EPRI | ELECTRIC POWER RESEARCH INSTITUTE

EARLY FAULT DETECTION FOR POWER LINES

Incubatenergy Labs 2020 Pilot Project Report

IND.T
INTELLIGENT NETWORK DIAGNOSTIC TECHNOLOGY

Startup

IND Technology

Ameren

Host

Ameren

Technology Solution

Overhead transmission and distribution (T&D) lines connect urban environments and span continental grids, frequently traversing remote and difficult-to-access terrain. Stringent reliability, vegetation management, and fire protection standards create the need for utilities to navigate along power line corridors and to conduct inspections from the ground, by helicopter, and by unmanned aerial vehicle. Periodic inspection is inefficient and incapable of detecting many failures, creating opportunity for innovation.

This pilot tested the early fault detection (EFD) technology developed by IND Technology (IND.T), which applies radio-frequency (RF) sensors and advanced analytics for monitoring power line conditions to detect and accurately locate failing network assets—those that are deteriorated, damaged, or compromised by external factors such as vegetation encroachment. In essence, EFD finds failure-causing faults before they happen. EFD data collection units are installed about every 3 to 5 miles along power lines to supply RF signal data for algorithms running on a secure cloud server and trained for electrical circuit diagnostics. EFD systems could potentially revolutionize utilities' network operation, asset management, and work planning processes while cutting the number of T&D line faults causing customer supply outages and fires.

*EFD capacitive coupling sensor mounted on a steel lattice tower to monitor a 138kV conductor **(left)**; and IND.T data collection unit affixed to tower leg showing three coaxial cables from up-tower sensors **(right)***

Project Overview

Working in collaboration with IND.T, Ameren and EPRI initiated a pilot project to assess EFD technology by importing 15 RF sensor and data collection units from Australia and installing them on 138kV wood pole and steel lattice tower lines and 34kV lines with underbuilt 12kV distribution circuits remotely located in rugged terrain in rural Missouri. As a secure EFD cloud server was already in place to support trials on high-fire-risk networks in California, installation of the RF sensor units was the only step required to commission the EFD systems.

Challenge: Customer and Community Resilience

The three power line routes were selected for the trial based on their history of "unknown cause" faults in order to increase the chance of issues being present in the relatively brief pilot period, as well as to observe the efficacy of the sensors and diagnostics. The first EFD unit was installed on August 20, 2020 on a wood pole 138kV transmission line at Dorsett South. After additional deployments, the project team explored the ability of the EFD system and its information outputs to gauge the timeliness of insights and prevent and mitigate potential failures. Avoided cost and ease of use also were evaluated.

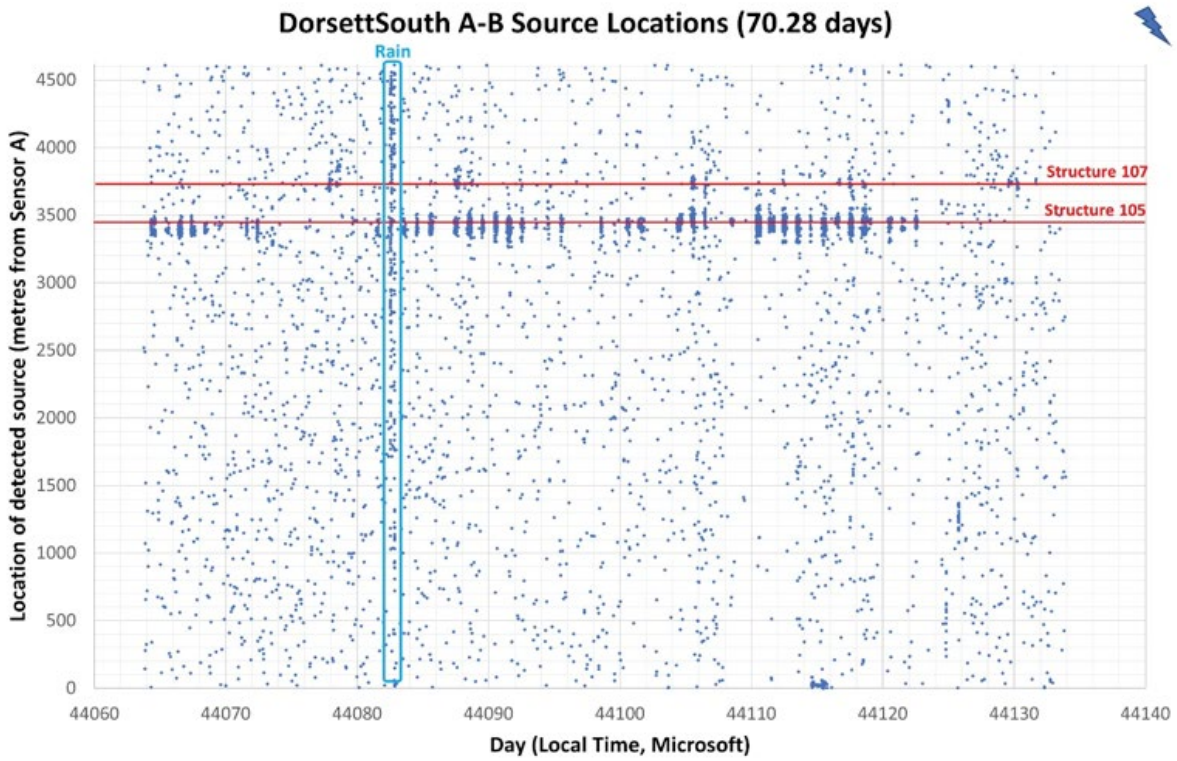
Results & Learnings

Ameren's EFD systems almost immediately identified and accurately located a range of issues on the trial power lines. The first suspect asset became apparent just 15 hours after commissioning the EFD system. Problems identified included a 138kV porcelain insulator string with partial discharge and a handful of distribution transformers with internal discharge, plus instances of suspected conductor damage and vegetation encroachment. Ameren responses, including some forensic investigations, have been scheduled for each of these issues.

The EFD system located issues within plus or minus 30 feet and demonstrated very sensitive detection of incipient faults. Its frequency-time signature analysis and pattern recognition gave indications of the type of failure detected and whether it was located on the monitored power line path or away from it on a tap-line or secondary supply service line. Issues were identified down to individual phases.

Some useful lessons were offered by the project:

- While EFD data collection units can be installed on most poles and towers, sometimes the selected locations were changed by a span or two to avoid constraints. This did not affect the operation of the EFD systems. All the EFD units installed by Ameren were powered from nearby 120V supplies. Each unit draws an average of only 5 watts, and solar power is feasible.
- The distance between the monitored conductor and the capacitive coupling sensors that feed signals to the EFD data collection unit must be close to the same (within plus or minus 2 inches) at each installation along the line. New pole and tower mounting methods were easily developed that achieved this.
- Some detected issues are inherently invisible to inspection because they are hidden within the asset, such as transformer internal discharge. In these cases, confirmation of the detection comes when the asset is swapped out. Other defects such as broken conductor strands can be readily seen on EFD-prompted site visits. This mirrors other EFD experience in Australia and California.
- The project was successfully completed under COVID-19 restrictions that prevented travel to the US by members of the IND.T team in Australia. Online training, procedure videos, and web-based meetings were sufficient for the installations to be fully successful through collaboration among IND.T and Ameren staff.



EFD chart showing intermittent partial discharge activity at an 138kV insulator string on Phase A, Structure 105

Implications & Next Steps

The Ameren pilot confirmed that IND.T's EFD system detects and locates incipient asset failures on power lines ranging from 12kV wood-pole distribution to 138kV steel lattice tower construction. In some cases, the EFD data were rich enough to remotely identify the probable cause and assess risk and urgency prior to a site visit. There is clear potential for utilities to use EFD results to inform grid operations, network maintenance, and asset management activities. This IND.T trial indicates opportunity for potentially radical beneficial change in these functions.

Once Ameren completes installation of all 15 units, EFD technology will continue to undergo demonstration testing through mid-2022, complementing field trials on networks on the U.S. west coast. Ameren is evaluating possible next steps for applying the technology in improving T&D asset health monitoring to deliver value into its network businesses in Missouri and Illinois.

Resources

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TESTIMONIAL: IND.T

We were proud to be selected for a trial of EFD on Ameren's networks and enjoyed working with such an enthusiastic team, though COVID-19 kept us physically a world apart. We were particularly excited to see EFD installed on transmission lines—our lab tests had confirmed EFD works on high-voltage lines, but this was our first real-life install. Finding a failing insulator string first day really capped it off.

Tony Marxsen, *Chairman*

TESTIMONIAL: Ameren

The idea that you can identify problems on your transmission system that are soon to come—event anticipation—is really, really important. Eliminating customer outages, driving affordability because we can efficiently group our work instead of heading out to fix things whenever they fail, and, dearest to my heart, risk management—not just put in better protection to respond to faults and limit consequences, but actually manage the risk of faults happening—all I can say is this tech is magic.

Jeff Hackman, *Senior Director, Business Development and Special Projects*

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