

The Value of Fault Passage Indicators for Distribution Grids

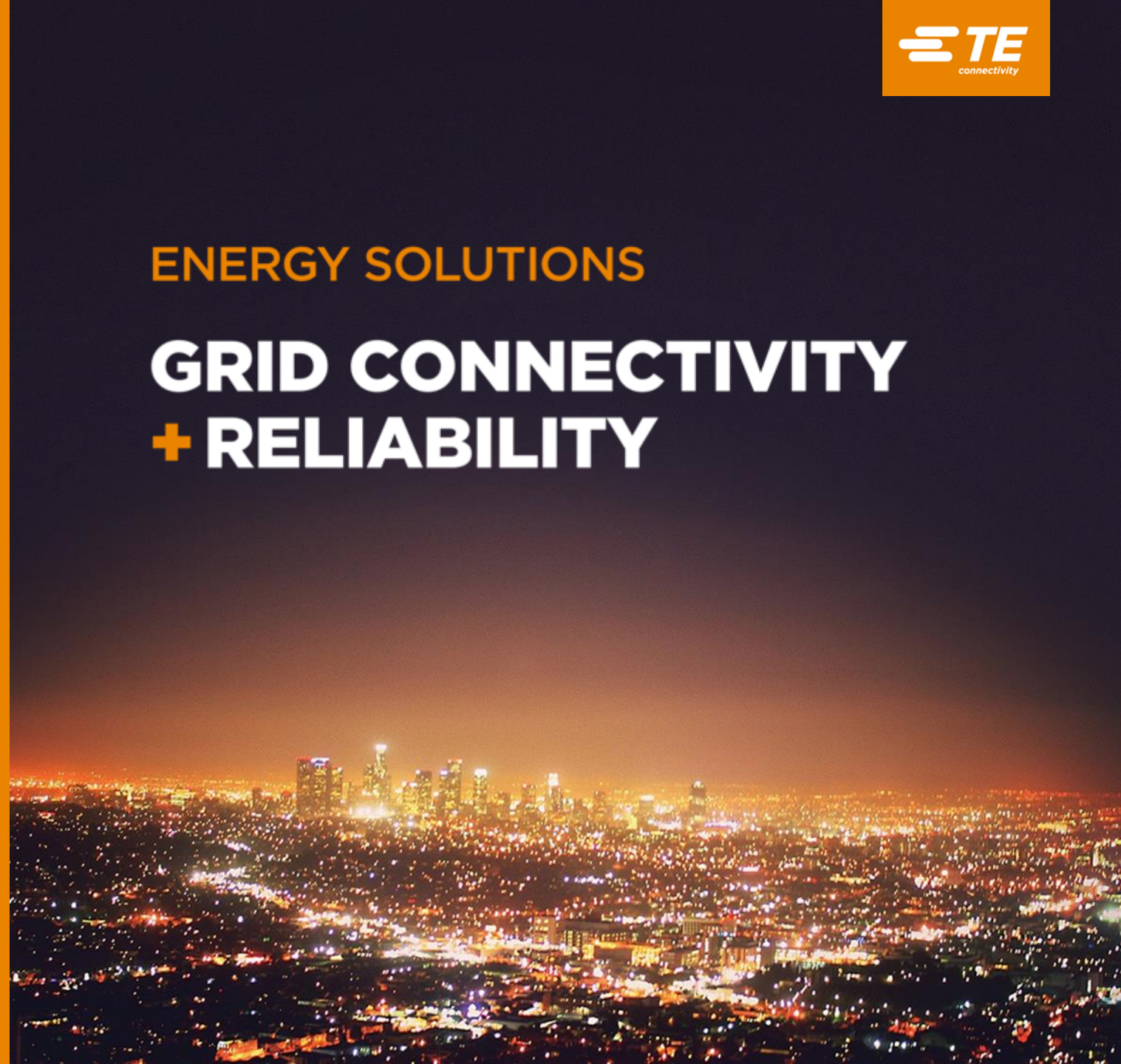
Vincent Cullen

Product Manager Grid Monitoring

EVERY CONNECTION COUNTS

ENERGY SOLUTIONS

**GRID CONNECTIVITY
+ RELIABILITY**





Vincent Cullen
Grid Monitoring

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- Dual bachelors degrees in Engineering (BSME) and Economics
- Active member of IEEE Standards Group
- Experience in cable testing for partial discharge
- Knowledge in bringing grid monitoring solutions to the IEEE market
- Expertise in cable and distribution systems

TE.com/smartgrid

For Maximum Grid Reliability

A worker wearing a blue hard hat and an orange safety vest is working on a laptop. The background shows a power substation at dusk.

INSTALLS EASIER

With a strong customer focus our solutions deploy easily to your grid

Two workers in hard hats are silhouetted against a bright orange sunset. A wind turbine is visible in the background.

PERFORMS SMARTER

Improve the reliability of existing grid assets by adding monitoring and control

A night view of a city skyline with many lit-up skyscrapers and a highway in the foreground.

RUNS LONGER

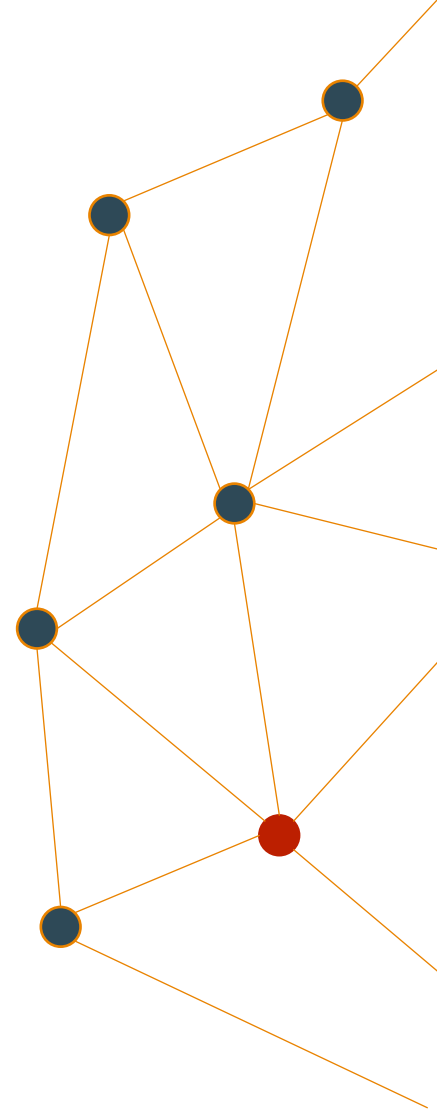
Ensure your grid will be ready for the demands of tomorrow

How do Grid Operators Find Faults in Overhead Lines?



Conventional overhead 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!**



How do Grid Operators Find Faults in Underground Cables?

When a fault condition occurs:

1. The grid operator gets and executes the switching order
2. Isolate & ground the circuit
3. Connect fault-finding equipment
4. Find fault location, complete repair, and restore the circuit

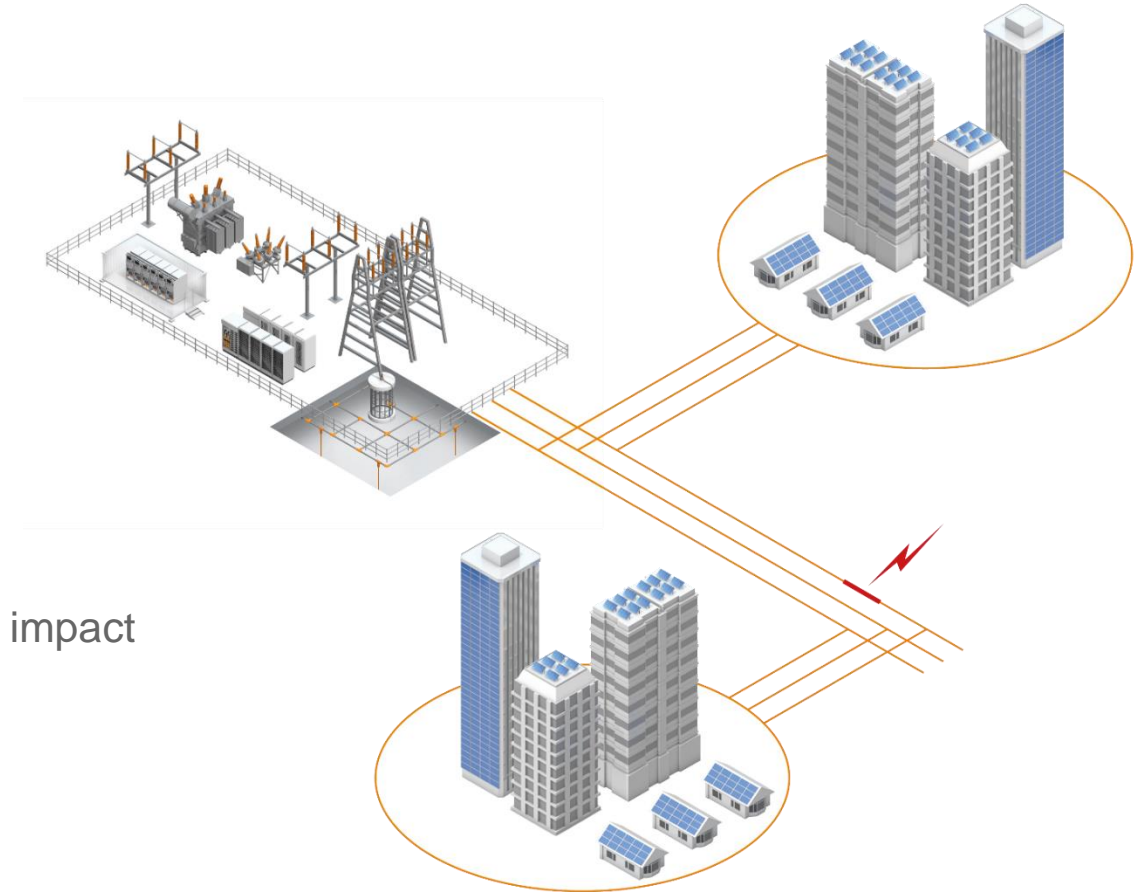
Can take 12h or more just to find the fault condition

Challenge: Little knowledge of fault location

- One fault can disrupt the operation of the entire circuit
- No information on fault location
- Long time required to restore the circuit increasing the outage impact

Solution: Grid Monitoring

- Detect and localize the source of the fault
- Prevent the condition from developing into a fault if possible



A large, clear glass hourglass is centered in the background. It is partially filled with a dark, viscous liquid that is dripping down the narrow neck. The background is a dark, textured blue.

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

Unplanned Outages for Utilities

- **Conventional Grid**

- Minimal monitoring
- Aging Infrastructure
- Large portion is overhead

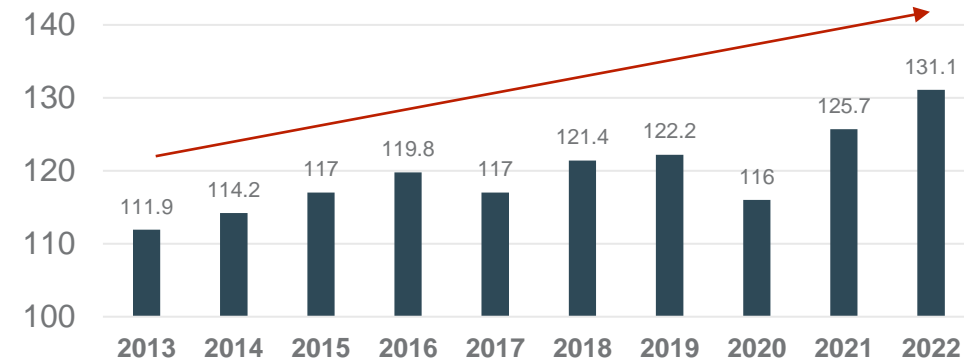
- **Smart Grid**

- Increased presence of monitoring and control
- Improvements for both reliability and resiliency
- Focus on undergrounding cables

Grid monitoring solutions can help you **locate faults** on underground and overhead distribution power lines **increasing grid reliability and safety.**

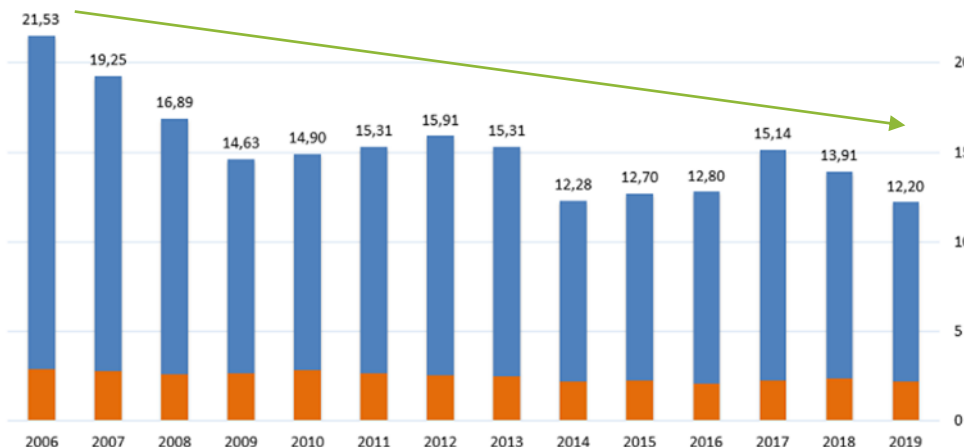
CONVENTIONAL GRID

Average duration of total annual interruptions in electricity service in the United States (largely overhead lines)* - **minutes per outage**



SMART GRID

Average duration of total annual interruptions in electricity service in Germany (largely underground networks) - **minutes per outage**



*Source: US Energy Information Administration, Annual Electric Power Industry Report

The Real Cost of Power Outages

4.7 hours

The average total annual interruption in electricity service hours per customer in the US

~2 hours

The average interruption per customer annually excluding major events

100,000 USD

The average cost of an outage for a Utility per hour

How can we improve grid reliability and resiliency?

A) Reducing presence of overhead distribution lines

B) Increasing grid monitoring

C) Increasing remote control of field devices

D) All of the above

Overhead Fault Indication

Underground Residential Distribution (URD)

EVERY CONNECTION COUNTS



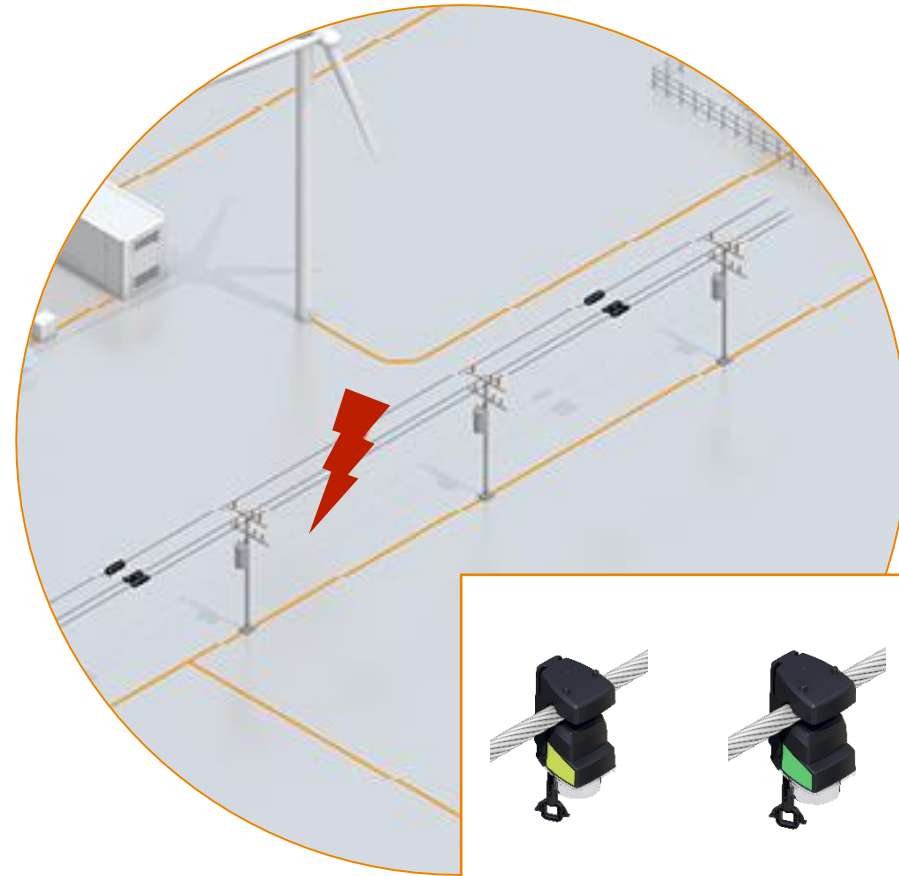
Benefits of Fault Current Indicators (FCIs)

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

The 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.



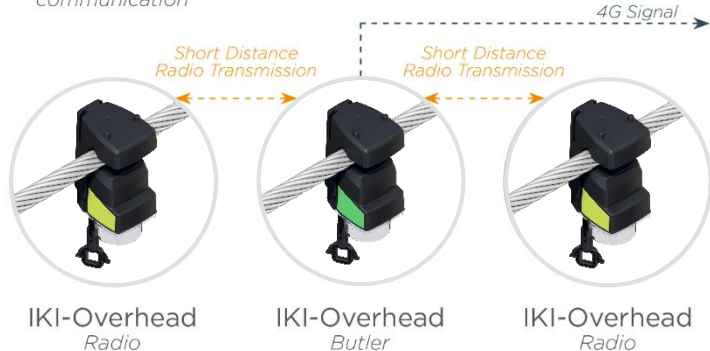
Overhead Fault Detection

Local and Remote Indication Systems



IKI-Overhead
Without
communication

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



IKI-Overhead
Radio

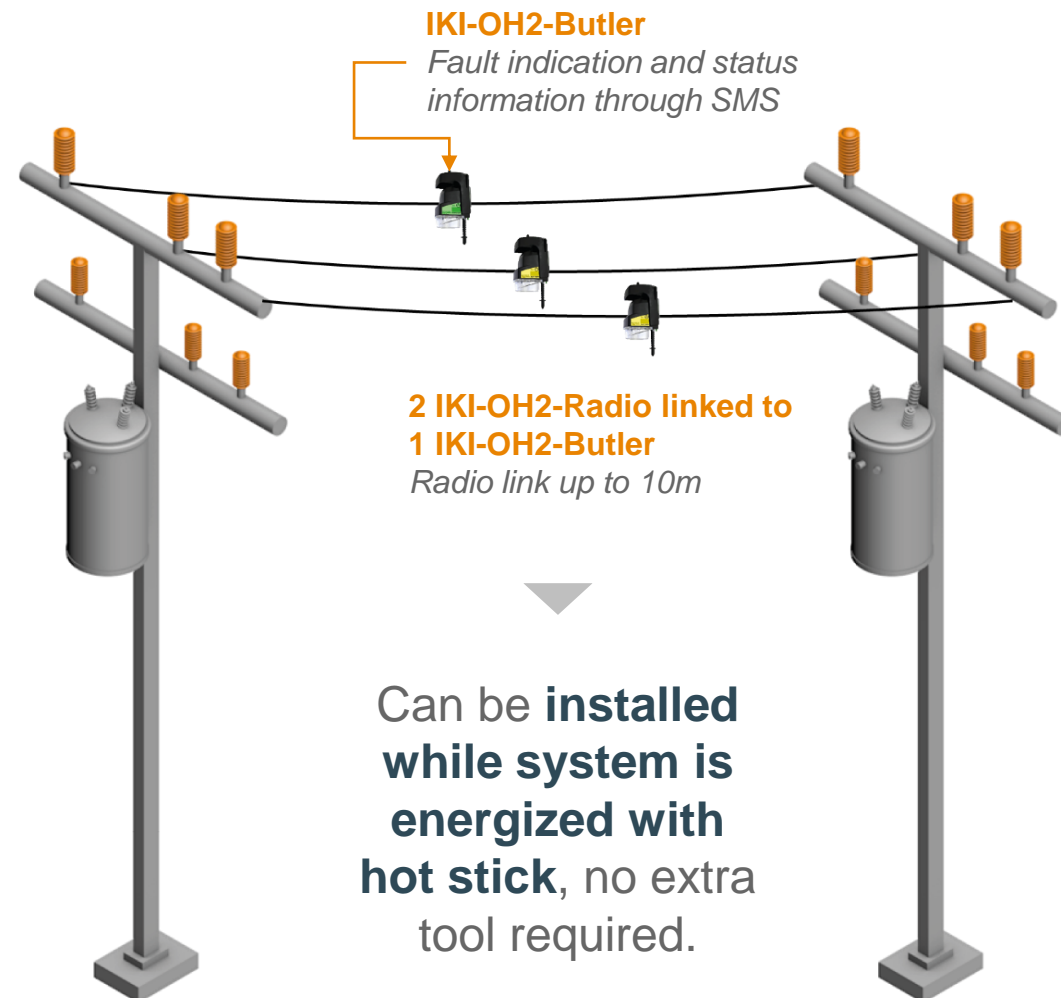
IKI-Overhead
Butler

IKI-Overhead
Radio

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





FEATURES

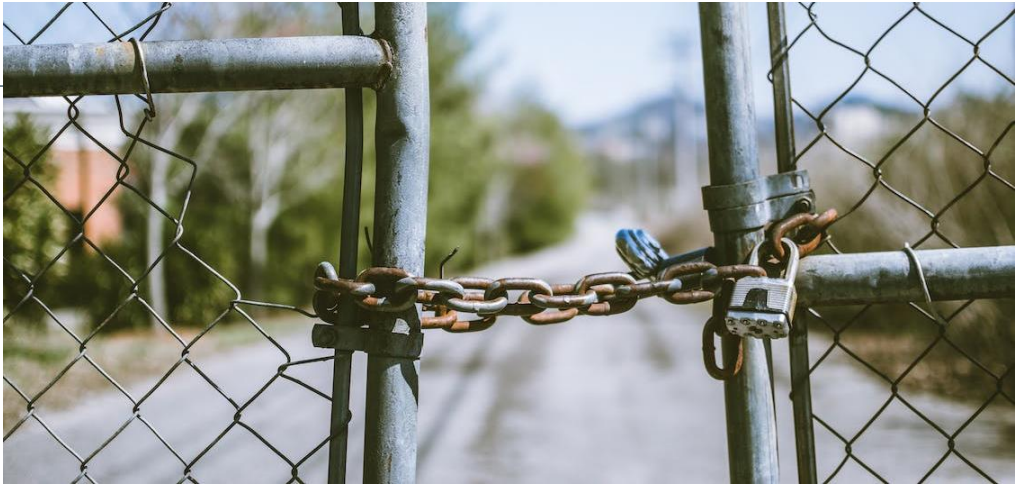
- Voltage: 1 - 35 kV
- Cross sections covered: #4 AWG – 1000 kcmil
- Fault current adjustable to 1000A
- Sends alerts over 4G (SMS)




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.

 Pole  Fault indicator

Single Phase Distribution Fault Indication

Underground Residential Distribution
(URD)

EVERY CONNECTION COUNTS



Locating Faults – Underground Residential Distribution

When a fault condition occurs:

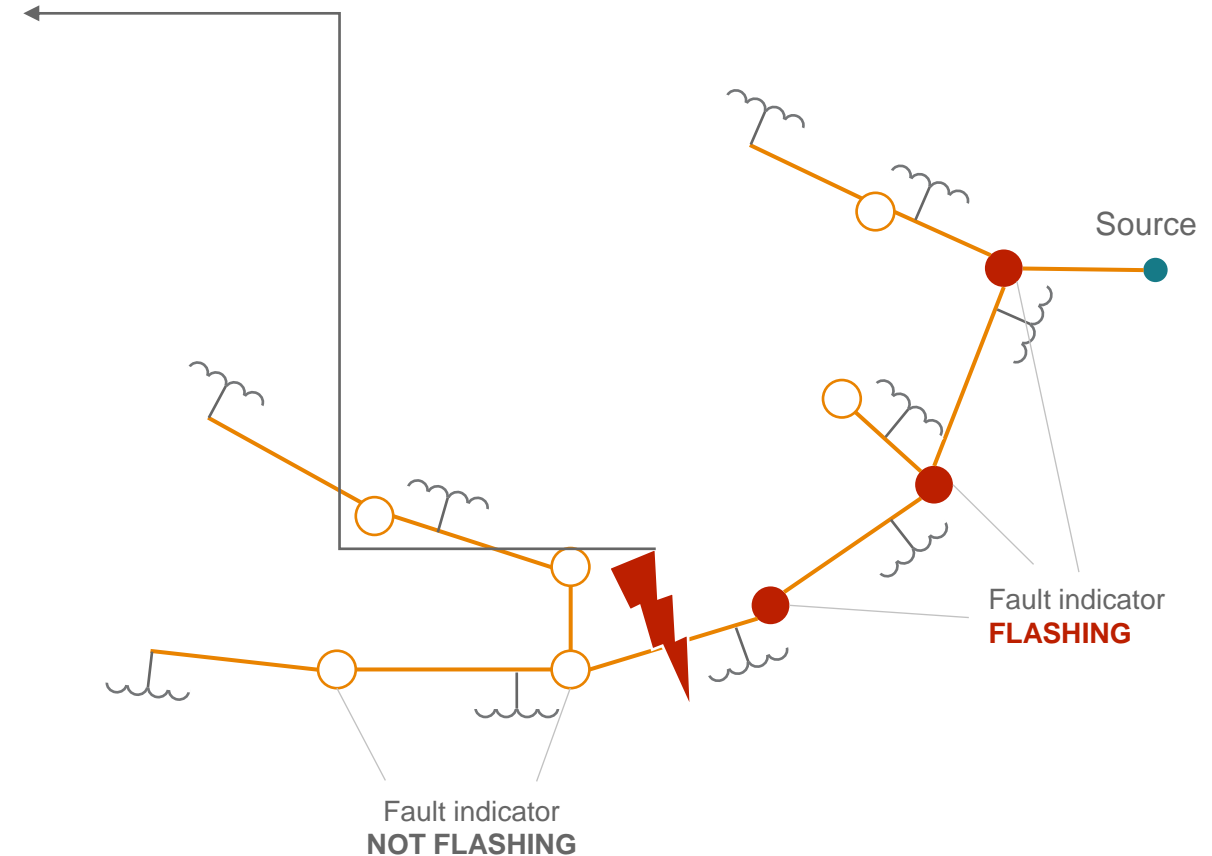
Fuse protection for loop or radial circuit will open

Challenge: Little knowledge of fault location

- Troubleshooting and repairs are **time-consuming**
 - Transformer vs. cable restoration requires different crews/equipment
 - Typical outage is **4+ hours**
- **Rear easement URD is especially difficult**

Solution: Equip pad-mounted transformers with fault indicators

- Fault located between last indicating and first non-indicating
- Add more indicators to make segments small

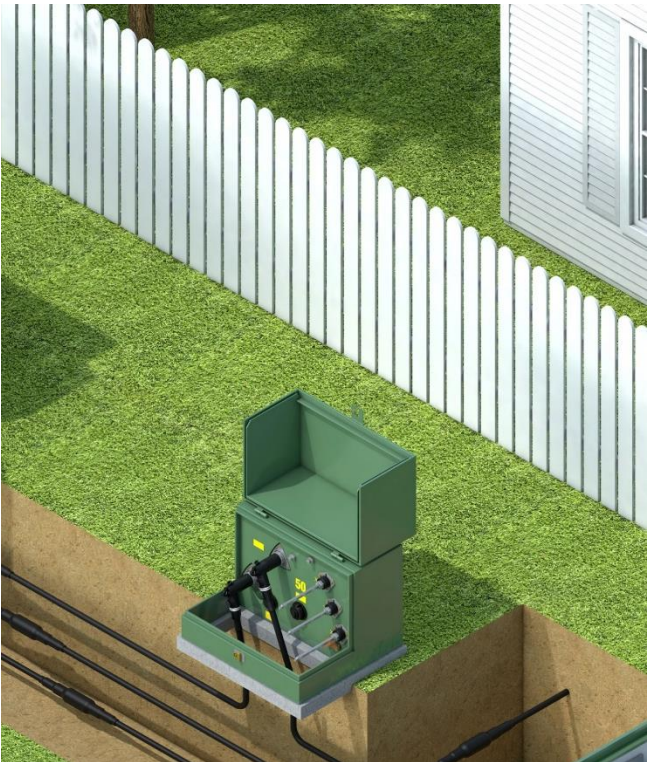
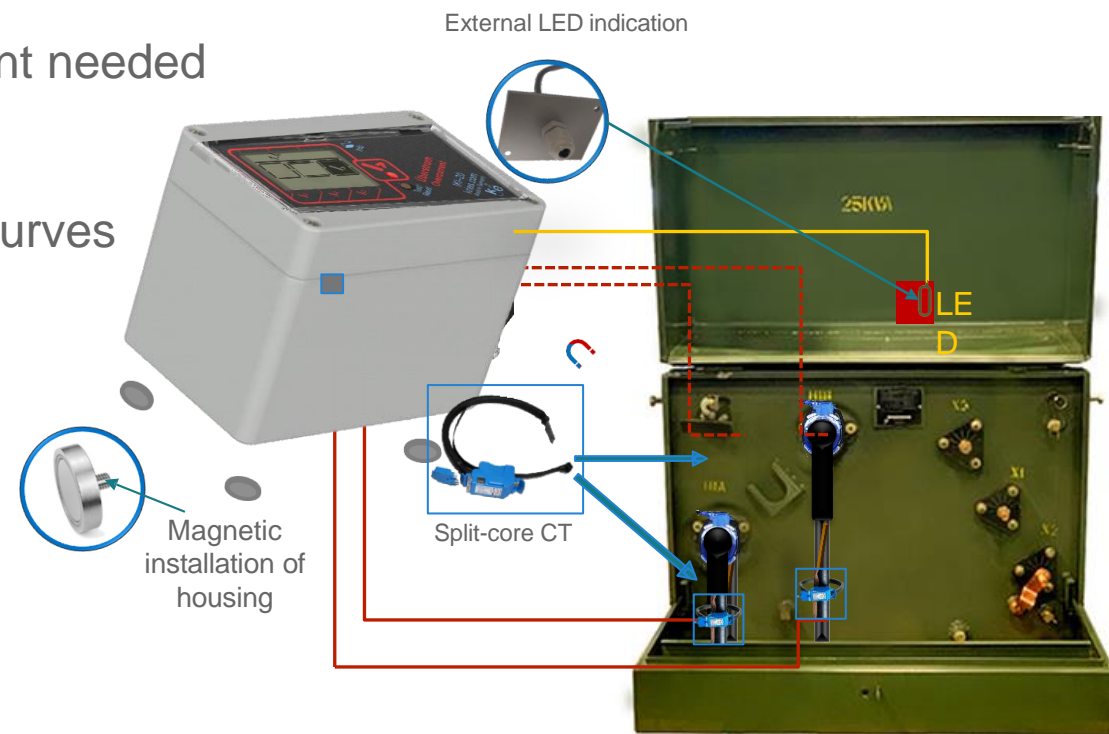


URD Radial Design Example

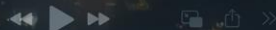
IKI-URD: Fault Indication for Single Phase Transformers

Desirable Features

1. Find faults more quickly, reduce SAIDI
2. Distinguish between transformer fault and cable fault
3. Self-powered device
4. No minimum load current needed
5. Field configurable
6. Coordinated with fuse curves



**Do you already use
fault monitoring products
in your grid?**



00:11

00:13

Three Phase Distribution Grid Monitoring

Fault Indication and Partial Discharge
Monitoring

EVERY CONNECTION COUNTS



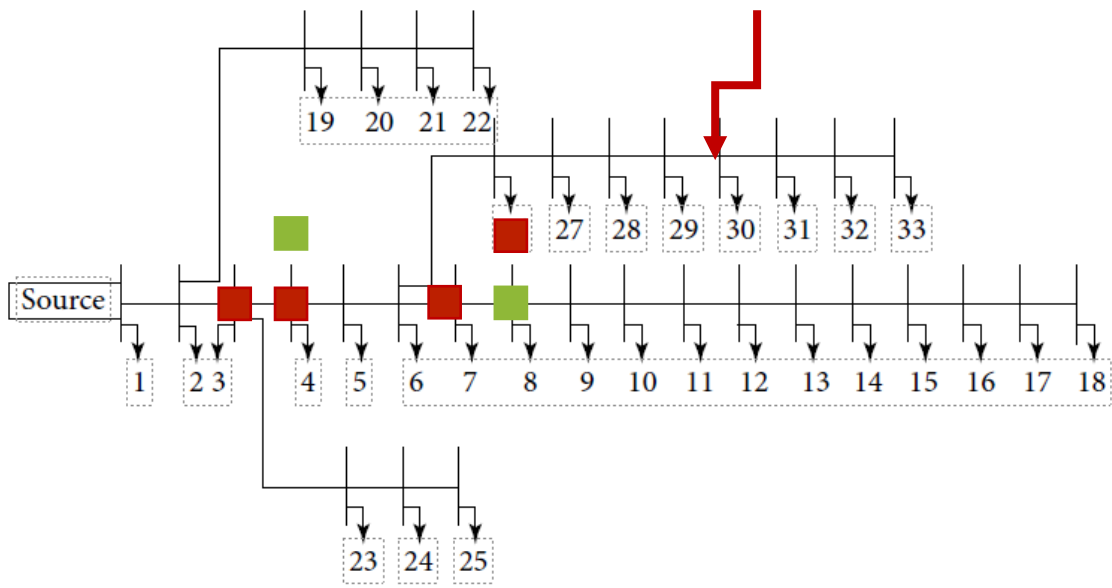
Challenges in Finding Fault Conditions

Challenges

- Underground circuits are complex
- Fault location is a long, time-consuming process
 - Can take one Utility customer **up to 24 hours to locate a fault (typical is 9-12 hours)**
- Very little information is known about the circuit in operation past the substation environment and before the meter

Needs

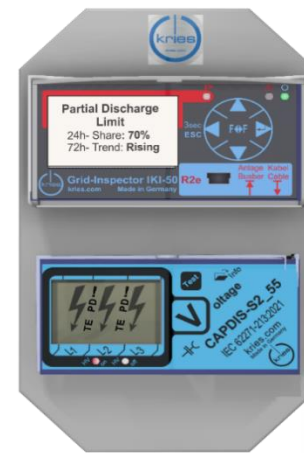
- Directional fault indication
- Directional load monitoring
- Failure prediction by Partial-Discharge Detecting
- Permanent voltage monitoring for maximum personal safety during switchgear operation



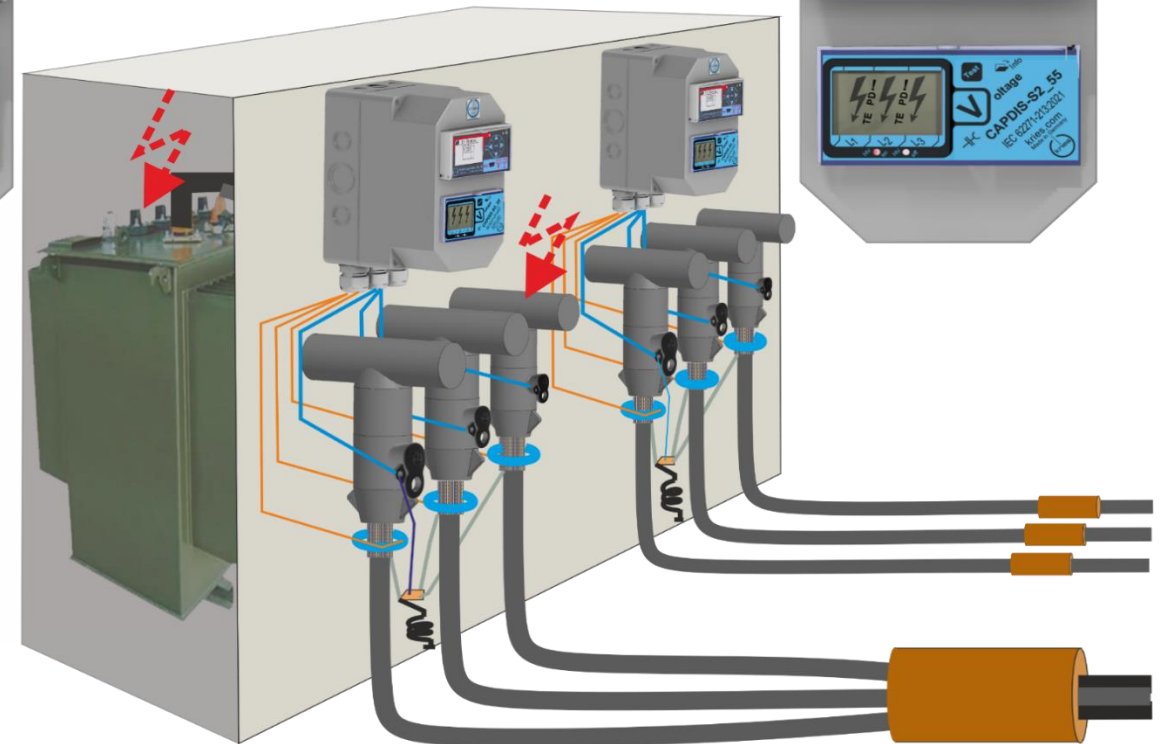
- Fault detected by device
- Fault not detected by device

Kries Feeder Inspector (KFDI) – More than Fault Indication

- By detecting partial discharge (PD) outage events can be avoided
- Simple indication of the presence of PD is more beneficial
- A simple system helps users quickly, and efficiently correct concerns before a fault condition occurs



PD inside Station or Termination indicates Insulation Loss and predicts Faults



EVERY CONNECTION COUNTS
