Surry Oscillation Event:
As Seen by Synchrophasors

NASPI Work Group Meeting
Toronto, ON Canada
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Electric Transmission Planning
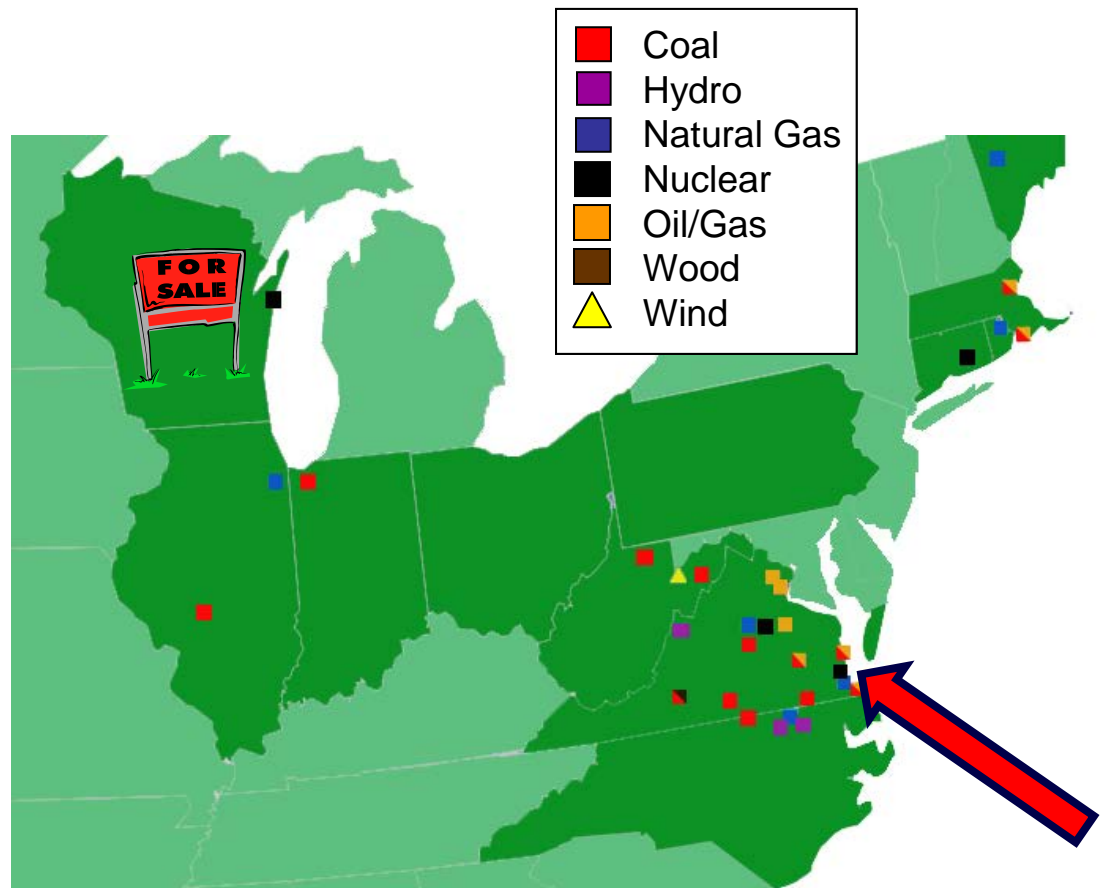*Dominion Virginia Power*
Richmond, Virginia USA

Dominion Generation

- 26,500 megawatts of capacity

- 6th largest producer in U.S.

- Largest generator in New England

Legend:
- Coal
- Hydro
- Natural Gas
- Nuclear
- Oil/Gas
- Wood
- Wind

FOR SALE

Dominion Virginia Power

- 6,000 miles of high-voltage transmission lines, up to 500kV

- 54,000 miles of distribution lines

- As many as 50,000 new customers annually

- 2.4 million franchise electric retail customer accounts in VA and NC

- 1.6 million unregulated retail customer accounts in 11 states

T&D Business

Electric Transmission

Legend	
🟢	500kV
🔵	230kV
🟠	138kV
🔴	115kV
🔵	69kV

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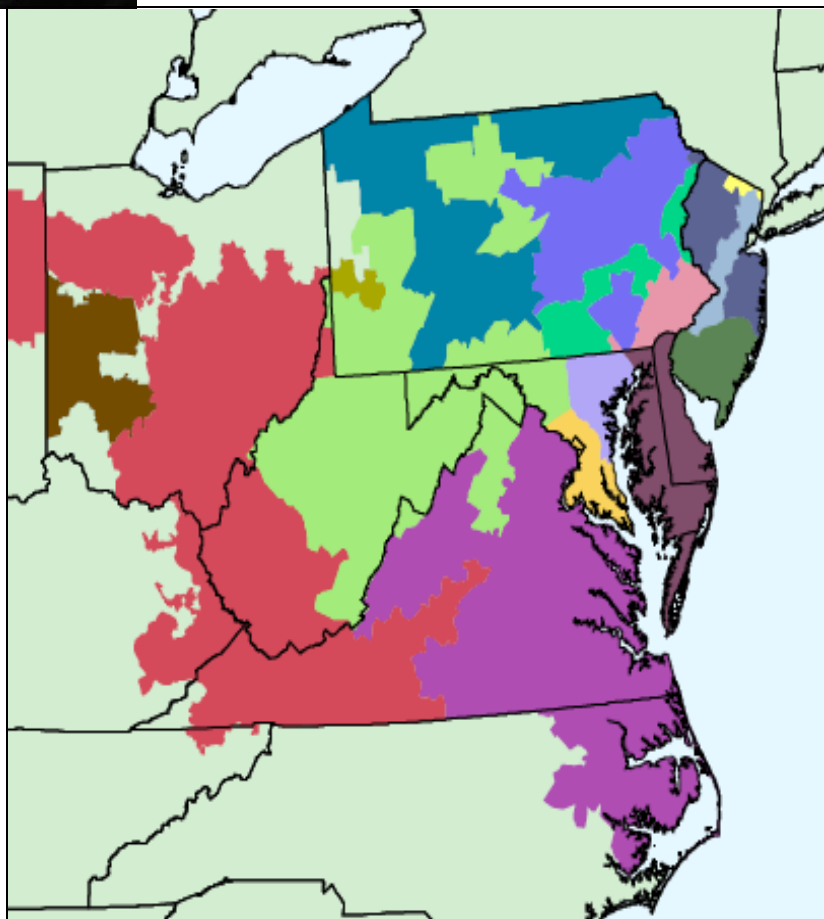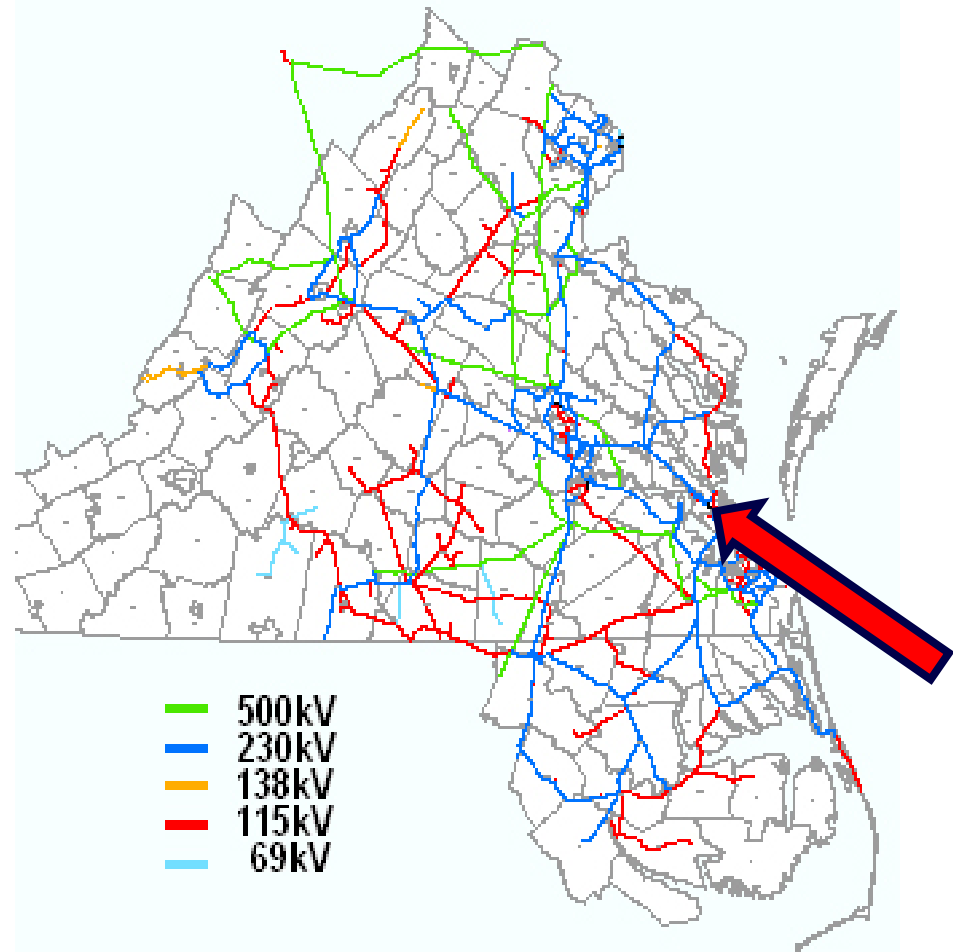
Background: Off-Peak Maintenance & Construction

Numerous 500kV & 230kV Line Outages Near Surry Power Station

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Weak Connection Between Plant and

Bulk Power System

- Six transmission lines, 230kV and above, in/around Surry Power Station
- Various 115 kV outages in South Hampton Roads Area

Small Signal Stability

Small signal stability events are those that are the result of small bumps to the system and grow in magnitude at a slower rate, with instability that can be of two forms:

1. Steady increase in generator rotor angle due to lack of synchronizing torque, or:

2. Rotor oscillations of increasing amplitude due to lack of sufficient damping torque.

Event Chronology

In the early morning of April 11, 2011 between approximately 01:15hr and 01:30hr (EDT) Surry experienced significant MW swings:
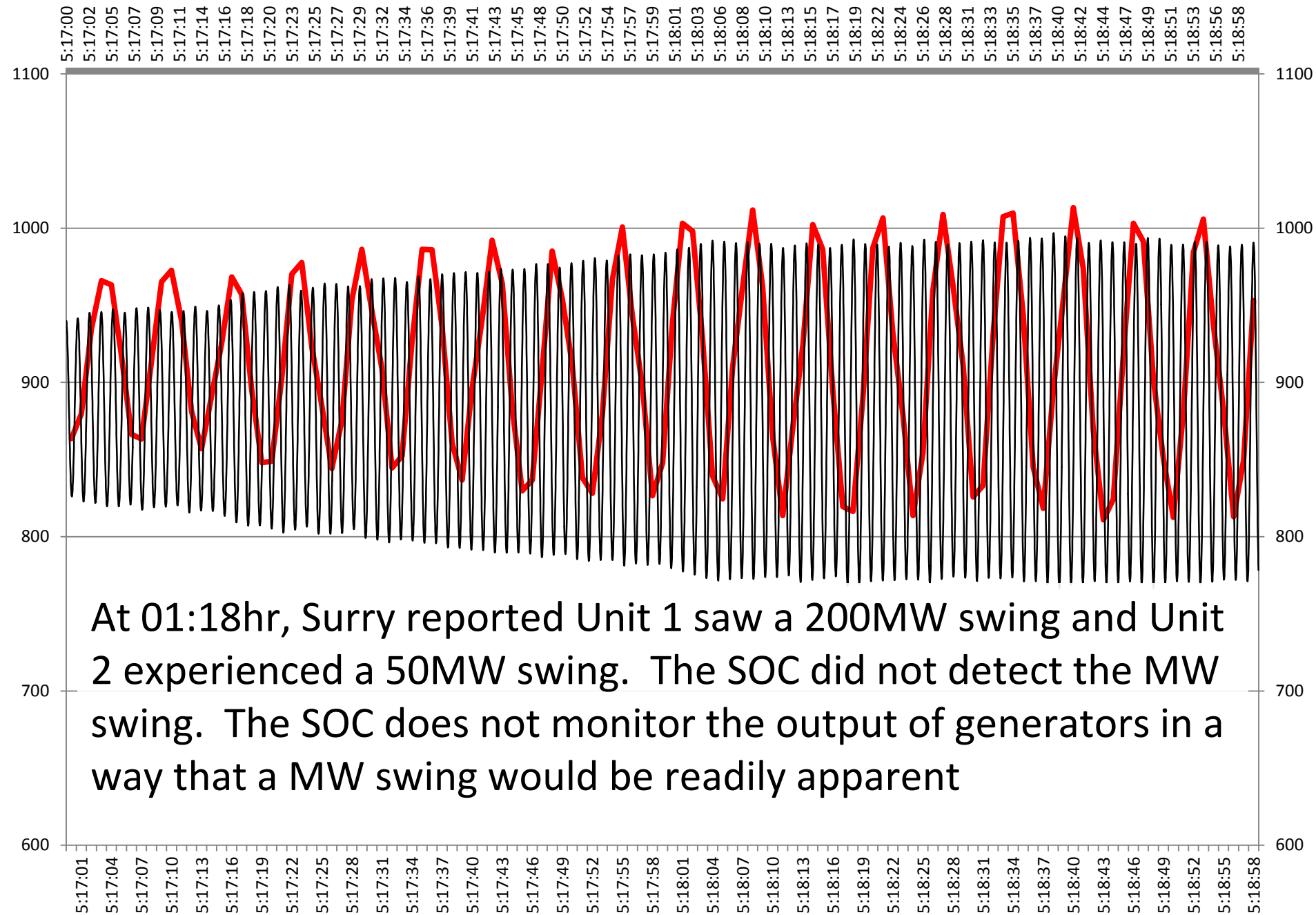

FM Data Plot for 04/10/2011 to 04/11/2011
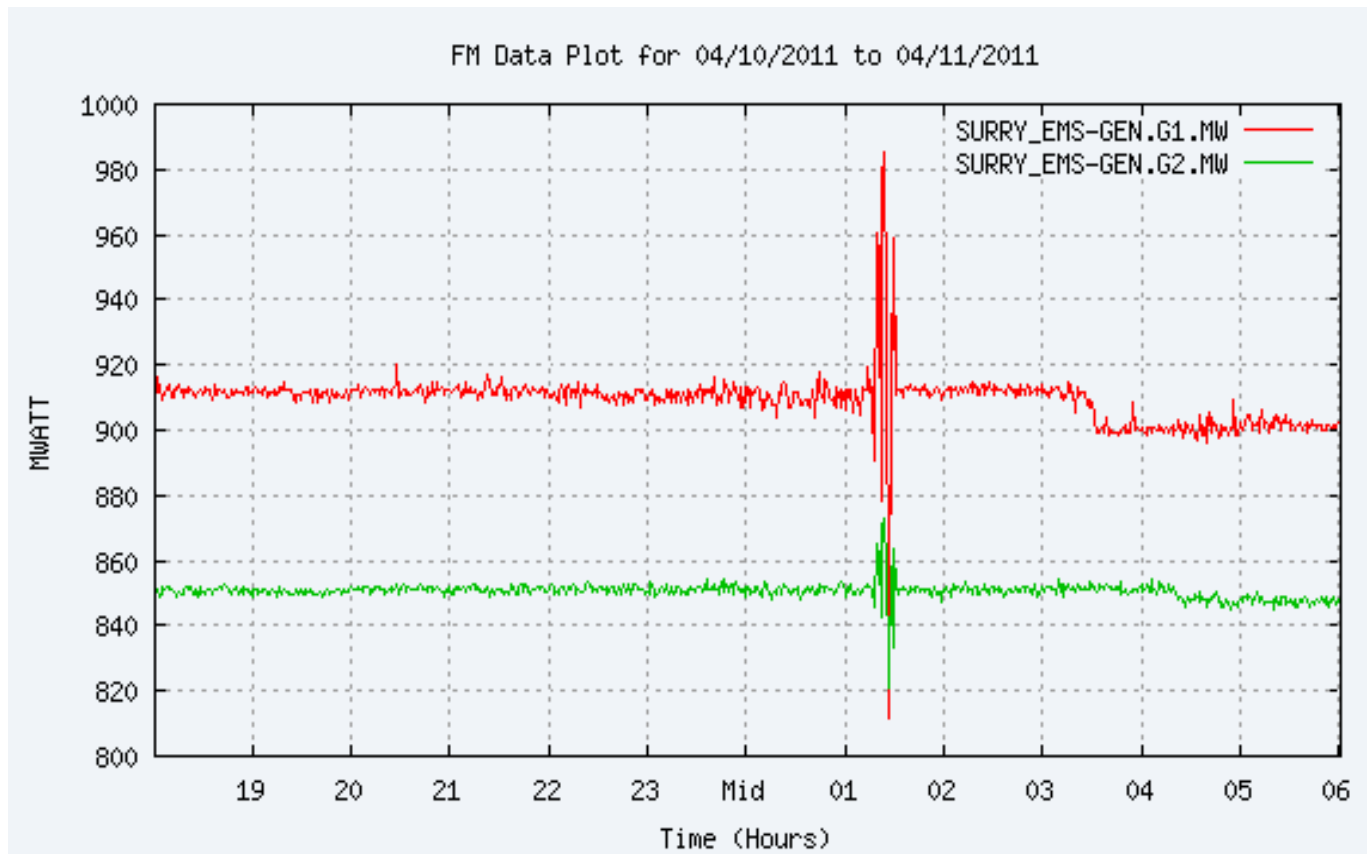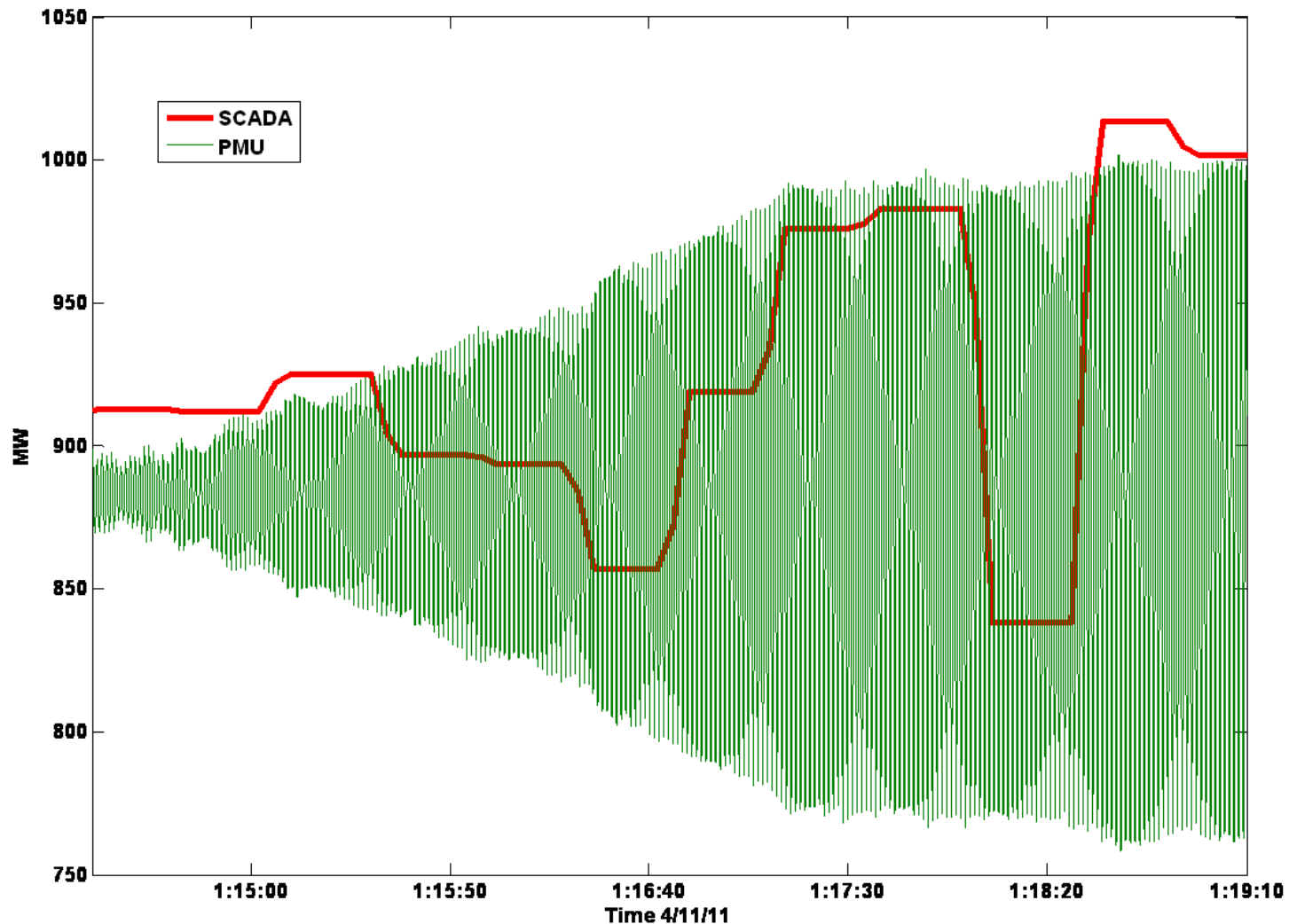
Leading up to the event…

- System lightly loaded
  - Bath county pumping (two of six units)
  - Dominion importing 1 900MW (6 900MW system load)
  - High voltages seen across network
- At 23:30hr, Dominion SOC request both Surry and North Anna to reduce voltage schedule
- At 00:30hr, Surry 1 experienced a 20MW swing. Surry 2 had no unusual output variations.

Surry Unit 1 MW — PCS — PMU

At 01:18hr, Surry reported Unit 1 saw a 200MW swing and Unit 2 experienced a 50MW swing. The SOC did not detect the MW swing. The SOC does not monitor the output of generators in a way that a MW swing would be readily apparent
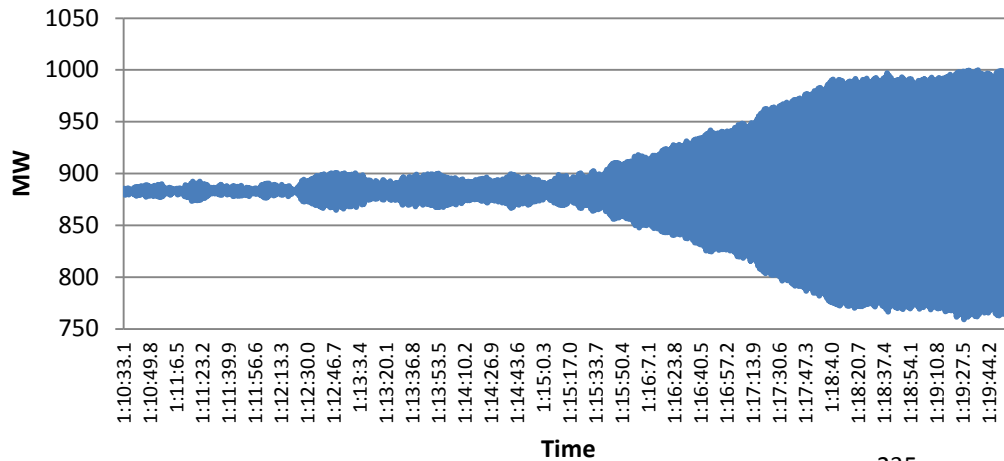
A different perspective:
SCADA vs. Synchrophasor

System Normal>>_

Other Generators Affected:

- Limerick unit 1 ±30 MW
- North Anna unit 2 ±17 MW
- Susquehanna unit 1 ±10 MW
- North Anna unit 1 ±8 MW
- Hope Creek ±7 MW
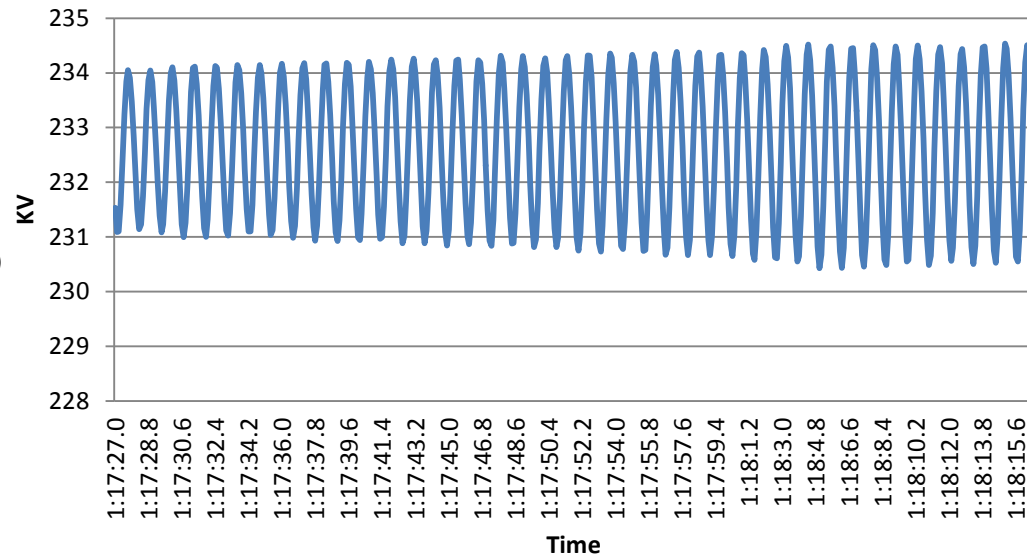- Salem unit 1 dipped 6 MW but reported no oscillations.

In-Depth Analysis of this Event Impossible without Synchrophasors

Real Power

Damping: 0%
Frequency: 0.845 Hz

Voltage

Based on the analysis of data retrieved from the event, the oscillations appear to be classified as a small signal stability event

Stability Studies

- Electric Transmission Stability Studies were performed in an attempt to replicate event.
- Planning's simulations closely match observed oscillation frequency (0.845 Hz)
- However, the simulated damping was initially found to be at 3.48%; under the preferred 4%.
- Actual damping factor was 0%
- This type of event can be difficult to model; but PJM's simulation based upon a saved power flow case from the PJM State Estimator did satisfactorily replicate the actual event.

PJM Study Results Based on Real Time Power Flow

Units	At 1:09		At 1:19		At 1:25	
	Freq (Hz)	Damp Ratio (%)	Freq (Hz)	Damp Ratio (%)	Freq (Hz)	Damp Ratio (%)
Surry 1&2, Limerick 1, Susquehanna 1	0.850	1.22	0.821	-0.182	0.858	3.250

# Synchrophasor Data Drives Model Improvements
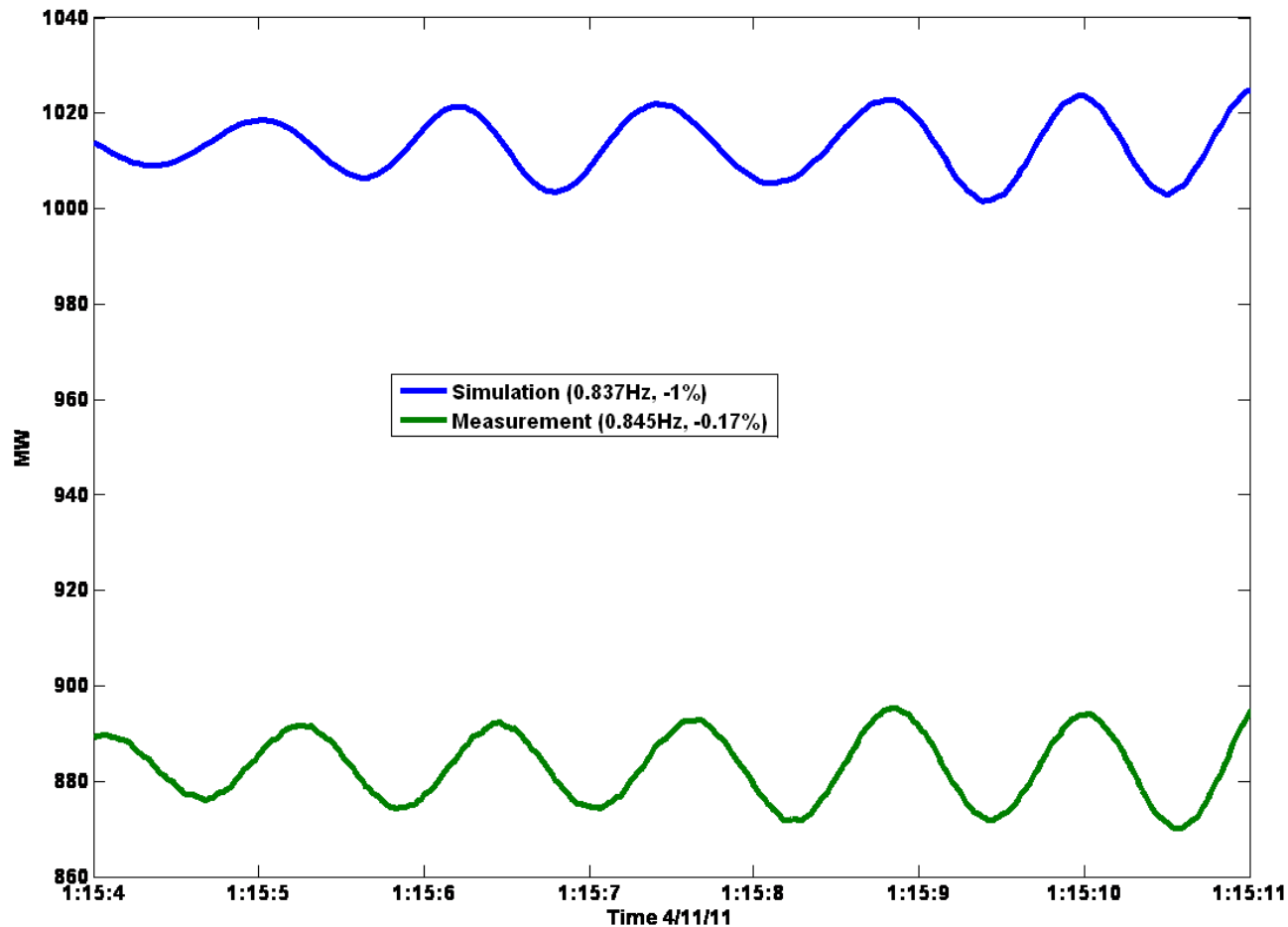
The end of the story (almost)

- At 01:29hr, another unit at Bath County run in pump mode
- Cloverdale reactors switched online
- Voltages schedules raised at Surry
- All switching activity paused
- At this point both units became stable

As a result of the event analysis, short and long term recommendations were developed to avoid a future recurrence of this event.
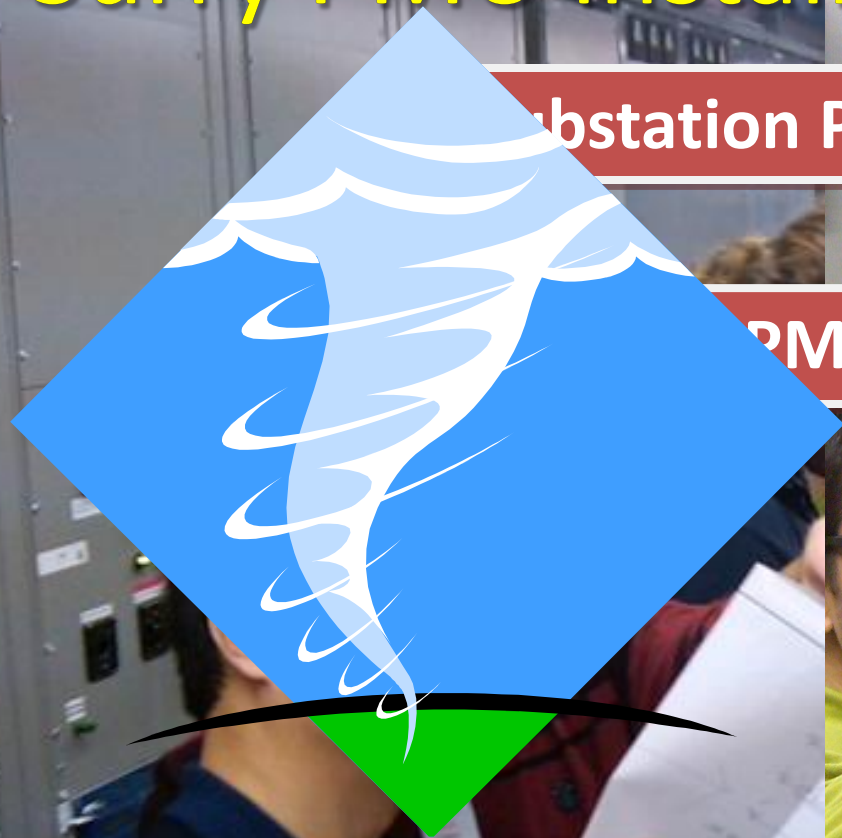
Eastern Interconnection: FNET Perspective
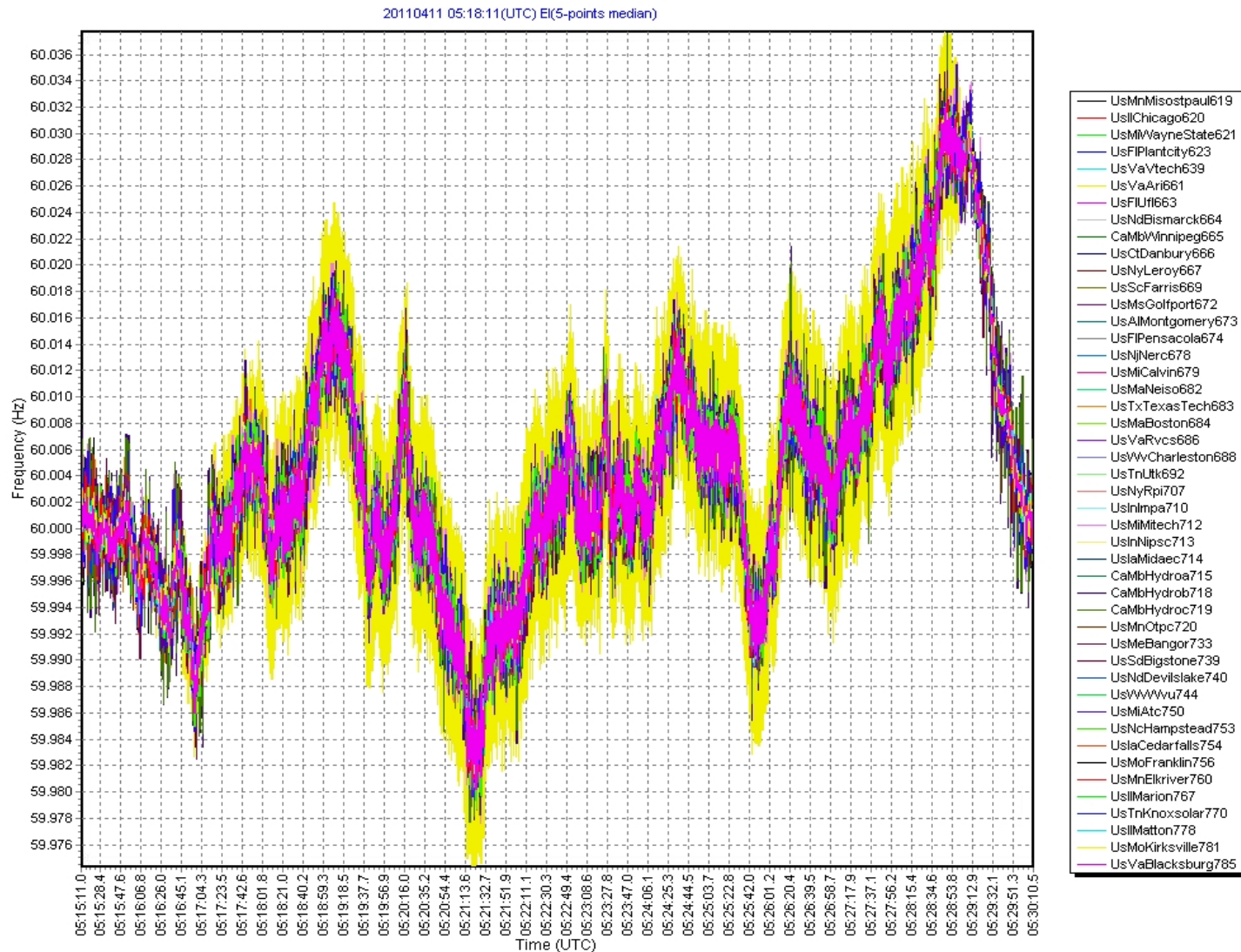
Surry PMU Install

Substation PDC

PMUs

EN NO. 1 Zone

Questions?

Dominion®