California ISO

Utilization of Synchrophasor Data

Aftab Alam
Manager, Operations Planning North

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About Me

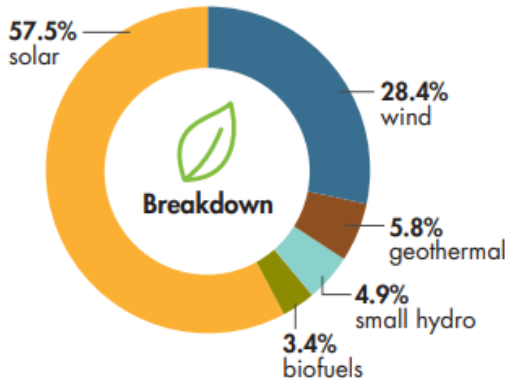
- Aftab Alam - Manager, Operations Planning North, California Independent System Operator (CAISO)

Aftab Alam provides engineering support for outage coordination and planning, real-time grid and market operations for the California ISO and Reliability Coordinator functions for RC West entities. He is also involved in the development of operating procedures and implementation of various real-time assessment applications such as real-time contingency analysis, voltage and transient stability analysis and oscillation monitoring required to provide situational awareness to operators. Prior to joining CAISO in 2011, Aftab was in Transmission Planning at ISO New England since 2007. Aftab completed his PhD and Masters in Electrical Engineering with a focus in Power Systems from Clemson University in 2007 and 2003 respectively. Aftab also serves on the NASPI leadership team and is involved with various working groups focused on system reliability at WECC, NERC and IEEE as a Senior Member.

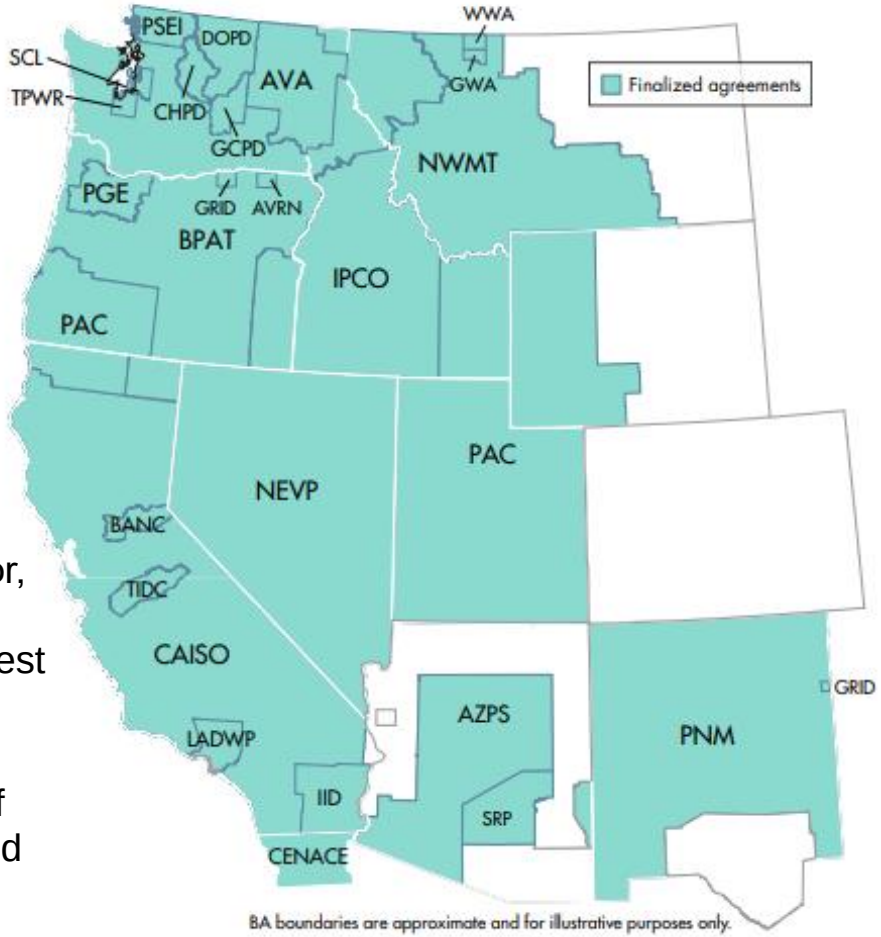
aalam@caiso.com

California Independent System Operator (CAISO) and RC West

- One of the 9 ISOs
- Largest of the 38 BAs in the Western Interconnection
- Handles 35% of the electric load in the West

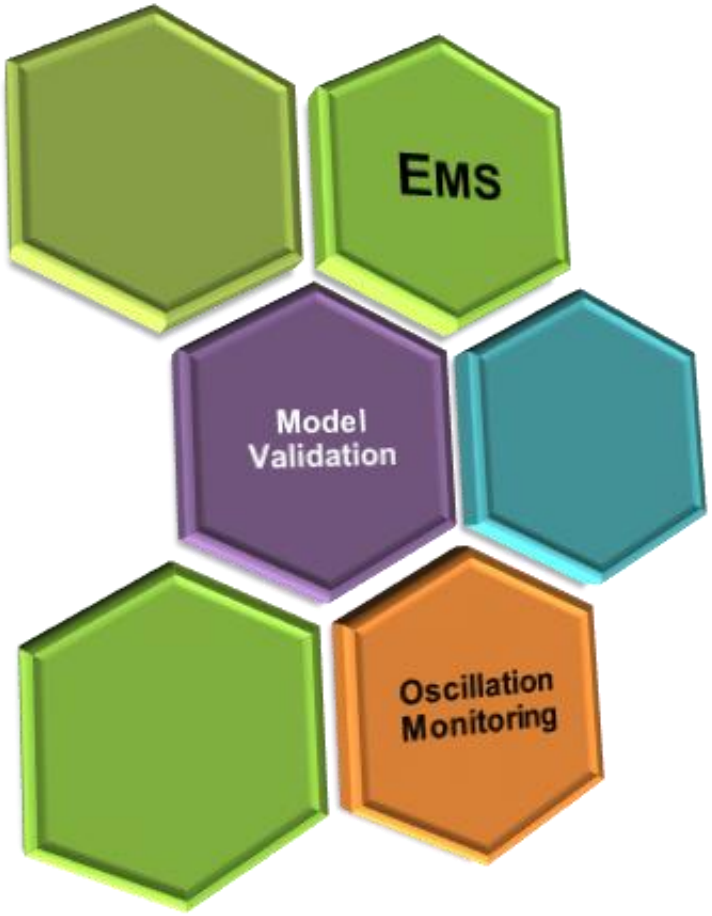


- The ISO's Reliability Coordinator, named RC West, launched operations on July 1, 2019 Largest of the 38 BAs in the Western Interconnection
- Official Reliability Coordinator of record for ~40 electricity BAs and TOPs in the Western Interconnection.



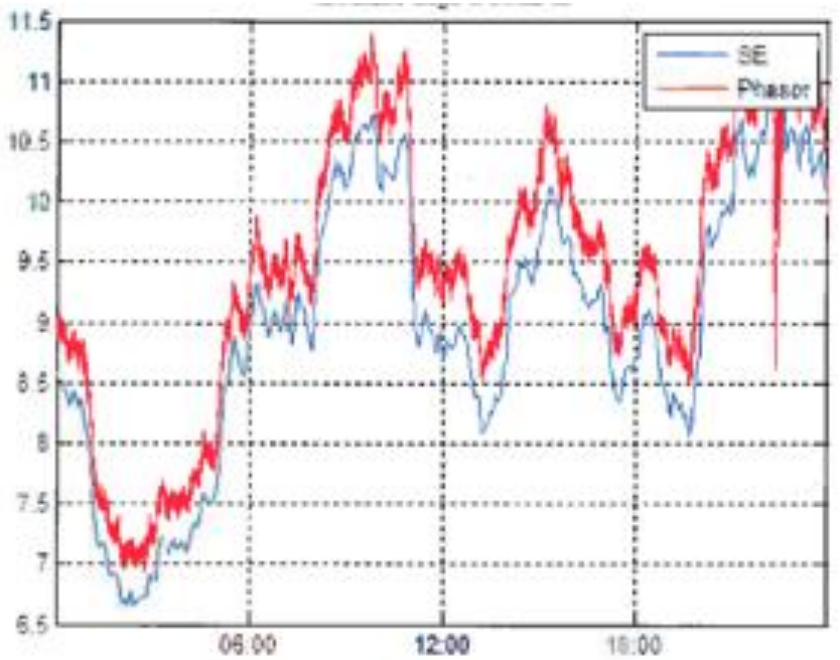
Utilization of Synchrophasor Data

- **Various different uses:**
  - Energy Management System (EMS)
  - Model and System Response Validation
  - Oscillation Monitoring



Energy Management System

- **Phase Angle Monitoring for Synch Checks**
  - State estimation provides pre-contingency voltage angles
  - Additionally, Real-Time Contingency Analysis allows operators to monitor the post contingency angle differences against synch check relay limits to determine whether lines with synch check relays can be reclosed successfully
  - Operators can be provided instructions on how to reduce angle differences at critical locations on EMS displays
- References:
  - Phase Angle Monitoring: Industry Experience Following the 2011 Pacific Southwest Outage Recommendation 27: http://www.nerc.com/comm/PC/Synchronized%20Measurement%20Subcommittee/Phase%20Angle%20Monitoring%20Technical%20Reference%20Document%20-%20FINAL.pdf
  - State Estimator Line-Based Phase Angle Alarming - Primer for Operations Engineers and System Operators: https://www.nerc.com/comm/PC/Synchronized%20Measurement%20Subcommittee/Primer_State_Estimator_Based_Angle_Difference_Alarming.pdf



PMU data helps to validate the angle differences determined by state estimation

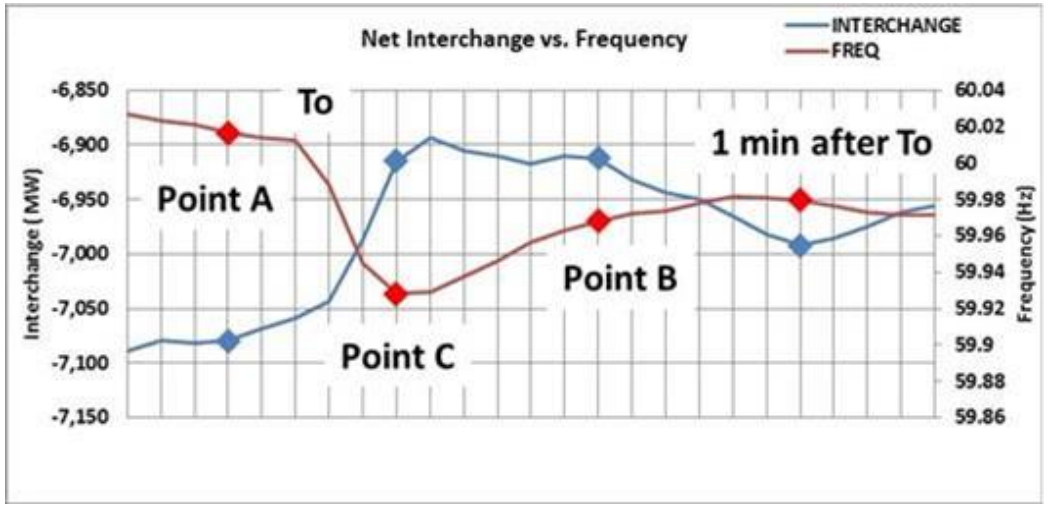
Energy Management System

- **Phase Angle Monitoring for Stability Limits**
  - Typically stability limits are respected by monitoring MW flows on critical interfaces
  - In certain conditions it is possible that that under different dispatch conditions leading to MW flows lower than the MW based stability limit, the stability concerns still exist. However angle based limits may stay constant for the different dispatch conditions
  - This warrants monitoring of stability limits based on angle differences to ensure stability limits can be maintained under different dispatch conditions (https://www.wecc.org/Reliability/August%202020%20Heatwave%20Event%20Report.pdf)

Tie Line Monitoring

2.10 Balancing Authority Area Requirements - Phasor Measurement Units on ISO Interties

As discussed in detail in section 6.4, the ISO must meet its frequency response obligation based on net actual MW interchange measurements, and for compliance purposes, frequency response reflects the change in interchange over the change in frequency for a period of time following a frequency disturbance. The ISO has identified a need to require Phasor Measurement Units (PMUs) at all interties at the boundary of its balancing authority area to provide more precision regarding the system's net actual interchange after a frequency disturbance event. The PMUs are needed to enhance the accuracy of measurements to demonstrate compliance with NERC Reliability Standard BAL-003-1.1.



- Power flow data from tie lines can provide accurate interchange data
- Active coordination with Transmission Owners to determine latency, availability and location requirements

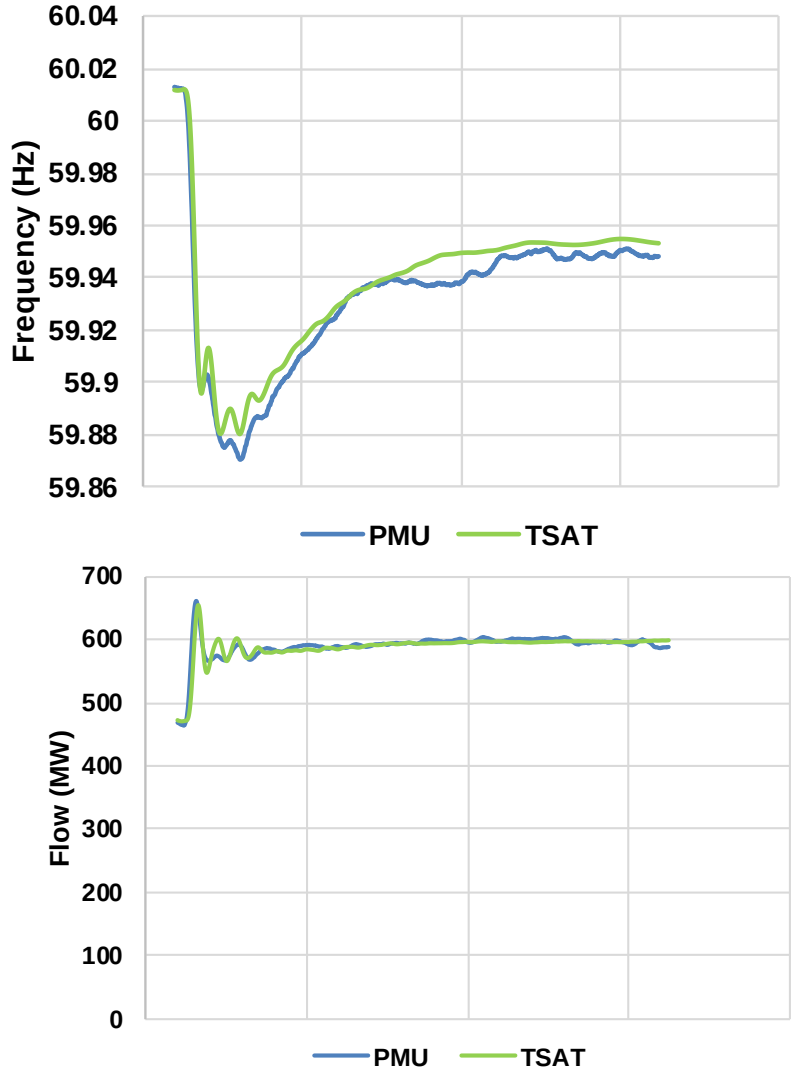
Utilization of Synchrophasor Data for Real-Time Model Validation

State Estimation

Real-Time Transient Stability Analysis

[Monitoring stability concerns and frequency response]

Compare dynamic simulations with Synchrophasor data and **validate system response, network and dynamic models**



Utilization of Synchrophasor Data for Planning Model Validation

- **MOD-033 Data requests**
  - NERC Reliability Standard MOD-033-2 (Steady-State and Dynamic System Model Validation) was created to establish consistent validation requirements to facilitate the collection of accurate data and building of planning models to analyze the reliability of the interconnected transmission system
  - RC West Process to provide actual system behavior data to any Planning Coordinator performing validation under NERC Reliability Standard MOD-033-2, R2 (http://www.caiso.com/Documents/RC0650.pdf)

Summary

- Angle data from Synchrophasors provides a backup for angle difference calculations needed for angle based monitoring in scenarios such as:
  - Reclosing of lines with synch check relays
  - Monitoring of stability limitations

- MW flows on tie lines can allow more accurate interchange calculations and it's change during a frequency disturbance event

- System Response from Real-Time and Planning Network and Dynamic Models can be validated by performing event analysis by utilizing state estimation and disturbance data

References

- Phase Angle Monitoring: Industry Experience Following the 2011 Pacific Southwest Outage Recommendation 27: http://www.nerc.com/comm/PC/Synchronized%20Measurement%20Subcommittee/Phase%20Angle%20Monitoring%20Technical%20Reference%20Document%20-%20FINAL.pdf
- State Estimator Line-Based Phase Angle Alarming - Primer for Operations Engineers and System Operators: https://www.nerc.com/comm/PC/Synchronized%20Measurement%20Subcommittee/Primer_State_Estimator_Based_Angle_Difference_Alarming.pdf
- Western Interconnection Modeling and Monitoring Common Methodology (http://www.caiso.com/Documents/RC0600A.pdf)
- August 2020 Heatwave Event Analysis Report (https://www.wecc.org/Reliability/August%202020%20Heatwave%20Event%20Report.pdf)
- RC West Steady-State and Dynamic System Model Validation: NERC MOD-033-2 (http://www.caiso.com/Documents/RC0650.pdf)