Hannigan, Edith@BOF

From: Evan Johnson <Evan.Johnson@OPR.CA.GOV>
Sent: Monday, April 22, 2019 2:15 PM
To: Hannigan, Edith@BOF
Subject: FW: Miscellaneous but not insignificant item
Attachments: Overview - Electric Hazard Early Detection Technology 04162019.docx

Evan Johnson
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From: Robert King <rking@goodcompanyassociates.com>
Sent: Friday, April 19, 2019 12:28 PM
To: OPR Wildfire Commission <wildfirecommission@opr.ca.gov>
Cc: Joseph McNulty (joe@whiskerlabs.com) <joe@whiskerlabs.com>; lee@krevatenergyinnovations.com
Subject: Miscellaneous but not insignificant item

In response to your request for comments, I would offer the following information about a technology now being commercially deployed for early detection of electric spark-related fire hazards. Please see the attached background piece, and let us know how else we can help support the important work of the Commission. It was the heart-rending stories of the CA fires that led us to explore the potential T&D applications of this technology.

Described in more detail in the attached paper, Whisker Labs has built upon the science behind lightning detection to develop a small device to detect scintillations (micro-sparks) on home circuitry. The small, inexpensive hardware item, about the size of a nightlight, plugs into any outlet in a home and takes readings millions of times a second, and uses embedded intelligence to send signals to a central dashboard when trouble is identified. An electrician can then be dispatched to make repairs before small problems deteriorate into actual fires. Watching the terrible fury of the CA fires in the last year, however, led us to ask if the same technology that micro sparking in home wiring couldn't also identify deteriorating conditions on larger circuits. The company is willing to work with any utility ready to undertake a pilot project.

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"Great discoveries and improvements invariably involve the cooperation of many minds"
-- Alexander Graham Bell

Emerging Technology for Early Detection of Fire Hazards Associated with Electric Power Distribution Systems[1]

Executive Summary

This paper makes a compelling case for deploying existing, commercially-available plug-in technology - across residential structures in a given geographic area - while partnering with university team(s) to conduct research and determine broad-deployment viability for detection of electromagnetic pulses and prevention of fire hazards on the grid.

Ting is a home-scale electrical fire hazard detection solution. About the size of a night-light, it can be plugged into a wall outlet anywhere in a home. Using powerline carrier signal technology and sophisticated data analytical capabilities, Ting identifies precursors to electrical fires in the form of micro-arc activity, or "scintillations" taking place in home wiring systems and things connected to it, before they develop into a safety hazard.

While hyper-sensitive to electrical arcing hazards inside the home, every Ting sensor also "sees", i.e., monitors, electrical activity on the utility grid in proximity to the home where it is installed. Deployed across multiple homes in a given geographic area, Ting has demonstrated the ability to sense and correlate grid-level events which could be used for earlier hazard detection and major fire prevention.

Wildfires A Growing Concern

Wildfires present a growing menace, as populations press expand in formerly natural areas, particularly in the drier western states, but the wooded eastern states, as demonstrated by the table below, face similar risks.

Top 10 States for Wildfires Ranked By Number Of Fires And By Number Of Acres Burned, 2017

Rank	State	Number of fires	Rank	State	Number of acres burned
1	Texas	9,827	1	Montana	1,366,498
2	California	9,560	2	Nevada	1,329,289
3	North Carolina	5,125	3	California	1,266,224
4	Georgia	3,929	4	Texas	734,682
5	Missouri	3,398	5	Oregon	714,520
6	Florida	3,280	6	Idaho	686,262
7	Mississippi	2,775	7	Alaska	653,023
8	Montana	2,422	8	Oklahoma	502,625
9	Arizona	2,321	9	Kansas	476,306
10	Oregon	2,049	10	Arizona	429,564

[1] For further information please contact Robert King, 512-773-6458 or rking@goodcompanyassociates.com

From January 1 to November 30, 2018, there were 52,303 wildfires, just under the record fire damage of 2017; with about 8.5 million acres burned. Most troubling is that the cost of fires also continues to soar as out of control fires overcome whole communities as they did in 2017 and 2018. Estimates of economic losses reached $18 billion in 2017 and will equal or exceed that in 2018, for wildfires which may regrettably become more well remembered for the tragic loss of life.

Electric Fires

Many fires have their genesis in electrical activity of some kind--as widely varied in scale as lightning or home electrical fires. The interaction of our electric delivery infrastructure with the natural environment, however, is also a significant cause of fires coming in for increasing scrutiny. A Texas Wildfire Mitigation Project found that 4000 fires, most local and of little consequence, but also larger conflagrations, were caused by utility transmission or distribution system events taking place in a period of less than 4 years preceding that study. Recent filings by PG&E indicate that at least 17 of 21 known fires within its service area in 2017 may have been connected with its electrical system interactions with the environment, and its responsibility has become a major political topic for the California legislature. That company's existence literally hangs in the balance due to potential liabilities associated with electric system connected fire hazards.

A number of approaches can be considered to help in part to reduce the fire hazard potential of electrical infrastructure, the most common and traditional being tree trimming programs and routine system maintenance and burying lines in particularly challenging environments. UC Berkeley has formed a fire research group to address engineering solutions to reduce the likelihood of fires from transmission and distribution systems.[2]

In addition, every utility employs Arc-Fault Circuit Interrupter (AFCI) equipment that automatically terminates electric power when significant faults are detected on a line. The Texas Wildfire Mitigation project used technology developed at Texas A&M, to sense electric perturbations before they reach the scale required to trigger an interruption of service, allowing for early detection of hazards, and often providing system operators the time to remedy faults. This project, however, relied upon somewhat expensive components that must be connected with the transmission and distribution system, in the substation, from which it was only possible to narrow possible fire hazards to a particular feeder.

The Early Detection Option

Thanks to technology, it is possible to reverse the worsening trend of tragic fire losses. Low-cost, high-tech equipment is now available, to sense the build-up of electrical charges or the occurrence of random sparking on damaged or deteriorating electrical equipment before it presents a danger. Advanced signal processing and computation capability enable us to find the tell-tale signal of trouble in time to undertake early prevention actions in most cases.

The story of this technology begins in the clouds, with the aid of cloud computing. Earth Networks developed the technology to detect the build-up of electrical charge in the clouds through wireless sensors, or receivers. Astoundingly, with the help of "big-data" analytics, the

[2] http://www.dailycal.org/2018/11/28/uc-berkeley-forms-fire-research-group-to-work-on-engineering-solutions-to-wildfires/

company's network of receivers, dispersed at intervals of as much as 50 to 100 miles, can pinpoint the location of cloud-to-cloud arcing before it becomes strong enough to form cloud-to-ground strikes. Clients depending on the accuracy of the Earth Network early detection network for human safety applications include NASA, NOAA, MLB, NFL, and Disney.

It turns out, the same technologies Earth Networks has been evolving and refining for two decades, also offer a means for much earlier detection of possible hazards associated with much smaller-scale electrical events. In fact, Earth Networks subsidiary, Whisker Labs, has recently launched a home-scale, electrical fire hazard detection system. Whisker Labs' inexpensive device it calls the "Ting," about the size of a night-light, can be plugged into a wall outlet anywhere in a home, and using powerline carrier signal technology, and today's big-data analytical capabilities, identify most micro-arc activity, or "scintillations" taking place in home wiring systems before they can become a safety hazard.

The Whisker Ting[3] takes readings 30,000,000 times every second. Following sophisticated processing and processing in real-time, a Ting sensor sends data constantly to Whisker Labs, which is able, through big-data analytics, to distinguish real signs of trouble from normal pulses associated with motors turning on or light switches being flipped. The company's dashboard alerts their in-house monitoring team when a technician should be dispatched to a customer's home to repair damage that may be from a bad installation, a nail piercing a wire inside a wall, a component showing wear, any of which are easy to fix if one detects it in advance. A credit towards remediation of an electrical fire hazard is part of the benefits of the Ting Fire service. Customers participating in the service may also receive a reduced home insurance premium.

Application to T&D Systems

Damaged components on the electric transmission and distribution system exhibit similar characteristics at a scale somewhere between that of lightning arcs and home wiring micro-arcs or scintillations. All arcs emit unique signatures that can now be remotely and instantly detected.

This was the focus of the Texas Wildfire Mitigation Project. Since the Texas initiative, however, Whisker Labs scientists have developed newer sensor and signal processing technology 1000 times more sensitive than typical utility arc detectors. And, because it is based on "reading" radio or electro-magnetic pulses, rather than electrical current variations, sensors need not even be directly connected to the electrical system. Together this means that new technology to recognize deteriorating conditions even earlier, can be purchased and installed at greatly reduced cost.

More exciting is a possible synergy between the company's current focus on preventing home fires and the possible application of the technology to utility distribution systems. As the distribution of home hazard detection equipment is deployed, Whisker Labs will see more and more about what is happening on the larger system, potentially eliminating the need to even monitor the T&D system directly. That is, with 5 or 10% of the homes reporting, Whisker will be able to see common signals (multiple homes receiving a pulse signal simultaneously) as having originated on the larger delivery system, and not within an individual home.[4]

Years of Research Yielding Real Results

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[3] See www.tingfire.com

[4] As an alternative the Ting can be fitted with a small inexpensive antennae, with which, if placed every mile or so on a transmission or distribution system, can precisely locate troubling spark activity.

An electrical arc is accompanied by an electro-magnetic pulse, or radio wave that can travel great distances. Lighting, for example, a sudden, high-power spark, is accompanied by a pulse that can be detected by a radio receiver, 50 to 100 miles away. Cloud-to-ground lightning represents only a small percentage of the total lightning discharges that occur in the atmosphere. In fact, in-cloud lightning flashes account for the vast majority of lightning activity. Earth Networks' unique capabilities detect long-range in-cloud lightning at high efficiencies, which is critical to the advanced prediction of potentially deadly weather events that often occur within 5 to 30 minutes of in-cloud flash initiation.

Earth Networks has been working for two decades to build a worldwide network of sensors and evolve and improve the technology and signal processing and analysis required to triangulate the precise location of lighting. Its Total Lightning Network is the first and most sophisticated of its kind, incorporates over 1,200 sensors in 40+ countries around the world.

Similarly, even the smallest scintillations (micro-sparks) emitted by an electrical fault on a residential wiring system, create an electro-magnetic pulse that will travels especially well along the wires throughout the home. In fact, the evolving Whisker technology for both sensing and identifying the unique signature of these pulses, comes from the now well-established technology of communications over powerlines.

In a residential setting, these fires often begin in walls or other hidden cavities and gain significant heat and headway before they are detected by home occupants or smoke detectors, leading to significant damage. Electrical malfunctions are one of the leading causes of residential home fires. Because of the hidden nature of the ignition source, electrical fires are also a disproportionate cause of death. Electrical fires are estimated to cause 420 deaths, 1,370 injuries, and $1.4B in residential damages annually.

To detect and help prevent dangerous and costly residential electrical fires, while providing a cost-effective and scalable solution for existing or new homes, the Whisker Labs team has developed a fully do-it-yourself (DIY) smart plug-in technology and associated intelligence that detects and alert homeowners to the presence of damaged and arcing wires. An accompanying smartphone application, and team of experts, guide homeowners through the necessary steps to mitigate a detected electrical fire risk. Several compelling customer case studies demonstrating efficacy have already been documented.

Still, as noted above, wildfires cause much larger economic damage, if not greater mortality every year, and a not insignificant cause of such fires stem from electric delivery systems. Many power-line components (e.g., switches, insulators, transformers) provide trouble-free service for decades, but transmission and distribution components eventually fail. Fires can be triggered[5] via a number of mechanisms including:

- A downed line,
- vegetation contact,
- conductor slap,
- repetitive faults, and
- apparatus failures.

[5] Taken from the Texas Wildfire Mitigation Project: https://wildfiremitigation.tees.tamus.edu/

Solution Development: Start Simply

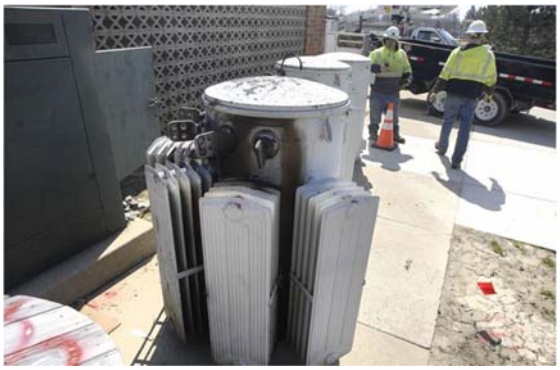
A typical circuit may have hundreds or even thousands of components, making it impractical to inspect or test all components on a frequent basis. The current solution to address fire threats is an Arc-Fault Circuit Interrupter (AFCI), a special type of circuit breaker that uses electronic technology to sense different arcing conditions and shut off power to the circuit if such conditions are detected.

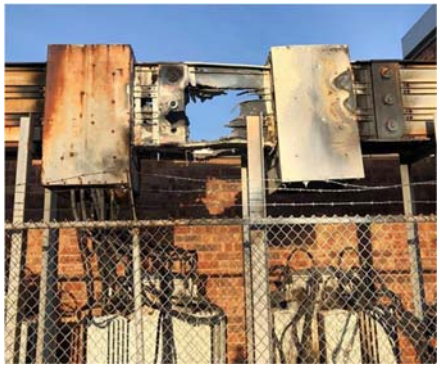
Similarly, AFCIs are now required in the National Electric Code (NEC) in new home construction and renovations. A major challenge with AFCIs is that they require a complete electrical system upgrade to install in existing homes, and are thus cost prohibitive, and challenging to deploy at scale. With installation, each AFCIs cost $160 to $260+ per breaker, so installed costs would run on average $2,000 per home. In 2017, the AFCI market size was $3.7B. In contrast, Whisker Labs' Ting, which samples nearly 30 million times a second, has much greater sensitivity and much lower false positive rates than current day arc detection/fault interrupters.

The wires that provide power to appliances are the medium over which fire precursor signals travel from origin to sensor in buildings. Precursors are impulsive discharges and result in electromagnetic signals that travel along the power distribution wires in a building. Every location in the wiring (both house fixed wiring and mobile cords to devices and appliances) allows a signal to be transferred to every outlet in a house. Although the precursor signals arrive at the sensor modified by the homes wiring configuration, Whisker Labs technology and analytics leverages methods developed in power line carrier communication techniques to measure and identify very broad frequency content, effectively differentiating the signal from the noise.

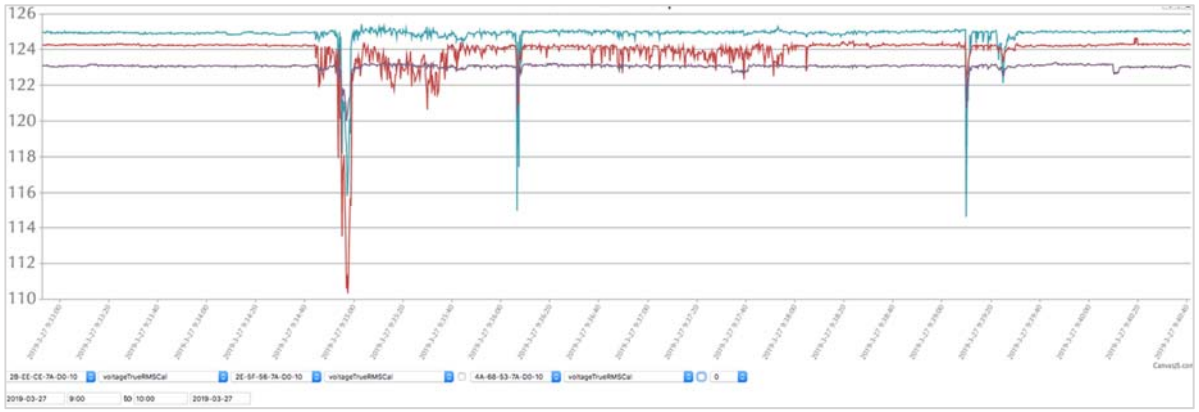
It is not a huge leap, therefore, to consider how this technology might apply to the early detection of deleterious arcing on the larger distribution systems of electric utilities. The technology, even the signature of larger system deterioration or failures should be the same, or very similar, although the company is anxious to test that hypothesis in collaboration with an interested university, utility and/or utility consortium. Existing DIY technology at the home level would allow us to know more about electromagnetic pulses on the grid than ever before.

Importantly, Whisker has been working with insurance companies to get early warning of house fires (which can also be the cause of larger area fires of course), and have produced mapping of simultaneous sparking across Bloomington, Illinois, for example already, providing an early deployment demonstration. Specifically, the photos below are the aftermath of a transformer fire at a local school. Neighbors reported fire just after 5am local time, caused by transformer arcing and failure.





The plot below from Whisker Labs shows arcing events correlated across several Ting sensors installed in homes in the area just before 4:35am (graph is UTC, 9:35am), lasting for about 5 minutes.



An initial exploration of the ability of this technology to detect T&D system level hazards could be undertaken quite simply and inexpensively, without the need for hardware development or modifications.

Making Ting available to homeowners across a geographic area would enable Whisker Labs to test the system's early detection capability on the connecting distribution system using geographically dispersed time-series data. If multiple homes in a given neighborhood, or on a given feeder, are receiving nearly-simultaneous high-power signals, mapping and analyzing of the devices across the region could help pinpoint danger points on the distribution system in need of further inspection and maintenance. A modest deployment of Ting in homes could be used to further validate the simplicity and accuracy of distributed sensors to also identify developing hazards on the connecting infrastructure. Once homeowner participants were identified and Ting shipped to each, a modest two-minute DIY installation process is all it takes to enable deep analytical insights and quickly allow exploration on a broad scale. Not to mention, homeowners receive the benefit of early electrical fire hazard detection within their home. This approach would represent an incredibly simple yet efficacious program for participating homeowners and industry alike.