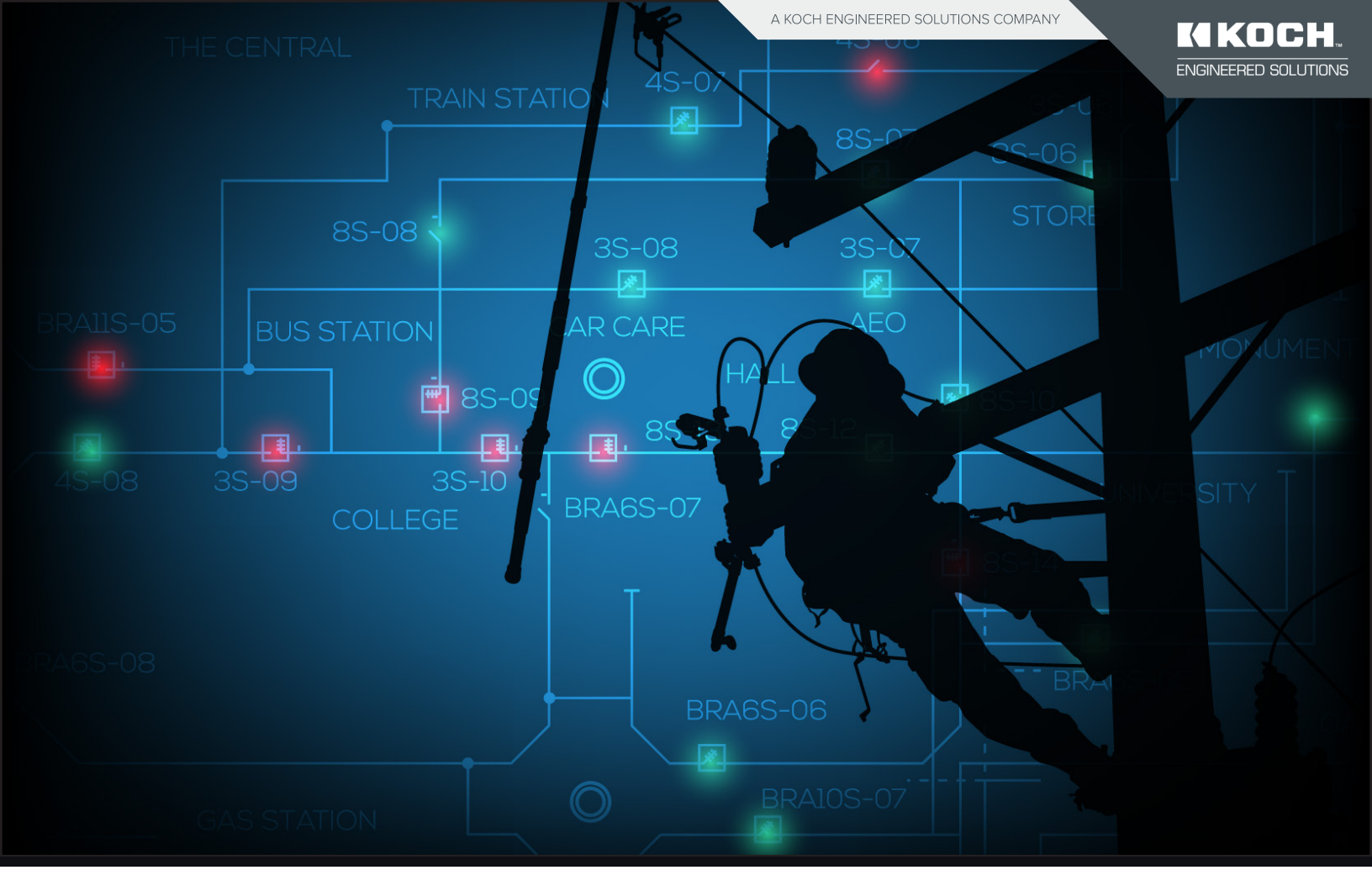

Predicting Distribution Outages

Does it work and is your utility ready?

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Does it work and is your utility ready?

Advances in edge computing data and analytics are enabling new opportunities for enhanced distribution system management. Predicting and preempting distribution grid outages is one such opportunity worthy of attention as it could significantly impact grid reliability, simultaneously improving SAIDI, SAIFI, and MAIFI metrics.

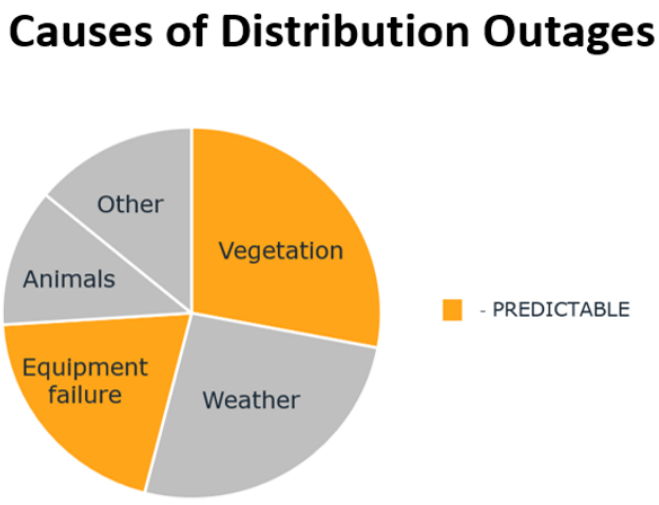
From a technical standpoint, predicting distribution system outages can be challenging as outages have numerous causes, and each distribution circuit has unique design, load, and impedance characteristics. However, the right data sets and refined machine learning can enable effective preemptive actions despite these complexities.

Some progressive utilities recognize the significant reliability value in predicting outages and are laying the groundwork to begin doing so. Still more are exploring what it would take to leverage this breakthrough approach to predicting outages.

To understand whether your utility is ready to begin predicting distribution outages, two important items must be evaluated: the most common causes of permanent faults on your system and change management feasibility in operations, planning, reliability, IT, and leadership.

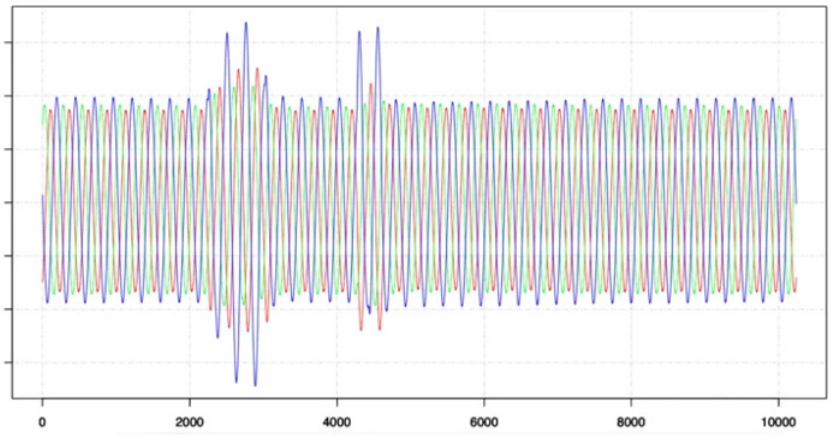
Is it possible to predict outages with good probability?

The answer to this question depends upon the cause of the distribution system fault. Some causes are very random and cannot be predicted, like faults caused by a motorist hitting a power pole or an animal causing a short on the power system. But two categories of permanent faults commonly produce incipient faults prior to a full-blown overcurrent event — those caused by equipment failure and vegetation encroachment. With machine learning and advanced analytics, these faults can be successfully predicted with good probability.



Equipment failure and vegetation faults can be predicted using intelligent line sensors to capture waveform anomalies and then running these anomalies through an advanced analytics engine to classify them. Anomalies are smaller deviations of current and voltage waveforms. They are too small or short in duration to be detected by protection equipment and cause reclosing or permanent faults.

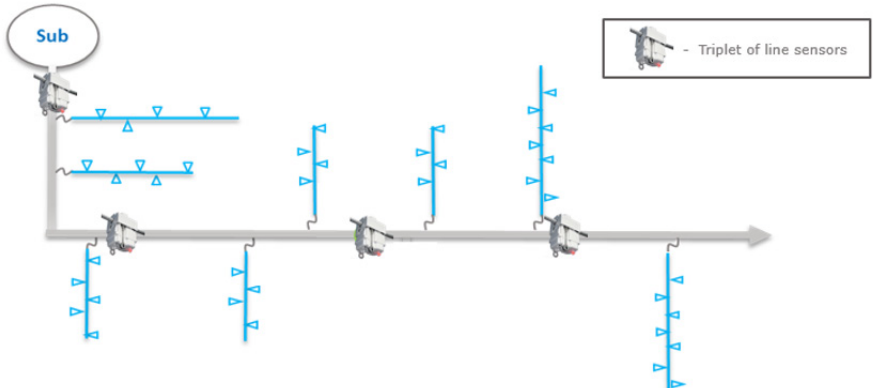
Waveform Anomalies



A large portion of anomalies represent normal operating conditions like a breaker closing, a capacitor bank turning on, rain hitting overhead power lines, or adjacent feeder events. These operational anomalies need to be filtered out. With analytics we can identify whether the remaining anomalies match signatures that are indicative of an impending permanent fault.

At 130 samples per cycle, intelligent line sensors have higher sampling frequency than conventional protection devices on the feeder like recloser controls. And sensors can be placed at multiple locations along the feeder to cost-effectively provide more precise location information. A best practice approach is to install four sets of sensors along a feeder, segmenting it at quarter points. This becomes important when a preemptive action needs to be taken in response to predictions, which is discussed later.

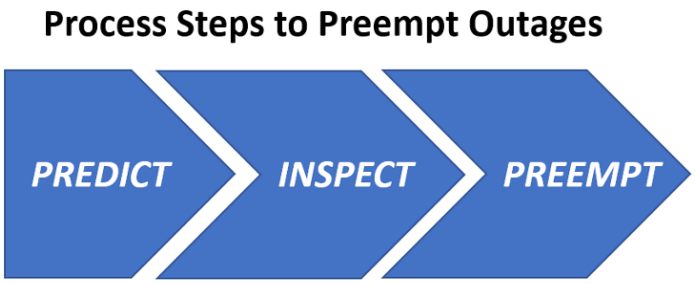
Feeder With Line Sensors at Quarter Points



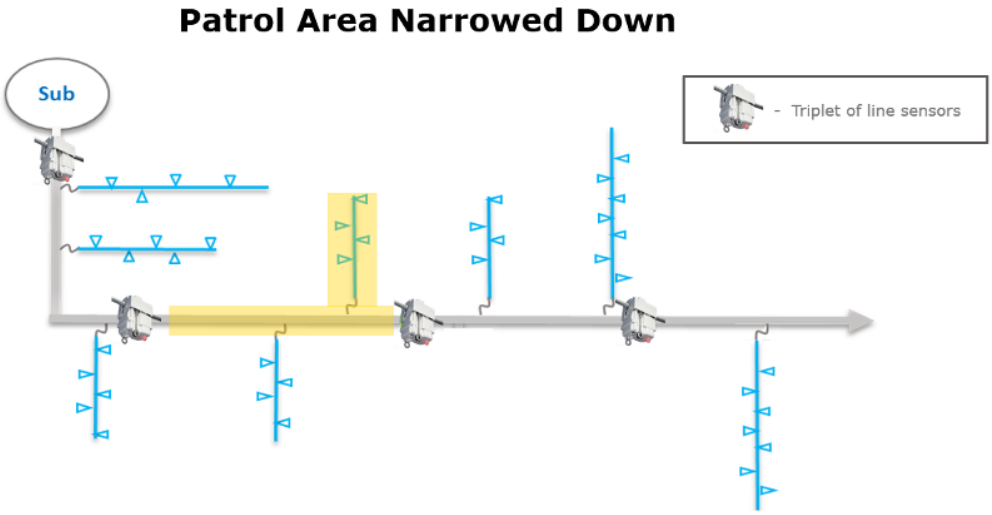
Is your utility ready to preempt outages?

This may be the most important question for utilities to consider. Predictive analytics can provide unmatched reliability improvements, but only if they are acted upon to preempt outages. And taking actions to investigate, locate, and mitigate impending outages creates the need for new processes or modifications of existing processes.

Preempting outages involves three key steps as shown below:



To be successful preempting outages, it's important to assess change management in several key areas of your utility:



Planning, Operations and Maintenance readiness

Let's take the case of an equipment failure prediction. When the analytics engine identifies numerous precursor anomalies that indicate a high probability of an impending equipment failure, this information is sent via a daily report to a utility field inspector to investigate.

By comparing data from multiple sensor locations, the segment of the feeder and phase where anomalies are occurring is identified. Note that some laterals can also be excluded from the patrol area because the phase with high anomalies is known. This is important because if we give the field inspector a narrowed down segment to investigate, the odds of finding the problem increase greatly and the time to do so is reduced.

The field inspector looks for possible problems on the target feeder segment. It could be that a pin insulator is broken, or a cut-out is cracked, or a lightning arrestor has detached wires. These are problems that an experienced field inspector can visually identify.

Once the issue is identified, a quick repair is needed from the line crew to preempt the likely outage. For the best chance of preempting an outage, it's necessary to inspect and address the issue within one to two days.

If the planning, operations, and maintenance teams can inspect a feeder segment and repair problems as promptly as laid out in this scenario, they should be able to support the process needed for preempting outages without significant change management.

Vegetation Management readiness

The process for predicting and preempting an outage caused by vegetation in contact with power lines is like equipment failure, except that the PREEMPT step likely involves tree trimming, not equipment repair.

Analytics model predictions indicating an impending outage due to vegetation encroachment are typically communicated to a utility's vegetation management contact. After the indicated feeder segment is inspected and an encroachment issue confirmed, the vegetation management crew trims the vegetation, preempting the outage.

As it is with equipment failure prediction, prompt response to indicated alerts or actions is needed for best reliability results. The inspect and trim steps for vegetation encroachment issues need to be performed within one to two days of the alert so the tree-trimming crew must be very responsive.

Because a nimble approach is key to gaining the reliability improvements associated with predicting impending vegetation encroachment outages, it's important to assess how your utility currently

manages tree trimming. Most utilities choose to optimize for efficiency with the resource intensive task of vegetation management, typically maintaining a cyclic trimming program that may repeat every 7-10 years. This type of program is not a feasible option to address the quick trimming needed for outage predictions.

For vegetation encroachment outage predictions to be effectively addressed, a quick and prescriptive trimming capability must be part of the overall vegetation management program. If your utility already has or is willing to implement a responsive, data-driven trimming approach, they can support preempting vegetation encroachment outages.

If your utility needs to implement this type of data-driven vegetation management capability, a phased change management approach is an option to consider. You can start by predicting outages, inspecting, and then measuring the percentage of cases where outages do occur. When there is confidence in the accuracy of predictions, it is easier to justify implementing new spot-trimming approach to realize the reliability gains and also mitigate wildfire risks.

Information Technology readiness

Because preempting outages is a new type of reliability use case which requires more data and analytics than traditional reliability programs, it's essential to evaluate your IT organization's ability to support such a project.

One important IT readiness factor is the use of cloud deployments. Most utility operational technology (OT) systems run in on-premises data centers, but for the line sensing and advanced analytics solution described above there are distinct advantages to using a cloud software deployment.

Advantages of cloud-hosted software deployment include:

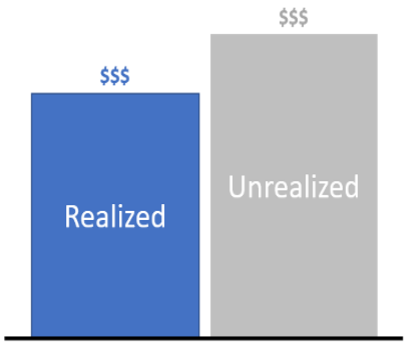
- Ease of scalability
- Reduced IT resource requirements
- Simplified integration with cloud-based analytics engines

If your IT group has experience with cloud deployments or is open to trying the cloud, then they are likely ready to support efforts to predict and preempt outages.

Leadership readiness

Advanced analytics projects utilize new technologies and estimating return on investment is different than with other technology solutions due to the probabilistic nature of the outcomes and required change management. To ensure buy-in and successful outcomes, your utility's leadership team needs to track both realized and unrealized reliability improvements for predicting outages.

Reliability Improvements from Predicting Outages



Realized reliability improvements are gained when a predictive alert is sent to the utility, the field inspector finds the failing equipment or vegetation encroachment, the equipment is repaired or trees trimmed, and subsequently the outage is avoided. The value of the resulting reliability improvements can be quantified by a utility in a variety of ways using saved Customer Minutes Interrupted (CMI), Operations and Maintenance (O&M) costs, or other metrics specific to the utility.

When realized value is an estimate of Customer Minutes Interrupted (CMI) that would have happened had nothing been done, the calculation uses feeder level Customer Average Interruption Duration Index (CAIDI) and estimates the closest upstream protective device that would have operated if the outage had occurred. For example, avoiding an estimated 3-hour outage for 50 people would yield a potential CMI savings of 9000. If CMI is valued at $2 per minute saved, a utility could value the preempted outage as $18,000 of realized value.

When predicting outages, the potential for unrealized improvements also exists. Scenarios where savings are unrealized after a predictive alert is raised include:

- A field inspector is not able to locate the failing equipment or vegetation encroachment through a visual inspection of the identified feeder segment
- An outage occurs before the inspection or repair is completed
- Problem is found during inspection but there is no process or effort to repair

Utilities should identify which unrealized scenarios can be addressed with change management and the associated reliability value of these potentially preventable outages.

For this example, again using CMI, let's say vegetation contact is predicted and identified during inspection, but a crew was not sent to do the necessary trimming and an outage occurred with a CMI value of $12,000. This is the unrealized value that could be realized with changes in vegetation management processes.

For a comprehensive picture of the full reliability value of preempting outages, both realized and unrealized values must be tracked and quantified. Realized value will measure the current ROI of the program while unrealized value can be used to drive change management and shift unrealized value into additional realized value over time.

In Summary

For progressive utilities looking to materially enhance distribution system reliability and resilience through proactive outage mitigation, intelligent line sensing and predictive analytics offer a cost-effective path to realize that vision for two of the leading causes of outages — equipment failure and vegetation. Field results show impactful ROI through reliability improvements when predictive alerts are promptly acted upon.

However significant the potential reliability value though, it's important to understand that predicting outage events with analytics and machine learning is a new type of technology project and outage management approach. As a result, your utility's readiness to begin preempting outages must be assessed. Are the planning, operations, IT, and leadership teams ready, able, and willing to embrace the necessary change management to make this type of ground-breaking project successful?

No matter how ready your utility is, if preempting distribution system outages is part of your utility's future grid modernization plans, Sentient Energy would love to help you achieve your reliability goals with a unique predictive analytics solution.