# Risk-Informed Wildfire Mitigation Strategies and Strategic Communications

## Guidebook for Utilities

**May 2025**



Version 2

# Contents



*Some of the measures included in this document are contemplated as additional precautionary measures intended to further reduce the risk of wildfires.*

# 01 Introduction

**Wildfire risk has changed.** Climate-driven weather whiplash is driving increased wildfire risk for communities across the globe. This is a challenge that electric grids were not built for. Keeping customers safe and ensuring reliable service requires a new way of operating the system, novel safety measures and an increased focus on addressing risk and communicating with customers and stakeholders.

## Guidebook Purpose

At PG&E, our stand is that Catastrophic Wildfires Shall Stop. To do this, we shaped our organization to focus on reducing wildfire risk and protecting communities. As we move through this transformation, we share the tools, processes and communications efforts that we have undertaken in a way that is as transparent as possible. We hope to help other utilities implement risk-informed wildfire strategies that best serve their level of risk and their customer base.

In 2024, we released version one of this guidebook, which focused on near-term wildfire mitigation efforts, public resources and our experiences and learnings. In this second version, we expanded the scope to include long-term wildfire mitigation efforts and provide additional lessons learned. This guidebook is intended to be a document which others can draw from and in the coming years contribute to. We firmly believe in our layers of protection approach and that there is not one single strategy that will fit every situation and utility. Each utility needs to find the best set of mitigations for their specific risk profile and the customers they serve. We welcome your feedback and any interest in contributing to raising the collective knowledge around wildfire mitigation.

Andrew Abranches
PG&E Senior Director,
Wildfire Preparedness and Operations



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# Evolving Wildfire Risk in California

Our changing climate is contributing to increasing weather-driven wildfire risk across California. Following periods of severe drought and heavy winds, we are now observing weather whiplash, a phenomenon characterized by brief and intense swings between heavy precipitation and hot, dry seasons.

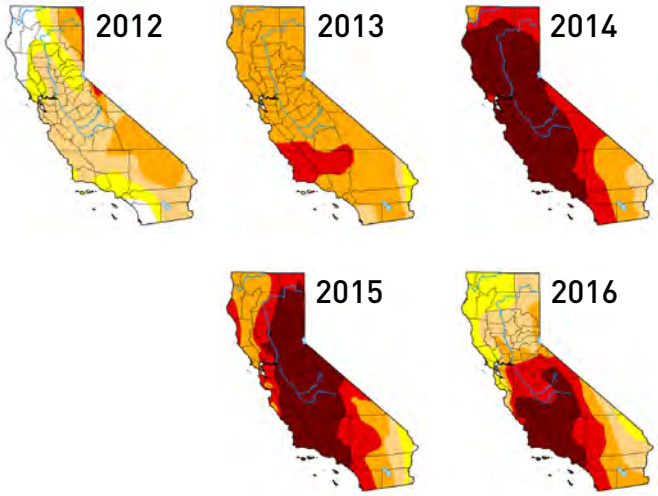
**HISTORIC DROUGHT**

**SEVERE WIND AND WEATHER EVENTS**

## 2012 - 2016

### Driest Period in California History

**~102 million** trees dead due to drought




U.S. Drought Monitor map for end of Q2 each year. Maps are available at **droughtmonitor.unl.edu**.

**Legend:**

- None
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

## 2017 - 2020

- **Oct. 2017:** North Bay Wind Events
- **2017:** 3rd Hottest Summer in CA History – 76.5°F Avg Temp
- **2018:** Most Destructive Wildfire Season Driven by Severe Winds[1]
- **Oct. 2019:** Historic Fire Weather Conditions
- **2020:** 4M+ Acres Burned by Wildfires
- **2020:** Lightning Storm

[1]Nov. 6 – 9 Jarbo Gap Winds (Camp Fire), Nov. 8 – 9 Santa Ana Winds (Woolsey)

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## WEATHER WHIPLASH

## 2021 - 2025

**2021:** 2nd Hottest Summer in CA History – 77.2°F Avg Temp

**Oct. 2021:** Bomb Cyclone + Atmospheric River

**July 2023:** Historic July Heat Wave

**2022 - 2023:** Nine Back-to-Back Atmospheric Rivers

**2024:** Hottest Summer in CA History – 77.3°F Avg Temp

**Feb. 2024:** Two Atmospheric Rivers Cause Flooding

**Jan. 2025:** Santa Ana Winds

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# PG&E's Community Wildfire Safety Program

As climate change and wildfire risk has continued to evolve, so has our approach to addressing these issues. Since launching our Community Wildfire Safety Program in 2018, we have built layers of wildfire protection by incorporating learnings year over year.

## Catastrophic Wildfires and Improvements in PG&E's Service Area since 2017

| | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|
| | **North Bay Fires** | **Camp Fire** | **Kincade Fire** | **Zogg Fire** |
| ACRES BURNED | **387,551** | **153,336** | **77,758** | **56,338** |
| STRUCTURES IMPACTED | **3,379** | **19,558** | **434** | **231** |
| MITIGATIONS ESTABLISHED | | • Launched Community Wildfire Safety Program<br>• Public Safety Power Shutoff (PSPS)<br>• Enhanced Vegetation Management (EVM)<br>• Camera/Weather Station Network | • Expanded PSPS<br>• Enhanced asset inspections<br>• Improved risk modeling<br>• Overhead system upgrades | • Removed idle facilities and open jumpers<br>• Improved risk modeling<br>• Shorter, smaller, smarter PSPS |

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| 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|
| **Dixie Fire** | **Mosquito Fire[2]** | **No catastrophic wildfires** | **Sites Fire[2]** |
| **963,309** | **76,788** | **—** | **19,195** |
| **1,405** | **78** | **—** | **0** |
| • Enhanced Powerline Safety Settings (EPSS)<br>• 10,000-mile Undergrounding Program<br>• Improved operational and risk modeling | • Expanded EPSS<br>• Catastrophic wildfire behavior modeling | • Enhanced EPSS with Down Conductor Detection<br>• Targeted vegetation management<br>• Implemented AI on HD cameras | • Expanded pole clearing<br>• Introduced real-time monitoring<br>• Rapid response capability |

[2]These ignitions are under investigation. PG&E filed an Electric Incident Report (EIR) for the event out of an abundance of caution.

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# Building on Our Wildfire Safety Progress

As outlined in our 2026-2028 Wildfire Mitigation Plan (WMP), we continue to evolve our wildfire safety efforts. The plan incorporates input from third-party validators, such as AlertCA, Cal Poly WUI Fire Institute, and UCLA Risk Institute, lessons learned from other utilities and feedback from local stakeholders. Our risk-informed plan minimizes wildfire risk while reducing customer impacts.

| Focus Areas | 2026-2028 Wildfire Mitigation Actions | |
|---|---|---|
| **Continuous Monitoring** | **Early Fault Detection** | Installing an additional 180 sensors per year to help identify when equipment repairs or vegetation maintenance is required. |
| | **Smart Meters** | Launching next-generation Smart Meters to identify powerline damage using real-time outage data. |
| | **Gridscope Devices** | Installing additional devices to better pinpoint damage on powerlines to restore power quicker. |
| **Operational Safety Procedures** | **Public Safety Power Shutoff** | Implementing new, advanced technologies and system improvements to reduce customer impacts. |
| | **Enhanced Powerline Safety Settings** | Utilizing safety settings on 44,000 miles of powerlines, protecting 1.8 million customers; installing additional technology to minimize customer impacts. |
| | **Safety and Infrastructure Protection Team** | Deploying additional trucks to respond more quickly to emergencies and pretreat more poles, which has a 92% success rate in protecting poles from wildfire. |
| **System Resiliency** | **Undergrounding Powerlines** | Undergrounding over 675 miles of powerlines in high wildfire risk areas from 2026-2027. |
| | **Wildfire Safety System Upgrades** | Installing over 500 miles of strengthened poles and covered powerlines from 2026-2027 (includes line removal). |
| | **Vegetation Management** | Trimming or removing 1M+ high-risk trees annually; installing remote sensors and utilizing analytics to enhance inspections. |
| | **Remote Grids** | Building 20+ additional remote grids to remove overhead powerlines in high fire-threat areas that are hard to access. |
| **Community Support** | **Community Outreach and Resources** | Building upon year-round emergency preparedness outreach campaign; launching additional customer resource programs. |

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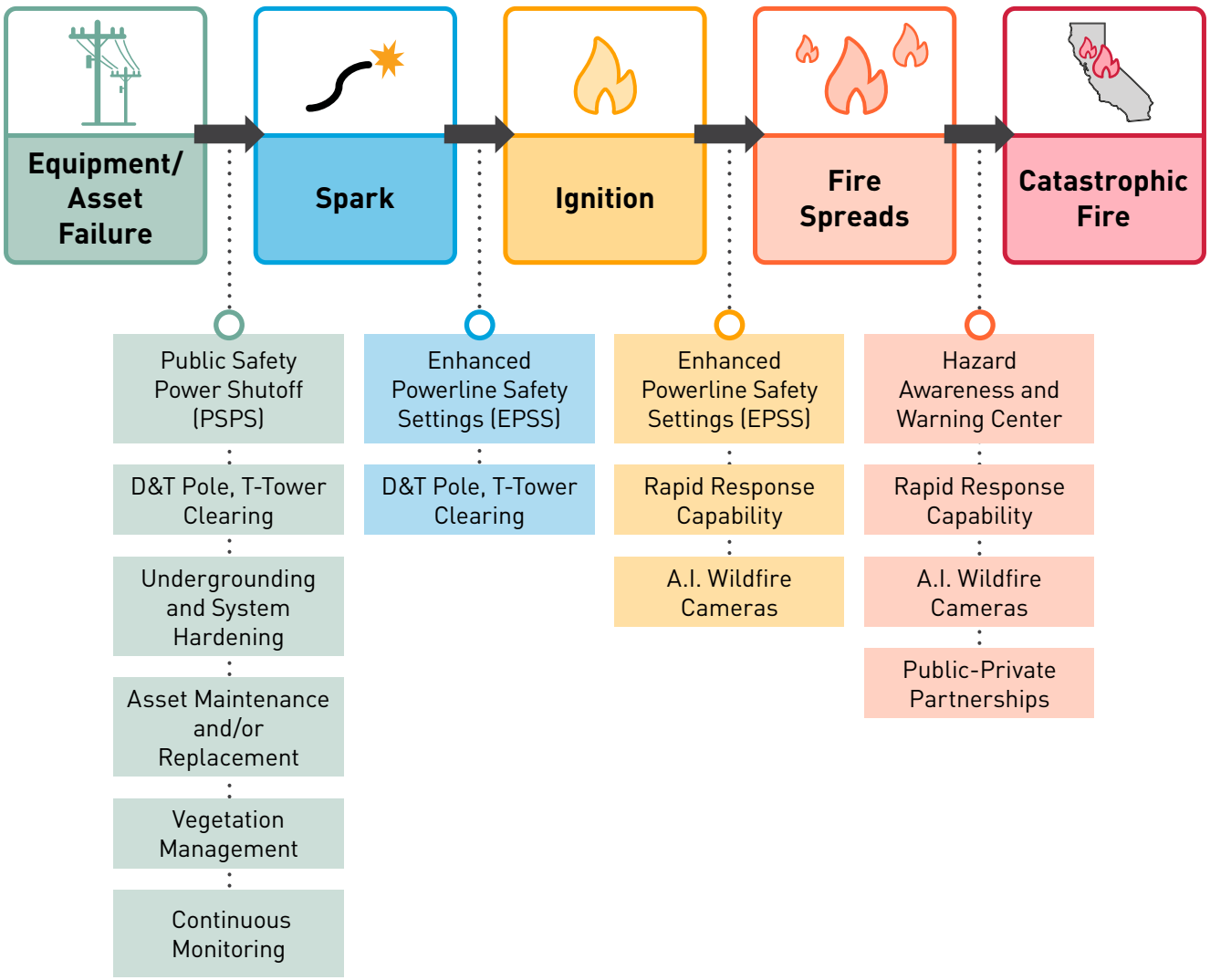
# Interrupting the Wildfire Sequence

These programs work together to mitigate wildfire risk and provide critical protection during different phases of the wildfire sequence. Interrupting this sequence is a key focus of our wildfire mitigation strategy. Different mitigation approaches may prevent catastrophic wildfires with similar effectiveness because they target different steps in the sequence. Our mitigation efforts are focused on before and after an ignition, which we will discuss throughout this guidebook. Our journey never ends and each day we get better. We have more work to do and more to learn from peers like you.

**Evolving Mitigations to Interrupt the Wildfire Sequence**

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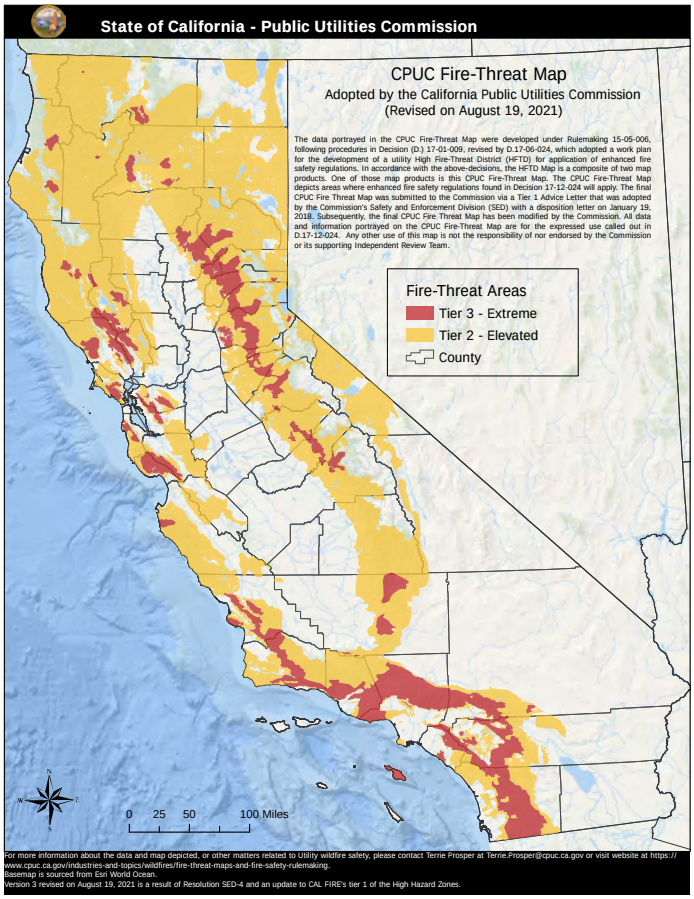
# 02 Identifying and Understanding Wildfire Risk

The first critical step in preventing wildfires is to identify where wildfire risk is greatest. Spatial and temporal resources, when combined, can help increase the understanding of risk between a utility's infrastructure and the environment in which it operates.

## Mapping High Fire-Risk Areas

### California Public Utilities Commission HFTD Map

In 2018, the California Public Utilities Commission (CPUC) developed a statewide High Fire-Threat District (HFTD) map that identifies areas at increased risk for wildfires due to strong winds, dry vegetation and other environmental factors.

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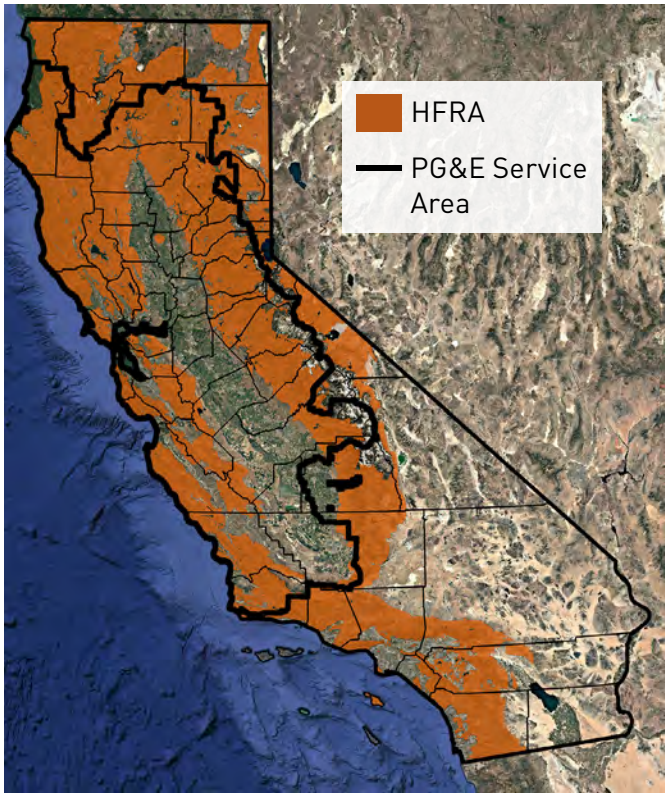
## PG&E High Fire-Risk Area Map

To better identify risk based on our electrical equipment, PG&E expanded upon the CPUC's HFTD map to create our High Fire-Risk Area (HFRA) Map.

- This map builds on the HFTD map by adding fire scars, potential for fire spread, National Weather Service Red Flag Warnings (RFW) and other historical data.
- We overlay HFRAs on our circuit maps to identify areas at high risk within our service area.
- This map is updated and re-evaluated annually to align with offshore wind risks and the latest land use and fuel conditions.




**These maps allow us to make risk-informed decisions and are the foundation of our wildfire mitigation programs.**

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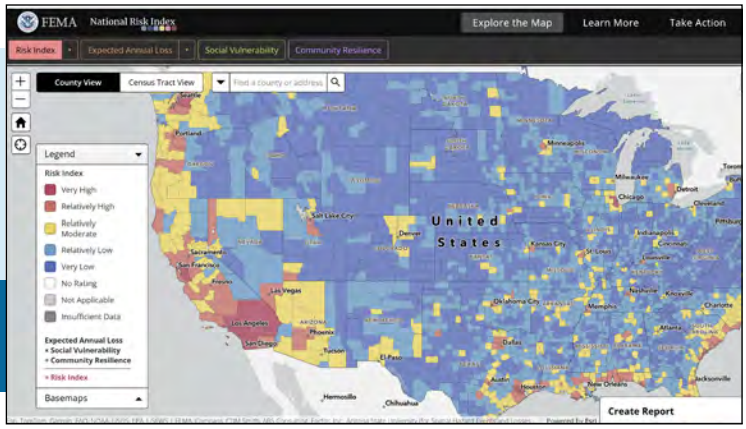
# Publicly Available Tools

In North America, there are several public resources offering maps of historical and current fire information as well as estimated fire risk.

**Federal Emergency Management Agency (FEMA)**
National Risk Index

[hazards.fema.gov/nri/wildfire](hazards.fema.gov/nri/wildfire)




**National Interagency Fire Center (NIFC)**
Information for Resource Management System

[nifc.gov](nifc.gov)


**National Fire Situational Awareness**

[maps.wildfire.gov](maps.wildfire.gov)


In addition to identifying historical impacts, utilities estimating fire risks need insight into current and forecasted weather conditions.

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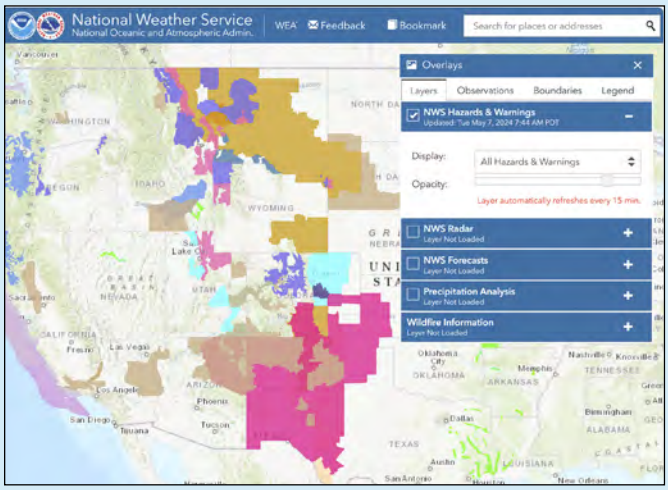
# Mapping High Fire-Risk Areas with Red Flag Warnings (RFW)

The National Weather Service (NWS) and National Oceanic and Atmospheric Administration (NOAA) provide RFW updates and mapping resources.

**National Weather Service (NWS) and National Oceanic and Atmospheric Administration (NOAA)**


weather.gov

RFWs provide critical information due to their ability to be imported or used as Geographic Information System (GIS) polygons. With the help of a GIS specialist, polygons can be incorporated into a utility's existing suite of wildfire risk identification tools. The ability to see wildfire risk in real time provides a powerful view into where and when risk is highest.

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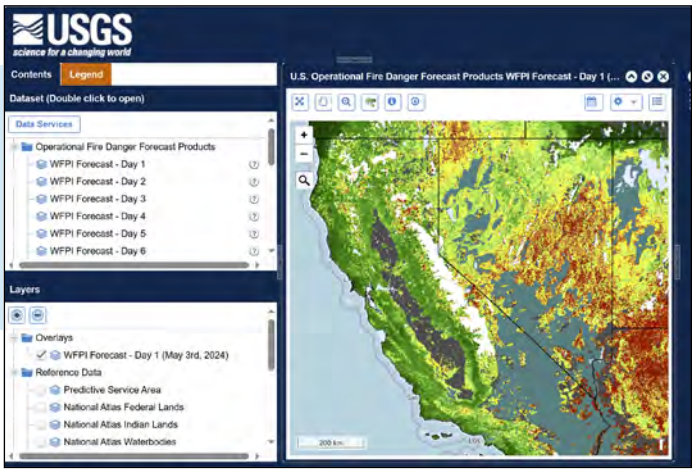
# Monitoring Potential Wildfire Risk

Fire Potential Index (FPI) is a valuable tool in assessing the potential for a wildfire to start and spread. This is an integral part of decision-making for our operational mitigations, such as our PSPS program.

## Publicly Available Tools

**The U.S. Geological Survey**
Interactive Wildland
Fire Potential Index

SCAN HERE




**The National Interagency Coordination Center**
Seven-Day
Significant Fire
Potential Index

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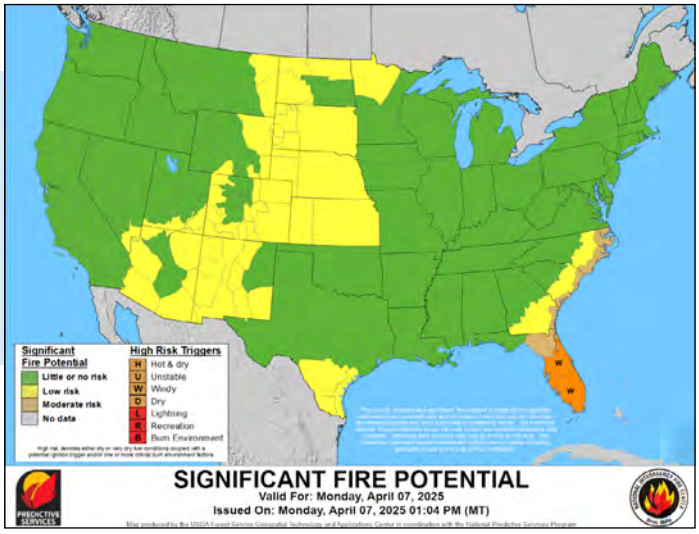


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## Overlaying Spatial and Temporal Risk on Electric Circuits and Assets

A utility can overlay a map of spatial and temporal risk onto their electric circuits. The result is a comprehensive view of areas prone to wildfire risk. It can also compile data on how many circuits, assets and communities are impacted. A utility can break down circuits and assets by type and prioritize mitigation efforts within those categories. Then, further analysis can be conducted into the communities that appear in these high fire-risk areas.

**Consider these questions to help understand local risk factors that may warrant additional mitigation efforts:**

- Is the community in or close to a fire scar?
- Are there ingress or egress challenges?
- Is there vegetation or electric infrastructure which may pose challenges to egress routes?

## Refining the Ability to Identify Wildfire Risk

As weather conditions continue to evolve, it is important to put processes in place for continuously updating a wildfire risk assessment tool. Annual updates can allow a utility to incorporate learnings from the prior season and new information based on a changing climate.

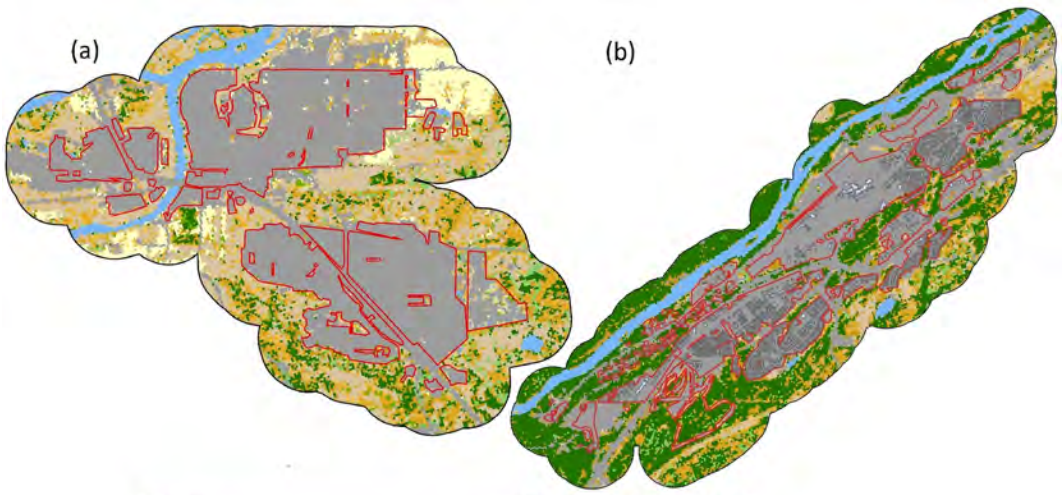
## Other Approaches to Assessing High Risk Areas

There are varied approaches to assess different types of wildfire risk with different levels of complexity. Our models incorporate weather as a decisive factor in assessing our changing wildfire risk and help inform our mitigation strategies. This approach offers a granular understanding of where fire risk is greatest and what potential fire consequences could be across our service area. However, for smaller applications or organizations, this approach can be difficult and expensive to stand up. Researchers continue to create new models to suit different needs across the fire safety space.

A recent example is high-risk community assessment research performed at the University of Alberta's school of Agriculture, Life & Environmental Sciences (ALES)[3]. Using publicly available satellite data, their model focuses on areas where fire is most likely to cross from wildlands into urban environments. By focusing on higher hazard tree density, their model can provide a starting point for communities and smaller organizations to begin reducing fire risk without having to capture and analyze meteorological data.

This simplified approach yielded suggested wildfire safety work very similar to more complex weather-driven models in the Alberta towns of Whitecourt and Hinton. This cost-effective approach could yield great benefits to organizations and communities beginning their wildfire journey.

## Vegetation Fuels near the Towns of Whitecourt and Hinton




(C)

| Classes | Whitecourt(%) | Hinton(%) |
|---|---|---|
| Boreal Spruce | 4.87 | 29.54 |
| Mature Jack or Lodgepole Pine | 2.22 | 1.97 |
| Immature Jack or Lodgepole Pine | 1.02 | 0.17 |
| Leafless Aspen | 22.28 | 5.12 |
| Aspen | 0.49 | 0 |
| Matted Grass | 5.79 | 0 |
| Non-Fuel | 44.55 | 43.6 |
| Water | 3.56 | 6.54 |
| Boreal Mixedwood - Leafless (15% Conifer) | 0.15 | 0.01 |
| Boreal Mixedwood (25% Conifer) | 2.95 | 0.69 |
| Boreal Mixedwood (50% Conifer) | 9 | 4.01 |
| Boreal Mixedwood (75% Conifer) | 3.13 | 8.36 |

**KEY**

Landcover classification for the towns of Whitecourt (a) and Hinton (b) and the fuel type percentage of each (c) using the study's model

[3]Source: Nima Karimi, Patrick Mahler, Jennifer L. Beverly. **Optimizing fuel treatments for community wildfire mitigation planning**. J. Environ. Manag., 370 (2024). https://doi.org/10.1016/j.jenvman.2024.122325 Corresponding author: Jennifer L. Beverly, jbeverly@ualberta.ca.

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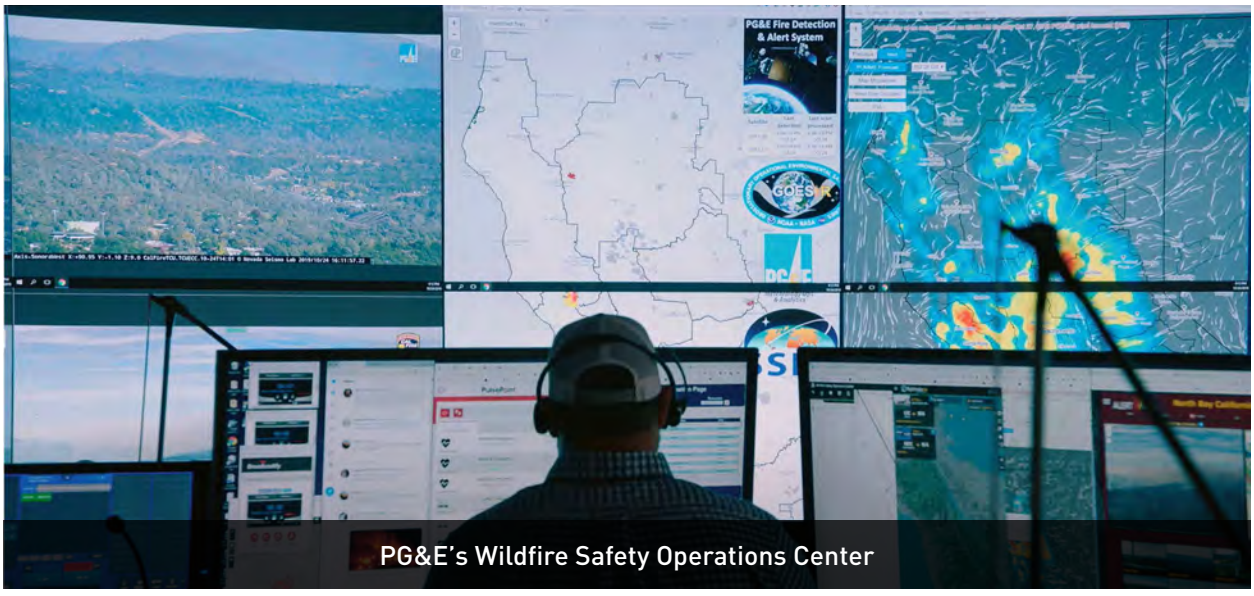
# 03 Forecasting, Monitoring and Responding to Severe Weather and Wildfire Risk

Understanding weather patterns and utilizing weather tracking capabilities is instrumental for the implementation of safety programs and determining when risk is high. This allows a utility to forecast, monitor and coordinate a response to severe weather and wildfire risk.

## Utilizing State-of-the-Art Tools and Tactics

We developed an in-house Operational Mesoscale Modeling System (POMMS) and a corresponding 30+ year downscaled climatology which is a sophisticated weather forecasting suite designed to enhance our ability to predict and manage weather-related risks. This high-resolution tool utilizes 30+ years of data to find patterns and inform our operational mitigation decision-making. The POMMS provides high resolution forecasts four times daily and is crucial for our wildfire risk management and severe weather preparedness.

To supplement this model and provide more precise situational awareness across our service area, we have installed almost 1,600 weather stations to monitor weather conditions, primarily in high fire-threat areas.




PG&E's Wildfire Safety Operations Center

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# Publicly Available Weather Models

## NOAA Global Forecast System (GFS)

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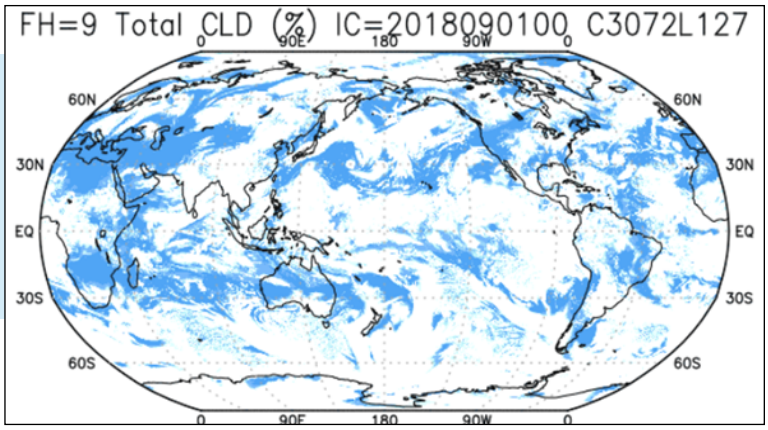


## European Centre for Medium Range Weather Forecasts (ECMWF)

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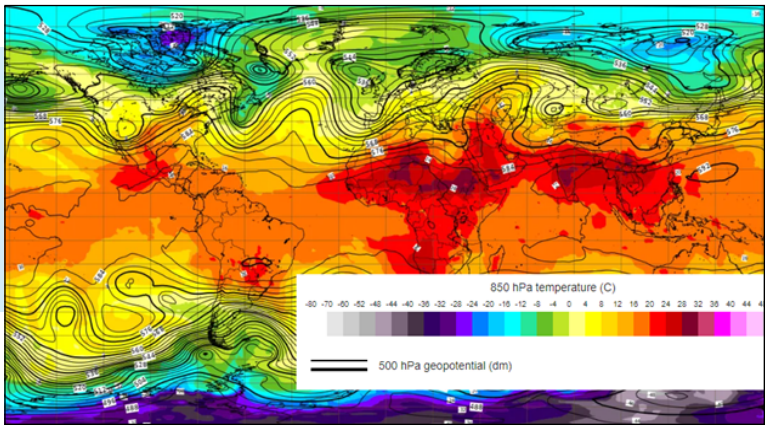


## Canadian Global Deterministic Prediction System (GDPS)

Government of Canada / Gouvernement du Canada

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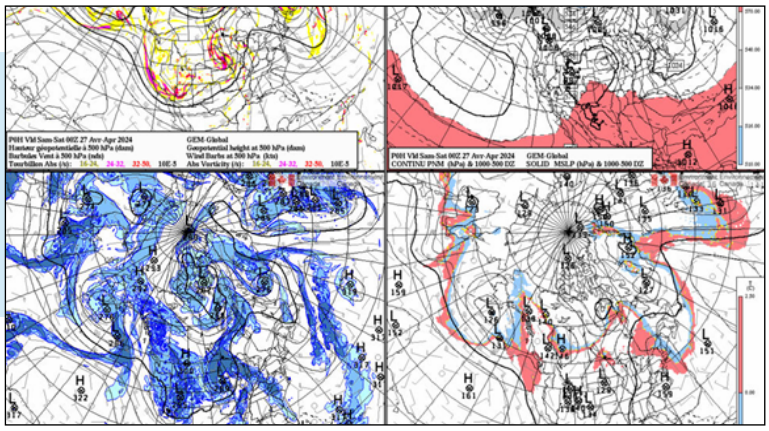

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# Publicly Available Weather Models (cont.)

## U.K. Met Office Global Modelling

Met Office

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## ICON Model

ICON

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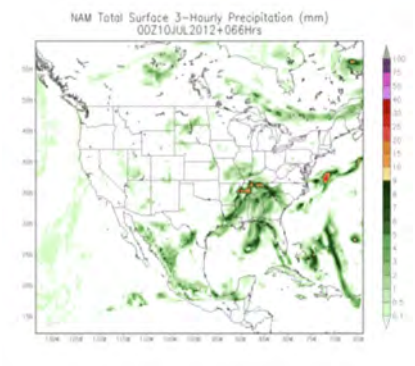
## National Oceanic and Atmospheric Administration (NOAA)

### North American Mesoscale Forecast System (NAM)

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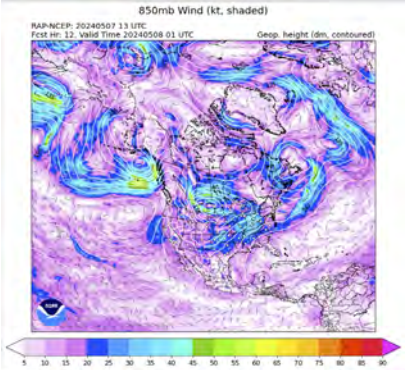
### Rapid Refresh (RAP) Model

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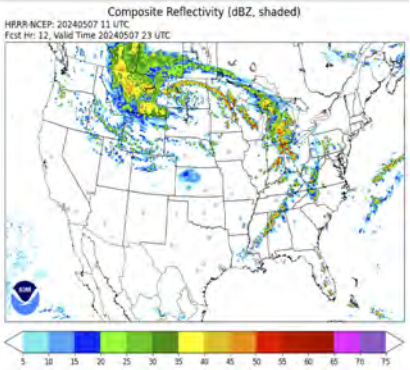
### High-Resolution Rapid Refresh (HRRR) Model

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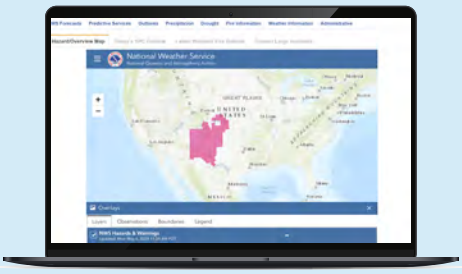
# Publicly Available Situational Awareness Networks

There are several publicly available tools that provide insights from situational awareness networks to help utilities coordinate response efforts.



**weather.gov**

### National Weather Service

Vital weather forecasts, warnings and advisories, including forecasts for fire weather, enabling proactive mitigation strategies.

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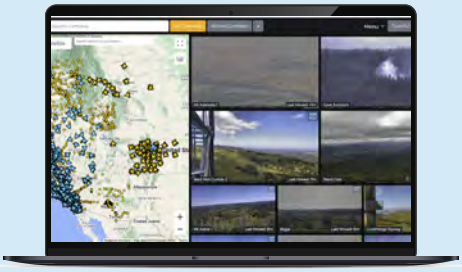

**alertwest.org**

### ALERTWest

Provides real-time data from high-definition cameras, weather stations and environmental sensors to identify areas at heightened wildfire risk.

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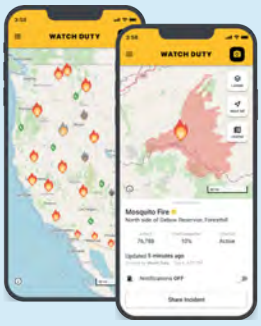

**watchduty.org**

### Watch Duty

This application consolidates various data sources, assisting utilities in monitoring wildfire incidents and tracking fire perimeters.

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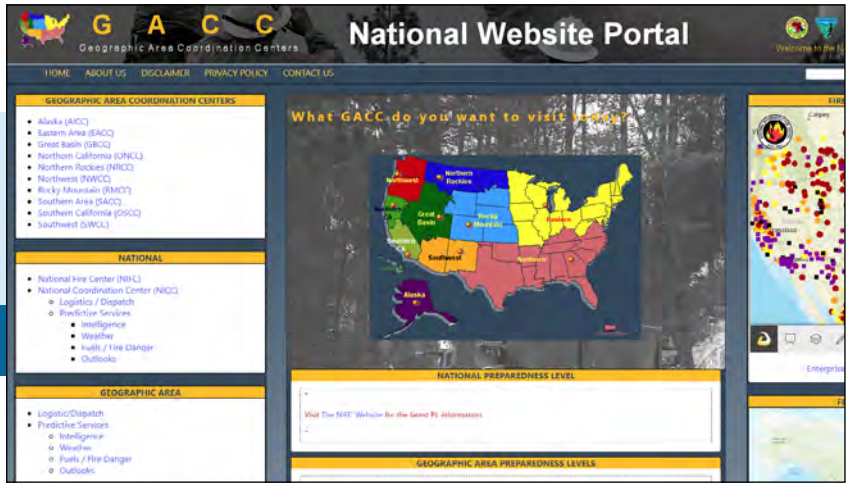
## Local Coordination

Maintaining close coordination with local weather services and Geographic Area Coordination Centers (GACC) is critical, especially during fire season, to ensure we are informed about changing weather conditions and forecasts.

**GACC National Website Portal**

**gacc.nifc.gov**



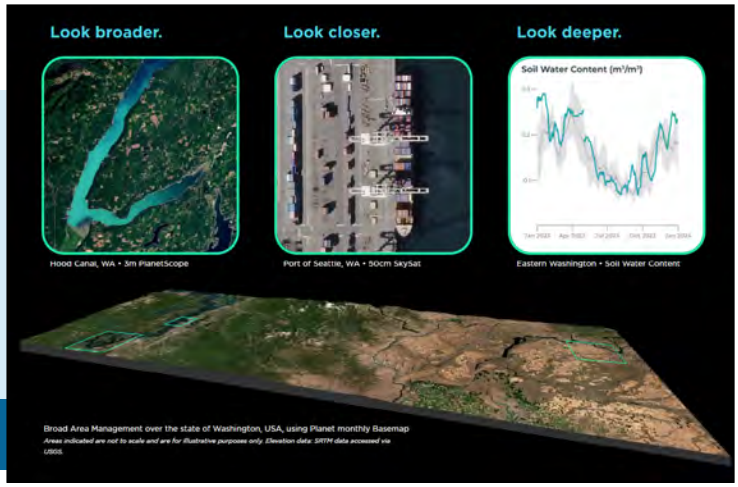

## Satellite Terrain Imaging

While our weather model and stations provide great awareness of current conditions, satellite terrain imaging offers valuable insights over time. Satellites can monitor how conditions across a service area have changed due to weather, including vegetation growth patterns, changes to local water conditions and other important data. Spotting these changes can help inform upcoming areas of focus and where additional situational awareness tools are needed.

**Planet Labs**

See satellite terrain imaging in action and learn about the types of satellites available.

**planet.com**

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## Soil Sampling and Patrols

Changing weather patterns can impact conditions on the ground and alter fire behavior. We combine insights from our weather model with data on ground and fuel conditions to produce our Fire Potential Index (FPI). This model accounts for soil moisture, various fuel types available in each area and fuel moisture to assess how likely an area is to burn should an ignition occur.

We lean on our teams spread across our service area to collect and share their findings in the field. Whether through our Public Safety Specialists (PSS) coordinating with local authorities or our Safety Infrastructure and Protection Teams (SIPT) collecting samples throughout our area, we maintain situational awareness of weather-related conditions that impact wildfire risk.

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# 04 Modeling Wildfire Risk

Developing risk models can be a major step in maturing a wildfire safety program. Our risk models are separated into two types: operational models used for quick decision making and planning models used for long-term mitigation decision making.

## Measuring Risk

Through our operational risk models, we gain insight into real-time fire conditions across our service area that allow for quick decision-making. By assessing and reacting to the outputs these models provide, we can determine where and when operational mitigations, like PSPS and EPSS, need to be activated for safety and can operate our grid effectively under various conditions.

Our planning risk models can be used to determine where and in what order to complete wildfire mitigation projects, like System Hardening, to mitigate the highest risk locations first.

### Operational Models

#### A. PG&E's Fire Potential Index (FPI)

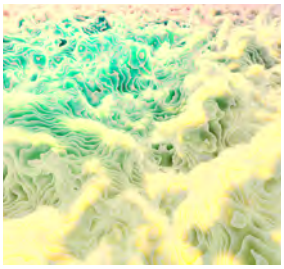
We use an FPI model to combine fire weather parameters, fuel moisture data, topography and fuel type data to predict the likelihood of large and catastrophic fires. It is calculated at a granular, 0.7 km hexagon grid level each hour of the day to drive operational decisions to reduce the risk of wildfires. The FPI model shows the probability that a fire will become large or catastrophic and is a critical part of our decision-making process.

### FPI Model

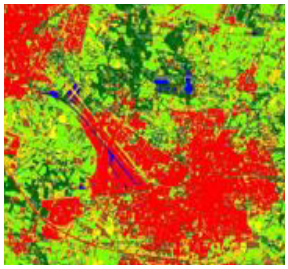
**The current FPI Model combines the following to predict the probability of large and/or catastrophic fires:**

**Fire weather parameters:** wind speed, temperature, vapor pressure deficit

**Fuel moisture data:** **dead fuel:** dead grass, fallen branches; **live fuel:** grass, growing shrubs



**Topography:** terrain ruggedness, slope, wind-terrain alignment



**Fuel type data:** grass, shrub, timber, urban

## B. PG&E's Outage Producing Winds (OPW) Model

This model is a multi-classification machine learning model applied to outage data and the weather at location and time of every outage. We use this model to make daily decisions to mitigate fire risk. It factors in historical outage data, weather, location and timing to determine outage likelihood. The data utilized to train this model includes vegetation overstrike derived from Aerial LiDAR, historical sustained and momentary outage data (by outage type), and PG&E reportable ignitions learned by cause type.

### Key OPW Model Features

#### Weather

Wind speed, turbulence, temperature, vapor pressure deficit

#### Vegetation Risk

Tree height + canopy cover of strike trees from Planet Labs (formerly SALO)

#### Local Performance

Outage trends specific to each location through node feature

*Some of the measures included in this document are contemplated as additional precautionary measures intended to further reduce the risk of wildfires.*

## C. Ignition Probability Weather (IPW)

Our IPW uses more than 30 years of weather data to provide the likelihood of an outage for specific circuits based on previous weather events. Like the OPW model, data is utilized to train this model and includes vegetation overstrike derived from Aerial LiDAR, historical sustained and momentary outage data (by outage type) and PG&E reportable ignitions learned by cause type. Ignition causes include vegetation, structural or electrical equipment errors, animals, third parties or can be undetermined if the cause is not identified. Notably, each outage cause has unique outage to ignition relations, with vegetation and equipment-structural having the highest ignition per outage relations based on our modeling.

### Calculating IPW

$$\mathbf{IPW = P(Ignition) = \sum_{type}^{cause\ types} P(Outage_{type}) * P(Ignition_{type} \mid Outage_{type})}$$

P = probability

## D. Catastrophic Fire Probability (CFPD)

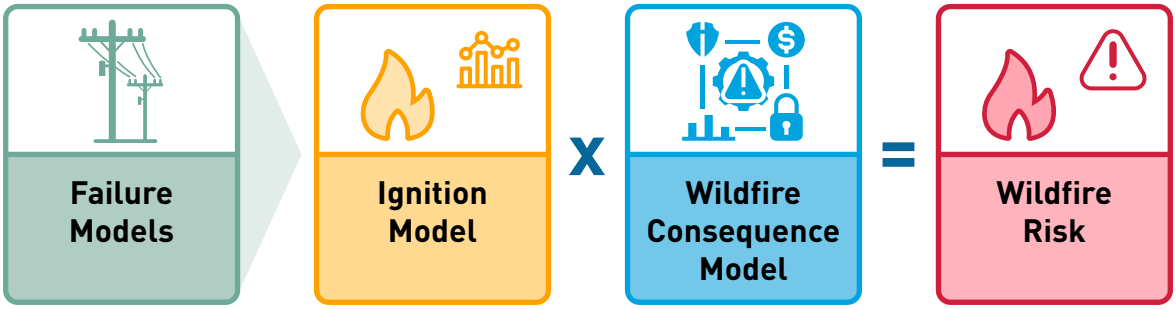
The Ignition Probability Weather (IPW) and Fire Potential Index (FPI) are analyzed together to determine Catastrophic Fire Probability. Based on these models, our teams determine whether PSPS and EPSS are necessary to prevent a catastrophic wildfire.

# Planning Models

## A. What is Our Planning Model?

Risk modeling involves assessing the likelihood and impacts of potential wildfires to help us prevent them in the future. By combining ignition likelihood with estimated wildfire consequences at a given location, we can determine the overall risk of a potential wildfire should an ignition occur.

### How Our Risk Model Works




By tracking and predicting failures, ignitions, and the consequences of a wildfire starting, we're able to compare risk across our assets and equipment.

**Risk Modeling Objectives**

- Provide situational awareness of risk
- Improve risk-informed decision making
- Evaluate and quantify risk reduction from wildfire mitigation initiatives

*Some of the measures included in this document are contemplated as additional precautionary measures intended to further reduce the risk of wildfires.*

## B. Why We Model Risk for Work Planning

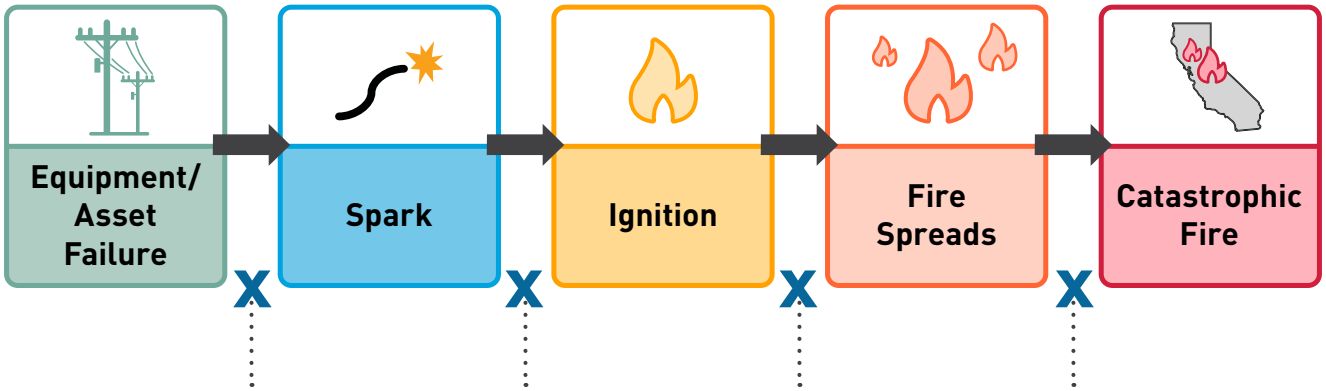
Insights from our models improve our mitigation strategy and communication with stakeholders by ensuring our risk reduction is measurable and achievable.

**These models help us:**

- Quantify risk and risk reduction.
- Supply better data for more accurate work planning decisions.
- Provide regulators with transparency into our decision-making process.
- Analyze the cost efficiency of mitigations.
- Set new industry standards in safety.

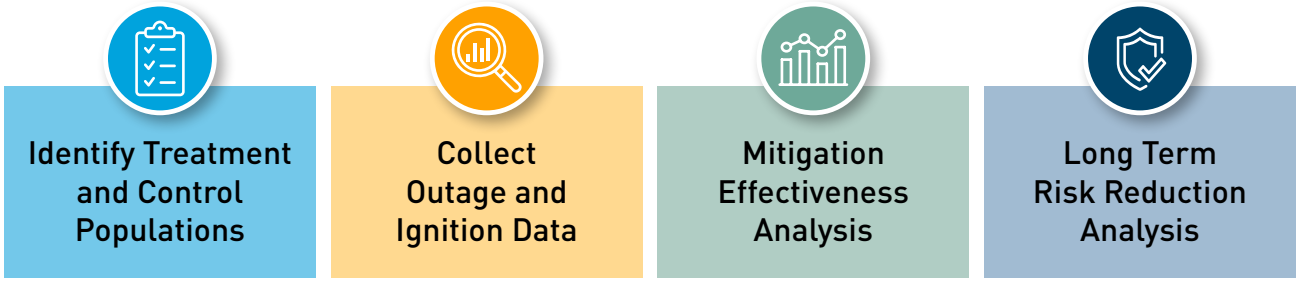
## C. Risk Reduction from Wildfire Mitigations

As we mentioned in the introduction of this guidebook, utility-attributable fires may follow a common sequence. Understanding how mitigations interrupt the wildfire sequence can help evaluate their impacts and identify gaps in protection.




**Mitigations interrupt the sequence and prevent catastrophic wildfires.**

Estimating the effectiveness of wildfire mitigations can enable planners to assess and compare risk reduction across multiple mitigations. We typically measure the effectiveness of a mitigation by tracking and comparing ignition rates at the "treated" population to the untreated, or control, population.

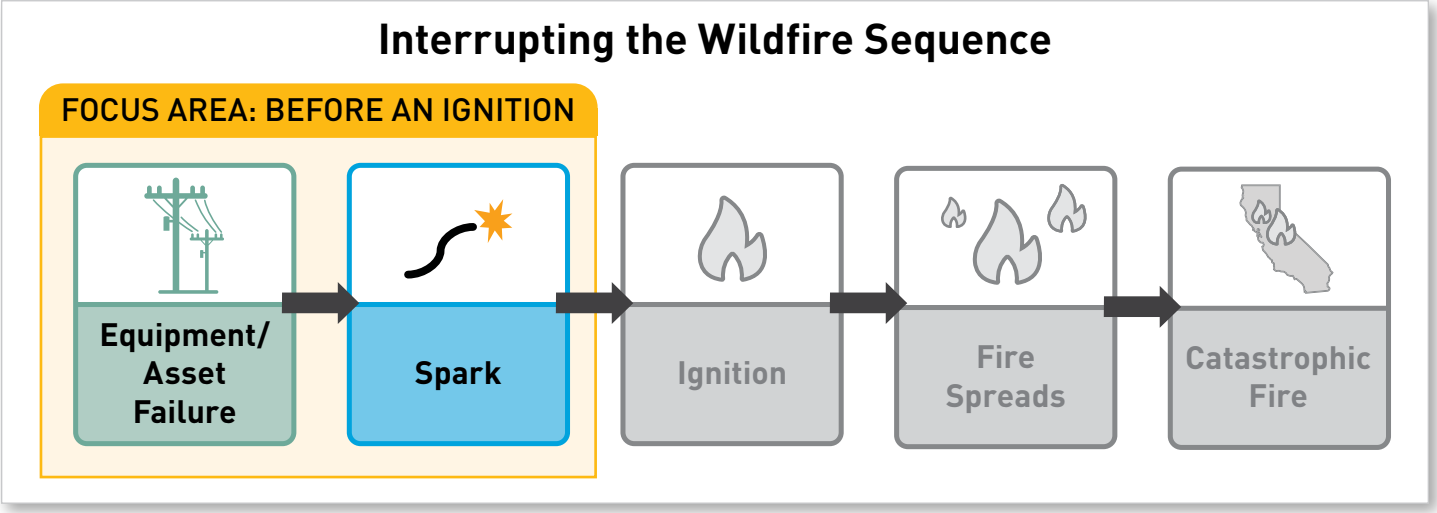



## D. Applications Beyond Work Planning

In addition to informing our wildfire safety operations and mitigation work, our risk models create the basis for important calculations we share externally with our regulators and partners. By understanding our wildfire risk, we can quantify our risk exposure. These calculations are shared in our 2024 Risk Assessment Mitigation Phase (RAMP) filing which can be found on the California Public Utilities Commission's (CPUC) website: **cpuc.ca.gov**.

# 05 Before an Ignition: Mitigations to Prevent an Ignition

By implementing mitigations that prevent equipment failures and sparks on our assets, we limit the likelihood of catastrophic wildfires.




## Continuous Monitoring

In anticipation of severe weather and periods where equipment may face an increased risk of wildfires, we built a network of weather stations and high-definition cameras and leverage innovative tools and technologies to help us monitor our electric system and detect threats to our equipment in real-time. This capability is becoming increasingly more important with climate change-driven weather whiplash.

### Innovative Tools and Technologies

We use multiple tools and technologies to provide data about the health and performance of our electric system.

- **A.I.-Enabled Weather Stations** provide insight into conditions across our service territory and allow our teams to better predict and respond to severe weather threats.

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- **A.I.-Enabled High Definition Cameras** give us visibility into high fire-risk areas. As part of the ALERTWest network, our cameras use A.I. to detect ignitions, notify authorities and help deploy suppression resources quickly.
- **Gridscope** is deployed on transmission towers and distribution poles, with multiple sensors and on-device signal processing to deliver continuous grid monitoring – even during outages. This technology can alert us of potential failures earlier and allow us to address dangerous conditions before they start a wildfire.
- **Early Fault Detection** captures data if there is an emerging potential fault on our powerlines. These devices are placed at 2.5 mile increments to monitor circuit performance and flag potential issues. This is available through a web portal and allows us to dispatch crews and/or repairs before the circuit faults. For high-risk issues, SMS and email alerts are shared with our teams to triage solutions. Currently, Early Fault Detection technologies are installed on eight circuits, with plans to expand to an additional four circuits in 2025.
- **Distributed Fault Anticipation** installed in substations that communicate with line sensors to determine the cause of a fault, like vegetation contact, arcing, sagging, broken equipment, animal interference and others. This technology tracks and stores fault locations and types to allow for investigation and remediation. Currently, we have deployed Distributed Fault Anticipation technology on 297 circuits with plans to expand to 40 additional circuits in 2025.
- **SmartMeters** installed at each home or business to help detect when there is a low current on a powerline or circuit. This technology is in the early stages of development and will further advance our continuous monitoring capability.

# System Inspections and Repairs

System inspections serve as our first line of defense in protecting communities. We use cutting-edge technologies to survey the health and safety of our electric system to proactively address any issues with our electric system.

**Our inspections regime is comprised of two main components:**

- **Patrols:** Coworkers complete a visual examination of overhead and underground facilities.
- **Detailed Inspections:** Includes careful examination and diagnostic testing on individual components of our equipment.

The goal of all inspections is to identify abnormal conditions on or near our equipment that can impact ignition and/or reliability risk. In these cases, we create a tag in our system.

Once identified and tagged in our system, we schedule repairs, which may include replacing our equipment.

We use a variety of technologies to ensure we are capturing actionable information during our inspections. In addition to visual inspections on the ground and from the pole, we use aerial and drone technologies and high-resolution imagery to achieve views above and on our equipment. These images are fed into our Sherlock Inspection Platform to help us analyze our equipment and flag potential repairs.

Our teams also use Light Detection and Ranging (LiDAR) and infrared technologies to see abnormal conditions that we cannot identify visually. Through these technologies, we can identify system degradation, potential failure points and asset health in greater detail.

**Views of a transmission insulator made possible by high-resolution imagery.**

As we continue to build out our continuous monitoring capacity, we plan to alter our inspections cadence to better align with capturing our highest risk tags and covering risk factors not captured by other means. This ensures that our inspections remain efficient.

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## Inspection and Repair Types Across Service Levels

| Asset Type | Inspection Type | Frequency |
|---|---|---|
| **Transmission** | **Detailed Inspection** | • Every three years or according to changes in risk profile |
| | **Infrared (Aerial or Handheld)** | • Every three years or according to changes in risk profile |
| | **Climbing** | • Every three years |
| | **Ground Patrol** | • Each off year from Detailed Inspection |
| | **Other** | • **Intrusive Pole:** Between 10-20 years<br>• **Switch Function Tests:** Every eight years<br>• **Intrusive Pole:** Conductor Measurement, Proactive Sampling/Testing |
| **Distribution** | **Detailed Inspection** | • Every three years |
| | **Overhead Equipment Inspection** | • Every three years |
| | **Ground Patrol** | • Highest risk areas |
| | **Aerial Inspection** | • Every three years or according to changes in risk profile |
| | **Infrared Inspection** | • As needed to investigate emerging issues |
| | **Other** | • **Aerial Pilot (Visual):** According to changes in risk profile<br>• **Intrusive Pole:** Between 10-20 years<br>• **LiDAR:** Once |
| **Substation** | **Aerial Inspection** | • Every three years or according to changes in risk profile |

# Public Safety Power Shutoff (PSPS)

High winds can cause trees and debris to contact powerlines and start a wildfire. To keep customers and communities safe, we may need to proactively de-energize our powerlines, as a last resort, to reduce the risk of wildfire. This is a PSPS. We use PSPS outages to help protect communities amid severe weather.

## Operational Decision Making

Identifying high fire-risk areas and forecasting severe weather guides our operational decision making around PSPS. To do this, we use several spatial and temporal data resources.

**These resources, also discussed elsewhere in this guidebook, include:**

- **Risk Modeling:** Assessing the likelihood of a wildfire in a given area.
- **Fire Potential Index (FPI):** Assesses the potential for a wildfire to start and spread. FPI is monitored hourly during high-risk periods.
- **Fire-Threat Maps:** Identifies areas at increased risk for wildfires due to strong winds, dry vegetation and other environmental factors.
- **Situational Awareness Tools:** Public weather models, such as NOAA Global Forecast System and the European Centre for Medium-Range Weather Forecasts, and networks, including NWS, AlertWest and Watch Duty, inform real-time detection and response to threats.

## Phases

**A PSPS has four phases: readiness posture, before de-energization, de-energization and restoration.**

1. **Readiness posture** occurs before we activate our Emergency Operations Center (EOC). If our meteorology team identifies a potential weather event, our experts meet to determine if and when to activate the EOC. Our teams prepare for a potential PSPS and continue closely monitoring the weather. Once activated, our EOC oversees weather monitoring, notifications, and inspection and repair teams. It serves as a central location for team members activated to support a PSPS.

2 **Before potential de-energization**, we continue to closely monitor weather forecasts, develop and refine the potential scope of the PSPS and reach out to customers and agencies that may be impacted. We provide several notifications to agencies, critical facility partners and customers prior to de-energization.

3 **De-energization** for safety requires coordination with several emergency and grid partners as well as external agencies, including impacted municipally owned utilities and the California Independent System Operator (ISO). We work with our agency and critical facility partners to provide resources for our customers at our Community Resource Centers (CRC) in addition to transportation support, hotels and meals, if needed. The decision to de-energize is made using the following factors:

**STEP 1**

**Evaluate if all of the minimum fire conditions are met.**

| >0.22 | <30% | >19MPH | <0.36 | <9-12% |
|---|---|---|---|---|
| Fire Potential Index | Humidity | Sustained Wind Speeds | Normalized Difference Vegetation Index | Dead Fuel Moisture |

**STEP 2**

**Conduct an in-depth review of fire risk using three measures:**

A. **Catastrophic Fire Probability ($CFP_D$):** We use machine learning to assess the likelihood of equipment failure during a given weather event and the risk of catastrophic wildfire if a failure occurs. This model uses a combination of the Ignition Probability Weather (IPW) Model and the FPI Model (see graphic on next page).

B. **Catastrophic Fire Behavior:** Even if the probability of a powerline or equipment failure is unlikely, we may still turn off power where the consequence of a wildfire would be extreme.

C. **Vegetation and Electric Asset Criteria Considerations:** We identify areas where tree or electric tags may indicate increased risk of ignition.

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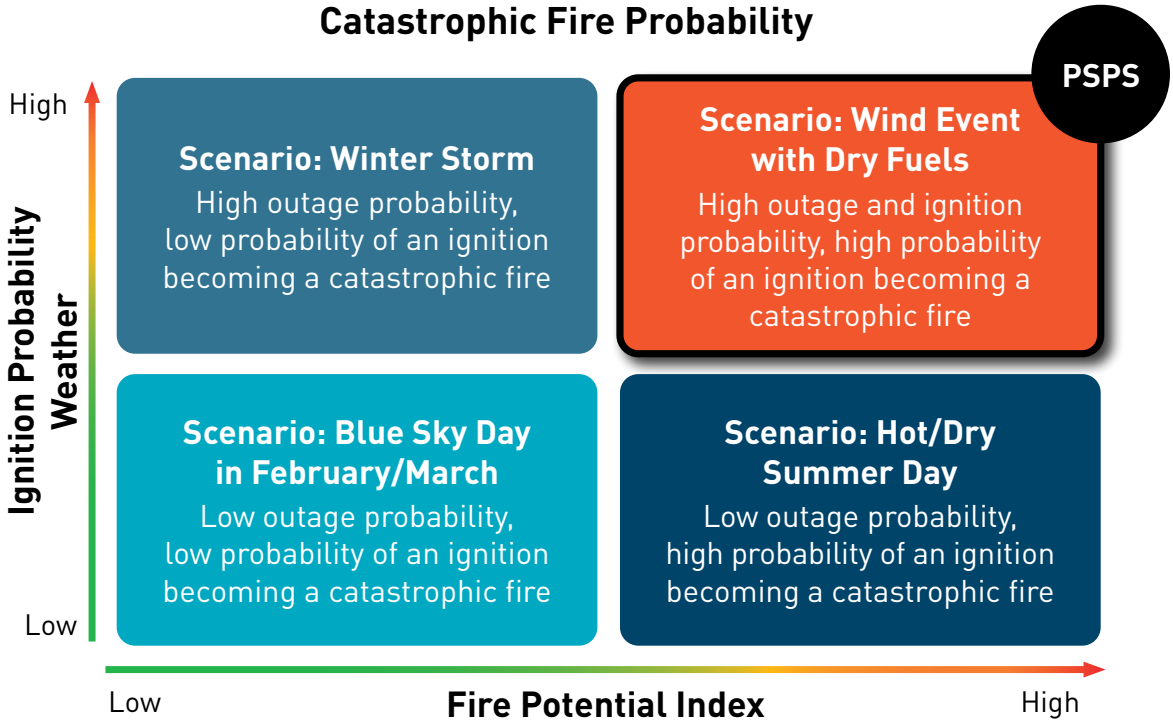


**STEP 3**

## Determine the event scope and power outage area

- Distribution PSPS guidance is modeled hourly across approximately 35,000 h3 hexagons that cover overhead distribution assets in PG&E's High Fire-Risk Area.
- A PSPS event will typically not be considered until PSPS guidance is met for 140 h3 hexagons in PG&E's High Fire-Risk Area; however, subject matter expertise is also applied in event including close consideration of external and agency forecasts.
- Because powerlines travel across long distances, customers outside the affected area may also be impacted.

4 **Restoration** happens once severe weather passes and our inspection team assesses de-energized assets to ensure it is safe to turn the power back on. Our goal is to restore power within 24 hours after severe weather has passed.

### STEP 1 Weather "All-Clear"

When weather conditions are below PSPS guidance (declining pressure gradients, decreasing winds and confirmed field observations show decreasing fire-weather conditions), crews begin patrol and restoration.

### STEP 2 Patrol and Inspect

Our crews visually inspect for potential weather-related hazards and damages to the lines, poles and towers. This is done by vehicle, foot and air.

### STEP 3 Isolate and Repair Damage

Where equipment damage is found, our crews work to isolate the damaged area from the rest of the system. Other parts of the system can then be restored.

### STEP 4 Restore Power

Once the poles, towers and lines are safe to energize, PG&E's Control Center completes the process and restores power to affected areas.

### STEP 5 Notify Customers

Customers are notified that power has been restored.

## Resources and Information Sharing

**We provide information and resources for our public safety partners, internal emergency operations and communications representatives via:**

- **Data Portals:** Three secure online data portals for key government and community partners to access grid and outage information, as well as planning information to help support customers and minimize impacts. These include:
  - **PSPS Portal** – Designed for Public Safety Partners that includes planning and event-specific maps and reports.
  - **Microgrid Portal** – Includes maps, current resiliency project locations and historical PSPS outage data for local agencies to plan and support local community resiliency efforts.
  - **Outage Portal** – Provides data on circuits currently enabled with Enhanced Powerline Safety Settings (EPSS), and active power outages on EPSS-protected powerlines, as well as maps and tools that detail customer impacts during outages.
- **Situation Report:** Posted on the PSPS Portal twice a day when the EOC is activated or a PSPS scope has changed, this report includes information about customer impacts, outage timings and mitigation effort. During restoration, the portal is updated hourly, allowing public safety partners across the service area to easily access the latest event information to support their response efforts.
- **PSPS Situational Intelligence Platform (PSIP):** This internal platform is where notifications are staged and internal reports are available. These resources include information on customer impact and all clear data for impacted tribes, counties and cities.

## Notifications

We send notifications to customers, public safety partners and critical facilities in advance of and during a PSPS: two days ahead, one day ahead, just before turning off power, once power is turned off and daily until power is restored. When possible, we also issue priority PSPS notifications to public safety partners, critical facilities and infrastructure and transmission-level customers up to three days before a PSPS so they can help prepare their communities.

### PSPS Communications Timeline

**Priority**

**72-48 hours before power is turned off**
After our EOC is activated, direct contact is made with state, local and tribal agencies and critical facilities, such as emergency hospitals, telecommunication providers, water and waste water agencies.

**Watch**

**48-24 hours before power is turned off**
We send a notification in advance of the planned de-energization.

**Warning**

**4-1 hours before power is turned off**
We send a notification when the planned de-energization is approaching.

**Cancellation/ Delay**

**If shutoff is delayed/cancelled**
We send a notification if weather conditions change and the shutoff time is significantly delayed, or if power will no longer be shut off.

**Shutoff**

**At power shutoff**
Customers and Public Safety Partners are notified that power is about to be or has been turned off for public safety.

**Power Restoration**

**Following weather "all clear"**
After weather has passed, we send notifications to customers daily until power is restored. We also notify agencies that system inspections are underway.

**Update**

**If there's an update**
We send a notification if the estimated time of restoration changes.

**Following power restoration**
We send a notification once power has been restored.

*Some of the measures included in this document are contemplated as additional precautionary measures intended to further reduce the risk of wildfires.*

# Strategic Improvements

PSPS has been a critical tool in keeping our customers and communities safe since 2019. Although PSPS impacts have declined significantly, we still use PSPS as a tool of last resort when weather conditions indicate wildfire risk.

## A. Refining PSPS

**We continue to refine this wildfire mitigation tool and implement improvements, including:**

- **Standardizing Data:** We use Foundry as an internal single source of truth for event data. By streamlining all event information through this centralized location, we can better track data and ensure all members of the EOC have accurate and timely situational awareness. This includes creating standard reports with event timing information.
- **Improving Notifications:** We have a standard timeline for communicating with customers and Public Safety Partners. By setting expectations of what information we share and when it becomes available, we can better support customers and stakeholders who may be impacted by PSPS. We also utilize external meetings and media briefings to ensure consistent and timely messaging. Additionally, we leverage technology and automation to improve our notification processes, benchmarking with other utilities where appropriate.
- **Providing Customer Support:** We are doing more to help customers and communities before, during and after a PSPS. Finding ways to reduce impact without compromising safety is a key priority. We partner with community-based organizations and establish Community Resource Center (CRC) locations to provide a variety of resources such as backup power, hotel stays and charging stations. Using mitigation tools such as backup generators and microgrids allows us to reduce impact within and around areas impacted by PSPS.

- **Minimizing Scope Impact:** We continue to conduct PSPS at more granular levels, leveraging emerging technology, to focus solely on the area of weather concern. Using tools like sectionalizing and SCADA devices, and improving our internal processes, we reduce the number of customers and duration of impact when safe to do so, also helping to alleviate strain on our field crews.

Going forward we will continue to evaluate PSPS and our range of wildfire mitigation efforts to ensure we are improving our systems while prioritizing customer safety.

## B. Other Operational Options

New and emerging technologies increase the flexibility of our electric system and mitigate customer impact, while keeping customers safe.

**These technologies have applications beyond PSPS to help prevent ignitions in high fire-risk weather conditions:**

- **SCADA Devices:** Replacing manual devices with SCADA devices allows for switching power on and off remotely. The ability to operate remotely reduces time, staging and strain on our crews as they no longer need to manually disable and re-enable devices during PSPS. It also reduces the amount of time it takes to restore power to customers, helping to reduce the impact of a PSPS.
- **Transmission Switches:** Separate a transmission line into smaller segments. These switches allow us to turn off power to a specific segment of a transmission line serving a substation to minimize impact.

# Vegetation Management

We manage trees and other vegetation located near our overhead electric facilities that could cause a wildfire or power outage.

Each year we develop a targeted work plan to identify and prioritize the highest risk areas. Our wildfire prevention initiatives exceed compliance requirements and help reduce outages for customers and improve safety. As climate change cycles us through rainy periods with lush vegetation growth and periods of drought and heat where that same vegetation becomes dry, proactively conducting tree work is imperative to protect our communities.

## Enhancing Wildfire Safety

Annually, we conduct routine vegetation inspections on transmission and distribution overhead electric facilities and clear vegetation around poles to keep communities safe. In addition, we have developed targeted vegetation management programs to reduce the risk of wildfires. As the wildfire risk within our service area continues to shift, we have modified our vegetation management strategies to prioritize more effective and efficient ways of protecting our electric system and customers. Today, our distribution wildfire safety vegetation work focuses on areas with the greatest wildfire risk and prioritizes work where most needed through three targeted programs: Tree Removal Inventory (TRI), Focused Tree Inspections (FTI) and Vegetation Management for Operational Mitigations (VMOM).

## Scope of Work

### A. Annual Routine Inspections

We inspect approximately 100,000 miles of distribution and transmission overhead electric facilities each year. This work is necessary to meet our state and federal requirements. In addition, we conduct a second annual patrol in the highest fire-risk areas to identify hazardous trees for mitigation and ensure minimum clearances of vegetation around our overhead electric facilities are compliant with applicable state and federal regulations.

## B. Annual Routine Tree Work

Following inspections, we promptly clear or trim any trees that are identified as a safety risk to overhead electric facilities that could potentially impact customers and communities. This work is necessary to comply with applicable regulations, mitigate wildfire risk and reduce power outages.

To meet state and federal requirements, we maintain a clearance of at least one and a half feet around distribution powerlines in Local Responsibility areas of the non-high fire-threat district and at least four feet in high fire-threat district and State Responsibility Areas. Greater clearances are achieved at the time of pruning to ensure year-round compliance.

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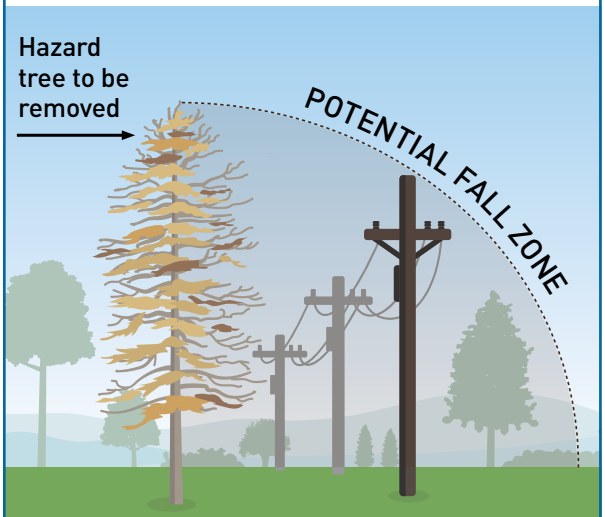
## C. Compliance Requirements

Our vegetation management work complies with the following federal and state requirements[4]:

### CPUC General Order 95, CA Public Resources Code 4293 and CPUC Resolution ESRB-4

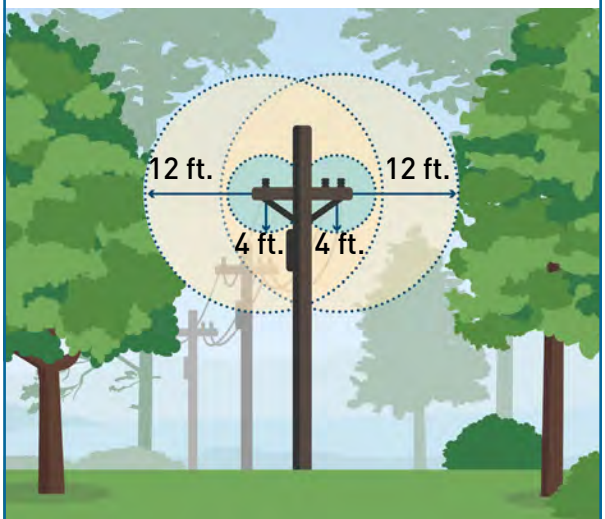
These regulations require the removal of hazard trees




Distribution and Transmission Lines[4]

### CPUC General Order 95[5] and CA Public Resources Code 4293[5]

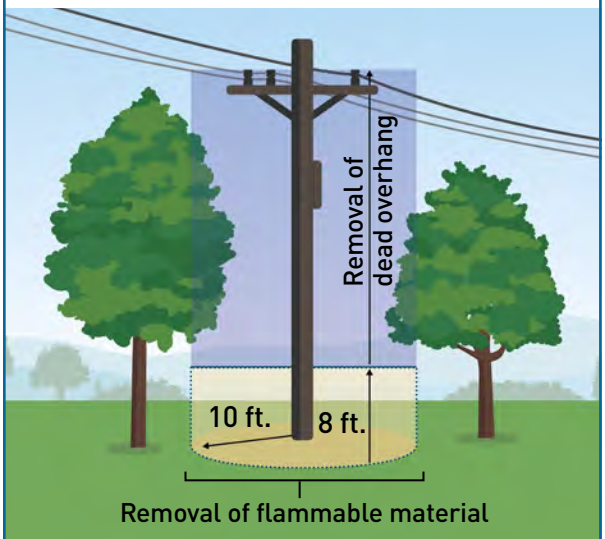
These regulations are part of our routine maintenance




Distribution and Transmission Lines[4]

### CA Public Resources Code 4292

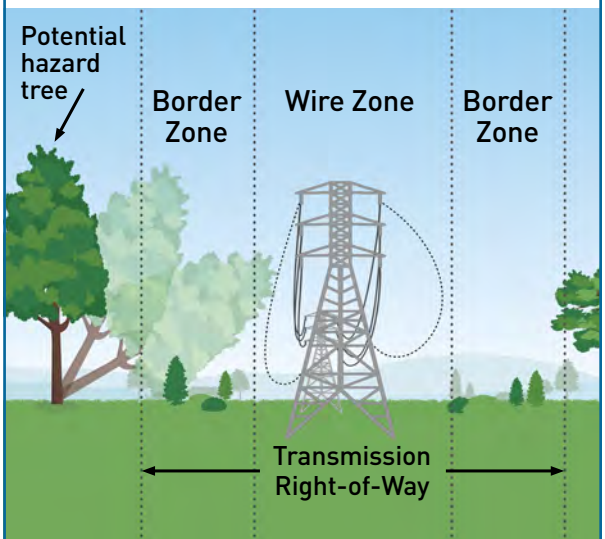
These regulations apply in certain areas with increased fire risk




Distribution and Transmission Lines[4]

### NERC FAC 003-5

This regulation are part of our routine transmission maintenance




Transmission Lines[4]

[4]These graphics display clearances for distribution lines. Clearances may be greater for transmission lines.
[5]CPUC General Order 95, Appendix E, and CA Public Resources Code 4293 apply in certain areas with increased wildfire risk.

*Some of the measures included in this document are contemplated as additional precautionary measures intended to further reduce the risk of wildfires.*

## D. Additional Work in High Fire-Threat Areas

In addition to our annual work to keep trees away from overhead electric facilities, in 2025 we are conducting three programs to further reduce wildfire risk.

Our Tree Removal Inventory (TRI) program reviews trees identified through previous enhanced vegetation efforts and cuts down any trees that still pose a safety concern. The Focused Tree Inspection (FTI) program conducts additional inspections and trims of vegetation in high fire-risk areas near circuits with an increased risk of vegetation-caused outages. Lastly, through our Vegetation Management for Operational Mitigations (VMOM) program, we trim or cut down additional trees near circuits that have historically experienced a high volume of outages due to vegetation contacting overhead electric facilities.

This work is included in our Wildfire Mitigation Plan with the sole focus of reducing risk for our communities. We are in the process of evaluating which components of FTI, TRI, and VMOM programs will be incorporated into our distribution routine patrol program in 2026.

## E. Wood Management

As part of our vegetation safety work, we will chip and haul away branches and limbs we trim that are less than four inches in diameter. We may provide the wood chips to the customer if requested. If small branches and limbs cannot be chipped, we will cut and scatter them on site in accordance with California Forest Practice Rules. Wood greater than four inches in diameter will remain in a safe location on site, as this wood belongs to and is the responsibility of the property owner. We are always happy to discuss specific wood on a customer's property, relocate or haul away wood as practical. Customers can also work with local service organizations or green waste facilities for wood hauling options.

## F. Quality Control

It's important that our vegetation work meets and/or exceeds state and federal requirements to keep our communities safe. To ensure work is conducted appropriately, we have qualified inspectors conduct follow-up inspections after work is completed. These inspectors are also trained to identify the level of risk trees and vegetation pose to our equipment and the environment.

*Some of the measures included in this document are contemplated as additional precautionary measures intended to further reduce the risk of wildfires.*

## G. One VM Database

The One VM database is essential to monitoring progress as well as informing future decisions. As we continue to streamline and improve our vegetation management programs, One VM will continue to support improved record keeping, which will also assist with regulatory reporting and wildfire risk analysis.

## H. Key Insights Enabled by Remote Sensing Tools

To help us evaluate wildfire risk and inform our vegetation work, we have improved our remote sensing tools. These tools help us identify potential risks sooner and allow us to be more proactive. Innovations include LiDAR, Satellite and Ortho Imagery capabilities.

## I. Program Growth, Performance and Costs

We have learned several valuable lessons that have contributed to the evolution of our vegetation management programs over time. Over the past five years, we've enhanced our sourcing strategies, safety, data-driven decision making, environmental strategies and constraints management, which have helped us improve the effectiveness of our work while reducing costs. Our work is informed by cost benefit ratios to address the work that is most impactful to the safety of the communities we serve.

# System Upgrades

System upgrades can include moving powerlines underground, installing strengthened poles and covered powerlines above ground, and in some cases removing powerlines or infrastructure that is no longer needed. Additional upgrades can include establishing standalone power systems or microgrids that operate independently from the electric grid, hardening substations and other infrastructure investment initiatives that improve the resiliency of our electric system. When used with other wildfire safety tools, system upgrades maximize wildfire risk reduction and in some cases improve reliability.

## History

PG&E's system upgrades work has evolved in recent years in response to increased drought, heat waves and other environmental factors that increase wildfire risk. To ensure we address the highest wildfire risk areas, we use computer modeling to predict where wildfire risk is the highest by looking at different factors, like the type of land, weather patterns, past wildfires, what trees and plants are in the area and more. This helps us prioritize our system upgrades in the locations where we can mitigate the most wildfire risk from our system. Additionally, elements of this work also help to improve electric reliability for communities by helping us avoid wildfire safety outages (Public Safety Power Shutoffs, etc.) and other service disruptions.

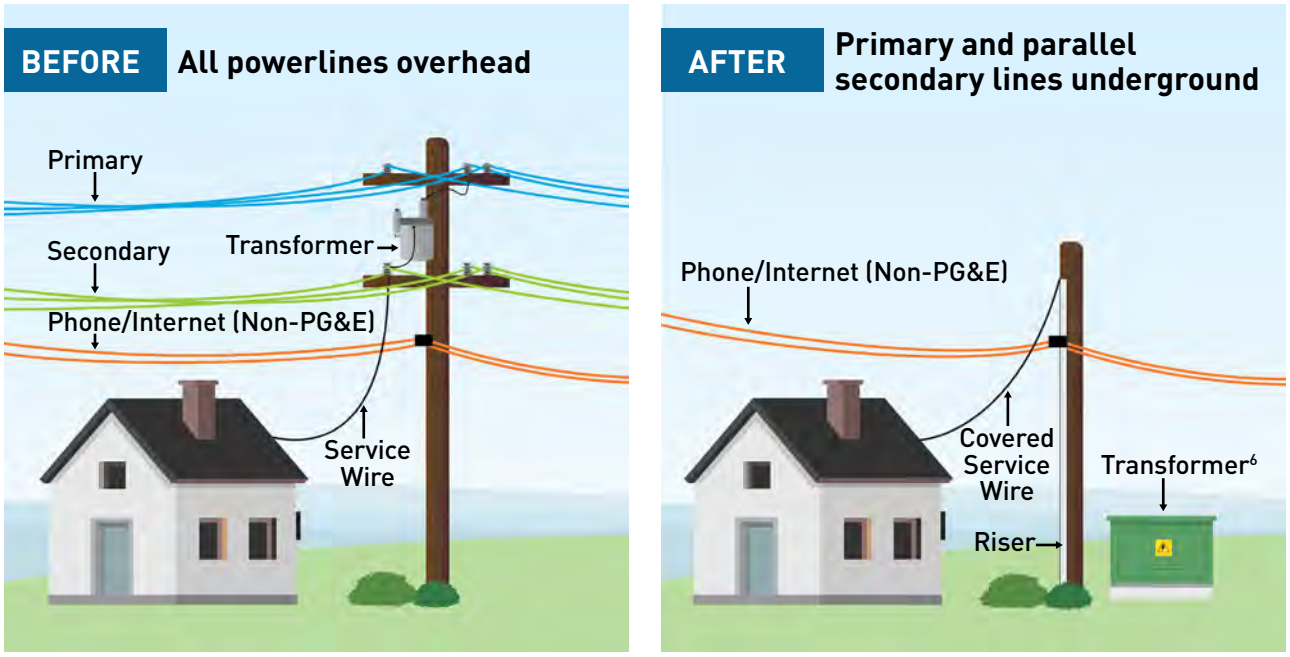
*Some of the measures included in this document are contemplated as additional precautionary measures intended to further reduce the risk of wildfires.*

# System Upgrades Overview, Scope and Implementation

## A. Undergrounding Program

Since launching our undergrounding program in 2021, we have successfully constructed and energized nearly 900 miles of underground powerlines, and we will complete more than 1,600 total miles of undergrounding through 2026. Once a line is moved underground, approximately 98% of the wildfire ignition risk is permanently eliminated – making it one of the best ways to permanently reduce wildfire risk. Underground lines are also less susceptible to external elements like wind, ice, tree damage and even vehicle collisions than overhead lines. This means that undergrounding also brings long-term reliability benefits and significantly reduces costs related to vegetation trimming, operations and maintenance over the long term.

**What PG&E's Undergrounding Looks Like**




As we have ramped up our undergrounding work over the last few years, we have realized efficiencies that have helped us reduce the average cost per mile. When the program first started in 2021, the cost per mile was approximately $4 million per mile. We then reduced costs to approximately $3 million per mile in 2023 and anticipate further reducing costs to approximately $2.8 million per mile by 2026. We continue to focus on improvements, identifying more efficient technologies and other measures to reduce the cost for our customers.

[6]Transformers may be placed above or below ground. Transformers are not required on every property.

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In addition, we have made enhancements to our customer journey over the years to ensure that customers are informed early and often during the undergrounding process. This includes sharing details about what to expect via phone calls, texts, letters, emails, web updates, community engagements and more.

In November 2023, the CPUC approved a plan allowing PG&E to underground approximately 1,230 miles of overhead powerlines from 2023 to 2026. Looking to the future, we are developing a 10-Year Electrical Undergrounding Plan that we will submit to the California Office of Energy Infrastructure Safety (Energy Safety). This long-term framework was made possible by the passage of Senate Bill 884, which PG&E supported as it will allow large utilities the opportunity to submit a long-term, 10-year undergrounding plan. In turn, this will help us to plan and execute large-scale undergrounding and keep customers at the forefront by driving down costs.

To date, our undergrounding efforts have received regulatory approval in smaller phases, covering only a few years at a time. With the new framework made possible by Senate Bill 884, we will be able to engage in long-term contracts to reduce costs, facilitate better coordination with local agencies, customers and stakeholders, and provide greater certainty and transparency into future undergrounding plans. This long-term undergrounding plan will also focus on when, where and how we decide to underground powerlines in comparison to other alternatives, such as installing strengthened poles and covered powerlines above ground.

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## B. Overhead System Upgrades/Hardening

As part of our ongoing efforts to prevent wildfires, we are installing strengthened poles and covered powerlines in high fire-risk areas. Upgrading overhead lines reduces wildfire ignition risk by approximately 67% and in conjunction with other wildfire mitigation efforts can achieve even greater risk reduction. This means that even once strengthened poles and covered lines are installed, we continue to use tools like PSPS, EPSS and vegetation management, to keep communities safe. We prioritize upgrades in the highest wildfire-risk areas as an effective alternative where undergrounding may not be feasible.

**These upgrades can include:**

- Replacing bare powerlines with strengthened, covered powerlines.
- Installing fire-resistant poles and cross arms.
- Installing more poles to support the weight of covered powerlines.
- Removing overhead poles and lines that are no longer needed.
- Original poles may also remain in place following the completion of system upgrades if they carry phone and internet lines.

We have completed more than 1,350 miles of wildfire safety system upgrades through the end of 2024 and have additional work planned for future years.


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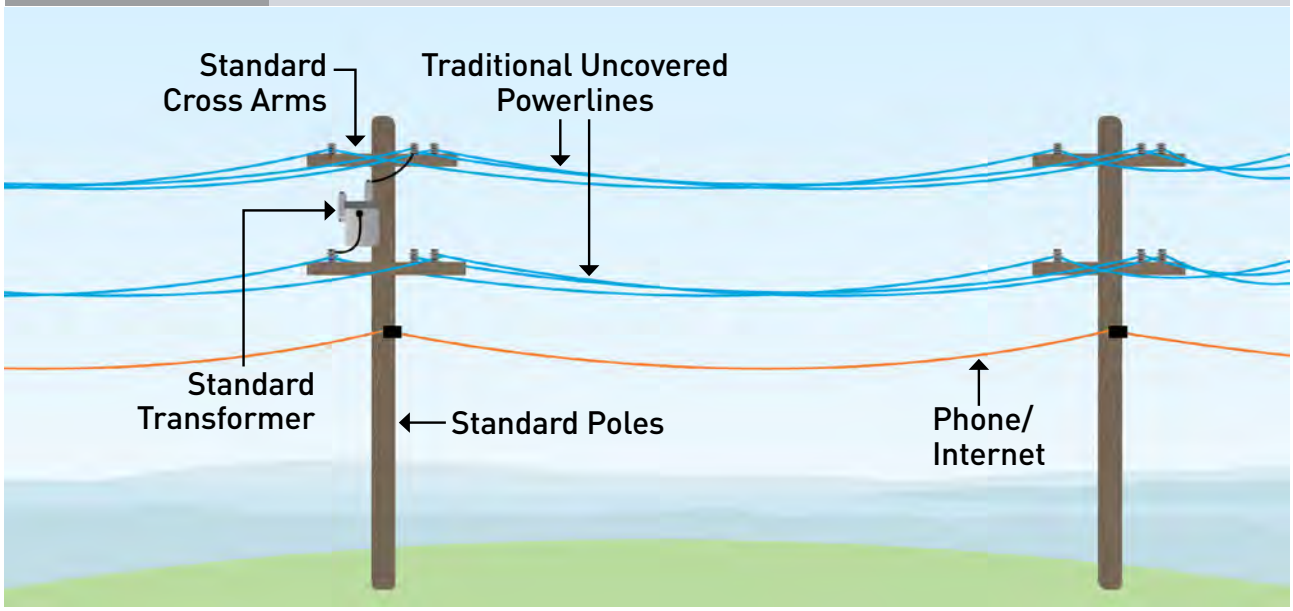
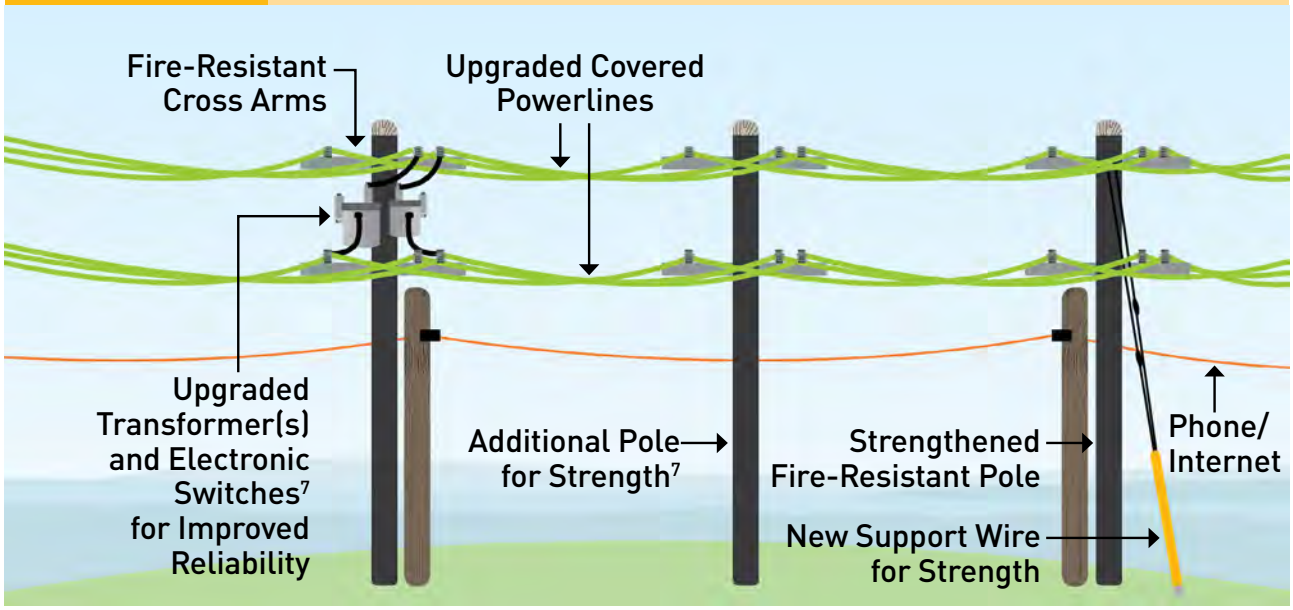
## What PG&E's Strengthened Poles and Covered Powerlines Look Like

**Before** **Traditional powerlines**




**After** **Strengthened poles and covered powerlines**




[7]Not required for all projects.

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## C. Line Removal

Deciding to remove any overhead distribution lines involves careful, deliberate analysis and thorough planning. This typically occurs in areas where lines are no longer needed or where power is supplied through alternative means, such as a remote grid. By removing lines that are no longer needed, we reduce wildfire risk, improve reliability, streamline our system and reduce costs to customers.

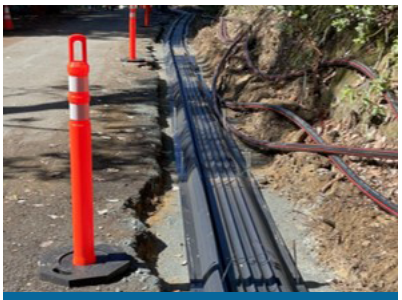
Before completing line removal projects, we contact customers in the area directly impacted to discuss the project and ensure that their current and future service needs are met. When redundant facilities are removed, we also reinforce the remaining lines in the area to maintain the capacity, reliability and flexibility needed to support the community.

We have completed more than 100 miles of line removal through the end of 2024 and plan to complete additional work where necessary in the future.

## D. Ground-Level Distribution System (GLDS) Pilot

We are piloting GLDS in areas where traditional undergrounding may not be feasible or practical. At a high level, GLDS packages electric cable in conduit in a specially molded tray, tied in with a basalt rebar, then sealed with a special geopolymer cement, placed at ground level and capped in thermoplastic. Our initial GLDS pilot has been effective, showing that this approach may be able to serve as a safe and viable alternative, particularly in environments where challenges like hard granite, lava rock, cultural sensitivities or environmental considerations make traditional trenching impractical.

Currently, we are conducting third-party testing and demonstration work within our facilities to develop construction standards and methodologies for expanding GLDS. We are also exploring additional locations to further pilot GLDS.



GLDS cable tray system

Geopolymer concrete pouring into tray system

Cover installed over cable tray system

*Some of the measures included in this document are contemplated as additional precautionary measures intended to further reduce the risk of wildfires.*

# Enhanced Powerline Safety Settings (EPSS)

For our customers' safety, we use EPSS to help prevent wildfires. These settings shut off power within one-tenth of a second, or faster, when a hazard contacts a powerline to prevent an ignition that could cause a wildfire. They provide significant ignition-reduction benefits.

We piloted these settings in 2021 on a select number of powerlines in high fire-risk areas in response to a significant increase in wildfire risk. Safety settings now protect approximately 44,000 powerline miles and 1.8 million customers in and around high fire-risk areas in our service area. In 2024, we saw a 65% reduction[8] in ignitions on powerlines enabled with EPSS. We also saw that during the most dangerous wildfire conditions, safety settings prevented over 600 wildfire hazards from causing an ignition, which could lead to a potential wildfire.

## Overview

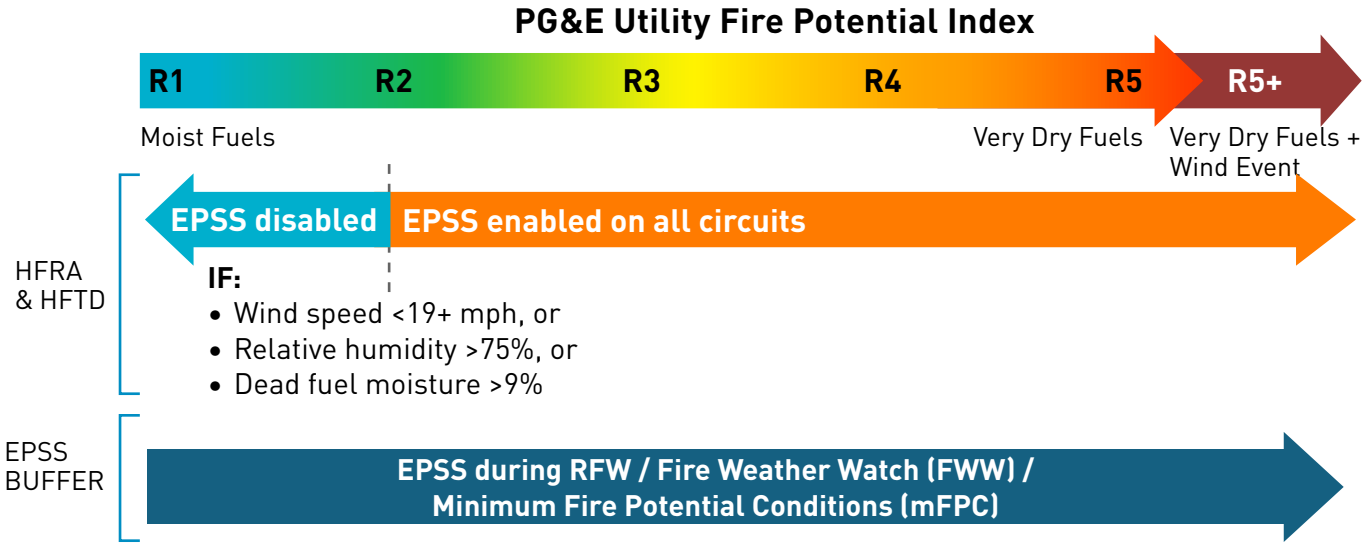
### A. Developing the Criteria for EPSS

By utilizing high fire-risk area mapping, situational awareness tools and information on historic wildfires, we established thresholds for enabling settings. We have an advanced machine learning-based Fire Potential Index (FPI) model that forecasts the fire potential across our entire service area on a scale of R1 to R5+. Based on a historical look back at over 2,000 fires, the most dangerous fires occur when conditions are R3 or greater. As a result, we keep track of the ignition events that occur when conditions are in R3 or greater, hence R3+. The goal of this accelerated work is to prevent R3+ ignitions taking place. For example, our peak season criteria involves enablement when risk meets or exceeds conditions that historically account for 97% of acres burned and 100% of property damage.

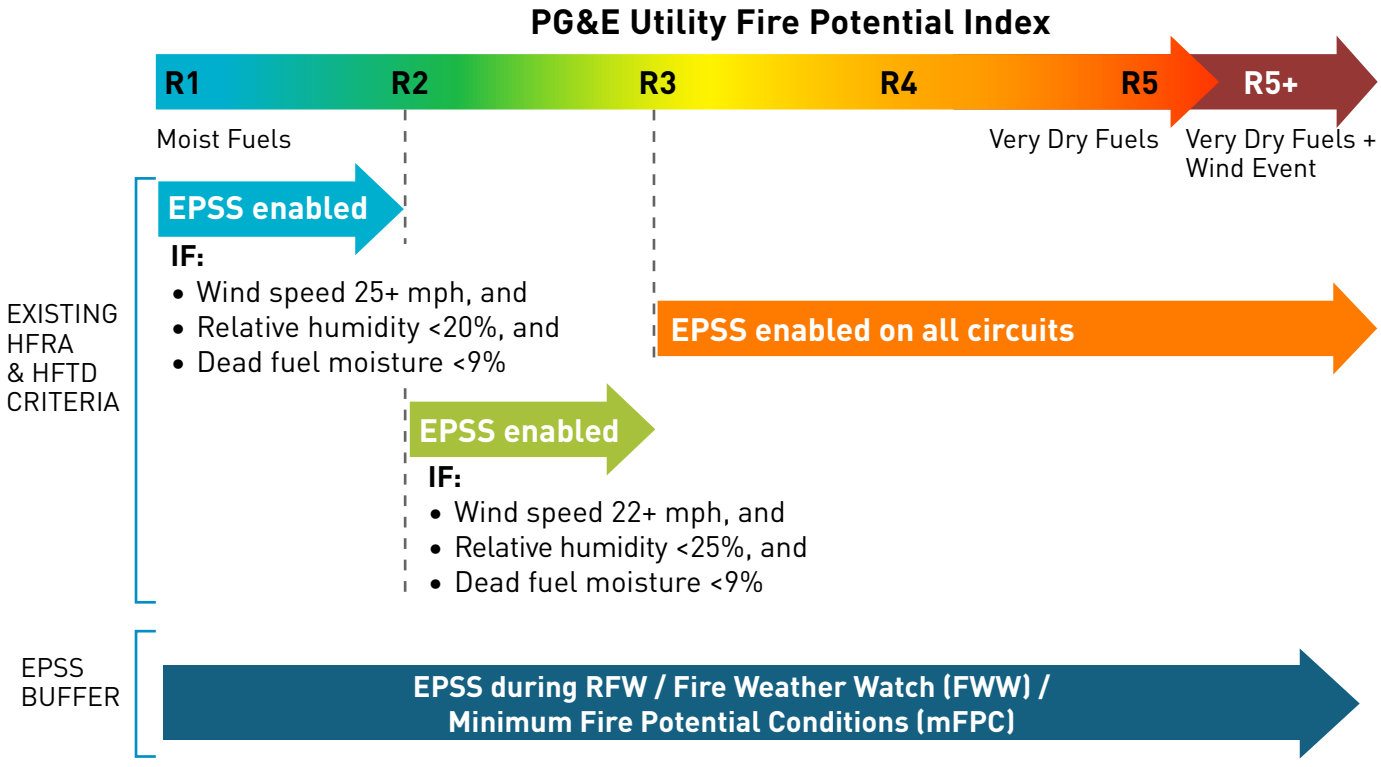
Once thresholds have been determined, our process outlines how enablement occurs. The majority of our EPSS protection devices are integrated with Supervisory Control and Data Acquisition (SCADA) systems, which allow for remote enablement by our distribution control centers.

[8]Based on an evaluation of the effectiveness of EPSS under conditions of elevated likelihood of destructive fire outcomes (R3 Fire Potential Index rating), compared to the 2018 – 2020 average prior to the establishment of EPSS.

## EPSS Enablement Criteria | PEAK SEASON




## EPSS Enablement Criteria | NON-PEAK SEASON

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## B. Responding to Hazards and Re-Energizing Circuits

It is crucial to treat any outage as a potential ignition. This means deploying personnel to rapidly respond to every EPSS outage location ensuring there is no ignition. Our goal is to arrive at all de-energized circuit zones within 60 minutes. Arriving at the outage location within 60 minutes also allows for timely patrol and restoration. While our primary goal is reducing wildfire, we are also focused on improving customer reliability.

**In addition to tracking CAIDI performance, we utilize several layers of reliability improvement, including:**

- **Fault Indicators:** Provide a bread-crumb trail to the fault location, shortening patrol times, reducing subsequent faults on the line and improving overall reliability.
- **Line Reclosers and Fusesavers:** Provides additional layers of protection and reduces overall footprint of outage impact through sectionalization of the circuit.
- **Down Conductor Detection (DCD):** Provides insight into difficult-to-see potential threats, such as high impedance faults on the electric grid. These faults may not be identified by existing equipment.
- **Gridscope:** Pole top sensors that quickly identify damage and fault locations in real-time, further reducing ignition potential.

## C. Preventing Wildfire Hazards from Causing Outages

There are a number of reasons an outage and/or ignition can occur. To prevent both, we conduct safety and reliability work throughout the year. After each outage, we have a dedicated team who reviews outage causes and identifies areas for improvement. While mitigation measures such as EPSS can help prevent an ignition from these contacts, installing preemptive measures in areas of repeat contact can reduce the risk of wildfires caused by ignitions.

Animals can cause ignitions when they contact energized powerlines. In some areas, this contact is more prevalent and can present a challenge when risk is high. While mitigation measures such as EPSS or Fast Trip Settings can help prevent an ignition from these contacts, installing pre-emptive measures like animal guards in areas of repeat contact can reduce risk.

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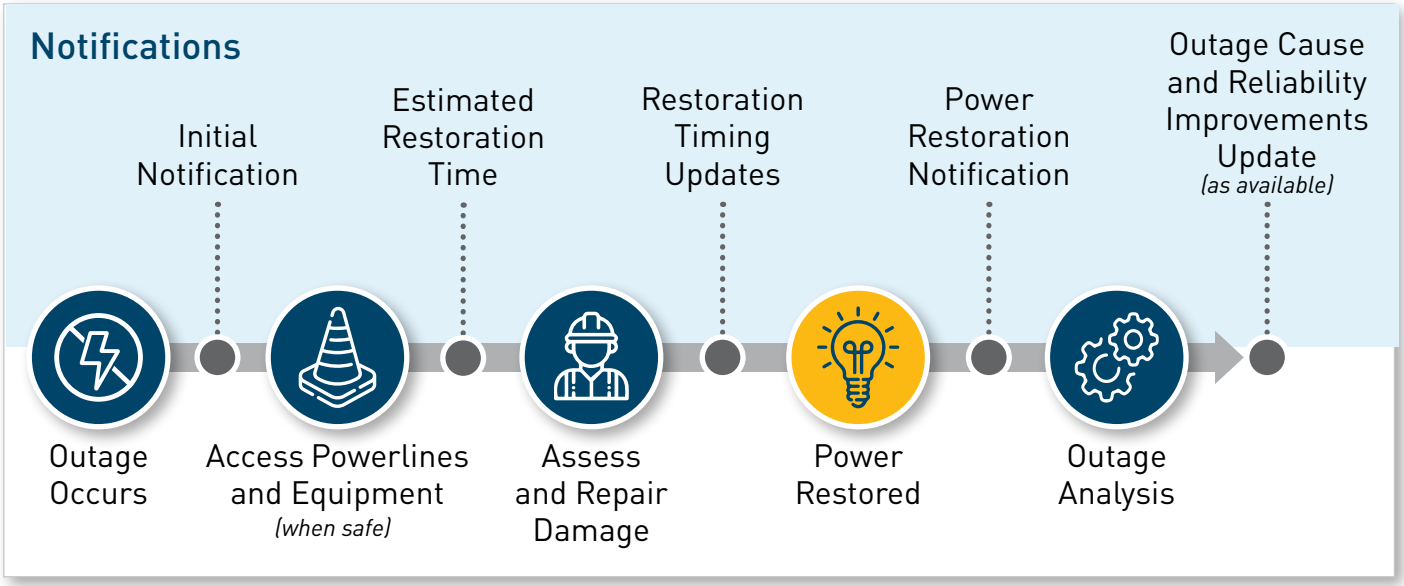
## D. Tools and Technologies

To increase our electric system's responsiveness to emerging risks and better identify outages, we use several technological innovations. These enhance EPSS protection and help improve reliability.

## E. Notifications and Communications

Since power turns off automatically from an unplanned safety threat, we cannot notify our customers in advance like we do for PSPS. Customer communications are sent following an outage, and provide a better understanding of their outage and work being done to keep the power on. This includes estimated restoration time, additional outage cause information and confirmation that power has been restored. We share outage updates through customers' preferred contact method, which can include automated calls, texts and emails.

**Customer Communications Timeline**

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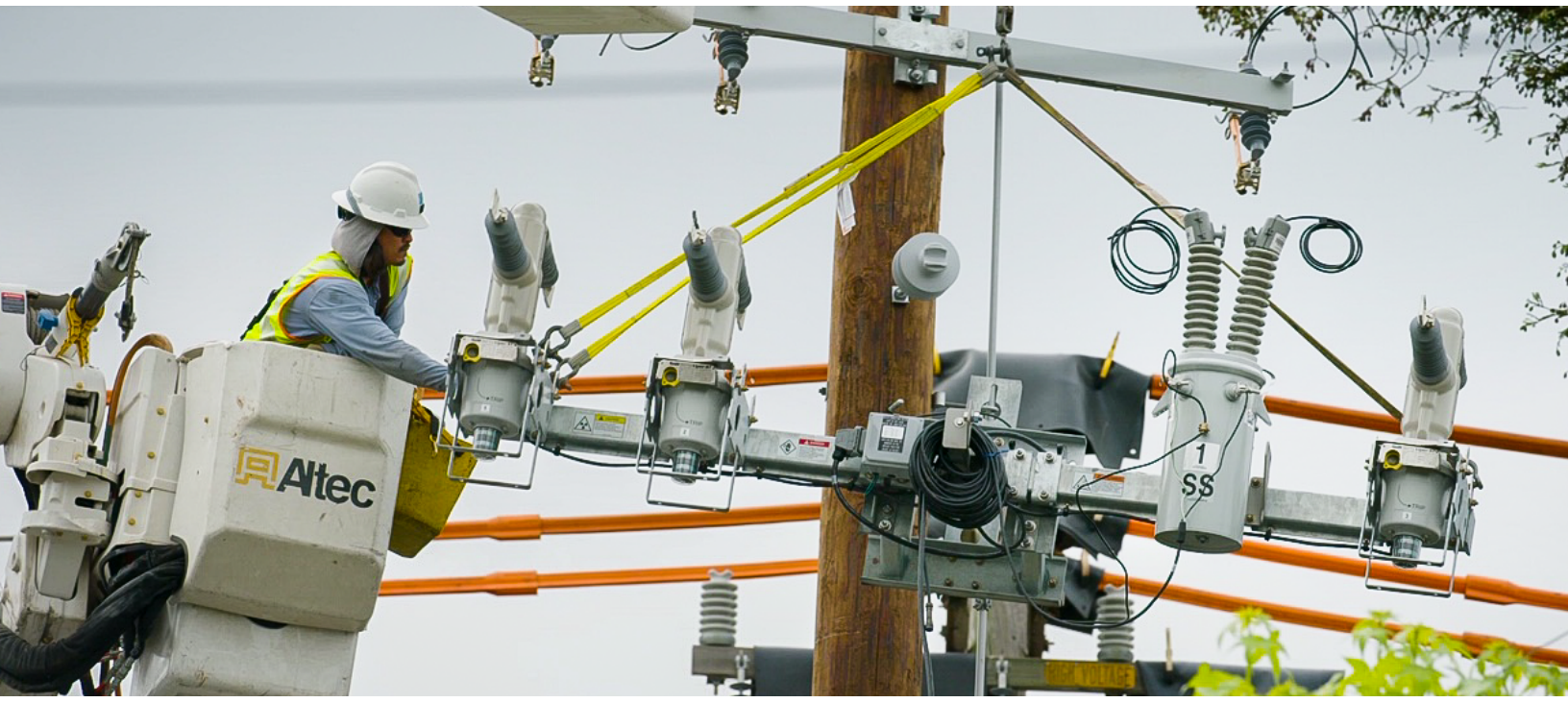
## Strategic Improvements

Our focus with EPSS is to continue to protect customers while advancing operational capabilities, reducing ignitions, expanding situation awareness and improving the customer experience.

**We are doing this through several key efforts:**

- Expanding DCD to all HFRA areas.
- Increasing capability to detect high impedance faults to better mitigate hard to detect hazards.
- Exploring automation of EPSS switching to allow for more targeted enablement of circuits to reduce customer impact.
- Expanding Gridscope installations and drone inspections.
- Enhancing outreach and reliability efforts for customers.

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# Leveraging Active Grid Response (AGR) to Maintain Reliability Across Circuits Equipped with EPSS

## A. Understanding Hazard Awareness Delay

Utilities typically only become aware of a grid hazard after it unleashes a surge of current powerful enough to trip circuit breakers. In some cases, high impedance hazards can take hours to trip the breaker. Once the power is out, line workers are dispatched with no insight into the hazard's type, location, or severity. They must patrol miles of power lines, often in dangerous conditions, searching for the issue before action can be taken to restore power. The time between when the hazard strikes and when the line worker identifies it, is what we define as Hazard Awareness Delay.

## B. Introducing Active Grid Response (AGR)

Active Grid Response (AGR) enables utilities to quickly assess, prioritize, and dispatch line workers directly to the hazard, significantly accelerating restoration efforts and eliminating Hazard Awareness Delay. Unlike systems that only detect electrical anomalies, AGR deploys smart, self-powered sensors on poles to interpret physical, structural, and environmental conditions around every span. Pinpointing the hazard's exact type, location, and damage severity before crews are dispatched also reduces exposure to crews as they patrol through dangerous areas and minimizes public risk by enabling faster hazard removal.

## C. Key Requirements for Achieving AGR

- **Immediate Detection:** High frequency measurements are captured continuously, ensuring hazards are detected at the precise moment they occur, even before they trip the circuit breaker.
- **Precise Localization:** Measurements are captured at every span, ensuring the hazard's exact asset-level location is pinpointed.
- **Detailed Identification:** The combination of electrical, physical, structural, and environmental signals are analyzed to identify the hazard's type and severity.
- **Monitoring During Outages:** Instruments are equipped with independent power sources, robust communication systems, and mechanical sensors so they can continuously identify hazards even during outages and severe storm conditions.

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## D. AGR Strengthens Enhanced Powerline Safety Settings (EPSS)

AGR minimizes the time customers are out of power following an EPSS outage. The moment a hazard triggers an EPSS outage, AGR delivers an immediate, detailed report specifying the hazard's type, damage severity, and precise location. Personnel are then dispatched directly to the site of the hazard to confirm there isn't an ignition before efficiently repairing and restoring power. AGR allows utilities to reduce the risk of ignition by enhancing the sensitivity of their protection devices without the reliability costs.

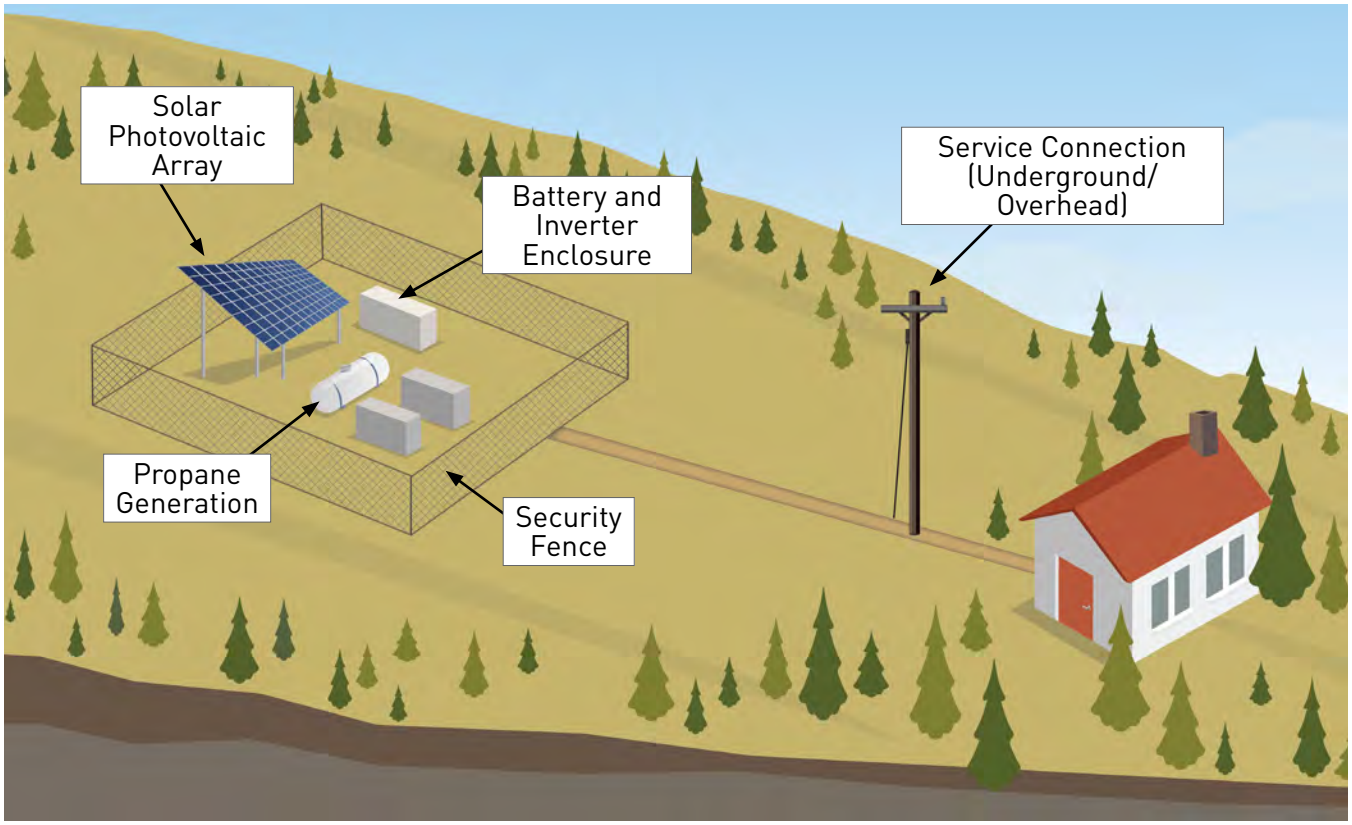
*PG&E is currently using Gridware's Gridscope to provide the capabilities of Active Grid Response.*

# Additional Tools and Technologies to Mitigate Risk

## Remote Grids

We install remote grids to provide power in less-populated, high fire-risk areas, including on eligible private properties. They are also an effective option for "end of the line" customers. These systems offer service separately from the grid. They combine solar, batteries and generators to reduce wildfire risk by removing electric poles and overhead powerlines. They also provide safe and reliable electric service and reduce service gaps during severe weather or outages.

**Remote Grid Example**

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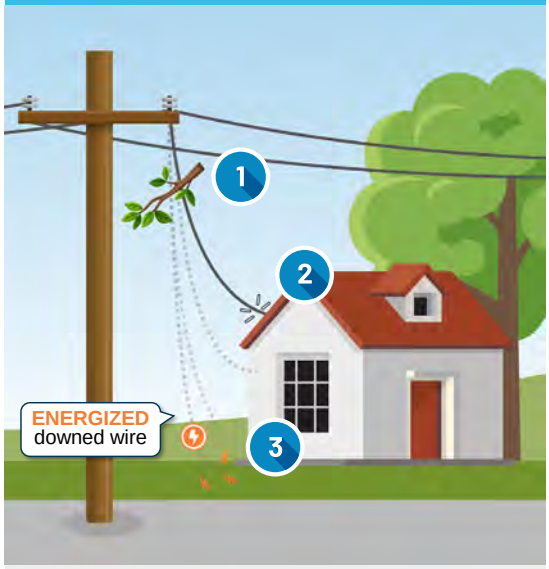
# Service-Level Breakaway Connectors

Service-level mitigations can be difficult as those assets extend beyond our right of way onto private property. In most cases, we do not have access to manage potentially hazardous vegetation. We conducted an analysis on past service-level ignitions and determined that while other ignition drivers continue to decrease, vegetation-related service failures have remained steady in our highest risk areas.

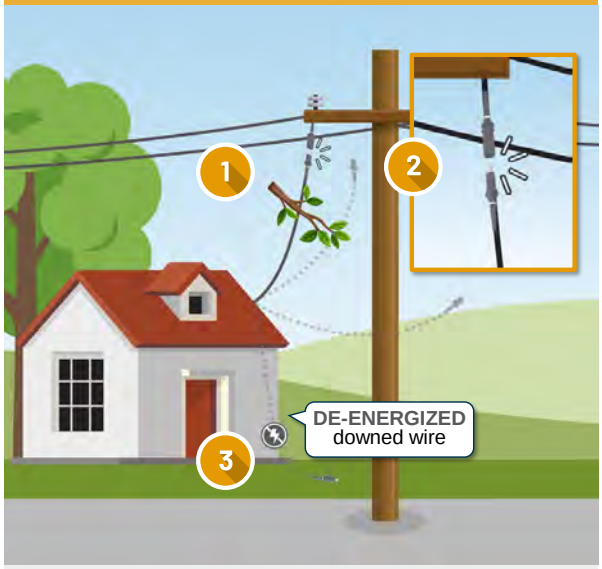
We are now installing service breakaway connectors on circuits with the highest risk and those with multiple vegetation incidents. In the event of a fall-in or external stress on a service drop, these connectors safely disconnect from the pole rather than the private property. By quickly disconnecting from the grid, the downed line is no longer energized and will not spark on the ground, preventing a potential ignition.

**Without Breakaway Connectors**




1. Vegetation strikes the service drop
2. Service drop severs from building and remains energized
3. Energized service drop creates ignition risk

**With Breakaway Connectors**




1. Vegetation strikes the service drop
2. Breakaway connector safely disconnects from pole on impact
3. Service drop is no longer energized and cannot cause an ignition

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## Off-Season Line De-Energization Strategies

While we conduct transmission line removal on qualifying idle facilities, there are other operating facilities that at different times throughout the year may not be required to serve our customers in the moment. These periods are predictable according to our understanding of electricity usage throughout our service area at different points throughout the year. Currently, we work to re-route service through lower (non-HFTD/non-HFRA) transmission lines where possible to service our communities. We are now exploring strategies to temporarily de-energize higher risk transmission lines during low demand seasons to further reduce ignition risk associated with this equipment.

## Shunt Splices Strategies

Conductor splices represent a potential single point of failure on our transmission assets. If a splice were to fail, it could lead to an energized downed conductor and potentially cause an ignition. When a shunt splice is installed directly over an existing splice, it eliminates the splice as an single point of failure and can prevent damaged lines from falling to ground. We prioritize this work according to the risk associated with various splice types and our wildfire consequence models.

## Reconductoring Strategies

When our conductor segments are at higher risk, they need replacement. When we find that our supporting structures are in good condition and that there is no additional electrical capacity need on a given line, we simply replace the conductor segment to reduce risk. This work is prioritized on lines that traverse HFTD/HFRA.

## Line Updating and Rebuild

Unlike reconductoring, we address high risk conductors segments through line upgrades and rebuilds when our supporting structures require repairs or when our new infrastructure must support additional capacity.

## Substation Upgrades

We pursue multiple strategies to mitigate against fire risk at our substations. Some strategies are shared with other assets, like pole clearing and vegetation management to reduce vegetation-related ignitions. Similarly, we conduct rigorous inspections on foot, with aerial technologies and LiDAR to catch potential points of failure at substations. Moving forward, remote monitoring technologies will continue to play a larger role in protecting our substations to ensure constant visibility.

Given their size, our hardening strategy around substations relies on creating and maintaining defensible space. These are evaluated according to three concentric bands based on the same CAL FIRE guidelines used for homes. To learn more, visit **readyforwildfire.org/prepare-for-wildfire/defensible-space/**.

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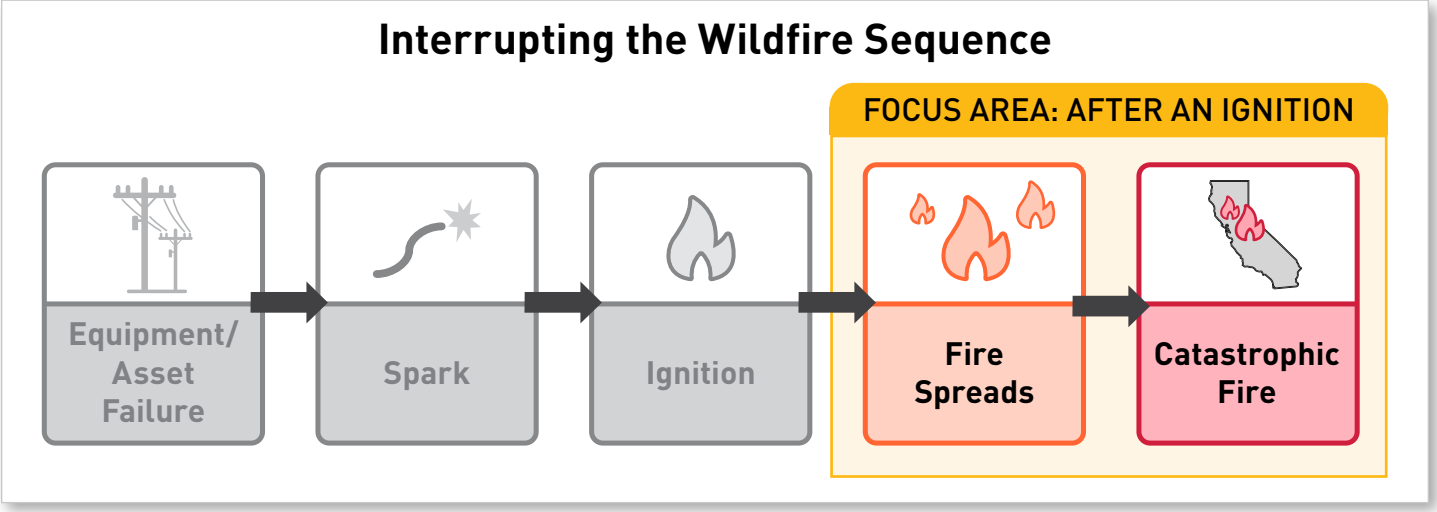
# 06 After an Ignition: Mitigations to Contain an Ignition

When an ignition does take place, urgent and effective response and coordination can help prevent it from becoming a catastrophic wildfire.




## Artificial Intelligence, Satellite Imagery and Our Hazard Awareness and Warning Center (HAWC)

Through our implementation of AI in high-definition cameras and our HAWC, we can alert our teams and authorities immediately following an ignition and support suppression resources to interrupt the wildfire sequence.

### AI-Enabled Cameras

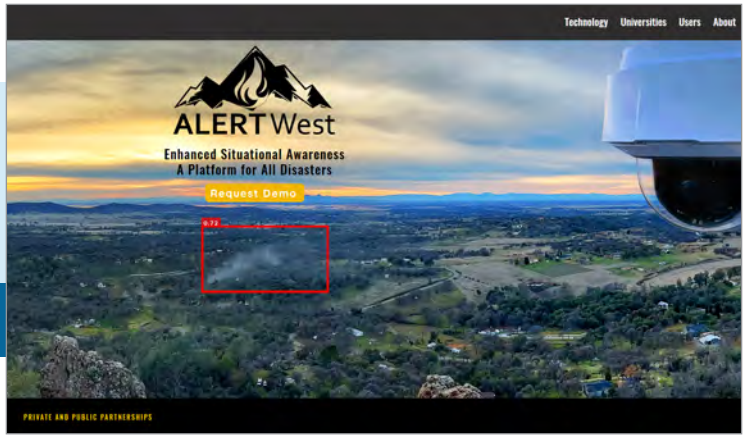
To improve our situational awareness, we sponsor high-definition cameras in partnership with the ALERTWest network to monitor our service area and track wildfires. We have sponsored more than 600 installations, and the information we gather from these cameras is available to the public at **alertwest.org**.

*Some of the measures included in this document are contemplated as additional precautionary measures intended to further reduce the risk of wildfires.*

All cameras in the ALERTWest network use AI to detect fires and share information with CAL FIRE Dispatch Centers and the HAWC. This helps CAL FIRE and PG&E quickly identify ignitions and mobilize suppression resources within minutes. This AI capability significantly outperforms prior ignition response strategies and has led to speedier containment of significant wildfires. In 2023, ALERTWest AI-enabled cameras detected 61% of California wildfires at least 18 minutes faster than IRWIN provided by **wildfire.gov**.

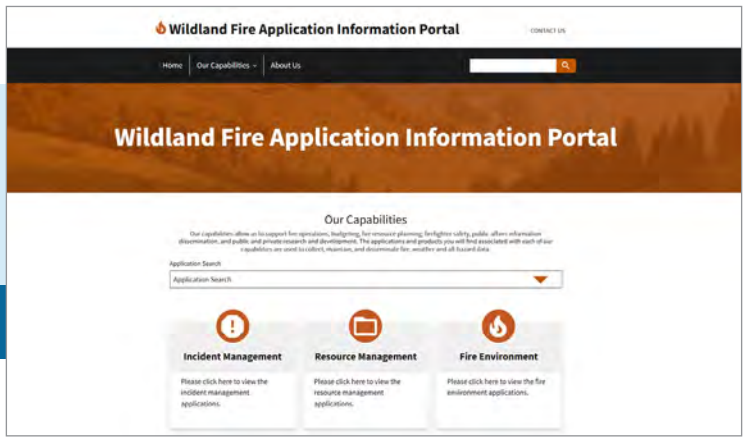
**ALERTWest Network**
High-Definition Cameras

**alertwest.org**




**Wildland Fire Application Information Portal**

**wildfire.gov**




## Satellite Imagery

External satellites also play a key role in ignition spotting and can be a great place to start real-time ignition monitoring. NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) and NASA and NOAA's Visible Infrared Imaging Radiometer Suite (VIIRS) use thermal imagery to monitor fire activity. The University of Wisconsin-Madison's Space Science and Engineering Center (SSEC) has developed an approach to capture and interpret data from these satellites and disseminate active fire data within seconds to partners. Visit **ssec.wisc.edu/** to learn more.

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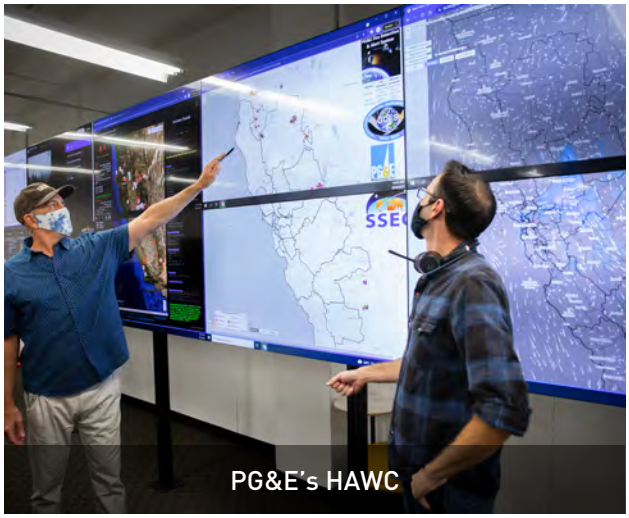
# HAWC

We founded our Wildfire Safety Operations Center (WSOC) in 2018 to monitor wildfire risk and to coordinate prevention and response efforts across our service area. In 2022, we launched our HAWC to fully realize our goal of a central source of reliable, real-time situational awareness not just for wildfire, but all emergencies or disasters that may occur in our service area. Our HAWC is staffed with experts in meteorology and fire science, meteorology operations and systems and analytics.

Inputs from all situational awareness, meteorology, risk modeling and real-time monitoring mitigations feed directly into the HAWC to allow for quick decision making and information sharing across our organization and with partners. This means information from satellites, our cameras, weather stations, asset sensors and monitoring equipment is all processed and decided upon at a central location.

PG&E's HAWC



PG&E's HAWC

# Safety and Infrastructure Protection Teams (SIPT)

Our SIPT is an important part of interrupting the wildfire sequence. These teams provide resources to prepare for and respond to emergencies.

Our SIPT professionals' primary responsibilities are to safeguard our coworkers, prevent ignitions and protect PG&E's infrastructure during an active wildfire. Our 48 crews are stationed throughout our service area at strategic locations in high fire-risk areas. They perform routine fire mitigation work and emergency response to fires that threaten our infrastructure. They also support local agencies with public safety needs and maintain access and evacuation routes.

Keeping communities safe requires year-round work and quick action during emergencies. To ensure their safety and effectiveness, all SIPT crew members conduct extensive safety training, including EMT certification. All field workers have previously worked for fire and other agencies. Each two to three member team is equipped with a fire engine, carrying firefighting tools like water, fire retardant, hand and power tools, and medical gear.

**Our SIPT Team in Action**






*Some of the measures included in this document are contemplated as additional precautionary measures intended to further reduce the risk of wildfires.*

## SIPT routine wildfire mitigations include:

- Fuel hazard reduction in PG&E's right of way
- Defensible space inspections and fuel hazard assessments at our facilities
- Fuel-moisture sampling
- Switching standby in HFRA
- Fire protection/medical response standby for our employees at high-risk work sites
- Maintaining ingress-egress routes

## SIPT emergency work activities include:

- Pre-treating poles with long-term fire retardant during wildfires*
- Fire protection at our facilities and critical infrastructure*
- Mop up of our fire-damaged assets*
- Vegetation management fire support during wildfire recovery
- PSPS support
- Outage response/911 standby/storm response

*Subject to approval by the Authority Having Jurisdiction (AHJ)

Our SIPT crews play a vital protection role before, during and after a fire. When fires do occur, they improve public safety, protect our infrastructure and decrease power recovery times. Ultimately, their work reduces risk for first responders, helps minimize the impact of an ignition and supports community recovery.

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# Rapid Response Capabilities

When wildfires threaten communities, various suppression resources work in concert to reduce consequences and protect people and property. In some instances, aircraft may be used to drop water and retardant to control the spread and supplement work by firefighters on the ground. At PG&E, we maintain and deploy our own fleet of heavy-lift helicopters to support fire suppression efforts in our service area. Rapid response plays a vital role in preventing ongoing fires from becoming catastrophic. As a wildfire spreads, water and retardant drops help slow progression and mitigate consequences.

## Air Attack

In 2022, we installed an internal tank system in our single existing heavy-lift helicopter to carry up to 1,000 gallons of water or retardant. Based on fire risk, this first helicopter was stationed in Marin County during the 2023 fire season to support quick suppression before an ignition produces consequences.

In 2024, we expanded our Air Attack program by partnering with Butte, Merced and Contra Costa Counties to station three additional helicopters. These areas, like Marin, represent higher ignition and consequence risk areas in our system. Beyond suppressing fires locally, we deploy our aircraft to large-scale firefighting efforts, like the Park Fire in 2024 and the Los Angeles fires in January 2025.

As part of our partnership with local jurisdictions, our air suppression resources are dispatched at the behest of either the local county fire department where the helicopter is stationed and/or CAL FIRE. Through partnership agreements with local fire authorities, we cover the costs of the aircraft and required crew.

**In 2024, our four Blackhawk helicopters:**

Engaged in
**22 wildfires**

Conducted
**2,000+ water drops**
representing
**1.7M gallons**
of fire-suppressing capacity

*Some of the measures included in this document are contemplated as additional precautionary measures intended to further reduce the risk of wildfires.*

# Community Resiliency Partnerships

We continue to identify new and innovative solutions to prevent catastrophic wildfires, including how we can grow community safety beyond our wildfire mitigation efforts. Our community resiliency pilots involve working with high fire-risk communities to provide funding and solutions to improve preparedness.

Over the last 10 years, we provided more than $25 million in grant funding to support wildfire safety efforts across our service area. By contributing to previously planned work or partially-grant-funded projects, we maximize our impact per dollar spent. We continuously monitor upcoming county-, state- and federally-funded local projects throughout our service area to determine whether they align with our goals and risk models.

## Types of Partnerships

Projects vary by geography, community needs and grant-funding availability across our service area. Below is a sampling of the types of projects we have supported through our community resiliency partnerships.

### A. Fire Fighting Resources

It is important that high-risk communities have access to the fire professionals, equipment and organizational support needed to combat increasing wildfire risk. Through these partnerships, we provide funding to support additional staff and improve local fire suppression capabilities. We strive to seed initial local improvements and provide our expertise to help communities source permanent funding.

Recently, we provided a $500,000 grant to the Clear Lake Environmental Research Center (CLERC), equivalent to a ~50% staffing increase for one year. In addition to direct suppression resources, these funds will help support new tools and fire safety awareness campaigns, integrate risk modeling to provide better information to local insurers and support grant writing operations in an effort to multiply our impact.

Hogback Ridge Crew in Lake County

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## B. Community Fuel Breaks

We partner with communities across our service area to support local fuel break projects. This work plays a significant role in slowing and/or stopping a fire from crossing a wildland-urban interface, where it's more likely to harm community safety and private property. Conducted in partnership with local Fire Protection Districts, our support extends beyond funding, as we often supplement ongoing work with advanced mapping, analytic tools and risk modeling to improve efficiency and effectiveness.

## C. Roadside Brushing

During a wildfire, roadways and other public infrastructure often serve as natural firebreaks to slow progression. By clearing or "brushing" vegetation on either side of a roadway in partnership with local communities, we can effectively expand that natural fuel break up to 300% of the road width. As roadways' environmental impact have already been analyzed and approved, work approval is often streamlined and provides the most benefit for the lowest spend. Brushing a roadway ensures that only surface risk is addressed, while trees and other natural shade coverage are preserved to maintain fuel moisture and topographical stability.

In many communities, roads where we conduct brushing may be the only ingress/egress route during a wildfire. This work provides the added benefit of shoring up roadways from fire impacts in key evacuation areas.

## D. Wood Management Practices

Many communities with high fire-risk conduct forest thinning and defensible space work to reduce potential fire intensity. For smaller communities, removing managed biomass can be an expensive and inefficient process. We are piloting partnerships with many communities to assist with wood removal by utilizing existing vegetation crews in the area and economies of scale.

We are also piloting creative solutions to use the additional wood. This includes turning scrap wood into valuable biochar by decomposing natural material in low oxygen conditions. Biochar has a variety of applications, both as a solid or liquid biofuel or as a carbon store to reduce greenhouse gases emitted into our atmosphere.

## E. Dip Tanks

Rapid response aircraft play a vital role in reducing the consequences associated with wildfire. Their effectiveness is contingent on access to bodies of water that a fixed-wing aircraft or helicopter can use to replenish water stores before returning to the fire to drop. During a fire, the distance between drop and refill sites can dramatically alter how much water can be air dropped.

We are piloting the use dip tanks that allow fire suppression aircraft to resupply with water and/or retardant closer to a potential wildfire. For communities in isolated areas without access to large bodies of water, dip tanks reduce the time between drops during an ongoing wildfire, ultimately allowing more time spent dropping suppressant. Tanks can be made in multiple different sizes, specifications and locations according to local community needs and our risk assessments.

## F. Partnership Outcomes

Our resilience partnerships pilots provided learnings and achieved performance goals. This approach appears to be cost-effective, replicable, and scalable.

### Wave 1 Resilience Partnership Project Outcomes

**A Hometown Wildfire Safety Collaborative**

- Fire and fuel crew expanded and stabilized.
- Four quality fuels treatment projects completed so far.
- Carbonizer partnership reduced VM wood costs.

**B Safer Evacuation Routes**

- Treated three linear miles along key evacuation route with overhead distribution.

**C Collaborative Grant for Fuels Treatment**

- $300K PG&E match helped attract $6M for bigger project.

**D Catalyzing Resilience Through a Forest Resilience Bond**

- Financing used for 1,355 acres of treatment so far.
- Protects Hydro assets, water, reduces consequence.

**E Forest Health Restoration on Private Lands**

- Treated 20 acres to protect high risk school.
- Completed novel biomass pilots.
- Balance of funding now being used for big grant applications which would create a 4:1 match.


### Key Learnings

- Feasible – 100% projects either completed or on track.
- We can catalyze and help direct third-party funding and treatments.
- Our model appears scalable, replicable, extensible.

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# Partners in Community Resilience

## A. Vibrant Planet

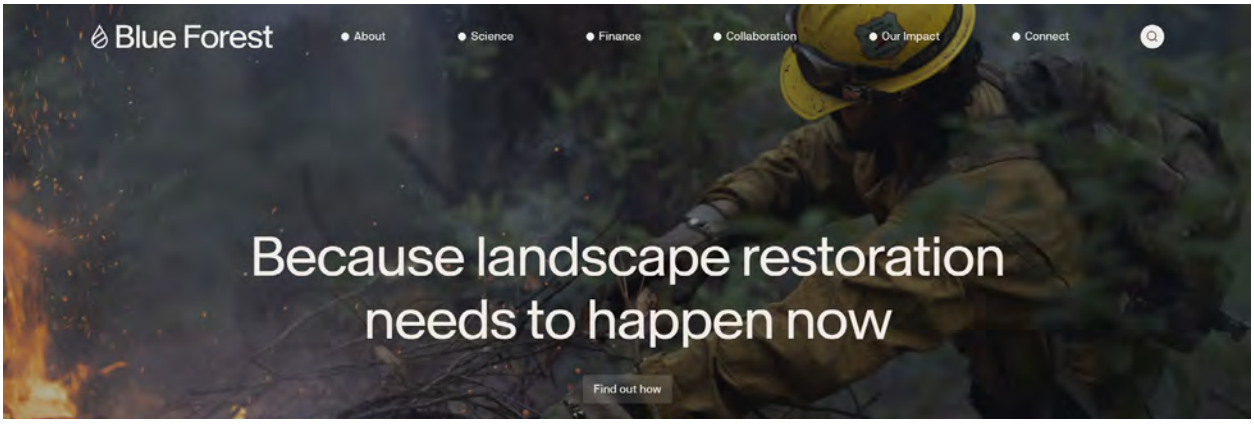
As our community resiliency partnerships have grown, we piloted Vibrant Planet's cross-stakeholder data, analytics and decision-making platform for wildfire mitigation through land management. Their analysis helps us ensure that our investment in community-led projects reduces wildfire consequences. Learn more by visiting **vibrantplanet.net**.

## B. Blue Forest

Blue Forest is a nonprofit conservation finance organization that sources flexible capital to accelerate large-scale land management. Through their forest resilience bonds, they partner with local stakeholders to evaluate prospective projects and source private funding for forest restoration work and to cover upfront costs.

We co-invested in one such bond on the Upper Mokelumne watershed, helping to defend nearby communities from fire, in addition to protecting our hydroelectric power generation assets. More recently, we invested in another financing pool in the Plumas National Forest to support a project that will directly protect local communities while reducing wildfire risk.

By partnering with communities, building on each other's mitigation work and collaborating on mitigation strategies, we can build fire resiliency corridors where wildfire risk is greatly reduced. Together we can make our communities safe from wildfires and a changing climate. For more information, visit **blueforest.org**.

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# Ignition Trends, Investigation and Analysis

When ignitions occur, preventing a wildfire is always our first priority. Once the ignition has been safely addressed, we deploy our ignitions investigation team to gather information about the incident, which helps inform improvements to our mitigations or determine if we need an additional mitigation measure.

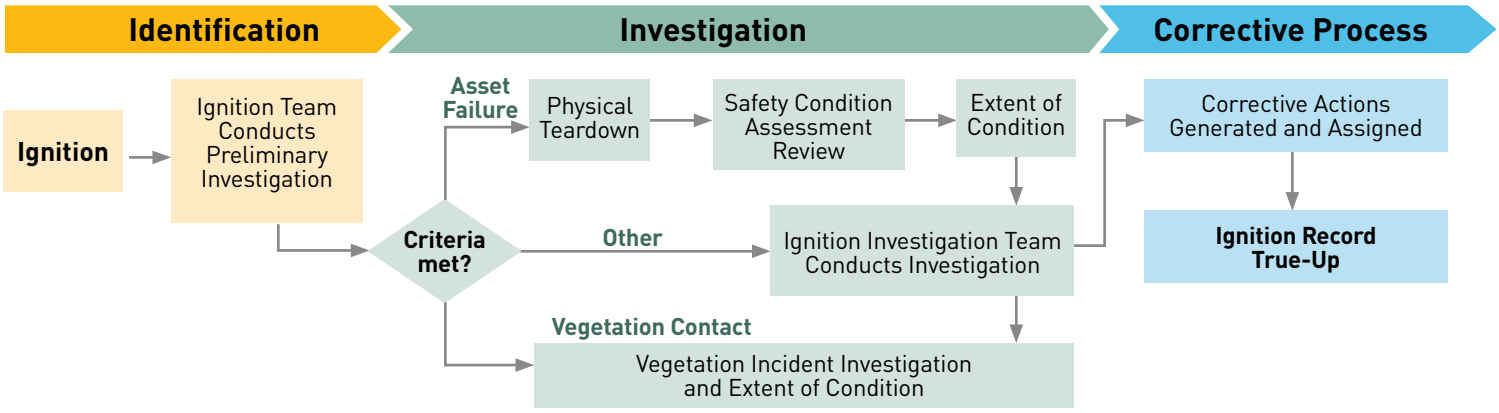
## Processes

Through investigations and analysis, we created a detailed cross-functional ignition review process. This work begins with our forensic analysis approach to determine the reason for ignition, from our system and from environmental factors.

**Investigations allow us to:**

- Analyze on-scene materials to better identify causes of equipment failures
- Leverage relevant PG&E data sources to inform wildfire safety priorities
- Have experts identify future risks based on learnings
- Share findings, gaps in mitigation strategies and inform next steps cross-functionally
- Leverage advanced technology for data collection and analysis to explore developing trends and generate better corrective actions
- Benchmark against ignition investigations organizations

Once ignition causes are determined, we analyze the event to identify corrective actions both at the ignition location and across our system broadly.

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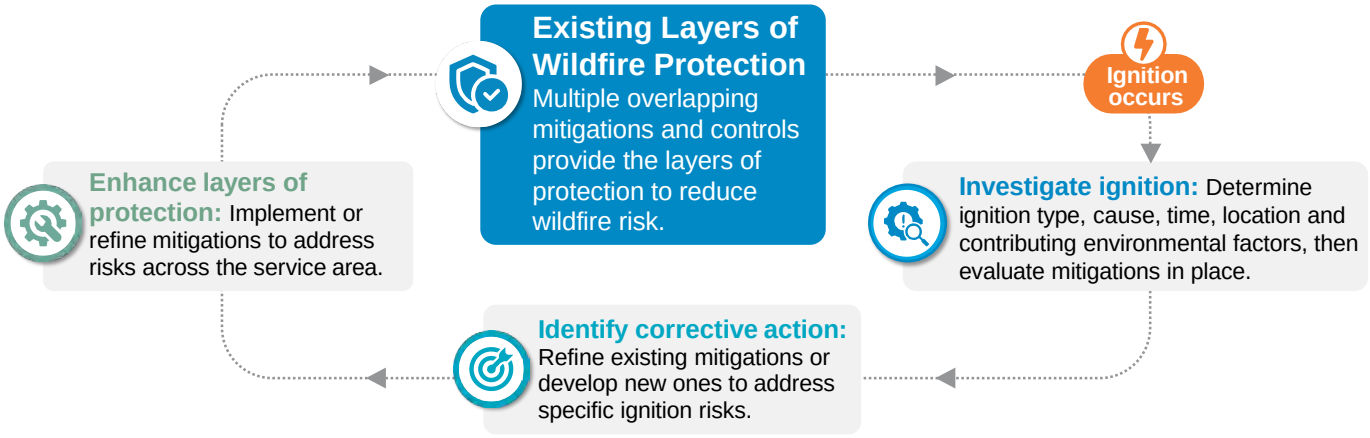
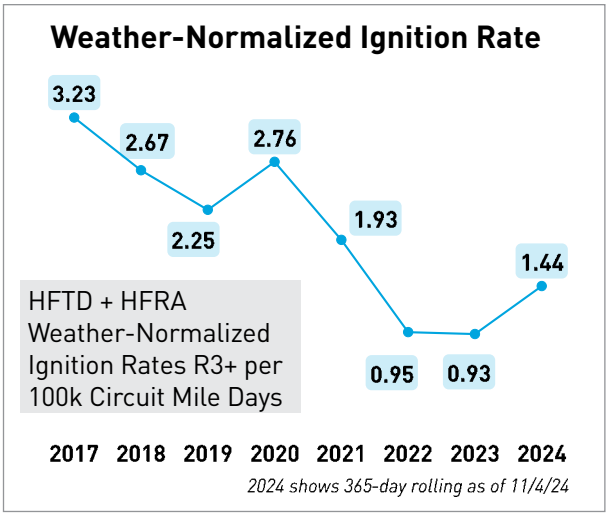
# Benefits of Ignitions Investigations

Our work planning risk model relies on ignition tracking to help us make decisions about what to prioritize and where to invest fire mitigation resources. By collecting, analyzing and interpreting ignition data, we create a feedback loop to continuously improve our layers of wildfire protection.




Through our analysis, we can track ignitions against standardized weather conditions to determine gaps in our mitigation. These insights are particularly beneficial as weather conditions fluctuate. This way, we can ensure that our mitigations are effectively targeting our riskiest conditions. For example, certain equipment failures may be less likely to occur on non-windy or lower temperature days. Seeing a decrease in annual ignitions during an inordinately cool and calm summer might lead us to overlook gaps in wildfire mitigation without an effective weather-normalized metric.

We also track and account for ignitions beyond those that are reportable to our regulators. Non-reportable ignitions include small fires and prevented and predicted fires. By monitoring all incidents, we cultivate a better understanding of where fires could potentially start and can act accordingly. These insights feed directly into our work planning models.




As we track all equipment failures, we also note cases where our operational mitigations prevented a potential ignition, such as ignitions prevented by PSPS or EPSS. This provides valuable insight into where risk exists in our system and where additional improvement is needed.

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# 07 Determining Mitigation Effectiveness and Developing Wildfire Mitigation Plans and Structure

We continually review the effectiveness of our wildfire mitigations through calculations and analysis to understand our overall risk profile. These calculations create a structure for risk mitigation, and they also play a vital role in helping us communicate our wildfire mitigation goals and strategies externally.

## Risk Assessment and Mitigation Phase (RAMP) Calculations

The RAMP filing is a report that identifies our top safety risks and proposed mitigation programs. The RAMP is part of a joint effort with the Commission and Safety Policy Division and other investor-owned utilities and stakeholders to enhance risk-informed decision making. This filing is part of General Rate Case (GRC) proceedings and can be found on the CPUC's website: **www.cpuc.ca.gov**.

This filing involves assessing ignition and risk consequences together to determine mitigation effectiveness and analyze associated costs. To quantify our wildfire risk in dollars, we use our risk scaling function.

**At its most basic, the function states:**

$$\text{Risk (in USD)} = \text{Likelihood of the Risk Event (LoRE)} \times \text{Cost of the Risk Event (CoRE)}$$

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**RAMP calculations capture both damage due to wildfire and other costs associated with operations. They yield three important insights:**

1. Our changing climate is expected to continue raising baseline risk for all electric utilities across the planet. Each year, meteorological predictions indicate that even if mitigations and their effectiveness remained the same, baseline risk would continue to increase.
2. Our operational mitigations (PSPS and EPSS) reduce a significant amount of our baseline risk, but not without impacting reliability. As weather becomes more severe, PSPS and EPSS would need to be implemented more often to maintain the same risk reduction benefit, leading to growing reliability costs.
3. We anticipate that our ongoing grid resiliency mitigation work between 2023 and 2027 will be robust enough to more than counteract the increase in risk from climate change during that period. Unlike operational mitigations, grid resiliency work does not introduce additional reliability-related costs. This highlights that resiliency work is key to addressing evolving wildfire risk and our changing climate in the long term.

## Calculating Ignition Risk

We calculate the effectiveness of our mitigations by analyzing all failures (ignition drivers), the frequency of those failures producing risk losses and the scale of those risk losses in dollars, as provided by our RAMP calculations.

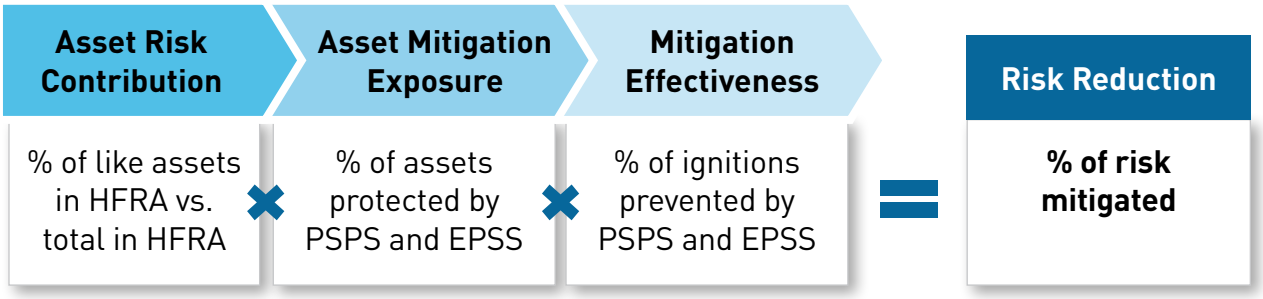
First, we determine the ignition risk contribution across all assets protected by a given mitigation, in this case, PSPS and EPSS. This contributes to the likelihood of failures across each asset type, weighted by frequency. We then determine mitigation exposure by analyzing which assets are covered by a given mitigation.

**Asset Wildfire Risk Contribution and Protection by PSPS and EPSS**

| Asset Class | Risk % Contribution | % Exposure Enabled: EPSS | % Exposure Enabled: PSPS |
|---|---|---|---|
| HFRA - Dx Service | 766 (3.9%) | 0% | 100% |
| HFRA - Dx Secondary | 686 (3.5%) | 0% | 100% |
| HFRA - Dx Primary | 14,854 (75.7%) | 100% | 100% |
| HFRA - Tx 60/70kV | 1,277 (6.5%) | 0.42% | 100% |
| HFRA - Tx 115V | 1,062 (5.4%) | 0.00% | 100% |
| HFRA - Tx 230/500kV | 276 (1.4%) | 26.89% | 100% |

## Calculating Ignition Risk Reduction

Using our risk models, we determine how often a mitigation captures a potential ignition from our assets. This effectiveness metric, when combined with asset risk contribution and mitigation exposure provides a percentage reduction in ignition risk.




## Risk vs. Exposure

We are also focusing on reducing risk exposure by targeting consequence. As we have shown through our wildfire sequence, we have identified that reducing reaction time to ignitions can play a crucial role in reducing the chance of a given ignition becoming catastrophic. Continuous monitoring and other remote sensing technologies can also greatly reduce our risk profile by identifying ignitions early and deploying suppression efforts before a larger fire occurs.

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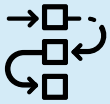
# Wildfire Mitigation Plan (WMP) and Maturity Modeling

Our WMP provides a detailed narrative of ongoing efforts to prevent catastrophic wildfires. Adhering to a WMP strategy lays the groundwork for effective wildfire mitigation. Through advanced modeling, we can also assess the effectiveness and maturity of our mitigations.

## WMP

Our WMP outlines and establishes both qualitative and quantitative commitments for programs related to wildfire safety. We and other investor-owned utilities in California are required to develop a WMP by the state. However, it may be a valuable voluntary step for other utilities to provide a detailed narrative for tracking and monitoring ongoing efforts to prevent catastrophic wildfires. Since implementing our WMP, we have seen improvements in risk reduction year over year. Our WMP outlines a plan for the next three years and is updated for the second and third year of each three-year period.



**The WMP is one component of a three-part filing:**

### 1 WMP

Details our initiatives to mitigate wildfire risks.

### 2 Maturity Survey

Collects insights through survey questions to evaluate the utility's current and future state maturity.

### 3 Data and Financials

Requires submission of extensive data, particularly risk and GIS information.

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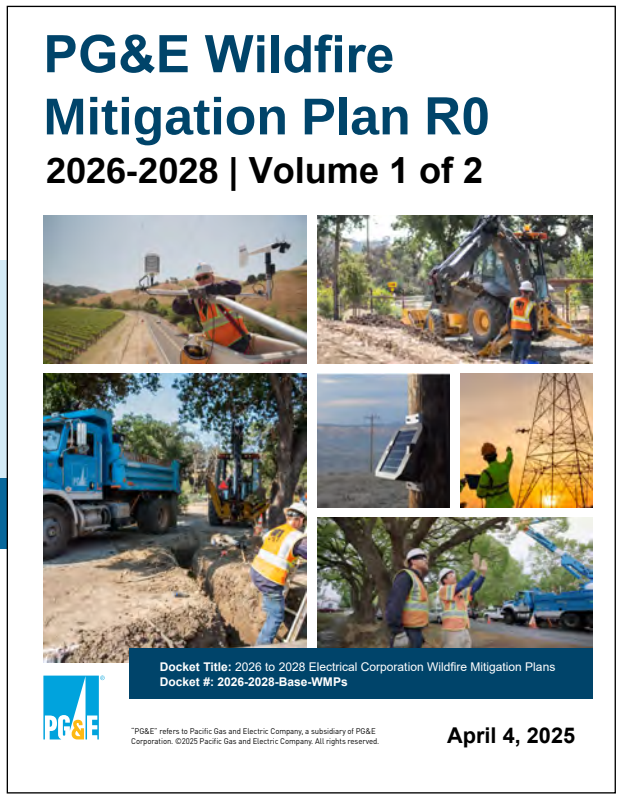
To bring oversight to important wildfire decisions within the WMP, we established a Wildfire Risk Governance Steering Committee. This group helps drive decisions that prevent catastrophic wildfires, mitigate wildfire risk and reduce customer impact. The Committee is made up of one chairperson and eight voting members with 12 additional advisors and alternates. Together, this body deliberates and determines strategy on work planning, risk modeling changes, corrective actions and other priorities while ensuring that decisions align with financial and regulatory requirements.

**Development of our WMP typically takes 10 months. Our drafting process follows four broad steps:**

1. Determining our wildfire risks and locations.
2. Identifying mitigations to address risks.
3. Developing a plan, goals and performance metrics.
4. Implementing our commitments.

Our current and past WMPs can be found on our website:

**pge.com/cwsp**

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# Maturity Modeling

## A. Wildfire Maturity Model

California's Office of Energy Infrastructure Safety (OEIS) has developed methodologies to assess wildfire risk reduction capabilities and examine the relative maturity of a utility's mitigation program. Their assessment is one of the tools we use to drive continuous improvement in wildfire mitigation over time.

## B. International Wildfire Risk Mitigation Consortium (IWRMC) Model

Over the last several years, we have participated in and partnered with IWRMC through meetings, conferences and information sharing regarding wildfire mitigation initiatives. In partnership, we developed an IWRMC model to better understand the current state of the global utility industry in relation to evolving wildfire risk, and to assist utilities in building their own roadmap for continuous improvement and prudent risk-mitigation investments.

# Wildfire Annex

Our Wildfire Annex includes actions and strategies to prepare for, mitigate against, respond to and recover from wildfire incidents that may impact PG&E equipment and facilities. This Annex outlines our operational coordination and communication plans, both internal and external and can include various support teams such as our Public Safety Specialist (PSS), Critical Infrastructure Leads (CIL) and SIPT. Additionally, the Annex references other technical and operational plans that demonstrate how we implement certain actions and strategies. As part of our Company Emergency Response Plan (CERP), we develop supplementary annexes by emergency type.

**The Wildfire Annex is reviewed annually, and incorporates:**

- Lessons learned from internal and external exercises and actual incidents.
- Changes to existing policies, procedures or programs.
- Feedback from PG&E subject matter experts, planning teams, internal and external key stakeholders, and users of this Annex.
- Changes to laws or regulations.

## Responding to Emergency Fire

### A. Emergency Criteria

When an emergency occurs, we activate our EOC to quickly respond.

**In the event of an ignition or wildfire, we immediately engage with the Authority Having Jurisdiction (AHJ) to align on needs such as:**

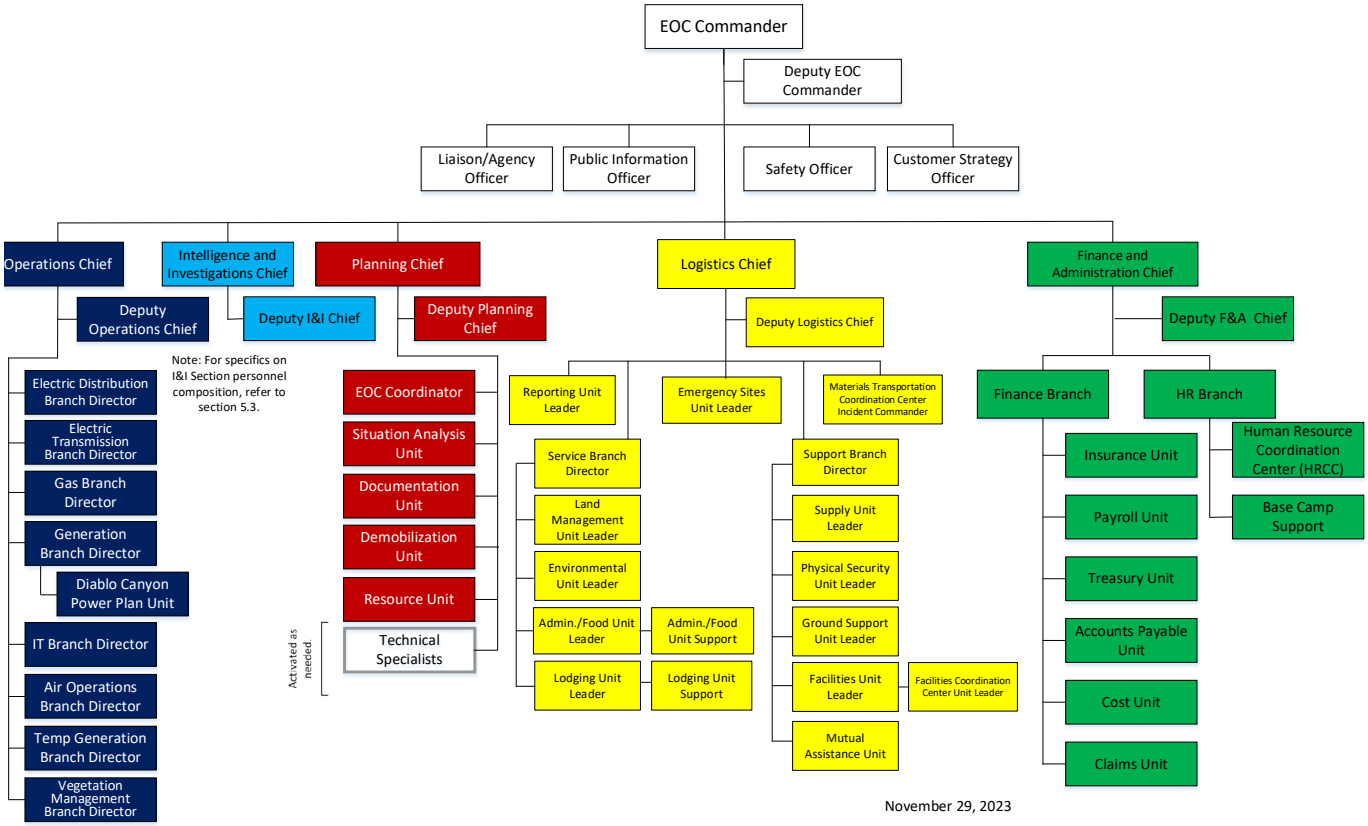
- De-energizing electric facilities.
- If gas assets are involved, assessing high-risk facilities.
- Gaining situational awareness of assets that are impacted or at risk.
- Clearing roadways impeded by assets.
- Identifying critical customers affected.

## Incident Classification System

| Level | Type | Description |
|---|---|---|
| **5** | **Catastrophic** | • Large area of the service territory affected, or multiple wildfires<br>• Affects many customers and business operations<br>• Extended multiple emergencies<br>• Significant cost and infrastructure risk/damage<br>• Full mobilization of resources |
| **4** | **Severe** | • Resources from multiple regions are needed to fight the wildfire<br>• Affects many customers<br>• Extended multiple incidents<br>• Resources may be shared between regions, including contractors and mutual aid |
| **3** | **Serious** | • An extended attack has been initiated by firefighting resources<br>• Involves large number of customers<br>• Resources may need to move between regions |
| **2** | **Elevated** | • A wildfire (of even minimal size)<br>• Requires more than routine operations<br>• Resources may be required to move within the region |
| **1** | **Routine** | • Fire is contained to a small area, such as a structure fire<br>• Involves a relatively small number of customers<br>• Local resources are sufficient to manage operations |

## B. Organizational Structure In-Event

### When activated, our EOC regularly follows the below sample organizational structure:



# 08 Strategic Communication and Engagement

Utilities are uniquely affected by our changing climate. Since climate change and evolving wildfire risk can impact electric service, we help provide the education and resources needed to help customers adapt.

## Communications Strategy

### Year-Round Communications

Sustained, proactive communications can help build trust with customers, stakeholders and regulators and create synergy toward shared goals. This means communicating with customers and stakeholders throughout the year about wildfire safety and the critical role that proactively turning off power when safety is at risk plays. It is important to remain clear and transparent about the mechanics and benefits of programs like PSPS and EPSS and explain how a customer could be affected even if they do not live in an HFRA or are not expecting elevated weather conditions in their area.

Customers, business owners and critical stakeholders are provided outage resources before wildfire season through proactive outreach materials, which are sent via direct mail, email and other channels throughout the year.

Reaching this wide variety of stakeholders requires a multi-touch, multi-tactic approach that spans different channels. From social media, emails and direct mailers to webinars, paid advertising and media engagement, we communicate wildfire preparedness information year-round to consistently be top of mind with customers. Since customers have their own communication preferences, a diversified campaign in multiple languages is most effective.

## Tailoring Outreach

Effective communication must be customized for diverse stakeholder groups and tailored to address specific needs and concerns. Tailored communications are fundamental in building trust, facilitating collaborative solutions and achieving mutual goals across varied groups. This starts with identifying all customer and stakeholder groups who may be affected.

**A comprehensive outreach strategy should focus on the following groups:**

- **Customers:** Drafting communications to ensure they are well-informed about their service and any disruptions that might occur during wildfire season. This includes emphasizing specific program functions so customers can prepare for different types of outages. After our outage resources are implemented across the HFRA territory, we also ensure we pre-test our messaging to be most effective and customize our communications to reach communities that primarily speak languages other than English, own businesses, live in high fire-risk areas or have specific health or medical needs.
- **Regulators and Policy Makers:** Active engagement with regulatory bodies at the state and federal level, including the Public Utilities Commission, the State's Office of Emergency Services and the Federal Energy Regulatory Commission (FERC), is essential to address joint priorities and ensure regulatory compliance.
- **Local Governments and Elected Officials:** Keeping local officials informed and establishing partnerships with local emergency managers helps communities be prepared in an emergency. Outreach to district offices of state and federal elected officials is helpful for alignment.
- **Tribes:** Native American tribal governments often have unique fire safety and electric service needs, responsibilities and resources that should be addressed through robust partnership.
- **Critical Customers and Facilities:** These customers (i.e., transmission-level, hospitals, telecommunication providers, water and wastewater facilities, etc.) benefit from specialized communication to manage service disruptions and resiliency plans.

- **Community-Based Organizations and Nonprofits:** Engagement with these groups focuses on emergency preparedness as they can play a key partnership role in customer support.
- **Media:** Media relations are managed to disseminate vital information broadly and define the narrative.
- **Coworkers:** Internal communications keep coworkers informed about company policies so they can effectively communicate the benefits of a wildfire safety program while interacting with customers.

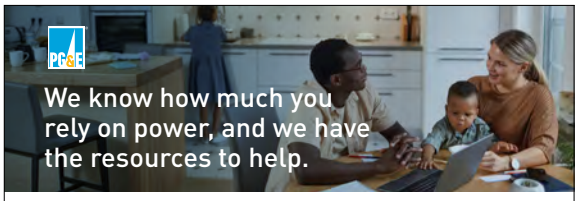
Ongoing engagement campaigns are essential for keeping key stakeholders well informed about initiatives to mitigate wildfire risks. Transparency is key. Communicating the potential impacts these measures can have, even in unexpected weather conditions, can help avoid distrust and surprise.

## Supporting Customers with Access and Functional Needs (AFN)

It is crucial to identify the customers within a service area with AFN or those who rely on power for heath or safety within our service area. These customers can be acutely impacted by wildfire safety outages and benefit from preparedness resources. It is important to customize communications for customers with AFN, particularly those with electric dependent medical needs, ensuring they are fully informed about available programs and the additional support resources they may receive.

We use various AFN outreach campaigns, including multi-cultural paid media. We provide materials in multiple languages, plus Braille and large font. This includes outreach to Community Based Organizations to provide essential information, email and direct mail campaigns and fact sheets. We are consistent in our outreach to build trust, and always lead with resources available to them, including specific campaigns to enable customers to self-identify for resources so that we can better communicate with relevant information.

# Customer Resources Fact Sheet




We work to always keep your power on, but safety outages can still happen. In case of an outage or financial hardship, support is available for you and your family.

### Backup power options

- **Generator and Battery Rebate Program:** You may be eligible for a rebate on the purchase of a qualifying generator or battery.
- **Portable Battery Program:** If you rely on medical devices, assistive technology or durable medical equipment, you may qualify for a portable backup battery.

SCAN HERE

### Local assistance through the California 211 Providers Network

The **California 211 Providers Network** is a free, confidential service that's available in more than 150 languages and can help you:

- ✓ Create a plan for power outages and emergencies
- ✓ Get support during an outage or emergency
- ✓ Sign up for bill assistance programs

For support, dial **211**, text 'Prepare' to **211-211** or visit **211.org**.

**Make sure we can notify you in the event of an outage.**

Update your contact information at **pge.com/alerts**.

### Bill discount programs

**California Alternative Rates for Energy (CARE)** and **Family Electric Rate Assistance (FERA)** are programs that provide eligible customers with a discount on their electric or gas bill. Visit **pge.com/care**.

### Support for those with medical needs

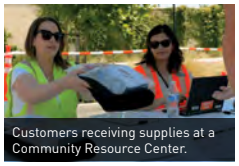
If you rely on power for certain medical needs, you may be eligible for PG&E's **Medical Baseline Program**. Apply at **pge.com/medicalbaseline**.

If you do not qualify for the Medical Baseline Program, you may sign up for our **Self-Identified Vulnerable Program**. Visit **pge.com/vcstatus**.

### Community Resource Centers

To keep you safe and prevent wildfires, we may need to turn off power during severe weather. This is called a **Public Safety Power Shutoff (PSPS)**. During a PSPS, Community Resource Centers provide:

- ✓ Power to charge your devices
- ✓ ADA-accessible restrooms
- ✓ Water, snacks, Wi-Fi and other supplies



Customers receiving supplies at a Community Resource Center.

### Food banks

Before and after a PSPS, food replacement is available through participating food banks.

SCAN HERE

More information on the above resources can be found at **pge.com/afn**.

### Disability Disaster Access & Resources (DDAR) Program

If you have an electrical medical device or assistive technology, have a disability or chronic condition, or rely on electricity to live independently, the DDAR Program may help you:

- Create an emergency plan
- Sign up for Medical Baseline
- Apply for backup power
- Find ADA-accessible rides and hotel stays

To learn more, visit **pge.com/ddar**.

For translation support in 240+ languages, or to request a print material in Braille, large print or audio, call **1-800-743-5000**.



# AFN Self-Identify Email

**2025 AFN Self Identified Email**
Subject line: Do you rely on power for your health and safety?
Preheader: Take the survey to self-identify for additional support


**We know how important reliable power is, especially when your health and safety depend on it.** This is why we are working to identify customers who rely on power for needs — including any independent living needs. Please respond to the survey using the link below.

**Take the survey »**

Your response is important. Please complete the survey by **[insert date here]** to self-identify.

Your response will help us provide relevant information and resources based on your or a member of your household's specific needs.

You may have received a letter from us with this survey. If you already responded, thank you; you do not need to complete the survey a second time.

Our goal is to provide you with the information and resources you need to stay safe. To learn more about resources available to minimize the impacts of wildfire safety outages visit pge.com/pspsresources.

For translation support in 240+ languages, or to request a print material in Braille, large print or audio, call **1-800-743-5000**.

# AFN Self-Identify Letter

**Important Message: You may qualify for additional resources to help support you and your family. Please complete and return the form to self-identify.**

[DATE]

«CUSTOMER_NAME: «FIRST_NAME>> AND <<LAST_NAME>>»
«BILLING_ADDRESS1»
«BILLING_ADDRESS2»
«BILLING_CITY»«BILLING_STATE» «BILLING_ZIP» «BILLING_PLUS4»

Dear «CUSTOMER_NAME»:

We know how important reliable power is, especially when your health and safety depends on it. This is why we are working to identify customers who rely on power for needs — including any independent living needs.

Extra support is available to you or anyone in your home who depends on power for their health and safety. These resources include backup power options, transportation during outages, additional notifications during a Public Safety Power Shutoff, backup power options, replacement meals and more.

Our goal is to provide you with the information and resources you need to stay safe. To learn more about our customer safety efforts, visit **pge.com/pspsresources**.

**ACTION REQUIRED**
Please fill out the back of this letter so that we can provide you with relevant resources based on your needs. Once filled out, please send it back in the accompanying pre-paid envelope by **[February XX, 2025]**.

*Please see the reverse for more to complete* ⟶

**1-800-743-5000** for language support in 240+ languages.

☐ Español ☐ русский язык ☐ Hmoob ☐ فارسی
☐ 中文 ☐ ਪੰਜਾਬੀ ☐ ไทย ☐ عربي
☐ tiếng việt ☐ 日本語 ☐ Português ☐ American Sign Language
☐ Tagalog ☐ ភាសាខ្មែរ ☐ हिंदी ☐ Other

☐ By checking this box and signing below, I certify that the information above is accurate.
NAME: _____ DATE: _____ SIGNATURE: _____



*Some of the measures included in this document are contemplated as additional precautionary measures intended to further reduce the risk of wildfires.*



BACK TO TABLE OF CONTENTS >>

## Supporting Every Community

Losing power can be disruptive, so utilities should consider implementing programs that help customers prepare for a wildfire safety outage and access resources. We offer various programs that support customers before, during and after an outage.

**A few of those programs include:**

- **Portable Battery Program:** We provide portable batteries to eligible Medical Baseline and Self-Identified Vulnerable customers who experienced at least one PSPS in 2022 or three or more outages on EPSS-protected circuits since 2024.
- **Generator and Battery Rebate Program:** Rebates are available for customers who either live in a HFTD or are served by powerlines protected by EPSS.
- **Backup Power Transfer Meter Program:** Customers who live in a HFTD or who are served by an EPSS-protected circuit can receive a free Backup Power Transfer Meter.
- **Permanent Battery Storage Rebate:** We offer rebates for eligible customers to install permanent batteries in their homes from a qualified product list.
- **Safety Action Center:** Information and tools are available online to help customers stay safe before, during and after an emergency.
- **The California 211 Providers Network:** We partner with 211 CA to provide preparedness assistance, connect individuals with local resources and provide support before, during and after times of critical need, such as a PSPS.
- **Disability Disaster Access and Resources (DDAR):** We partner with DDAR to provide support before and during a PSPS for eligible customers who may be dependent on electricity.
- **Food Bank/Meals on Wheels Support:** Meal replacement is available to communities impacted by a PSPS. Food banks provide meals during the PSPS outage and up until three days after power restoration. We also partner with Meals on Wheels to deliver additional meals to affected home-bound seniors.

# Establishing Key Partnerships

Establishing key partnerships in the wildfire ecosystem is critical for utility organizations as it enables better management of risk, information sharing and improving collectively through lessons learned. By collaborating with other utilities, local governments, public safety partners, emergency management, environmental organizations and technology providers, utilities can enhance their ability to predict, prevent and respond to wildfires.

## Key Partnerships

### A. Utility Partners

Engaging with other utilities in your state, actively participating in industry forums and collaborating with local communities can build relationships and create a shared understanding. Further, sharing key learnings and data across our industry allows utilities to improve strategy by leveraging the experiences and insights of others.

### B. Academia, Nonprofits and Nongovernmental Organizations (NGOs)

We partner with academic organizations, such as Stanford University, nonprofits and NGOs to leverage new and emerging research and innovative technologies in wildfire detection, monitoring and prevention. By collaborating with these organizations, we gain knowledge that can improve our wildfire efforts. These partnerships are critical to developing new solutions using emerging tools and establishing relationships with future leaders in the wildfire mitigation space.

### C. Suppliers

It is important for utilities to collaborate with suppliers and ensure access to the latest technologies and equipment that safely prevent wildfires. By working together, utilities can stay ahead of regulatory changes and adopt best practices for safety. Utilities can connect with these suppliers through industry events, trade shows and conferences, such as the Red Sky Summit, which we partner with each year. Technologies should be tested and piloted, with the lessons learned enabling long-term effectiveness.

# 09 Conclusion

Climate change and evolving wildfire risk are presenting our industry, and our customers, with a new normal. Addressing this new normal will take all of us, working together. Collaboration, knowledge sharing and communication are key, not just in the utility industry, but across all industries and communities that are facing these challenges.

We hope this guidebook plays a role in raising our collective understanding of how to mitigate wildfire risk and keep the communities we are privileged to serve safe.

**Learn more about wildfire mitigations plans below:**

SCAN HERE

**Pacific Gas and Electric Company's Wildfire Mitigation Plan**

SCAN HERE

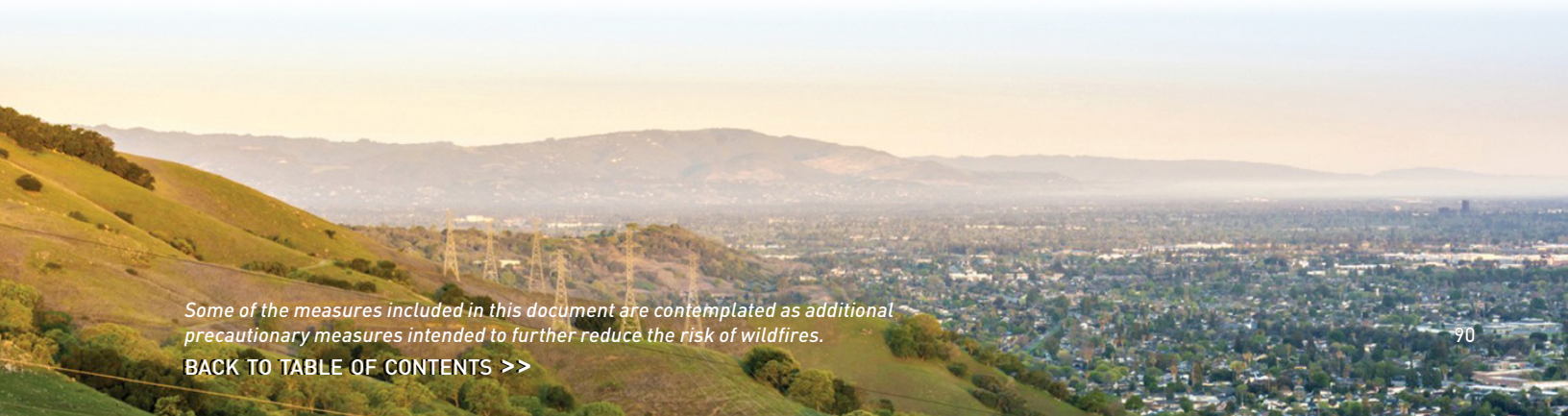
**San Diego Gas and Electric's Wildfire Mitigation Plan**

SCAN HERE

**Southern California Edison's Wildfire Mitigation Plan**

SCAN HERE

**Various Wildfire Mitigation Plans**



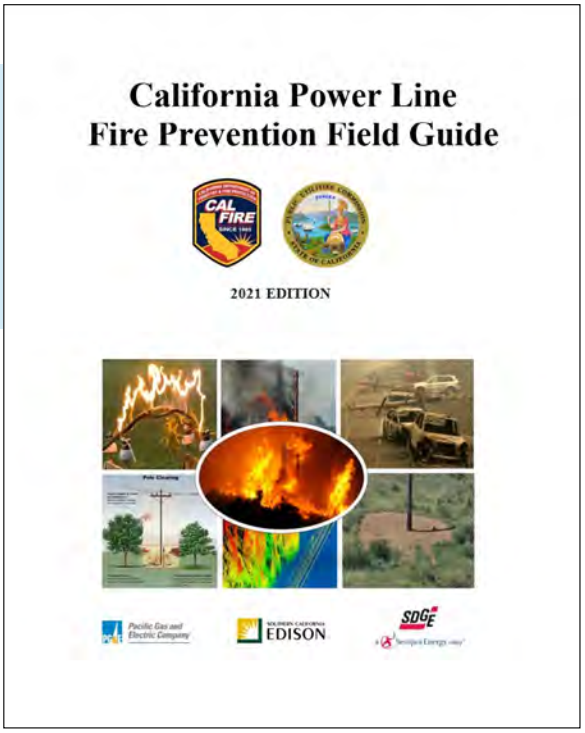
*Some of the measures included in this document are contemplated as additional precautionary measures intended to further reduce the risk of wildfires.*

# Appendix

# Additional Tools and Strategies

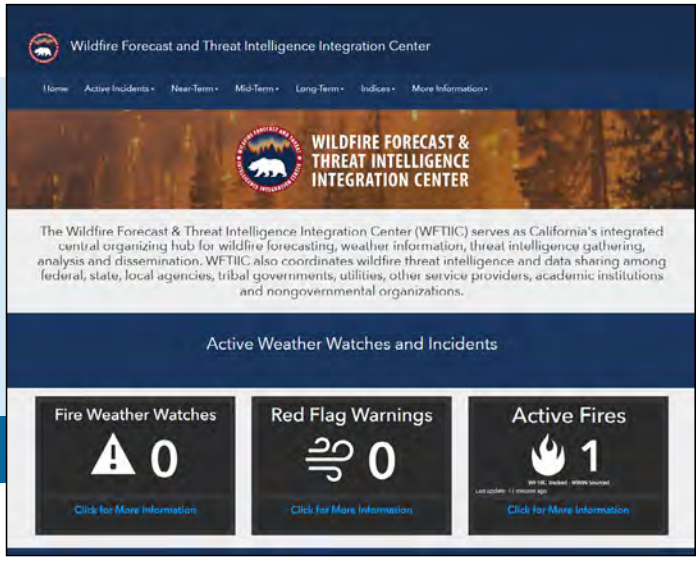
**CAL FIRE**
Prevention Field Guides

SCAN HERE




**Wildfire Forecast and Threat Intelligence Integration Center (WFTIIC)**
California Wildfire Forecasting and Data Sharing

hub.wftiic.ca.gov/



# Wildland Fire Embers and Flames:
## *Home Mitigations That Matter*
Executive Summary

VIEW FULL REPORT

*February 2023*

In a wildfire, buildings ignite through a complex ignition mechanism linked to embers and flames. Due to the variety of possible ignition scenarios, a single hardening strategy is not effective at reducing the chance homes will ignite. To meaningfully reduce the risk, a two-tiered approach that applies the current state of the science is necessary and must include:

1. foundational, systemic protection of a home against **embers**
2. an additional layer of mitigations to guard against **flame** exposure

*Wildland Fire Embers and Flames: Home Mitigations That Matter* discusses available literature on the vulnerability of each component of the home and the need for this systematic, all-inclusive application of these mitigations.

## Mitigations Against Embers and Flames

| | |
|---|---|
| **Roofs** | As a large, elevated surface with complex geometry and a range of slopes, roofs are prone to ember accumulation and eventual ignition if the roof is not fire resistant. A Class A roof covering reduces this vulnerability. |
| **Gutters** | In gutters, leaves and pine needles accumulate, providing embers with a susceptible fuel bed. Gutters should be kept clean with a noncombustible cover to limit debris accumulation. Noncombustible gutters also shield the fascia board from flame exposure. |
| **Vents** | Vents are exposed to flames and embers. Protect the vent from flames by choosing vents made of a noncombustible material. Vent openings must be protected with a 1/8-inch or finer noncombustible mesh screen to prevent large embers from entering the house and igniting the house from the inside. Similarly, dryer vents should have a noncombustible louver or flap. |
| **Zone 0** | Winds carry debris and embers during wildfires, which settle near homes as the wind interacts with the structure. Combustibles should be kept at least 5 feet from the home to minimize the risk of short flames to the home and provide no fuel for embers to land on. A well-maintained Zone 0 with no combustibles also acts as a fuel break to stop surface fires approaching the home and reduce the likelihood of home ignition. |
| **Fences** | Combustible fences provide a path of fuel for fire to reach a home. Even for homes with noncombustible cladding, flames from a burning fence can threaten eaves and nearby windows. Installing a noncombustible fence inside Zone 0 breaks the path of fire to a home.<br><br>The combination of trapped debris between back-to-back fences and the fence itself creates an extremely susceptible fuel bed for embers. This fence design should be avoided in the WUI. |

| | |
|---|---|
| **Decks** | Deck assemblies (walking surfaces, joists, and posts) are vulnerable to embers and flames. Embers can fall between deck boards and ignite the joists beneath or combustibles in the underdeck area. The odds of underdeck flame impingement are minimized if the underdeck area is well-maintained with no combustible materials. Where decks are low to the ground, enclosing the underdeck area with 1/8-inch or finer noncombustible mesh reduces the likelihood of debris and ember accumulation. A solid walking surface limits the ignition potential of the deck joists as no embers can reach them; this means the joists are unlikely to become a pathway for fire to reach the home.<br><br>To best reduce the odds of deck ignition, choose a noncombustible deck assembly (including joists, railings, posts, and walking surface). |
| **Accessory Buildings** | When spot fires ignite accessory buildings like sheds and gazebos, short local flames transform into tall flames that radiate significant amounts of heat and/or touch nearby buildings. To limit these kinds of exposures, all accessory buildings within 30 ft of the home should be built with the same mitigation measures as the home. |
| **Eaves** | The geometry of eaves traps heat from flames and hot gases. While field evidence of ignitions is anecdotal, protecting eaves with noncombustible soffits mitigates the ignition potential. |
| **Walls** | When flying embers hit a wall, the embers lose their kinetic energy, fall to the ground, and accumulate. A 6-inch vertical noncombustible clearance at the base of exterior walls limits the exposure to siding from embers.<br><br>While a 6-inch vertical clearance protects a wall from embers, more action is needed to provide protection from flames. Their geometry makes walls suitable recipients of radiation and flame contact in WUI fires. The spread of flame through walls can be slow, but surface flame spread on combustible siding occurs quickly. This exposes windows and eaves to direct flame contact and can begin the cascade of damage for a home. Noncombustible cladding eliminates the chance of such flame exposures. |
| **Windows** | Windows are vulnerable to flame contact and radiation. Multipaned windows are more resilient by providing multiple layers of protection before flames can penetrate the home. Tempered glass further increases resilience because of its higher resistance to flame radiation. |
| **Doors** | Flames are less likely to reach exterior doors with proper defensible space around the home. However, wind-blown embers may still accumulate at the base of a door or penetrate small openings around the door and ignite the door jamb. Therefore, the entire door assembly should be mitigated. Fire-rated doors are the most practical solution due to the lack of noncombustible door assemblies (door jamb) on the market. |
| **Bay Windows** | The geometry of bay windows traps heat underneath them. While field evidence of ignitions is anecdotal, enclosing this area with noncombustible materials eliminates the risk. |

# Vendor and Supplier Technologies

To create further opportunities for collaboration across the utility industry, this guidebook includes third-party content from suppliers and partners. The following content highlights technologies, equipment and strategies that are currently deployed by utilities to help them manage their wildfire risk. PG&E is not responsible for the content or technologies shown.

**Thought Leadership**
White Paper

# Harnessing AI for wildfire prevention

## The power to detect and prevent high impedance faults


***Souvik Chandra, PhD***
*Senior Specialist Engineer*
*Eaton*

***Nisar Baloch, PE***
*Global Product Manager for Overhead Switchgear and Control*
*Eaton*

***Madhab Paudel, PE***
*Lead Distribution Protection Engineer*
*Eaton*

***Xiangying (Linda) Meng, PhD***
*Data Science Specialist*
*Eaton*



### Executive summary

**Fortifying the electric grid against the threat of wildfires has never been more important. Each year, wildfires cause an increasing amount of catastrophic damage. Over the last twenty-plus years, the reach of wildfires in the U.S. has more than doubled since the 1990s. On average, there are 61,410 wildfires and 7.2 million acres burned annually.[1]**


### Digital solutions for wildfire mitigation

According to recent research from the University of California, Berkley, powerline faults can be reduced upward of 72% through sensors already deployed at many utilities. Some of these powerline faults, such as high impedance (HiZ) faults, are incredibly difficult to detect. Today, there is no reliable technology to predict, detect and reduce the potential for these powerline faults. But that is about to change.

Our experts at Eaton Research Labs (ERL) and our Center for Intelligent Power (CIP) are leading our R&D efforts, working hand-in-hand with utilities, government agencies and industry organizations to develop site-ready solutions for fire hardening. Included in that work are projects to develop novel solutions using artificial intelligence (AI) to reliably predict and reduce the potential for powerline faults to initiate wildfires.

1 Source: Congressional Research Service, June 2023 update


This material is based on work supported by the Engineer Research and Development Center and Construction Engineering Research Laboratory (ERDC-CERL) through contract number W9132T-21-C-0008. The opinions, findings and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of ERDC-CERL.


Powering Business Worldwide

## Detecting and addressing HiZ faults

### HiZ faults are caused by trees falling on powerlines, downed powerlines and arcing through a failed insulator on a power pole.

When undetected, these public safety hazards may lead to arcing, which can start a wildfire when fuel such as dry vegetation is present.

These faults have small fault current traits that are similar in amplitude to normal loads on the grid. Unlike typical electric (short-circuit) faults that are generally cleared by protective devices (like circuit breakers or reclosers) within a few power cycles due to their high-fault current magnitude, HiZ faults are hard to detect.

The characteristics of HiZs depend on a variety of conditions, adding further complexity. Specific tree variety, utility grounding practice, soil conditions, humidity, power system topology, system voltage, weather conditions and load type impact the fault current and characteristics. For example, vegetation-related faults are known to develop gradually over time as the material slowly chars until it suddenly ignites.

As a result, utilities have resorted to public safety power shutoffs (PSPS), or temporary outages, to reduce risk. By turning the power off in an area during high-risk conditions, utilities can eliminate the risk of a HiZ during the outage, but that is not a long-term solution and it comes with its own challenges.

Military bases and critical infrastructure are also at risk of outages and wildfires. Military installations are dependent on uniquely long stretches of electrical lines in remote places. So, the Department of Defense (DoD) also needs to be able to quickly identify and de-energize powerlines at risk of spreading wildfires.

## Government, industry and research labs team up to look for a solution

### It is vitally important to identify powerline-initiated faults faster and far more accurately to prevent wildfires.

To develop a solution, Eaton, the U.S. Army Corps of Engineers and the National Renewable Energy Laboratory (NREL) teamed up to develop and demonstrate a data-driven HiZ detection technology that uses state-of-the-art sensing technology and advanced machine learning algorithms.

The team conducted hundreds of experiments and performed simulations to develop an understanding of the electrical signature of HiZ faults.

Extensive tests were performed at Eaton's Thomas A. Edison test center in Franksville, Wisconsin, which is one of only five short-circuit distribution class test labs in North America. The Eaton lab has high-power and high-voltage labs equipped with 8.3 kilovolt (kV) and 25 kV power feeders, along with a 500 megavolt-amperes (MVA) motor generator set. It is an accredited lab for electrical testing with special capabilities in high-fault current and load testing.

The team's tests included downed-conductor events on different surfaces (like concrete, dry grass, asphalt, sand and more) with varying levels of moisture and other external conditions. Additionally, the team tested tree contact to live powerlines for various tree species found in North America; these tests were vital to analyze unique fault characteristics that are specific to tree variety.

At Eaton, we used this data to develop a novel, AI-based comprehensive solution to detect and de-energize powerlines during these events using common edge devices on the grid, such as recloser controls. After testing and validating its HiZ solution on grid edge devices at the Eaton lab with high levels of accuracy, we are in the next stage of validating this technology.

Next, Eaton collaborated with multiple electric utilities in North America to further understand the unique opportunities and real-world nuances of wide-scale deployment of this wildfire mitigation strategy. We are getting feedback on our approach to ensure the development of a reliable solution. In these utility pilots, Eaton's solution is commissioned on utility distribution systems that are serving loads to customers using Eaton's Cooper Power™ series NOVA™ recloser and Form 7 control.

These pilots are providing opportunities for further validation of Eaton's solution and a deeper understanding of the corner cases (like false positives), helping further refine Eaton's technology. Once the utility pilots are completed, Eaton will proceed to commercialize the solution, aiming to solve a longtime challenge faced by electric utilities and help significantly reduce the risk of wildfires.

## AI-based Eaton technology delivers on accuracy for HiZ detection

**The AI-based technology currently being tested in the field is composed of three primary novel elements: integrated sensing, machine learning and edge-based implementation.**

In lab-emulated tests, our novel analytics are detecting HiZ faults with greater than 90% accuracy at the Eaton high-power lab in Franksville, Wisconsin. Eaton is working closely with select utilities to deploy the technology on the grid and get more data, which will improve the reliability of our approach.

When it comes to integrated sensing, Eaton's apparatus and intelligent electronic devices support the integration of high-fidelity electrical measurements with current and voltage sensors. These sensors are embedded in the apparatus during manufacturing or integrated as a third-party product during field installation.

The fault detection algorithm is built on the latest advancements in machine learning technology that have recently solved long-standing challenges in AI and cognitive systems. The success of these approaches relies on a rich set of data to develop, train and validate the machine learning models. Therefore, Eaton and its project partners created a comprehensive library of the signature HiZ patterns by leveraging Eaton's laboratories and test facilities, NREL's grid simulation capabilities and field data from multiple utilities.

Because many powerlines are in remote locations with limited connectivity, the fault detection technology is being implemented within a field or edge device during the utility pilots without depending on communication.

Novel methods for reducing the complexity and optimizing the machine learning–based detection algorithm to run on low-cost, processing and memory constrained hardware have been created.

We believe this technology holds immense promise and versatility for utility and military applications, as it can be integrated into grid-edge monitoring and control devices with access to high-fidelity data. Currently, most utilities rely on traditional threshold-based protection, which lacks the necessary observability and protection capabilities to enable swift action by grid operators. Once this HiZ signature recognition and proactive protection solution is commercialized, it can be implemented across existing edge platforms—such as recloser controls, line sensors and capacitor bank controls—to significantly enhance grid visibility and bolster wildfire prevention efforts.

## Industry collaboration is essential for the future of wildfire prevention

**At Eaton, we are committed to solving the world's most difficult power management challenges, and fortifying the electric grid against the threat of wildfires is a top priority.**

Our utility customers across North America are investing heavily to fortify their distribution systems to reduce the risk of catastrophic wildfires. We are helping the industry accelerate these efforts through our comprehensive approach to wildfire mitigation, which includes significant research and development investments.

In partnership with the U.S. Army Corps of Engineers, NREL and several North American utilities, Eaton is pioneering a new era of wildfire prevention technology. We are harnessing the potential of everything from digitalization and the Internet of Things (IoT) to advanced materials, additive manufacturing, power electronics and AI to meet the evolving power management needs of the world and our customers. Today, that means leveraging our technological advancements to build a safer electric grid and a more resilient future for our customers and communities.

## INNOVATION AT EATON

At Eaton, innovation is about developing future-proof technologies that solve global power management challenges. By combining the best expertise, the right strategy mix and collaborative partnerships, we are focused on solving the industry's most difficult challenges.

Our innovation strategy relies on trusted partnerships across academia, national labs, research institutes, non-profits, suppliers, competitors, government agencies and industry specific organizations around the world. These partnerships allow us to give back to our communities through industry education and training, while generating unique opportunities for collaboration.

Together, with our customers and partners, we are breaking the boundaries of what electrical systems can do to advance safe, reliable electrical systems.

To learn more, visit **Eaton.com/wildfiremitigation**

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Cleveland, OH 44122
United States
Eaton.com


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July 2024



Powering Business Worldwide

Follow us on social media to get the latest product and support information.

# The EFD™ System

Our Early Fault Detection (EFD)™ system detects and locates incipient electrical failures such as damaged conductors, vegetation contact, and failing insulators. Using distributed radio frequency (RF) sensors installed every two to six circuit miles, this device is suitable for all application voltage and pinpoints incipient failures to an accuracy of +/- 30 feet.

EFD™ uses device-level cellular or satellite communications, allowing for system-wide installations. RF detection data is sent to a secure back-end, where further data processing is performed to localize pre-fault conditions.



EFD™ offers 24/7 system-health monitoring, enabling utilities to proactively identify, locate and mitigate wildfire risks on their systems. Using IND.T's suite of software tools, utilities can leverage EFD™ data to prioritize proactive maintenance activities, offering a new method of operating utility systems.

INDT

Intelligent Network
Diagnostic Technology

E Source

# International Wildfire Risk Mitigation

## CONSORTIUM

Connect with utilities worldwide to share data, technology, and expertise, and establish wildfire risk mitigation strategies through learning and collaboration.

## Member benefits

**Monthly working groups**
Meet with focused interest groups to address wildfire-related issues, share strategies, and set industry standards.

**Quarterly webinars**
Learn from members, industry leaders, and technology vendors about emerging challenges and advancements.

**Benchmarking**
Participate in surveys, compare your performance with the metrics of your peers, and apply findings to improve your strategy.

**Wildfire risk mitigation maturity model**
Assess wildfire risk status and build a roadmap for continuous improvement and risk mitigation.

**Technology reviews**
Evaluate technology solutions and engage vendors through facilitated sessions.

**Conferences**
Attend multiday events for presentations, priority setting, and networking.

**Member portal**
Access wildfire mitigation plans, past materials, meeting notes, webinar recordings, industry news, and research.

**Opt-in opportunities**
Participate in focused, opt-in projects like research, joint development, new technologies, benchmarking, and performance analysis.

## WORKING GROUP TOPICS

**Operations and protocols**
- Grid-edge digital orchestration and optimization tools
- Interventions for risk prevention
- Power shutoff processes and decision criteria

**Asset management**
- Risk-based asset inspections
- Aerial inspections and smart image processing
- Robotic process automation assessments

**Vegetation management**
- Data management and mobility solutions
- Risk-based vegetation management
- Holistic land management strategies

**Risk management**
- Risk-based protection techniques
- Advanced weather forecasting and modeling
- Comprehensive value frameworks

## Steering group members

aps · AusNet · PG&E · Powercor Australia · SDGE · Southern California Edison

www.esource.com | 1-800-ESOURCE | IWRMC@esource.com

Osmose

# Wildfire Protection

Products & Services Engineered to Address the Root Causes of Electrical Fires & Resist Wildfires

Pole top degradation or decay and groundline strength loss are the two most common wood utility pole failure mechanisms. Both can lead to energized equipment falling, igniting combustible material on the ground, and resulting in a fire. Prevention, restoration, and resistance are the keys to comprehensive wildfire protection.

## PREVENTION

### Pole Topper®

Maintain structural integrity with durable, lasting, moisture- and UVresistant pole top coverage, mitigating decay and sunlight degradation.

Moisture content determined over 90 months:

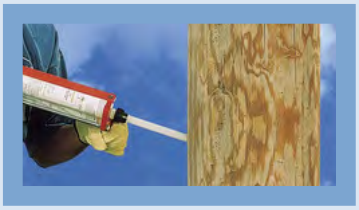
| | Inner | Outer |
|---|---|---|
| Uncapped | 83.6% | 28.2% |
| Capped | 13.3% | 11.0% |

Decay not typically active in moisture content below 20%

## RESTORATION

### OsmoWeld®

Multi-purpose filler restores strength lost to voids as a result of woodpecker damage, decay, and split tops.



### AquaWrap®

Fiberglass wrap rebuilds pole shape while restoring strength from large voids or clustered holes.

## RESISTANCE

### ArmorBuilt® Wildfire Shield

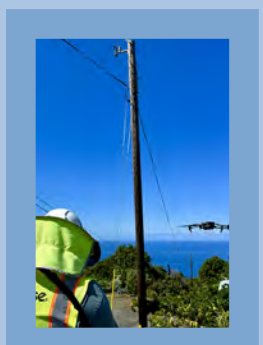
A heavy-duty fire-retardant mesh tested to ASTM standards, that protects wood poles from fire damage.

### Fire-Guard®

A proven fire-retardant coating designed to protect wood from fire damage.

## Tough Truss® Trussing Systems & Structural Resiliency Solutions

A combination of overhead drone imaging, LiDAR, and thorough groundline evaluation provides a holistic view of asset structural health. It creates a roadmap for a detailed, engineered solution to restore and upgrade pole strength from groundline to pole top, mitigating risk of failure in the most likely places.



UAS operations underway

Tough Truss® restoration and upgrade systems can prevent failure and enhance pole strength, providing support to withstand extreme winds and added loads from covered conductors. These systems typically offer 5x the cost savings over replacement, with an average of 3-5x in cycle improvement. In some cases, they have proven to withstand extensive fire damage.

Catastrophic fire damage to trussed pole

technosylva

PG&E has partnered with Technosylva since 2019 to advance situational awareness across its operations and bring data-driven decision-making to its long-term asset planning.

Technosylva helps leading electric utilities across North America reduce the impact of wildfires and extreme weather with advanced and validated analytical capabilities that significantly enhance risk management for both operational decision-making and long-term asset planning.

## The Challenge Faced

Operations leaders need to accurately understand and quantify a dynamic, complex, and previously underestimated risk. This isn't just about modeling fire behavior; it's about translating that knowledge into actionable mitigation strategies and operational decision-making to address liability, regulatory compliance, investor confidence, and stakeholder trust. Electric utilities can move from reactive to proactive, from generalized risk assessments to granular strategies, and ultimately, ensure long-term financial stability and operational resilience.

## Gain Better Decision-Making for Your Operations

Technosylva solutions help electric utilities leverage weather forecasts and environmental data to predict potential wildfire behavior and gain a clear understanding of evolving threats across their service territory. By simulating potential fire spread and intensity in near real-time, utilities can proactively identify high-risk areas and make informed decisions regarding resource allocation and potential Public Safety Power Shutoff (PSPS) events. This predictive capability improves situational awareness, enabling more precise and timely interventions to mitigate immediate wildfire risks and minimize community impact.

## Leverage Data-Driven Justifications for Your Long-Term Planning

Technosylva equips electric utilities with analytical frameworks to prioritize long-term risk reduction strategies. By integrating historical wildfire data, asset information, and predictive modeling, utilities can identify vulnerable infrastructure and areas where mitigation efforts will be most effective. This enables them to make data-driven decisions on asset hardening, vegetation management, and other mitigation efforts. The ability to quantify potential risk reduction associated with different planning scenarios allows optimized resource allocation and a more strategic approach to reducing overall wildfire risk.

## Quantifying the Avoided Catastrophe

Technosylva advances electric utilities with wildfire reanalysis for critical post-event reporting to regulatory bodies. Regulators frequently inquire about the specific conditions influencing such operational decisions during extreme weather events. By reconstructing past scenarios with historical weather and fuel conditions, electric utilities can illustrate fire spread and potential consequences if an ignition occurred. This provides critical detail and data to justify PSPS decision-making and prevention effectiveness to regulators and the communities served.

Visit Technosylva.com/solutions/electric-utility to learn more.

BLACKBURN™ OVERHEAD SYSTEMS

# Blackburn® Storm-Safe® service entrance disconnects

More uptime, more safety and more satisfaction.

Blackburn®


Mechanical breakaway link separates service at the pole to prevent damage to utility equipment and customer premises. The line always comes down de-energized, enhancing safety for crews and the public.

**Let's write the future of safety. Together.**

**Learn more here:**

Sense deploys AI-based software on the latest generation of AMI 2.0 meters, powering both engaging consumer-facing applications (real-time view and analysis of energy use in homes) and real-time visibility and management of the grid. Key grid applications range from planning and forecasting, to demand flexibility, to detecting faults and failures in the grid - including anomalies directly related to fire risk.

High resolution energy data processing right on the meter is the breakthrough capability that enables applications like Sense (www.sense.com) to process almost a billion times more data than what was available with AMI 1.0. This unlocks real-time analysis and insights for both consumers and utilities, and enables AMI 2.0 meters with Sense to be used as a distributed sensing network for the entire distribution grid. Faults and failures throughout the grid show up as disturbances at the edge of the grid - using data from multiple endpoints, we can predict, detect, classify, and localize these anomalies.

By combining the sensing and computation capabilities of AMI 2.0 with sensors and control in the grid, we can enhance a wide range of wildfire related needs including vegetation management, detecting high impedance faults, detecting downed power lines, and other outages. When equipped with real-time networking, detection can be done quickly enough to influence real-time operation of the grid (including EPSS or Fast Trip Settings).

To fully realize these new AMI 2.0 use cases, here are the minimum requirements of next generation meters:

## Data

The previous generation of AMI meters provided 15 minute interval data generally made available hours later. To support applications like Sense, currently available meters have continuous sampling of voltage and current waveforms with resolution of at least 15,000 samples per second. The latest meters are now sampling voltage waveforms at up to 1 million samples per second, allowing for enhanced detection and localization of faults like arcing.

## Computation, Memory, and Storage

With this much higher resolution data, there is no practical way to send all the data to a utility or service provider. The answer is to no longer think of meters as data collection devices, but instead move much of the processing and intelligence to the edge. Next generation meters leverage a distributed software model where much of the processing happens locally on the meter combined with networking and cloud-side processing where appropriate.

## Networking

The distributed computing model outlined reduces network needs, but there are still use cases dependent on networking capabilities. For many use cases, the existing utility networks are sufficient. But, for use cases that require a larger amount of data, or need real-time interaction, the network needs go beyond the existing utility networks. This includes leveraging consumer WiFi for the consumer-facing use cases and cellular networking for utility-facing applications.

sense

## Real-time Grid Visibility

Taken together, these capabilities of AMI 2.0 paired with software like Sense, make it possible to have a real-time view of the entire distribution system. With these capabilities in a fraction of homes, it is already possible to see a variety of grid faults and failures. But the real power will come when AMI 2.0 is rolled out to all homes within a distribution system. With high resolution processing at every edge node, along with a map of the system, it becomes possible to know the power flow of the entire system, and to triangulate faults and failures. This can then be combined with other sensing and control in the grid for significant enhancements to the operation of the grid.

**IMAGE 1**

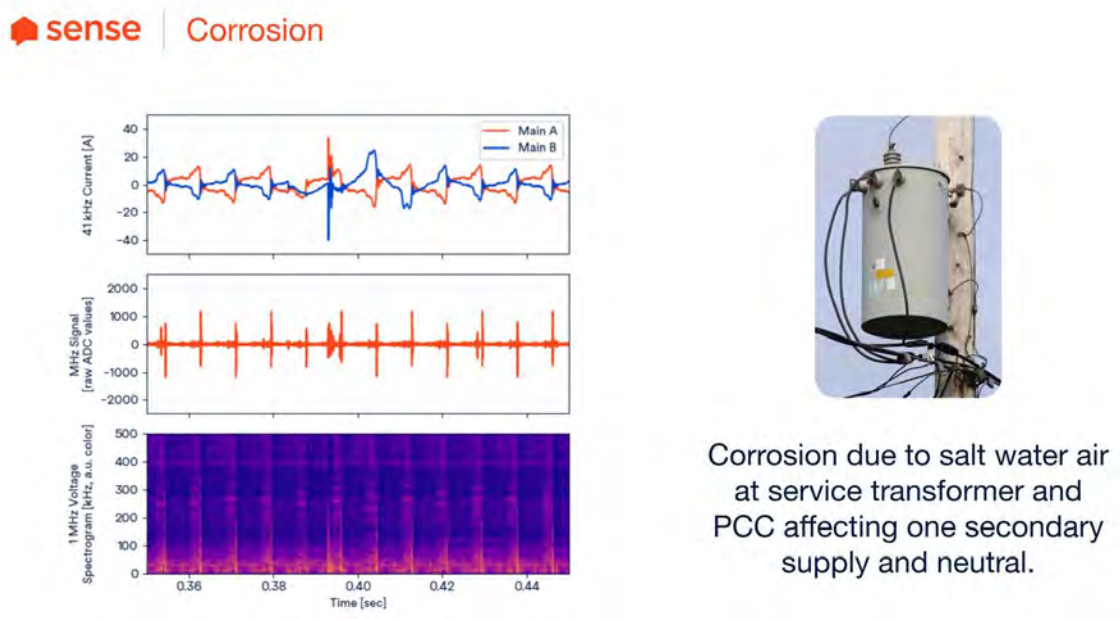
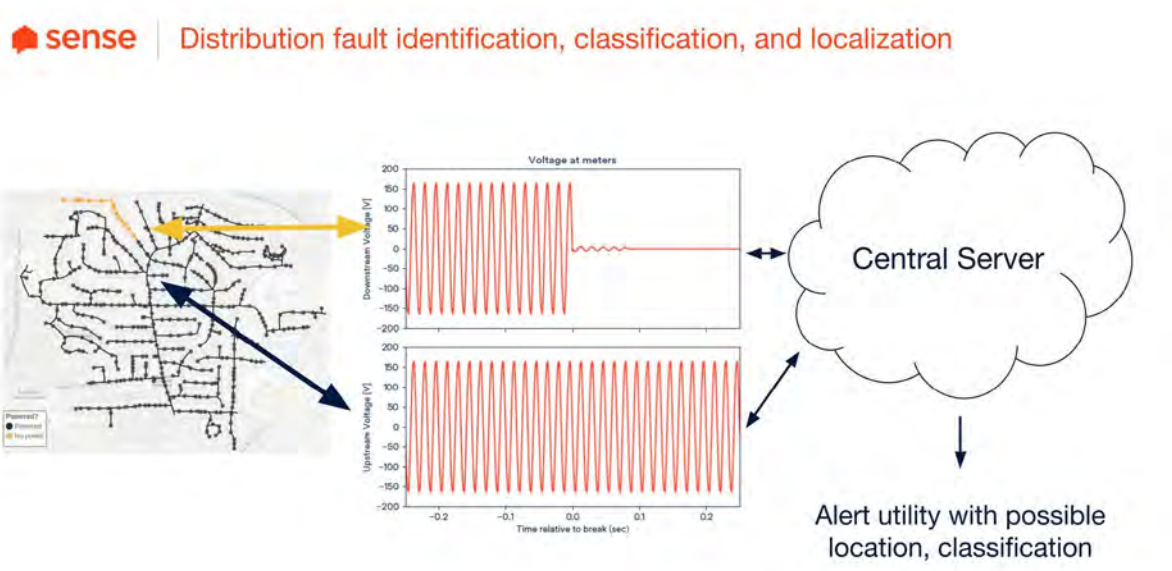



**IMAGE 2**



## Building a Layered Remote Sensing Strategy for Wildfire Mitigation

### Why a Multi-Modal Approach Matters

As wildfire risk grows more complex, no single data source can capture the full picture. A layered remote sensing strategy—combining satellite data, LiDAR, and field inspections—offers a more comprehensive, risk-informed view of vegetation and ignition hazards.

Each mode has strengths:

- **Satellite and aerial imagery** offer broad, cost-effective coverage across remote and rugged terrain
- **LiDAR** delivers high-resolution, 3D detail of vegetation and infrastructure
- **Foot patrols** allow for ground-truthing and validation of specific threats

When used together, these tools allow utilities to cost-effectively identify and mitigate wildfire risk across broad territories with accuracy and confidence.

#### 1. Build Foundational Situational Awareness

Satellite and aerial intelligence are the most scalable approaches to monitoring vegetation across large, often inaccessible territories. These methods offer system-wide situational awareness on vegetation health, growth, and risk—ideal for early detection and prioritization. This foundational awareness helps utilities plan cost-effective prevention, preparation, and even long-term restoration efforts.

#### 2. Choose the Right Tech for the Job

Using foundational satellite and aerial data to pinpoint high-risk zones, utilities can deploy more precise technologies like LiDAR for rich 3D intelligence on canopy height and density and asset risks. Targeted deployment maximizes both cost and impact. Foot patrols and drones can validate emerging hazards.

#### 3. Take Data-Driven Action

With layered insights, utilities can act confidently. Trimming plans, patrol schedules, and capital investments are backed by affordable, cross-verified intelligence. The result: fewer surprises, safer crews, and wildfire mitigation strategies that are both defensible and cost-effective.

Layered remote sensing transforms wildfire mitigation from a reactive process into a proactive, data-informed strategy. By pairing scale and affordability with precision, utilities can reduce ignitions, protect crews, and increase grid resilience.

# Tech Tools Appendix

## Overstory's AI-Powered Vegetation Intelligence


Overstory helps utilities like PG&E stop catastrophic wildfires before they spark by transforming how they detect, prioritize, and mitigate vegetation risk. Using high-resolution satellite imagery and AI, Overstory delivers system-wide intelligence on vegetation risk, fuel loads, growth, and ignition potential—enabling proactive action all the way from wildfire prevention and preparation to long-term recovery and resilience.

- **Build Situational Awareness:** Get a complete view of vegetation and fuel conditions across the network —by volume, species, health, and fire exposure. Use that visibility to prioritize trimming, patrols, inspection, and investment over time.
- **Spot Threats in Hard-to-Reach Areas:** Remote and rugged terrain often hides the most dangerous threats like hazard trees and high fuel loads. Overstory uncovers them before red flag conditions arrive —and helps track ignition and fuel risk in areas where traditional patrols fall short.
- **Keep Crews Safe:** Crews can't always operate safely under red flag conditions. Plan and prioritize fieldwork in advance, confirm completion remotely, and reduce unnecessary exposure.
- **Maximize Resources:** Use data to guide investments —like cameras, sensors, and field work —based on where they can reduce risk most. Focus efforts on the highest-exposure spans and assets to improve operational efficiency and impact.
- **Justify Decisions with Data:** Back up wildfire mitigation efforts to regulators, insurers, and communities with defensible data. Inform precise decisions about where to trim, inspect, invest —or, when necessary, de-energize —reducing ignition risk while protecting both customers and crews.

**Closing the Visibility Gap: AI-Driven Insights for Wildfire Mitigation**

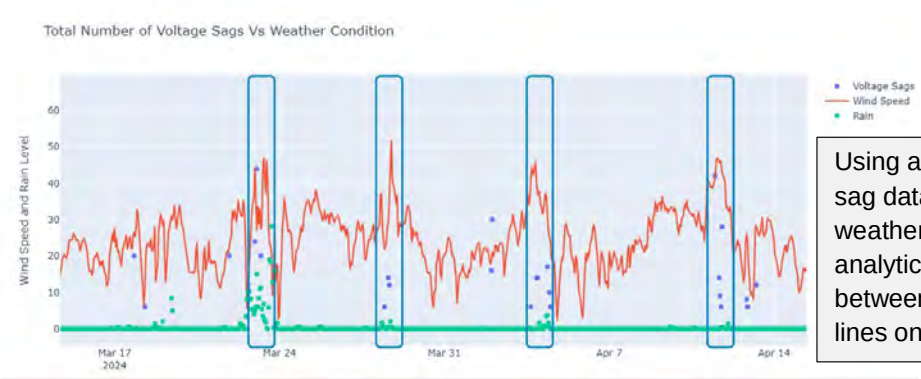
There is no single fix for wildfire risk. True mitigation requires an ecosystem of strategies—combining infrastructure monitoring, vegetation management, weather data, and predictive insights. At Ubicquia, our wildfire mission is to close the grid's visibility gap with smart sensors and AI analytics that work together to identify hazards before they escalate.

Ubicquia's **UbiGridâ DTM+**, **TVM**, **UbiCellâ**, and **UbiHubâ** platforms create a digital mesh across utility infrastructure—from transformers to poles to streetlights. These devices detect key indicators of wildfire ignition, including line slap, excessive voltage sag and voltage transients, pole tilt and impact, vegetation encroachment, and equipment degradation. Each sensor feeds real-time data into **UbiVuâ**, our unified platform that provides AI-driven alerts and predictive analytics through a single pane of glass.

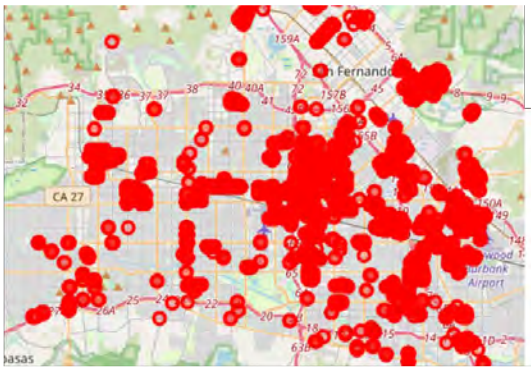
This sensor fusion generates a **network effect**: the more devices that are deployed, the more accurate the situational picture becomes. Our system identifies high-risk areas using voltage signatures, tilt anomalies, thermal profiles, and visual AI. UbiVu correlates this data with weather conditions—such as wind, humidity, and temperature—to issue alerts that correspond to evolving fire danger levels.

The result is a faster response, fewer truck rolls, and a move from reactive to predictive wildfire mitigation. Ubicquia's platforms don't replace foundational approaches like vegetation trimming or PSPS—but they **enhance them with early warnings**, automated insights, and precise targeting. Together, we can turn grid data into life-saving decisions.

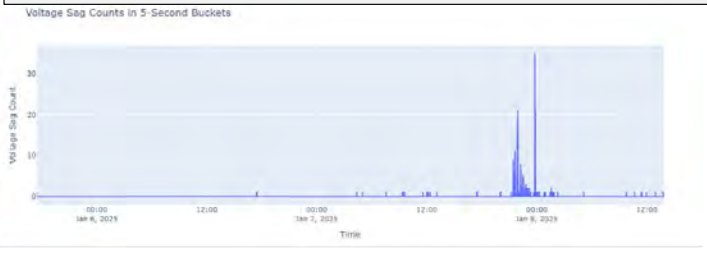
UbiVu Grid Images below:




Using a network of DTM+ devices, sag data can be integrated with weather conditions and advanced analytics to spot potential contact between vegetation and primary lines on feeders.




A high density of UbiCell streetlight control sensors in the San Fernando Valley area detected a very high count of voltage sag events, starting at 9:56 PM Jan. 7 and 11:47 PM Jan. 7, near the reported time of the Hurst fire. Sag data can be integrated with weather conditions and advanced analytics to warn of a developing problem.

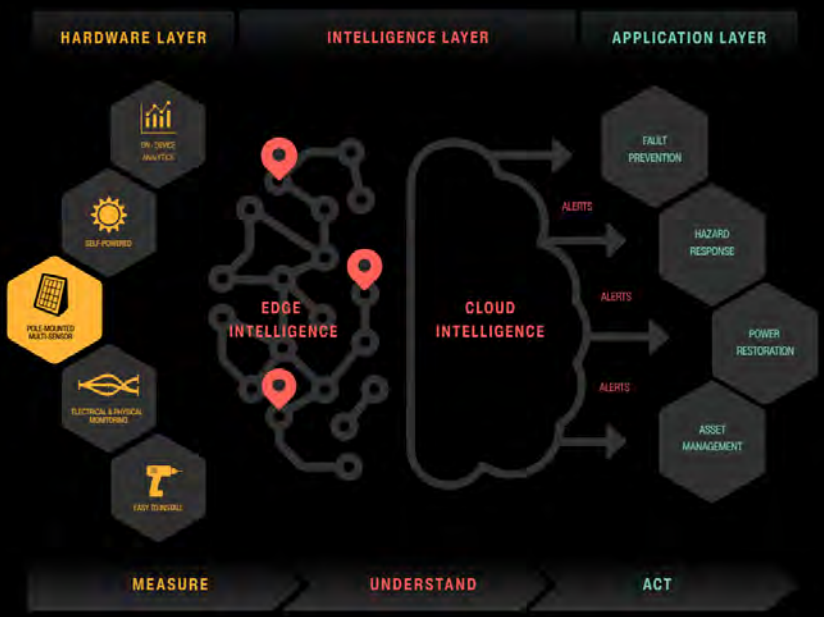


Gridware

# Eliminating the Hazard Awareness Delay.

Gridware addresses the challenges of Hazard Awareness Delay with an Active Grid Response (AGR) Platform powered by Gridscope. This end-to-end system enables utilities to quickly assess hazards, prioritize responses, and send line workers directly to the source, increasing safety while improving restoration times.

## Gridware AGR Platform.




www.gridware.io

**Fault prevention:**
Operations teams can identify emerging hazards in real time, and develop prevention plans to resolve them in advance.

**Hazard response:**
Control teams can quickly understand and address hazards in real time, mitigating response delay.

**Power restoration:**
Operations teams can triage and dispatch crews with precision to restore power quickly and safely.

**Asset management:**
Engineering teams can observe health trends of assets mounted on the pole as well as the pole itself.


Gridscope multi-sensors are installed on utility poles to monitor physical, structural, and environmental conditions around each span. These self-powered devices use on-device analytics to equip line crews with accurate information identifying the exact type, location, and severity of hazards before they are dispatched.

**On-device analytics:**
High frequency measurements are continuously captured and analyzed at the edge to ensure notifications are sent the moment a hazard occurs.

**Easy to install:**
Device protrudes no more than a pole step and is installed at any height in minutes. This enables deployment at a density which enables exact asset-level pinpointing of hazards.

**Electrical & physical monitoring:**
A combination of physical, electrical, and environmental sensors are included to accurately identify the type and severity of hazards while suppressing false positives.

**Self powered:**
Devices are solar powered, battery backed, and continue to identify hazards during outages or storm conditions.

**www.gridware.io**

Gridware

PANO FOR UTILITIES

# Enhanced Wildfire Detection and Situational Awareness

Pano AI is a leader in early wildfire detection and intelligence, enabling utilities and fire agencies to respond more quickly and safely to wildfire incidents. Pano's solution equips utility companies with tools to help **protect their infrastructure, support community safety, and maintain a reliable power supply** amid increasing wildfire risks.

> With increasingly challenging weather conditions, Pano's AI-powered detection system allows us to respond faster and more effectively to wildfires, safeguarding our community and supporting more reliable service.
>
> **Chris Vetromile**
> Wildfire Mitigation Manager, Austin Energy

## Asset Protection & Reliability

Early detection can help protect your assets and improve reliability during fire season.

## Accelerated Time-to-Value

Pano's full-service deployment expedites situational awareness for wildfire mitigation programs.

## Community Engagement

Strengthen relationships with fire agencies by providing free access to Pano's alerts and incident monitoring.

**Request a demo today** www.pano.ai

# Pano Rapid Detect

A fully integrated, end-to-end solution enabling rapid detection and response


Pano AI is a full-stack, turnkey, early wildfire detection solution that integrates camera technology, artificial intelligence, and a web-based interface to enable leaders and emergency managers on the front lines of the wildfire crisis with actionable intelligence to help reduce the harm of natural disasters and improve firefighter safety in the wake of the growing wildfire crisis.

### Cutting-Edge Hardware & Data Integration

Dual ultra-HD cameras designed to capture a 360° panorama every minute, coupled with integration of 3rd party data such as weather data and satellite imagery (where available).

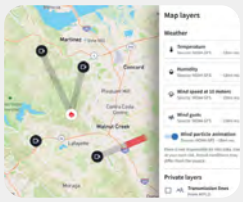
### AI Detection Backed By Human Intelligence

Pano's cloud-based AI monitors for fire incidents 24/7, backed by Pano Intelligence Center analysts who review and confirm incidents.

### Automatic, Configurable Alerts

Automatic detection and alerting of incidents to all users, including first responders, with options to receive notification via SMS or email.

### Easy-to-Use Interface




Pano 360 empowers operations managers with real-time situational awareness, including optical zoom and first-party data integrations, for proactive incident monitoring and response coordination.

## Request a demo today

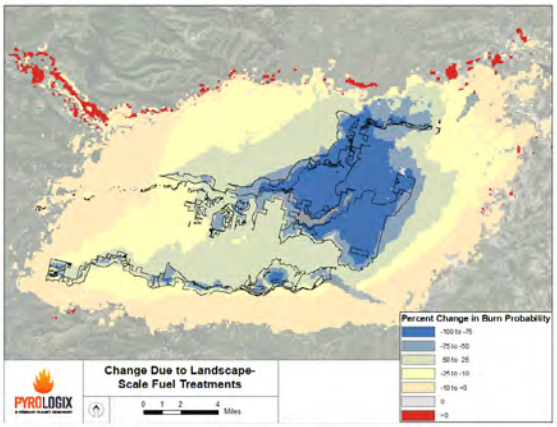
www.pano.ai

# Pyrologix's Utility Wildfire Risk Analytics

Our fire scientists, engineers, and analysts provide industry leading wildfire hazard and risk analysis, with decades of experience in wildfire consulting, research, and operations. The Pyrologix team has authored over 50 peer-reviewed publications that have established the foundations of some of the most widely used wildfire risk science frameworks.

Comprehensively assess your utility wildfire risk:

- **Understand your risk** using wildfire hazard and risk analytics provided across your service area, including structure exposure, ignition potential, fire consequence, and utility threat indices.
- **Estimate your enterprise liability** by simulating millions of wildfires (full spectrum of durations) and quantify exposure to extreme events.
- **Prioritize grid hardening activity** based on differentiated ignition likelihoods and consequences along utility corridors.
- **Quantify the ROI** from your mitigation activities, including fuel treatments.
- **Visualize fire spread.** Our system provides on-demand fire simulation and animation capabilities for scenario analysis and planning.




PYROLOGIX
A VIBRANT PLANET COMPANY

HITACHI
Inspire the Next

Meet cycle goals and improve grid resilience with a closed-loop digital solution for work planning and field patrols

# Meet cycle goals and improve grid resilience with a closed-loop digital solution for work planning and field patrols

## Are you planning or reacting?

Vegetation management supervisors face numerous obstacles from planning to managing work. Current planning methods are time-intensive and often fail to capture the complications and nuances of vegetation and terrain conditions. Plus, a huge portion of their day is often consumed by lower-value processes such as invoicing, budgeting, customer notifications, requests for capital project access, easement processes or general information; this leaves very limited time for actual planning.

And as for the planning itself? Today, it largely relies on helicopter and ground inspections, which puts pressure on the team to get to the next problem, since they are primarily looking for urgent issues. Work is often constrained by the equipment location and crew availability. These challenges have been exacerbated by the rise of extreme weather events, which take a toll on transmission lines and other utility assets, threatening grid reliability and resiliency.

Vegetation teams must keep equipment up and running, and manage both planned and reactive work requirements in an efficient manner while ensuring the safety of their equipment and personnel.

Hitachi Vegetation Manager, part of Lumada Field Service Management (FSM), addresses these challenges with a highly scalable and intuitive application that leverages artificial intelligence (AI) and advanced analytics to improve the accuracy and effectiveness of an organization's vegetation management activities and planning efforts. This best-practice toolkit predicts emergent risks, optimizes cut plans and provides a single source of truth for vegetation data.

## Closed-loop resiliency

Hitachi Vegetation Manager is comprised of three integrated subsystems:

- **Cut Planner:** Back-office application designed for vegetation managers at HQ to visualize vegetation risks, control program costs and create optimal cut plans.
- **Field Planner:** Mobile application designed for arborists, foresters and foremen on the ground to manage parcels, capture jobsite data, and track crew progress.
- **Field Patrol:** Mobile application designed for personnel performing patrols either in the air or on the ground for quick assessments and informing planning processes.

This first-of-its-kind closed-loop resiliency software bridges existing siloed systems and processes, providing field and back-office insights, and allowing vegetation managers to handle the work complexities and business rules that surround the right-of-way.

**2,000+ hours of utility operators' experience and design inputs** have shaped the development of Hitachi Vegetation Manager, to bring vegetation management supervisors a solution for their toughest challenges.

Vegetation Manager uses images from a variety of visual sources, including photo, video and industry-leading Maxar satellites. The incorporation of satellite technology allows utilities to survey their entire territory to automatically confirm line clearances and maintain compliance with regulations. Satellite technology also provides organizations with more comprehensive insights at scale, allowing them to reduce cost and emissions by minimizing truck and helicopter trips. **By combining the images with climate, environmental and cut plan data, Vegetation Manager enables instant grid-wide visibility and machine learning powered insights so that organizations can optimize decision making.**

# Prevent vegetation-related issues and improve grid resiliency

**Vegetation inspection & patrol**
Walking, driving and aerial patrols can capture vegetation and asset risks while directly monitoring, communicating and creating maintenance scopes in near real-time for back-office planners.

**Vegetation forecasting & threat detection**
Using best-in-class imagery from Maxar, our vertically integrated satellite partner, Hitachi Vegetation Manager maintains an inventory of trees in and around the ROW that includes height, canopy shape, health and growth characteristics.

> By forecasting growth rates, utilities can understand not only where current risks lie but also predict future conflicts, allowing them to decide how and when to best intervene. Our algorithms are more than **90% accurate** out of the box.

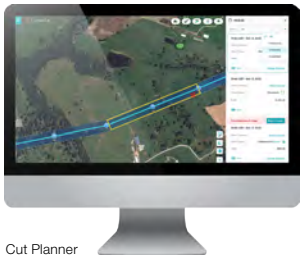
**Vegetation planning & program management**
Leveraging insights from our proprietary algorithms, Vegetation Manager can optimize cut plans based on the organization's resource and budget constraints. The solution will automatically prioritize work based on the likelihood and consequence of the risks and calculate optimal maintenance cycles for different areas of the grid. This includes managing multi-year vegetation management programs to track progress on cycle maintenance goals.

**Field preparation & customer approval management**
Non-technical users can manage pre-work site readiness processes by viewing and capturing critical planning information. The system assists in providing crews with the right context around the worksite, such as where to stage equipment, and identifies field risks such as environmental or wildlife hazards. It also streamlines customer notification, approval/signoff and permit management processes.

**Field deferrals, delays & plan impacts**
Vegetation Manager enables users to understand the impacts of deferrals on cut plans and the entire vegetation management program. Users in the field can update the progress of work and verify its completion or note any deferrals or impacts to work.

**Integration with field/workforce management systems**
Vegetation Manager integrates directly with Lumada FSM to combine vegetation and asset data in one place. Additionally, it will automatically generate comprehensive work packages that can be transferred directly to an integrated third-party workforce management system (WMS). Through this integration, insights from the WMS can be relayed to update progress in the planning function of Vegetation Manager.

**Reporting**
Through all steps of the vegetation management process, users have full visibility into planned and completed work. Various types of reports can be generated for both internal control and regulatory reporting purposes.


Cut Planner


Field Planner


Field Patrol

**Hitachi Energy**
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hitachienergy.com


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# ALERTWest

## WHAT IS ALERTWest?

A TRUSTED UTILITY PARTNER

**WILDFIRE INTELLIGENCE PLATFORM**

- Largest wildfire camera system in the US
- Live camera feeds, AI wildfire detection, and risk modeling built into a single platform
- Supports early detection, faster response, and proactive decision-making
- Purpose built with feedback from PG&E & CAL FIRE

**AT SCALE PARTNER**

- 1,500 PTZ cameras, 11,000 total cameras, 10 States + Alberta province, 3,500 system users

**2024 AI WILDFIRE DETECTION RESULTS**

- Detected over 2,600+ fires – beating 911 callers 30% of the time

## HOW ALERTWEST SUPPORTS UTILITIES

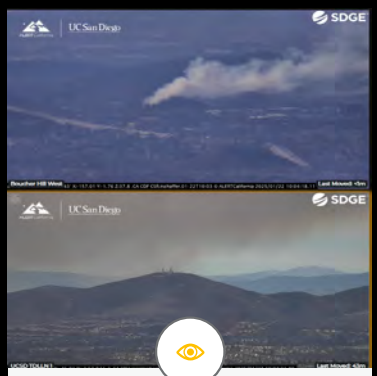
END-TO-END WILDFIRE INTELLIGENCE

| BEFORE IGNITION | DURING IGNITION | AFTER IGNITION |
|---|---|---|
| **PROACTIVE FIRE MODELING**<br>Supports Proactive Mitigation Efforts & PSPS Decision Making | **AI WILDFIRE DETECTION**<br>Early Alerts & Expedited Fire Agency Response | **FIRE PROPAGATION MODELING**<br>Supports Fire Agency Containment & Utility Response Strategies |
| **SITUATIONAL AWARENESS**<br>Cameras Provide Real-Time Monitoring of High-Risk Areas For Emerging Threats | **COORDINATED RESPONSE**<br>Enhanced By Data Sharing and Live Camera Feeds | **POST EVENT ANALYSIS**<br>Historical Archive Refines Future Mitigation and Response Plans |

# ALERTWest

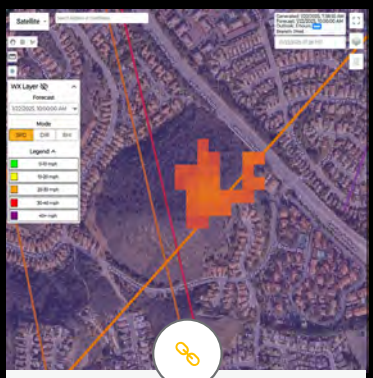
## THE POWER OF CAMERAS + FIRE MODELING

See the Fire. Predict the Spread. Act Faster.



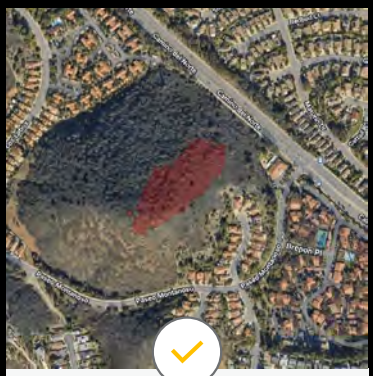

### DETECT, TRIANGULATE, VISUALIZE

Cameras provide instant, ground-truth views to guide resources and decisions as conditions evolve.



### PREDICTIVE SPREAD MODELING

AI forecasts where the fire is going - direction, speed, and impact to infrastructure.



### FASTER, SMARTER DECISIONS

Integrated tools mean earlier detection, clearer intel, and faster, targeted response.


## Contact Us!

**SCOTT SCHIFANDO**

VICE PRESIDENT OF OPERATIONS

# Advanced Residual Current Compensation System

***Abstract*—Minimizing the risk of wildfires caused by electrical failures in overhead lines becomes more and more an important topic, also because of the global warming. Most of all electrical faults in distribution networks are single line to earth faults. If the energy impact at the fault location is minimized, the probability of the dry vegetation ignition is reduced. In compensated distribution networks the Advanced Residual Current Compensation (ARCC) system can be used to compensate the fault current very fast and with a high accuracy. The BoostPro function additionally speeds up the residual current compensation and the earth fault itself can be recognized with the admittance method, which works reliably also for high impedance earth faults. The main part of the capacitive fault current is compensated by a stepless adjustable arc suppression coil (ASC). In case of changes in the network, the ASC must be tuned quickly according to the new network capacity, therefore a new frequency adaptive trigger criterion is used.**

## I PRINCIPLE OF RESIDUAL CURRENT COMPENSATION

In compensated networks an Arc Suppression Coil (ASC, Petersen coil) is used, to compensate the capacitive earth fault currents by the inductive current of the ASC (base compensation). Also, in case of ideal adjustment of the ASC, the active part of the fault current, caused by all the ohmic losses in the network, cannot be avoided. With the Advanced Residual Current Compensation (ARCC®) it is possible to also compensate the active part of the fault current and in ideal case the fault current becomes 0A. For this compensation a single-phase power inverter is used to inject the compensation current into the star point of the distribution transformer. If the fault current is minimized, the faulty phase has earth potential at the fault position.

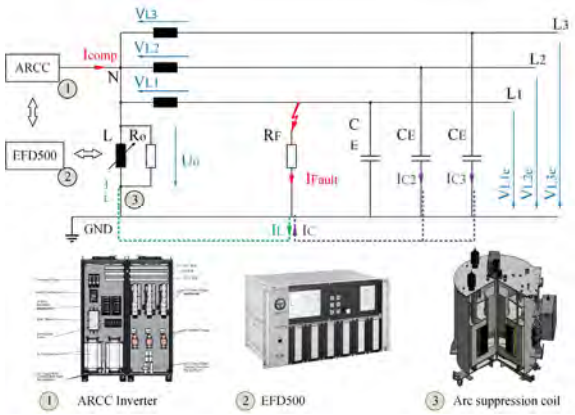



Fig.1: advanced residual current compensation in compensated networks.

The network parameters and the required compensation current $I_{compStatic}$ for earth faults in phase $L_1$, $L_2$, $L_3$ can be calculated during the tuning process of the ASC [1].

The earth fault and the faulty phase is detected by means of the admittance method [2], afterwards the power inverter injects the compensation current $I_{comp} = I_{compStatic}$, which is then permanently adopted according to the measured network voltage and frequency.

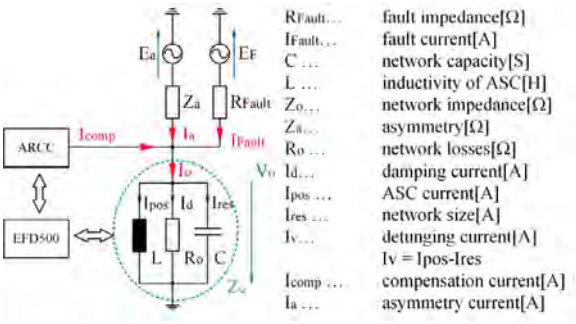



Fig2: Simplified zero sequence equivalent scheme, network parameters

For a simplified network with negligible natural asymmetry current $I_a$ and no voltage and frequency variations, the static compensation current $I_{compStatic}$ corresponds for earth faults at phase $L_1$ to the complex sum of the damping current $I_d$ and the detuning current $I_v$ ($I_{compStatic} \approx I_d + iI_v$). For earth faults at phase $L_2$, $L_3$ the compensation current must be additionally rotated.

## II SEQUENCE OF THE ADVANCED RESIDUAL CURRENT COMPENSATION

1) Calculation of the network parameters and the required compensation current IcompStatic for earth faults in phase L1, L2, L3 by means of a current injection of the ARCC®.
2) Move the ASC to the desired tuning point, the tuning point should be close to the resonance point for highest sensitivity and thus shortest reaction time for earth fault detection and start of the residual current compensation.
3) After the ASC is tuned, all network parameters are known and for each new measured value of the zero-sequence voltage Vo the fault admittance YFault (=1/RFault) can be calculated. Furthermore, a monitoring for changes of the network size is applied. During the tuning process the compensation will not be started (limitation due to parameter accuracy and available power of the inverter).
4) Start of the residual current compensation in case YFault exceeds the desired threshold and the earth

faulty is identified as single line earth fault either in phase L1, L2 or L3 (Fig. 3).

5) Permanent adoption of the compensation current according to the measured network voltage and network frequency.

6) Automatic or manual (forced trigger) start of a verification process to identify if the earth fault is still in the network. For the verification calculations a short time superimposed current injection is necessary, which is performed by the ARCC® inverter.

7) In case the earth fault is identified in the network either the faulty feeder is signalized, and the compensation is further applied, or the faulty feeder is switched off. In case the earth fault could not be identified (restriking characteristic), the compensation current is slowly reduced, in case reignitions are observed, full compensation is applied again, and the faulty feeder is signalized.

## III IDENTIFICATION OF THE FAULTY PHASE

The earth fault and the faulty phase is detected by the admittance method which calculates the fault admittance $Y_{Fault}$ of the simplified zero sequence equivalent scheme (Fig. 2). The earth fault is detected in phase $L_1$ if the desired fault admittance threshold is exceeded ($Y_{Fault}$ > threshold) and the angle of the driving fault voltage $E_F$ is within the angle trigger sector of phase $L_1$.

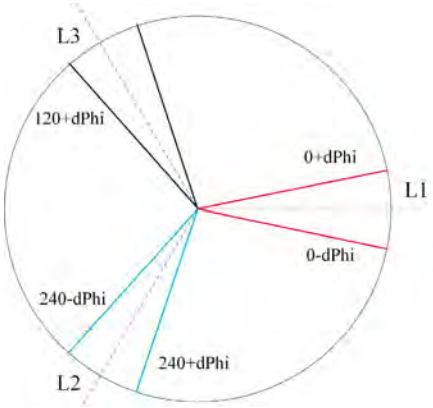



Fig3: Angle trigger sector $L_1$, $L_2$, $L_3$, identification of the faulty phase

## IV BOOSTPRO® FUNCTION

The biggest challenge for the new developed advanced residual current compensation system for the Bush Fire Safety program [3] was the specification request, that for the fault impedance $R_{Fault}$=*400Ohm* the remaining phase to earth voltage of the faulty phase at the busbar in a *22kV* network must be reduced to *1900V* within *85ms* to minimize the energy release at the fault location and thus to minimize the risk of a fire hazard.

The residual current compensation starts very quickly but the bigger the network and the lower the damping of the network is, the more difficult it is to fulfill the *85ms* criterion. The speed of reducing the phase to earth voltage depends on the time constant T of the network according (8).

$$T = 2 \cdot C \cdot \frac{R_o \cdot R_{Fault}}{R_o + R_{Fault}} \qquad (8)$$

With a simple but highly effective idea the compensation can be speed up and the *85ms* criterion can also be met for earth faults with higher impedances or for bigger networks.

To speed up the compensation the new developed BoostPro® function adds for a short time an additional dynamic part to the injected compensation current, the formular shows the situation for an earth fault in phase $L_1$.

$$I_{comp}(t) = I_{compStatic}(t) + I_{Boost}(t) \qquad (9)$$

$$I_{Boost}(t) = \frac{V_{L1e}(t)}{I_{Boost}(t)} \qquad (10)$$

The dynamic compensation current $I_{Boost}$, which is driven by the ARCC inverter, works like an artificial earth fault with a fault impedance $R_{Boost}$ in the same phase as the real earth fault. Therefore, the fault current $I_{Fault}$ and thus the affected phase to earth voltage $V_{L1e}$ can be reduced significantly faster.

The total time needed to meet the *1900V* criteria is determined by the time constant of the network and the start delay of the inverter. Because the inverter is built up as a current source, the algorithm was implemented directly in the inverter main controller. The main controller has a fast CPU where all 3 voltages $V_{L1e}$, $V_{L2e}$, $V_{L3e}$ are measured and a new set value $I_{Boost(t)}$ for the selected phase is calculated for each new sample and added to the static compensation current. The time offset is negligible because of the high sampling rate used.

The inverter of the ARCC® system has a power rating of 160kW / 320 kVA and is controlled by the earth fault protection device EFD500 [4].

## ARCC™ WILDFIRE MITIGATION SYSTEM

Trench's Advanced Residual Current Compensation (ARCC™) system **compensates for ground-fault currents** providing utilities with the security they require to operate electricity networks even in an environment impacted by global warming

**SCAN ME**

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This Guidebook was developed in partnership with PG&E by Keadjian Associates, a leader in strategic wildfire communications and engagement.