborate with more than 450 companies in 45 countries, driving innovation to ensure the public has clean, safe, reliable, affordable, and equitable access to electricity across the globe. Together, we are shaping the future of energy.

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