Near-Term, Risk-Informed Wildfire Mitigation Strategies

Guidebook for Utilities

Version 1 | May 2024

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

KEY LEARNINGS

Wildfire risk has changed. Climate change 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, new safety measures and an increased focus on addressing risk.

Guidebook Purpose

At PG&E, we have fundamentally changed our organization with a focus on reducing risk and protecting customers. In this guidebook, we have highlighted tools and processes that help with near-term, risk-informed wildfire mitigation.

This guidebook is intended as an iterative document. The initial version primarily focuses on PG&E's experience and learnings, and public resources. In future iterations, we plan to expand the scope to incorporate broader insights, helping to enhance our collective knowledge of wildfire mitigation efforts. Through information sharing and partnership, we can collectively keep the customers we are privileged to serve safe.

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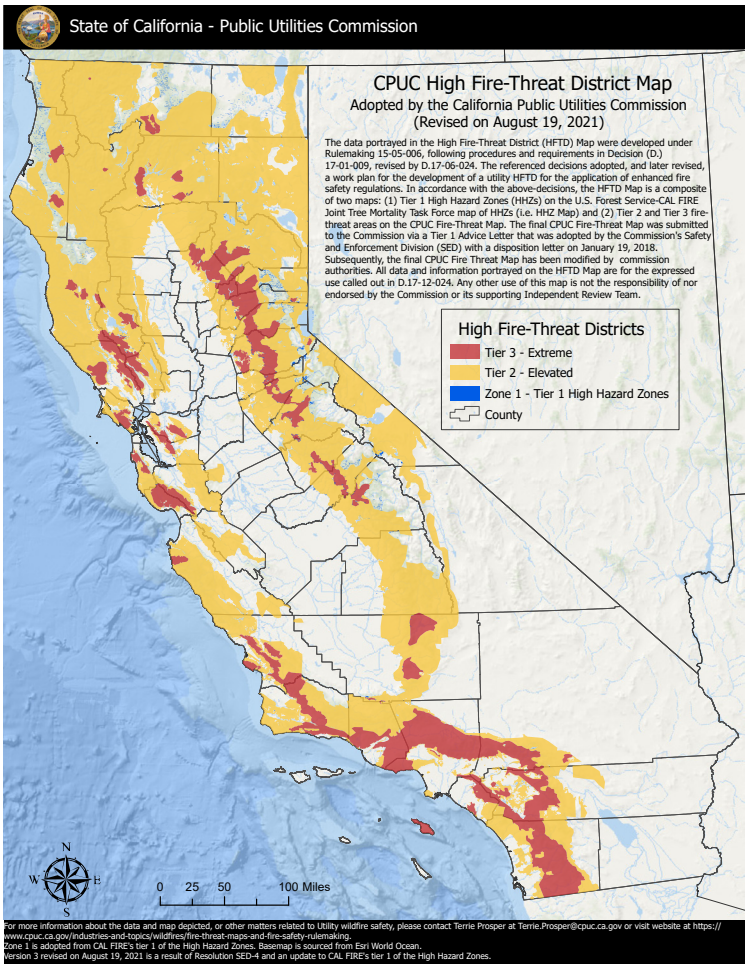
02 Identifying and Understanding Wildfire Risk

KEY LEARNINGS

Identifying high fire-risk areas is a crucial first step in preventing wildfires. Pinpointing the locations of highest risk across a service territory provides critical data that informs operational decisions. When combined, spatial and temporal resources help increase the understanding of risk between the electric utility's infrastructure and the environment in which it operates.

At PG&E, we use the **California Public Utilities Commission's (CPUC) statewide Fire-Threat Map**.

- This map identifies areas at increased risk for wildfires due to strong winds, dry vegetation and other environmental factors.
- The CPUC established the **High Fire-Threat District (HFTD) map** in 2018, which combines areas that are at an increased risk of wildfire with areas served by electric infrastructure.



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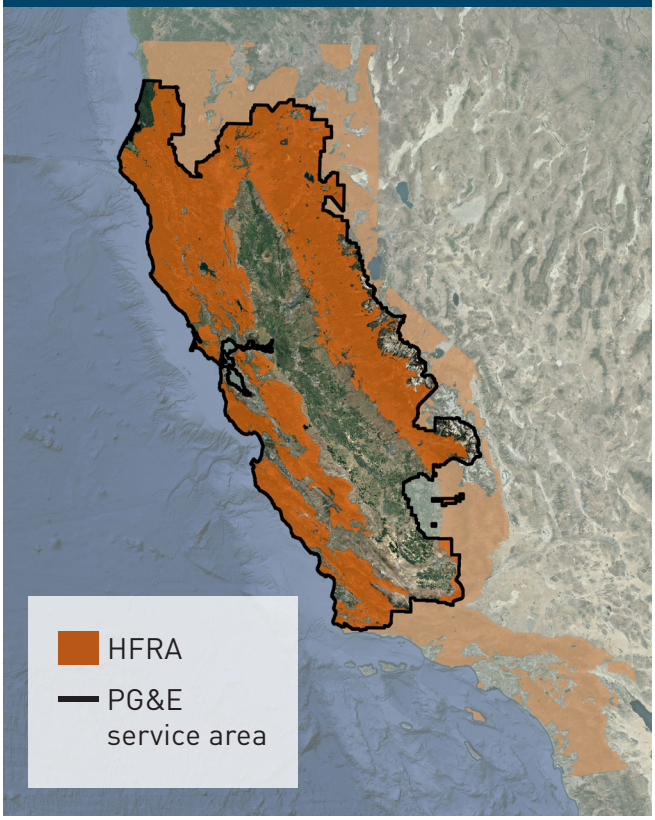
To further enhance risk identification, we created a **High Fire-Risk Area (HFRA) Map**.

- This map uses the HFTD information and adds in 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 risk within our service territory.
- This map is updated and re-evaluated annually to align with offshore wind risks and the latest land use and fuel conditions.

PG&E HFRA Map



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

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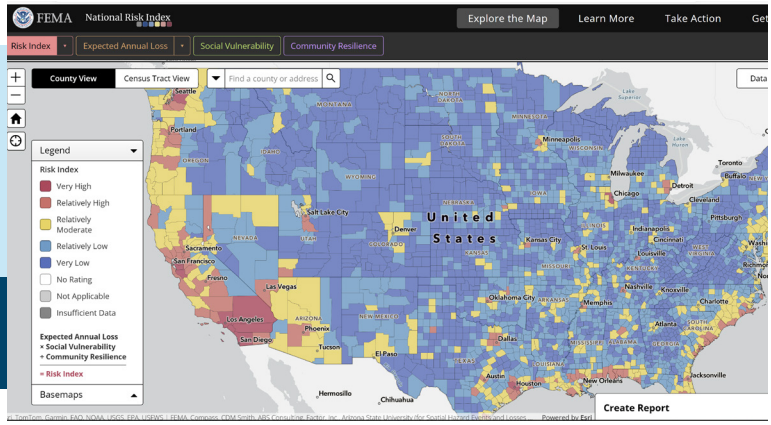
Tools and Resources for Identifying Wildfire Risk

1 Identifying Where Wildfire Risk Exists

Understanding where wildfires have occurred and which areas are at an increased risk of experiencing them is key. To identify these, there are several public resources offering real-time and historical maps.

Federal Emergency Management Agency (FEMA)
National Risk Index

hazards.fema.gov/nri/wildfire

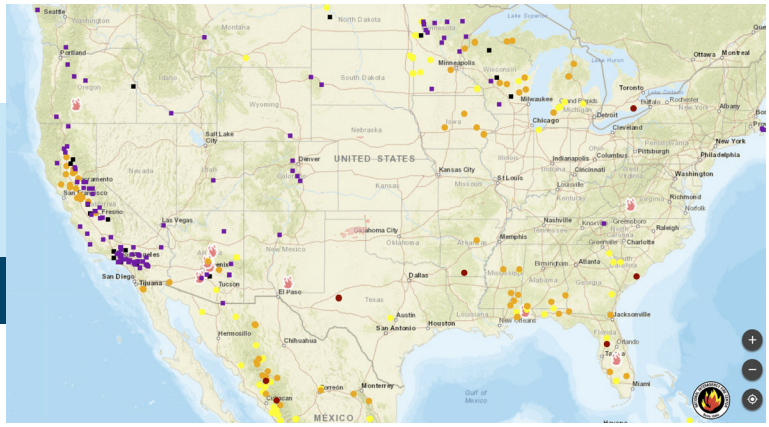


National Interagency Fire Center (NIFC)
Information for Resource Management System

nifc.gov

National Fire Situational Awareness

maps.wildfire.gov



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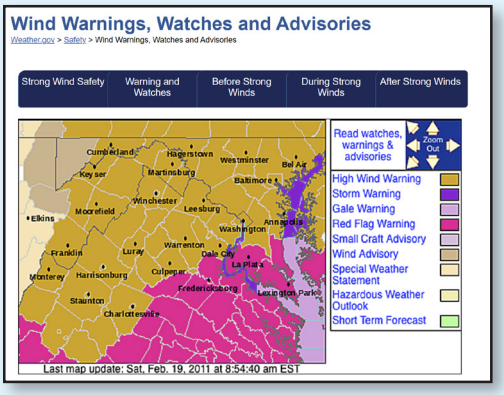
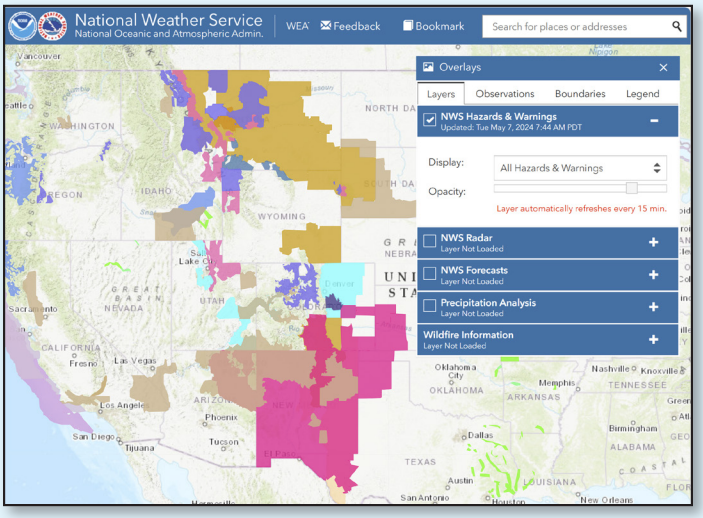
2 Mapping High Fire-Risk Areas with Red Flag Warnings (RFW)

In addition to identifying historical impacts, it is important to have insight into current and forecasted weather conditions.

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

NWS and NOAA provide RFW updates and mapping resources.





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.

In addition to utilizing RFWs, building partnerships and coordinating with local weather services is key. Both the NWS and Geographic Area Coordination Centers (GACC) have local teams which allow a utility to stay closely aligned with changing weather conditions.

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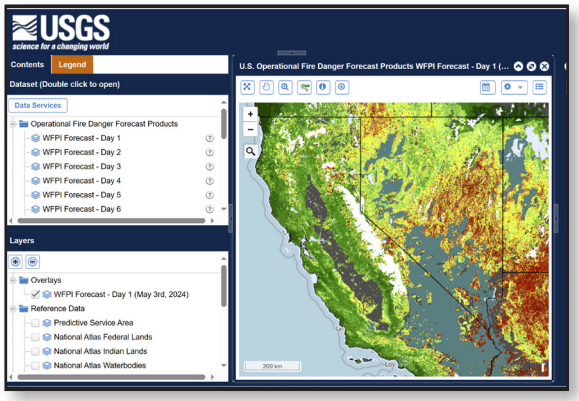
3 Utilizing a Fire Potential Index (FPI)[1]

FPI is an important tool in assessing the potential for a wildfire to start and spread. It is also an integral part of decision-making when it comes to operational mitigations, such as Public Safety Power Shutoff (PSPS).

The U.S. Geological Survey (USGS) provides a public FPI for the U.S.



4 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 will also provide the ability to 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.

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?

5 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 to a wildfire risk assessment tool can allow a utility to incorporate learnings from the prior season and new information based on a changing climate.

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03 Forecasting, Monitoring and Responding to Wildfire Risk

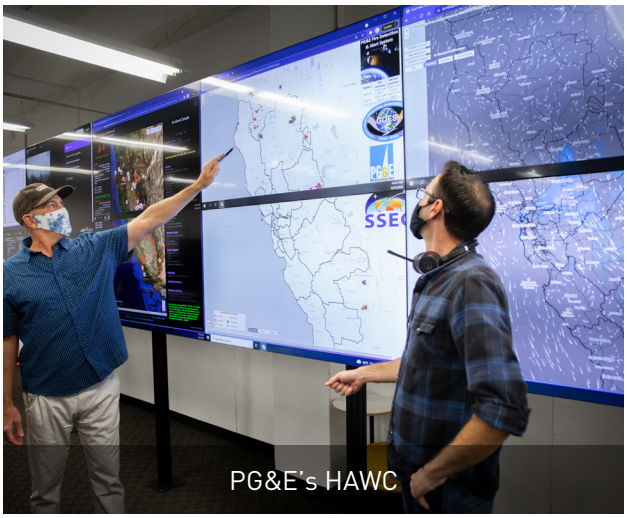
KEY LEARNINGS

To effectively forecast, monitor and respond to wildfire risk and severe weather, we established dedicated meteorology and hazard monitoring teams. These teams include experts in meteorology and fire science, meteorology operations and systems, and analytics teams.

The team uses weather models, a network of high-definition cameras and weather stations, along with existing public networks to forecast, monitor and respond to wildfire risk. Additionally, we have a Hazard Awareness and Warning Center (HAWC) that operates continuously, providing early and real-time detection of wildfires and other hazards.

We also developed an in-house Operational Mesoscale Modeling System (POMMS) which is a sophisticated weather forecasting tool designed to enhance our ability to predict and manage weather-related risks. The POMMS provides high-resolution forecasts four times daily and is crucial for our wildfire risk management and severe weather preparedness.

PG&E's HAWC



PG&E's HAWC

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Tools and Resources for Enhancing Situational Awareness

While we have worked to build internal teams and capabilities, many of the tools we use are publicly available. They are an excellent resource for building situational awareness capabilities on top of wildfire risk mapping. These tools are best utilized by trained experts.

1 Public Weather Models

NOAA Global Forecast System (GFS)

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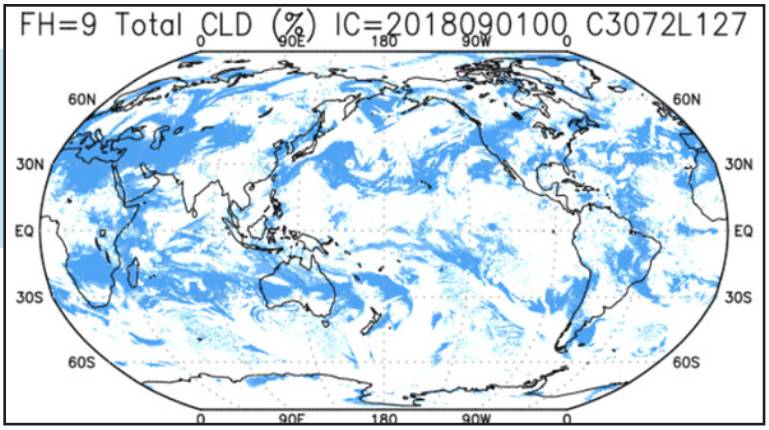

European Centre for Medium Range Weather Forecasts (ECMWF)

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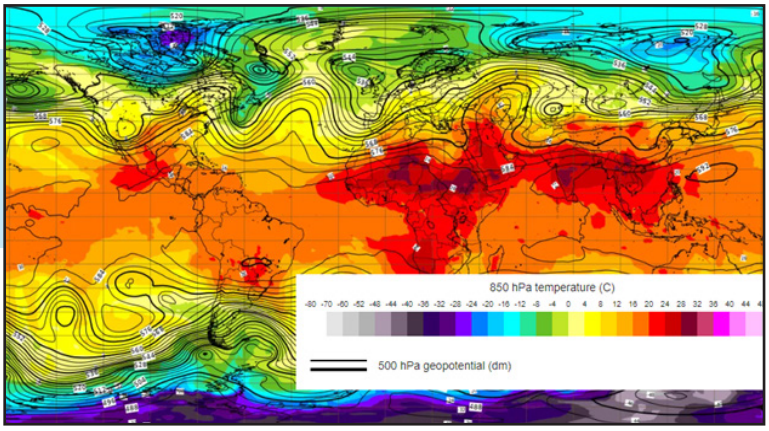

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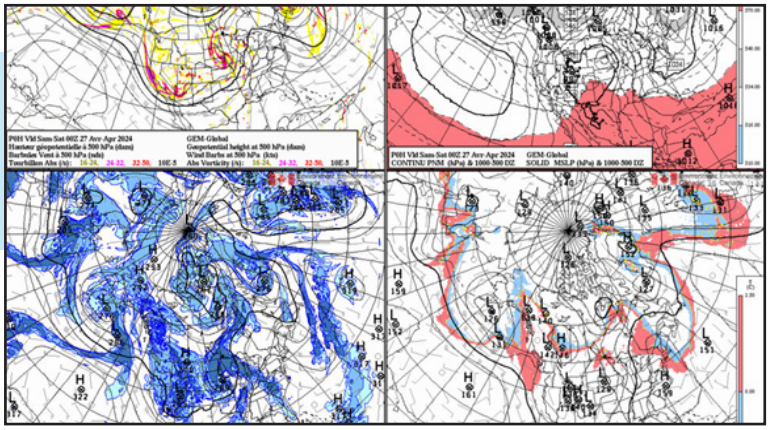
Government of Canada | Gouvernement du Canada

Canadian Global Deterministic Prediction System (GDPS)



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Met Office

U.K. Met Office Global Modelling

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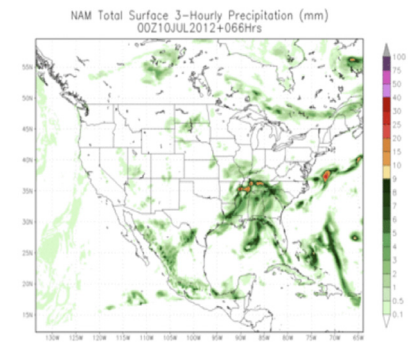
ICON Model

SCAN HERE

National Oceanic and Atmospheric Administration (NOAA)

North American Mesoscale Forecast System (NAM)



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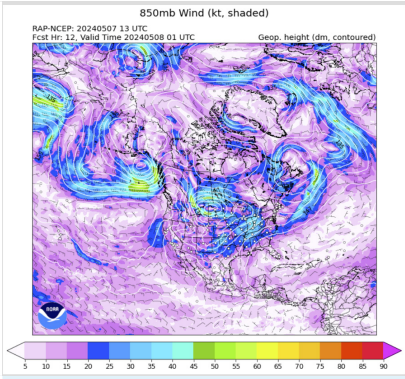
Rapid Refresh (RAP) Model



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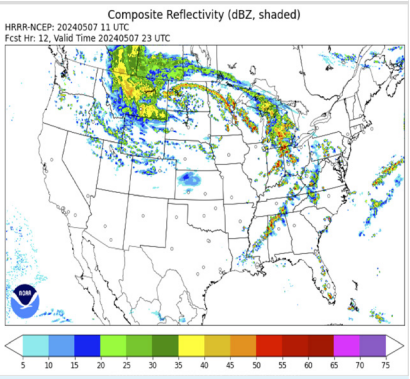
High-Resolution Rapid Refresh (HRRR) Model



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2 Connecting to Broader 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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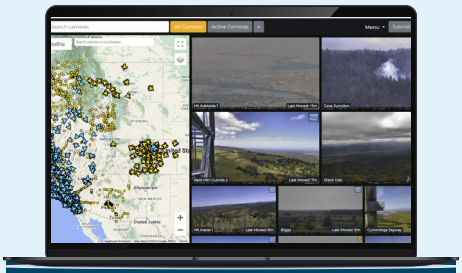

alertwest.org

ALERTWest

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

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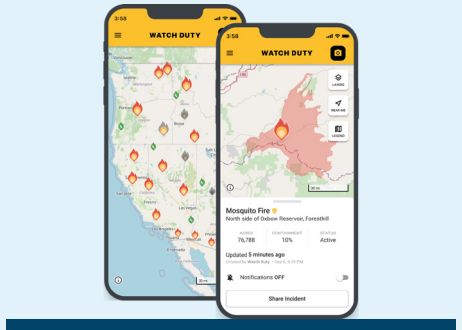

watchduty.org

Watch Duty

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

SCAN HERE

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

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04 Operating the Grid During High-Risk Periods

KEY LEARNINGS

When wildfire risk is high, it is imperative to adapt the electric grid and operations accordingly to reduce ignitions. We utilize weather-driven responses to reduce ignitions when wildfire risk is highest.

Tools and Strategies for Operating the Grid During High-Risk Periods

1 Disabling Reclosers

Reclosers help reduce sustained outages by automatically testing the line after a fault is detected, but their operation can increase ignition risks if a fault condition remains present (e.g., a downed power line) when wildfire risk is high. In response to periods of high fire-risk, it may become prudent to disable the automatic reclosing of transmission and distribution circuit breakers and line reclosers to prevent an ignition. By assessing areas that are potentially at risk and closely monitoring weather conditions, it is possible to identify which reclosers need to be disabled at any given time.

2 Implementing Enhanced Powerline Safety Settings (EPSS) or Fast Trip Settings

Utilities across California have adopted EPSS, or Fast Trip Settings, to prevent wildfires. These settings enhance the responsiveness of electrical systems, rapidly detecting primary faults on distribution lines and immediately de-energizing the circuit. When enabled and a fault occurs, protective devices like circuit breakers and line reclosers automatically shut off power, preventing hazards, such as a tree branch falling into the line, from causing an ignition.

If powerlines are EPSS- or Fast Trip-capable, processes should be put in place to manage these settings throughout periods of high-risk in order to minimize the impact to customers. For transmission lines, communication aided protection is the best way to enable high-speed fault clearing. Where communication aided protection is not available, radial transmission lines may be adjusted for hi-speed clearing without significant reliability impact.

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A. Determining the sensitivity of devices

Decisions to adjust the sensitivity and fault clearing speed of these settings should consider the trade-off between reliability and risk of an ignition. In addition to fast trip settings, considering more advanced protection strategies such as Downed Conductor and High-Impedance Fault Detection should be evaluated for implementation on circuit breakers and line reclosers. With safety as the most important responsibility, adjusting the sensitivity to avoid ignitions may result in outages for customers.

B. Developing the criteria for enabling settings

By utilizing high fire-risk area mapping, situational awareness tools and information on historic wildfires, you will need to establish thresholds for enabling settings. For example, our peak season enablement criteria involves enablement when risks meet or exceed conditions that historically account for 97% of acres burned and 100% of property damage.

We utilize several analyses in our decision-making, the two primary analyses being: the Outage Producing Winds (OPW)[2] Model and the Utility Fire Potential Index (FPI). Both models are based on historical data and state-of-the-art analytical techniques. The OPW Model and the FPI are used together to forecast when ignitions are most likely to become extreme, which is considered in our decision making and enablement process.

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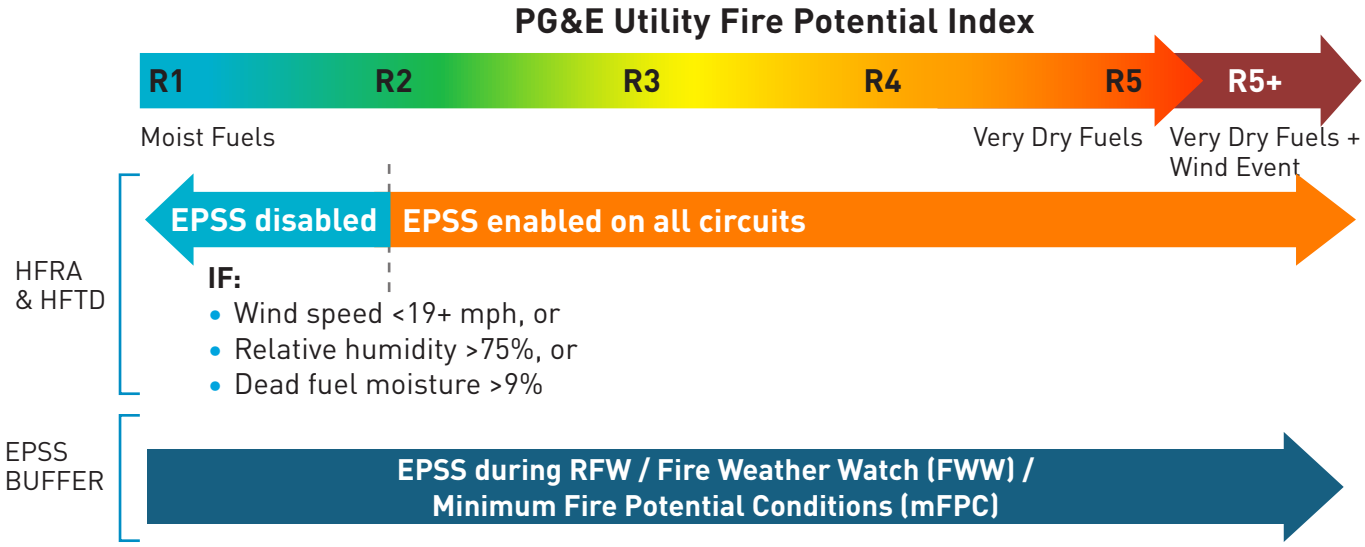
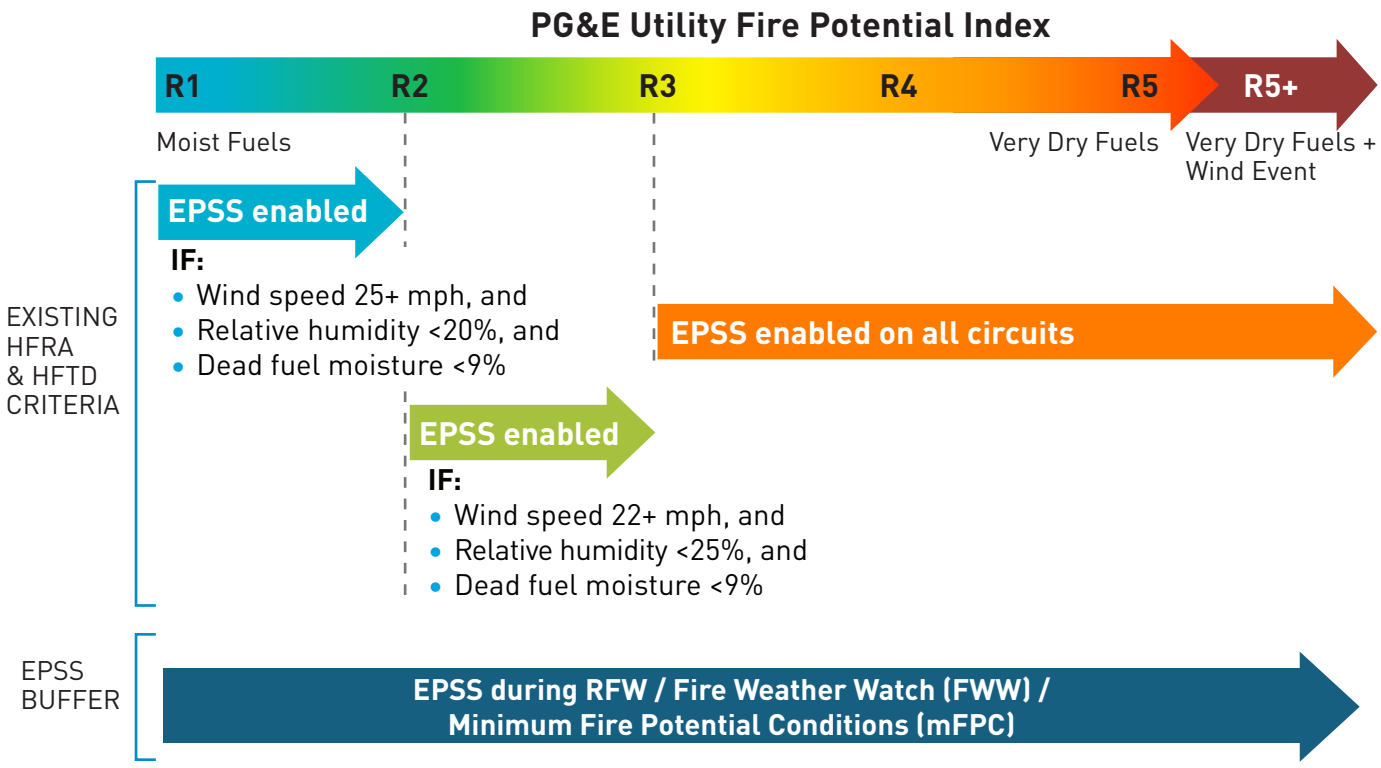
EPSS Enablement Criteria | PEAK SEASON



EPSS Enablement Criteria | NON-PEAK SEASON



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C. Enabling settings

Once thresholds have been determined, a process should be enacted which 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 from the distribution control centers.

D. Responding to hazards and re-energizing circuits

It is crucial to treat any outage as a potential ignition. That means establishing targets for personnel to respond to the outage location and ensure there is not an 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. In order to minimize the time a customer is out of power following an EPSS outage, we have established CAIDI targets to measure timely restoration. In 2024, our goal is to restore EPSS outages within 185 minutes.

E. Disabling settings

In conjuction with determining enablement thresholds, it is important to determine when conditions warrant disablement. Given the reliability trade-off that comes with these settings, returning powerlines to normal settings as safely and quickly as possible will ensure normal operating conditions.

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3 Public Safety Power Shutoff (PSPS)

PSPS is proactively de-energizing customers during severe weather, as a measure of last resort. We conduct PSPS outages in three phases.

PHASE 1: MONITORING WEATHER AND PREPARATION

When our meteorology team flags potential fire conditions, we activate our Emergency Operations Center (EOC) with dedicated staff from all different departments to fully support the PSPS outage. We aim to activate approximately three days before de-energization, weather permitting. During this phase, we closely monitor weather forecasts, develop and refine the potential outage scope, proactively communicate to potentially impacted agencies and customers, and host a decision meeting to determine if de-energization is needed for safety. To determine if we need to de-energize for safety, we follow the steps below:

STEP 1

Evaluate if all of the minimum fire conditions are met.

>0.7	<30%	>19MPH	<9-11%
Fire Potential Index	Humidity	Sustained wind speeds	Dead Fuel Moisture

STEP 2

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

A. **Catastrophic Fire Probability (CFP)[3]:** 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[4] 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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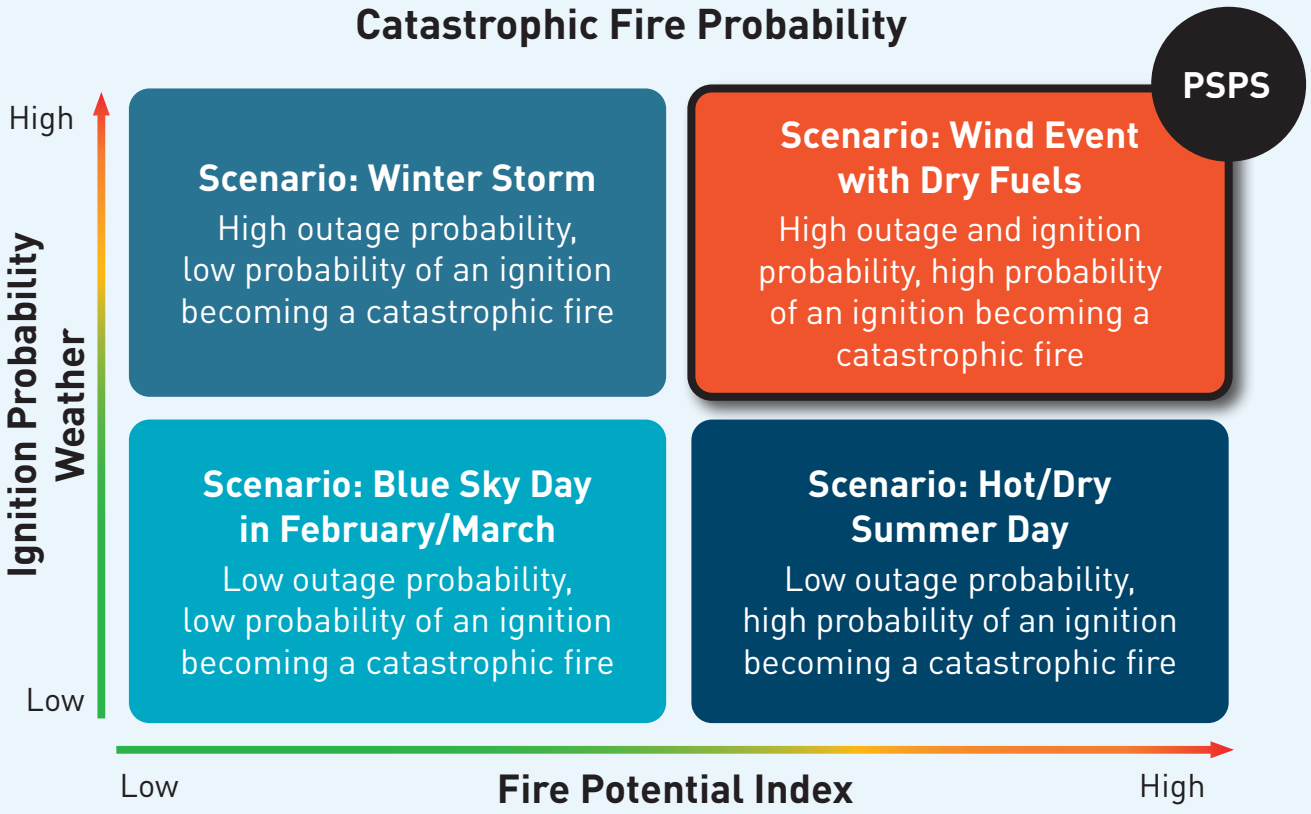

STEP 3

Determine the event scope and power outage area

- Each of the three measures in step 2 are evaluated hourly across more than 45,000 small geographic areas called grid cells. Each area is four square kilometers.
- We define and prepare for a potential PSPS if at least 25 grid cells out of >45,000 are meeting our CFP in an hour.
- We then scope all circuits, meeting step 2 for PSPS, and identify start and end times to facilitate customer and community notifications. If real-time conditions warrant, the circuits within these areas are de-energized.
- Because powerlines travel across long distances, customers outside the affected area may also be impacted.

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PHASE 2: DE-ENERGIZATION

If de-energization is required for safety, we coordinate with internal emergency and grid support centers, along with external agencies such as municipally-owned utilities or the California Independent System Operator (ISO) to de-energize power. At this time, we are also supporting agencies and critical facilities on localized issues, providing customers with resources, such as Wi-Fi and charging stations at our Community Resource Centers (CRC).

PHASE 3: RESTORATION

After the weather has passed and it is safe to do so, our crews will visually inspect for damage to ensure the lines are safe to energize. Our goal is to restore power to all customers within 24 hours after 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.

Patrols and restorations are based on infrastructure, customer criticality and impacts, with additional considerations on circuit configuration, patrol types required and resource availability.

There isn't a 'one-size-fits-all' approach and strategy to restore each circuit. PSPS circuits are "pre-sectionalized" into patrol zones to be individually inspected and re-energized, which helps avoid patrolling the entire line prior to restoration.

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4 One Time Off-cycle Inspection

Inspection of all utility assets in HFRAs before wildfire season to identify degraded equipment that could cause ignitions during normal operations.

5 Transmission Switching

Our teams implement specialized instructions for transmission line switching within Tier 2 (Elevated) and Tier 3 (Extreme) HFTDs and HFRAs. Field personnel (e.g., qualified electrical workers [QEWs], T-men) must be at the device before re-energizing the line device for FPI ratings of R2 and above. Field personnel are equipped with preparedness tools at the switch site, ready to address any unexpected ignition promptly.

Line switches on 60 kV, 70 kV and 115 kV lines across Tier 2 and Tier 3 HFTD and HFRA are operated in de-energized state under all FPI ratings for scheduled, forced and emergency work, including line relay events. In specific situations, operation of a line switch in an energized state may be necessary.

Additionally, our Electric Transmission Grid Control Center (GCC) annually reviews transmission lines and associated SCADA and non-SCADA devices that cross into Fire Index Areas (FIAs). This review helps us identify locations where we will disable automatic reclosing on lines 115 kV and below in protection zones to prevent powerline damage, while following patrol and energize/test requirements. It also worth noting that near these transmission towers, our teams conduct vegetation clearing for at least 10 feet around each tower and establish utility defensible spaces to keep equipment and communities safe.

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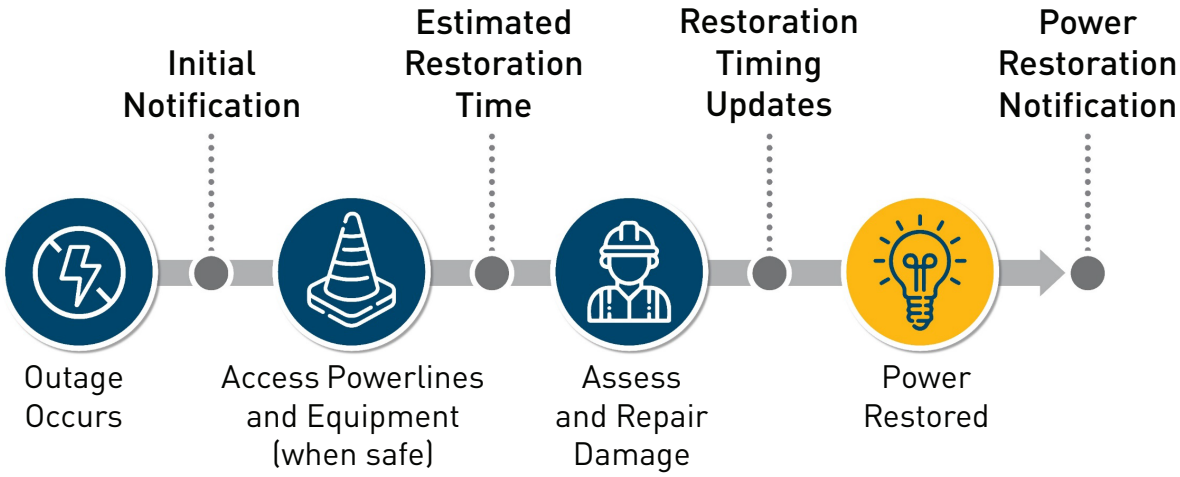
6 Operational Mitigations Communications

Wildfire safety outages can be impactful for customers. It is imperative that customers hear from a utility early and often when operational mitigations are considered. Our communication methods before, during and after safety outages are robust and varied.

A. **EPSS Notifications:** Since EPSS-enabled lines automatically shut off power when a wildfire hazard is detected, advance notifications are not possible. However, customers should receive sustained communications after an outage occurs.



We leverage our website, social media, partnerships with Community Based Organizations (CBO) and local news to keep all stakeholders updated and engaged.

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B. PSPS Notifications: We aim to notify customers about PSPS events two days ahead, one day ahead, just before turning off power, once power is turned off and daily until restoration. Priority notifications are also sent to agencies and critical facilities and infrastructure in advance.

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
We send notifications when power is about to be or has been turned off for public safety.

Post-Weather Event

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 restoral changes.

Power Restoration

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

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05 Reducing Electric Grid Risk

KEY LEARNINGS

To ensure public safety, we implemented multiple layers of protection in our electric grid. Moving powerlines underground in high fire-risk area is a very effective way to prevent equipment from causing ignitions, but it requires multi-year planning and regulatory approval to execute. In the interim, we are collaborating with customers and communities on near-term solutions to reduce risk.

In addition to vegetation management, making adjustments to existing equipment that is susceptible to wildfire risk is a straightforward way to reduce wildfire risk from an electric grid. This includes installing animal and bird guards.

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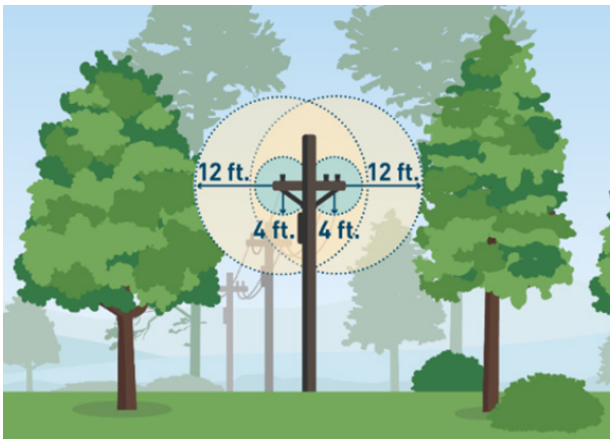
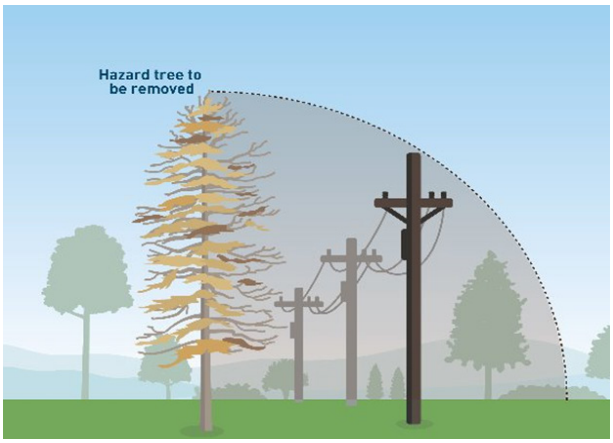
Tools and Strategies for Reducing Risk

1 Managing vegetation

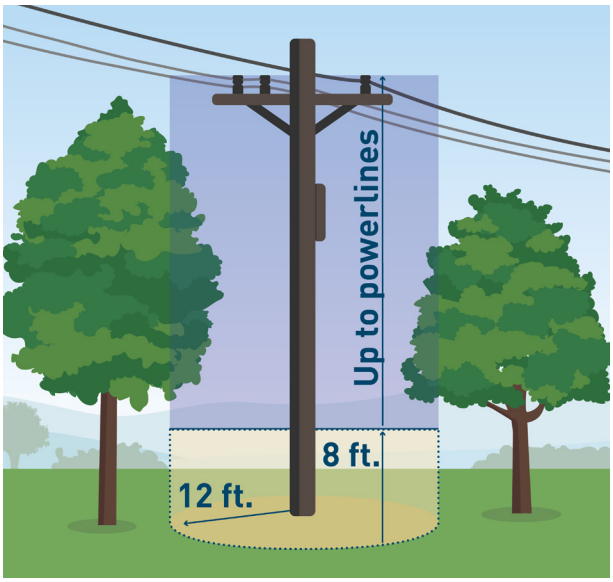
To meet California requirements, We maintain a clearance of 1.5 feet around powerlines in non-high fire-threat areas and at least four feet in high-fire threat areas, with even greater clearances recommended at pruning time to ensure year-round compliance.





2 Pole Clearing

Additionally, pole clearing is another control. This method involves removing dead, dying or diseased vegetation surrounding the base of an electrical pole. Utilizing this process clears out all vegetation that is within a 10-foot distance and 8-foot-tall proximity to the base of poles and towers carrying non-exempt equipment.



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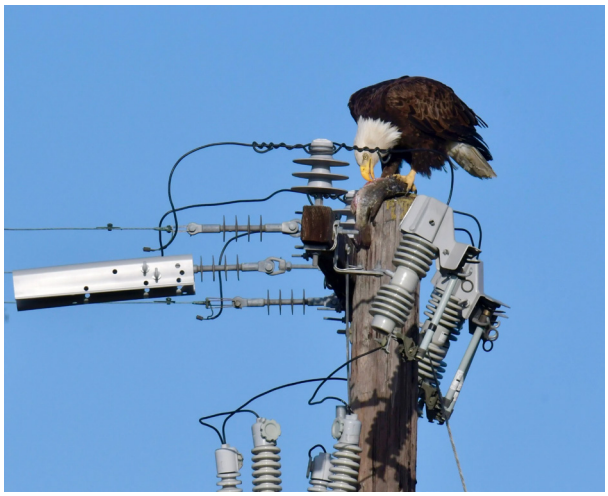
3 Installing animal and bird guards



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 a pre-emptive measure like animal guards in areas of repeat contact can reduce risk.

4 Replacing non-exempt equipment

Non-exempt equipment can pose an ignition risk. By addressing it, especially before wildfire season, another avenue of risk can be mitigated.

Sequencing this work can assist in risk reduction:

A. **Identify all non-exempt equipment** in the service territory
B. **Prioritize inspections** of this equipment in areas of high fire-risk
C. **Prioritize equipment replacements** by: riskiest high fire-risk areas, all other high fire-risk areas and non high fire-risk areas

While it is important to build a comprehensive wildfire mitigation program with layers of protection, immediate and cost-effective mitigation measures can begin to provide a foundation.

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06 Communications and Engagement

KEY LEARNINGS

Utility organizations and their regulators are uniquely impacted by the effects of our changing climate. Since climate change can impact electric service, it is also important to focus on the education and resources needed to help customers adapt.

Using proactive communications in tandem with day-to-day safety and preparedness improvements helps to establish the partnership required to meet emerging challenges.

Tools and Strategies for Communicating Externally

1 Engaging in Year-Round Strategic Communications

Sustained, proactive communications can help build trust with customers, stakeholders and regulators and make sure everyone is working together toward shared goals. This means communicating with customers and stakeholders throughout the year about wildfire safety and the critical role that safety power outages play.

It is important to remain clear and transparent about the mechanics and benefits of PSPS/EPSS and explain how any customer could be affected even if they aren't expecting elevated weather conditions in their area.

Long before wildfire season kicks off, customers, business owners and other stakeholders, and visitor bureaus in high fire-risk areas for short-term vacationers, should be informed and prepared with a thorough understanding of the resources available to them.

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Reaching this wide variety of stakeholders requires a multi-touch, multi-tactic approach that spans different channels. From social media and direct mailers to webinars and paid media, there is no one-size-fits-all approach to information sharing. Since customers have their own communication preferences, a wide-scale campaign is likely to be most effective.

2 Tailoring Outreach to Each Stakeholder Audience

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 impacted. A comprehensive outreach strategy should focus on the following groups:

- **CUSTOMERS:** Drafting various forms of communications is vital to ensure customers are well-informed about their service and any disruptions that might occur during wildfire season. Because this is a broad group with diverse needs, we 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 a local jurisdiction's regulatory bodies and the Federal Energy Regulatory Commission (FERC) at the state and national level is essential to address joint priorities and ensure regulatory compliance.
- **LOCAL GOVERNMENTS:** Keeping local officials informed and establishing partnerships with local emergency managers helps communities to be prepared in the event of an emergency.
- **TRIBES:** Native American tribal governments often have unique fire safety and electric service needs, responsibilities and resources that should be addressed through proactive communications.

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- **CRITICAL CUSTOMERS AND FACILITIES:** These customers (i.e., transmission-level, hospitals, telecommunication providers, water and waste water facilities etc.) benefit from specialized communication to manage service disruptions and resiliency plans.
- **COMMUNITY AND NON-PROFIT ORGANIZATIONS:** Engagement with these groups focuses on emergency preparedness and can play a key partnership role in customer support.
- **MEDIA:** Media relations are managed to disseminate important information broadly and define the narrative.
- **COWORKERS:** Internal communications keep employees informed about company policies so they can effectively communicate the benefits of a wildfire safety program while interacting with customers directly.

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.

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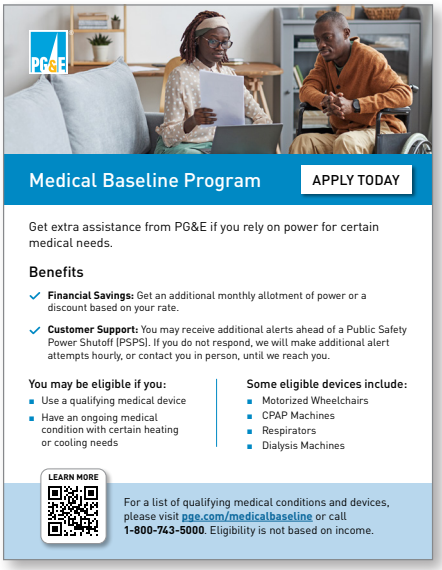
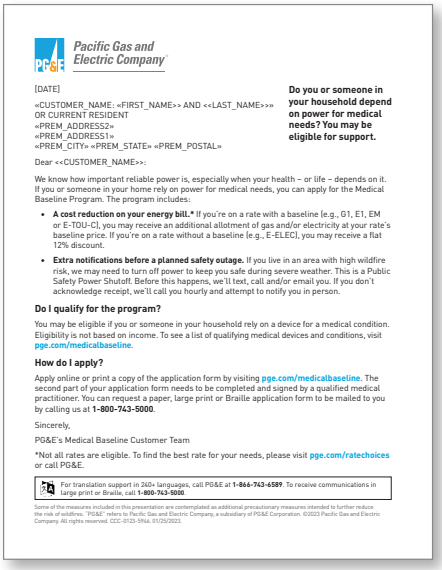
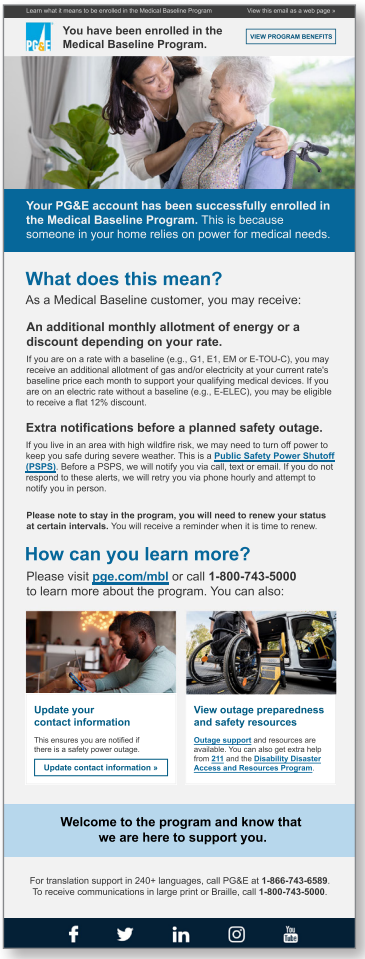
3 Supporting Customers with Access and Functional Needs

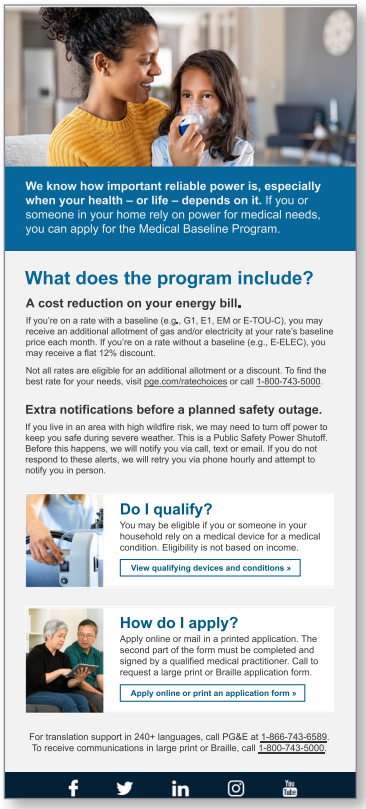
It is crucial to identify the customers within a service territory with Access and Functional Needs (AFN). These customers can be acutely impacted by wildfire safety outages and greatly benefit from preparedness resources. It is important to customize communications for customers with AFN, particularly those with medical needs, ensuring they are fully informed about available programs and the additional resources they may receive if they qualify.

Considerations should be given to multi-cultural paid media campaigns and providing materials in multiple languages, plus Braille and large font. Outreach to these customers should be consistent and lead with resources available to them.









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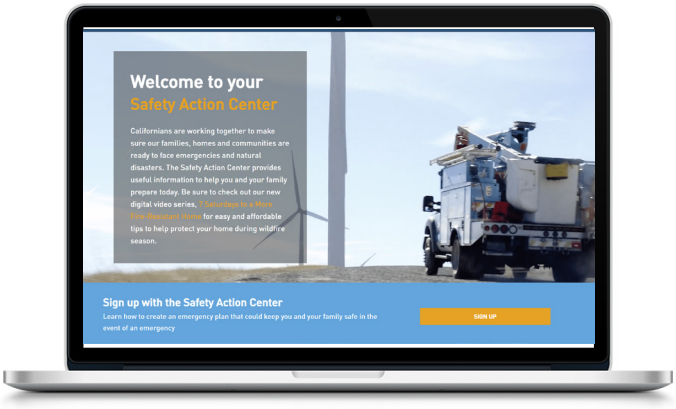
4 Supporting customers and communities

Losing power can be disruptive, so it is important to consider implementing programs that help customers prepare for a safety outage and access resources during one. We offer various programs that support customers before, during and after wildfire safety outages.

- **Portable Battery Program:** Portable batteries are available for eligible Medical Baseline and Self-Identified Vulnerable customers who experienced at least one PSPS in 2021 or five or more EPSS outages in 2022.
- **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.
- **Safety Action Center:** Information and tools are available online to help customers stay safe before, during and after an emergency.
- **211 partnership:** We partner with 211 to provide local resources and support before, during and after times of critical need, such as a PSPS.



- **Food Bank/Meals on Wheels support:** Meal replacement is available to communities impacted by PSPS. Food banks provide meals up until three days after PSPS restoration. We also partner with Meals on Wheels to deliver meals to affected home-bound seniors.

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07 Conclusion

Throughout our wildfire safety journey, we have continued to adapt and build upon learnings. This guidebook, a reflection of that journey, is intended to benefit the sharing of information across our community. We also want this guidebook to be a starting point, a foundation for future versions. With ongoing dialogue and direct input from you, we intend to develop subsequent versions of this document.

Through our collaboration and partnership, we aim to achieve our shared objective: ensuring the safety of the customers and communities we serve.

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

Appendix

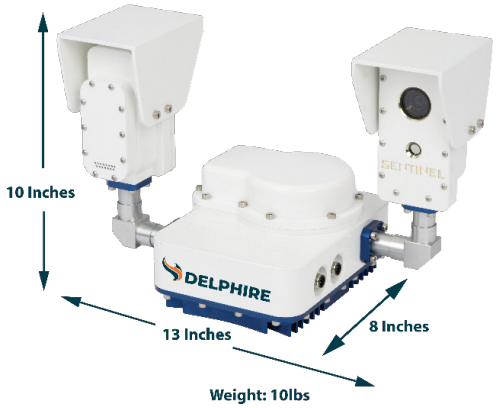
Some of the measures included in this document are contemplated as additional precautionary measures intended to further reduce the risk of wildfires.

Innovative and Emerging Technologies

There are a number of emerging technologies that may assist in near-term wildfire mitigation, including Delphire's Sentinel FD3 and Gridware's Gridscope. These are highlighted below.

1 Delphire's Sentinel FD3

Delphire's Sentinel FD3, developed under a DOE Phase II SBIR, prevents the damage caused from wildfires by providing Electrical Utilities and communities with a real-time, Artificial Intelligence (AI) based detection system that reports fires in their earliest stages and stores images and sensor data for root cause verification. In addition, we provide ongoing monitoring of the area which can identify key risk factors that can be mitigated for future prevention including vegetation treatments, deployment of fire retardant and general hazards in the area.



Our Sentinel FD3 system is power efficient (operates from a solar panel and battery) and processes the data at the edge (AI/ML). This means that our system can be deployed where it is needed, rather than where infrastructure is available.

We also included weather sensors (temperature, humidity, wind speed/direction), thermal cameras (to detect heat or see through thick smoke) and chemical sensors (to detect smoke in the area).

The edge processing allows us to operate even where no cellular signal is available, as our data footprint is small enough to leverage Iridium Satellite modems. The Edge AI component also filters down the data from thousands of our monitoring stations so that they can be handled by just one operator to discern false positives in seconds.

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By providing this rapid visual confirmation, from anywhere, we are the only solution that can stop the fires from reaching their critical self-sustaining stage and provide root-cause analytics to enhance future prevention.

We can also differentiate from other AI-based wildfire detection technologies by working below the forest canopy line near communities and along the grid infrastructure while using AI algorithms for detection of fire and/or smoke, chemical sensors to detect gases and/or smoke, and a thermal camera to detect smoldering heat. This combination allows us to reliably detect several different types of fires, expected in different geographical areas, each during the incipient phase, while gathering key data impactful to the insurability of communities.

2 Gridscope

Deployed on transmission and distribution poles, GridscopeTM leverages multiple sensors and on-device signal processing to deliver continuous, real-time grid monitoring - even during outages.

Gridware®

Locating Faults in a Flash

Real-time monitoring designed to make the existing grid more reliable and resilient:

- **Always on.** Operates independent of the grid using solar power to remain online even during power outages.
- **Always connected.** Communicates in the remotest areas using a combination of device-to-device, cellular and satellite communications.
- **Durable.** Designed to survive harsh environments with resistance to UV, water, dust extreme winds and snow.
- **Cloud-free intelligence.** Analog and digital signal processing with advanced analytics engine developing actionable insights locally on the device.
- **Easy to Install.** Plug-and-play installation in minutes with no disruption to operations or infrastructure upgrades needed.

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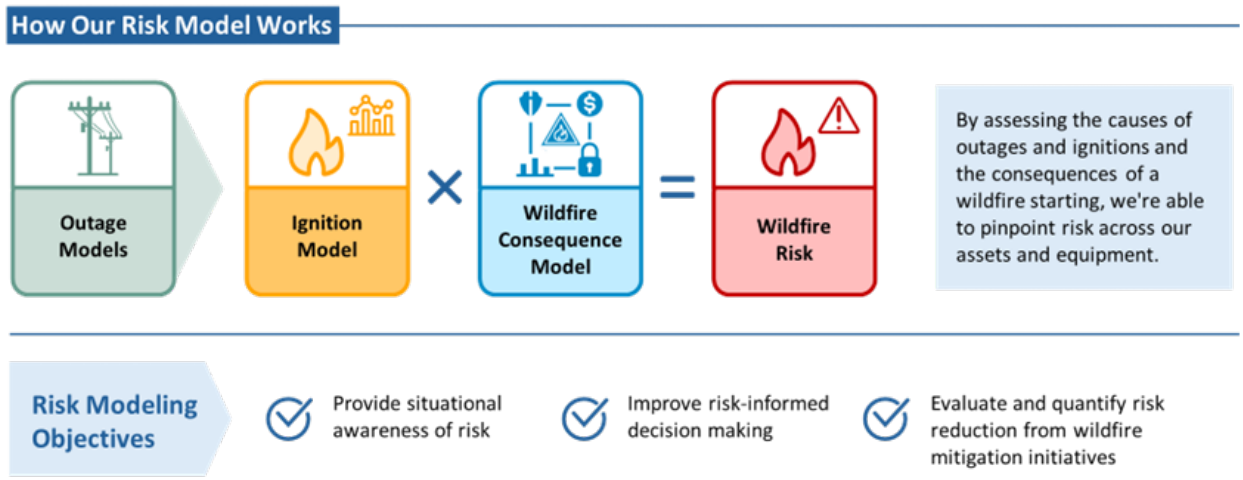
Planning Risk Models

Our risk modeling supports all our wildfire mitigation activities. Developing risk models can be an important step in maturing a wildfire safety program.

1 What is Risk Modeling

Risk modeling involves assessing the likelihood and impacts of potential wildfires to help us prevent them in the future.



2 Why We Model Risk

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

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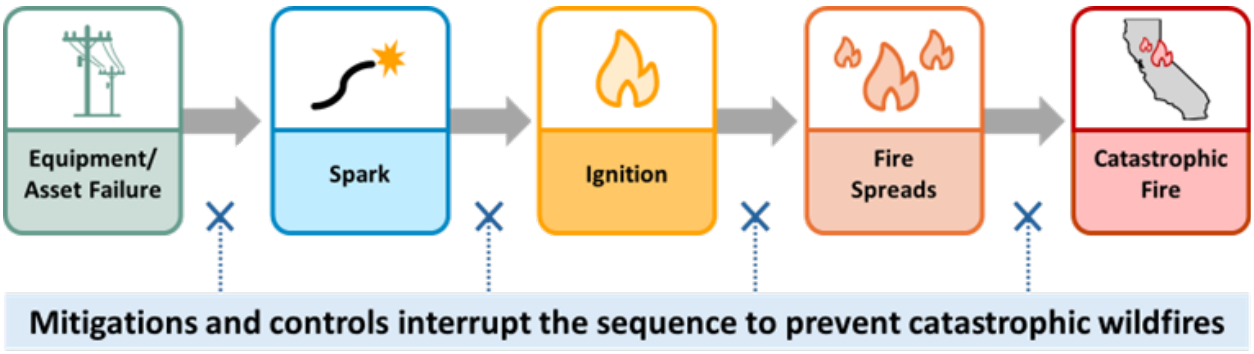
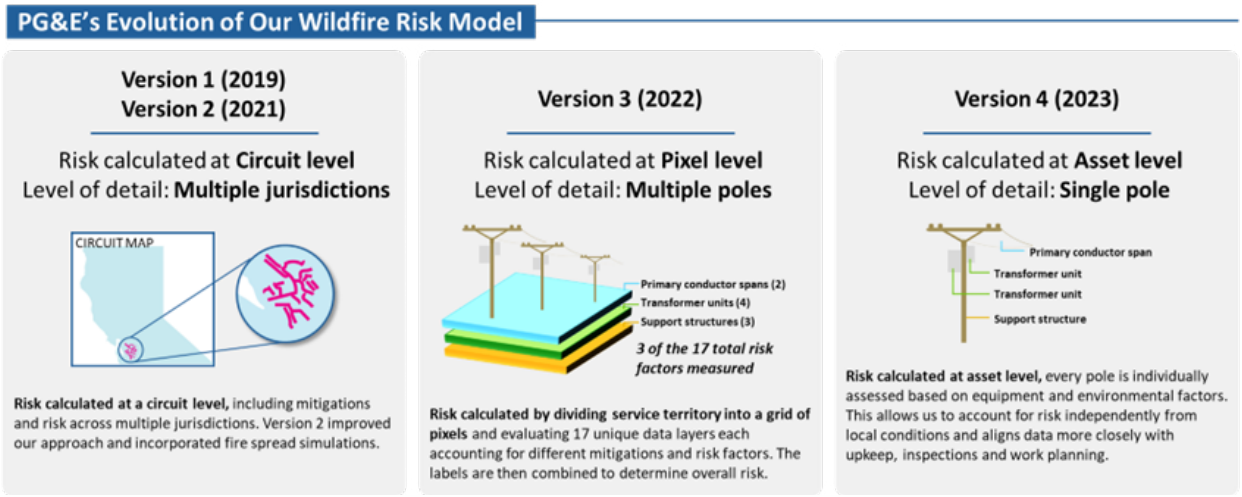
3 Interrupting the Wildfire Sequence

Utility-attributable fires may follow a common sequence. At any given location, our models provide insight as to which mitigation strategy will be most effective.



4 Advancing our Risk Model

We continue to improve our risk modeling to better target our wildfire mitigation work and provide a more granular view of risk.



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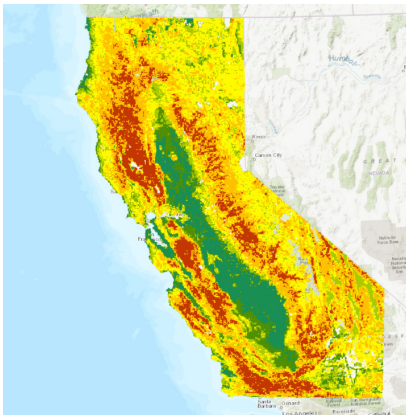
References

[1] **PG&E's Fire Potential Index (FPI)** combines fire weather parameters, fuel moisture data, topography, and fuel type data to predict the likelihood of large and/or catastrophic fires. It is calculated at a granular, 2 km pixel level each hour of the day to drive operational decisions to reduce the risk of utility-caused fires.

Fire Potential Index (FPI) Model



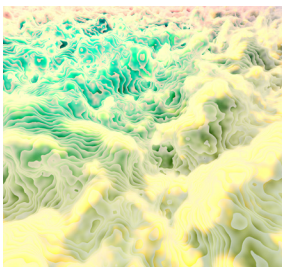
The FPI Model shows the probability that a fire will become large or catastrophic, which is considered as part of the PSPS decision-making process.

FPI is used as a daily and hourly tool to drive operational decisions to reduce the risk of utility-caused fires. In 2019 it was enhanced, then again in 2021 with additional data and improved analytical capabilities.

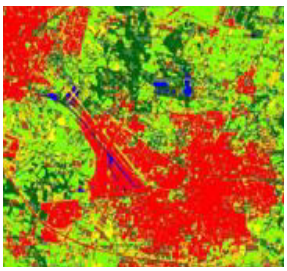
The current FPI Model combines the following to predict the probability of large and/or catastrophic fires:

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

Fuel moisture data: <u>dead fuel:</u> dead grass, fallen branches; <u>live fuel:</u> grass, growing shrubs



Topography: terrain ruggedness, slope, wind-terrain alignment



Fuel type data: grass, shrub, timber, urban

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[2] **PG&E's Outage Producing Winds (OPW)** is a Catboost multi classification machine learning model applied to outage data and the weather at location and time of each 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. Major key features for determining an OPW model are weather (wind speed, turbulence temperature, precipitation vapor pressure deficit), vegetation risk, and local performance.

[3] **Catastrophic Fire Probability (CFPd),** 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 a PSPS event is necessary. The most likely scenario for a PSPS event. PSPS events are most necessary when there is a wind event with dry fuels, these events have a high outage and ignition probability and a high probability of an ignition becoming a catastrophic fire.

[4] **Ignition Probability Weather (IPW)** uses more than 30 years of weather data to provide the likelihood of an outage for specific circuits based on previous weather events. Similar to the OPW model, data is 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. To determine the IPW, our team uses the Ignition Rate per Cause, 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 type has unique outage to ignition relations, with vegetation and equipment-structural having the highest ignition per outage relations based on our modeling.

Calculating IPW

$$IPW = P(\text{Ignition}) = \sum_{\text{type}}^{\text{cause types}} P(\text{Outage}_{\text{type}}) * P(\text{Ignition}_{\text{type}} | \text{Outage}_{\text{type}})$$

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Contributors

We sincerely thank all contributors and participants of Version 1 of this Guidebook, including those not individually listed. Your expertise and dedication have been crucial in shaping this vital source.

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