
Dominion Energy's WAMS Deployment for Operations

NASPI Work Group Meeting

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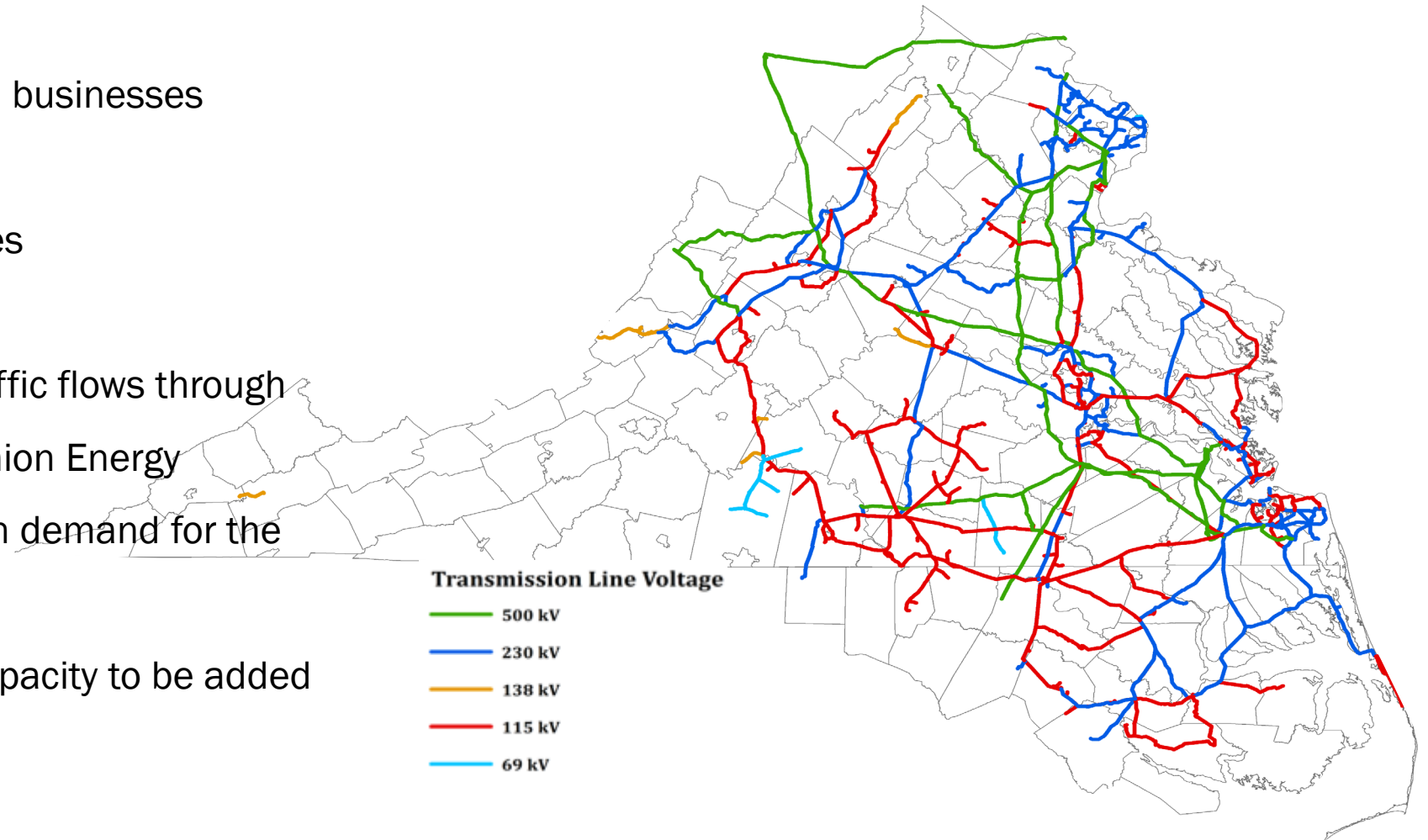
On mission to provide the reliable, affordable, and increasingly clean energy that powers our customers every day.



Thomas F. Farrell II Building
Richmond, VA

Dominion Energy Electric Power Transmission

- 3.6 million supplied homes and businesses
- 34 GW of installed capacity
- 6700 miles of transmission lines
- More than 900 substations
- 70 – 75% of Global Internet traffic flows through data centers supplied by Dominion Energy
- Expected 5.5% annual growth in demand for the next decade
- Up to 21 GW of clean energy capacity to be added by 2039



Dominion Energy Unique Features

Largest concentration of data centers in the world

- Over 300 data centers
- Can introduce harmonics on the transmission system



Significant deployment of renewable resources

- Large numbers of renewables require coordination to avoid oscillations



High concentration of government critical facilities

- Secure and reliable service is required



Ever-growing industrial and residential energy consumers

- Over 3 million electric customers
- Reliable and efficient service is required.

DE Synchrophasor Solutions

Fast and Efficient System Dynamics Intelligence

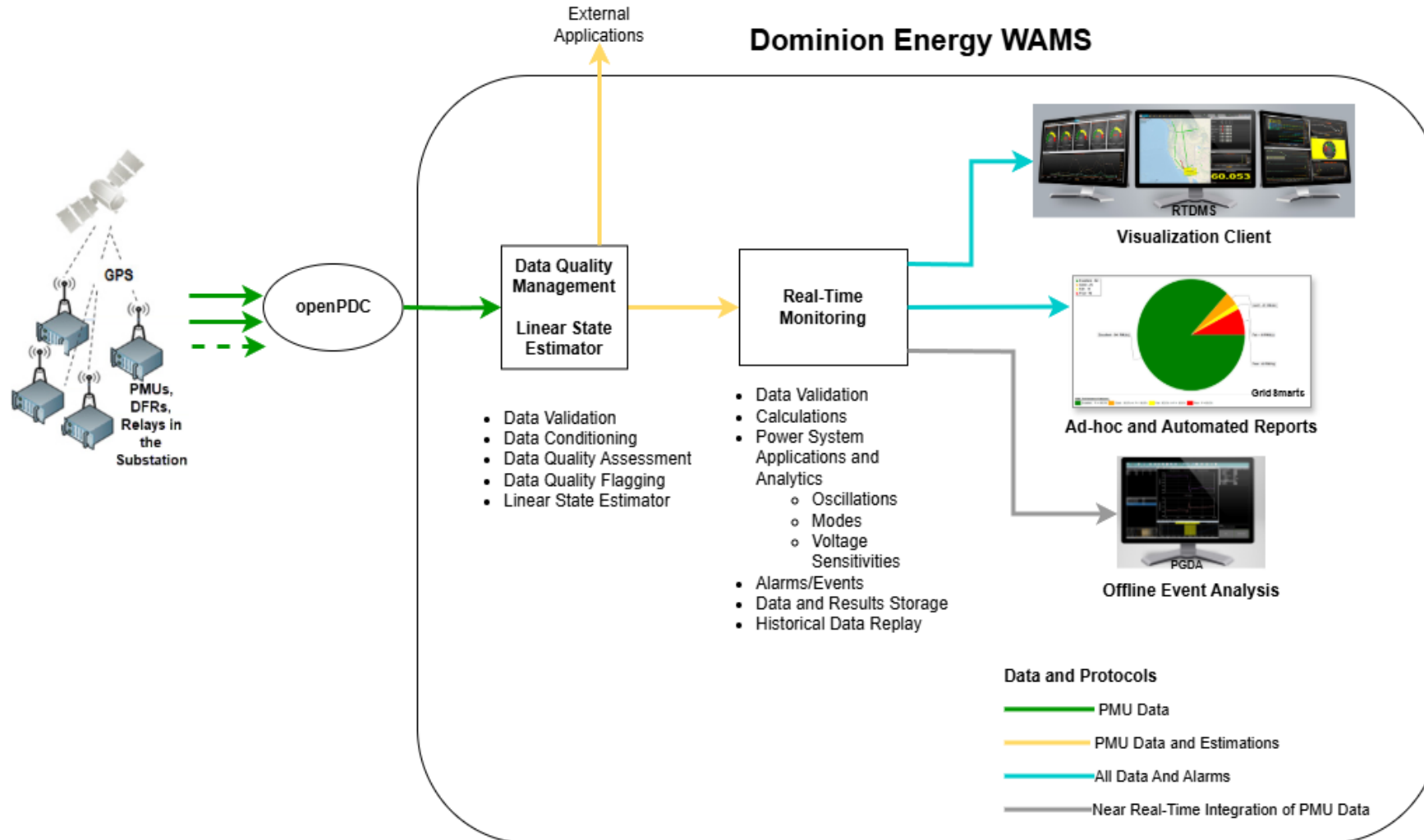
- Oscillations
- Phase Angles
- Islanding
- Post-Event Analysis



Full Suite of EPG's Synchrophasor Applications

- 1000+ PMU (plan to increase to 2000)
- WAMS
- Linear State Estimator (LSE)
- eGRID - Synchrophasor-based EMS for real-time assessments
 - Synchrophasor Power Flow and Contingency Analysis
 - Ambient Adjusted Ratings (AAR)/Dynamic Line Ratings (DLR)

DE WAMS Architecture





EPG WAMS SOLUTION AT DE



EPG INTRODUCTION

- EPG was established in 2000 by a team of electric utility executives
- Our suite of software applications offer Advanced Real-Time and Off-Line Analytics
- Solutions are architected and designed to integrate with existing customer infrastructure – all brands of PMUs and other vendor solutions
- EPG Synchrophasor solutions are in use by over 40 Grid Operators and Transmission Utilities for WAMS, LSE, Analytics and Advanced Applications

EPG WAMS OVERVIEW

■ Visualization

- Fully Customizable
- Geographic Map View
- Incident Indicator – Traffic Light Type Alarm Display
- Alarm Summary
- Numeric Displays
- One-line Diagrams
- Charting (e.g. Polar Chart, Gauge Chart (Speedometer), DF/DT Bar Chart, Strip Chart Complex Plane Chart, etc.)
- Replay and Playback functionality

■ Integration

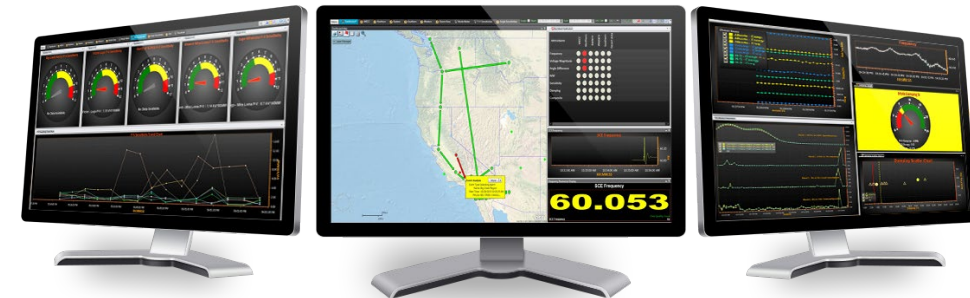
- Integration with Offline Analytics Application
- Integration with EMS/SCADA
- Historians/Databases
- Simulators
- GIS Integration
- PMUs and PDCs

■ WAMS Capabilities

- Web Based Reporting
 - PMU Performance Reports
 - PMU Data quality
 - Data Trend Reports
 - Alarm Summaries
- Real-time Alarms and Notifications
 - Multi-level alarms (up to 8 levels)
 - Composite Alarms
 - User Configurable Alarms
 - User Defined Calculations
 - Audible Alarms
 - Pop-up Notifications
 - E-mail Notifications

■ Analytics

- Wide Area Situational Awareness
- Oscillation Monitoring, Detection and Source Location
- System Dynamics Monitoring
- Phase Angle and Grid Stress Monitoring
- Islanding Detection and Restoration
- Outage Restoration, Line Reclosing
- Voltage Stability Monitoring
- Generation Trip Detection
- Load Trip Detection
- Generator Response Assessment After Faults
- Inertia Monitoring
- System Strength Monitoring
- Model Validation
- Event Analysis
- IBR Performance Assessment



DE PRIORITIES FOR WAMS

- Oscillations
 - IBRs/renewables
 - Generators
- Data centers
- Data quality
- Rollout for Operations

DE WAMS SOLUTION: RTDMS FOR OPERATIONS

- Wide Area Situational Awareness Dashboard

- At a glance, operators can see the system health, grid dynamics, and any active alarms
 - Multi-Layer Geographical Map
 - Alarm Panel and Incident Indicator
 - System Frequency trend and numerical view

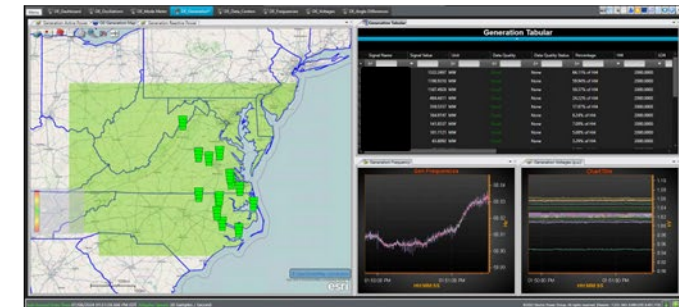
- Specialized Displays

- Oscillations and Mode Meter
- Generation, Renewables, and Data Centers
- Frequencies, Voltages, Angle Differences

Oscillations – Forced Oscillations and Natural Modes



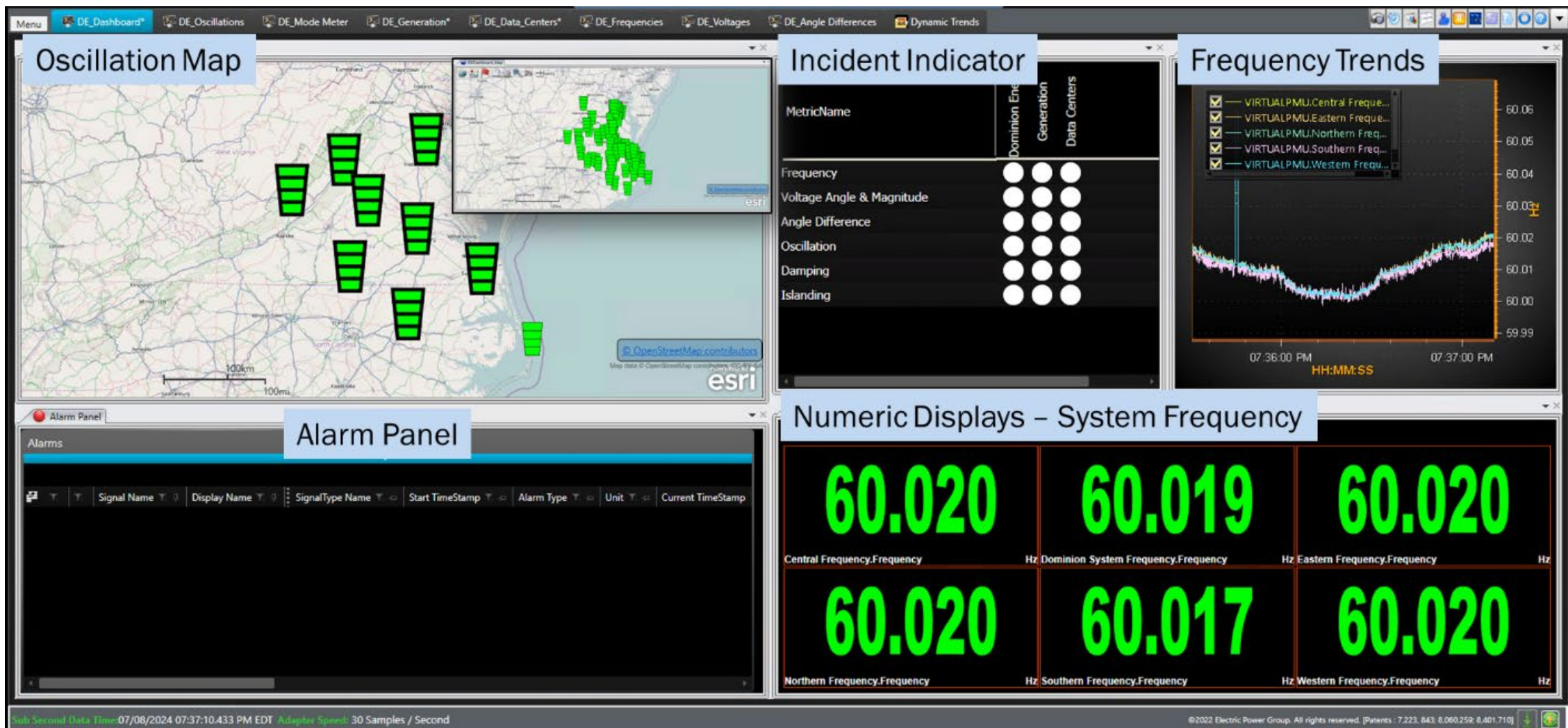
Generation Display – Solar, Wind



Data Center Display

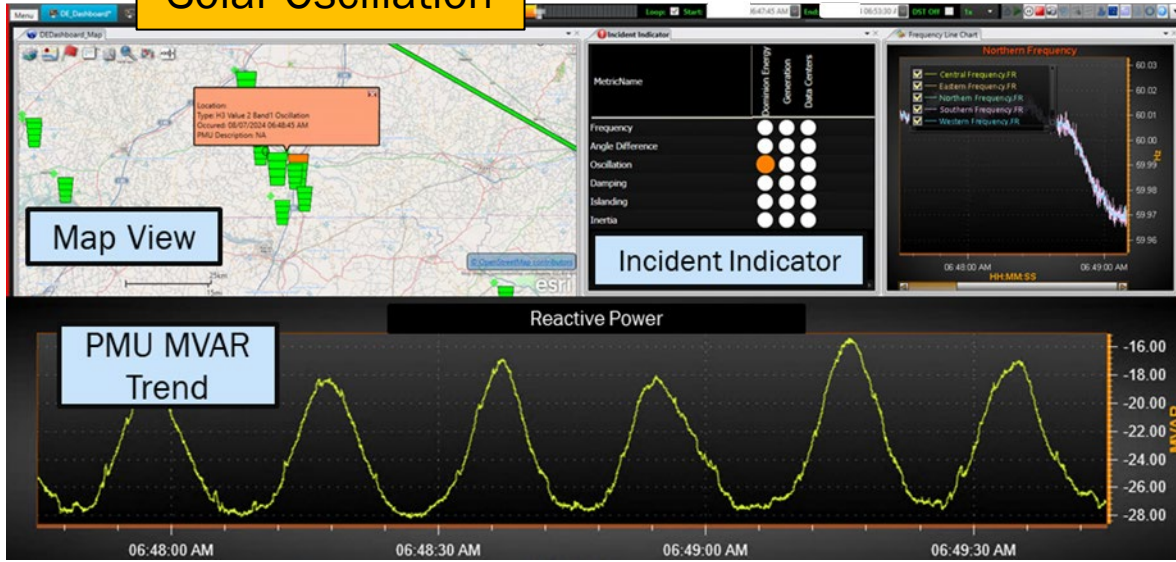


DE RTDMS DASHBOARD

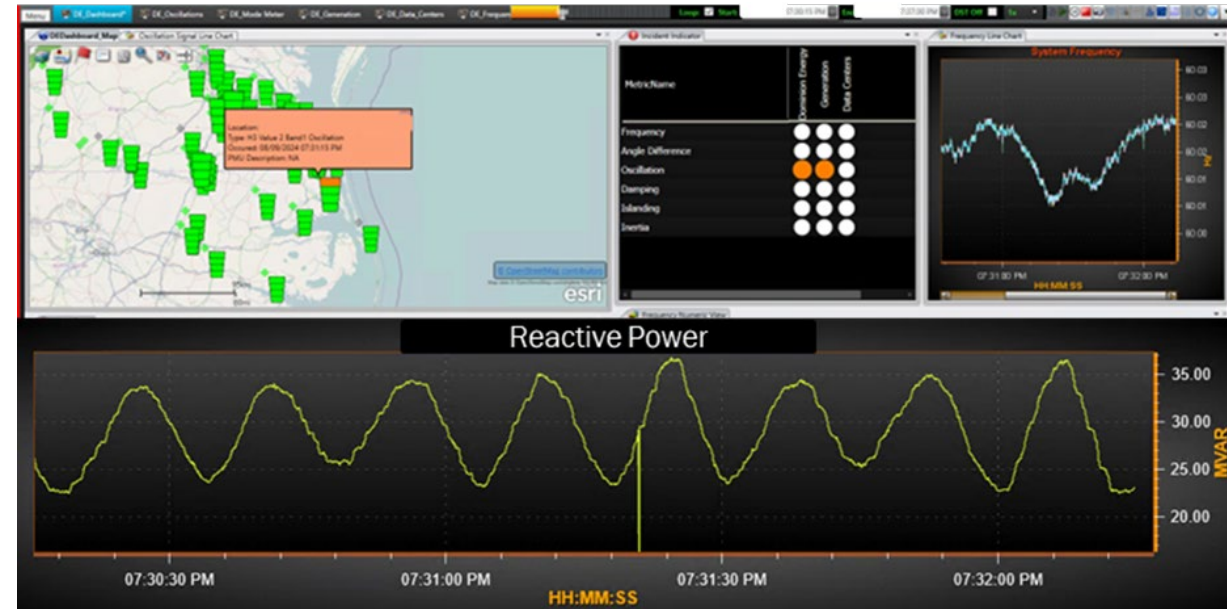


OSCILLATIONS

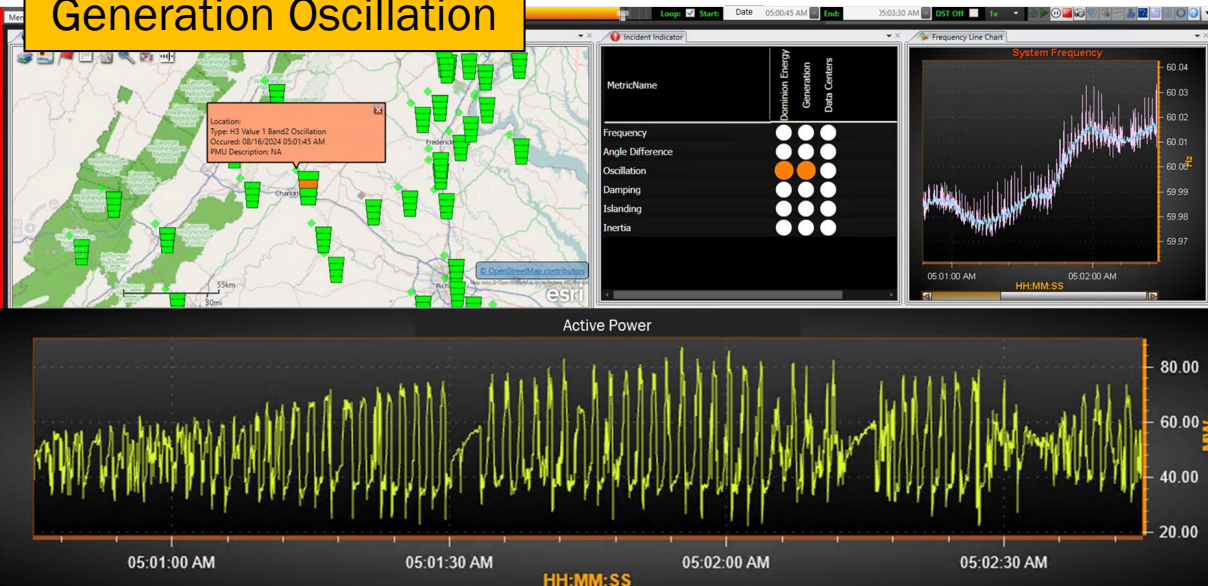
Solar Oscillation



Multiple Generators Oscillation

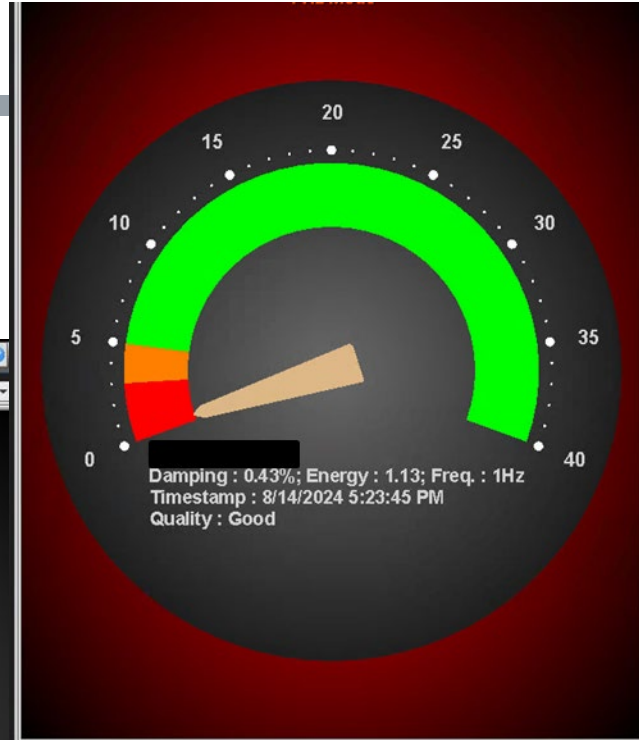
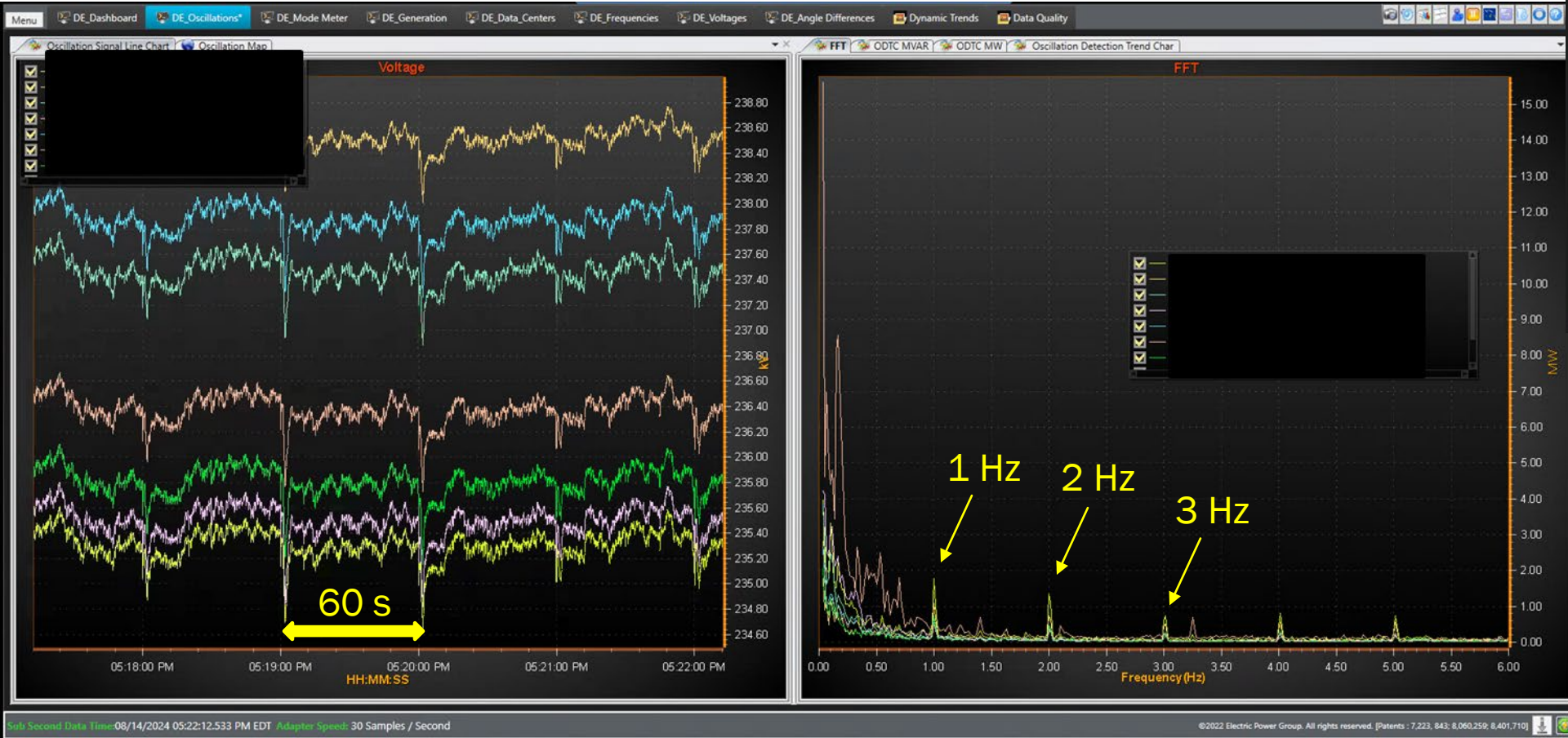


Generation Oscillation

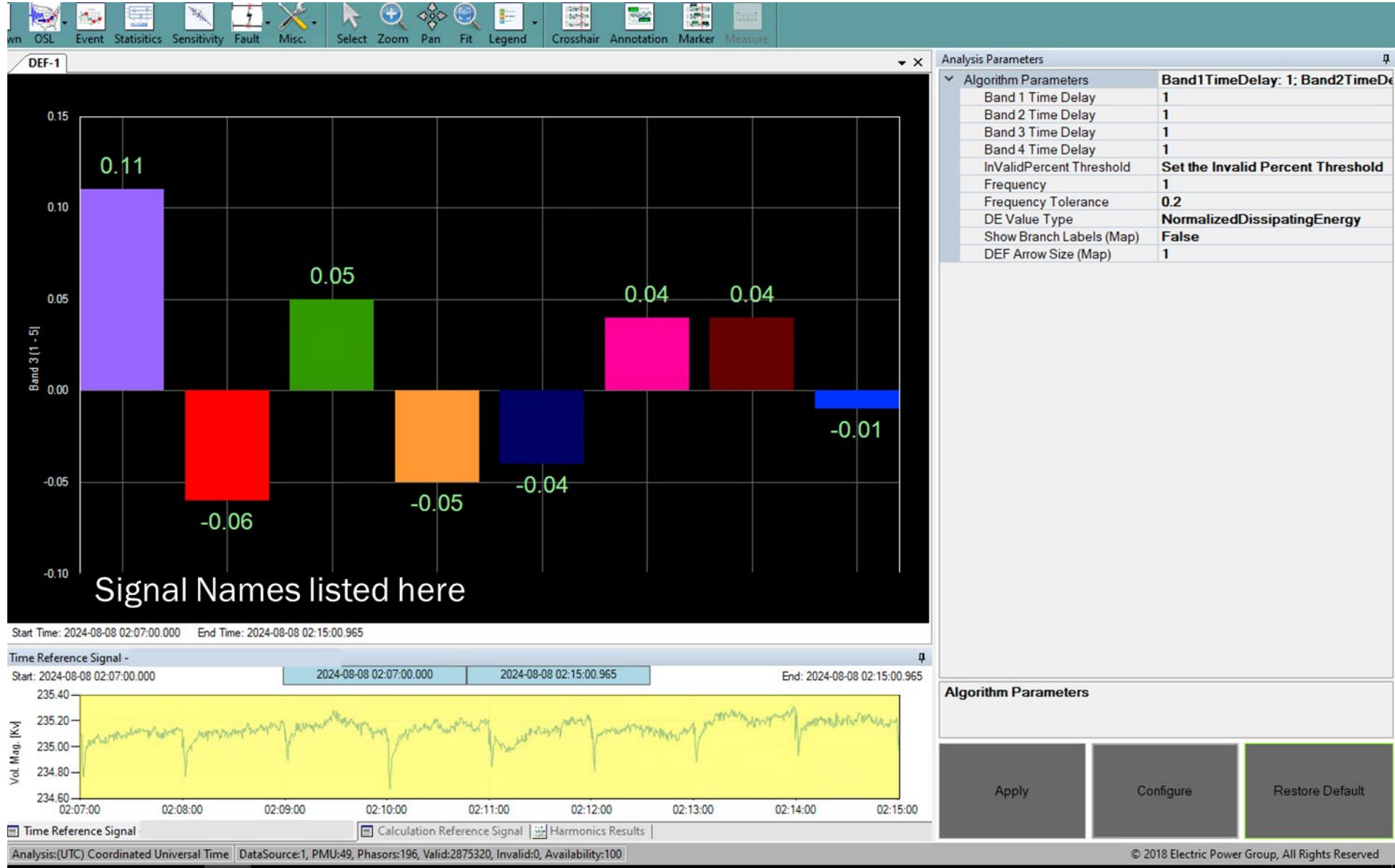


DATA CENTERS - 1HZ OSCILLATIONS

- RTDMS revealed consistent, 1Hz oscillations at PMUs nearby to Data Centers
 - These 1Hz oscillations last 24/7

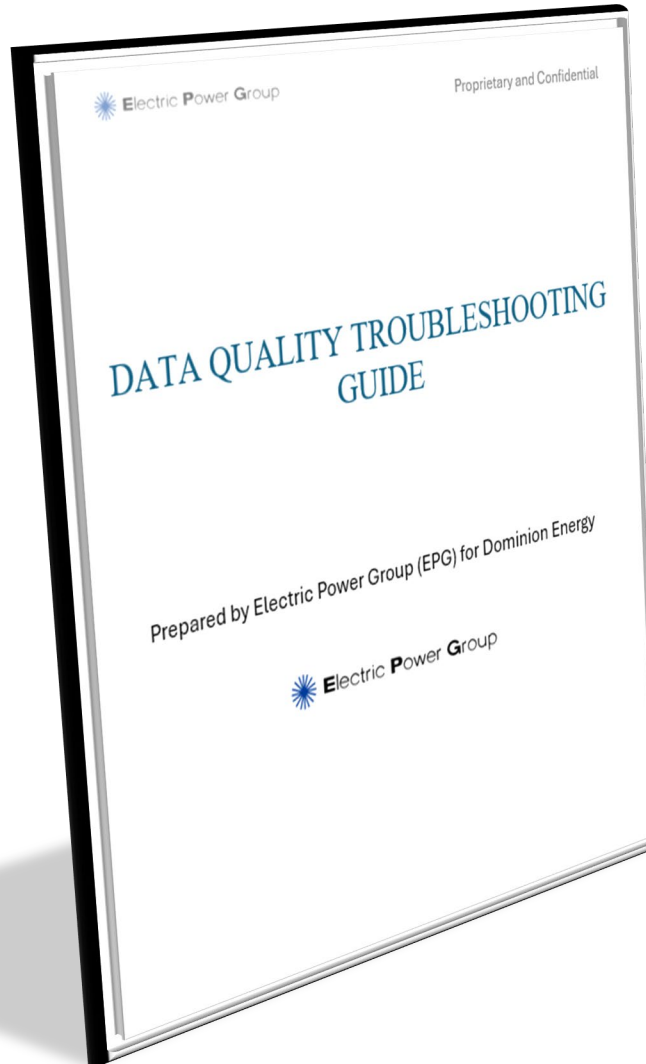


DATA CENTERS - 1HZ OSCILLATIONS SOURCE LOCATION ANALYSIS



DATA QUALITY

- EPG worked with Dominion to catalog a variety of data quality issues and composed a data quality troubleshooting guide
- This guide identifies and classifies the different symptoms of data quality issues and determines their root cause and remedial actions



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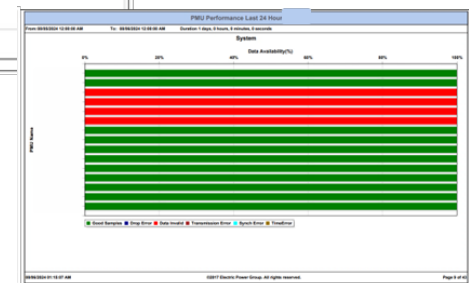
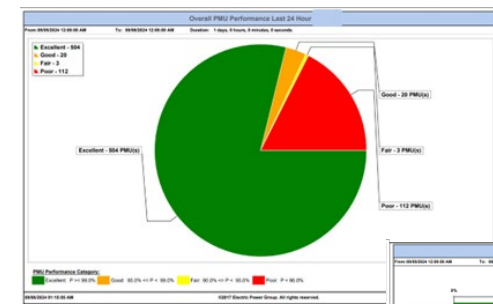
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WAMS ROLLOUT FOR OPERATIONS

- Key features of the DE WAMS rollout for operations include:
 - Early involvement of operators
 - Orientation and training sessions
 - Support for creating operating procedures
 - Integration with the video wall in the Control Room
 - Integration with EPG's synchrophasor-based EMS
 - Roll-out to Operators

SUMMARY

- Dominion Energy power system is evolving - renewables, data center loads, resource mix
- Monitoring grid dynamic metrics including oscillations, damping, phase angles is important for reliability and system stability
- DE WAMS and Synchrophasor initiatives are fully supported by top management
- DE mobilized SMEs from different disciplines including planning, operations, security, and IT early-on to assure buy-in and acceptance
- WAMS has demonstrated value in monitoring of oscillations and determining source location
- DE and EPG teams continue to work collaboratively

