# VELCO & VEC Pilot Project on Novel High-Resolution Point-On-Wave Monitoring for Transmission Event Analysis & Model Validation


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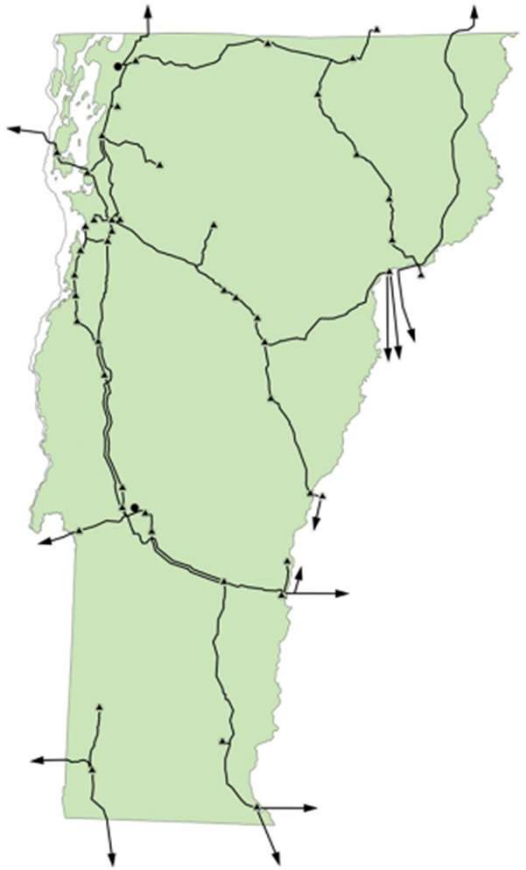
# Vermont Electric Power Company (VELCO)

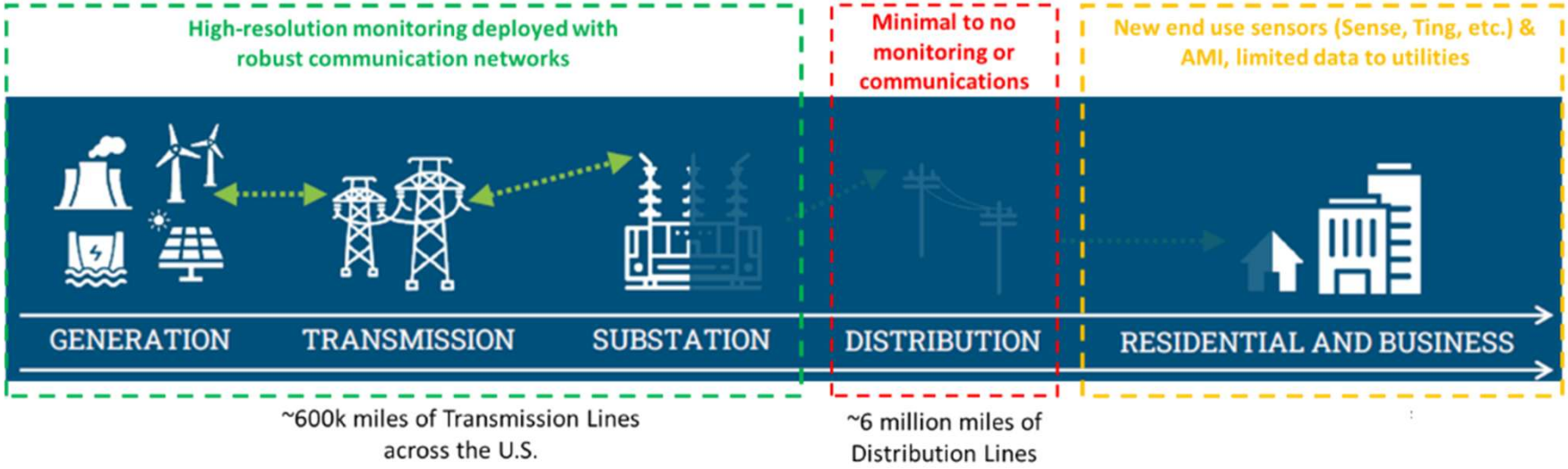
- First U.S. transmission-only company (1956), delivering sustainable hydropower to Vermont
- NERC Transmission Operator, Planner, and Owner
- Owned by Vermont's 17 distribution utilities (one is Vermont Electric Cooperative [VEC]) and a public benefits corporation
- For-profit structured to deliver cooperative-like value to every grid connected customer
- 740 miles of transmission lines
- 1,600+ miles fiber optic communication networks that monitor/control electric system and aid Vermonters' high-speed data internet access
- Adding 800+ more miles of fiber to connect **400 MW** of distributed energy resources
- Forecasted day-time minimum load in 2033 is **-175 MW**



# Vermont Net Load influenced by DER behavior on 4/19/2025 (cloudy) and 4/20/2025 (sunny)

# Distribution System has minimal to no monitoring outside the substations

- Limited measurement data on the U.S. distribution system is primarily due:
  - Vast scale (10x the size of our Transmission system)
  - High cost of installing sensors down the distribution circuits (i.e., outside of substations, on poles, etc.)
  - Very high cost of installing high-speed communication networks across distribution circuits

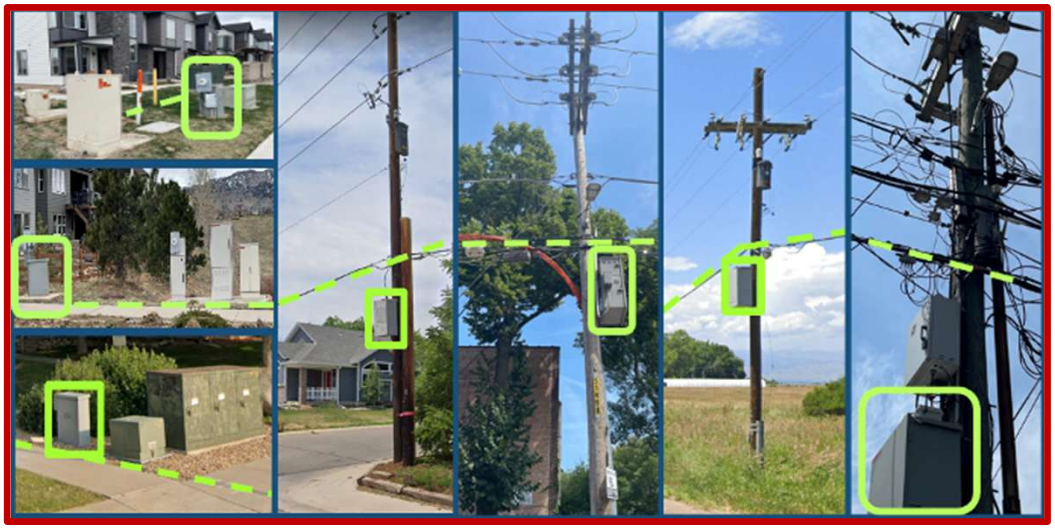


# Potential New Solution to the Distribution Monitoring Problem

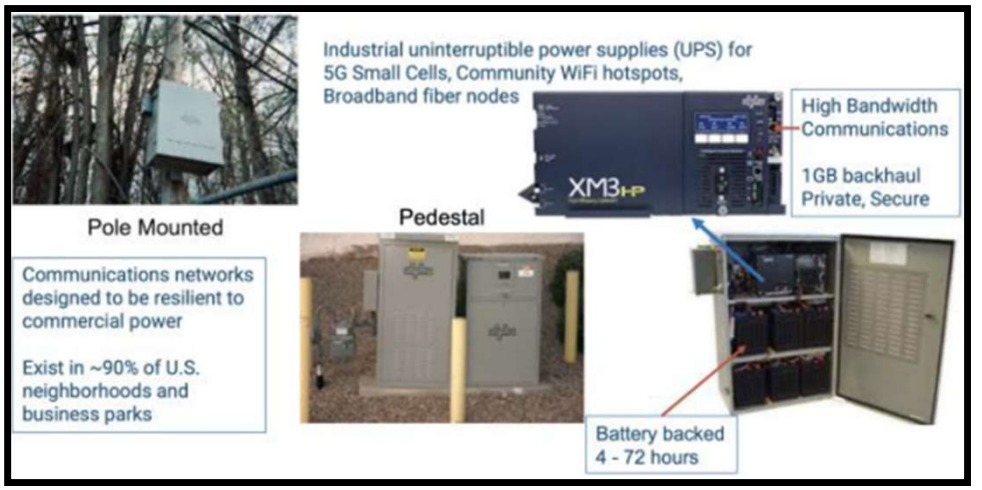
New point-on-wave (POW) monitoring technology that takes advantage of existing communication broadband networks to provide high-resolution monitoring of the grid

- Takes advantage of the existing broadband lines (cable, internet) going to every home and business that is typically built under the electric distribution lines
- Broadband network has more than 600,000 existing universal power supply (UPS) devices across the country
- Each UPS gets single-phase AC power from the electric distribution system
- POW sensors can be installed inside the UPS enclosures to monitor the distribution system voltage and then transmit that data directly on the broadband communication network
- Combines two infrastructures that run together to every home and business to provide extensive electric distribution monitoring

# Point-On-Wave Monitoring Technology Leveraging the Existing Broadband Network



**Broadband Network Adjacent to Electrical Distribution Network**




**Broadband Network Industrial UPSs**

Source: "Synchro-Waveform Measurements and Data Analytics in Power Systems", IEEE PES-TR127.
Images courtesy Grid**Visibility**, inc.

# Point-On-Wave Monitoring Technology Capabilities

**Sensor Description**

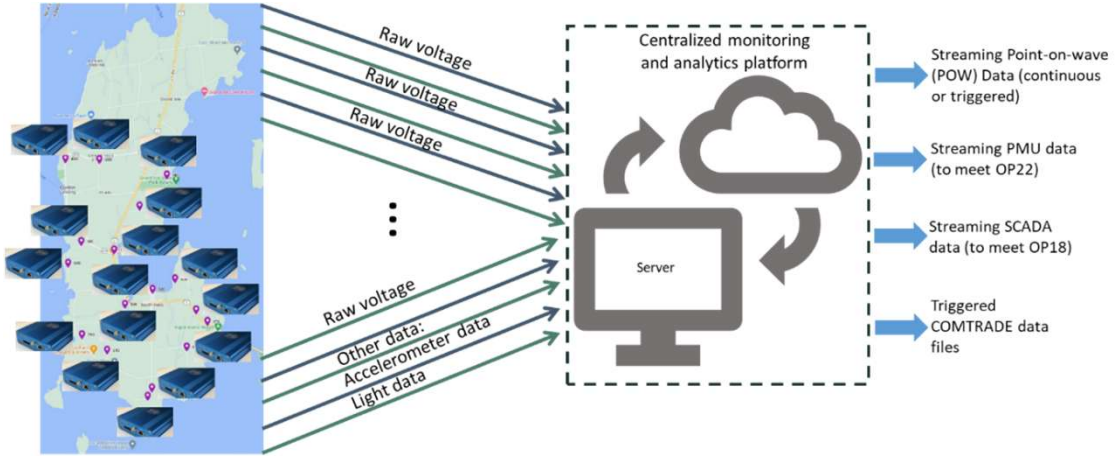
- Capture voltage waveforms at 10,000 samples per second
- GPS time synchronization
- Built-in lightning and motion detection
- Sensors stay active during outages due to UPS backup power
- 88% of U.S. homes within 1 km of a broadband UPS → wide potential coverage
- Data streams to a central platform with low latency for near-instant monitoring and analysis

# VELCO & VEC Pilot Project

March 2024

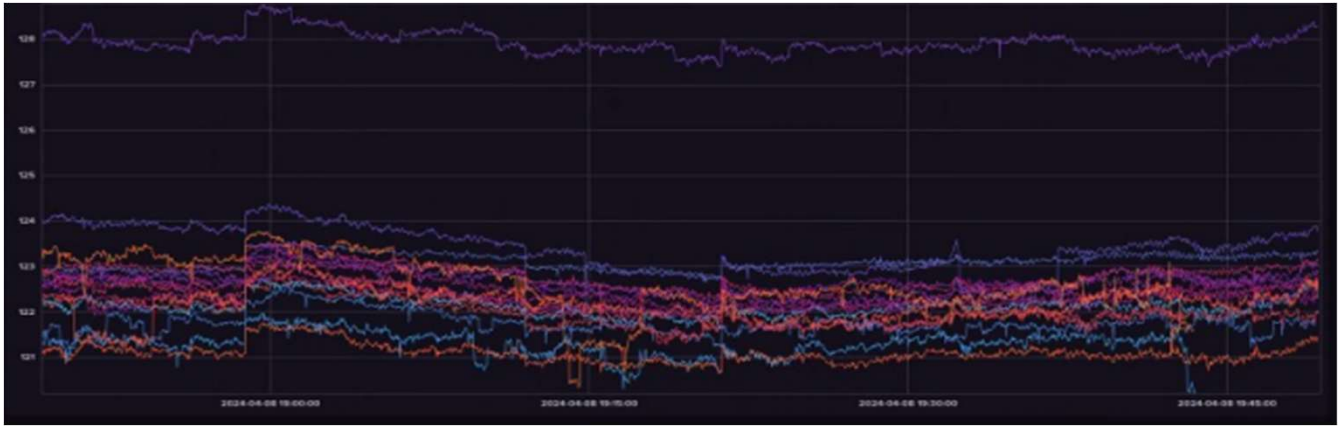
17 sensors installed in 6 hours

- VELCO & VEC piloted the technology in Vermont on VEC's distribution system
- Installing 17 sensors on two VEC distribution circuits
- Initially installed in time to capture the 2024 solar eclipse
- Captured additional events: faults, switching events, harmonics

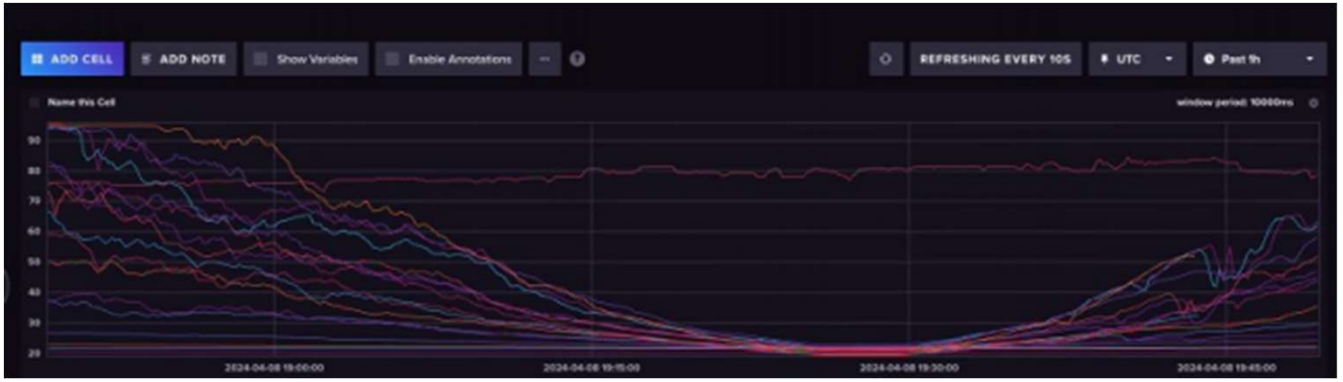



# Solar Eclipse Captured

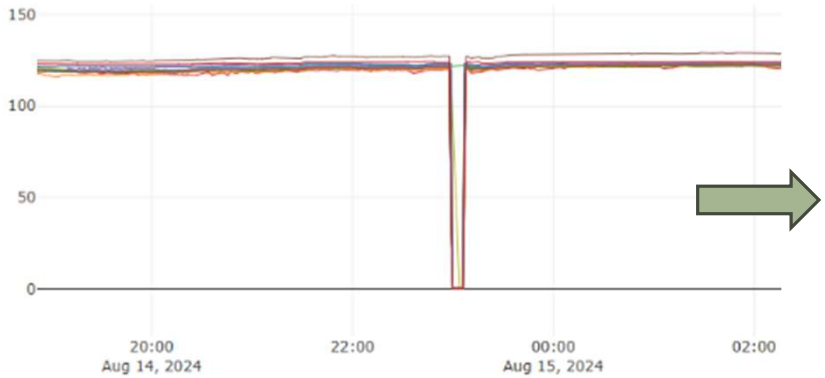
Distribution Voltages

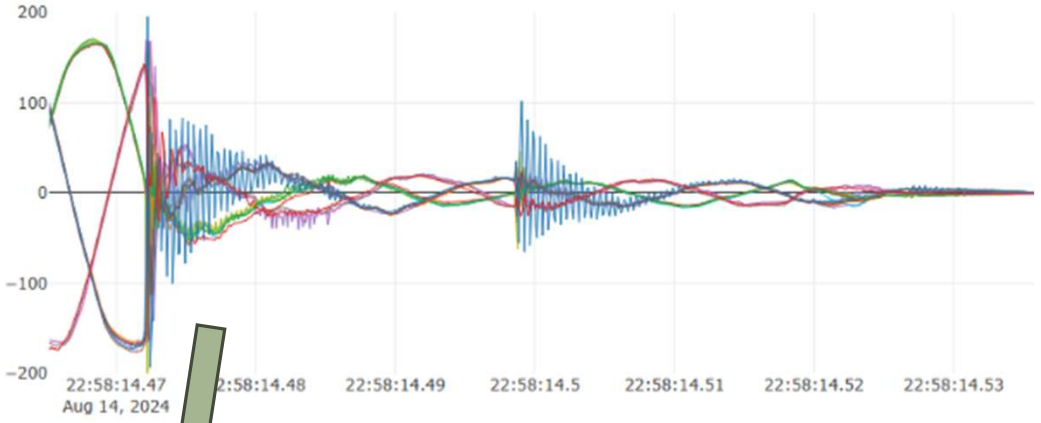


Ambient Light at Sensors

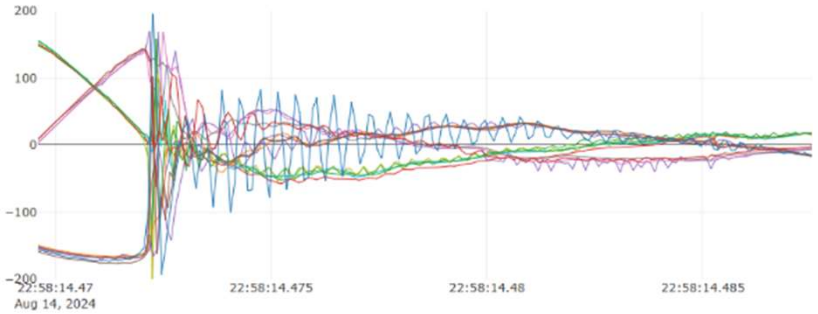


# Lightning Strike causing 115kV 3-phase Fault



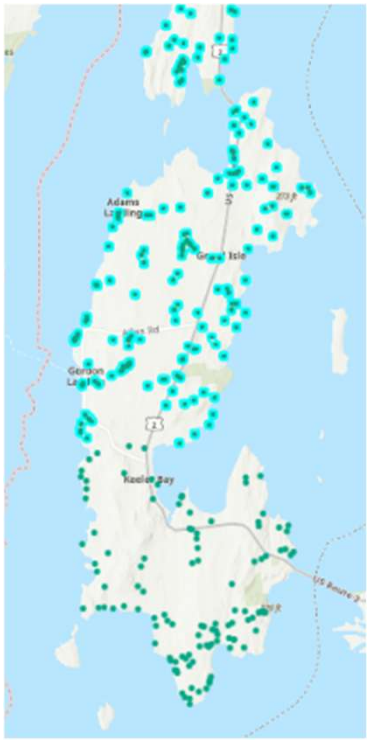

Fault as seen on the distribution system



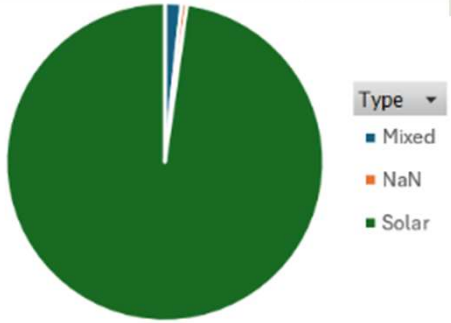

Waveforms courtesy Grid**Visibility**, inc.

# DER Penetration in the Pilot Area

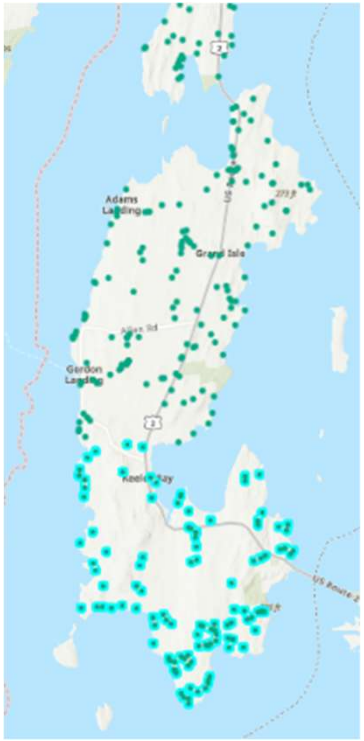
**Feeder 1**



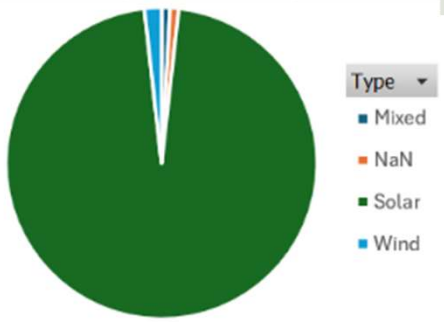
| Type of resource | Quantity | Capacity [kW] |
|---|---|---|
| No defined | 1 | 0 |
| Mixed | 3 | 24.5 |
| Solar | 175 | 6,829.36 |
| Wind | 0 | 0 |
| **TOTAL** | **179** | **6,853.86** |




**Feeder 3**

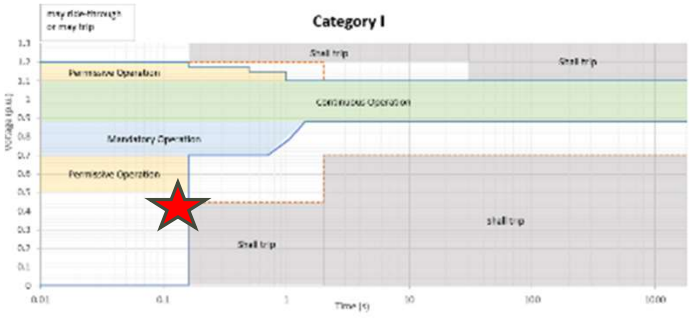


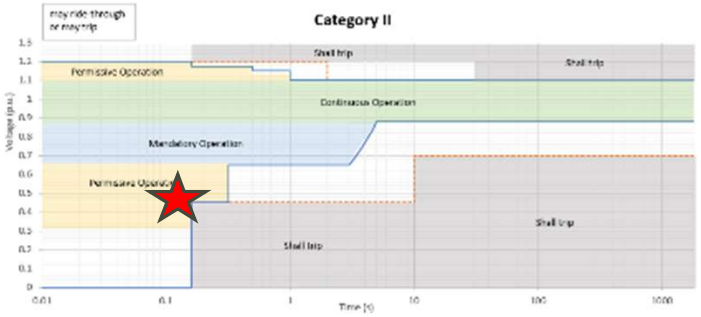
| Type of resource | Quantity | Capacity [kW] |
|---|---|---|
| No defined | 1 | 0 |
| Mixed | 1 | 6.41 |
| Solar | 109 | 817.59 |
| Wind | 2 | 5 |
| **TOTAL** | **113** | **829** |

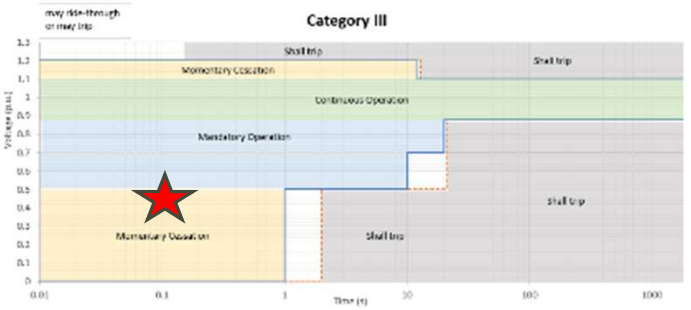



**Location of DERs Across Feeder 1 and Feeder 3 in the South Hero Area**

# Nearby system fault allowing DER Ride-through performance against IEEE 1547

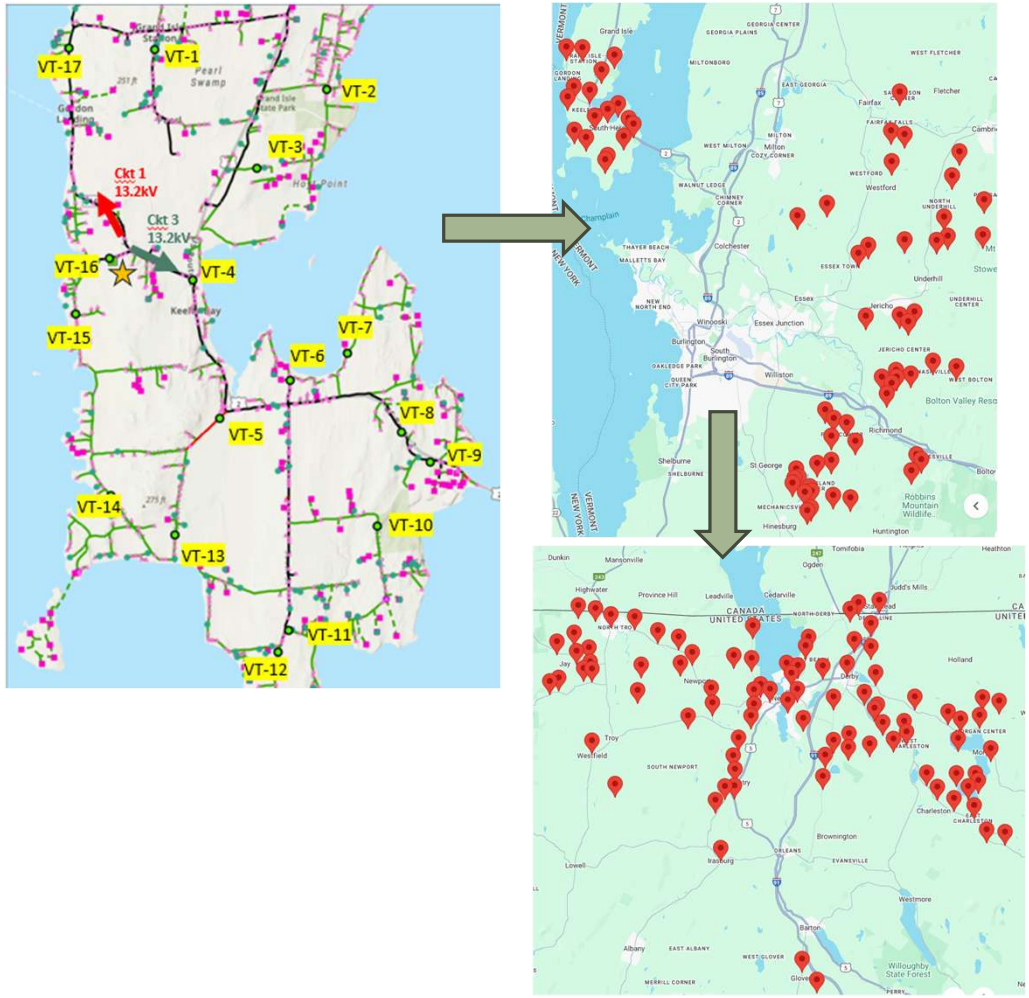




Waveforms courtesy Grid**Visibility**, inc.

# VELCO & VEC Pilot Project




**Point-on-Wave Monitoring Sensors in South Hero (left) and additional Vermont Areas (right)**

**March 2024**
install 6 hours

- VELCO piloted point-on-wave monitoring technology in South Hero, Vermont, installing 17 sensors on two distribution circuits

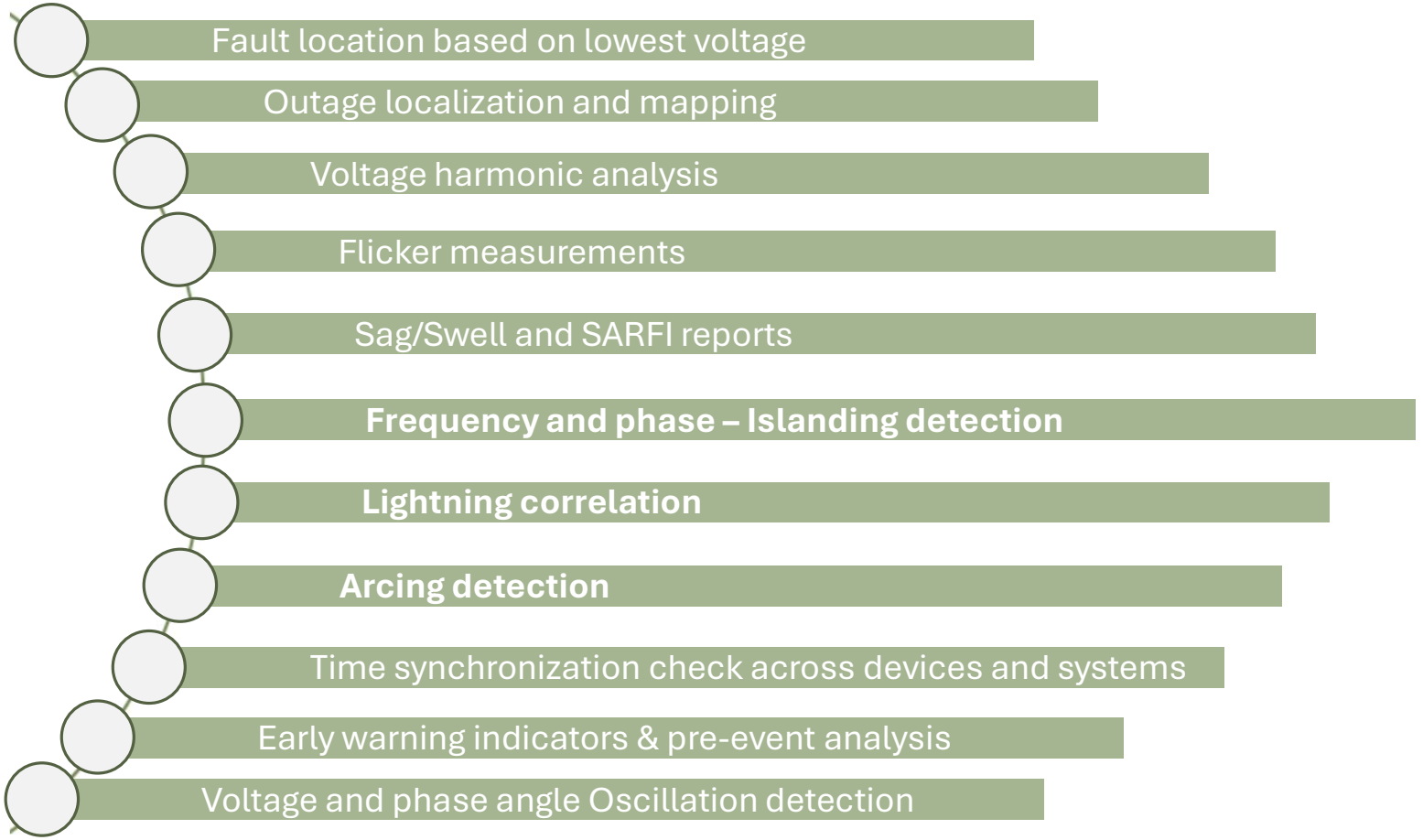
**October 2024**
Install 2 days

- VELCO, with funding from Oak Ridge National Laboratory (ORNL), installed 34 additional sensors across multiple substations east of Burlington

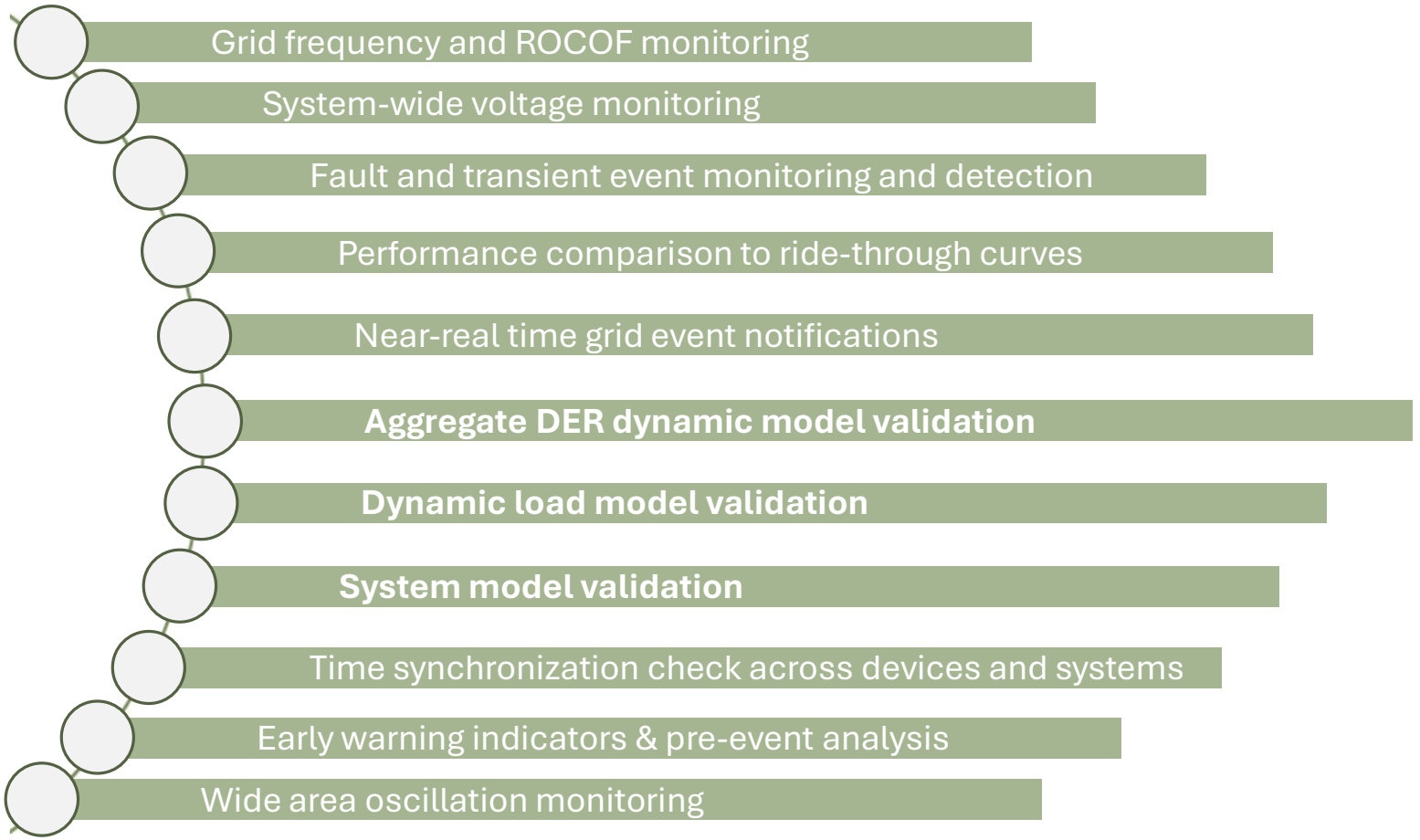
**December 2024**
Install 5 days

- VELCO funds 100 additional sensors surrounding Newport

# Potential Distribution Use Cases (Voltage monitoring)



# Once distribution monitoring becomes widely available, the Transmission use cases are endless

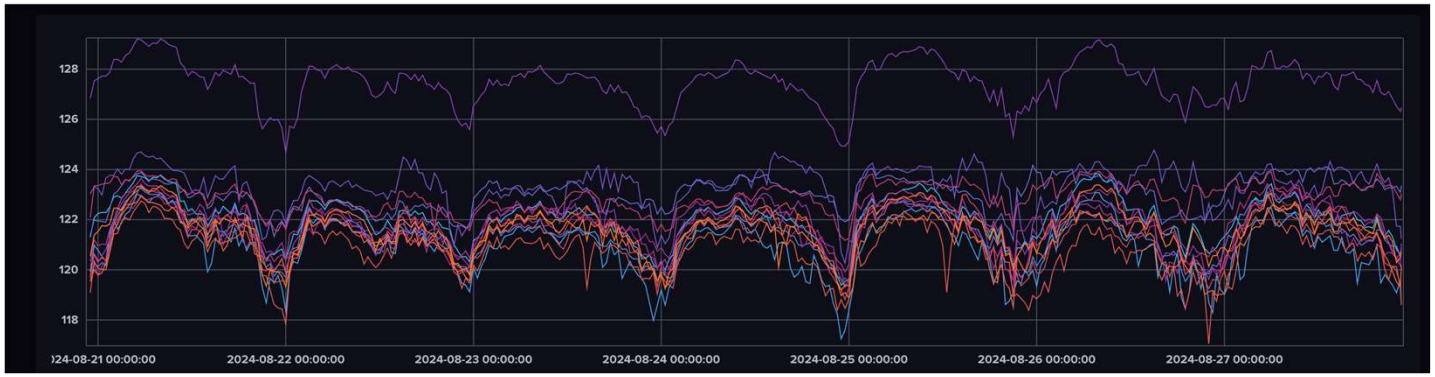


# Future Work

- Algorithms to detect events of interest in real time
- Once events are identified, pass high resolution data to appropriate analysis tool.
- Send notifications to the proper parties.
- What is an “event of interest”? We’re still trying to figure that out!
  - Appropriate level of detection and notification so that the events become ignored.
  - Some events may last days, or it may take hours or days to recognize the pattern. How do we deal with those?
  - We welcome discussion and feedback on this topic.

# Conclusions

- As distribution systems continue to evolve and change with the ever-increasing growth of DERs, monitoring of the distribution becomes critically important
- New POW monitoring pilot project leveraging the broadband infrastructure helped rapidly improve grid visibility and support Transmission use cases, including distribution load model validation and DER model validation
- Successful deployment requires overcoming challenges in proof-of-concept, hardware design, and cybersecurity
- Future applications will continue to get developed and realized as we start to see the distribution system using high-resolution waveform data → real world training for AI, system wide frequency monitoring, and many more applications on the horizon



# Thank you!

**QUESTIONS?**

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