WISP

Western Interconnection Synchrophasor Program

Vickie VanZandt & Dan Brancaccio

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NASPI North American SynchroPhasor Initiative

Acknowledgement and Disclaimer

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WECC

Western Electricity Coordinating Council

Assuring reliability in the Western Interconnection

Key Activities

- WECC's "Western Interconnection Synchrophasor Program" is installing more than 600 phasor measurement units (PMUs) and 69 phasor data concentrators (PDCs) across the Western Interconnection.

Aims and Strategies

- Provide grid operators and reliability coordinators with more frequent and time-synchronized system information.
- Better system visibility will help system operators avoid large-scale regional outages, better utilize existing system capacity, and enable greater utilization of intermittent renewable generation resources.

Results and Benefits

- 19 organizations are participating in the project, providing 100% coverage for the Western Interconnection.
- Real-time information and automated controls being deployed will enable grid operators to allow an additional 100 MW of operational capacity on the California-Oregon Intertie (COI). Similar system benefits are possible in other parts of the system.

Transmission System Modernization

Phasor Measurement Unit

Facts & Figures

Total Project Budget:
$107,780,000

Federal Share:
$53,890,000

Project Area:
Western Interconnection, 1.8 million square miles

Project Team:
19 utility organizations

Program Participants

- WECC – Program Awardee
  - **Program Director:**
    - Jeanne Bullion — jbullion@wecc.biz
  - **Program Manager:**
    - Vickie VanZandt — vrvanzandt@gmail.com
  - **Technical Delivery Manager & Technical Architect:**
    - Dan Brancaccio — dbrancaccio@wecc.biz
  - **Program Controller:**
    - Scott Woodbury— swoodbury@wecc.biz

Program Participants (cont.)

Cost Share Participants	Total PMUs	WISP PMUs	PDCs
Bonneville Power Administration	134	(126)	5
California ISO / CEC	0		2
Idaho Power Corporation	17	(5)	1
NV Energy	18	(18)	6
Pacific Gas & Electric (sub-recipient)	202	(202)	26
PacifiCorp	8	(8)	2
Salt River Project	42	(18)	2
Southern California Edison	90	(15)	4 Gateways
WECC			6
TOTAL	511	(392)	54

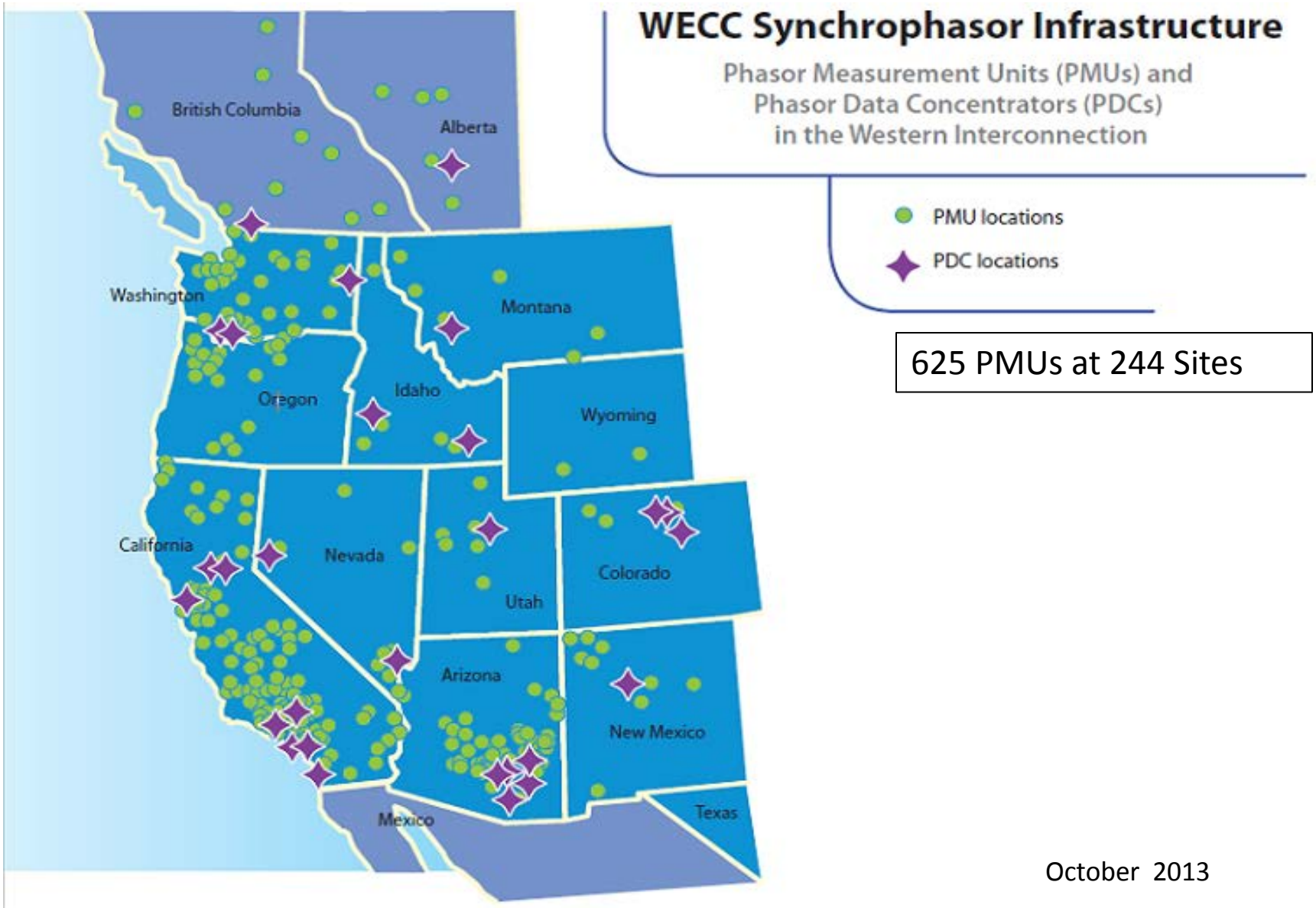
Program Participants (cont.)

10 Additional Participants in WISP	PMUs	PDCs
Alberta Electric System Operator	16	1
Arizona Public Service	15	2
British Columbia Hydro	12	3
Los Angeles Dept. of Water & Power	15	1
Northwestern Energy	2	2
Public Service of New Mexico	5	1
San Diego Gas and Electric	41	2
Tri-State G&T	1	1
Tucson Electric	2	1
Western Area Power Administration	5	1
TOTAL	114	15

PMUs and PDCs

Total existing or planned PMUs	625
Total existing or planned PDCs:	69
PMUs currently deployed:	522
PMUs currently streaming data:	218

Class A data mix sample rate 30Hz and 60Hz


WECC Synchrophasor Infrastructure
Phasor Measurement Units (PMUs) and
Phasor Data Concentrators (PDCs)
in the Western Interconnection
PMU locations
PDC locations
625 PMUs at 244 Sites
British Columbia
Alberta
Washington
Montana
Oregon
Idaho
Wyoming
California
Nevada
Utah
Colorado
Arizona
New Mexico
Mexico
Texas
October 2013
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Communications

- Dedicated, private Wide Area Network (WAN)
- Provided by Harris Corporation
  - WAN from RCs to TOs/ISOs edge routers under contract
  - Centralized management
  - All 19 Participants connected to the WAN today
- Peer-to-peer communication occurring among Participants

Archives

- Storage duration and capacity:
  - o All Data On-Line – 15 months
  - o Disturbances – 7 years
  - o 100+ TB

Applications

- Data flows for applications
  - o WECC RCs host a full suite of applications:
    - Modal Analysis
    - Voltage Stability
    - Angle Monitoring
    - Registry
    - Wide Area View
    - Historical Archives and Data Mining
  - o Some Participants hosting their own applications.

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Possible Next Steps

Phase 1: Qualifying the Data

- PMU/PDC Data Quality
  - Bad Data Detection and Management
- Interconnection Baseline Correlation (Angle, Modal Damping, Oscillation Energy, etc)
- Requirements Use Cases for Western Participants for Wide Area View
- Common Application Data Format Agreement
- Improve and evolve Registry into a National Prototype

Phase 2: Decision Criteria

- Dynamic Nomograms for Major Western Transfer Paths
- Determine Potential Corrective Actions for Stressed Power System States (Operating Procedures)
  - Coping with Loss of Inertia, Low Damping Conditions, High Angle Separation
- Deploy next phase of Wide Area View
- Mature Applications – integrate into Operations staff

Phase 3: Deploying Advanced Applications

- Prototype Dynamic Nomograms for Optimum Transmission Capacity
- Evolve use of WAN with Gateways for publish and subscribe format for bandwidth efficiency
- Voltage Prediction for Reactive Switching
- Renewable Resource Integration
- Prototype Dispatcher Training Simulator with EMS and Synchrophasor Data simultaneously - to include modeling of:
  - Relay Action, RAS Action, Missing Generator Controls Actions (turbine)

Possible Next Steps

- Applications to be used by:
  - Planners (model validation, event analysis)
  - Operators (oscillation, voltage stability, state estimation, contingency analysis, angle separation, restoration assessment and mitigation)
  - Operating Engineers (limit setting, event analysis, development of operating procedures)
- Obstacles:
  - Lots of hard (grueling) work to validate data
  - Need availability to be close to 100% (more redundancy)
  - $ and dedicated time from SME's

Success Stories So Far

1. Unprecedented Sharing of Data
   - Comprehensive Data Sharing Agreement
   - Data shared through dedicated, secure website
2. Improved Generator Models
   - Calibration and Validation process tested
   - Applied to many generating units in the West
3. Killer WAN moving data to RCs and among Participants
   - Managed, secure network
4. Forced oscillations found

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Success Stories So Far

5. PMU values incorporated on SCADA one-lines
   - Display measurements side by side
6. RC Operator and Engineer Training
   - Concepts completed
   - Application training ongoing
   - Training material shared
7. Phasor Displays available to operating staff
   - OSIsoft, eTV, PP, WAV, etc

Success Stories So Far

8. Oscillation Detection (available)
   - o scans power plants and interties for sustained oscillations
9. Mode Meter (available)
   - o estimate damping of inter-area power oscillations
   - o operating procedures and decision support tools are being developed
10. Phase Angle Differences (available)
11. Island Detection (deployed)

Challenges and lessons learned

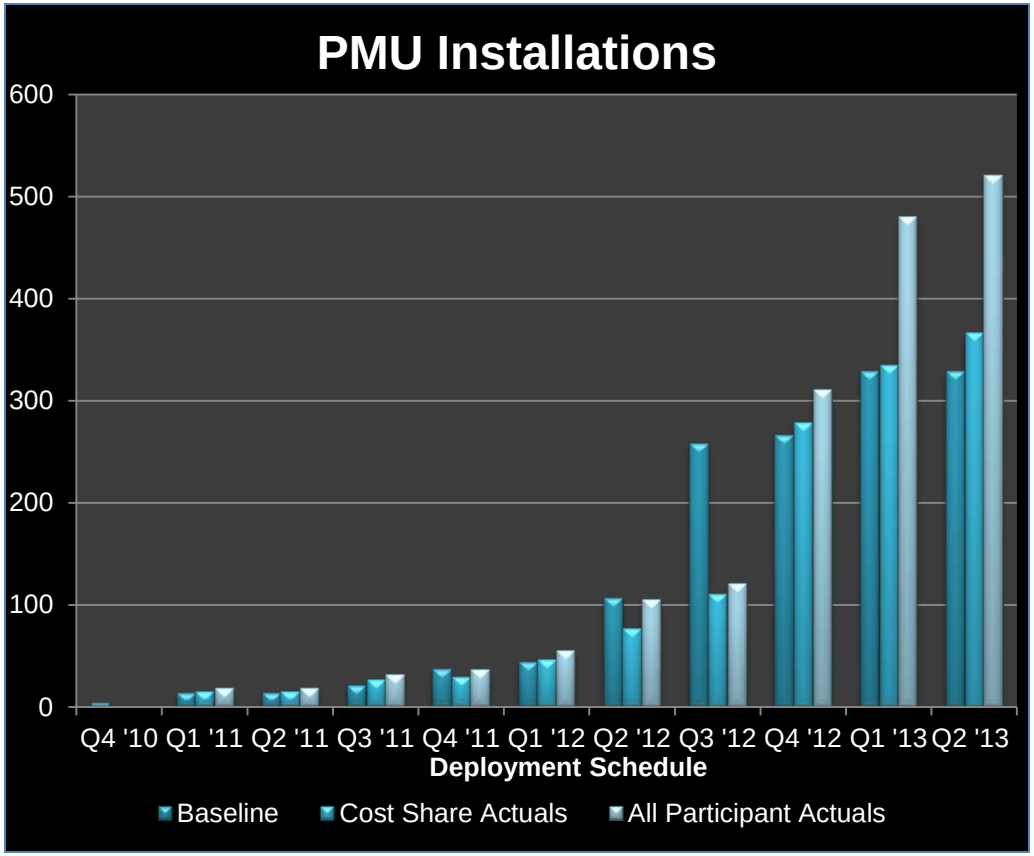
- Biggest Technical Challenges:
  - Qualifying the Data
  - Data mining tools for data extraction;
  - Difficulty in deploying a common naming convention;
  - Upgrading first releases of vendor products to CIP security standards;
  - Applications unproven (finding and working out the bugs);
  - Integrating old PMUs and PDCs; and
  - Applications stressed by large data volumes

Challenges and lessons learned

- Biggest programmatic/execution challenges
  - Took much longer than originally expected:
    - WAN deployment delayed by individual contract negotiations;
    - Infrastructure construction constrained by significant generator outages;
    - Competition for construction resources; and
    - Synchronizing resource availability.
    - Additional data sharing agreement:
      - Difficult to garner full participation

PMUs

- Total PMUs expected to be deployed by 18 participants: 625 at 244 sites
- Total PMUs Currently Deployed: 522
- Total WISP PMUs Now Installed: 377
- Availability statistics (2 week period in October): 84% above 96%, 16% below

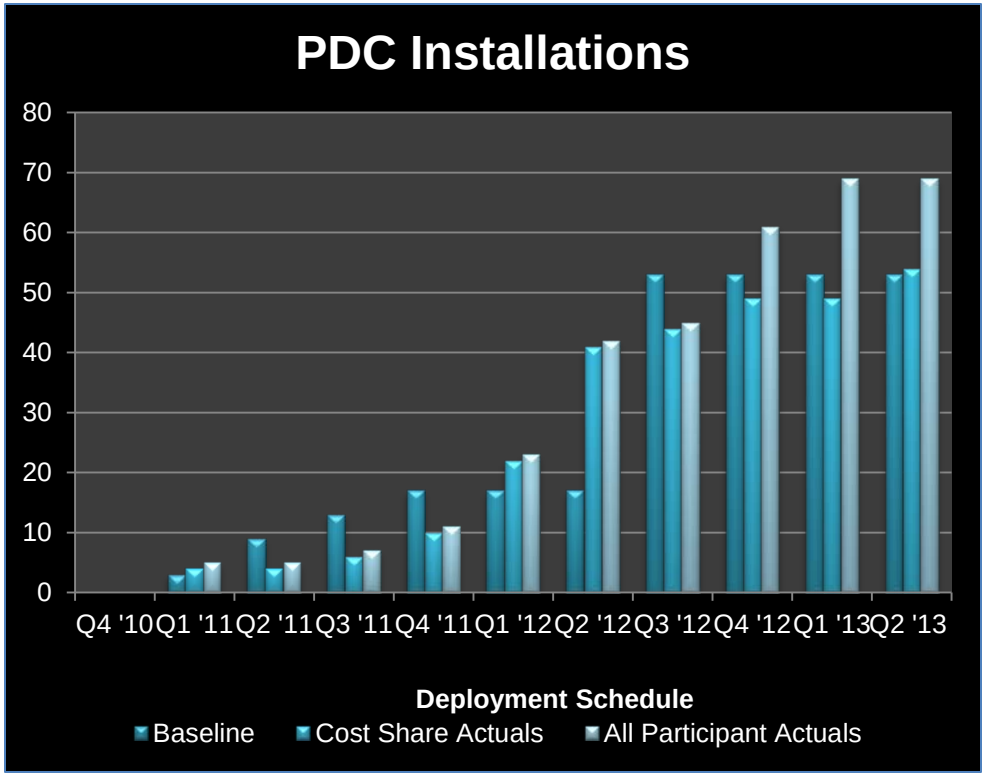


PMUs (cont.)

- Data Quality:
  - o 95 percent of PMUs delivering quality data some issues with older PMUs;
  - o A small number of PMUs have timing issues (one is convinced it is 2034); and
  - o In all cases so far, timeliness issues have been PMU related not communication system related, even when communications are over serial connections.

PDCs

- RC centers with PDCs: 2
- BA/TO control centers with PDCs: 21
- Field PDCs: 25
- Total Now Installed: 69



Applications

- Data flows for applications
  - Some central applications are available to all TOs, TOPs, BAs, and RCs who have executed the WECC Universal Data Sharing Agreement through WECC's Reliability Portal WECCRC.org:
    - Secure Internet-Based Site; and
    - Access to Registry, Archives, Disturbance Reports, Wide Area View (WAV), Next-Day Studies, etc.

Phasor Data Sharing

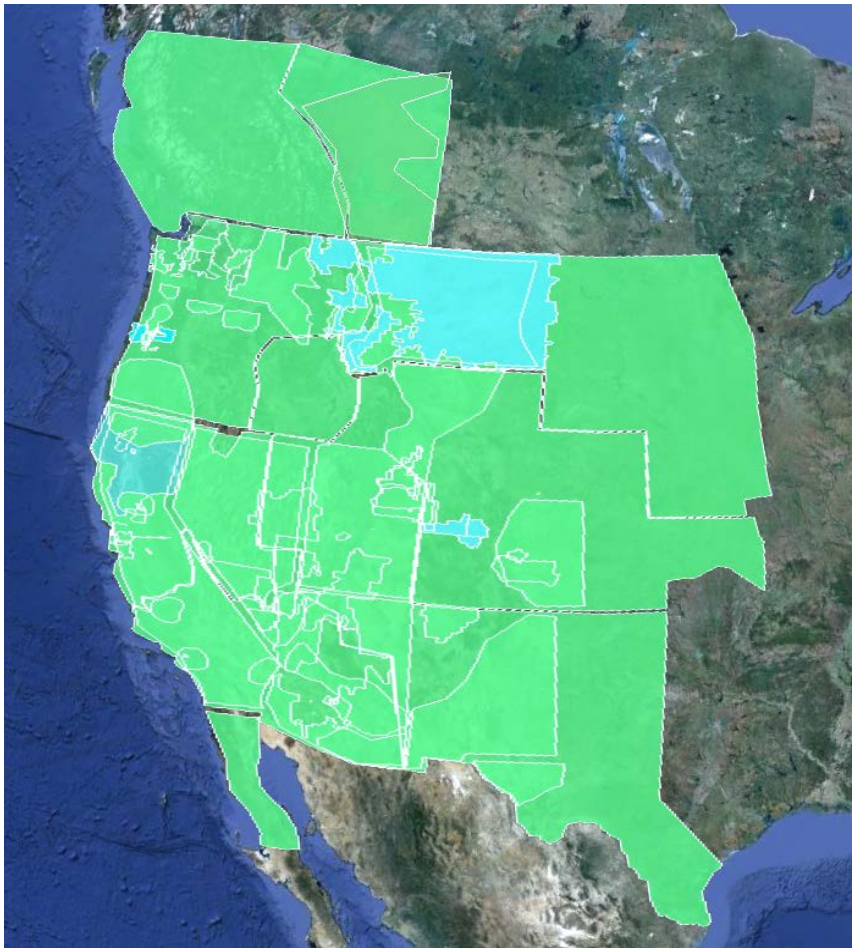
- 18 TOs provide phasor data to the WECC RCs (everyone who has a PMU);
- Many are exchanging data with each other over the WAN; and
- 97 Parties are eligible to receive phasor data through WECCRC.org, they have executed the WECC Data Sharing Agreement (covering phasor and operating reliability data).

Data Sharing Agreement Coverage

Green = NDA Signatory

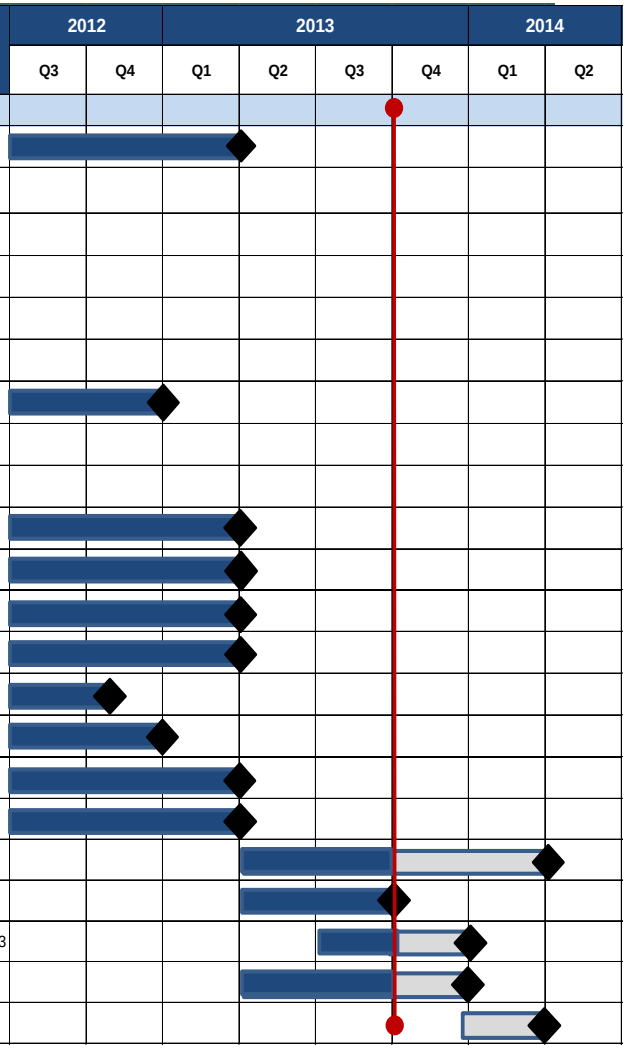
Blue = Waiver Signatory

100% Participation



WISP Milestone Schedule

WBS	WECC Project Tasks	Baseline Finish	Schedule / Actual Finish	Status	Comments
1.1	WISP Program Management Office	Mar-13	Mar-13	Complete	
1.2	WECC Phasor Data Concentrators (PDC) Deployment	Aug-12	Dec-11	Complete	
1.3	WECC Data Center Expansion (Vancouver, WA)	Apr-11	Jun-11	Complete	
1.4	WECC Data Center Expansion (Loveland, CO)	Oct-11	Dec-11	Complete	
1.5	WISP System Architecture Design	Feb-12	May-11	Complete	
1.6	WECC IT Infrastructure - Test Environment	Jun-11	Jun-11	Complete	
1.7	WECC IT Infrastructure - Production Environment	Aug-12	Dec-12	Complete	
1.8	WISP WAN Core Network and Local Loop	Nov-11	Nov-11	Complete	
1.9	WISP WAN Edge Router Installation & Configuration	Apr-12	May-12	Complete	
1.10	WECC Development and Integration	Oct-12	Mar-13	Complete	
1.11	NASPInet Phasor Gateway Demonstration	Aug-12	Mar-13	Complete	
1.12	Wide Area Situational Awareness (Alstom Grid)	May-12	Mar-13	Complete	
1.13	Voltage Stability Application (V&R Energy)	Feb-13	Mar-13	Complete	
1.14	Historical Data Archive (OSIsoft) - Post Event Analysis	Nov-12	Nov-12	Complete	
1.15	Modal Analysis Software (Montana Tech Solution)	Sep-12	Dec-12	Complete	
1.16	Systems Integration and Testing	Sep-12	Mar-13	Complete	
1.17	WISP Systems Transition to Production	Mar-13	Mar-13	Complete	
1.18	Project Extension	Mar-14	Mar-14	On Track	Project Extended through March 2014
1.18.1	RC Control Room Expansion - Loveland	Sep-13	Sep-13	Complete	
1.18.2	RC Control Room Expansion - Vancouver	Dec-13	Dec-13	On Track	Construction started on October 14, 2013
1.18.3	WASA Application Enhancements	Oct-13	Dec-13	Task Delay	Rollout of final release of eterravision scheduled for December of 2013
1.18.4	WISP Project Close	Sep-13	Dec-13	On Track	



Communications

- Data flows and speeds:
  - PMU to PDC communication controlled by each Participant — latency varies among Participants.
  - PDCs to RCs for centrally processed applications:
    - Edge router to edge router latency requirement is 30 ms average over 10 min, experiencing 19 ms; and
    - Jitter requirement is 2 ms average over 10 min, experiencing 1.4 ms.
    - WAN availability 99.99 percent (measurement beginning May 2012).
  - Expecting 2100 phasor measurements initially — WAN capable of 10X this volume limited only by ‘last mile’ connection.

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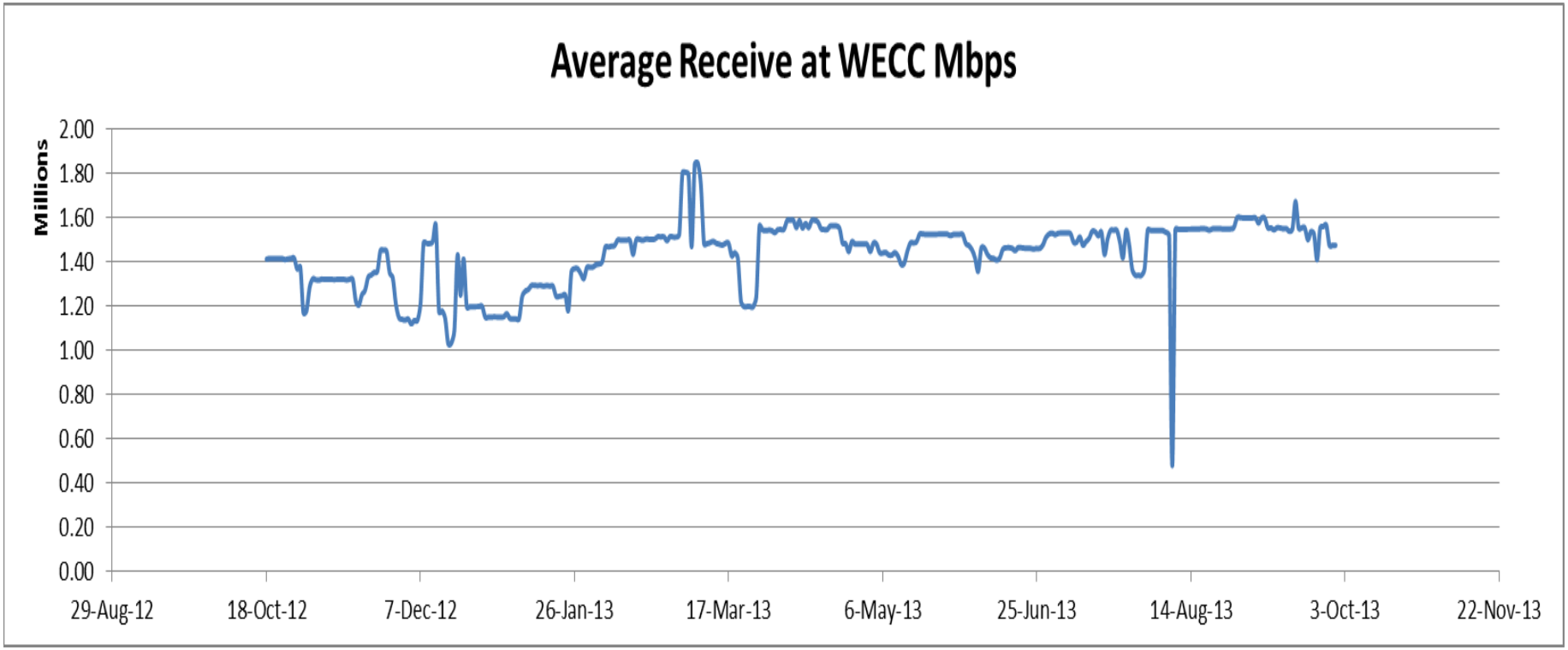
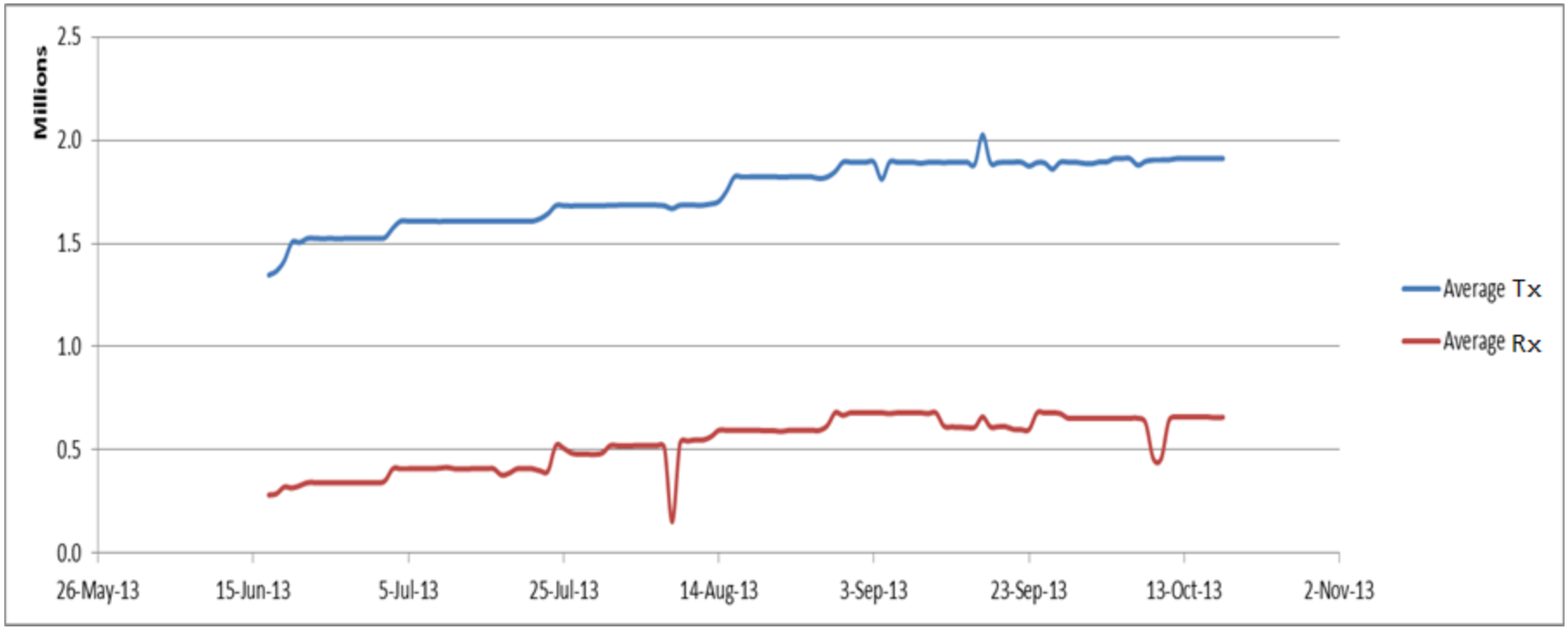
Communications

- Data flows for applications
  - o Applications required to meet performance requirements with 4200 phasor measurement volume;
  - o All data flows up to the RC archives in real time; and
  - o Some Participants archive their own data and exchanged directly with peers.

Data Flow: Average Receive at WECC



Data Flow:
Average Transmit and Receive at BPA



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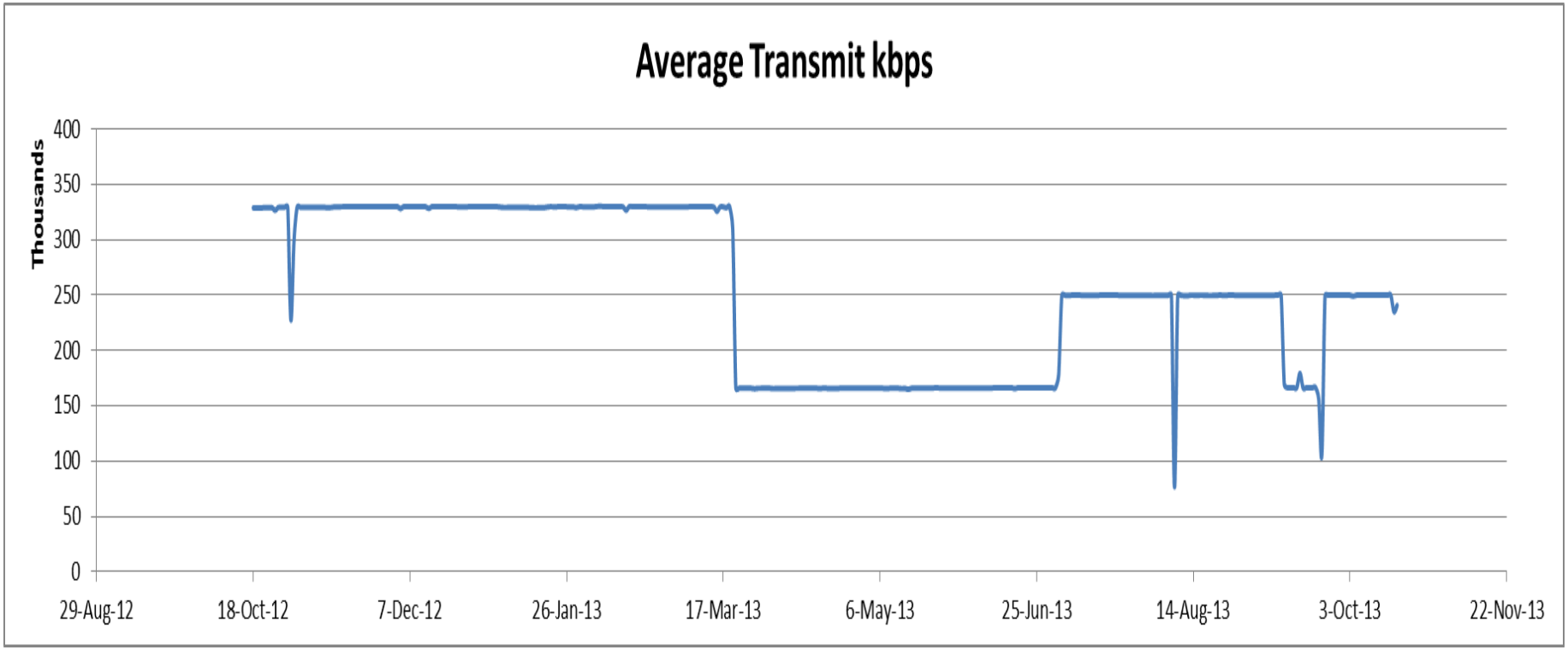
Data Flow:
Average Transmit at Participant - 15 PMUs



Major Operational Applications

- Number of TOs/ISOs sharing phasor data: 18
- Wide-Area Situational Awareness:
  - Alstom eTV - General visualization: March 2013
  - Alstom/Psymetrix – Monitoring, alarming and archiving: March 2013
    - Montana Tech/University of Wyoming/PNNL, Psymetrix, Washington State University – Oscillation Monitoring
  - OSISoft – Archiving: April 2013
  - V & R Energy – Voltage Stability: March 2013

Major Operational Applications

- Wide Area View: entities see what the RC sees
- Automated Report Generation: Testing Complete Jan. 2013
  - System performance following events.
    - For baselining, model validation, trending.
- Renewable generation now covered by PMUs: 2421 MW.

Participant Spotlight: Bonneville Power Administration

- BPA is a key utility participant in WISP
- BPA installed 124 PMUs in 52 substations
  - Redundant, diverse, and secure infrastructure
  - Designed to be NERC CIP compliant
  - Additional data PMUs are installed at wind power plants
- Control Center Network
  - Open application framework based on OSI Soft PI platform
  - Environment for accelerated development, prototyping, testing and deployment of applications
  - Several applications are developed and implemented
  - OSI Soft PI used as Data Historian
- Data Exchange
  - BPA sends most of its data to WECC RC
  - BPA exchanges data with Alberta ESO, Northwestern, Idaho Power, LADWP, SCE, SRP, Nevada Power, Tri-State and PNM

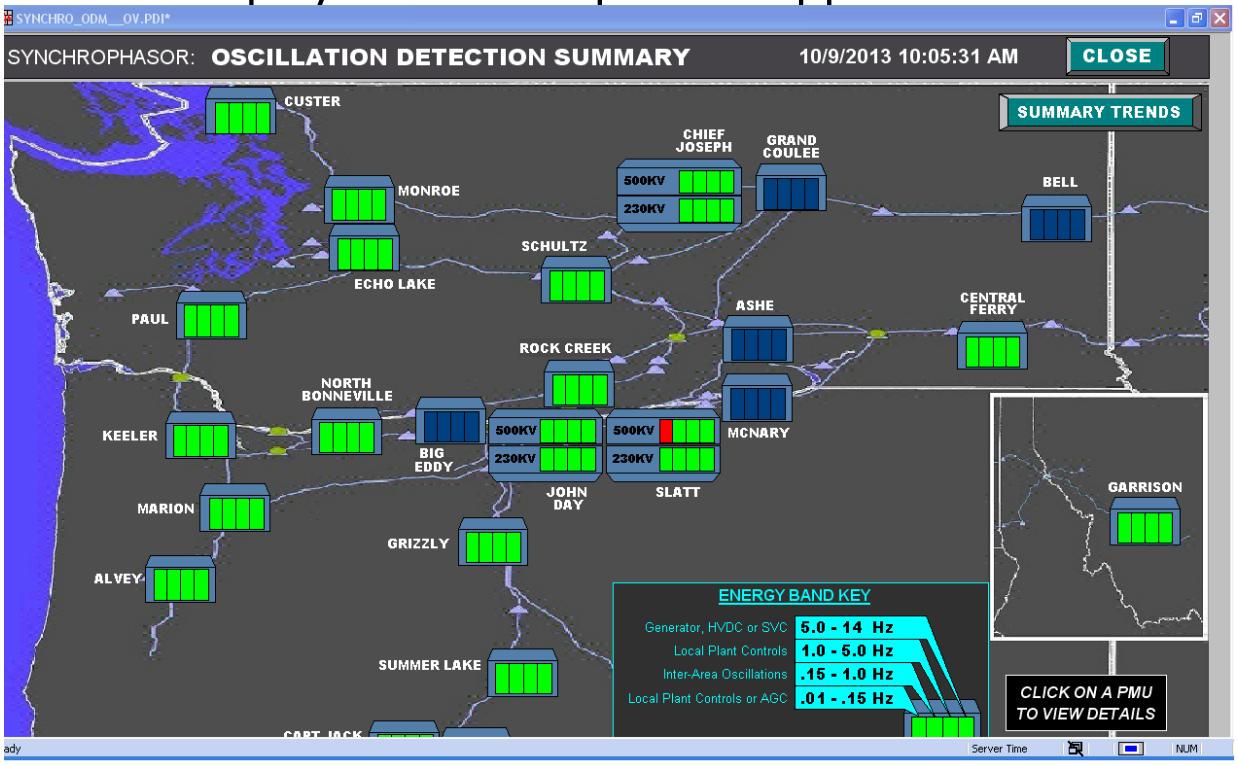
Participant Spotlight: Bonneville Power Administration

- Control Room Applications
  - Customized trend displays using OSI Soft Process Book (deployed)
    - Five synchrophasor displays are available for video wall
  - Oscillation Detection (deployed)
    - scans power plants and interties for sustained oscillations
  - Mode Meter (available)
    - estimate damping of inter-area power oscillations
    - operating procedures and decision support tools are being developed
  - Phase Angle limits (available)
  - Island Detection (deployed)
  - Dispatcher training is performed

- Engineering applications
  - Frequency response analysis and baseline (deployed)
  - Oscillation analysis (deployed)
  - Power Plant Model Validation (deployed)

Participant Spotlight: Bonneville Power Administration

- Oscillation Detection application went live on October 1, 2013
  - Application is developed with WISP funds by Montana Tech
  - Scans power plants and interties for signs of growing oscillations
  - Alarms senior dispatcher when an oscillation is detected
  - Displays are developed to support decision-making



Each PMU has four oscillation bands

When oscillation energy exceed alarming threshold, a band turns red

Dispatcher can click on PMU to display signal trends

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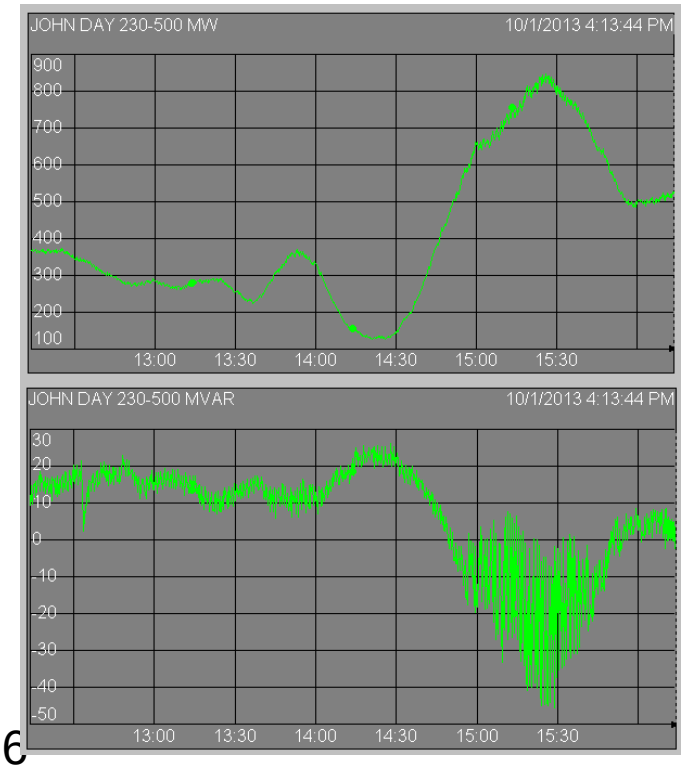
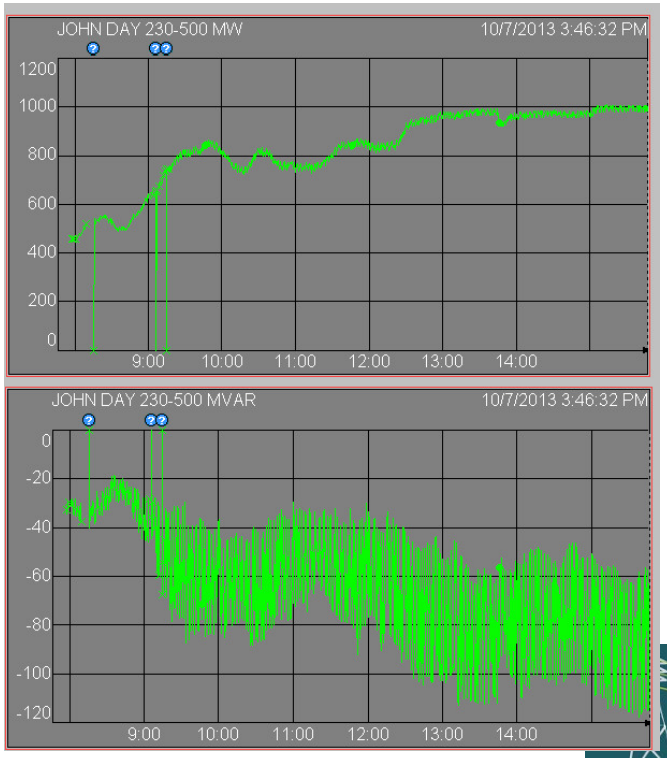
Participant Spotlight: Bonneville Power Administration

- Reliable Integration of Wind Generation
  - BPA is collaborating with NREL, EPRI, UVIG, Enernex and Sandia on wind power plant model validation using BPA wind PMU data
  - Sustained high frequency oscillations were detected at one of wind power plants, BPA is working with plant operators on resolving the issue





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Synchrophasor Training

- User Acceptance of New Technology
  - Dedicated training-and-outreach initiatives are in place to ensure active mitigation – offered to TOs, TOPs, BAs:
    - **Help Desk:** Trends are carefully monitored each week;
    - **Training:** WECC Developed professional suite of interactive training webinars, combined with companion quick-reference materials, are provided with each deployment of program features; and
    - **Communications:** End-user communications (specific program updates, electronic newsletters, and briefs) are regularly published.

Questions/Comments