Preventing Wildfires with Advanced Line Sensing and Grid Analytics

Approximately 20% of wildfires are attributed to electric utilities and power lines. Utilities can and should prevent or eliminate 100% of the causes and sources of wildfire ignition. Advanced line monitoring and analytics can detect and locate 80% of wildfire ignition sources on three-phase electrical grids. This paper discusses the need, the cost, and the value of stopping wildfires before they start using real-time monitoring and analytics to reduce risk, improve reliability, and save lives.

1. Problem: Identifying and Categorizing Wildfire Ignition Sources

Wildfires can be created by many electrical, environmental, and physical conditions. Most utilities lack access to high-frequency, localized data on fault behavior, making early risk detection impossible without advanced sensors.

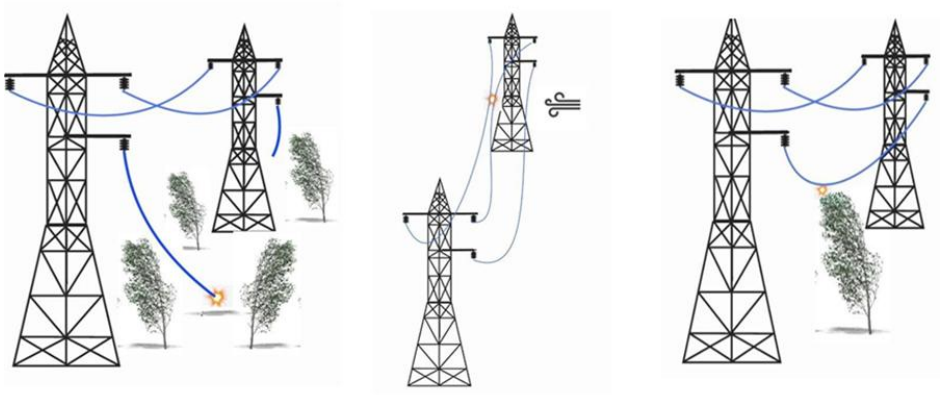
Utility hardware failures are a significant source of wildfire ignition, especially in regions with dry vegetation and frequent high winds. These failures can produce sparks or electrical arcing that ignite nearby flammable materials under the right conditions.

Key Root Causes of Wildfires from Utility Hardware:

- **Downed Power Lines:** Energized lines can fall due to severe weather, strong winds, or equipment failure. When they contact the ground, especially dry vegetation or conductive surfaces, they can generate sparks and ignite fires.
- **Aging or Faulty Equipment:** Deteriorated or poorly maintained hardware can overheat or arc, igniting nearby combustibles. For example, the 2018 Camp Fire was traced to a worn hook on an aging transmission tower.
- **Vegetation Contact:** Inadequate vegetation management allows trees or branches to touch power lines. Contact can cause arcing or line breakage, particularly in windy conditions, leading to ignition of surrounding vegetation.
- **Conductor Slap:** High winds can cause adjacent power lines to swing into one another, creating high-energy arcing that may ignite nearby materials.

- **High Impedance Faults:** These faults produce arcing without drawing enough current to trip protective devices, allowing sustained energy discharge that can start fires.
- **Substation Failures:** Though less frequent, substation equipment—such as oil-filled transformers—can overheat or fail, leading to potential fire hazards.

Vegetation encroachment on powerlines is one of the most common causes of catastrophic utility-related wildfires. With climate-driven changes, longer droughts, high winds, and hotter seasons—utility infrastructure is under more pressure than ever before. It's not only trees contacting lines, or conductors slapping during wind events; it's also undetected line drops and failing equipment that can all spark devastating fires within seconds.



Heat generating electrical faults that are sources of wildfire ignition.

2. Cost of the Problem: Billions in Losses, Lives, and Liability

Repeated wildfire events damage public perception and reduce trust in utility providers, prompting stricter regulations and potential penalties. Legal actions are shaping a precedent of severe financial and legal repercussions for utilities. Beyond public safety power shutoffs, fire-related damage can result in prolonged grid outages that hinder emergency response and economic recovery.

The financial, human, and societal costs of wildfires are staggering:

- $140 billion+ in damages from U.S. wildfires since 2017
- Utility liability in recent cases has exceeded $10 billion per event
- Insurance markets are collapsing in wildfire-prone states like California
- Public safety power shutoffs (PSPS) have affected millions, causing economic disruption
- Loss of life and community destruction erodes public trust in utilities

Utilities are spending heavily to mitigate this risk, in many cases, $1M–$100M annually per service territory; yet many still rely on manual patrols, helicopter flyovers, or basic visual inspections. These methods are reactive, slow, and often too late.

3. The Solution: Categorizing Wildfire Ignition Sources and Assessing them with Meta-Alert™ AI Analytics for Early Detection

	This list represents most of the grid failures or contributors on a three-phase electrical grid that are Wildfire ignition sources.			
Category	**Failure Type**	**Description**	**Ignition Source**	**Detected by Sensors**
1. Conductors	Conductor clashing	Conductors slap together due to wind or sag	Arcing, hot metal particles fall on dry vegetation	**YES**
	Broken or downed conductor	Wire snaps due to overload, fatigue, or vegetation impact	Sparks, live wire ignites ground	**YES**
	Galloping conductors	Wind-induced oscillations in ice-covered wires	Mechanical stress, arcing	**YES**
2. Insulators	Flashover	Voltage surges or contamination lead to breakdown	Arcing on pole or tower near flammable materials	**YES**
	Tracking or surface arcing	Polluted or damaged insulators slowly arc over time	Heat buildup and ignition	No
	Failed insulator string	Mechanical or electrical breakdown drops conductor	Live wire falls to ground	**YES**
3. Vegetation Contact	Tree contact	Branches grow or fall onto energized lines	High-impedance fault, sustained arc	**YES**
	Wind-blown branches	Debris thrown into lines during storms	Line-to-line or line-to-ground fault	**YES**
	Inadequate clearance	Maintenance failure allows vegetation growth into lines	Fire ignition risk	**YES**
4. Arcing	Arc flash from failed equipment	Arcs from switches, fuses, or breakers	Ignition of nearby flammable materials	**YES**
	Fault-induced arcing	Line contact or equipment fault causes flashover	Fire from persistent arcing	**YES**

5. Equipment	Transformer or recloser failure	Internal failure, explosion, or oil ejection	Sparks or flaming oil droplets	No
	Capacitor or switchgear failure	Arc or explosion due to internal fault	High-energy ignition source	**YES**
	Pole-top fire	Tracking or bird nests catch fire	Flaming debris falls to ground	No
6. Structural	Pole or tower collapse	Age, rot, erosion, or impact causes fall	Live wires contact dry vegetation	**YES**
	Guy wire or anchor failure	Mechanical instability causes sag or collapse	Conductor contact or breakage	**YES**
7. Weather	High wind events	Wind causes swing, slap, or structural failure	Breakage or vegetation contact	**YES**
	Lightning	Strikes create faults or ignite dry wood	Fire ignition on pole or ground	**YES**
	Extreme heat and drought	Vegetation becomes highly flammable	Increased chance of fire spread	No
8. Protection Systems	Recloser maloperation	Multiple reclosing attempts into fault	Prolonged arcing can start fire	**YES**
	Delayed tripping	Fault not cleared quickly enough	Sustained arc contact with flammable material	**YES**
	Relay failure	Fault detection delayed or missed	Leads to long fault duration	**YES**
9. Overloading	Conductor thermal sag	Excess current causes line to sag into trees	Arcing, fire from contact	**YES**
	Overvoltage or surge	Switching or fault creates insulation failure	Arc and equipment failure	**YES**
10. Wildlife/Debris	Animal or bird contact	Contact across phases or to ground	Fault and possible arcing fire	**YES**
	Balloons or foreign object contact	Metallic or conductive debris spans conductors	Arc and ignition source	**YES**

11. Human Error	Poor maintenance	Aging or failing parts not repaired	Unpredictable failures	No
	Unsafe work practices	Hot work or energized contact near vegetation	Sparks or flames	No
12. Substations	Arc flash in yard	Internal fault causes flashover or explosion	Fire within or beyond substation	No
	Oil-filled equipment failure	Transformer or breaker ruptures, leaks or burns	Flaming oil spray, ground ignition	No
13. Grounding	Broken ground wire	Higher voltage exposure near pole or equipment	Risk of heat and spark discharge	**YES**
	Neutral displacement	Imbalance causes unexpected voltages	Potential arcs or overloads	**YES**
14. Fault Currents	High-impedance fault	Tree or vegetation fault with low enough current to avoid detection	Long-lasting arc	**YES**
	Arcing ground or phase faults	Fault creates continuous arc	High fire risk, especially in dry areas	**YES**
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EGM's solution integrates Meta-Alert™ AI-driven analytics with real-time advanced line sensors.

EGM sensors can identify short circuits to ground and phase to phase faults. They identify and locate conductors intermittently touching trees and vegetation. They can measure the magnitude and direction of the wind (horizontal conductor movement) and galloping (vertical conductor movement) and provide an indication of physical breakage of the conductor. They detect high impedance short circuit faults, chattering of reclosures, overloading of conductors that may cause an overheating condition indicated by sag and current and voltage surges can be detected. Arcing caused by broken, or dirty, or cracked insulators will be detected by the sensors with their high sampling rate and the AI software.

Unlike periodic inspections, this system operates continuously, automatically, and intelligently.

How Meta-Alert Works

- Advanced sensors collect high-resolution electrical, environmental and physical parameters and signatures. The system improves with use—learning local fault patterns, seasonal trends, and grid idiosyncrasies to improve accuracy over time.

- Meta-Alert doesn't rely on one fault type—it builds a multi-layered model of fault behavior across time, frequency, and electrical signatures.
- False Positive Reduction—Meta-Alert's AI engine uses machine learning to continuously refine fault categorization, minimizing false alerts and increasing operator trust.
- AI and rules-based logic identifies and separates normal operations and then categorizes anomalies, faults, and unknown operations in real time.
- Alerts are created based on waveform signature pattern matching, then geo-tagged and sent to operations to integrate with satellite, fire-risk overlays, or drone deployment for validation and prioritization for field work.
- Meta-Alert analytics can be integrated with SCADA and Distribution Management Systems for seamless situational awareness and action.

4. Benefits to Utilities, Customers, and Society

Stakeholder | Benefit

Customers | Fewer PSPS events, lower outage frequency, reduced cost of power delivery

Communities & Society | Enhanced public safety, lower risk of property loss and evacuations, fewer environmental impacts

Utility Operators | Improved grid reliability and Improved SAIDI and SAIFI metrics, reduced wildfire liability, targeted vegetation management, and faster response

Electric utilities stand to save millions on annual O&M costs by optimizing vegetation management maintenance programs. Time-based vegetation management programs are ineffective and are costly due to continuously changing weather conditions. Utilities need to move from time-based vegetation management methodologies to proactive methodologies. The utility does this by moving to proactive maintenance in trimming and cutting vegetation where and when it is needed as opposed to following a set time schedule planned out three-to- five years in advance. Meta-Alert AI Analytics alerts a utility that there is vegetation encroachment on any of their circuits and they can target those areas for trimming before routine maintenance saving millions of dollars through targeted and timely tree and vegetation maintenance. An example of this is in rural areas where utilities do not have easy access to the properties where vegetation encroachment exists and therefore may go unattended. By notifying the utility that they have momentary faults correlated with wind events, they are aware of the conditions, and they can troubleshoot where the disturbances are occurring.

5. The Broader Value of Analytics: Cost Trends & Risk Reduction

Changing Cost of Wildfires

The last couple of years have seen a large uptick in the number and sizes of wildfire breakouts. And this is not just a Western US problem. We have seen recent breakouts in New Jersey, Pennsylvania, Ontario, and most recently Manitowoc, CA. And these are causing huge issues in our industry.

Besides the destruction that these wildfires create, they are causing insurance companies to increase premiums, limit coverage, and even pull out of these markets that are affected by wildfires. It is affecting utilities, businesses, and homeowners. They lead to MASSIVE lawsuits. Not only between the States and Utilities, but between individuals/groups and utilities, and between individuals and insurance companies.

Example Utility Spend on Wildfire Mitigation:

- $3.5 billion (PG&E, 2023)
- $1 billion (SCE, annual wildfire mitigation plan)
- Hundreds of millions in smaller utilities

It is clear and evident that advanced line sensor-based monitoring systems and analytics are best suited to assist utility operations to prevent and mitigate wildfires occurrences. Average wildfire cost per acre burned has tripled in the last decade, and wildfire insurance premiums have risen over 500% in some states. EGM's system offers a proactive, scalable, and affordable complement to these programs—detecting risk before it becomes ignition.

6. Call to Action

Get Ahead of the Fire Risk

Schedule a wildfire risk mitigation discussion with EGM to see how Meta-Alert™ AI analytics and real-time grid monitoring can reduce wildfire exposure, improve system reliability, and protect the communities you serve.

📧 Contact: info@egmgrid.com

🌐 Learn more: www.egmgrid.com/wildfire

📅 Book a pilot: Available for co-ops, munis, and investor-owned utilities