Managing the California Grid with Renewables

An Introduction to Synchrophasors

California Energy Commission

Transmission Research

Paving the Way for Renewables

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Sacramento Public Tsakopoulos Library Galleria

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Overview of Today's Presentation

- **CERTS, supported by CEC PIER and US DOE has worked closely with CAISO on phasor technology research in support of real-time system operations since 2001**
- **Today's presentation covers:**
  - **How phasor technology can be used to improve electric power system reliability**
  - **Current phasor research accomplishments working with CAISO**
  - **The outlook for future acceleration of deployment of phasor technologies and applications at CAISO and WECC, including renewables integration**

Phasor Technologies Give Operators *MRI-like* Visibility of Power Systems

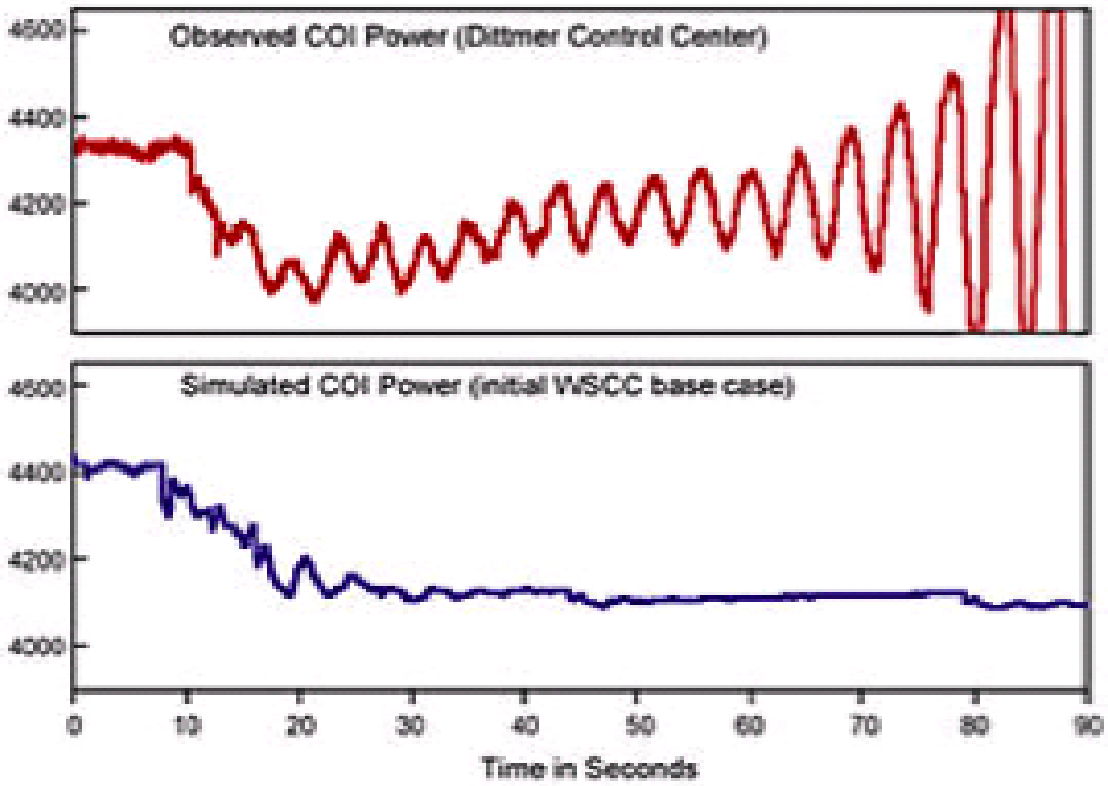
ATTRIBUTE	Traditional Grid Monitoring (SCADA)	PHASOR Technologies
Resolution	1 sample every 2-4 seconds	10-60 samples per second
Measured Quantities	Magnitude Only	Magnitude & Phase Angle
Time Synchronization	No	Yes
Focus	Control Area (Local) monitoring & control	Wide area (interconnection) monitoring & control
Observability	Steady state only	Steady state, dynamic and transients
Monitoring Angles, Damping, Frequency Response, & Other Metrics	No	Yes
Oscillation Detection	No	Yes

Phasor technology is *NOT* a replacement for SCADA, rather it *complements* existing SCADA systems

Inaccurate Dynamic Models were a Cause of the WECC 1996 Breakup

Actual System Performance

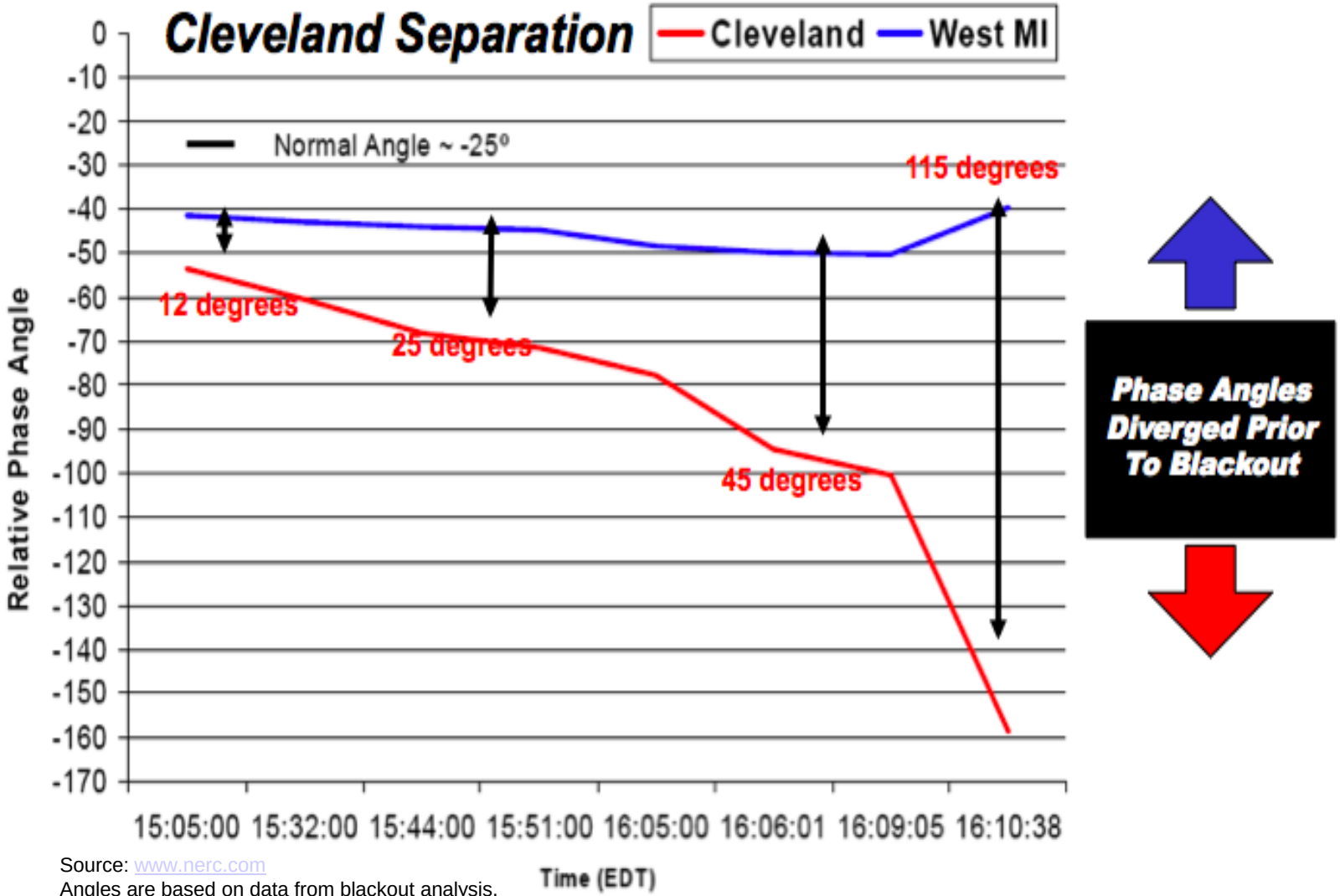
- unstable system behavior observed.



Model Simulation

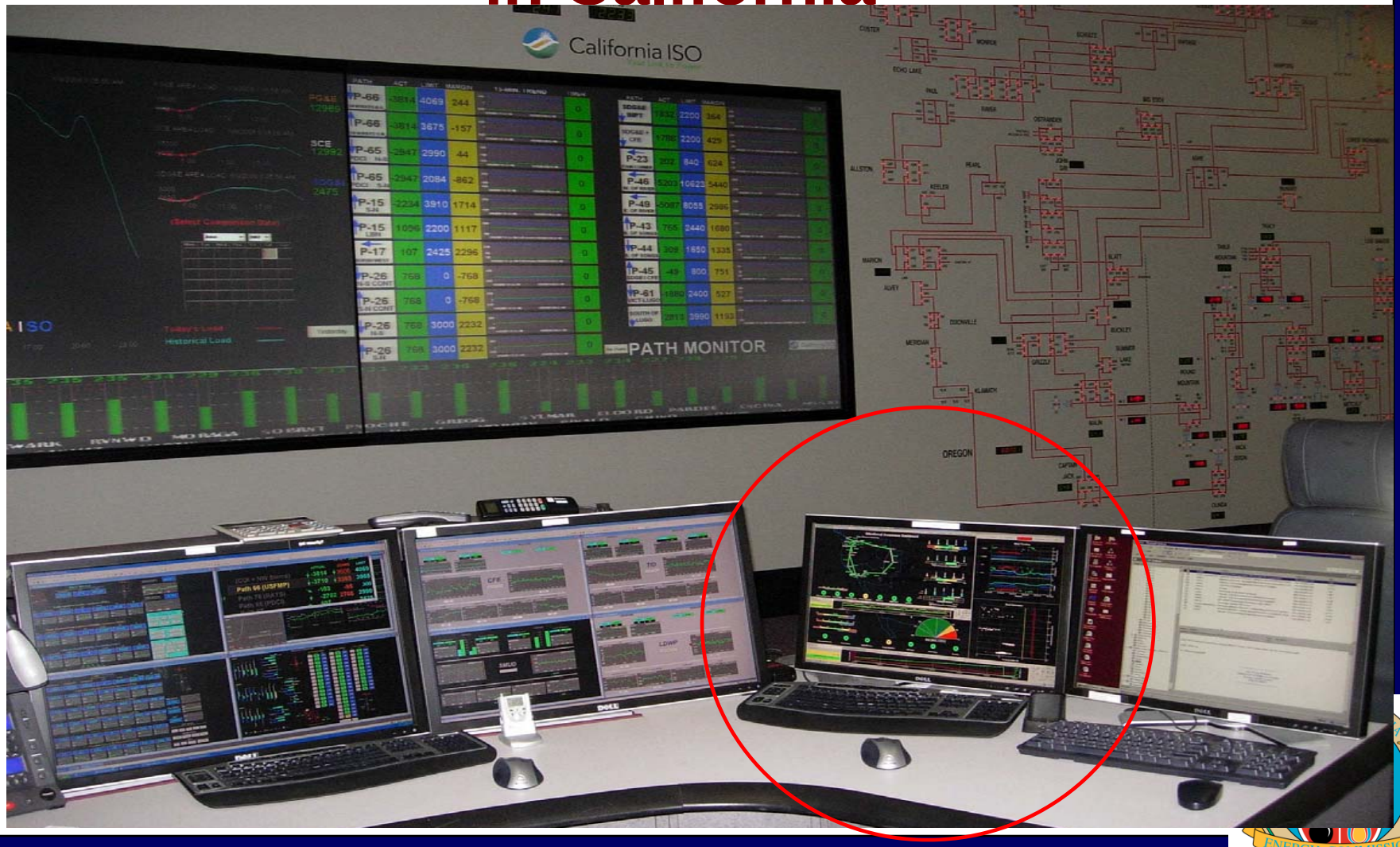
- predicted stable system performance.

Lack of Wide-Area Visibility Was a Cause of the EI Aug 14th, 2003 Blackout



Source: www.nerc.com
Angles are based on data from blackout analysis.
Angle reference is Browns Ferry.

CAISO, SCE, PG&E, and SDG&E Are Pioneering The Use of Phasor Technologies in California



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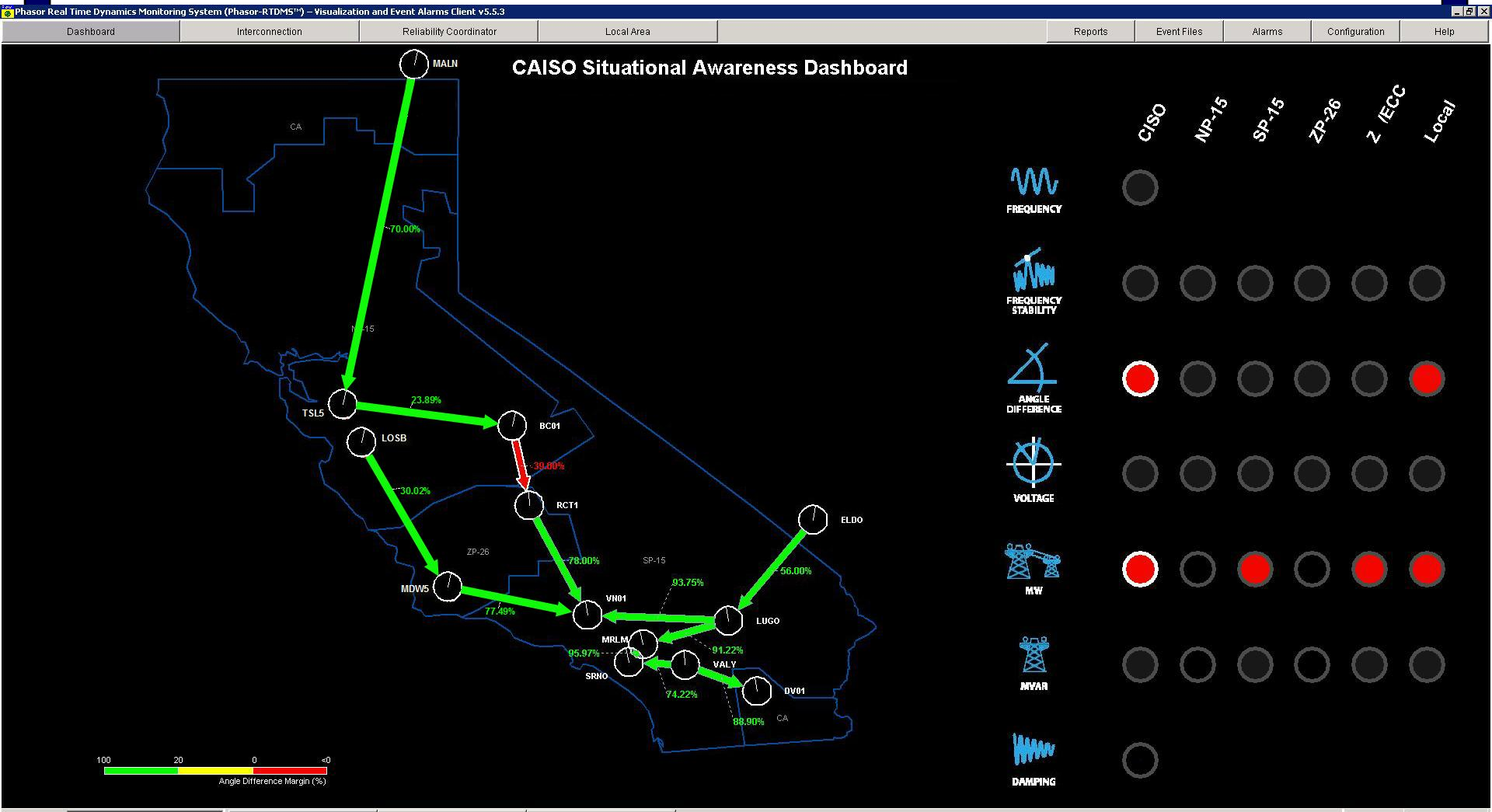
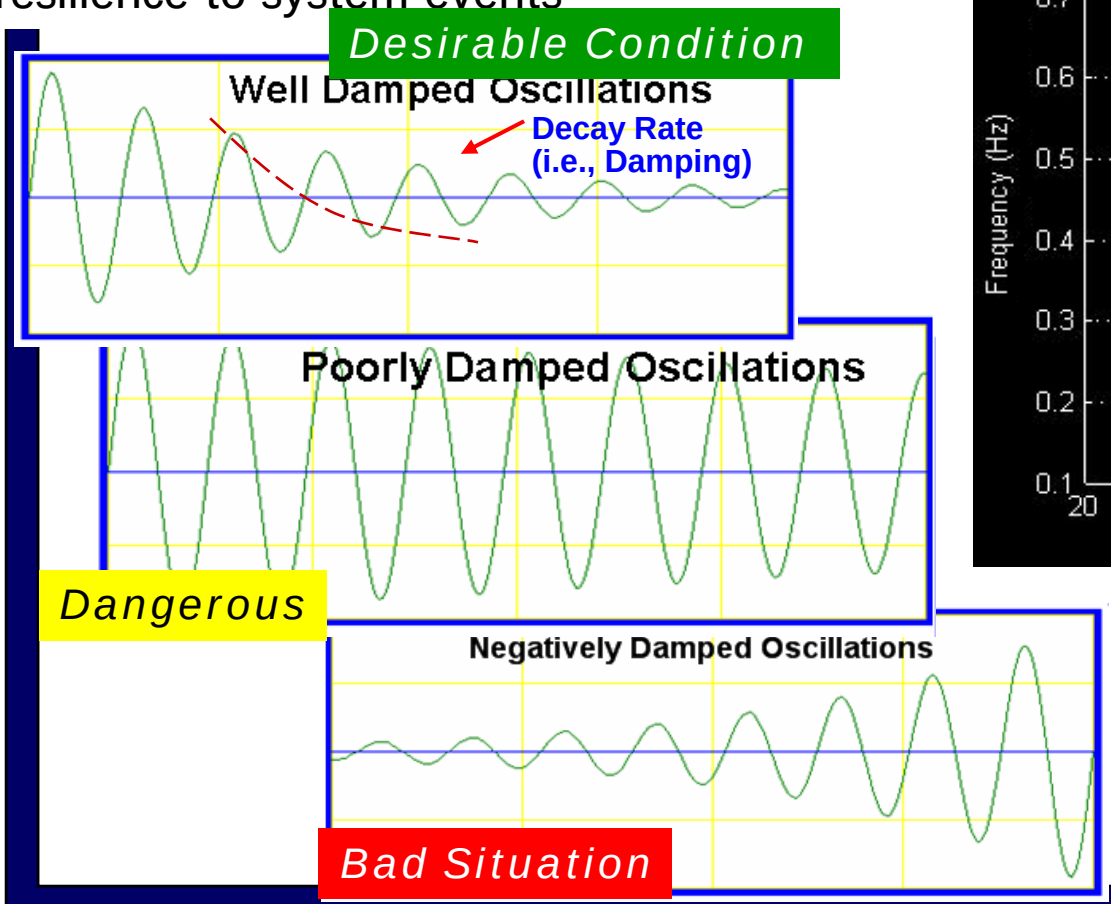
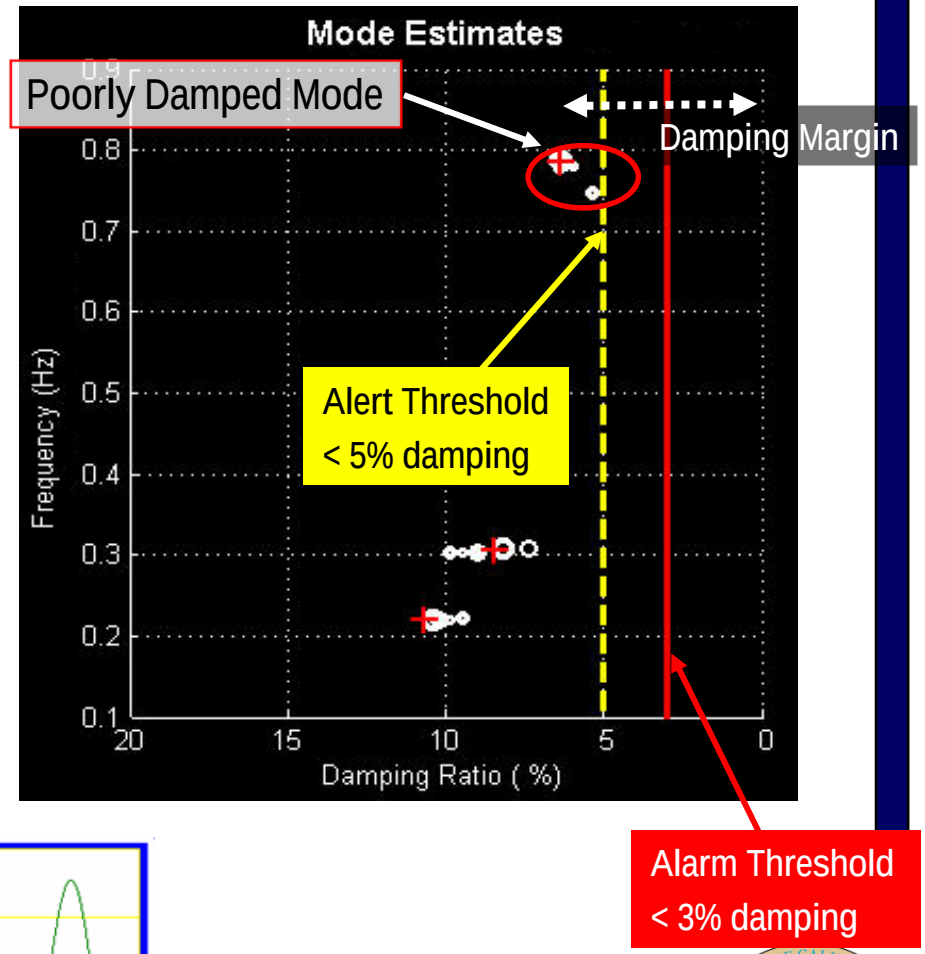


Expected Research Results – Translate Concept to Prototype –Grid Robustness

Question: How well can the system withstand disturbances?

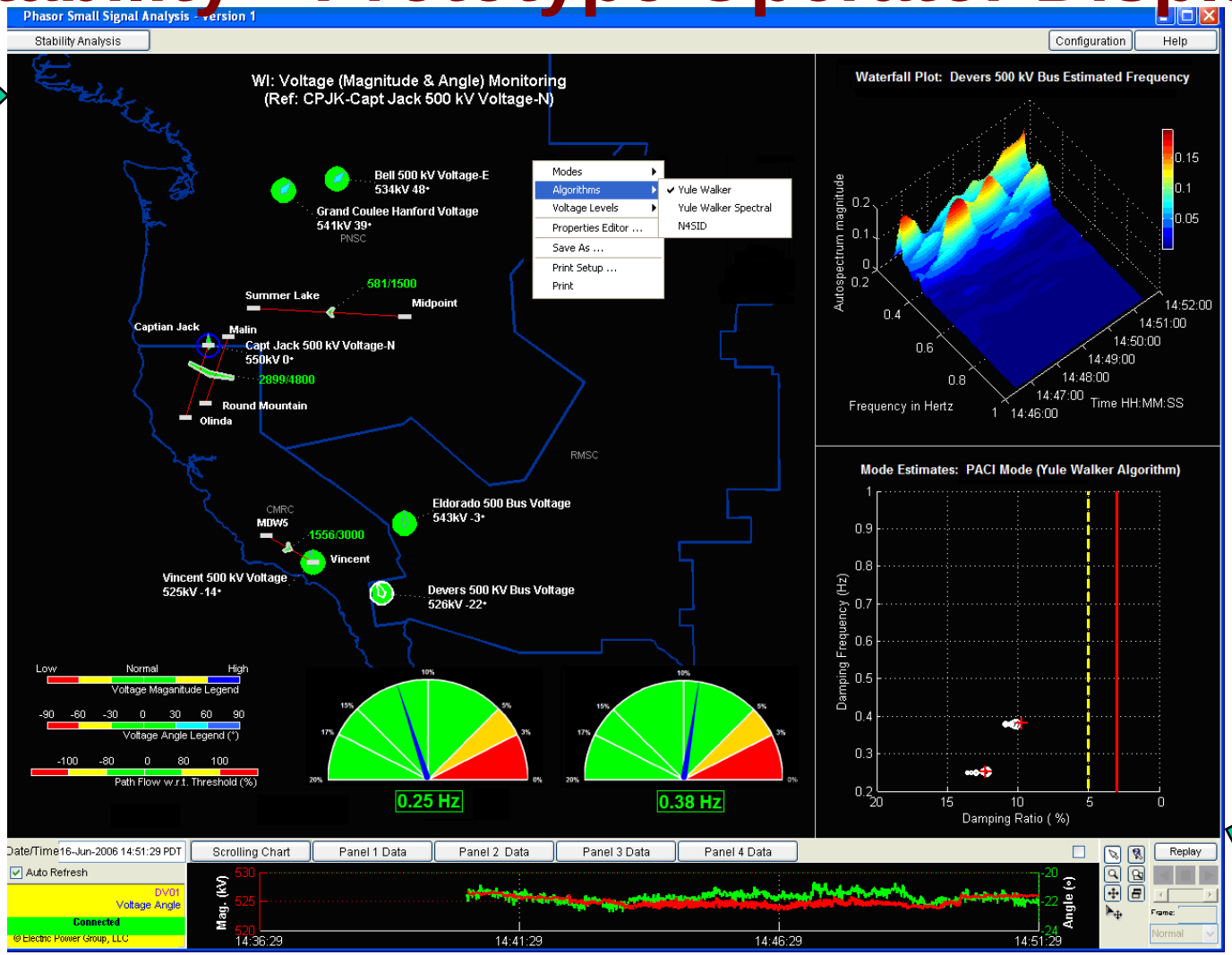
Damping (in %) is a measure of the grid's resilience to system events





Stability Monitoring – Small Signal Stability – Prototype Operator Display

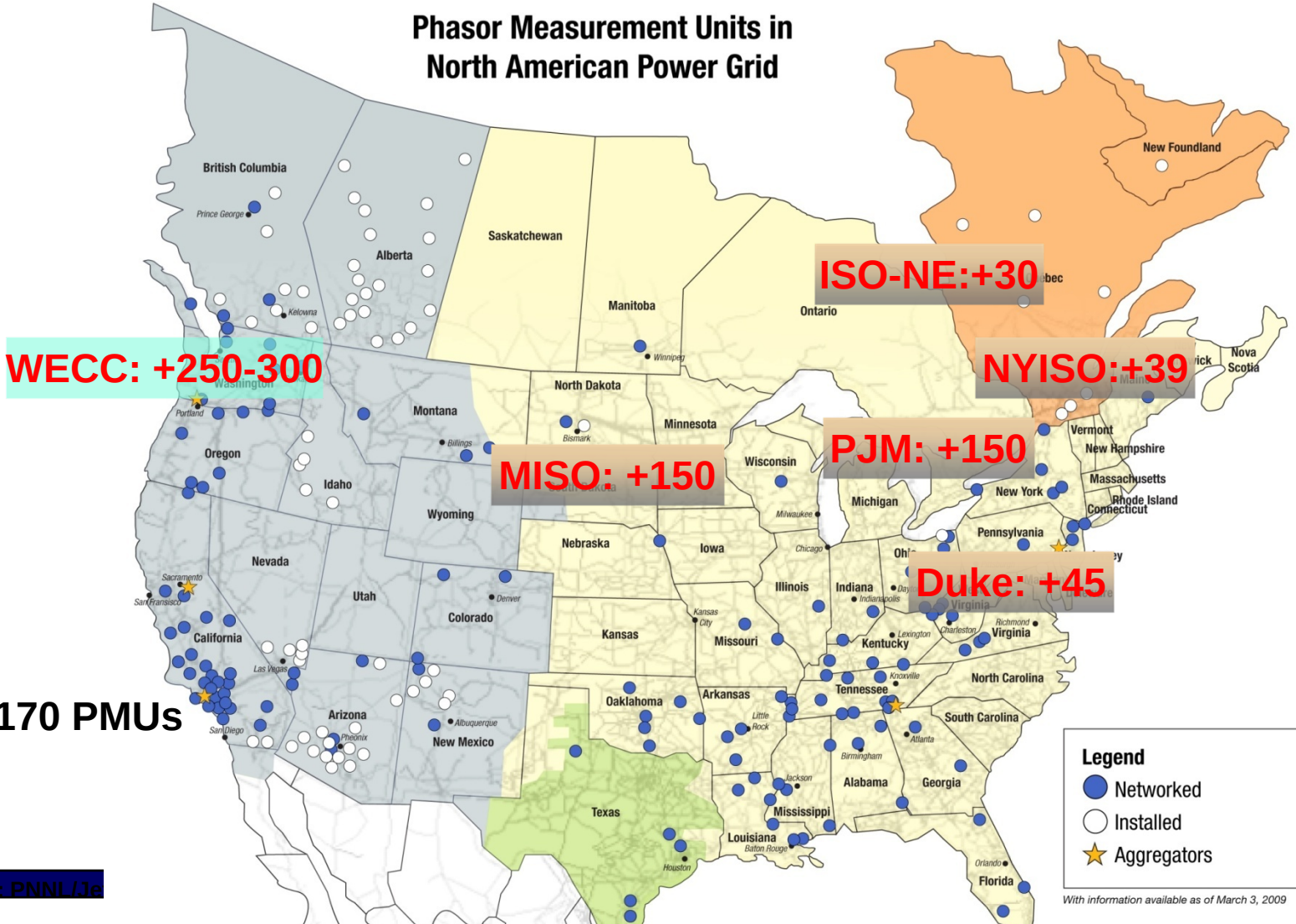
Monitor :
Low Frequency oscillatory modes across the interconnection



Waterfall to identify oscillation freq. and it's trend over time

Frequency-damping plots to track % damping of different oscillatory modes in real time (3% and 5% alerting and alarming thresholds shown)

ARRA Smart Grid Investment Grants are providing $~150+M for phasor technologies

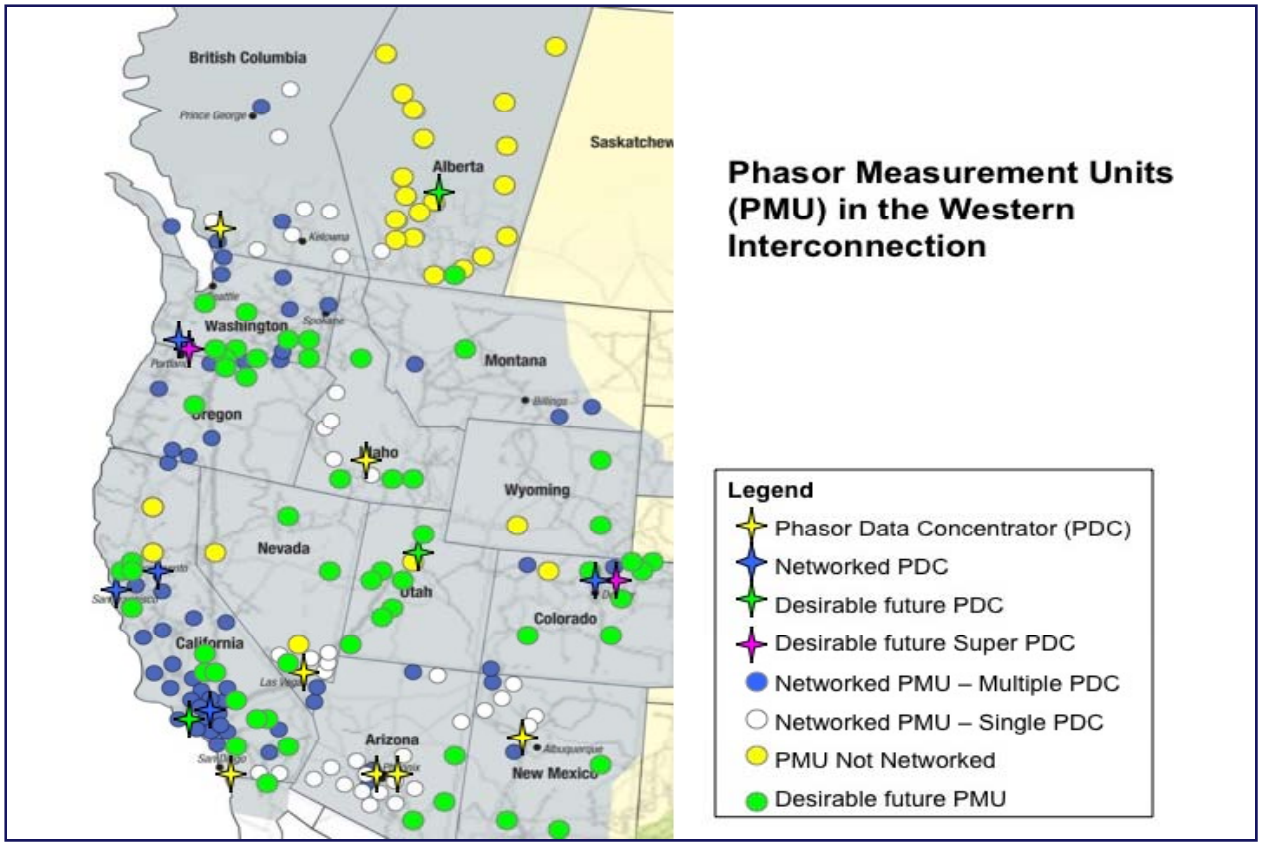


~ 170 PMUs

Credit: PNNL/Je

Western Interconnection Synchrophasor Project

GOAL – ALL 500 KV SUBSTATIONS, RENEWABLES AND KNOWN CONGESTION POINTS



CAISO Timelines – Synchrophasor Projects

2010 to 2013

1. PRODUCTION QUALITY ARCHITECTURE (2010)
2. INTEGRATION WITH PI DATA HISTORIAN (2010)
3. VISUALIZATION IN THE CONTROL ROOM WITH RTDMS & GOOGLE EARTH APPS (2010)
4. SMALL SIGNAL STABILITY WITH ALARMING
5. STATIC MODEL BASELINING/BENCHMARKING

2010 to 2015 and Beyond

6. VOLTAGE STABILITY MONITORING
7. REAL TIME OSCILLATION CONTROL
8. STATE ESTIMATION & SYNCHROPHASORS
9. DYNAMIC MODEL BENCHMARKING
10. PSS VALIDATION & VERIFICATION

Red	**Necessary and Critical**
Blue	**Critical with Added Benefits**
Green	**Moderate Needs & Requires more Investigation**

Source: Jim McIntosh, NASPI Meeting, Feb. 2010

Renewables Integeration

- **Utilization of Smart Grid and Phasor technologies to boost utilization of existing transmission to facilitate renewables integration**
- **Proposed Areas for Research**
  - Current constraints, limiting factors, technology solutions
  - Smart Grid Phasor Applications Feasibility Assessment – dynamic ratings, RAS, SVC Dispatch, Global Voltage monitoring and local control, equipment monitoring
  - Research prototypes, testing, demonstration, field trials, implementation
- **Context:**
  - California needs to integrate 30,000 MW of renewables in next 20-years (CERTS/EPG Study)
  - Transmission is a key enabler for integration
  - Current transmission use is limited by stability constraints – e.g., 20,000 MW transmission gateway capacity in Southern California vs. 10,000 MW ratings; COI thermal capacity of 7,000 MW vs. rating of 4,800 MW
  - New transmission – long lead time, siting issues, expensive