Synchrophasors in System Operations at Dominion Energy

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- 2.6 million customers in Virginia and northeastern North Carolina
- 6,700 miles of electric transmission lines
- 58,510 miles of distribution lines
- 31,000 megawatts (MW) of electric generating capacity
- Net Zero carbon and methane emissions by 2050

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Synchrophasors in Dominion Energy

2009 – Kicked off synchrophasor initiative; DOE SGIG kickoff;

2012 – Began standardized relay/PMU sensor deployment

2013 – DOE SGIG Demonstration

Linear State Estimator v1.0 released as OSS

2014 – CERTS Synchrophasor Data Conditioning and Validation Project

2015 – DOE FOA970 Kickoff

2017 – DOE FOA970 Demonstration

Linear State Estimator v2.0

2017 – DFR PMU Conversion begins

Total transmission system coverage

2019 – Scaling towards Sustainability

High Performance Analytics Sandbox for Use Case Development

- Over 400 PMUs installed
- 5-year project to upgrade relay with PMU capability
- Data Analytics Engineering Group
- Synchrophasors in Operation

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Synchrophasors in Operation

- Primary Drive
  - Spare tire: system observability when losing EMS
  - Ability to ensure EMS solutions and check questionable scenarios
- Expanded Functionality
  - Wide area frequency monitoring
  - Oscillation detection and mode monitoring
  - Islanding detection and control
  - System transient and dynamics monitoring
- 500kV Pilot Project – Full Observability
  - Three main applications
  - Real time contingency analysis

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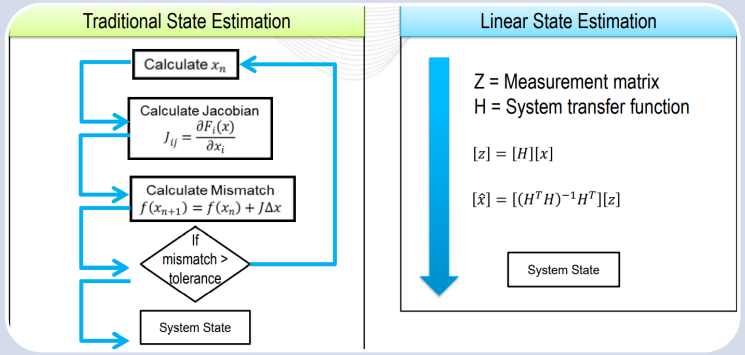
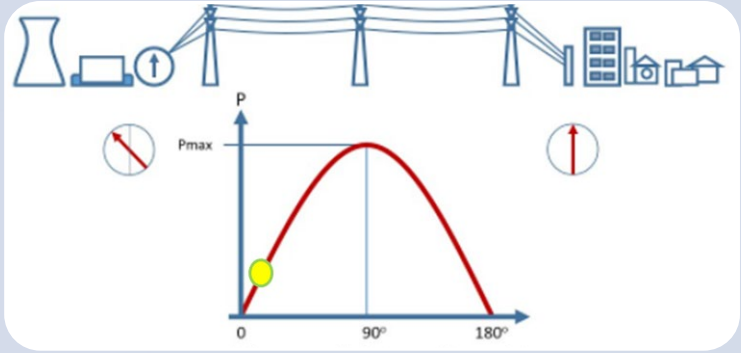
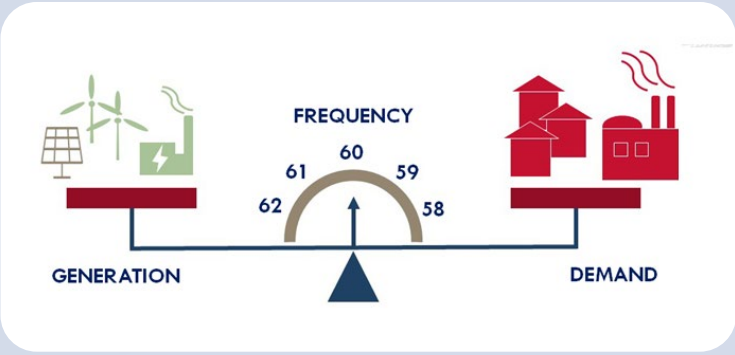
Pilot Project Applications







LSE

Direct matrix transform

Always solves

Serve its own downstream contingency analysis

Phase Angle Monitoring

System stress indicator

Prevent cascading events

Reclosing/Resynchronization

Frequency Monitoring

System power balance indicator

Major Generator Trip/Load Shedding

Oscillation Detection

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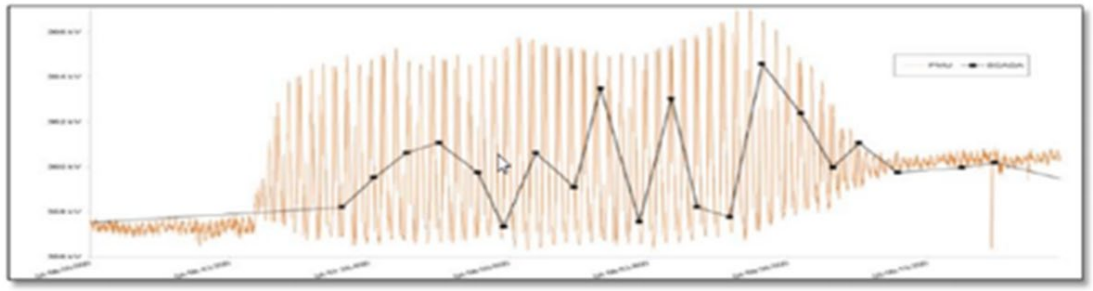
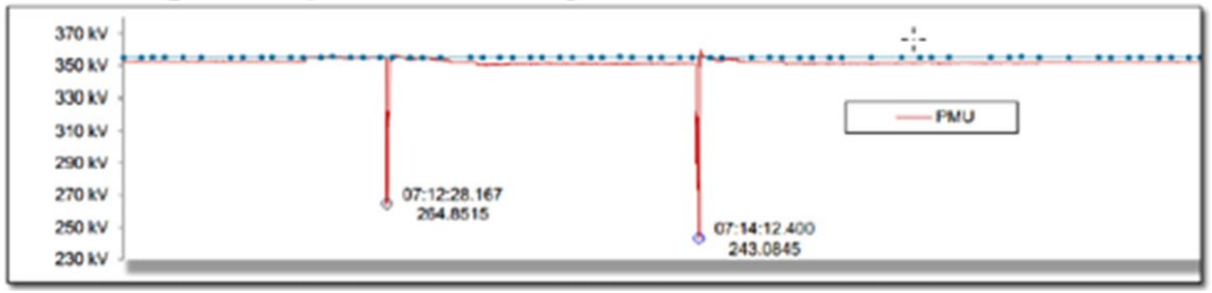
Operator Acceptance - Training

- Cycle Training: Three Cycle Trainings last year
- Connection Point
  - Show Case
  - Historic Event seen by SCADA vs. Synchrophasor Data
  - Operational Concerns vs. Synchrophasors Solution

- **Oscillations**



- **Voltage Drops Missed by SCADA**



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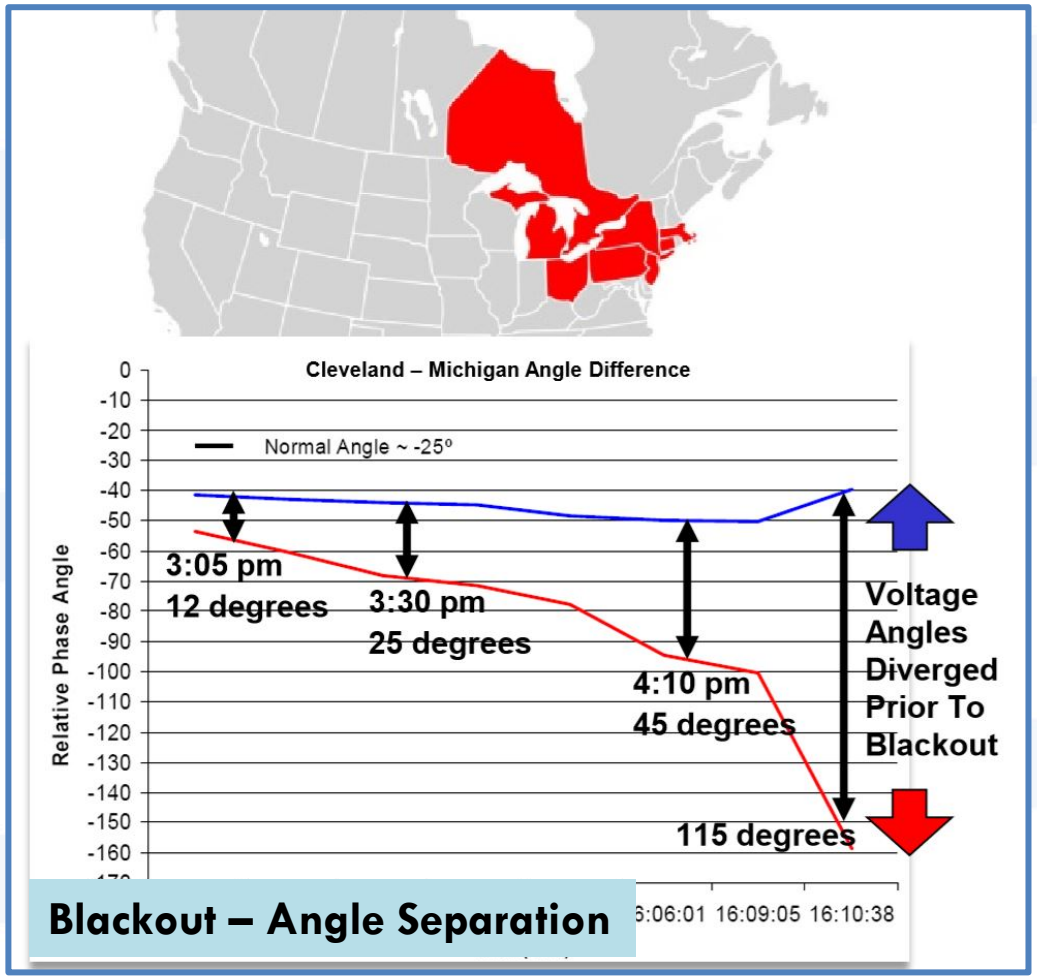
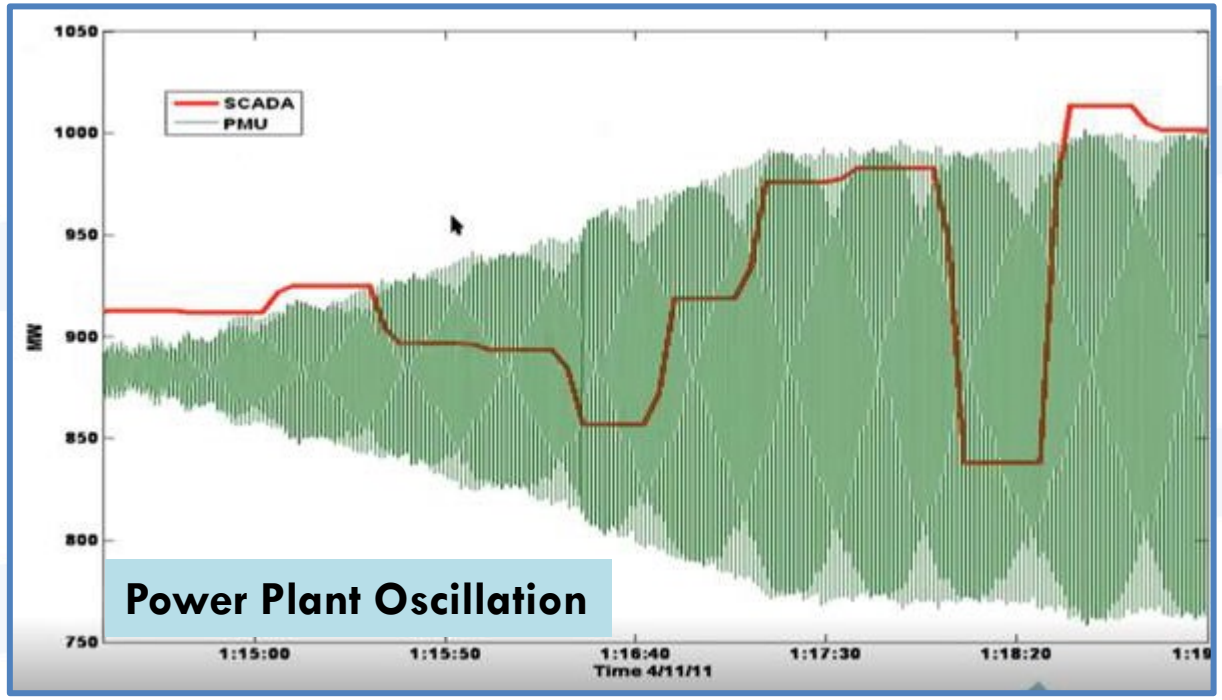
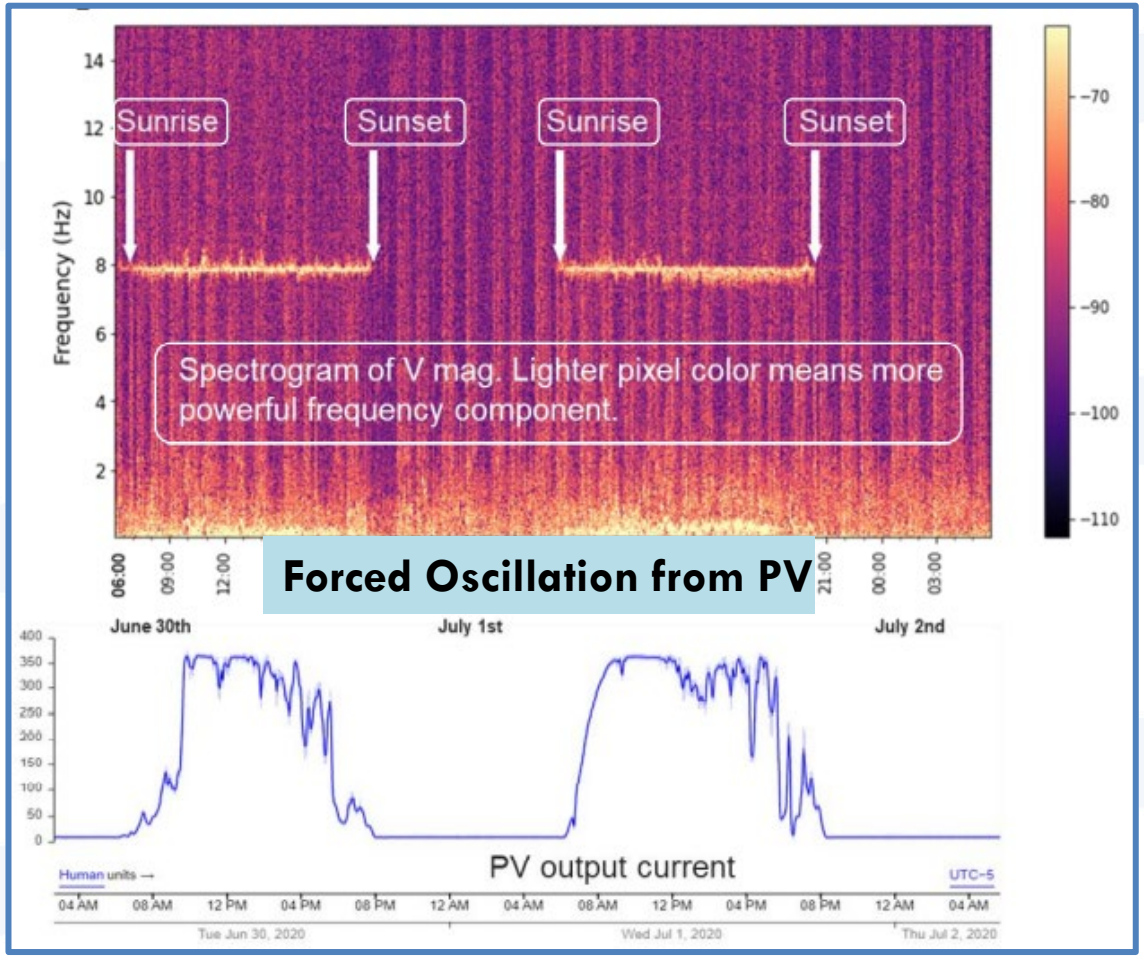
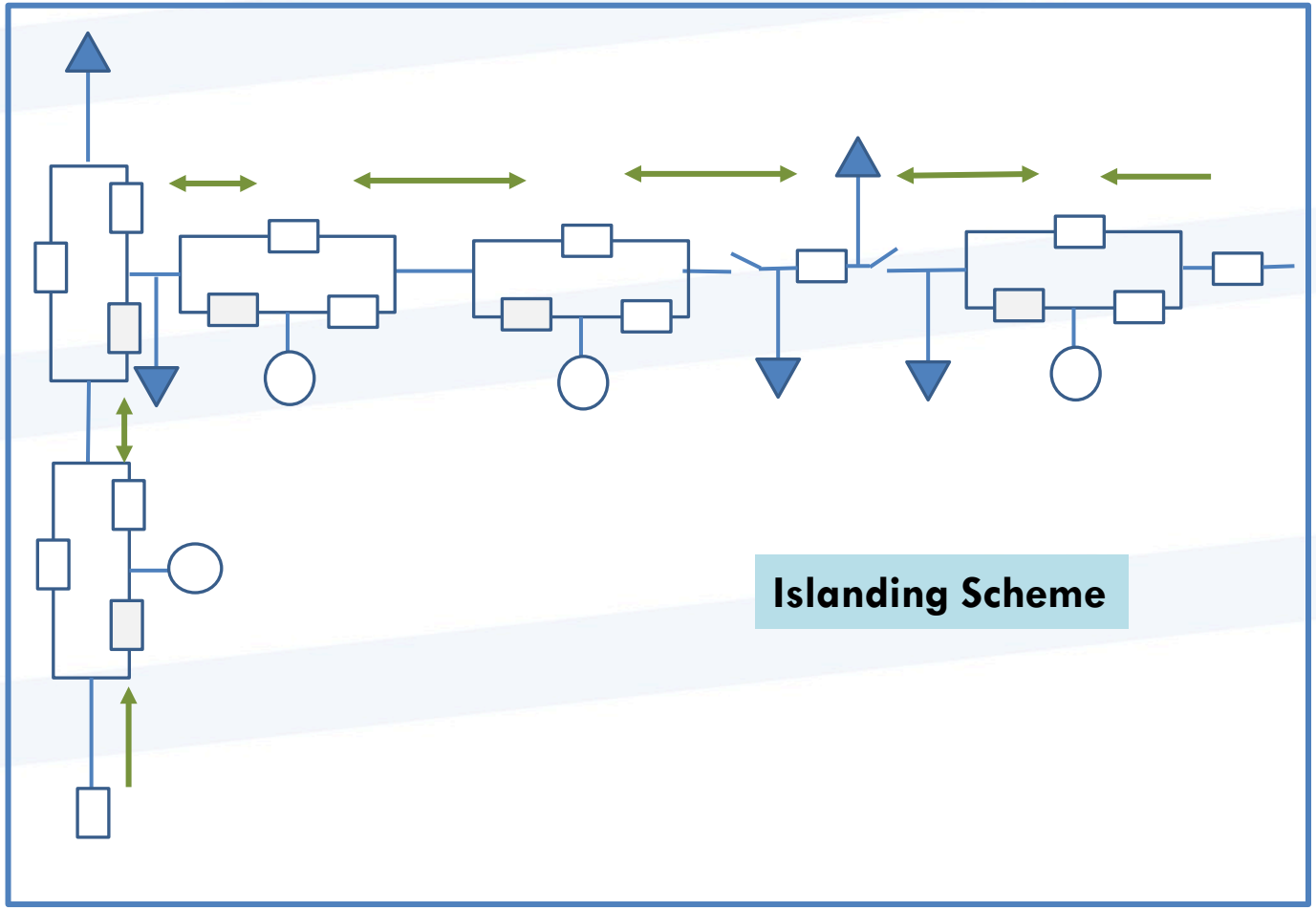
Operator Acceptance - Historic Event





Operator Acceptance - Operational Concerns





CIP Implementation

- Architecture and data flow to support real-time and non-operational use cases.
- Ensure data flow is secure and meets all the security requirements:
  - Comply with NERC requirements and guidelines for WAMS
  - Comply with all relevant NERC CIP Security Requirements as required to utilize LSE inside of a SOC environment
  - Other needs as surfaced from IT, security, networking, and compliance

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Recommendation

- Relay PMU Standard
  - Communication Protocol
  - Relay setting and substation control drawing
  - Substation PDC and OpenPDC Configuration
  - Data check out process
- Relay PMU Data Quality
  - Report and Maintenance
  - Substation Technician
- Increase Support Head Count
  - Compare to SCADA support for EMS system

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