Powering Resilience: Hardening Strategies for Evolving Grids

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Chris Kniedler, *Director of Product Management Overhead Solutions*
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EVERY CONNECTION COUNTS

Agenda

Meet Your Speakers

What Is Grid Hardening?

Enhancing Connection: Managing Increased Load On The Grid

Increasing Protection: Animal, Vegetation, and Wildfire Interactions

Expanding Detection: Addressing Challenges With Grid Transparency

Key Takeaways

Meet Our TE Experts

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Director of Sales
North America

Chris Kniedler
Director of Product Management
Overhead Solutions

Hemanth Jala
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Smart Grid Americas

Poll Question

What is the primary challenge your organization faces in improving grid reliability?

a) Aging infrastructure
b) Severe weather events
c) Cybersecurity threats
d) Funding or budget constraints
e) Other

Outages Cannot Be Completely Eliminated

Yes, outages will keep happening.

All overhead lines are exposed to:

- Forces of nature (wind, lightning, ice)
- Vegetation contact
- Wildlife intrusion
- Vehicle collisions
- Wildfires
- Equipment failures / aging infrastructure

Outages can be reduced with protective equipment or practices,
but <u>not</u> completely eliminated.

What Is Grid Hardening?

Enhancement of the reliability of electrical power grids to better withstand and recover from adverse conditions.

Causes

- The U.S. grid has been experiencing an aging level of demand for many years
- Infrastructure was originally designed for different levels of demand
- Utilities are facing challenges in increased load, increased weather, and environmental disruptions

80%

of major U.S. Power Outages between 2000 and 2023 were weather-related.

About 70%

of the U.S. grid is over 25 years old.

$100,000 USD

average cost of an outage per hour.

Sources: 1.Powering Up Resilience: Transforming the Grid with Technical Advancements and Proactive Strategies, 2024 2.Enhancing and Hardening the U.S. Power Grid, 2023 3. The Rand Group LLC, 2021.

What Is Grid Hardening?

> **Power demand is increasing for the first time in two decades amid demand from artificial intelligence, electric vehicles and crypto currency. In addition, new wind and solar farms need transmission to get power to cities.” (Gardner, 2024)**

Effects

- The U.S. department of Energy is granting utilities billions of dollars in enhancing energy infrastructure to face climate, overload, and cyber threats.
- Utilities are on the consistent search for technologies and strategies to keep the lights on while minimizing costs.

Sources: 1. Grid Hardening Grants. U.S. Dept.Of Energy, 2024 2. US grants nearly $2 billion to harden power grid against extreme weather, Reuters, 2024

Poll Question

Which benefit of advanced overhead line connectors do you consider most critical for ensuring a lasting connection?

a) Enhanced durability and resistance to environmental stressors
b) Improved electrical conductivity and reduced energy losses
c) Easier installation and reduced maintenance requirements
d) Compatibility with modern grid technologies

Enhancing Connection: Managing Increased Load On The Grid

EVERY CONNECTION COUNTS

Use Case: Preventing Power Outages from Aging and Under-performing Connectors

Challenges

Corroded or inefficient connectors lead to higher resistance and higher risk of energy loss.

Faulty connectors create potential safety hazards, such as electrical arcing or conductor sagging.

Grid is experiencing increased loads and growing demand.

Solution: high-performance overhead connectors

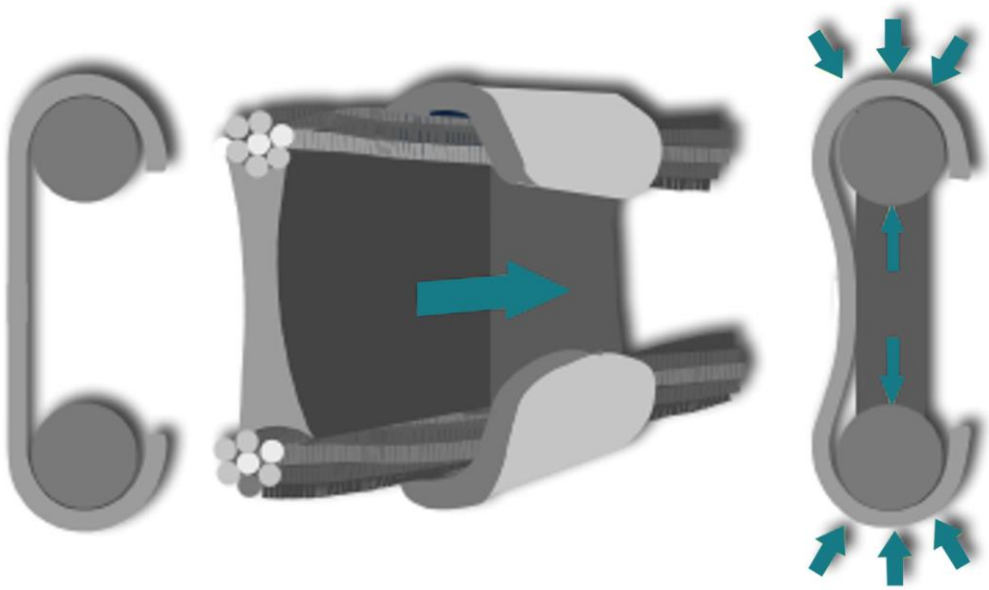
- **High Durability:** Made from corrosion-resistant materials (e.g., aluminum alloy or copper)
- **Easy Installation:** Wedge pressure technology allows quick and secure installation

Wedge Pressure Technology

- **Elastic property** of C-member maintains constant force within the connection for the life of the connector while compensating for thermal expansion and mechanical creep.

- Robust design providing **high resistance to environmental stress** factors such as temperature extremes, wind/vibration, and airborne contaminants.

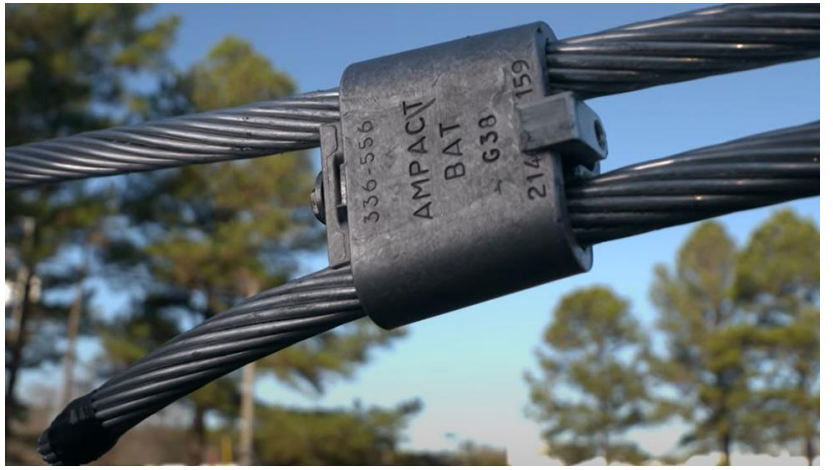
- Provides a simple, **foolproof method for connector installation**. No fatigue for the operator completing a series of installations ensuring **repeatability & reliability**.



Benefits of Wedge Pressure Technology

Designed to **help overcome the physical and electrical limitations of traditional compression or bolted connectors**, this technology can maximize contact between the connector and conductor surfaces

Resolves problems associated with the oxidation of metallic surfaces.



How is it used?

Combines the abrading action between the conductor and connector surfaces with an inhibitor that seals the connection. This prevents air from reaching the mated material. The **result is a longer-lasting, more reliable electrical connection.**

In-Line Disconnect Switch

Facilitates sectionalizing of the grid, enabling utilities to **isolate faulted sections** while maintaining power to unaffected areas.

How is it used?

ILD’s are used to **provide circuit isolation** for aluminum overhead distribution power lines.

Poll Question

How prepared do you feel your current grid infrastructure is to prevent wildlife & wildfire-related issues?

a) Very prepared – proactive measures are in place
b) Somewhat prepared – some measures are in place but need improvement
c) Not prepared – significant upgrades are needed
d) Unsure

Increasing Protection: Animal, Vegetation, and Wildfire Interactions

EVERY CONNECTION COUNTS

Use Case: Wildfires & Equipment Failure Risks

Challenges

Fire Risk from Wildlife Electrocution: Flashover or equipment failures have the potential to ignite wildfires, especially during dry and windy conditions.

Solution

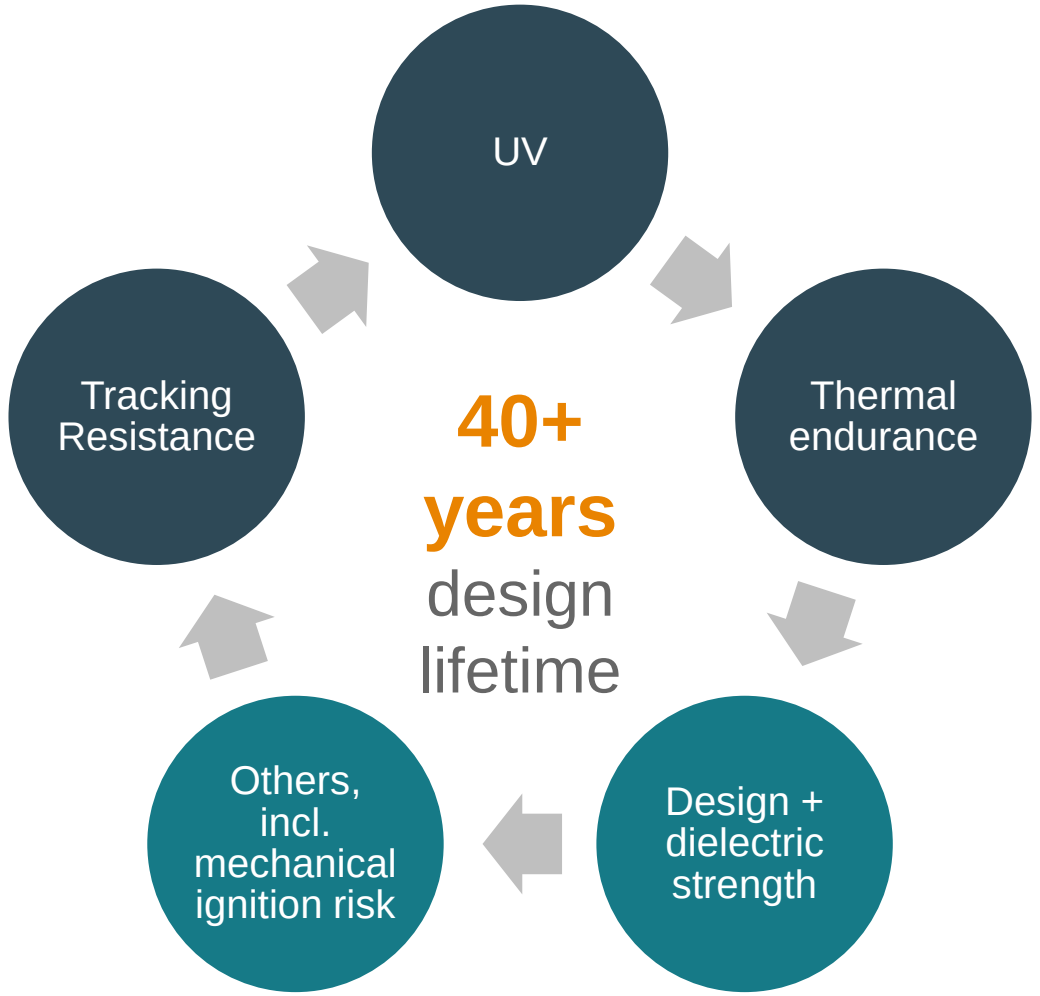
Flashover Prevention: Devices that reduce or eliminate wildlife-induced flashovers at critical points.

Fire-Resistant Materials: Components designed to withstand extreme heat and prevent sparking during faults.

Key Material Characteristics You Should Look for

To achieve technical success in service, we must embrace a **materials development philosophy** that puts a strong focus on the following material characteristics:

a. TERT (tracking and erosion resistance)
b. UV stability (long-term aging)
c. Thermal endurance (lifetime predictor)



Ensures product designs meet and exceed the most stringent standards and test methods.

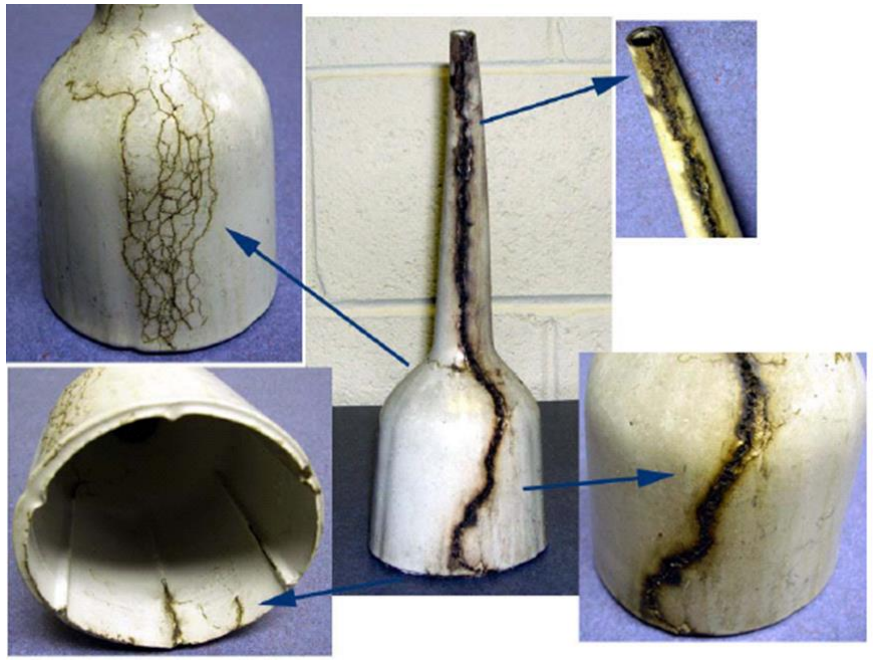
Tracking – Failures in Field

How is it tested?

ASTM-D2303 Tracking and Erosion Test (TERT).

Examines the ability of a material to defend itself against contamination and leakage current.

If combined with moisture, will cause a wildlife cover to track, **compromising its insulating properties** over time.

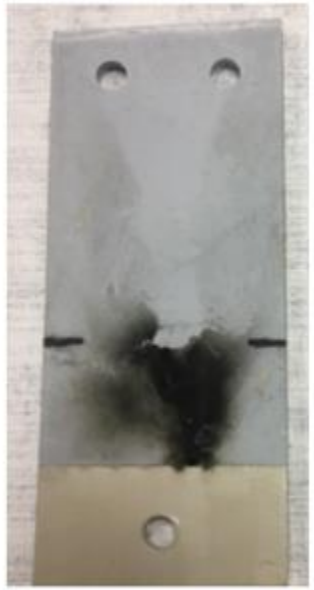


What we recommend:

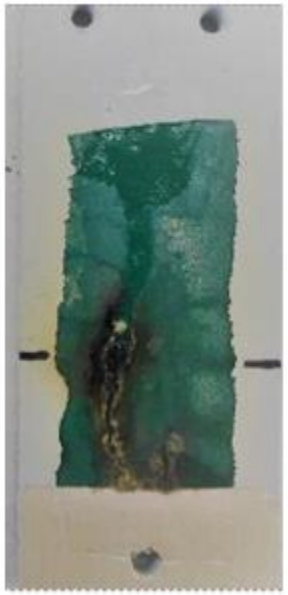
- **Step test**: Voltage is increased each hour and contaminant rate increased periodically.
  - We recommend in lieu of continuous voltage test.

V0 and Tracking Resistance

Commonly Used Brominated Material Failure Times



TERT<20 Min.
Tracking



TERT ~20 Min.
Tracking

What We Recommend: TE V0+ Material

TERT >180 Min.
No Tracking

Use Case: Animal Interactions and Government Regulations

Challenges

Regulatory Compliance: Increasing pressure from regulators to adopt preventative measures for wildlife (i.e. avian protection plans)

Solution

Proactive implementation of wildlife protection equipment meets or exceeds regulatory standards, **avoids fines (into the 6 figures), avoids criminal prosecution, and enhances reputation.**

Retrofitting as a Prevention Mechanism

What is Retrofitting?

Hardening existing **electrical and grounded equipment** with insulating materials, such as silicon and polymers. AKA “bird-guarding” or “wildlife protection”.

Why it matters

- **Regulatory Compliance**
- **Reliability**
- **Fire Mitigation**
- ★★★ **Customer Satisfaction**

Other reasons to retrofit:

1. **Worker safety** – reduced time in the field due to reduced outages.
2. **Wildlife protection** – protecting endangered animals from interactions with hazardous equipment.
3. **Asset Protection** – Reduction of unplanned costs due to equipment failures.

Poll Question

What is the biggest challenge your organization faces in detecting grid faults?

a) Limited real-time visibility

b) High false positive rates

c) Insufficient budget for technology upgrades

d) Lack of skilled personnel

Enhancing Grid Transparency: Accelerating Outage Detection

EVERY CONNECTION COUNTS

An Outage Happened. What Now?

Time is money!

You must aim at **FLISR**, safely and as quick as possible

F ault
L ocation
I solation
S ervice
R estoration

What tools are available?

SCADA systems

Advanced meter systems

Relay event records

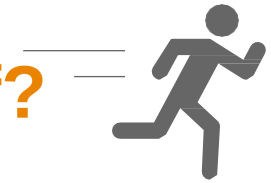
CHALLENGE: Vast areas are unmonitored, require visual inspection.

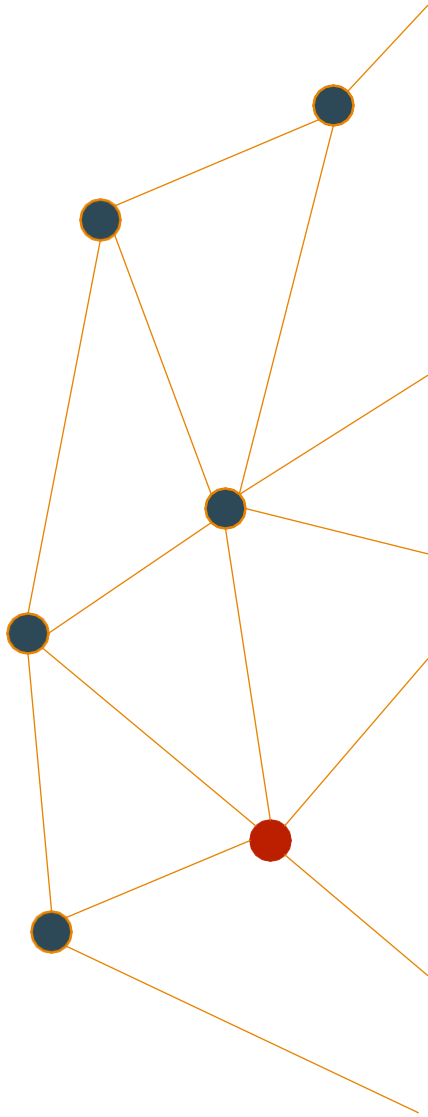
How do Grid Operators Find Faults?

Conventional grids require a troubleshooter to "ride out" the circuit… BUT

- **Circuits** may be less than a mile to **over 40 miles long**
- Some parts **not street accessible**
- Circuits likely have **multiple branches**
- The process can take an hour, **4 hours or more!**

What if... that time could be cut in half?





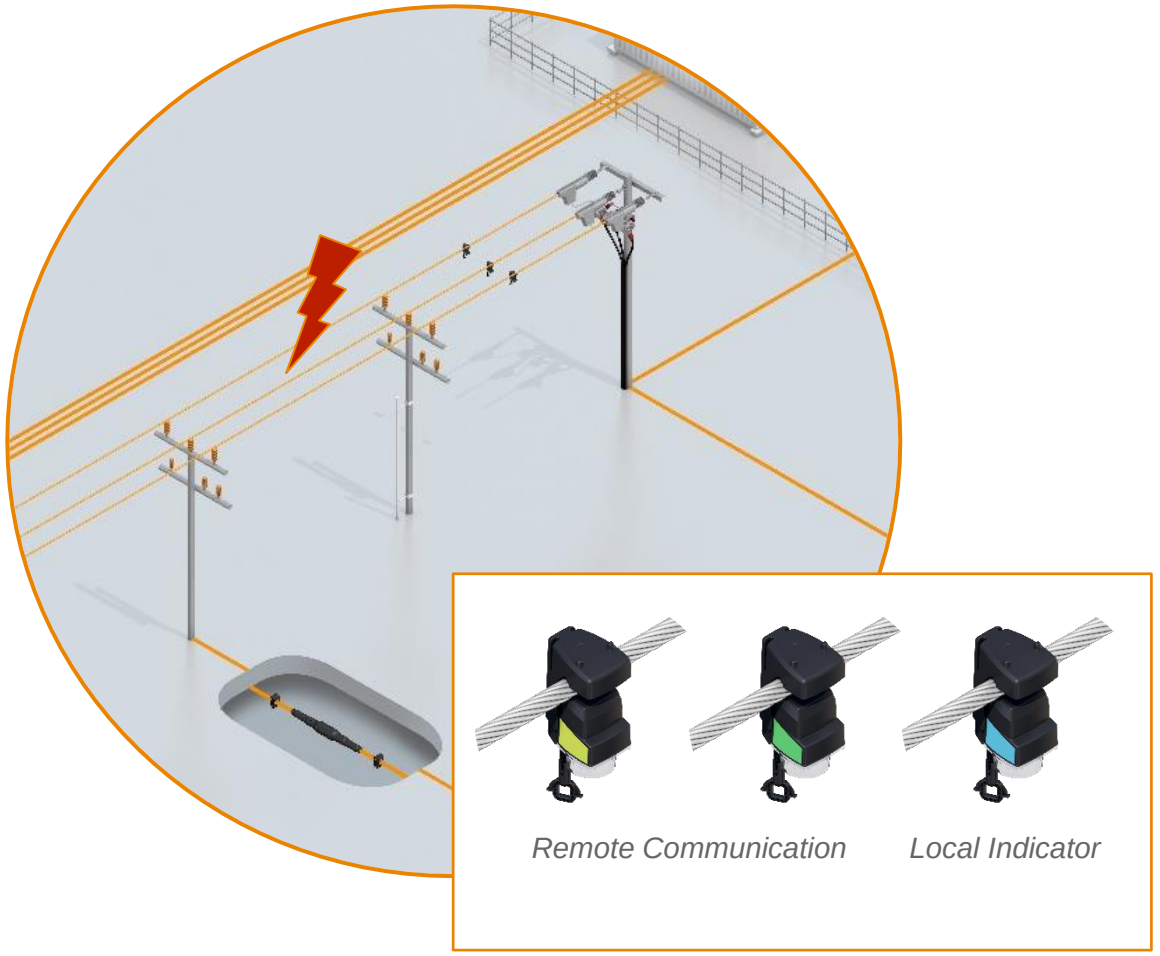
Benefits of Fault Current Indicators

A **fault indicator** is a device placed directly on the overhead conductor which provides **visual or remote indication of a fault on the electric power system**.

Fault is located between the last indicating and the first non-indicating fault indicator.

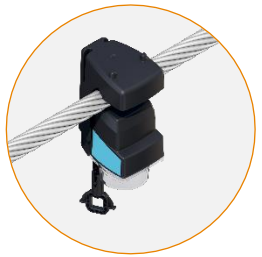
How is a fault indicator used?

- Troubleshooters will see if the **fault indicator is flashing.**
- **Communicating fault indicators** can also notify Operations, Engineering, or SCADA master system.



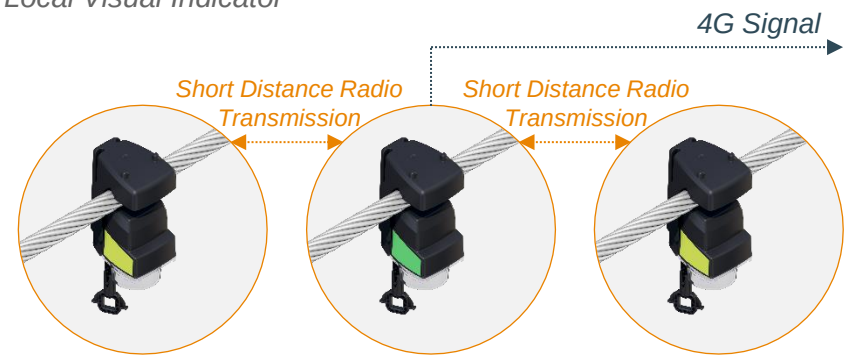
Overhead Fault Detectors

Local and Remote Indication Systems



1. LED strobe-only devices, for local visual indication.

Local Visual Indicator

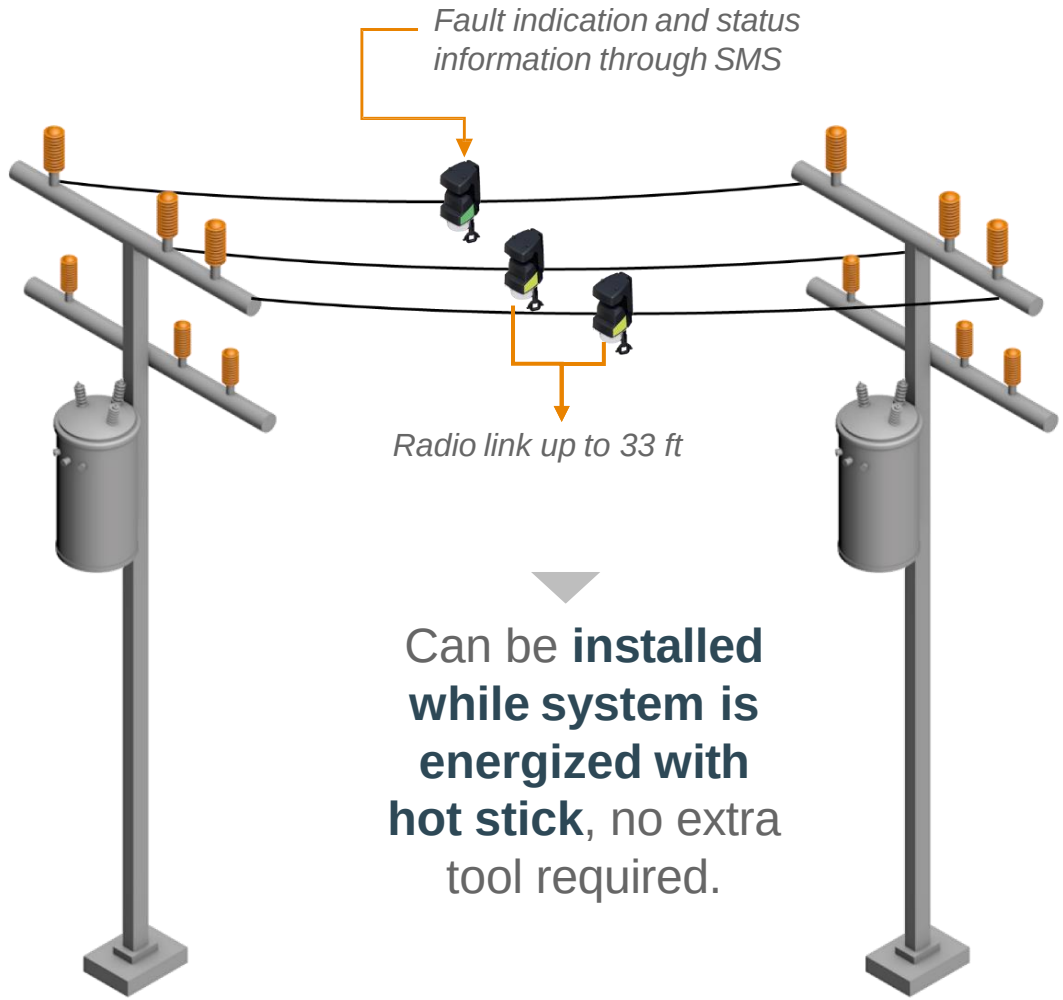


Set for Remote Communication

2. Communicating devices, with SMS over 4G for SCADA integration.

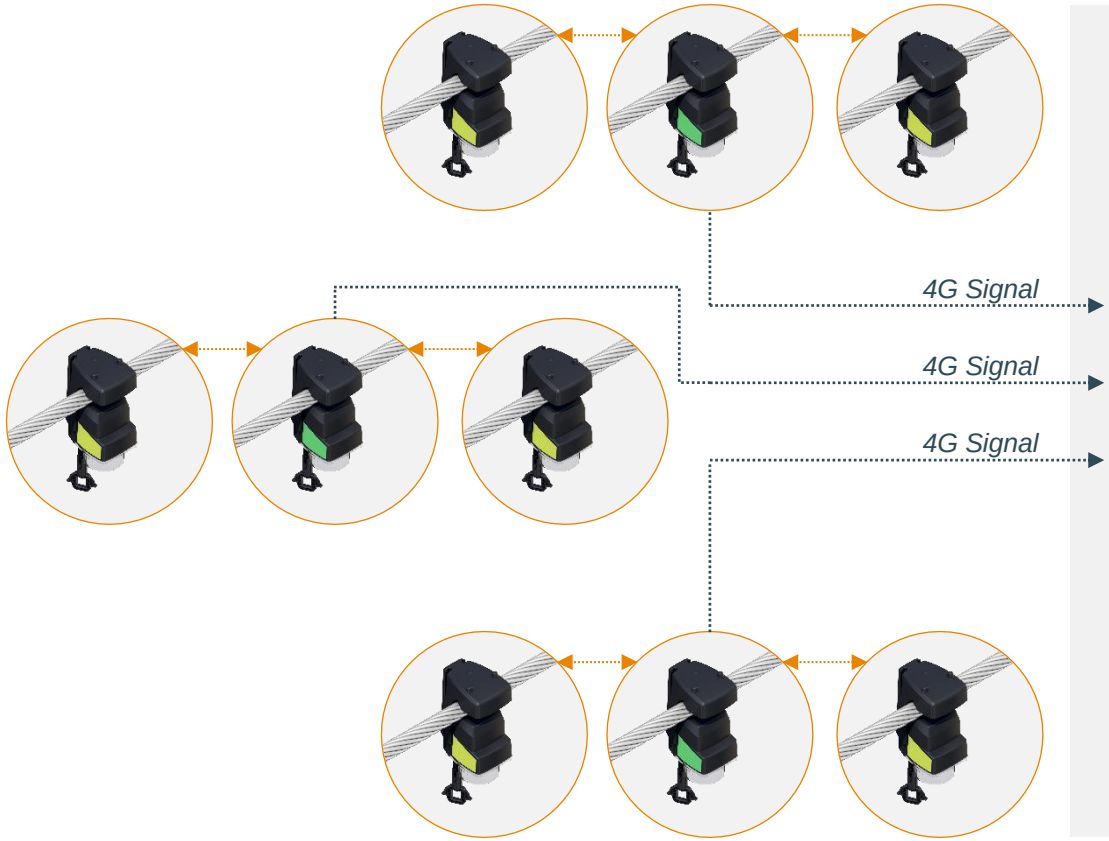
Features

- Voltage: 1 - 35 kV
- Conductor sizes: #4 AWG – 1750 kcmil
- No minimum load current required
- Sends alerts over 4G (SMS)



Can be **installed while system is energized with hot stick**, no extra tool required.

Device Integration with SCADA



IEC 104 or DNP-3 direct cable connection

Gateway
serves up to 2000 sets

Existing SCADA System

Use Case: Long Circuits

Challenges

May take **hours to find fault**: time is money!

May have **multiple branches**.

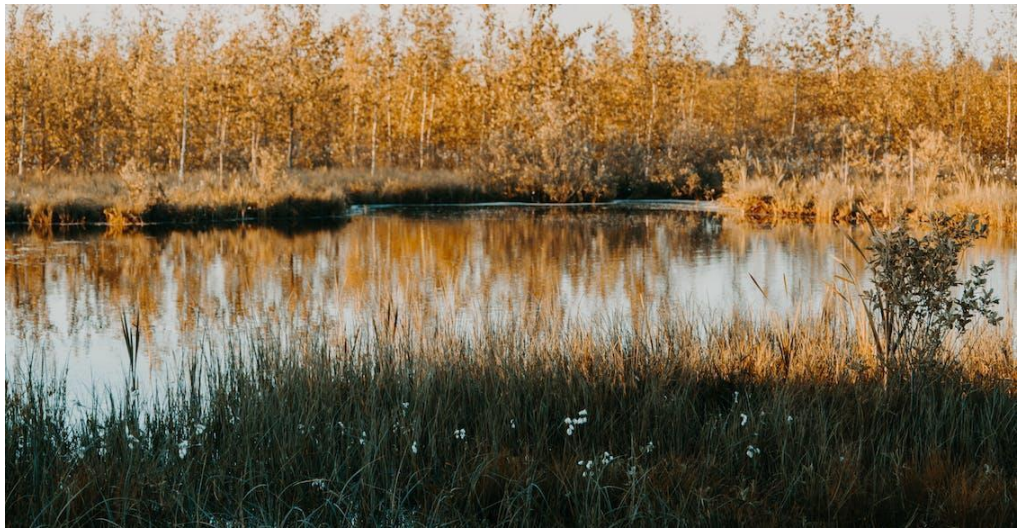
Solution

- **Segment circuit into smaller parts** with fault indicators.
- **One set breaks circuit in half**, cutting inspection time in half.
- **Add more fault indicators** to further reduce time to find fault proportionally.

Use Case: Difficult to Access Areas

Challenges

- May require **walking out circuit**
- May require **special vehicle** or boat
- May require **long drive** to access
- Rivers, swamps, rear easements, fenced property



Solution

- Place **fault indicators on source edge** of difficult area.
- If fault indicators **not flashing**, no need to enter.

Use Case: Problematic Circuits

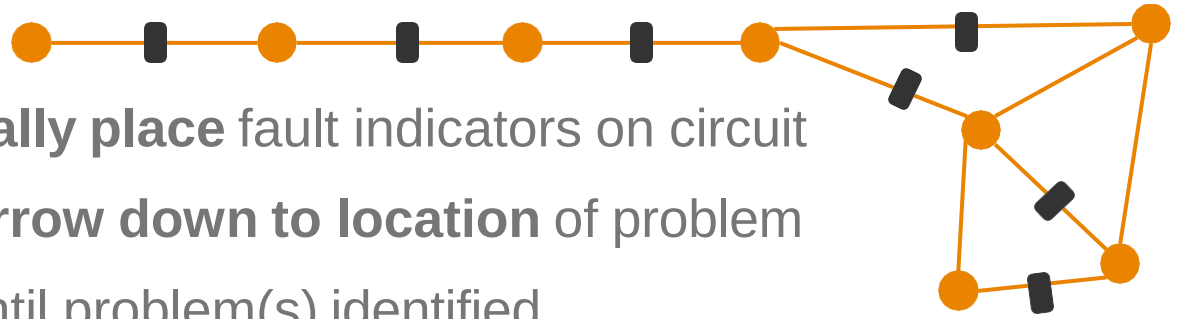
Challenges

Root cause difficult to locate, may be multiple root causes.

May have **chronic momentary outages.**

May cause **regulatory risk.**

Solution



- **Strategically place** fault indicators on circuit
- Use to **narrow down to location** of problem
- **Repeat** until problem(s) identified

One Connectivity Partner for Safe, Reliable, High-Performing Power Grids

From generation to transmission, to distribution, to wherever energy is needed – we are one source for multiple connectivity and insulation needs:

CONSULT	DESIGN	TEST	TRAIN
• Our TE experts and network of authorized distributors can support you wherever you are located • Knowledgeable global and local technical support to help you optimize solutions to meet your needs	• Collaborate with our engineering team to create a custom solution • Our research and development teams have years of experience and thousands of patents, which can be leveraged for your ideas	• We test custom build solutions in our labs	• We provide tailored installation training • Competency assessments for installers, trainers and supervisors

34 million

Number of people affected by power outages in the United States in 2023

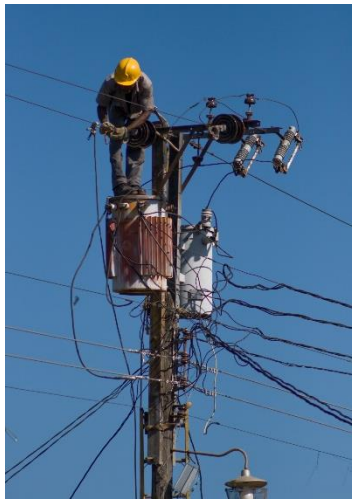
Source: Census.gov-2024

Key Takeaways

Wedge Pressure Technology enables **a long-lasting connection through easy installation**.

The material science behind the solution to wildfire and animal interactions is **a key component to maintain grid reliability**.

Detecting faults on the grid using smart grid technology allows a rapid response that **minimizes downtime** and **optimizes operational costs**.



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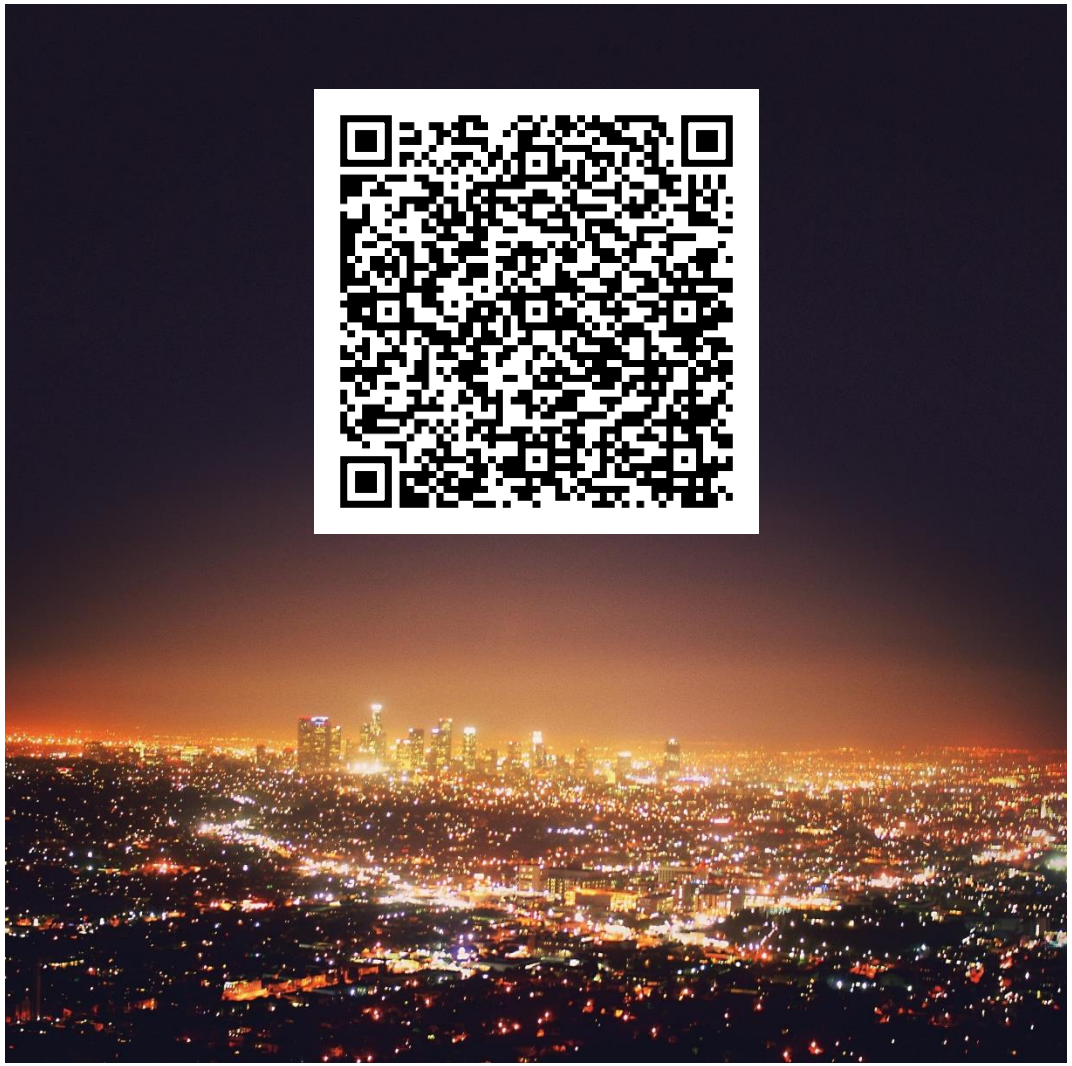

EVERY CONNECTION COUNTS