

# Underground Transmission Cable Monitoring – Lessons Learned at AEP

Reynold Cornell – AEP CIGRE Grid of the Future November 4<sup>th</sup> 2019



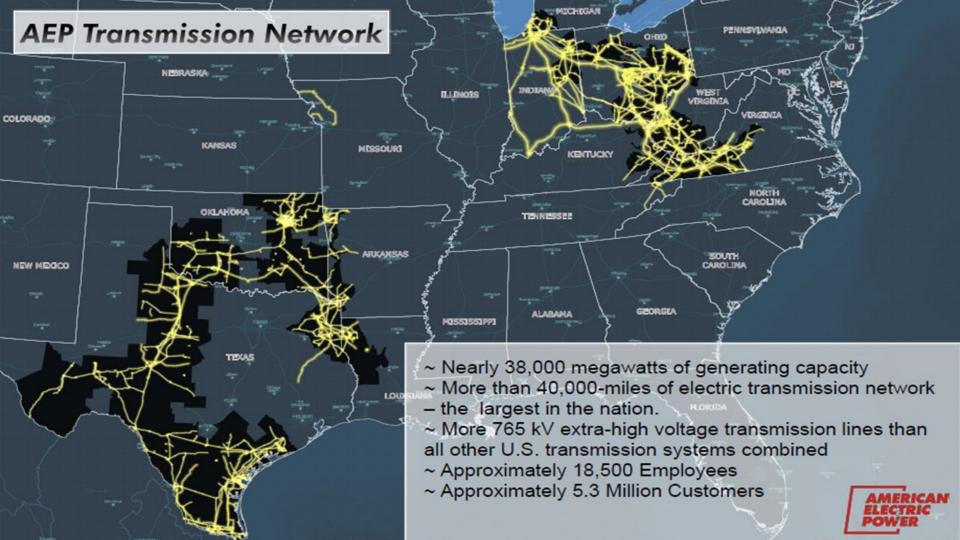


### **AEP** Overview

### **Drivers for Monitoring**

### **UG Cable Monitoring Pilots**

#### Next Steps





#### **AEP UG Cable Statistics**



• 34kV – 138kV



T-Line

T-Line Mileage – 40,000 miles • Up to 765kV

### **Asset Health Center Goals**



ROUNDLESS ENERGY

#### **Current Benefits Achieved**

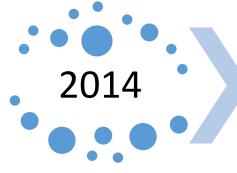
- Failure Prevention
  - 13 EHV Transformer Failures Prevented
  - **<u>\$50M</u>** in maximum potential savings
  - Remote monitoring reduces travel to stations

#### Maintenance Optimization

- Reduction in maintenance activities
- Cooling and wiring issues discovered via monitoring
- Reducing alarms to operations
- Prioritize Renewal
  - Online monitor data used in algorithms for condition based, data driven decisions
  - Decision making process improvements due to condition based monitoring equipment



#### **Asset Health Timeline**



2015

2017

- First Transformer Monitoring Save
- Catastrophic UG Network Failure – Columbus, OH
- Multiple 138kV UG power cable failures

Implementation of Asset Health Center Software First UG Cable Partial Discharge Monitoring Installations

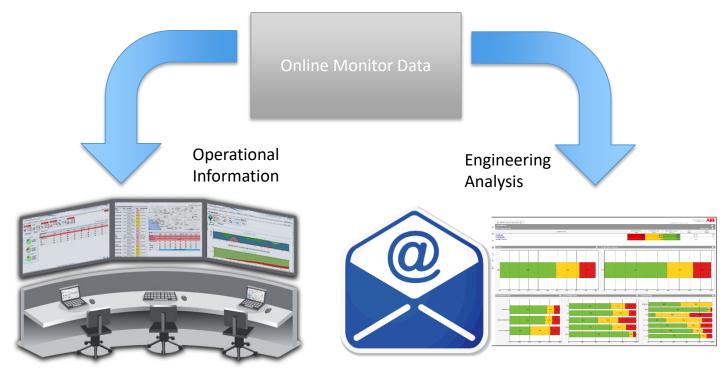
- Additional PD Monitoring Installations
- First UG Cable DTS Monitoring Installations

2019





#### AEP's Data Driven Communications Solution



**AEP SCADA & Operations** 

# UG CABLE PARTIAL DISCHARGE MONITORING

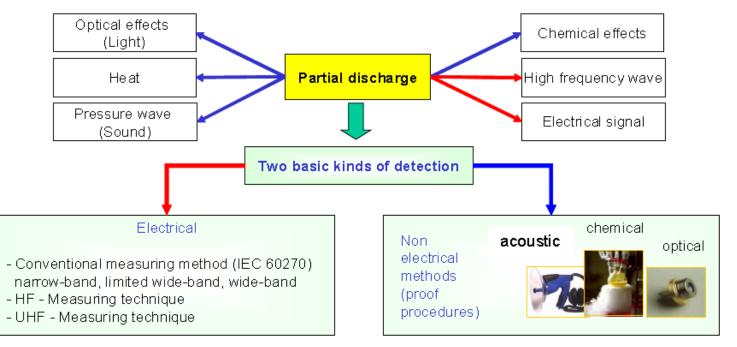
**Overview and Experiences** 





## What is Partial Discharge?

#### Physical effects of partial discharge



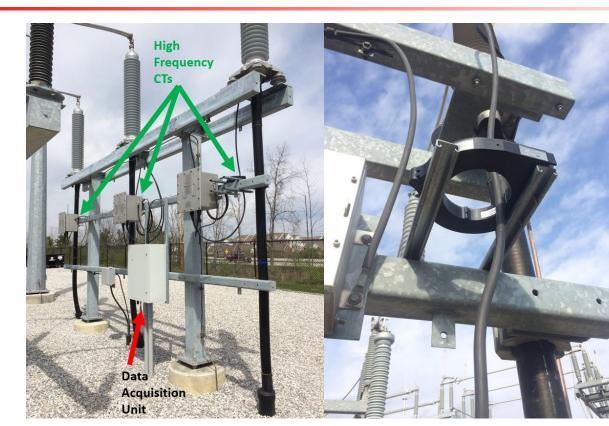


## **Partial Discharge Measurement**



- Partial Discharge induces high frequency signals in cable
  - Signal travels in both directions
- Detection Principle
  - Capture HF signals emitted by PD at termination points
  - Analyze signals to identify faults and eliminate noise

### **Installation Diagram**



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## **Cable PD Monitoring Systems**

- 138kV Circuits Fully Monitored: 1
   Circuit 1 0.53 miles
- 138kV Circuits Partially Monitored: 3
  - Circuit 2 2.63 miles
  - Circuit 3 1.13 miles
  - Circuit 4 4.42 miles
- First Installation: 2016
- Latest Installation: 2019

### **Partial Discharge Analysis**

ation Data Summary Events Alar Sensor Name						
Britton-Davidson-PhaseA	💿 Day 💿 Wee	k 🔘 Month 🧕	Year			
Britton-Davidson-PhaseB	Date Time	Event Type	Max Amplitude (µV)	Max Pulses	Max 🔺	Pulse Shape
Britton-Davidson-PhaseC Britton-Dublin-PhaseA	2019-06-25 10:23	Non-PD	47717	115		
Britton-Dubin-Phase8	2019-06-18 21:40	PD	22845	20		25000
Britton-Dublin-PhaseC	2019-06-18 21:38	PD	22757	23		
	2019-06-18 21:37	PD PD	22202	21		2000
	2019-05-04 16:34 2019-05-03 08:00	PD	24593 22319	39 25		
	2019-05-03 07:45	PD	23439	20		15000
	2019-05-01 08:05	Non-PD	49810	22		
	2019-04-28 01:20	PD	24783	20		10000
	2019-04-27 20:40	PD	24/03	23		
	2019-04-27 20:38	PD	24607	22		
	2019-04-26 12:11	Non-PD	20346	225		
	2019-04-26 11:12	PD	20527	22		السلامي المالية المركز الم الم الم الم المركز المركز المركز المستقدين والمحتين المحتية المستقدين المستقدين المركز
	2019-04-26 04:14	PD	25419	21		
	2019-04-26 04:12	PD	36663	27		
	2019-04-26 03:50	PD	30660	23		-5000
	2019-04-26 00:13	PD	23869	22		
	2019-04-26 00:09	PD	25098	21		-10000
	2019-04-25 03:41	PD	22194	24		
	2019-04-25 03:38	PD	21296	25		-15000
	2019-04-25 03:21	PD	27320	32		
	2019-04-25 03:20	PD	26683	38		
	2019-04-20 02:37	PD PD	31336 30707	22		
	2019-04-20 02:32 2019-04-20 01:36	PD	28134	23 22		
	2013/04/20/01.36	- FD	20134	22	•	
	Event Type	Max Amplitude (µV	Max Pulses	Max Discharge	Pala	
	E Verk Type FD	22845	20	Max Discharge	nale	Phase Resolved Distribution
						2500
						2000
						2000
						<u></u>
						4 10000
						5000
	1					

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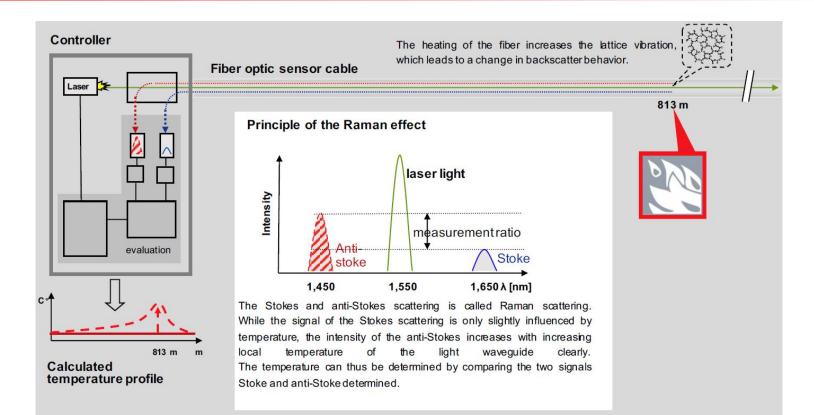
# UG CABLE DISTRIBUTED TEMPERATURE SENSING

**Overview and Experiences** 





### What is DTS?



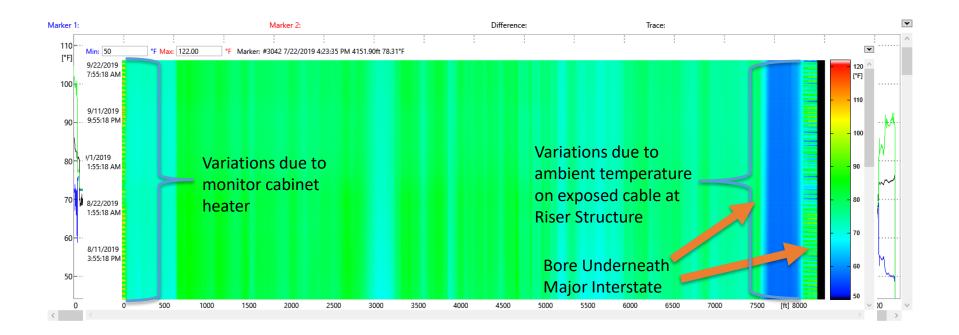


## Pilot Installation #1

- 40kV Circuit 69kV design
   Circuit 5 1.34 miles
- System Commissioned and Operational by Vendor#1
- Working/learning about the Real Time Thermal Rating software
- No alarms to transmission operations
  - Email alerts only



#### **Pilot Installation #1 Monitor Data**



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## Pilot Installation #2

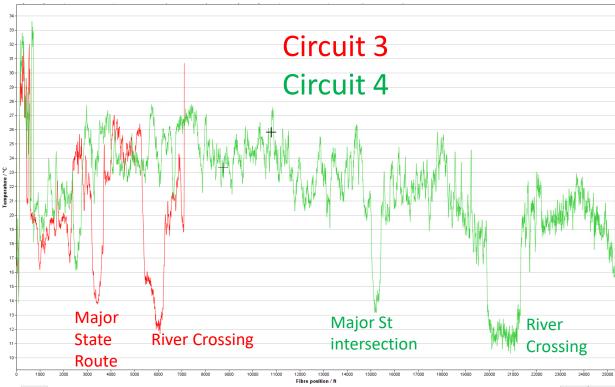
- Two 138kV UG Cable Circuits
  - Circuit 3 1.13 miles
  - Circuit 4 4.42 miles
- System Commissioned and Operational by Vendor 2 in June 2019
- Working/learning about the Real Time Thermal Rating software
- No alarms to transmission
  operations
  - Email alerts only





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#### **Pilot Installation #2 Monitor Data**



Step size: 01:00:00 💲

Date: 9/24/2019 - 4:20:27 PM 🗘

# LESSONS LEARNED & NEXT STEPS



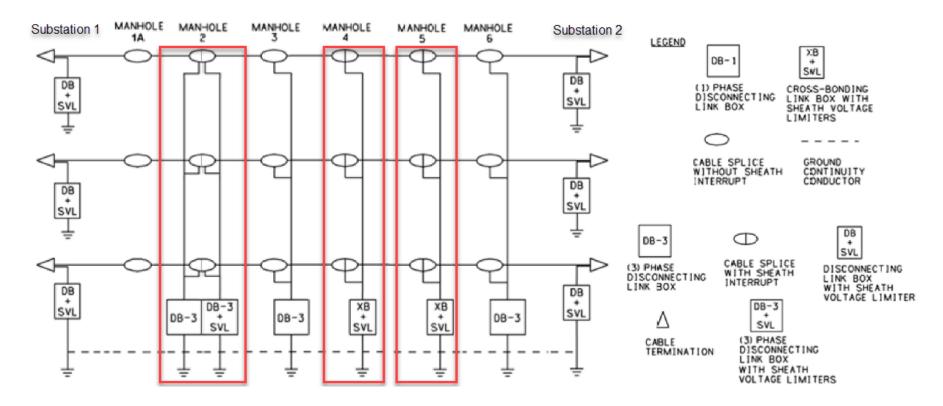
#### 2018 Cable Failure – Circuit #2



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#### **Cable PD Monitoring - Grounding**



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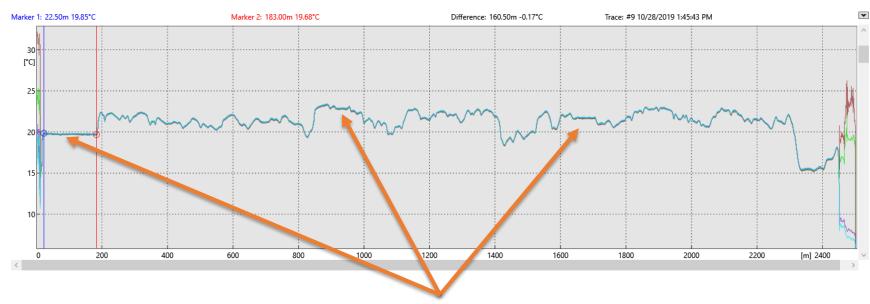


#### 2018 Cable Failure – Continuing to Learn





#### **DTS Fiber Documentation**



Fiber Maintenance Loop Locations



### **Next Steps**

#### **Pilot Installations**

- 2019 PD / DTS Installation
- 2020 DTS Installations

#### Data Analysis and Visualization

 Incorporate monitor data into Asset Health Center algorithms

#### Technology Evaluation

- Continue evaluating PD monitoring
- Evaluate DTS vendors
- Evaluate possible UG Cable Standard

#### Other Technology Deployments

- Can DTS be utilized for other AEP Transmission Assets?
  - Transformers
  - T-Lines
  - Substation
- Batteries



Thank you!

# **QUESTIONS?**