Technology At Work

Helping Grid Components "Fail Gracefully"

EPRI Investigates More Resilient Designs, Controlled Failure Points, Inspection, and Maintenance

By Tom Shiel

What do automobile designs and electric grid designs have in common?

Both incorporate features that minimize damage during major accidents. When a car crashes, "crumple zones" in the vehicle's outer parts absorb the energy of the impact, reducing damage to the passenger cabin and preventing or reducing injury. Similarly, when a tree falls on a distribution power line during a major storm, certain design features can minimize damage to poles and overhead structures.

For several years, EPRI research has worked to better understand how overhead line components and structures fail. In 2018, it is now identifying resilient overhead structure designs and providing utilities with a tool for prioritizing resiliency investment.

"Broken poles need to be replaced and require expensive repairs," said EPRI Technical Executive John Tripolitis. "The key is to minimize the number of poles that break, whether it be from a falling tree, ice accumulation, or high winds. We want to design these components so that they fail gracefully, or in a known manner. If we can preserve the poles and contain damage to the pole-top components, this can result in easier and quicker repairs."

Prior EPRI stress tests on poles have shown that a pole's strength is correlated with its top circumference. In 2018, EPRI is testing distribution poles and pole-top components to determine the structures most resistant to pole breaks.

EPRI is exploring how designing controlled failure points into the system can reduce damage. For example, when struck by trees, conductors can slip through conductor ties, minimizing the forces on poles and pole-top components and reducing repair costs.

An additional challenge is that structures must meet National Electric Safety Code. "We're not weakening the structure," said EPRI Engineer/Scientist Joe Potvin. "We're designing it so that it breaks in a specific way when a significant force is applied."

"Our research is showing quite a bit of promise," Tripolitis said. "Several companies have sent us pole-top designs so we can test them."

EPRI also is looking at inspection and maintenance practices. "In field studies where we dropped trees on lines, we learned that the forces on the system tend to seek out weak spots—places with deteriorated components such as rotted crossarms," said Tripolitis. "Weak spots can cause unpredictable failures." In 2018, EPRI plans to identify inspection and maintenance approaches that can pinpoint and strengthen weak spots.

Getting the Most 'Bang for the Buck' out of Resiliency Efforts

Hardening poles and overhead structures is one of numerous strategies for making the grid more resilient. Other strategies include vegetation management, burying lines, and enhanced technologies such as advanced meters, stronger poles and components, and automated switches.

For utility planners, a primary challenge is to determine the best strategies for a particular distribution system.

"When I'm looking at a set of circuits that I want to harden, I could choose among various options—move the circuits underground, upgrade the poles, use larger wire, apply automation technologies, and others," Tripolitis said. "So how do I choose?"

To inform such decisions, EPRI is developing a tool for estimating the reduction in outage risk per dollar spent for a given resiliency strategy. It evaluates circuits' risk factors with respect to the likelihood of outages. For example, dense tree stands can increase risk.

"If tree density data is not available, a utility could assess risk using historical data on outages caused by trees and other vegetation," said Tripolitis.

Circuit age is another risk factor, with older circuits posing a greater risk. Most utilities have good information on the age of wood poles but not small pole-top components.

"You can use the age of the poles on a circuit as a proxy for circuit age," Tripolitis explained.

Users input the set of circuits to be evaluated, the resiliency strategies to be compared, their costs, the circuit risk factors, and the anticipated change to the risk factors associated with each strategy.

"The tool produces a ranking of resiliency strategies based on their expected ability to reduce circuit risk—their relative 'bang for the buck,'" said Tripolitis.

Key EPRI Technical Experts

John Tripolitis