

Revealing the Invisible: The Growing Importance of Radiated Emissions

William (Bill) HOWE

Sr. Program Manager – Power Quality
EPRI

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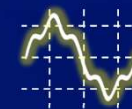
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Power Quality



Transmission &
Distribution PQ



PQ Data &
Analytics

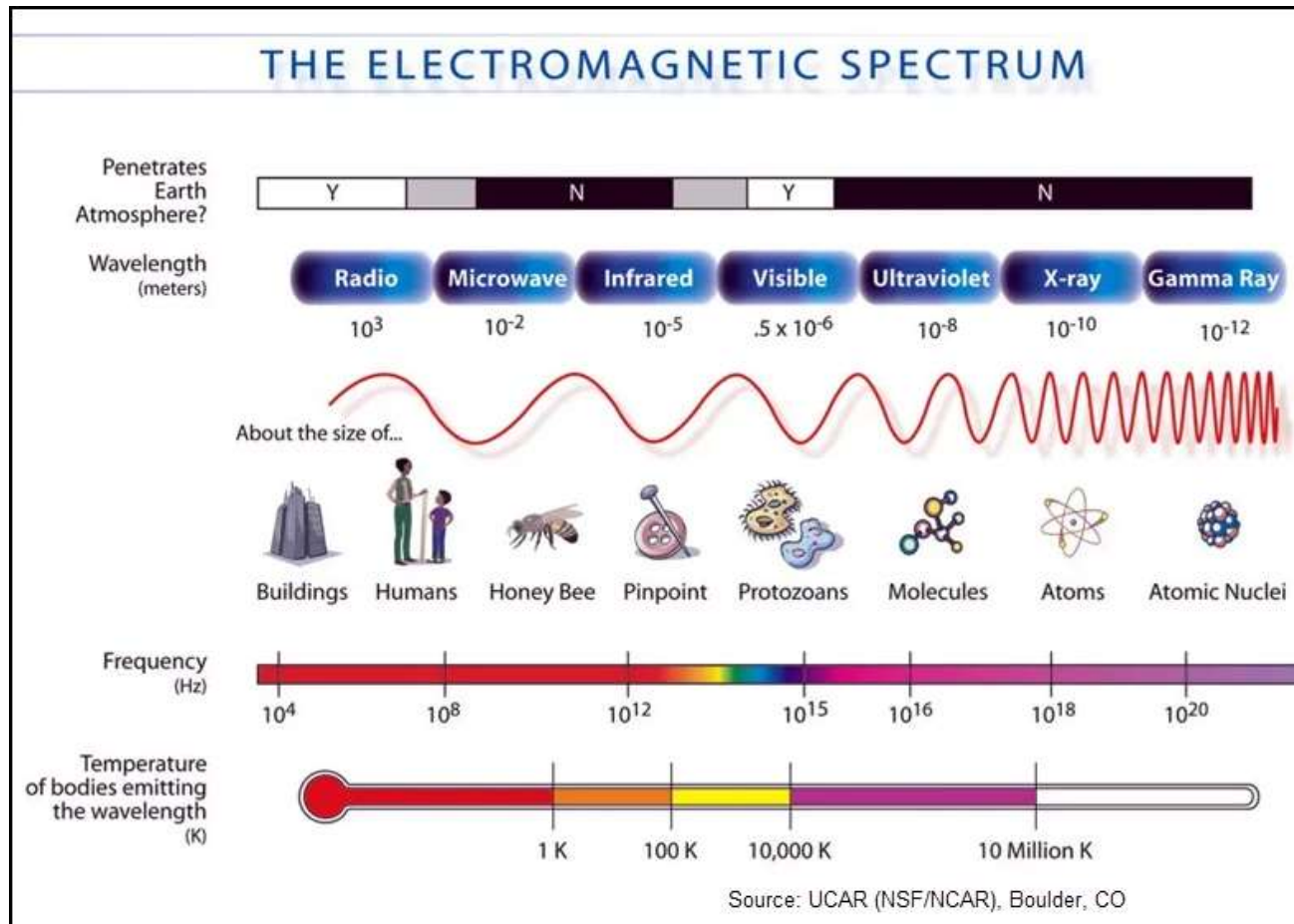


PQ
Compatibility



PQ
Knowledge

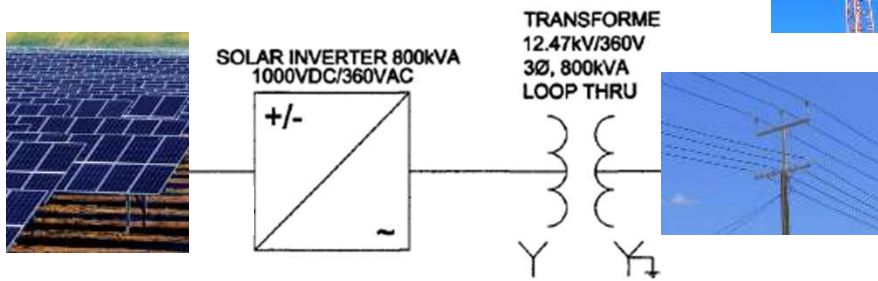
The Electromagnetic Spectrum



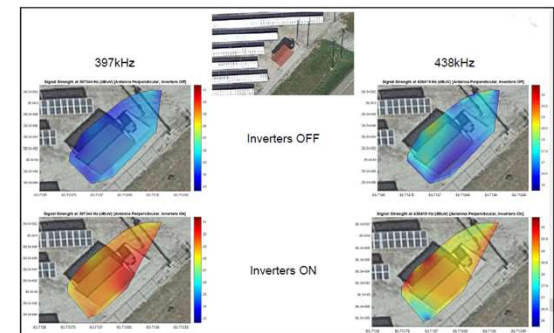
- Ubiquitous, but mostly invisible
 - Except for audible or vibration
- Interesting frequencies:
 - Audible to humans: 20 Hz (10^1) to 20 kHz (10^4)
 - AM radio: 540 kHz (10^6) up to 1700 kHz (10^7)
 - Electrical arcing: 100 kHz (10^6) to 1 GHz (10^9)
- Emphasis on higher frequencies emerged out of interest/concerns about high frequency noise
 - 2 – 150 kHz
 - Inverter-based Resources (IBR)

Early Investigations: PV Farms and Radio Interference

- US-based solar farm connected to a 12.47 kv distribution line through Y-Y transformers (3x800kva)
- Technician detected AM band (540-1600 kHz) RF interference during inverter operations
- Problem correlated to improper grounding

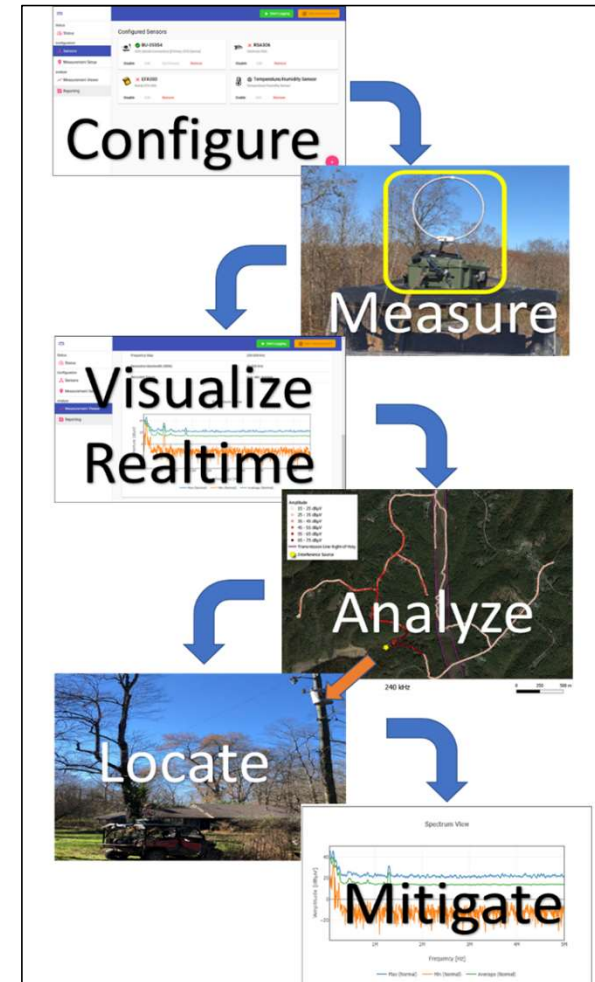


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2nd Generation: Portable Radiated Emissions Measurement System (PREMS II)

- **Revealing the invisible:** EPRI's Power Quality Program (Program 1) developed the PREMS II system to detect "invisible" RFI & EMC issues, such as anomalous frequency interference problems and potential equipment failures.
- **Broadband measurement:** This innovative tool helps utilities quickly scan their electric grids and identify problems before equipment failure occurs, addressing issues that typical visual inspections might miss and at a much faster pace than traditional acoustic or Infrared scanning.
- **Consistent and repeatable:** By integrating GIS system data overlays, PREMS II enables efficient scanning and pinpointing of areas needing further inspection.
- **Proactive applications:** Utilities involved in the prototype stage and supplemental project have championed this technology, now using it in their RFI-related troubleshooting and maintenance workflows.

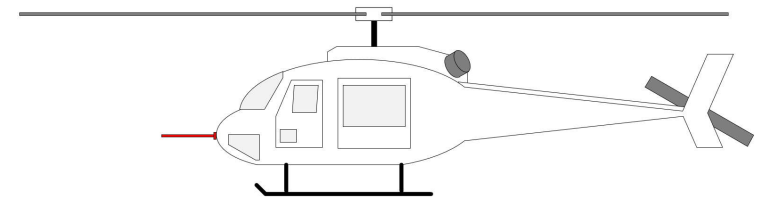


Portable Radiated Emissions Measurement System (PREMS II)

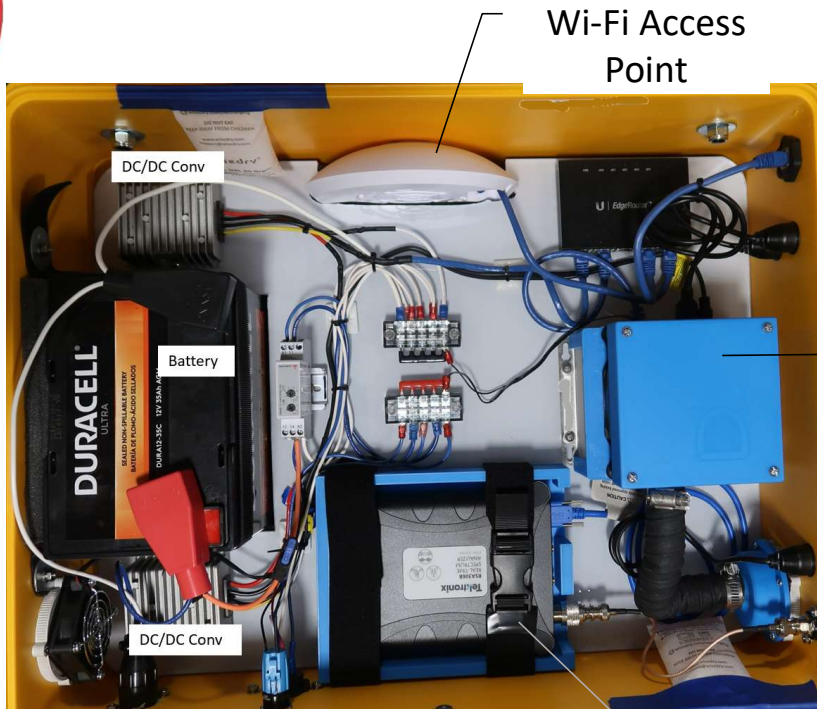
- Portable system, to help locate frequency emissions that are causing interference issues
- The system can scan frequency emissions from 9kHz to 6.2GHz, with appropriate antennas
- Transported in the back of a service vehicle or a side-by-side
- Operator can interface the system via a laptop, tablet, or Smart phone via a web interface
- Measurement data can be exported for use with GIS software for visualization
- A GPS is used to help correlate sensor data within GIS



Basic Prototype Configuration



PREMS II Hardware



E-Net

USB Sensor Ports

Industrial On-Board PC
W/EPRI PREMS
Application

USB Sensor Port

Antenna Port

Charger Port Voltage
Meter &
Power Switch

Tektronix Spectrum Analyzer

Available Sensors



Loop Antenna:

Electrical Specifications

Frequency Range: 9 kHz - 30 MHz

Connectors: BNC (f)

Maximum Input Power: 20 W

Pattern Type: Omnidirectional

Polarization: Linear



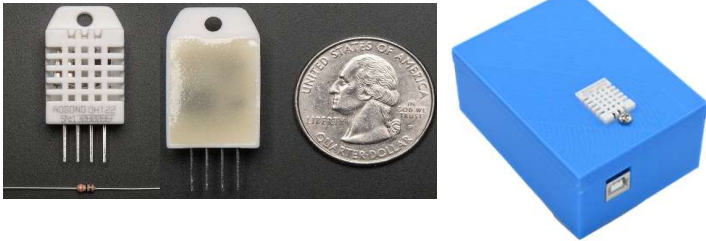
Tektronix RSA306B

Spectrum Analyzer

RF input frequency range:
9 kHz to 6.2 GHz

Available Sensors (cont.)

Temperature and Humidity



DHT22 Specs:

Temperature range	-40 - 80°C (accuracy $\pm 0.5^\circ\text{C}$)
Humidity range	0 – 100% (accuracy 2 – 5%)
Body size	27mm x 59mm x 13.5mm
Sampling rate	every 2 seconds



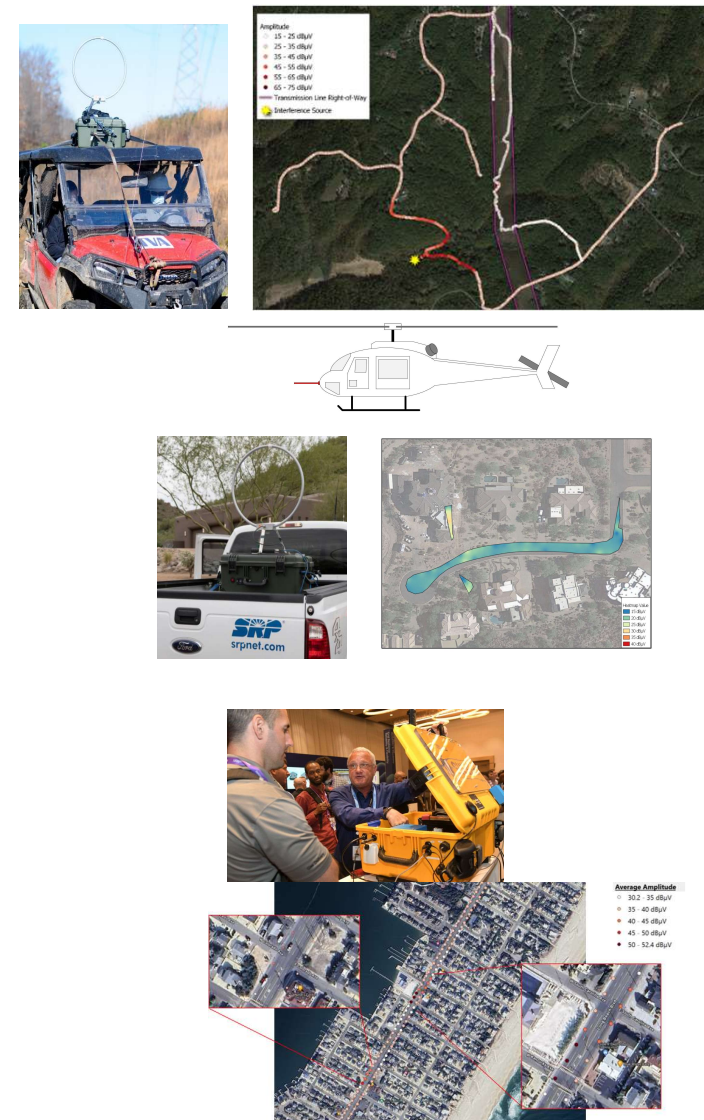
GPS

Accuracy

Position Horizontal	<2.5m (7.5 feet) 2D RMS SBAS Enable
Velocity	0.1m/sec 95% (SA off),
Time	1 micro-second synchronized to GPS time
WAAS	Enabled for North America

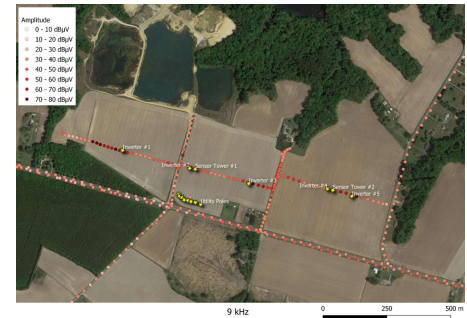
Success Stories/Review of PREMS Applications

- **TVA:** TVA contracted EPRI to use the PREMS Prototype (formerly the Mobile Measurement Platform, or MMP) to resolve a **seven-month internet outage** issue in a residential neighborhood during COVID. The problem was identified and fixed within 1.5 days using PREMS II. This fall, EPRI and TVA will use PREMS on helicopter platforms to scan transmission cables for failing splices and conductors.
- **SRP:** In early 2020, SRP employed EPRI and the PREMS Prototype to **locate interference issues** causing power-line communication-based smart home devices to malfunction. EPRI identified a specific new home as the source of the interference.
- **ACE:** Atlantic City Electric has been a leader in deploying PREMS II to identify issues related to connection hot spots and failed components around Long Beach Island. The system has **detected pending equipment failures** before they occurred, such as hot taps on capacitor banks, corroded disconnect switch underarms, bad splices, faulty transformer connections, and CPS transformer internal issues. ACE conducts multiple scans per year throughout their territory.

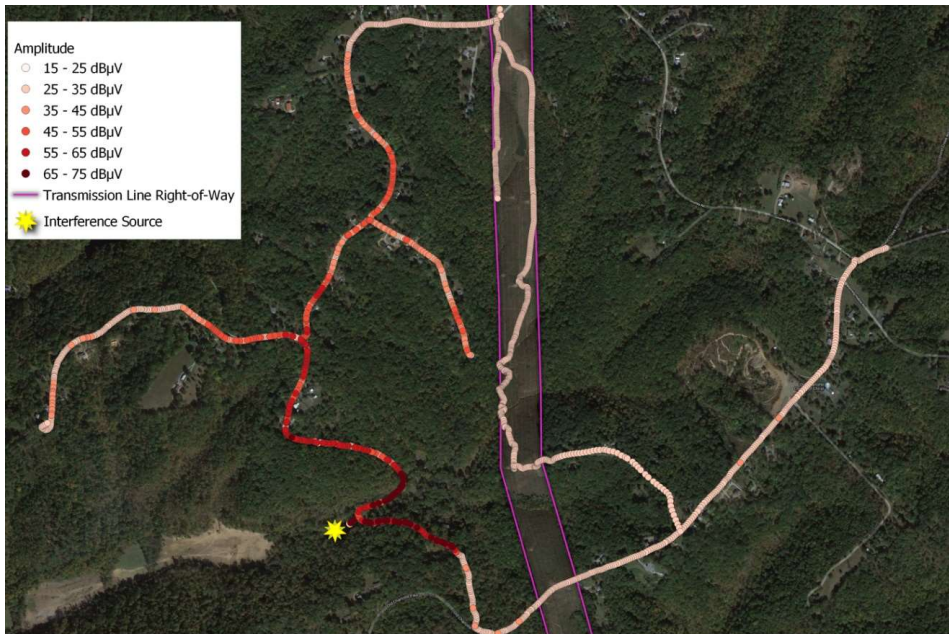


Success Stories/Review of PREMS Applications

- **Dominion:** Dominion initially had EPRI use the PREMS prototype to help solve an interference issue between **hardwired telephone communications and local PV farm**. After joining the PREMS II supplemental, they joined the supplemental project to obtain their own unit, which they now use routinely to find both grid and customer issues. Their feedback has been crucial in developing and refining PREMS II.
- **CPS Energy:** CPS Energy originated the idea for EPRI to develop the PREMS II. They are using it for **scans in their territory** and have used to help with issues reported by a local telecom provider. They are looking to employ PREMS in their **wildfire management** program.
- **Georgia Power:** Georgia Power recognized the value of the PREMS II system and added it to their fleet to conduct **RFI scans** and identify sources of anomalies as needed.



Unique Case Study Pt 1

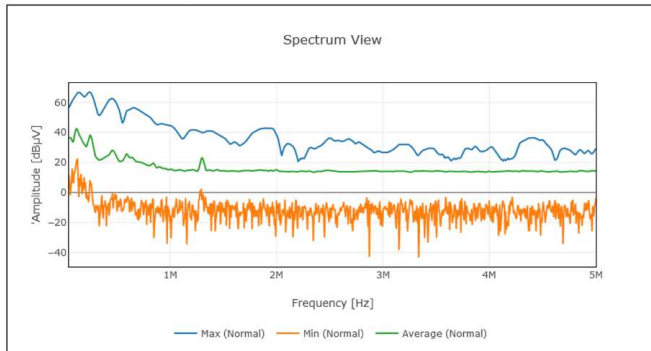


240 kHz

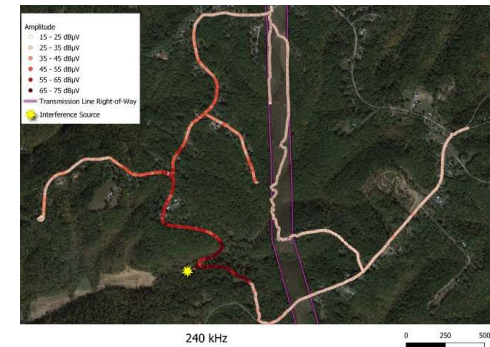
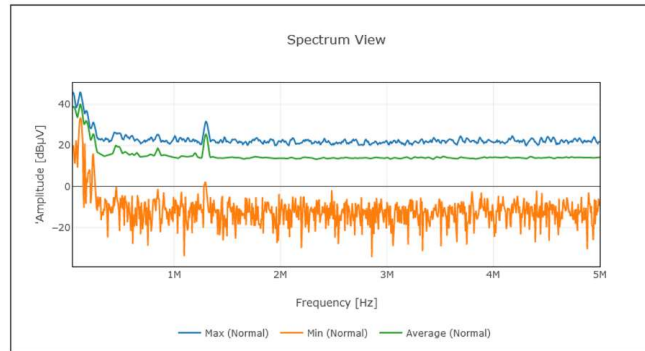
0 250 500 m



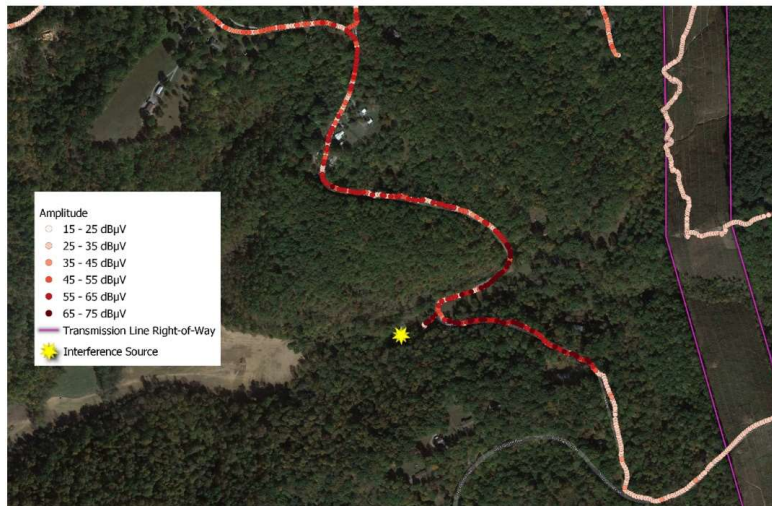
Before Mitigation



After Mitigation



Before Mitigation



After Mitigation



Radiated Emission Measurement

The Future

- Proactive periodic mapping of networks
- Static/stationary monitoring of substations
- **Incorporation into PQ Monitors**



PQ Monitoring

The Future

- 3-Ph Voltage and Current, of course, but with ...
- Integration of other sensors
 - Radiated emissions
 - Arc detection
 - Weather
 - Noise/sound/vibration
 - Visual
- Embedded/local AI capabilities
- Leveraging existing:
 - Processing
 - Storage
 - Telecom
 - Etc.



Proactive PQ

Leveraging existing sensors & staff for significant savings

- Proactive PQ creates opportunities to improve:
 - Economic Performance
 - **Grid Performance Metrics**
 - Environmental Protection
 - **Worker and Public Safety**
 - Customer Satisfaction



The before/after of a failed substation Coupling Capacitor Voltage Transformer (CCVT) sensor. *Proactive detection of declining health is now straightforward using PQ data.*

Source: American Electric Power

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