Wildfire Workbook
Chapter Two
Mitigation Measures - Grid Hardening, Operational Practices, and Vegetation Management

Jody Raines
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01 Chapter Introduction

This chapter covers grid hardening measures, operational practices, and vegetation management. There are several Deep Dives that delve into the subject matter as suggested by members of the Wildfire Working Group, such as a discussion of the types of vegetation and how it varies greatly across the nation, and the impact that these variations in naturally occurring plants, terrain and forestation may have on management with respect to minimizing wildfire risk. Deeper dives into operational and grid hardening approaches are also provided, with cost/benefit information for consideration.

Summary

- Utilities can fortify infrastructure and manage vegetation to reduce wildfire ignition risks, with standards for grid hardening utilizing methodologies including undergrounding and covered conductors, and proactive vegetation protocols in high-risk zones.
- Cost-effectiveness balanced with risk reduction guides grid hardening decisions, while vegetation management activities prioritize high-risk areas and adjust based on weather conditions.
- Regular surveys and quantitative risk assessments for infrastructure visibility serve to balance short-term reliability with long-term safety.

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Grid Hardening Overview

Understanding Ignition Sources

Wildfires can be sparked by electrical distribution (and transmission) systems through several mechanisms:

- **Power Line Contact**: Lines clash with each other or vegetation during high winds, causing sparks or arcing.
- **Equipment Failures**: Malfunctions in transformers, insulators, or other components leading to sparks or overheating.
- **Vegetation Proximity**: Overgrown trees or brush near lines igniting from electrical faults or arcing.
- **Animal Interference**: Birds, squirrels, or other animals causing short circuits by bridging conductors.
- **Environmental Conditions**: High winds, low humidity, and high temperatures exacerbating ignitions.

Utilities can harden and strengthen their grids against wildfires through methods like undergrounding power lines, using covered conductors, and implementing microgrids. Regulators can ask how utilities assess the cost-effectiveness of these methods, prioritizing areas based on wildfire risk and population density. For example, PG&E has a plan to underground 10,000 miles of power lines in high-risk areas (System Hardening & Undergrounding).

Catalog of Grid Hardening Approaches

Below is a breakdown of several grid hardening strategies specifically addressing wildfire risk, organized by approach, with tables summarizing costs and benefits where applicable.

1. Undergrounding Power Lines

- **Description**: This involves relocating overhead distribution (or transmission) lines underground to eliminate exposure to vegetation, wind, and other ignition triggers, significantly reducing wildfire ignition risks.
- **Cost**: Ranges from $1.4 million to $5 million per mile, depending on terrain, population density, and voltage level. For example, PG&E plans to underground 10,000 miles in California, with ratepayer costs potentially offset by federal grants.

- **Benefits**
  - Nearly eliminates ignition risk from downed lines or vegetation contact.
  - Improves reliability by reducing outages from weather events.
  - May minimize Public Safety Power Shutoffs (PSPS).
  - Decreases the need for future tree and vegetation work, lowering long-term maintenance costs.
  - May increase lifespan of underground lines, depending on where they are installed and considering environmental factors.
  - It can be cost-effective in areas with frequent severe weather, like storms or hurricanes.

- **Considerations for Cost-Benefit Analysis:**
  - **Pros:** Significantly reduces potential for utility-caused catastrophic wildfires.
  - Provides long-term reliability and potentially reduces operations and maintenance costs.
  - **Cons:** High upfront capital investment costs and slow deployment (years per project). Not feasible for all regions due to geological or financial constraints. May result in longer outage times to find and fix faults. May create additional costs and implementation complications for communications equipment that may share utility poles.
  - **ROI:** Best suited for high fire-threat zones with dense populations.
  - **Example:** An example is in Beadle County, South Dakota. A FEMA case study shows that burying lines cost $11,570 per mile in 1996, compared to an estimated $18,000 per mile for overhead lines by 2010. However, the underground lines paid for themselves after just two damaging weather events, as the cumulative cost of repairing overhead lines after multiple storms exceeded the initial burial cost. This suggests undergrounding is cost-effective in regions prone to severe weather like tornadoes and ice storms.
  - Another more updated example is a report by Public Utilities Fortnightly published in 2022 that points to decreased cost for directional boring may result in lowered costs for undergrounding.

2. Covered Conductors

- **Description**: Installing insulated power lines, known as covered conductors, to prevent ignition from vegetation contact or line faults, offering potentially faster and less costly alternative to undergrounding, depending upon siting, permitting and approvals.
- **Cost**: Ranges from $100,000 to $500,000 per mile, significantly less than undergrounding, making it a scalable option for utilities.
- **Benefits**
  - Reduces ignition risk by insulating lines from vegetation and debris, preventing arcs and sparks, possibly caused by slapping conductors in wind events.
  - Has potential to allow faster deployment than undergrounding, enabling rapid risk reduction in high-threat areas.
  - Enables higher wind speed thresholds before PSPS, improving reliability and customer satisfaction.

- **Considerations for Cost-Benefit Analysis**
    - **Pros**: Cost-effective alternative to undergrounding, with faster deployment and potential risk reduction. Simulations show covered conductors produce negligible current and energy during contact (e.g., 0.04 mA vs. 2730 mA for bare wires), preventing ignitions. Utilities like Southern California Edison (SCE) have deployed thousands of miles of covered conductor, estimating a 55%–65% reduction in catastrophic wildfire losses.
    - **Cons**: Does not eliminate all risks (e.g., downed lines can still cause fires). Requires ongoing maintenance to ensure insulation integrity, adding recurring costs.
    - **ROI**: High in moderate to high-risk areas where undergrounding is cost prohibitive. California's Public Advocates Office recommends prioritizing covered conductors for faster, broader risk mitigation.
    - **Example**: SCE's deployment of 6,200 circuit miles by 2023 covers ~60% of overhead conductor circuit miles in high fire risk areas, demonstrating scalability and effectiveness. SCE estimates a related 55% reduction over one year and a related-65% reduction over three years in catastrophic wildfire losses.

3. Pole Strengthening, Wrapping and Replacement

- **Description**: Replacing wooden poles with fire-resistant materials (e.g., steel or concrete) and securing them with guy wires to withstand high winds and fire exposure, enhancing grid stability.
- **Cost**: Ranges from $10,000 to $50,000 per pole, depending on material and location, making it a moderate-cost option compared to undergrounding.
- **Benefits**
    - Reduces the likelihood of pole failure igniting fires, particularly during high wind events.
    - Enhances grid stability during extreme weather, reducing outages and improving reliability.
    - Can be prioritized in high-risk areas based on risk models, optimizing resource allocation.

- **Considerations for Cost-Benefit Analysis**

    - **Pros**: More affordable than undergrounding, with significant risk reduction in fire-prone areas. Data-driven prioritization (e.g., PG&E's risk model targeting 22% of lines for 95% of risk) optimizes impact and climate adaptation studies suggest resilience benefits.
    - **Cons**: Does not address conductor-related ignitions. Replacement is labor-intensive and requires ongoing inspections, adding to operational costs. May push risk to the next weakest link (cross arm, conductor).
    - **ROI**: Cost-effective for high-risk rural areas. While specific wildfire-focused cost-benefit analyses are limited, studies on climate adaptation (e.g., for wind resistance) indicate potential savings of hundreds of millions of dollars over asset lifecycles, indirectly supporting wildfire mitigation.
    - **Example**: Florida Power & Light's $5 billion investment in grid reliability efforts, including pole replacement post-Hurricane Wilma also reduced wildfire risk, demonstrating co-benefits. Replacing wooden poles with stronger materials like concrete and steel makes them less susceptible to damage from storms, and also less susceptible to sparks from downed power lines. Their program also includes inspecting and replacing poles on a regular basis.

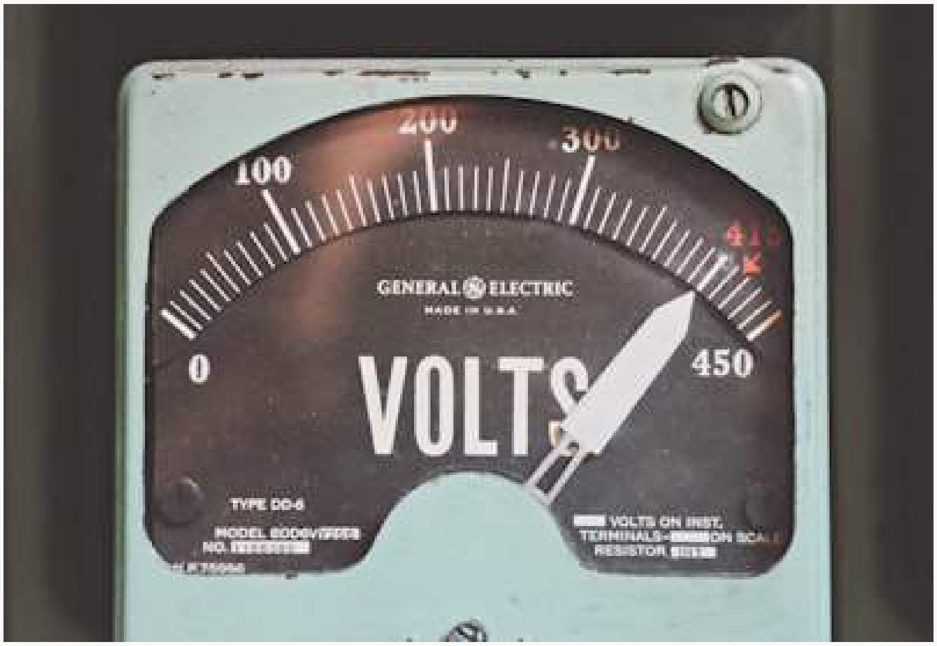
4. Technology Driven Vegetation Management

- **Description**: Using technologies like LiDAR, satellite imagery, machine learning, and manual trimming to manage vegetation near power lines, reducing contact-related ignitions, a leading cause of utility-related fires.
- **Cost**: Annual costs range from $5,000 to $30,000 per mile, depending on technology and vegetation density, making it a recurring but scalable investment.
- **Benefits**
    - Prevents vegetation contact, accounting for 19% of wildfires from 2016-2020, significantly reducing ignition risks.
    - Real-time monitoring with technologies like LiDAR improves precision and efficiency, aligning efforts with risk profiles.
    - Meets regulatory mandates (e.g., California's CPUC requirements), for compliance and safety.

- **Considerations for Cost-Benefit Analysis:**

    - **Pros:** Immediate impact on risk reduction. Technologies like machine learning lower long-term costs by targeting high-risk areas, with PG&E's data showing targeted management reducing 98% of risk in undergrounded lines, and additional layers of wildfire protection to reduce CPUC reportable ignitions on EPSS enabled lines in High Fire District areas contributing to significant reduction in risk.
    - **Cons:** Recurring costs and environmental concerns (e.g., habitat disruption). Effectiveness depends on consistent execution, requiring ongoing investment.
    - **ROI:** High when integrated with risk models. Part of a broader $100 billion investment gap for wildfire mitigation across U.S. utility grids, suggesting cost-effectiveness in high-risk areas.
    - **Example:** An example of using LiDAR, machine learning, and manual trimming for vegetation management near power lines is the work done by **Pacific Gas and Electric (PG&E)** in California.
        - **LiDAR Deployment:** PG&E employs helicopter-mounted LiDAR systems to survey thousands of miles of their transmission and distribution lines. LiDAR creates high-resolution 3D point clouds, mapping vegetation, power lines, and terrain with centimeter-level accuracy. For instance, in their wildfire-prone service areas, LiDAR identifies trees within critical clearance zones (e.g., 4 feet from distribution lines or 10 feet from transmission lines), detecting potential hazards like overhanging branches or leaning trees.

- **Considerations for Cost-Benefit Analysis (continued):**
  - Machine Learning Analysis: PG&E integrates LiDAR data with machine learning models to analyze vegetation risks. These models, trained on historical outage data and vegetation characteristics, classify trees by risk level based on proximity, species, and growth patterns. For example, a 2020 initiative used machine learning to prioritize areas with fast-growing species like eucalyptus near power lines in Northern California. The models also incorporate weather data to flag high-risk zones during fire season, improving proactive maintenance.
  - Manual Trimming: Based on the prioritized risk map from machine learning, PG&E deploys certified arborists to trim or remove hazardous vegetation. In 2022, PG&E's vegetation management program involved trimming over 1.4 million trees across 25,000 miles of power lines. Crews use tools like chainsaws and aerial lifts to clear branches, ensuring compliance with California's strict clearance regulations (e.g., CPUC General Order 95). In environmentally sensitive areas, they work with ecologists to minimize impacts, such as preserving habitats for endangered species.
  - Outcome: PG&E's use of LiDAR and machine learning has reduced tree-related outages by approximately 30% in targeted areas. This approach enhances grid reliability, mitigates wildfire risks, and optimizes resource allocation, saving millions in outage-related costs. For more details, see PG&E's wildfire mitigation strategies: PG&E Wildfire Safety.



5. Fast-Trip Settings and Protective Devices

- **Description**: Implementing advanced safety settings (e.g., fast-trip or enhanced powerline safety settings) to de-energize lines rapidly during faults, preventing ignition, a low-cost operational measure.
- **Cost**: Ranges from $50,000 to $200,000 per circuit for installation and calibration, offering a scalable and rapid deployment option.
- **Benefits**
    - Shuts off power before faults ignite vegetation, reducing ignition risks during high wind events.
    - Low-cost compared to physical infrastructure upgrades, enabling system-wide deployment with minimal disruption.
    - Complements other hardening measures, enhancing overall risk reduction.

- **Considerations for Cost-Benefit Analysis**
  - **Pros**: Rapid deployment and significant risk reduction. Studies by the Energy Institute at Berkeley Haas find fast-trip settings are significantly more cost-effective than undergrounding per avoided ignition and per avoided structure burned, even after accounting for outage impacts.
  - **Cons**: Increases outage frequency and is typically paired with other mitigations, requiring precise calibration to avoid unnecessary shutoffs, which can affect customer satisfaction.
  - **ROI**: High due to low cost and immediate impact. PG&E reports reduced ignitions since July 2021, supporting its effectiveness.
  - **Example**: A 2025 study using data from 25,000 miles of high-risk lines confirms fast-trip settings reduce risk more cost-effectively than conventional measures.

6. Advanced Sensors and Monitoring Systems

- **Description**: Deploying sensors, cameras, and weather stations to monitor grid health and detect wildfire risks in real time, enabling preemptive action and enhancing situational awareness.
- **Cost**: Ranges from $1,000 to $10,000 per sensor, plus $100,000 to $1 million for system integration, offering a scalable technology solution.
- **Benefits**
    - Early detection of faults or fire conditions prevents ignitions, providing actionable insights for proactive management. This requires a plan with the right people and actions.
    - Granular data reduces the scope and duration of PSPS, improving customer experience.
    - Enhances response coordination with local jurisdictions, utilities, and emergency management agencies, supporting community safety during wildfire events.

- **Considerations for Cost-Benefit Analysis**
  - **Pros**: Cost-effective for large-scale risk monitoring. Provides real-time data for risk assessment, with utilities like SDG&E using synchrophasor-based systems for line break protection. Essential for early detection, as highlighted by NASA's Fire Information System.
  - **Cons**: Requires ongoing maintenance and data integration, with effectiveness depending on system-wide adoption and interoperability.
  - **ROI**: High in high-risk areas, though specific cost-benefit analyses are limited. The technology's role in real-time risk management makes it a critical component, with potential savings from reduced PSPS impacts.
  - **Example**: PG&E's sensor network supports precise PSPS decisions, reducing customer impact and enhancing operational efficiency.

7. Microgrids and Distributed Energy Resources (DERs)

- **Description**: Installing localized power systems (e.g., microgrids, battery storage) to maintain service during PSPS or wildfire-related outages, enhancing community resilience.
- **Cost**: Ranges from $1 million to $10 million per microgrid, depending on capacity and complexity, representing a high upfront investment.
- **Benefits**
    - Reduces reliance on high-risk transmission lines, maintaining power for critical infrastructure during outages.
    - Mitigates PSPS effects on vulnerable populations, enhancing community safety.
    - Supports integration of distributed energy resources.

- **Considerations for Cost-Benefit Analysis**
  - **Pros**: Enhances resilience and reduces PSPS impact, with federal funding offsetting costs. Benefits increase with scale, particularly in high-risk, densely populated areas.
  - **Cons**: High upfront costs and complex integration with existing grids. Not a direct ignition prevention measure, limiting its wildfire-specific impact.
  - **ROI**: Moderate to high in high-risk areas, with potential for long-term savings from reduced outage costs. Federal support, like Holy Cross Energy's $145 million WARN project, demonstrates cost-sharing feasibility.
  - **Example**: Holy Cross Energy's project across 16 states enhances resilience, leveraging federal and private investments for broader impact.

8.Reclosers

- **Description**: Reclosers are automatic switching devices integral to electric power systems, designed to isolate faults such as short circuits or overloads by temporarily interrupting and restoring power. In the context of wildfire mitigation, electric utilities are increasingly leveraging reclosers by adjusting their settings to enhance sensitivity, enabling rapid de-energization of power lines when potential faults are detected.
- **Cost**
    - **Equipment and Installation**: $2,000–$50,000 per recloser, plus $5,000–$15,000 for **installation.**
    - **Upgrades**: $1,000–$20,000 per unit for settings or hardware **retrofits.**
    - **Operational**: $500–$2,000 per recloser annually for maintenance, plus $50,000–$200,000 for training and $10,000–$50,000 for monitoring **systems.**
    - **Indirect**: $100,000–$1 million annually for outage-related costs.
- **Benefits:**
    - **Wildfire Prevention**: Reducing ignition risks potentially saves billions in potential liabilities, property damage, and fire suppression costs.
    - **Grid Reliability**: Over time, reclosers prevent catastrophic failures, reducing outage duration and costs compared to wildfire-related disruptions.

- **Considerations for Cost Benefit Analysis**

    - **Pros:** Utilities like PG&E, SCE, and SDG&E demonstrate that recloser investments are a cost-effective component of wildfire mitigation, despite challenges like increased outages.
    - **Cons**: Advanced reclosers with real-time monitoring require integration with SCADA systems, adding $10,000–$50,000 per substation or control center (Source: Eaton Reducing Wildfire Risk).
    - Maintenance is required, includes inspections, testing, and minor repairs, costing $500–$2,000 per recloser annually (Source: T&D World Recloser Maintenance).

- **ROI**: Studies suggest reclosers are cost-effective, with a return on investment through avoided wildfire costs. For instance, Eaton notes that intelligent grid solutions like reclosers reduce outage duration and environmental impact, outweighing initial costs (Source: Eaton Reducing Wildfire Risk).
- Example: **San Diego Gas & Electric (SDG&E)**: Sensitive Relay Profile (SRP), used since 2010. **Cost Details**: Remote activation of sensitive settings costs $1,000–$5,000 per recloser event, with annual program costs of $10–$20 million for recloser maintenance and outage management (Source: CPUC SDG&E Fast Trip Presentation

The Difference Between Reclosers and “Fast Trip”

Feature	Recloser	"Fast Trip"
Primary Function	A device that automatically interrupts a circuit and re-energizes it, typically with multiple attempts.	A rapid action or setting on a protective device to interrupt a circuit almost instantly upon detecting a fault.
Purpose	To minimize long-term outages caused by temporary faults, such as a tree branch briefly touching a line.	To quickly de-energize a line and prevent a sustained arc during high-risk periods (e.g., to reduce wildfire risk).
Standard Operation	Performs a programmed sequence of opening and closing. For example, it might trip, then try to reclose after a few seconds. If the fault persists, it trips again.	It is a setting within the recloser's protective controls, often used for the first trip in a sequence. It can also be a one-time, non-reclosing trip on another device.
Response to Permanent Fault	Locks open after several attempts to reclose have failed. A utility crew must then repair the line and manually reset the recloser.	The device will trip, and its subsequent actions (reclose or lock out) are based on the full sequence programming of the recloser or other protective equipment.
Application	Widely used on overhead power distribution lines, where temporary faults are common.	Increasingly used in high-risk areas, like those prone to wildfires, to prevent a sustained arc from igniting vegetation.

Summary of Approaches, Cost Range and Benefits

Below are tables summarizing the costs and benefits for each approach, facilitating comparison:

Approach	Cost Range	Key Benefits
Undergrounding Power Lines	$1.4M–$5M per mile	Eliminates ignition risk, improves reliability, reduces maintenance
Covered Conductors	$100K–$500K per mile	Reduces ignition risk, fast deployment, enhances PSPS thresholds
Pole Strengthening and Replacement	$10K–$50K per pole	Enhances stability, reduces pole failure risk
Enhanced Vegetation Management	$5K–$30K per mile annually	Prevents contact ignitions, improves precision with tech
Fast-Trip Settings	$50K–$200K per circuit	Rapid fault de-energization, low-cost, system-wide deployment
Advanced Sensors	$1K–$10K per sensor + integration	Early detection, real-time risk assessment, reduces PSPS scope
Microgrids and DERs	$1M–$10M per microgrid	Maintains service during outages, enhances community resilience

Approach	Cost-Benefit Analysis Summary
Undergrounding Power Lines	High cost, high impact; concerns due to cost distribution, best for dense high-risk areas
Covered Conductors	Cost-effective, rapid deployment; high ROI in moderate-risk areas, complements other measures
Pole Strengthening and Replacement	Moderate cost, indirect wildfire benefits; ROI high in rural high-risk areas, needs more study
Enhanced Vegetation Management	Low cost, immediate impact; high ROI with targeted tech, part of $100B investment gap
Fast-Trip Settings	Low cost, more cost-effective than other grid hardening measures per avoided ignition, rapid deployment
Advanced Sensors	Cost-effective for monitoring, ROI high in high-risk areas, detailed benefits need more data
Microgrids and DERs	High cost, moderate ROI; enhances resilience, federal funding offsets costs

Operational Practices

1. Public Safety Power Shutoffs (PSPS)

- **Definition and Explanation**: PSPS involves temporarily de-energizing power lines during high-risk weather conditions, such as high winds or low humidity, to prevent electrical infrastructure from sparking wildfires. Utilities like Puget Sound Energy and Hawaiian Electric have used this strategy effectively.
- **Relative Cost**: Low. It requires operational adjustments rather than significant capital investment.
- **Potential Benefits**: Reduces ignition risk during peak danger periods, though it may disrupt service and lead to economic losses for customers.
- Regulatory Questions:
    - How does the utility determine when to implement PSPS?
    - What criteria are used to identify high-risk areas for PSPS?
    - How are PSPS events communicated to customers and stakeholders?
    - How are vulnerable communities identified and communicated with?
    - Is there a process to identify essential facilities?

2. Grid Hardening

- **Definition and Explanation**: Grid hardening involves upgrading infrastructure to withstand wildfire risks, such as undergrounding power lines or using fire-resistant materials. This strengthens the grid against environmental threats.
- **Relative Cost**: High. Undergrounding can cost millions per mile, and other upgrades demand substantial funding.
- **Potential Benefits**: Offers a long-term reduction in ignition risk and improves overall grid reliability, though it requires significant upfront investment.
- **Regulatory Questions**
    - What percentage of high-risk power lines have been undergrounded or hardened?
    - What is the timeline for completing grid hardening projects in high-risk areas?
    - How are grid hardening projects prioritized?
    - What other methods are being used to grid harden?

3. Proactive Vegetation Management

- **Definition and Explanation**: This strategy entails regular trimming and maintenance of vegetation near power lines to prevent contact that could spark fires. It is a proactive measure to manage natural fuel sources.
- **Relative Cost:** Moderate. Ongoing labor and maintenance are required, but costs are lower than major infrastructure projects.
- **Potential Benefits**: Decreases vegetation-related ignition risks, though it does not eliminate them entirely and requires consistent effort.
- **Regulatory Questions**
    - What is the utility's vegetation management plan, and how often are trimming and inspections conducted?
    - How is compliance with vegetation management standards ensured in high-risk areas?
    - What technologies or methods are used to monitor vegetation growth and health?
    - How do you balance the cost of vegetation management with other mitigation efforts?

4. Advanced Monitoring and Detection

- **Definition and Explanation**: Utilities deploy technologies like cameras, sensors, and satellites to detect wildfires early and assess risks in real time, enhancing situational awareness.
- **Relative Cost**: Moderate to high. Involves initial technology investment and ongoing maintenance.
- **Potential Benefits**: Enables early intervention, potentially reducing wildfire spread and damage, though it does not prevent ignitions.
- **Regulatory Questions**
    - What technologies are used for wildfire detection and monitoring?
    - How is real-time data integrated into risk assessment and decision-making?
    - What is the coverage area of monitoring systems in high-risk zones?

5. Operational Protocols

- **Definition and Explanation**: These are adjustments to grid operations, such as disabling automatic reclosing switches or using fast-trip settings, to minimize ignition risks during high-risk conditions.
- **Relative Cost**: Low to moderate depending upon whether the change is manual. (if already installed). Primarily involves procedural changes rather than physical upgrades. Implementing these procedural changes can be time consuming and will increase the cost.
- **Potential Benefits**: Lowers ignition risk with minimal investment but may affect service reliability and is not a comprehensive solution.
- **Regulatory Questions**
    - What specific operational changes are implemented during high-risk periods?
    - How is the balance between reliability and wildfire risk reduction managed?
    - What training do staff receive on wildfire risk mitigation protocols?

6. Emergency Response Planning

- **Definition and Explanation**: This involves creating and rehearsing plans to respond to wildfire incidents, including coordination with local agencies and communities for swift action.
- **Relative Cost**: Low. Focuses on planning, training, and coordination rather than infrastructure costs.
- **Potential Benefits**: Enhances response speed and effectiveness, minimizing damage and downtime, though it is reactive rather than preventive.
- **Regulatory Questions**
  - Can the utility provide details of its emergency response plan for wildfire incidents?
  - How often are drills or exercises conducted with local agencies and communities?
  - What metrics are used to evaluate the effectiveness of the emergency response plan?

03

Vegetation Management Strategies

Vegetation management involves regular tree trimming and clearing brush near power lines, especially in high-risk zones. It is a cornerstone of wildfire risk mitigation, as contact between powerlines and trees or brush can ignite fires. Utilities typically identify appropriate vegetation management cycles for the specific terrain in their service areas, adjust activities based on weather and adopt technologies like drones or LiDAR for monitoring. Effective vegetation management strategies reduce ignition risks, enhance grid reliability, and ensure public safety. Regulators can inquire about protocols for federal or state land, ensuring collaboration with land agencies (Vegetation Management Program).

Practices for Vegetation Management

1. Regular Inspections and Maintenance

- **Description: Conduct regular inspections of overhead powerlines and surrounding vegetation to identify potential hazards.** In high fire-threat areas, more frequent inspections are necessary due to elevated risks.
- **Implementation**: Utilities like Pacific Gas & Electric (PG&E) inspect approximately 100,000 miles of powerlines annually (PG&E Vegetation Management). Inspections prioritize areas with historical tree-related outages or high fire risk. Avista in North Idaho has routine vegetation management on a 5 year cycle, while they have another program to do 100% distribution inspections for risk trees. Idaho Power and PacifiCorp are on a 3-year cycle for routine and have annual inspections in highest risk zones.

- **Technology Integration**: Use advanced tools such as Light Detection and Ranging (LiDAR), drones, aerial imagery, and infrared cameras to assess vegetation encroachment efficiently. The Western Area Power Administration (WAPA) employs these technologies to prioritize maintenance in high fire-threat areas (WAPA Risk Management).
- **Benefits**: Regular inspections prevent vegetation contact, reducing the likelihood of ignitions. Data-driven prioritization optimizes resource allocation.

- **Description**: Prune or remove trees and vegetation that may grow into or encroach powerlines and other infrastructure, adhering to specific clearance requirements based on fire threat levels.

2. Pruning and Removal of Vegetation

- **Clearance Standards**
  - **Distribution Lines**: Maintain at least 18 inches of clearance in non-high fire-threat areas and 4 feet in High Fire-Threat Districts (HFTD), with 12 feet recommended at pruning to ensure year-round compliance (PG&E Vegetation Management).
  - **Transmission Lines**: In the "wire zone," vegetation should be maintained at no more than 10 feet tall when fully grown (may not apply in HFTD). In the "border zone," trees must not exceed 15 feet. In the "outer zone," remove trees with potential to fall into powerlines.
  - **Poles and Towers**: Clear vegetation within a 10-foot radius around the base and remove brush up to 8 feet above ground.

- **Implementation**: PG&E prunes or cuts down over one million trees annually to maintain safe distances. Utilities can focus on hazard trees identified through risk models.
- **Benefits**: Proper pruning reduces ignition risks by preventing contact during high winds or dry conditions. Clearances around poles minimize fire spread.

3. Use of Certified Professionals

- **Description**: Employ trained and certified arborists to ensure proper vegetation management techniques.
- **Standards**: Use professionals with International Society of Arboriculture (ISA) credentials, such as Certified Arborists, Certified Tree Climbers, or Tree Risk Assessment Qualification (TRAQ) Inspectors.
- **Implementation**: PG&E requires qualified workers for all tree work, ensuring compliance with safety and fire prevention standards.
- **Costs**: High. As utilities all over the west are hiring the limited, available trained professionals, the demand is driving contracted prices upwards.
- **Benefits**: Certified professionals minimize errors, enhance safety, and ensure regulatory compliance, reducing the risk of outages or fires.

4. Integration of Wildfire Risk Models

- **Description**: Use data-driven wildfire risk models to prioritize vegetation management efforts in high-risk areas.
- **Implementation**: PG&E employs risk models to identify areas with high historical tree-related outages or elevated fire risk, targeting 95% of risk in 22% of line miles (PG&E Vegetation Management). Models incorporate terrain, vegetation density, weather patterns, and fire history.
- **Benefits**: Risk models optimize resource allocation, focusing efforts on areas with the greatest potential for ignition, thereby maximizing impact.

5. Integrated Vegetation Management (IVM)

- **Description**: Implement IVM (Integrated vegetation management) programs that combine selective herbicide applications, mechanical trimming, prescribed burns, and biological methods to control vegetation growth.
- **Implementation**: Corteva Agriscience recommends IVM with selective herbicides to manage trees and tall-growing brush, promoting low-growing plant communities (e.g., grasses, herbs) as fuel breaks (Corteva Vegetation Management). CAL FIRE uses prescribed fire and mechanical means to reduce surface and ladder fuels (CAL FIRE VMP).
- **Specific Applications**
    - Chemical side-trimming to control branches threatening equipment.
    - High-volume foliar applications and spot treatments for entire trees or brush.
    - Dormant-season applications to extend treatment windows.
- **Benefits**: IVM enhances ignition prevention, optimizes fuel management, and creates fire-resistant landscapes. Low-growing vegetation reduces fire spread.

6. Community Engagement and Landowner Coordination

- **Description**: Engage with local communities and landowners to ensure cooperation and access to rights-of-way (ROWs) for vegetation management.
- **Implementation**: Provide clear communication about activities, including herbicide use, and allow property owners to opt out (PG&E Vegetation Management). Corteva’s "Notify Your Neighbor" guide improves landowner communications (Corteva Fuel Breaks).
- **Benefits**: Community support facilitates timely access to ROWs, reducing delays and conflicts. Transparent communication builds trust.

7. Compliance with Regulations

- **Description**: Adhere to state and federal regulations governing vegetation management, which vary by region.
- **Examples**:
    - **California**: Comply with California Public Utilities Commission (CPUC) guidelines and CAL FIRE regulations, including stricter clearance standards in HFTD (CPUC Wildfires).
    - **Federal Lands**: Follow Bureau of Land Management (BLM) policies under Section 512 of the Federal Land Policy and Management Act, requiring ROW holders to manage vegetation and hazard trees (BLM Policy).
- **Implementation**: Ensure vegetation management plans meet or exceed state and federal fire safety standards, with detailed reporting for activities on federal lands.
- **Benefits**: Compliance reduces legal and financial risks while aligning with national wildfire mitigation goals.

8. Post-Fire Vegetation Management

- **Description**: After wildfires, inspect and clear hazardous vegetation to prevent future ignitions and support grid recovery.
- **Implementation**: PG&E conducts post-wildfire inspections and vegetation clearing to manage regrowth (PG&E Vegetation Management). CAL FIRE recommends prescribed burns to control regrowth in burned areas.
- **Benefits**: Post-fire management prevents secondary ignitions and supports ecosystem recovery, enhancing long-term resilience.

9. Planting and Landscaping Guidance

- **Description**: Encourage proper tree and shrub planting to reduce future pruning needs and promote safety.
- **Implementation**: Advise landowners to plant the right tree in the right place, avoiding tall-growing species near powerlines. Most states recommend calling 811 before digging or planting.
- **Benefits**: Proactive planting reduces long-term maintenance costs and ignition risks.

10. Technology-Driven Monitoring

- **Description**: Leverage advanced technologies for real-time monitoring and early detection of vegetation risks.
- **Implementation**: Use LiDAR, drones, and infrared cameras to monitor ROWs, as practiced by WAPA and PG&E. The Wildland Fire Assessment System (WFAS) provides fire potential forecasts to guide management decisions (WFAS).
- **Benefits**: Technology improves efficiency, reduces costs, and enables proactive risk mitigation, especially in remote areas.

Considerations for Varied Terrain

The U.S. encompasses diverse terrains, each requiring tailored vegetation management strategies to address specific wildfire risks:

Forested Regions (e.g., Pacific Northwest, Southeast)

- **Challenges**: Dense tree canopies act as fire ladders, increasing crown fire risks. Hazard trees are a primary concern.
- **Strategies**
  - Prioritize tree pruning and removal, focusing on species prone to falling or contacting powerlines.
  - Use selective herbicides to control understory growth, reducing ladder fuels.
  - Implement fuel breaks with low-growing vegetation along ROWs.
- **Example**: Utilities in Oregon and Washington focus on hazard tree removal in coniferous forests to prevent ignitions during windstorms.

Grasslands and Chaparral (e.g., California, Southwest)

- **Challenges**: Dry grasses and brush ignite easily and spread fires rapidly, especially during dry seasons.
- **Strategies**
    - Manage grass and brush through mowing, grazing, or herbicide applications.
    - Create fuel breaks by promoting low-growing, fire-resistant plants.
    - Increase inspection frequency during peak fire seasons.
- **Example**: Southern California Edison (SCE) manages chaparral in HFTD with enhanced clearances and fuel breaks (SCE Wildfire Mitigation).

Urban and Suburban Areas

- **Challenges**: Dense infrastructure and residential areas require precise vegetation management to prevent outages and fires.
- **Strategies**
    - Maintain clearances around powerlines in residential and commercial zones.
    - Educate residents on defensible space and proper tree planting.
    - Use manual trimming to minimize environmental impact.
- **Example**: PG&E works with urban communities to prune trees near distribution lines, ensuring compliance with CPUC standards.

Mountainous or Remote Areas

- **Challenges**: Limited access complicates inspections and maintenance, while wind and topography exacerbate fire spread.
- **Strategies**
    - Use drones and helicopters for inspections and maintenance in hard-to-reach areas.
    - Prioritize high-risk corridors identified through risk models.
    - Coordinate with local fire agencies for joint efforts.
- **Example**: WAPA uses aerial imagery in mountainous Western regions to monitor ROWs (WAPA Risk Management).

Wetlands and Sensitive Ecosystems

- **Challenges**: Environmental regulations restrict vegetation management methods to protect ecosystems.
- **Strategies**
    - Use manual trimming or selective herbicides to minimize ecological impact.
    - Conduct environmental assessments before treatments.
    - Collaborate with regulatory agencies to ensure compliance.
- **Example**: Utilities in Florida adapt practices to protect wetlands while maintaining clearances.

High Fire-Threat Districts (HFTD)

- **Challenges**: Extreme fire risk requires stricter standards and proactive measures.
- **Strategies**
    - Implement enhanced clearance standards (e.g., 4 feet for distribution lines).
    - Conduct multiple inspections annually.
    - Integrate with operational measures like Protective Equipment and Devise Settings (PEDS).
- **Example**: PG&E and SCE prioritize HFTD for intensive vegetation management (CPUC Wildfires).

Challenges and Solutions

Access Issues

- **Challenge**: Rural or remote ROWs may be difficult to access, delaying maintenance.
- **Solution**: Use drones, helicopters, or LiDAR for remote inspections. Partner with landowners to secure access agreements.

Cost and Resource Constraints

- **Challenge**: Vegetation management is costly, with annual costs ranging from $5,000 to $30,000 per mile (Corteva Vegetation Management).
- **Solution**: Leverage federal funding, such as the DOE's Grid Resilience and Innovation Partnerships (GRIP) program, which supported Xcel Energy's $242 million vegetation clearance project. Prioritize high-risk areas to optimize budgets.

Regulatory Variability

- **Challenge**: Varying state and federal regulations complicate national standardization.
- **Solution**: Follow national guidelines from organizations like the Edison Electric Institute (EEI) and American Public Power Association (APPA) while adapting to local requirements (EEI Wildfire Mitigation).

Environmental and Community Concerns

- **Challenge**: Herbicide use and tree removal can face opposition due to environmental or aesthetic concerns.
- **Solution**: Offer herbicide opt-outs, use environmentally friendly methods, and communicate benefits clearly to stakeholders.

Case Studies

PG&E (California)

- **Practices**: Inspects 100,000 miles of powerlines annually, prunes or removes over one million trees, and uses risk models to prioritize HFTD. Maintains 4-foot clearances in HFTD and employs certified arborists.
- **Impact**: Reduced ignition risks in high-risk areas, though challenges remain with outage frequency from EPSS (PG&E Vegetation Management).

WAPA (Western U.S.)

- **Practices**: Uses LiDAR, drones, and aerial imagery to monitor ROWs, focusing on high fire-threat areas. Complies with North American Electric Reliability Corporation (NERC) standards.
- **Impact**: Prevents ignitions by reducing vegetation fuels, enhancing grid reliability (WAPA Risk Management).

Xcel Energy (Colorado)

- **Practices**: Implements a $242 million GRIP-funded project for vegetation clearance, integrating with grid hardening measures.
- **Impact**: Enhances resilience in fire-prone regions, supported by federal funding

Southern California Edison (SCE)

- **Practices**: Manages vegetation in chaparral-heavy HFTD with enhanced clearances and fuel breaks. Uses risk-based inspections and certified arborists.
- **Impact**: Reduces wildfire risks in Southern California's fire-prone landscapes (SCE Wildfire Mitigation).

Integration with Broader Wildfire Mitigation

Vegetation management is part of a holistic wildfire mitigation strategy, including:

- **Grid Hardening**: Use covered conductors and pole strengthening to complement vegetation efforts (EEI Wildfire Mitigation).
- **Operational Measures**: Implement PEDS (Protective Electrical Devise Settings) to de-energize lines during faults, reducing ignition risks (CPUC Wildfires).
- **Technology Deployment**: Use sensors and cameras for real-time risk assessment, enhancing vegetation monitoring.
- **Community Preparedness**: Promote defensible space and educate residents on fire safety (CA Fire Safe Council).

Practices to Consider:

1. **Adopt a Risk-Based Approach**: Use wildfire risk models to prioritize high-risk areas, optimizing resource allocation.
2. **Leverage Technology**: Invest in LiDAR, drones, and infrared cameras to enhance inspection efficiency, especially in remote terrains.
3. **Engage Communities**: Build trust through transparent communication and herbicide opt-out options.
4. **Secure Funding**: Research applicable federal programs to offset costs of mitigation actions.
5. **Standardize and Adapt**: Consider national guidelines from EEI and APPA while tailoring practices to local regulations and terrains.
6. **Integrate with Other Measures**: Combine vegetation management with grid hardening, EPSS, and community outreach for maximum impact.

Infrastructure Visibility and Health

Utilities need to track infrastructure location and condition through frequent surveys, using methods like aerial inspections or GIS systems. Regulators should ask about risk assessment processes and how issues are prioritized, ensuring continuous improvement (Electric Utility Asset Management).

Methods for Tracking Infrastructure Location and Condition

1. Geographic Information Systems (GIS)

- **Description**: GIS is a cornerstone technology for electric utilities, enabling the creation of detailed digital maps that track the location and condition of assets like power lines, substations, transformers, and poles. Platforms like ArcGIS Utility Network and GIS Cloud provide robust frameworks for asset management, spatial analysis, and regulatory compliance.
- **Implementation**: Utilities collect data through field surveys, aerial inspections, and sensor networks, integrating this information into GIS databases. These systems allow utilities to visualize infrastructure, analyze usage patterns, and identify risks such as aging equipment or vegetation encroachment.
- **Benefits**: GIS supports real-time monitoring, predictive maintenance, and data-driven decision-making. It also facilitates compliance with regulatory requirements by providing accurate asset inventories.
- **Example**: In Iowa, the Iowa Utilities Commission collaborates with the Department of Management to maintain an updated GIS-based map of electric service boundaries, ensuring accurate tracking of utility infrastructure across the state (Iowa Utility Map).

2. Aerial Inspections and Remote Sensing

- **Description**: Aerial inspections using drones, helicopters, or satellites allow utilities to survey large areas quickly, identifying issues like sagging power lines, damaged poles, or vegetation encroachment.
- **Implementation**: Drones equipped with high-resolution cameras or LiDAR create 3D models of infrastructure, while satellites provide broad coverage for remote regions. These methods are particularly effective in areas with difficult terrain or high wildfire risk.
- **Benefits**: Aerial inspections reduce the need for manual surveys, improving safety and efficiency. They provide comprehensive data for GIS integration and risk assessment.
- **Example**: Xcel Energy, operating in Colorado and other states, uses drones to inspect infrastructure in fire-prone areas as part of its $600 million wildfire mitigation program. Drones help identify equipment needing repair or replacement, enhancing grid reliability (Xcel Energy Wildfire Mitigation).
- **Additional Example**: In Michigan, utilities use aerial inspections to monitor transmission lines, contributing to detailed service area maps maintained by the Michigan Public Service Commission (Michigan PSC Map).

3. Ground-Based Surveys

- **Description**: Field crews conduct ground-based surveys using handheld devices or mobile apps to collect detailed data on infrastructure condition, such as corrosion, wear, or structural damage.
- **Implementation**: Workers record GPS coordinates, condition ratings, and maintenance history, synchronizing this data with GIS systems for real-time updates. These surveys complement aerial inspections by providing granular insights.
- **Benefits**: Ground surveys ensure accuracy for specific assets and verify aerial data, supporting targeted maintenance efforts.
- **Example**: Southern California Edison (SCE) employs field crews to inspect distribution lines in high fire-threat districts, integrating findings into GIS systems to prioritize vegetation management and equipment upgrades (SCE Wildfire Mitigation).

4. Utility Location for Underground Assets

- **Description**: Underground infrastructure, such as cables and pipes, is tracked using ground-penetrating radar (GPR), electromagnetic locators, or tracer wires.
- **Implementation**: Active locating methods send signals through conductive materials to map their location, while detectable tapes or wires are used for non-conductive assets like plastic pipes. Utilities often coordinate with "811" services to mark underground assets before excavation.
- **Benefits**: Accurate mapping prevents damage during construction, ensures safety, and supports regulatory compliance.
- **Example**: Nationwide, utilities participate in the "811" Call Before You Dig program to locate underground infrastructure, reducing the risk of accidental damage during maintenance or construction (Utility Location).

04

Deep Dive: What is PSPS

Public Safety Power Shutoff (PSPS) is a strategy where electric utilities proactively turn off power in specific areas of their system to prevent their equipment from starting wildfires. It is used when weather conditions, like high winds and dry vegetation, increase the risk of power lines sparking fires. Utilities rely on weather forecasts and real-time data to decide when to implement PSPS, often as a last resort to ensure community safety.

Why and How It's Used

PSPS is employed to mitigate wildfire risk in regions prone to fires, especially during extreme weather. Utilities monitor conditions like low humidity, strong winds, and dry vegetation. These conditions can support the ignition and spread of wildfires. By proactively shutting off power, utilities mitigate the risk of such incidents. The process involves notifying customers in advance when possible, de-energizing lines, and restoring power after inspections confirm safety.

Examples of PSPS Events

Utilities in high-risk areas, particularly in California, have used PSPS multiple times. For instance, Pacific Gas and Electric (PG&E) implemented PSPS in October 2021 during high-wind events to prevent fires. Southern California Edison (SCE) and Hawaiian Electric have also used PSPS during similar conditions, targeting areas with elevated wildfire risk.

Risks of PSPS

While generally thought of as effective in reducing the risk of electric utility caused catastrophic fires, PSPS can disrupt daily life, cause economic losses, and pose safety risks, especially for those relying on electricity for medical needs. Short-notice shutoffs due to sudden weather changes can limit preparation time, and extended outages may lead to food spoilage or unsafe generator use. Regulators should also consider the implications to critical infrastructure.

Public Safety Power Shutoff (PSPS) Definition and Purpose

Public Safety Power Shutoff (PSPS) is a proactive measure used by electric utilities to temporarily de-energize power lines in areas at high risk of wildfires, preventing electrical infrastructure from sparking fires. It is typically implemented during severe weather conditions, such as high winds, low humidity, and dry vegetation, which can cause trees or debris to contact power lines, potentially igniting catastrophic wildfires. The primary purpose of PSPS is to enhance community safety by reducing the likelihood of utility-related fire ignitions, which can become catastrophic events, particularly in regions prone to wildfires like California, Oregon, Washington, and Hawaii.

How PSPS is Implemented

The implementation of PSPS involves a structured process driven by data and coordination:

- **Risk Assessment**: Utilities rely on forecasts from fire scientists and meteorologists, combined with real-time field observations, to identify high-risk conditions. Key triggers include:
  - High winds that could damage power lines or blow debris into them.
  - Low humidity levels that increase fire spread potential.
  - Dry vegetation near power lines, acting as fuel.
  - Red Flag Warnings issued by weather authorities.
- **Customer Notification**: Utilities aim to notify customers in advance, typically 2-3 days ahead, through emails, phone calls, or texts. However, sudden weather changes may result in same-day or short-notice alerts.
- Power Shutoff: Power is turned off to specific circuits or regions, often in high-risk wildfire zones (e.g., Tier 2 and Tier 3 areas as defined by the California Public Utilities Commission).
- Inspection and Restoration: After the high-risk period, crews inspect lines to ensure they are safe before restoring power, a process that can take hours to days depending on conditions and daylight availability.

PSPS is considered a last-resort measure, used only when other wildfire mitigation strategies, such as vegetation management or grid hardening, are insufficient to address immediate risks.

Why PSPS is Used

PSPS is employed to address the growing threat of catastrophic wildfires, particularly in areas where changing conditions lead to hotter, drier summers and longer fire seasons. Electrical infrastructure has historically contributed to some of the most destructive wildfires, accounting for roughly half of California's most devastating fires despite being responsible for less than 10% of total wildfires (CPUC PSPS Overview). By temporarily shutting off power, utilities prevent scenarios where damaged or arcing power lines could ignite dry vegetation, especially during extreme weather events. This strategy is critical in high fire-threat areas, where the interconnected nature of the grid means that even non-targeted regions may be affected.

Examples of PSPS Events

PSPS has been widely used, particularly in California, where wildfire risk is acute. Notable examples include:

- **Pacific Gas and Electric (PG&E)**: PG&E has used PSPS as a measure of last resort since 2018, particularly in high fire-risk communities, during windy, dry conditions. (Public Safety Power Shutoffs| PG&E).
- **Southern California Edison (SCE)**: SCE has frequently used PSPS in its 50,000-square-mile service area, particularly in high fire-risk communities, during windy, dry conditions (SCE PSPS Information).
- **Hawaiian Electric**: Implemented PSPS during hot, windy weather in areas with dry vegetation surrounding power lines, as part of its wildfire safety strategy (Hawaiian Electric PSPS).
- **Puget Sound Energy (PSE)**: In Washington, PSE has used PSPS in areas at higher wildfire risk during strong winds and dry conditions, balancing safety with reliable energy delivery (PSE PSPS).

These examples highlight the widespread adoption of PSPS in regions with elevated wildfire risks, driven by specific weather events that threaten electrical infrastructure.

Risks and Challenges of PSPS

While PSPS is effective in reducing wildfire ignition risks, it introduces several challenges and potential risks for communities, businesses, and vulnerable populations. These include:

1. Disruption of Daily Life

- **Duration**: PSPS events can last from a few hours to several days, depending on the weather event and the time required for line inspections. In California, the average duration is nearly two days, with some outages extending beyond six days (PSE Healthy Energy).
- **Impact**: Outages disrupt work, school, and daily activities, leading to missed productivity and inconvenience.

2. Economic Hardships

- **Business Losses**: Businesses, particularly small ones, may face significant financial losses due to downtime or inability to operate.
- **Household Costs**: Individuals may incur costs from food spoilage, alternative power sources, or temporary relocation.

3. Safety Concerns

- **Medical Needs**: People who are reliant on electricity for medical devices, such as ventilators or refrigerated medications, face heightened risks during outages, especially if unprepared.
- **Vulnerable Populations**: Infants, the elderly, and those with disabilities are particularly at risk, requiring special attention during PSPS events.

4. Limited Notification

- **Short Notice**: While utilities strive to provide advance warnings (e.g., 2-4 days), erratic or sudden weather changes can result in same-day notifications, limiting preparation time (SCE PSPS Alerts).
- **Communication Challenges**: Customers who do not receive or act on notifications may be caught off-guard.

5. Preparation Challenges

- **Generator Safety**: Improper use of gasoline generators, such as operating them indoors, can lead to carbon monoxide poisoning.
- **Fuel Access**: Gas stations may be inoperable during outages, limiting access to fuel for vehicles or generators.
- **Data Usage**: Using cellphones as hotspots can quickly exhaust data plans, hindering communication.

6. Widespread Impact

- **Grid Reliability**: Although PSPS targets high-risk areas (e.g., Tier 2 and Tier 3 zones per the CPUC Fire Threat Map), the interconnected grid can lead to outages affecting broader regions, including low-risk areas.
- **Community Impact**: Entire communities may face disruptions, even if only a portion is at high risk.

7. Psychological and Social Impact

- **Frustration and Anxiety**: Repeated PSPS events can lead to customer frustration, particularly in frequently affected areas.
- **Community Strain**: Prolonged outages can strain community resources and resilience, especially in rural or underserved areas.

8. Cascading Effects and Unintended Consequences

- **Impact to other lifeline services:** PSPS will impact services that are reliant upon electricity, including other utility services such as water and communications.
- **Community Strain:** Planning backup power supply for vulnerable populations and utility services, including water (wells relying on electricity), wastewater treatment, medical equipment, and medical services all need to be prepared and informed when PSPS is enacted. Emergency Operations Centers and Communications may also be impacted.

Mitigation Strategies for PSPS Risks

To address these risks, utilities and communities can take several steps:

- **Enhanced Notifications**: California utilities like SCE, SDG&E and PG&E provide alert systems (e.g., SCE PSPS Alerts) to keep customers informed.
- **Customer Preparation**: Encouraging customers to prepare emergency kits, backup power solutions, and plans for medical needs (Prepare for Power Down). Interesting note that at least on utility – Puget Sound Energy in Washington – fully covers the cost of back-up power for certain medical customers.
- **Community Support**: Establishing Customer Resource Centers during PSPS events to provide power, information, and support.
- **Infrastructure Improvements**: Investing in grid hardening and vegetation management to reduce the frequency of PSPS events.

Table: Summary of PSPS Characteristics and Risks

Aspect	Details
Purpose	Prevent wildfires by de-energizing power lines during high-risk conditions.
Triggers	High winds, low humidity, dry vegetation, Red Flag Warnings.
Duration	Hours to days (average ~2 days in California).
Examples	PG&E, SCE, Hawaiian Electric, PSE.
Risks	Disruptions, economic losses, safety concerns, limited notice.
Mitigation	Advance notifications, customer preparation, community support.

Summary:

PSPS is a tool for wildfire prevention, particularly in regions with high fire risk, but it comes with significant trade-offs. By temporarily shutting off power, utilities reduce the risk of catastrophic wildfires caused by electrical infrastructure. However, the disruptions, economic impacts, and safety concerns associated with PSPS require careful management, robust communication, and community preparedness to minimize harm. As wildfire risks continue to grow due to environmental changes, PSPS will likely remain a key strategy, necessitating ongoing improvements in its implementation and support systems.

05

Deep Dive: PSPS Adoption and State by State Analysis

Key Points:

- PSPS programs can be found mainly in western states like California, Oregon, Washington, and Colorado, with recent adoption in Idaho, Hawaii, and Texas.
- Eastern states and US territories have not yet adopted formal PSPS programs-regulations.
- Utilization of de-energization or PSPS may be considered controversial in some areas due to communication issues and customer impact.

Analysis of Public Safety Power Shutoff Adoption Across All States and Territories

This review provides an examination of Public Safety Power Shutoffs (PSPS), also known as de-energization events, across all fifty states and US territories, focusing on regulations, laws, bills, orders, or mentions. The analysis aims to collate information and present a structured overview, acknowledging the complexity and variability in implementation and need. Note that regulations change quickly, and this information was compiled as of May 2025.

Background and Context

Public Safety Power Shutoffs (PSPS) are proactive measures where utilities temporarily cut power to prevent wildfires, particularly during high-risk weather conditions like strong winds and dry vegetation. These events, proactive de-energization, were notably utilized in California starting in 2018, with significant regulatory developments following, especially after major wildfires. The practice has since expanded to other states facing similar risks, such as Oregon, Washington, and Colorado, driven by increasing wildfire threats due to dry, hot, windy conditions.

The research involved extensive web searches to identify state-specific regulations, focusing on public utility commission (PUC) websites, utility announcements, and news articles. Given the scope, the analysis prioritizes states with known PSPS activity, while noting the lack of information for others and US territories.

Electric distribution companies may, in the absence of a formal PSPS program, elect to de-energize their system in the presence of an imminent or ongoing risk.

Detailed Findings by State and Territory

States with PSPS Programs

These states have formal PSPS programs, often regulated by their public utility commissions or implemented by utilities, to mitigate wildfire risks:

- **Arizona:** Arizona Public Service (APS) has a PSPS program for high-fire-risk communities in Coconino, Gila, and Yavapai counties, with notifications for affected customers (Arizona Public Service PSPS). The Arizona Department of Emergency and Military Affairs also supports PSPS efforts (Arizona Emergency Information Network).
- **California:** The California Public Utilities Commission (CPUC) regulates PSPS, allowing utilities like Pacific Gas and Electric (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E) to pro-actively shut off power during dangerous conditions. The CPUC sorts regions into wildfire risk tiers, with detailed guidelines for notification and reporting (California Public Utilities Commission PSPS).
- **Colorado:** Xcel Energy implemented its first PSPS in April 2024, affecting 55,000 customers in Boulder, with the Colorado PUC investigating potential regulations due to communication issues (CBS Colorado).
- **Hawaii:** A utility announced a new PSPS program in July 2024, reflecting growing wildfire concerns (Hawaii Electric).
- **Idaho:** Avista Corp., Idaho Power, and PacifiCorp have adopted PSPS programs. Both Idaho Power implemented its first PSPS in July 2024 and Avista Corp implemented its first PSPS in September 2024. (Idaho Power PSPS).
- **Montana:** NorthWestern Energy, serving Montana, South Dakota, and Nebraska, has a PSPS program, with details on de-energization during high-risk conditions (NorthWestern Energy).
- **Nebraska:** NorthWestern Energy serves Nebraska and has a PSPS program, similar to Montana (NorthWestern Energy).
- **Nevada:** Utilities in Nevada have implemented PSPS due to wildfire risks, though specific regulations are less documented.

- **New Mexico:** Xcel Energy serves New Mexico and has implemented PSPS, with a notable event in March 2025 affecting 17,000 customers (Xcel Energy Newsroom).
- **Oregon:** The Oregon Public Utility Commission (OPUC) oversees PSPS by utilities like Pacific Power and Portland General Electric (PGE), focusing on extreme weather. Pacific Power notes PSPS events, including in September 2022, affecting thousands (Pacific Power, Portland General Electric).
- **South Dakota:** NorthWestern Energy serves South Dakota and has a PSPS program, similar to Montana and Nebraska (NorthWestern Energy).
- **Texas:** Xcel Energy serves parts of Texas and has implemented PSPS, with a notable event in March 2025 due to wildfire risk (Xcel Energy Newsroom).
- **Utah:** Rocky Mountain Power, part of PacifiCorp, serves Utah and has a PSPS program, with watches and shutoffs in high-risk areas (Rocky Mountain Power).
- **Washington:** Investor owned utilities Avista, PacifiCorp and Puget Sound Energy (PSE) have PSPS programs, as does Chelan Public Utility District, all used as a last resort during high-risk wildfire weather, with notifications to impacted customers (Puget Sound Energy). The recent passage of HB1522 requires the UTC to write rules on PSPS applicable to all electric utilities.
- **Wyoming:** Rocky Mountain Power serves Wyoming and has a PSPS program, similar to Utah (Rocky Mountain Power).

States Without Formal or Regulated PSPS Programs

These states do not have formal PSPS programs, reflecting lower wildfire risks or different utility practices, often relying on burn bans and emergency responses for managing wildfire risks:

- **Alabama:** No PSPS program; managed through the Alabama Forestry Commission with burn bans (Alabama Forestry Commission).
- **Alaska:** No PSPS program; wildfire risks managed by the Alaska Division of Forestry, with no utility shutoff policies for wildfire prevention (Alaska Division of Forestry).
- **Arkansas:** No PSPS program; relies on the Arkansas Forestry Commission for wildfire prevention (Arkansas Forestry Commission).
- **Connecticut:** No PSPS program; managed through the Department of Energy and Environmental Protection, with utility shutoff policies focusing on consumer protections (Connecticut Public Utilities Regulatory Authority).
- **Delaware:** No PSPS program; wildfire risks addressed by the Delaware Forest Service, with no PSPS mentions (Delaware Forest Service).
- **Florida:** No PSPS program; managed through the Florida Forest Service, with burn bans and emergency protocols (Florida Forest Service).
- **Georgia:** No PSPS program; managed through the Georgia Forestry Commission, with burn permits and public safety measures (Georgia Forestry Commission).
- **Illinois:** No PSPS program; wildfire risks managed by the Illinois Department of Natural Resources, with no utility shutoff policies for wildfires (Illinois Department of Natural Resources).

- **Indiana:** No PSPS program; managed through the Indiana Department of Natural Resources, with no PSPS mentions (Indiana Department of Natural Resources).
- **Iowa:** No PSPS program; wildfire risks addressed by the Iowa Department of Natural Resources, with no utility shutoff policies (Iowa Department of Natural Resources).
- **Kansas:** No PSPS program; managed through the Kansas Forest Service, with no PSPS mentions (Kansas Forest Service).
- **Kentucky:** No PSPS program; managed through the Kentucky Division of Forestry, with burn bans and emergency responses (Kentucky Division of Forestry).
- **Louisiana:** No PSPS program; managed through the Louisiana Department of Agriculture and Forestry, with no utility shutoff policies for wildfires (Louisiana Department of Agriculture and Forestry).
- **Maine:** No PSPS program; managed through the Maine Forest Service, with no PSPS mentions (Maine Forest Service).
- **Maryland:** No PSPS program; managed through the Maryland Forest Service, with no utility shutoff policies for wildfires (Maryland Forest Service).
- **Massachusetts:** No PSPS program; managed through the Department of Fire Services, with utility shutoff protections during emergencies but not for wildfire prevention (Massachusetts Department of Public Utilities).
- **Michigan:** No PSPS program; managed through the Michigan Department of Natural Resources, with no PSPS mentions (Michigan Department of Natural Resources).
- **Minnesota:** No PSPS program; managed through the Minnesota Department of Natural Resources, with no utility shutoff policies for wildfires (Minnesota Department of Natural Resources).

- **Mississippi:** No PSPS program; managed through the Mississippi Forestry Commission, with no PSPS mentions (Mississippi Forestry Commission).
- **Missouri:** No PSPS program; managed through the Missouri Department of Conservation, with no utility shutoff policies for wildfires (Missouri Department of Conservation).
- **New Hampshire:** No PSPS program; managed through the New Hampshire Division of Forests and Lands, with no PSPS mentions (New Hampshire Division of Forests and Lands).
- **New Jersey:** No PSPS program; managed through the New Jersey Forest Fire Service, with no utility shutoff policies for wildfires (New Jersey Forest Fire Service).
- **New York:** No PSPS program; managed through the Department of Environmental Conservation, with no PSPS mentions (New York Department of Environmental Conservation).
- **North Carolina:** No PSPS program; managed through the N.C. Forest Service, with burn bans and emergency responses (North Carolina Forest Service).
- **North Dakota:** No PSPS program; managed through the North Dakota Forest Service, with no utility shutoff policies for wildfires (North Dakota Forest Service).
- **Ohio:** No PSPS program; managed through the Ohio Department of Natural Resources, with no PSPS mentions (Ohio Department of Natural Resources).
- **Oklahoma:** No PSPS program; managed through the Oklahoma Forestry Services, with no utility shutoff policies for wildfires (Oklahoma Forestry Services).
- **Pennsylvania:** No PSPS program; managed through the Pennsylvania Department of Conservation and Natural Resources, with burn bans and emergency responses (Pennsylvania DCNR).

- **Rhode Island:** No PSPS program; managed through the Department of Environmental Management, with no utility shutoff policies for wildfires (Rhode Island Department of Environmental Management).
- **South Carolina:** No PSPS program; managed through the South Carolina Forestry Commission, with burn alerts and emergency management (South Carolina Forestry Commission).
- **Tennessee:** No PSPS program; managed through the Tennessee Division of Forestry, with no PSPS mentions (Tennessee Division of Forestry).
- **Vermont:** No PSPS program; managed through the Department of Forests, Parks and Recreation, with no utility shutoff policies for wildfires (Vermont Department of Forests, Parks and Recreation).
- **Virginia:** No PSPS program; managed through the Virginia Department of Forestry, with no PSPS mentions (Virginia Department of Forestry).
- **West Virginia:** No PSPS program; managed through the West Virginia Division of Forestry, with no utility shutoff policies for wildfires (West Virginia Division of Forestry).
- **Wisconsin:** No PSPS program; managed through the Wisconsin Department of Natural Resources, with no PSPS mentions (Wisconsin Department of Natural Resources).

US Territories Without PSPS Programs

US territories generally do not have formal PSPS programs, as their primary environmental risks (e.g., hurricanes, typhoons) differ from wildfire risks:

- **American Samoa:** No PSPS program; managed through the American Samoa Department of Agriculture, with no utility shutoff policies for wildfires (American Samoa Department of Agriculture).
- **Guam:** No PSPS program; managed through the Guam Fire Department, with no PSPS mentions (Guam Fire Department).
- **Northern Mariana Islands:** No PSPS program; managed through the Commonwealth of the Northern Mariana Islands Department of Lands and Natural Resources, with no utility shutoff policies for wildfires (CNMI Department of Lands and Natural Resources).
- **Puerto Rico:** No PSPS program; managed through the Puerto Rico Department of Natural and Environmental Resources, with no PSPS mentions (Puerto Rico Department of Natural and Environmental Resources).
- **US Virgin Islands:** No PSPS program; managed through the Virgin Islands Department of Planning and Natural Resources, with no utility shutoff policies for wildfires (Virgin Islands Department of Planning and Natural Resources).

Analysis and Observations

Formal and officially recognized PSPS programs are concentrated in western states with high wildfire risks, driven by historical fire incidents. California's PSPS approach is the most formal (in terms of documentation, program requirements, etc.) with Oregon, Washington, and Colorado following, and recent adoption in Idaho, Hawaii, Texas, and others. Eastern states and US territories lack formal PSPS, due to different wildfire risk profiles and regulatory priorities.

Controversies, such as Xcel Energy's communication issues in Colorado and Texas, underscore the need for clear guidelines to balance safety and customer impact. The research also notes potential economic and health disruptions from PSPS, particularly for vulnerable populations, as highlighted by Disability Rights California (Disability Rights CA).

06

Deep Dive: GLDS and Advanced Conductors for Wildfire Mitigation

Key Points:

- **GLDS (Ground-level Distribution System)** places power lines at ground level to reduce wildfire ignition risks, offering a cost-effective alternative to traditional undergrounding. Ground-level Electric Transmission System or GETS, refers to transmissions systems at ground level and is not be confused with Grid Enhancing Technologies, also known as GETs. GLDS here refers to applications both on the distribution and transmission system.
- **Advanced conductors**, like covered conductors, use insulating coatings to prevent faults and sparks, significantly lowering wildfire risks.
- Both technologies seem effective but are not complete solutions and require integration with other measures like vegetation management.
- Costs for GLDS are likely lower than undergrounding, while covered conductors cost about $800,000 per mile, compared to $3.3 million for undergrounding.
- Utilities like PG&E and SCE are adopting these technologies, but technology is still in pilot stage.

What Are GLDS and Covered Conductors?

Ground Level Distribution System (GLDS), is a method where power lines are installed at or near ground level, avoiding aerial hazards like wind or falling trees that can spark wildfires. It is less costly than burying lines deep underground. Advanced conductors, particularly covered conductors, are power lines coated with insulating materials to prevent electrical faults when they touch vegetation or debris, reducing the chance of starting fires.

How Do They Help with Wildfires?

GLDS eliminates the risk of overhead lines causing fires by keeping them out of reach of wind, trees, or other hazards (although placing conductors at ground level can introduce damage due to excavation). Covered conductors prevent sparks by insulating lines, so even if a branch falls on them, no fire-starting arc occurs. Both approaches make the electrical grid less likely to ignite a wildfire in fire-prone areas.

Costs and Considerations

GLDS is cheaper than traditional undergrounding, which can cost millions per mile, but exact costs are unclear as it is still in testing. Covered conductors cost around $800,000 per mile, a significant investment but far less than undergrounding. Both require maintenance and may not prevent all fire risks, so they work best with other strategies.

Examples

PG&E is testing GLDS in San Mateo County, California, with a half-mile section energized in 2023. SCE has installed over 2,500 miles of covered conductors, with plans for 6,200 miles by 2023, and has reported cases where these lines prevented fires during incidents like fallen trees.

GLDS and Covered Conductors for Wildfire Mitigation

Description

Ground Level Distribution System (GLDS) is an innovative hybrid approach to power line installation aimed at reducing wildfire ignition risks without the prohibitive costs of traditional undergrounding. While not widely adopted and still being evaluated, GLDS involves placing power lines at or near ground level, reducing exposure to aerial hazards such as wind, falling trees, or conductor contact that can spark fires. Unlike full undergrounding, which requires extensive excavation, GLDS employs surface-level or shallow installations, making it more feasible in challenging terrains like rocky or forested areas. This approach mitigates key ignition mechanisms, including conductor-vegetation contact, conductor slap (lines colliding in wind), and downed lines sparking fires, which are significant contributors to utility-related wildfires. Pacific Gas & Electric (PG&E) is pioneering GLDS through field trials to evaluate its safety, power-carrying capacity, and lifecycle performance, with support from the Electric Power Research Institute (EPRI) for testing and validation.

Cost

Specific cost figures for GLDS are not publicly available, as it remains in the pilot stage. However, it is designed to be significantly less expensive than traditional undergrounding, which can cost between $1 million and $3.3 million per mile, depending on terrain and complexity. Traditional undergrounding is often 5–10 times more costly than overhead lines due to excavation and labor requirements. GLDS, as a “no excavate” approach, avoids these high costs by using surface-level installations with materials like conduit, geopolymer cement, and thermoplastic caps. Implementation costs include materials, installation, and ongoing maintenance, but exact figures are not yet disclosed due to the technology’s early-stage development. Additional expenses may arise from training line crews and developing new maintenance protocols.

Cost Breakdown

Component	Estimated Cost	Notes
Materials (conduit, cement, etc.)	Not specified	Likely lower than undergrounding materials
Installation	Not specified	Surface-level, no excavation reduces labor costs
Maintenance	Not specified	Includes inspections, repairs, and replacements
Training/Tools	Variable	New protocols for line crews

Benefits

- **Reduced Ignition Risk**: By placing lines at ground level, GLDS eliminates exposure to aerial hazards, preventing conductor-vegetation contact, conductor slap, and downed lines from sparking fires, which are major causes of utility-related wildfires.
- **Enhanced Grid Resilience**: Ground-level placement protects lines from environmental hazards like high winds or falling debris, ensuring reliable power delivery during wildfire events, and supporting restoration efforts.
- **Cost-Effectiveness:** Compared to traditional undergrounding, GLDS offers a more affordable alternative while achieving comparable wildfire risk reduction, making it a practical solution for high fire risk areas (HFRA). While the concept of Ground-Level Distribution Systems (GLDS) aims to offer a more adaptable alternative to traditional excavation-dependent underground cable installations, the suitability of installing GLDS in various ground types and geographies is not absolute. Rocky, unstable ground can impact accessibility. Areas with suspected contaminants, wetlands or flood plains require special assessment. Routing through cultural or archeological significant areas can post permitting issues. Seismic activity, high water tables, and infrastructure capacity and access all factor into the suitability of GLDS.
- **Scalability Potential:** The no-excavation approach makes GLDS feasible in diverse terrains, potentially allowing broader adoption in wildfire-prone regions.

Cost-Benefit Analysis

Pros

- **Significant Risk Reduction**: GLDS addresses key ignition mechanisms, offering near-equivalent wildfire risk reduction to undergrounding at a lower cost.
- **Cost Savings**: Avoids the high excavation costs of traditional undergrounding, making it a viable option for utilities with budget constraints.
- **Resilience Benefits**: Supports continuous power delivery during wildfire events, enhancing community safety and grid reliability.
- **Regulatory Support**: Aligns with regulatory mandates for wildfire mitigation, potentially attracting grants or incentives.

Cons

- **Early-Stage Technology**: As an emergent technology, GLDS lacks long-term performance data, posing risks related to durability and scalability.
- **Implementation Challenges**: Requires new training and tools for line crews, as well as public education to ensure safe interaction with ground-level lines.
- **Maintenance Needs**: Ensuring the system survives wildfire events and maintains power capacity (e.g., avoiding summer derating) requires ongoing investment.
- **Not a Complete Solution**: Does not address non-line-related ignition sources, such as equipment failures, and excavation damage, necessitating a layered mitigation approach.

Return on Investment (ROI)

The ROI for GLDS is potentially high in high fire risk areas, where preventing wildfires can save billions in damages and liabilities, as seen in past California fires like the Camp Fire. Reduced outage costs and improved reliability further enhance financial benefits. However, as GLDS is still in the pilot phase, concrete ROI data is limited. Potential savings include avoided wildfire damages, reduced regulatory fines, and lower outage-related losses. Regulatory incentives or grants, such as those from the Department of Energy's Grid Resilience and Innovation Partnerships (GRIP) program, could offset costs, improving ROI. In lower-risk areas, the high upfront costs may result in a longer payback period.

ROI Factors

Factor	Impact on ROI	Notes
Wildfire Risk	High	Higher risk increases savings from fire prevention
Outage Costs	Moderate	Reduced outages lower economic losses
Regulatory Incentives	Moderate	Grants or cost-sharing improve financial viability
Maintenance Costs	Negative	Ongoing expenses reduce net savings

Example

PG&E is conducting a field trial of GLDS, with the first half mile of GLDS circuit energized in early November 2023 on the Woodside 1101 circuit in San Mateo County, California. This proof-of-concept involves packaging electric cable in conduit within a molded tray, tied with basalt rebar, sealed with geopolymer cement, placed at ground level, and capped in thermoplastic. The trial aims to evaluate the technology's safety, power-carrying capacity, and durability, with EPRI collaborating on custom testing to ensure robust lifecycle operation.

Critical Analysis

Effectiveness

GLDS appears highly effective at reducing ignition risks by eliminating aerial hazards, addressing key mechanisms like conductor-vegetation contact and downed lines. However, as an emergent technology, its long-term performance, particularly in surviving wildfire events or maintaining power capacity under heat stress, requires further validation. Integration with other mitigation strategies, such as vegetation management and protective relays, is essential for comprehensive risk reduction.

Cost vs. Benefit

GLDS offers a compelling cost-benefit profile by providing near-equivalent wildfire risk reduction to undergrounding at a fraction of the cost. The no-excavation approach makes it feasible in diverse terrains, but the upfront investment and maintenance costs are still significant. The benefits of reduced wildfire risk and enhanced grid resilience are substantial, particularly in high-risk areas with limited evacuation routes.

Climate Context

With climate change increasing the frequency and intensity of wildfires, GLDS could be a tool for grid resilience and more will be known as this technology matures. Its ability to maintain power delivery during extreme weather conditions aligns with the need for adaptive infrastructure in fire-prone regions. Real-time monitoring and predictive analytics can further enhance its effectiveness by anticipating high-risk conditions.

Utility Accountability

Utilities like PG&E are exploring the feasibility of investing in GLDS as a potential cost-effective solution to mitigate ignition risk. With technologies still in their pilot stage, transparent reporting and regulatory oversight are crucial to ensure effective and safe implementation.

Covered Conductors for Wildfire Mitigation

Description

Covered conductors, including conductors, spacer cables, tree wire, and high-capacity conductors with high tensile strength, like Aluminum Conductor Steel-Supported (ACSS), are engineered to minimize wildfire ignition risks while improving grid efficiency. Covered conductors, the focus here, are overhead power lines with multi-layer insulating coatings (e.g., polyethylene, cross-linked polyethylene [XLPE], or ethylene propylene rubber [EPR]) that prevent faults caused by contact with vegetation, wildlife, or debris. These coatings reduce arcing and sparking, major ignition sources during wildfires. Utilities like Southern California Edison (SCE) and San Diego Gas & Electric (SDG&E) have widely adopted covered conductors as part of their wildfire mitigation strategies, often complementing other measures like vegetation management and Public Safety Power Shutoffs (PSPS).

Cost

Covered conductors are significantly less expensive than traditional undergrounding. **SCE estimates the cost of insulating lines with covered conductors at approximately $800,000 per mile, compared to $3.3 million per mile for undergrounding (based on 2022 figures).**

Cost Breakdown

Component	Estimated Cost	Notes
Covered Conductor	$800,000/mile	Includes materials and installation
Maintenance	Not specified	Annual inspections for wear/abrasion, downed wire potential, need to patrol following storm events
Pole Replacements	Variable	~25% of poles due to increased weight
System Upgrades	Variable	Integration with existing infrastructure

Benefits

- **Fault Prevention**: Insulating layers prevent phase-to-phase or phase-to-ground faults when objects like tree branches, metallic balloons, or animals contact the lines. SCE tests show currents below 1 mA (milliampere) and no arcing during contact, preventing ignition. SCE (Short-Circuit Current) tests evaluate the safety of electrical devices by measuring currents during fault conditions, like unintended contact. When these tests show currents below 1 mA and no arcing during contact, it indicates the device is designed to prevent hazardous outcomes like ignition. Here's why:
    - **Low Current (Below 1 mA)**: Currents below 1 mA are generally considered safe for humans and insufficient to generate enough heat to ignite flammable materials. For context, typical ignition thresholds for gases or materials require currents in the range of tens or hundreds of milliamps, depending on the environment. Staying below 1 mA ensures the energy is too low to cause sparks or heat buildup.
    - **No Arcing**: Arcing occurs when an electric current jumps across a gap, producing a spark that can reach temperatures high enough to ignite flammable gases or materials. The absence of arcing in SCE tests means the device's design (e.g., insulation, contact separation, or current-limiting features) prevents conditions where a spark could form during contact or fault scenarios.
    - **Preventing Ignition**: Ignition requires a combination of sufficient energy (from current or arcing) and a flammable medium. By keeping currents below 1 mA and eliminating arcing, the device ensures that neither the heat from current flow nor a spark can initiate combustion, even in potentially hazardous environments like those with flammable gases or dust.

- **Reduced Ignition Risk**: Covered conductors eliminate sparks when lines fall onto dry brush or rocks, unlike bare wires, which can ignite vegetation. Note that covered conductors do not completely eliminate sparks due to portions being bare where splices or connections are made.
- **Cost-Effective Hardening**: More affordable than undergrounding, covered conductors are a practical way to harden the grid in high fire risk areas (HFRA). Note: "High fire threat" describes current conditions, indicating that a fire could start and spread easily, while "high fire risk" refers to the long-term potential damage a fire could cause, considering factors like fuels, terrain, and weather in an area. High fire threat levels can change daily based on weather, whereas high fire risk is a more static assessment of hazard.
- **Grid Reliability**: By reducing faults, covered conductors improve power quality and reliability, minimizing outage durations and enhancing customer service.

Cost-Benefit Analysis

Pros

- **Significant Risk Reduction**: Covered conductors reduce wildfire ignition risk by approximately 65%, a substantial improvement over bare wire.
- **Cost-Effectiveness**: At $800,000 per mile, they are far less expensive than undergrounding, making them scalable for large-scale deployment.
- **Reliability Benefits**: Fewer faults lead to reduced outages, improving grid performance and customer satisfaction.
- **Regulatory Support**: Aligns with wildfire mitigation mandates, including affordability, potentially attracting regulatory incentives or grants.

Cons

- **Limited Effectiveness**: Only about 65% effective at reducing wildfire risk, compared to nearly 100% for undergrounding.
- **Maintenance Requirements**: Annual inspections and maintenance are needed to detect wear or abrasion, adding to costs.
- **Infrastructure Upgrades**: Increased weight and diameter may require pole replacements, increasing implementation costs.
- **Not Fully Insulated**: Covered conductors are not rated for full line-to-ground voltage, posing residual risks during maintenance or severe incidents.
- **Potential for energization**: Conductor may remain energized on the ground due to protective insulated covering which can lead to public safety concerns.

Return on Investment (ROI)

The ROI for covered conductors is high in high fire risk areas due to significant reductions in wildfire ignition risk and prevention of large-scale fire damages, which can cost billions (e.g., PG&E's liabilities in past fires). Reduced outage costs and improved reliability further enhance financial benefits. SCE's Grid Safety and Resiliency Program (GSRP) demonstrates the long-term value of covered conductors, with estimated reductions in catastrophic wildfire losses by 55–65%. Regulatory incentives and grants, such as those from the California Public Utilities Commission (CPUC), can offset costs, improving ROI. In lower-risk areas, the high upfront costs may result in a longer payback period.

ROI Factors

Factor	Impact on ROI	Notes
Wildfire Risk	High	Higher risk increases savings from fire prevention
Outage Costs	Moderate	Reduced outages lower economic losses
Regulatory Incentives	Moderate	Grants or cost-sharing improve financial viability
Maintenance Costs	Negative	Ongoing expenses reduce net savings

Example

Southern California Edison (SCE) has installed over 6,00 miles of covered conductors and as of September 2025, covering approximately 60% of overhead conductor circuit miles in high fire risk areas (HFRA). Real-world successes include:

- A eucalyptus tree fell on a covered conductor in Malibu for 2 hours, causing no fault or circuit interruption, preventing ignition.
- A vehicle hit a pole with covered conductor in Ojai, causing wires to contact trees, but no fault or circuit interruption occurred, preventing ignition. These incidents highlight the effectiveness of covered conductors in preventing wildfires during high-risk scenarios.

Critical Analysis

Effectiveness

Covered conductors are highly effective at reducing ignition risks from electrical faults, particularly those caused by vegetation or debris contact. SCE's testing shows negligible current and no arcing during contact, significantly lowering wildfire risk. However, they are only about 65% effective compared to undergrounding and do not address other ignition sources, such as equipment failures or human activities. A layered approach, including vegetation management, PSPS, and protective relays, is essential for comprehensive risk reduction.

Cost vs. Benefit

At $800,000 per mile, covered conductors offer a strong cost-benefit profile compared to undergrounding, with substantial reductions in wildfire risk and improved grid reliability. However, maintenance costs and potential pole replacements add to the total cost of ownership. The benefits are most pronounced in high-risk areas, where preventing wildfires can save billions in damages and liabilities.

Climate Context

With wildfire frequency and intensity increasing across the country, covered conductors are a critical tool for mitigating risks in dry, windy conditions. Their ability to prevent faults during high-risk weather aligns with the need for resilient grid infrastructure. Integration with real-time monitoring and predictive analytics can further enhance their effectiveness.

Utility Accountability

Utilities like SCE and SDG&E are adopting covered conductors as part of broader wildfire mitigation strategies, driven by both safety and liability concerns. Historical cost-cutting potentially contributed to current risks, as seen in past California wildfires. Regulatory oversight and transparent reporting are crucial to ensure utilities prioritize safety over cost considerations.

Summary

GLDS and advanced conductors are vital tools for wildfire mitigation. GLDS reduces ignition risks by placing lines at ground level, offering a cost-effective alternative to undergrounding, with PG&E's pilot demonstrating its potential. Advanced conductors, particularly covered conductors, prevent faults and enhance grid resilience, with SCE's extensive deployment showing real-world success. Both technologies must be integrated with other strategies, such as vegetation management, PSPS, and protective relays, to maximize effectiveness. Continued research, regulatory support, and transparent utility practices are essential to ensure these technologies protect communities from wildfires in an increasingly fire-prone world. Note that while this represents a lot of information on GLDS, it is still a pilot and not yet at the scale of other grid hardening efforts.

07

Deep Dive: Vegetation Management on Federal and State Lands

Federal Guideline

Vegetation management in utility easements on federal land is primarily governed by federal agencies like the Bureau of Land Management (BLM) and U.S. Forest Service (USFS). Utilities must comply with the Federal Land Policy and Management Act (FLPMA), which allows for rights-of-way (ROWs) on public lands. Key practices include:

- Minor trimming, pruning, and weed management, with notification to the BLM, and hazard tree removal without pre-approval for imminent threats.
- Market-value timber removal requires BLM approval and may need additional environmental analysis.
- Recent legislative proposals, such as Section 2310 of S. 1460 and H.R. 1873, aim to streamline these processes, allowing ROW holders to submit plans for review within 90–180 days and enabling emergency pruning with 24-hour notification.

A 2016 Memorandum of Understanding (MOU) between federal agencies and utilities, detailed at EPA IVM Practices, facilitates cooperation to balance environmental and utility needs.

State Guidelines

On state land, vegetation management is regulated by state utility commissions and local ordinances. Utilities often develop their own programs, complying with state laws and using Integrative Vegetation Management IVM practices. For example:

- California's General Order 95 mandates specific clearances, such as 31.7 inches for 230 kV lines.
- States like Alabama and Georgia have utility-specific guidelines, with companies like Alabama Power maintaining 30-foot easements (for distribution. Transmission right of way widths vary based on voltage and acquired rights) and using herbicides.
- Minnesota's stormwater manual, found at Minnesota Stormwater Manual, offers insights into vegetation maintenance, relevant for overlapping utility easements.

Federal Guidelines and Regulatory Framework

Federal lands, encompassing approximately 245 million surface acres managed by the BLM and significant forest areas by the USFS, are subject to federal laws and agency policies. The Federal Land Policy and Management Act (FLPMA), Title V, governs rights-of-way (ROWs) for utility infrastructure, with nearly 16,000 electricity transmission and distribution authorizations on BLM-managed lands.

BLM and USFS Policies:

- Vegetation management on federal ROWs includes provisions for minor trimming, pruning, and weed management, requiring notification to the BLM. Hazard tree removal for imminent threats can proceed without pre-approval, streamlining emergency responses.
- For market-value timber or vegetation removal, BLM approval is mandatory, potentially requiring additional environmental analysis under the National Environmental Policy Act (NEPA).
- The 2016 Memorandum of Understanding (MOU), detailed at EPA IVM Practices, signed by the EPA, Edison Electric Institute, Utility Arborist Association, and federal agencies, facilitates cooperative vegetation management. It aims to implement cost-effective, environmentally sound plans that reduce adverse impacts while ensuring uninterrupted electrical service.

Legislative Proposals:

- Recent legislative efforts, such as Section 2310 of S. 1460 (Energy and Natural Resources Act of 2017) and H.R. 1873 (Electricity Reliability and Forest Protection Act), propose amendments to FLPMA. These include:
- Guidance from the Secretaries of Interior and Agriculture on vegetation management, facility inspection, and operation/maintenance, considering applicable laws, local reliability, fire safety, and the 2016 MOU.
- ROW holders can submit vegetation management plans, with review timelines of 90 days for H.R. 1873 and 180 days for S. 1460. Plans meeting existing standards may qualify for categorical exclusion under NEPA.
- Emergency pruning or removal authority, with notification to the agency within 24 hours. H.R. 1873 allows utilities to act if authorization is not granted within 3 business days, subject to categorical exclusion.
- Annual reporting requirements on emergency responses and compliance with standards, encouraging training programs for employees on reliability and fire safety.
- The Bureau of Land Management supports both proposals, indicating willingness to work on technical recommendations, reflecting a proactive approach to addressing vegetation management challenges.

National Standards:

- The Federal Energy Regulatory Commission (FERC) has established national vegetation management standards, including FAC-003-4, enforced by the North American Electric Reliability Corporation (NERC). These standards, detailed in FERC Transmission Line Management, address clearance between certain transmission lines and vegetation to support stability of the bulk power system, reporting outages, and ensuring grid reliability.
- Minimum radial clearances at trimming time, as per FERC guidelines, are as follows:

Voltage Range	Clearance (feet)
2,400–72,000	3
72,001–110,000	5
110,001–230,000	10
230,001–345,000	15
345,001 and above	20

These clearances are critical for preventing tree contact, a leading cause of outages, as highlighted by the 2003 Northeast blackout affecting 50 million people.

State Guidelines and Practices

State lands are regulated by state utility commissions, local ordinances, and utility company policies, with significant variation across jurisdictions. These guidelines often align with federal standards but may impose additional requirements, particularly in wildfire-prone states.

State Regulatory Framework

State public utility commissions (PUCs) enforce vegetation management regulations, often requiring utilities to develop and submit Vegetation Management Plans (VMPs). For example:

- **California:** The California Public Utilities Commission (CPUC) mandates clearance requirements under General Order 95, Rule 35, Appendix 'A', with specific distances such as 31.7 inches for 230 kV lines and 120 inches for 500 kV lines, enforced 24/7. This has tripled utility vegetation management costs, as noted in FERC reports.
- **Oregon:** Recent legislation like HB 3666 (2025) grants utilities wildfire safety certificates for approved VMPs, potentially limiting liability, while HB 3917 creates a catastrophic wildfire fund, balancing victim compensation, and utility solvency.
- **Utah:** The 2020 law protects utilities from negligence charges if they have approved VMPs, capping damages at rebuild costs or property value loss, with a $1 billion fire fund funded by ratepayer surcharges.

- Local ordinances, such as those from state highway departments (69% of utilities cite influence) and city/county street tree ordinances (58%), add further complexity, as seen in interactions with agencies like the Tonto National Forest and Navaho Nation.

Utility Company Practices

Utilities develop their own vegetation management programs, often using Integrated Vegetation Management (IVM) practices, which balance mechanical, chemical, cultural, and biological treatments. Examples include:

- **Alabama Power**: Maintains a 30-foot-wide easement for overhead distribution lines, using non-restricted herbicide applications and mowing, as detailed at Alabama Power Vegetation Management. They prioritize shallow-rooted plants and restrict trees to prevent re-sprouting. The purpose is to encourage the growth of compatible low-growing, non-woody plants, such as grasses and other species. These new low-growing plant communities provide greater plant biodiversity, improving wildlife and pollinator habitats.
- **Santee Cooper:** Uses EPA-registered herbicides and provides Permissible/Non-Permissible Guidelines for vegetation within easements, found at Santee Cooper Vegetation Management.

- **Georgia Power**: Emphasizes easements for maintaining clear rights-of-way, with agreements for permitted uses, as seen at Georgia Power Easements
    - These practices ensure compliance with state and federal regulations, balancing aesthetic concerns with reliability, as noted in utility interactions with state highway departments and local governments.
- **State-Specific Considerations**: In Minnesota, the stormwater manual, available at Minnesota Stormwater Manual, provides operation and maintenance considerations for vegetation, relevant for utility easements overlapping stormwater management areas. It emphasizes long-term planning, including mowing, hand weeding, and selective species removal, tailored to site-specific goals and regulatory requirements.

Vegetation Management Considerations

- **Clearance Requirements**: Utilities must maintain adequate clearances around power lines, with federal standards (e.g., FERC's FAC-003-4) and state-specific rules (e.g., California's General Order 95) setting minimum distances. These are critical for preventing outages and ensuring safety, especially in wildfire-prone areas.
- **Environmental Stewardship**: IVM practices, promoted by the EPA at EPA IVM Practices, reduce pesticide use, promote biodiversity, and control invasive species, aligning with federal and state environmental goals.
- **Stakeholder Collaboration**: Utilities must work with federal and state land managers, as well as property owners, to ensure compliance with easement agreements. This includes coordinating with agencies like the USFS and BLM, as seen in examples like the Tonto National Forest (176 acres affecting reliability since 1997) and Navaho Nation (370 trees, ongoing since 1998).
- **Emergency Preparedness**: Given the wildfire context, with over 48,000 wildfires burning more than 8 million acres in 2017 (above average, per the National Interagency Fire Center), proposed legislation (H.R. 1873 and S. 1460) would require utilities to have plans for emergency vegetation removal, and provisions for rapid response and post-action reporting.

Vegetation Management Challenges

- **Balancing Interests**: There is ongoing tension between utility needs for reliable electricity, environmental concerns raised by federal agencies, and property rights of landowners. For instance, 44% of utilities cite USFS/BLM requirements as a challenge, while 69% note state highway department influences, highlighting jurisdictional variations.
- **Liability and Cost Recovery**: State laws like Utah's 2020 legislation cap damages, potentially reducing utility incentives for proactive management, while California's strict liability doctrine has the potential to burden ratepayers. This controversy is evident in legislative debates, with trial lawyers and victims opposing liability limits.
- **Environmental Impact**: Increasing wildfire risks amplify the need for vegetation management, but funding and cost recovery mechanisms (e.g., rate hikes, wildfire funds) remain contentious, especially in states like Oregon and California.

Summary

Vegetation management on federal and state land with utility easements is a multifaceted issue governed by federal laws (e.g., FLPMA, FERC standards), state regulations (e.g., PUC rules, local ordinances), and utility-specific policies. Key guidelines include compliance with clearance requirements, use of IVM practices, and stakeholder collaboration, with ongoing legislative efforts aiming to streamline processes. The balance between reliability, safety, and environmental stewardship remains a critical challenge, requiring adaptive strategies to address evolving risks and stakeholder needs.

08

Deep Dive: How Animals Can Spark Wildfires

Animals might accidentally start wildfires by interacting with power lines. Here is how:

- **Touching Wires**: A bird landing on two wires or a squirrel scampering across equipment can create a spark or short circuit, igniting nearby grass or brush.
- **Building Nests**: Birds often nest on poles or transformers, using sticks and straw that can catch fire if a fault occurs.
- **Knocking Stuff Loose**: Animals can dislodge branches or debris onto lines, causing wires to slap together and send sparks flying.
- **Chewing Damage**: Squirrels or rodents sometimes chew through wire insulation, exposing live wires that can arc and ignite.

Animal-related incidents can be devastating, especially in dry, vegetated areas, according to reports from the U.S. Forest Service.

Real-World Examples: Animal-Caused Fires and Utility Fixes

Let's look at a few cases where animals sparked wildfires and how utilities responded:

Example 1: Pacific Northwest Utility Fire (2015)

- **What Happened**: A squirrel caused a fault on a power line in Idaho, sparking a fire that burned 50,000 acres and damaged homes.
- **Utility's Response**: The utility paid fines for inadequate maintenance and started installing animal guards on poles and insulating key equipment in rural areas.
- **Takeaway**: Routine checks and animal protections may have prevented the spark. The utility now prioritizes these in high-risk zones.

Example 2: Southwest Utility Fire (2007)

- **What Happened**: A bird triggered a short circuit on a power line in Arizona, leading to a wildfire that scorched 150,000 acres and destroyed structures.
- **Utility's Response**: The utility settled lawsuits and invested in weather monitoring systems and cameras to spot risks early. They also added animal covers to equipment.
- **Takeaway**: Combining animal guards with real-time monitoring cuts ignition risks. This utility's approach has reduced similar incidents.

Example 3: Hawaii Wildfire (2023)

- **What Happened**: Downed power lines, possibly linked to environmental factors or animal activity, contributed to a deadly Maui fire that killed 101 people and caused billions in damages.
- **Utility's Response**: Facing lawsuits, the utility upgraded infrastructure and added animal protections while improving power shutoff plans.
- **Takeaway**: Proactive shutoffs and animal guards are key during extreme weather.

Strategies to Stop Animal-Caused Fires

Here are practical, proven ways utilities can reduce wildfire risks from animals, based on industry trends and real-world successes:

1. **Add Animal Guards and Insulation**:

- Install covers on transformers and insulated jumpers to keep animals from touching live parts.
- Example: A Midwest utility installed guards on 8,000+ poles in fire-prone areas, cutting animal-related faults by 30%.

2. **Step Up Vegetation Clearing**:

- Keep a 10–15-foot clear zone around power lines to limit the chance of animal-related debris starting fires.
- Some utilities use drones and tech like LIDAR to spot overgrown areas, as seen with utilities in Oregon.

3. **Use Smart Monitoring Tech**:

- Deploy weather stations, cameras, and sensors to catch fire risks in real time, like utilities in the Southeast have done.
- Sensors can detect animal-caused faults, letting crews respond fast.

4. **Set Up Fast-Response Systems**:

- Adjust equipment to cut power in milliseconds if a fault occurs, reducing spark time.
- Utilities in fire-prone states report fewer ignitions with these “fast-trip” settings.

5. **Inspect Regularly**:

- Check poles and lines at least yearly, or more often in high-risk areas, following NFPA guidelines.
- Drones and AI help spot animal nests or damaged gear, as tested by utilities in Kentucky.

6. **Plan Power Shutoffs Carefully**:

- Develop clear PSPS plans for high-risk weather, considering animal activity as a trigger.
- Communicate shutoffs to customers to reduce disruptions, a practice refined by utilities in the Pacific Northwest.

7. **Collaborate with Communities**:

- Encourage residents to report animal activity near lines, like nesting birds.
- Team up with local fire agencies to boost wildfire response, as recommended by the American Public Power Association.

09

Deep Dive: Utilities Documenting Maintenance

Keeping detailed records of maintenance is critical for utilities to stay compliant, run smoothly, and manage risks. Here is how they do it:

Maintenance Logs:

- Utilities track inspections, repairs, and vegetation work in digital systems like SAP or Maximo.
- Logs note dates, locations, equipment conditions, and issues like animal damage or nests.
- Example: A Southeast utility documents 80,000+ miles of lines yearly to ensure safety.

Wildfire Mitigation Plans:

- Many states require utilities to submit plans detailing how they reduce fire risks, including animal protections.
- These plans are updated regularly and shared with regulators like public utility commissions.

Incident Reports:

- If a fire involves utility equipment, companies must report it to regulators, often within days, per state rules.
- Reports cover causes (like animal contact), equipment status, and response.

Compliance Audits:

- Utilities keep records to prove they meet state and federal standards, like National Fire Protection Association (NFPA) codes.
- Audits check inspection frequency, equipment health, and record accuracy.

Data and Tech:

- Utilities use sensors, drones, and AI to track grid conditions and prioritize maintenance.
- Example: A Colorado utility uses wildfire risk software to map and document high-risk areas.

Why Documentation Matters for Liability

Good record-keeping can make or break a utility's case when wildfires lead to lawsuits. Here is why:

Showing They Did Their Job:

- Detailed logs of inspections, repairs, and animal protections prove a utility took reasonable steps to prevent fires, which can reduce negligence claims.
- Example: A utility in Texas avoided major penalties by showing thorough maintenance records after a small fire.

Meeting Regulatory Rules:

- Following state and federal standards, backed by solid documentation, can lower fines and legal risks.
- Poor records, like those in a 2018 Western wildfire case, led to hefty fines for a utility that skipped inspections.

Court Evidence:

- Maintenance logs, incident reports, and mitigation plans are used in court to show whether a utility was negligent.
- In a 2007 Southwest fire, incomplete records cost a utility millions in settlements.

Managing Strict Liability:

- In some states, utilities are liable for damages from their equipment, even if they were not negligent. Good records can help justify cost recovery from ratepayers.
- Example: A Northwest utility used strong documentation to secure regulatory approval for cost recovery after a fire.

Building Trust:

Clear, public records in mitigation plans boost confidence among customers, regulators, and investors, helping utilities avoid financial hits like credit downgrades.

Tips for Regulators to Support Safer Utilities

Here is how you can help utilities prevent wildfires and keep solid records:

Set Clear Maintenance Rules:

- Require animal guards and fast-response settings in high-risk areas.
- Enforce regular inspections, aligned with NFPA standards.

Push for Better Documentation:

- Standardize how utilities record maintenance and report incidents.
- Evaluate wildfire mitigation plans for animal-specific risk details.

Encourage Smart Tech:

- Offer incentives for utilities to use AI, drones, or sensors for monitoring and record-keeping.
- Support pilot programs, like those using satellite imagery in the Midwest.

Balance Power Shutoffs:

- Gain insight into PSPS plans to ensure they are rolled out effectively without overly disrupting customers.
- Require utilities to document and explain shutoff decisions.

Clarify Liability Rules:

- Work on fair liability laws that encourage proactive maintenance without bankrupting utilities.
- Consider wildfire funds, like those in some Western states, to share costs.

Build Partnerships:

- Encourage utilities to share best practices through groups like EEI and the American Public Power Association.
- Collaborate with wildlife agencies to manage animal habitats near power lines.

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Deeper Dive: Vegetation Management for Wildfire Prevention in Electric Utilities, Regional Variations

Vegetation management is a critical component of wildfire management for electric utilities, as overgrown plants near power lines can cause electrical faults, sparks, or arcing that ignite dry vegetation, leading to wildfires. This practice involves regular inspections, trimming, removal of hazard trees, herbicide applications, and the use of technologies like LiDAR, drones, and satellite imagery to maintain clearances and reduce fuel loads. Effective management minimizes outage risks, enhances grid reliability, and prevents catastrophic fires, but it must be adapted to local conditions. Variations in terrain, geography, vegetation types, growth rates, and access challenges influence strategies, as utilities face unique risks in different geographic regions. Below, are some considerations across major U.S. terrains and geographies, drawing on utility practices and environmental factors.

Southeast (Humid Subtropical Regions, e.g., Georgia, South Carolina, Tennessee)

- **Types of Vegetation**: Invasive vines like kudzu (Pueraria Montana), along with dense broadleaf trees, shrubs, and understory plants. Kudzu, known as "the vine that ate the South," forms thick mats that climb poles, wires, and trees, potentially weighing down lines or creating conductive paths during storms.
- **Growth Rates**: Extremely rapid; kudzu can grow up to 1 foot per day in warm, moist conditions, covering structures within months if unchecked, as noted in USDA Forest Service's Kudzu Biology and Management. Other vines and weeds proliferate year-round due to mild winters and high rainfall.
- **Access and Trimming Challenges**: Terrain is often flat to rolling but densely vegetated, making manual access labor-intensive. Utilities use ground crews for trimming, but overgrowth can obscure lines. Herbicides are preferred for long-term control to reduce trimming frequency, with initial treatments every 90-120 days shifting to annual maintenance, as outlined by the Utility Vegetation Management Association and Georgia Power's Vegetation Management Program. Mechanical trimming is minimized through integrated programs that prevent regrowth.
- **Impact on Wildfire Management**: Kudzu and similar vines increase wildfire risk by adding ladder fuels that allow ground fires to reach power lines or tree canopies. In dry spells, dead kudzu becomes highly flammable. Utilities mitigate this through right-of-way clearing and kudzu-specific herbicide applications to prevent sparks from vegetation contact, enhancing grid resilience against weather-related outages that could ignite fires, as detailed in EPRI's Wildfire Risk Mitigation Strategies.

Plains and Grasslands (e.g., Great Plains, Great Basin)

- **Types of Vegetation**: Predominantly grasses, including invasive annuals like cheatgrass (*Bromus tectorum*), along with shrubs and forbs. These form continuous fine fuels that dry out seasonally.
- **Growth Rates**: Fast during wet springs (biomass can double in weeks), but grasses cure (dry) quickly in summer heat and droughts, becoming highly combustible. Invasive species like cheatgrass outcompete natives, leading to denser fuel loads, as described in Balch et al. (2013).
- **Access and Trimming Challenges**: Open, flat terrain allows easy vehicle and equipment access over vast areas, but remote locations require mobile platforms for inspections. Management includes mowing, prescribed burns, and herbicides rather than tree-focused trimming. Drones and satellite data help monitor large expanses efficiently, as practiced by the Western Area Power Administration.

- **Impact on Wildfire Management**: Grasses act as "flashy fuels" that ignite easily and spread fires rapidly with wind, altering fire regimes and increasing large wildfire frequency (e.g., >405 hectares). Utilities integrate dynamic vegetation data into risk models, focusing on fuel reduction to prevent line-ignited blazes, other prescribed measures as described in PG&E's Wildfire Mitigation Plan. High herbaceous biomass and bare ground exposure are key predictors of fire probability, necessitating proactive treatments to curb invasive spread and maintain clearances.

Forests (e.g., Pacific Northwest, Northern Forests)

- **Types of Vegetation**: Dense conifers (e.g., pines, firs), hardwoods, and understory brush. Hazard trees include dead, diseased, or tall specimens prone to falling or growing into lines.
- **Growth Rates**: Moderate to fast, with seasonal spurts; understory regrows quickly after disturbances, creating ladder fuels, according to USDA Forest Service's Pacific Northwest Forest Ecology.
- **Access and Trimming Challenges**: Thick forests and variable terrain (e.g., hills) complicate access, often requiring specialized equipment or aerial inspections. Cycles involve annual checks for transmission lines and five-year rotations for distribution, using LiDAR for remote sensing, as implemented by Bonneville Power Administration.
- **Impact on Wildfire Management**: Vegetation provides abundant fuel for crown fires, especially in dry seasons. Utilities prioritize removing "grow-in" (encroaching) and "fall-in" (unstable) trees to prevent sparks, collaborating with agencies for integrated management that reduces overall forest fuel loads, as recommended by the National Wildfire Coordinating Group.

Mountains (e.g., Rockies, Sierra Nevada)

- **Types of Vegetation**: Mix of conifers, aspens, and alpine grasses/shrubs at higher elevations; denser forests lower down.
- **Growth Rates**: Slower at high altitudes due to short growing seasons, but faster in valleys; snow and erosion affect regrowth, Chao et al, 2017. And USDA study.
- **Access and Trimming Challenges**: Steep slopes and rugged terrain limit ground access, increasing reliance on helicopters, drones, and tech for inspections. Weather extremes (e.g., snow, winds) delay work, as noted in Xcel Energy's Vegetation Management Practices.
- **Impact on Wildfire Management**: High-elevation fuels dry out in summer, enabling upslope fire spread. Utilities adapt with risk-based prioritization, removing hazards to prevent ignitions in hard-to-control areas, often integrating with forest service fuel treatments, as outlined by the USDA Forest Service's Rocky Mountain Region.

Deserts and Arid Southwest (e.g., Arizona Deserts)

- **Types of Vegetation**: Sparse shrubs (e.g., creosote), cacti, and invasive grasses; less tree-dominated than forests.
- **Growth Rates**: Episodic, booming after rains but dormant in droughts; invasives like buffelgrass grow rapidly and persist, as studied Rau et al (rev 2011).
- **Access and Trimming Challenges**: Remote, arid landscapes allow vehicle access but cover large areas; heat and dust complicate operations. Mobile apps and drones aid in scheduling and documentation, as utilized by Arizona Public Service.
- **Impact on Wildfire Management**: Fine, flashy fuels ignite quickly in hot, dry conditions, spreading to urban interfaces. Year-round maintenance, including pruning and herbicides, targets rapid post-rain growth to reduce fuel continuity and prevent utility-sparked fires, as described in Southern California Edison's Vegetation Management.

Summary Table

Region/ Terrain	Dominant Vegetation Types	Growth Rate	Access/Trimming Challenges	Wildfire Risk Factors
Southeast (Humid Subtropical)	Vines (e.g., kudzu), broadleaf trees	Very fast (up to 1 ft/day for kudzu)	Dense growth obscures lines; herbicide-focused	Ladder fuels, storm-induced faults
Plains/Grasslands	Grasses (e.g., cheatgrass), shrubs	Rapid in wet seasons, quick curing	Open but vast; mobile tech needed	Fast-spreading ground fires, wind-driven
Forests (Pacific Northwest)	Conifers, understory brush	Moderate-fast, seasonal	Thick canopy, hilly; LiDAR/drones	Crown fires, high fuel loads
Mountains	Conifers, grasses at elevation	Slower at heights, variable	Steep slopes; aerial access	Upslope spread, remote ignitions
Deserts/ Southwest	Shrubs, episodic grasses	Boom-bust with rain	Remote, arid; drone inspections	Flashy fuels, drought amplification

Summary of Deep Dive

Utilities employ integrated vegetation management (IVM) tailored to these regional factors, using data-driven tools like LiDAR, drones, and risk models for prediction and prevention. Climate change exacerbates risks by altering growth patterns and drying fuels, underscoring the need for adaptive, region-specific strategies to safeguard infrastructure and communities, as highlighted in EPRI's Climate Impacts on Vegetation Management and NOAA Hazard Mapping Fire and Smoke Product.

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17. FERC Transmission Line Vegetation Management (Clearances)

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Additional Resources

- NREL renewable energy and energy efficiency technologies
- System Hardening & Undergrounding PG&E
- A guide to grid hardening AiDASH
- A Comprehensive Forecasting Framework for Grid Hardening
- Community Wildfire Mitigation Best Practices Toolbox
- Missing the mark Effectiveness and funding in community wildfire risk reduction
- Analysis of utility wildfire risk assessments and mitigations in California ScienceDirect
- California Wildfire Mitigation Program Cal OES
- Targeted Grid Hardening for Public Safety Sentient Energy
- Manage Vegetation to Mitigate Wildfire and Power Outage Risks Corteva Agriscience
- Vegetation Management Program CAL FIRE
- PG&E Public Safety Power Shutoffs Information
- SCE Public Safety Power shutoffs Overview
- Puget Sound Energy PSPS Details
- Hawaiian Electric PSPS Strategy
- CPUC Public Safety Power Shutoffs Dashboard
- PSE Healthy Energy PSPS Analysis
- CPUC Fire Threat Map for High-Risk Areas
- SCE PSPS Alerts and Notifications
- Prepare for Power Down Resources
- Best Management Practices for Community Wildfire Protection Plans US Forest Service
- Best Practices for Fuel Break Establishment Corteva Agriscience
- Wildfire Safety PNM
- Community Wildfire Safety Program PG&E

- 10 Tips to Prevent Wildfires U.S. Department of the Interior
- Unasylva Fire as a forest management tool FAO
- 4 Pressures Utility Vegetation Managers Face Urbint
- From prevention to resilience Strategies in wildfire mitigation National Association of Counties
- Wildfire Risk Management Solutions Quanta Technology
- Electric Utility Asset Management & Wildfire Risk Mitigation Exponent
- Wildfire Risk Solutions for Electric Utilities Technosylva
- Wildfire risks in the US are soaring Utility Dive
- Technosylva Wildfire Risk Science & Technology Solutions
- Wildfire Risk Platform Technosylva
- Wildfire Risk Management Solutions Detection & Alerts AEM
- Wildfire Defense Systems Inc.
- 6 Actions Utilities Can Take to Mitigate Wildfire Risks ICF
- Wildfire risk mitigation an asset perspective Direxyon
- Protecting Our Electric Grid from Wildfire Department of Energy
- System Hardening & Undergrounding PG&E
- Wildfire Risks in the US Are Soaring Utility Dive
- Resilient Power Grids Stanford Report
- Covered Conductor A Wildfire Mitigation Solution T&D World
- Risk-Cost Tradeoffs in Power Sector Wildfire Prevention Energy Institute Berkeley Haas
- 6 Actions Utilities Can Take to Mitigate Wildfire Risks ICF
- Smart Grid Line Sensors and Analytics Help Electric Utilities to Mitigate Wildfire Risks T&D World
- Corteva Agriscience Utility Vegetation Management
- Corteva Agriscience Best Practices for Fuel Break Establishment
- CAL FIRE Vegetation Management Program

- PG&E Vegetation Management Safety Practices
- PG&E Yard Safety and Tree Planting Guidelines
- Edison Electric Institute Wildfire Mitigation and Liability Strategies
- Bureau of Land Management Routine Operations to Reduce Fire Risk
- Western Area Power Administration Wildfire Risk Management Focus
- American Public Power Association Wildfire Mitigation Planning Resources
- California Public Utilities Commission Wildfire Safety and Prevention
- Wildland Fire Assessment System Fire Weather and Potential Forecasts
- Southern California Edison Wildfire Mitigation Plans and Documents
- California Fire Safe Council Community Wildfire Risk Reduction
- GIS for Electric Utilities ESRI Industry Overview
- GIS Cloud Guide to GIS for Electric Utilities
- ENUGU Electricity Distribution Company GIS Case Study
- Michigan Public Service Commission Electric Utility Service Area Map
- Iowa Utilities Commission Electric Service Area Boundary Map
- PowerMag Electric Utilities Risk Management and Resilience
- Xcel Energy Wildfire Mitigation Program Details
- SafetyCulture Electrical Risk Assessment Guide
- Edison Electric Institute Wildfire Mitigation Strategies
- Juvare Incident Management Platform
- Southern California Edison Wildfire Mitigation Plan
- California Public Utilities Commission Wildfire Safety Resources
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- PSE Healthy Energy PSPS Analysis

- CPUC Fire Threat Map for High-Risk Areas
- SCE PSPS Alerts and Notifications
- Prepare for Power Down Resources
- EPRI Wildfire Tech Database - Hybrid Undergrounding
- PG&E Currents - Overhead to Underground Pilot Program
- T&D World - Covered Conductor: A Wildfire Mitigation Solution
- SCE - Targeted Undergrounding for Wildfire Mitigation
- Energized by Edison - How Covered Conductor Lines Help Reduce Wildfire Risk
- CNBC - Burying Power Lines for Wildfire Prevention
- DOE - Protecting Our Electric Grid from Wildfire
- EPA Integrated Vegetation Management Practices
- Alabama Power Residential Vegetation Management
- Santee Cooper Ground Floor Management
- Georgia Power Land Tree Management Easements
- Minnesota Stormwater Manual Vegetation Maintenance
- FERC Transmission Line Vegetation Management
- USDA Active Forest Management

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NARUC
National Association of Regulatory Utility Commissioners

1101 Vermont Ave, NW • Suite 401 • Washington, DC 20005
www.naruc.org • (202) 898-2200