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Power Plant Model Verification using PMUs

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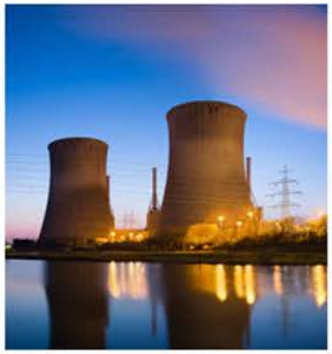
NASPI Work Group Meeting

March 2016

RELIABILITY | ACCOUNTABILITY



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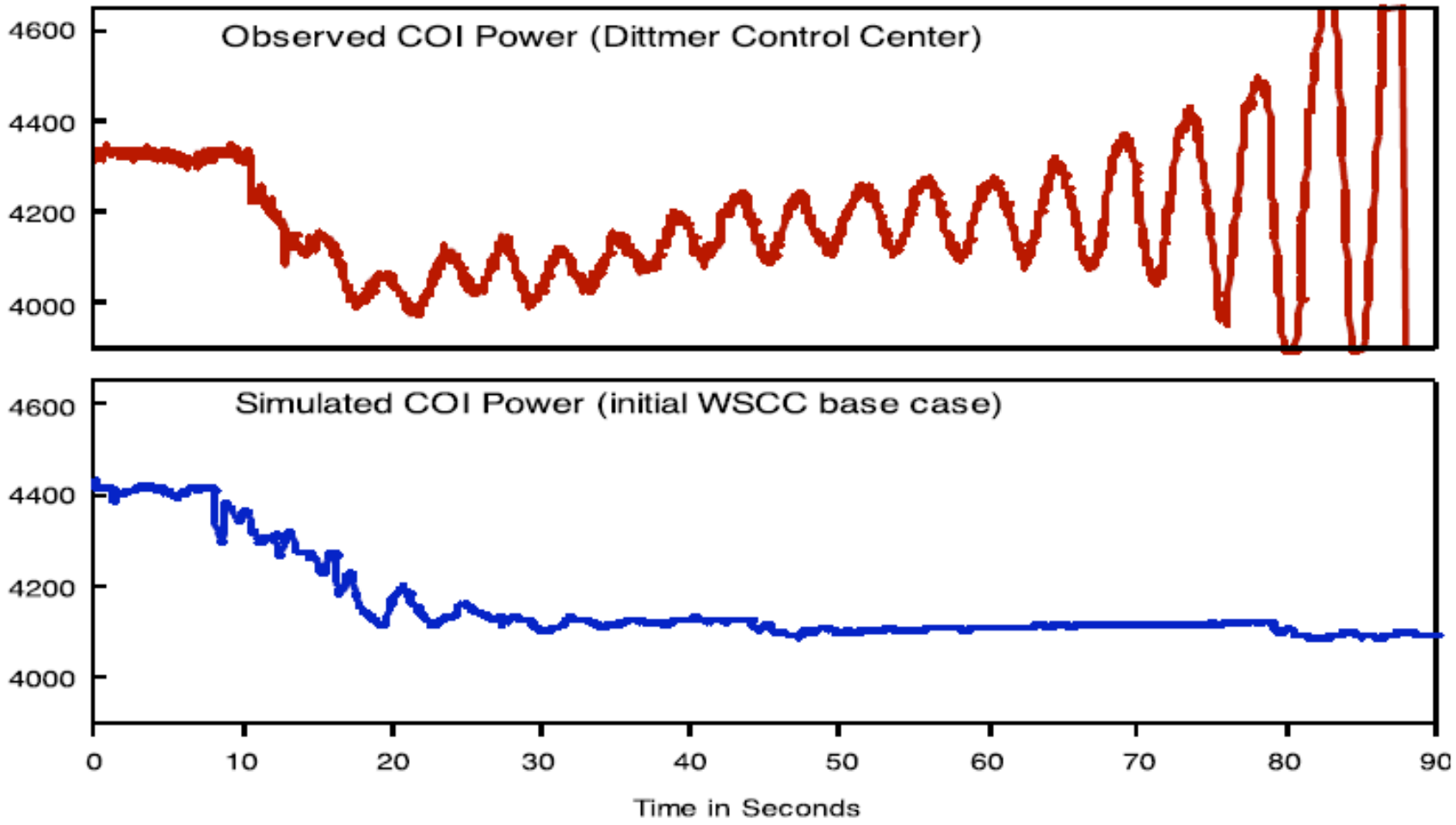
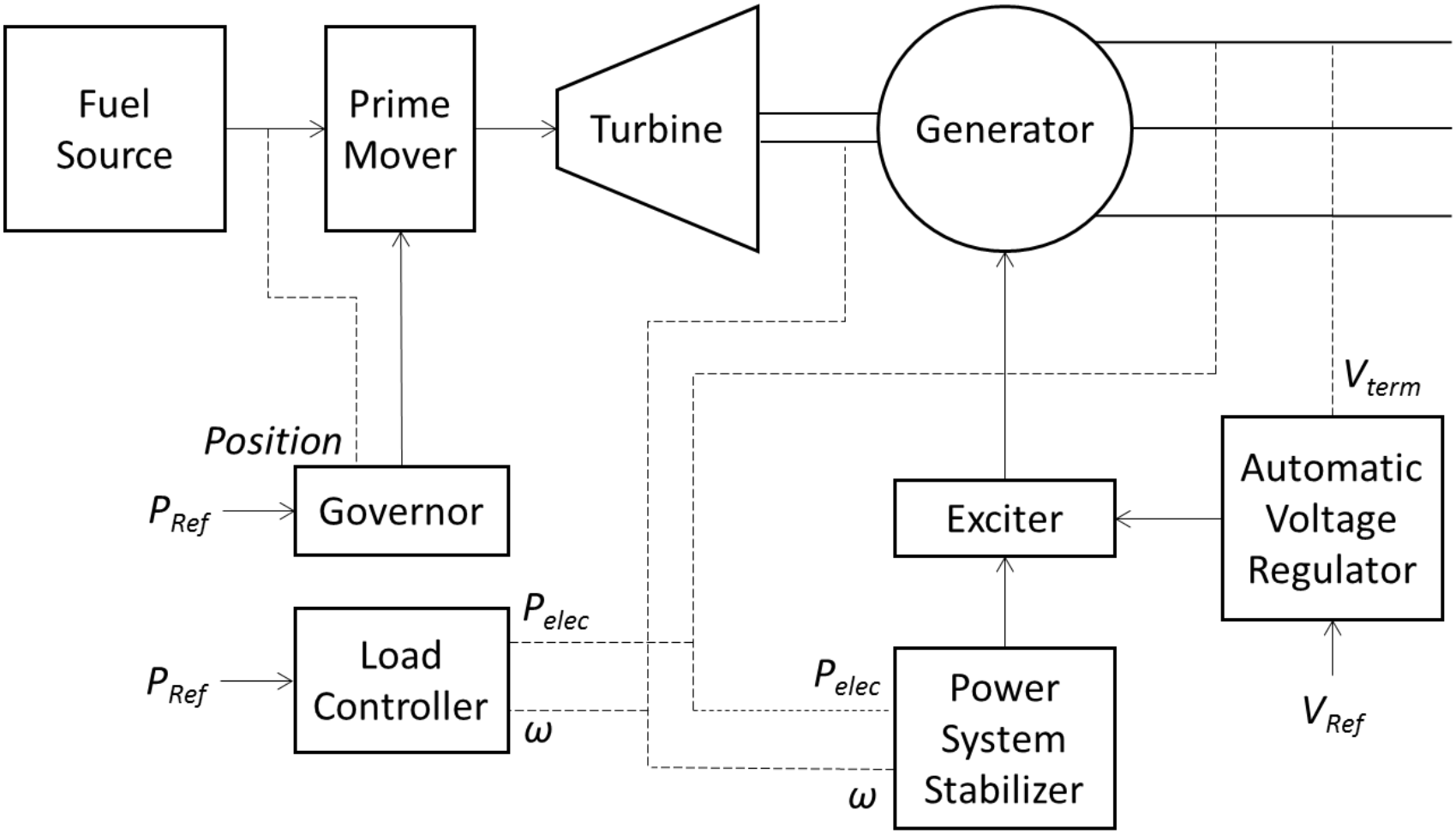
Importance of Accurate Models



Verifying Power Plant Component Models



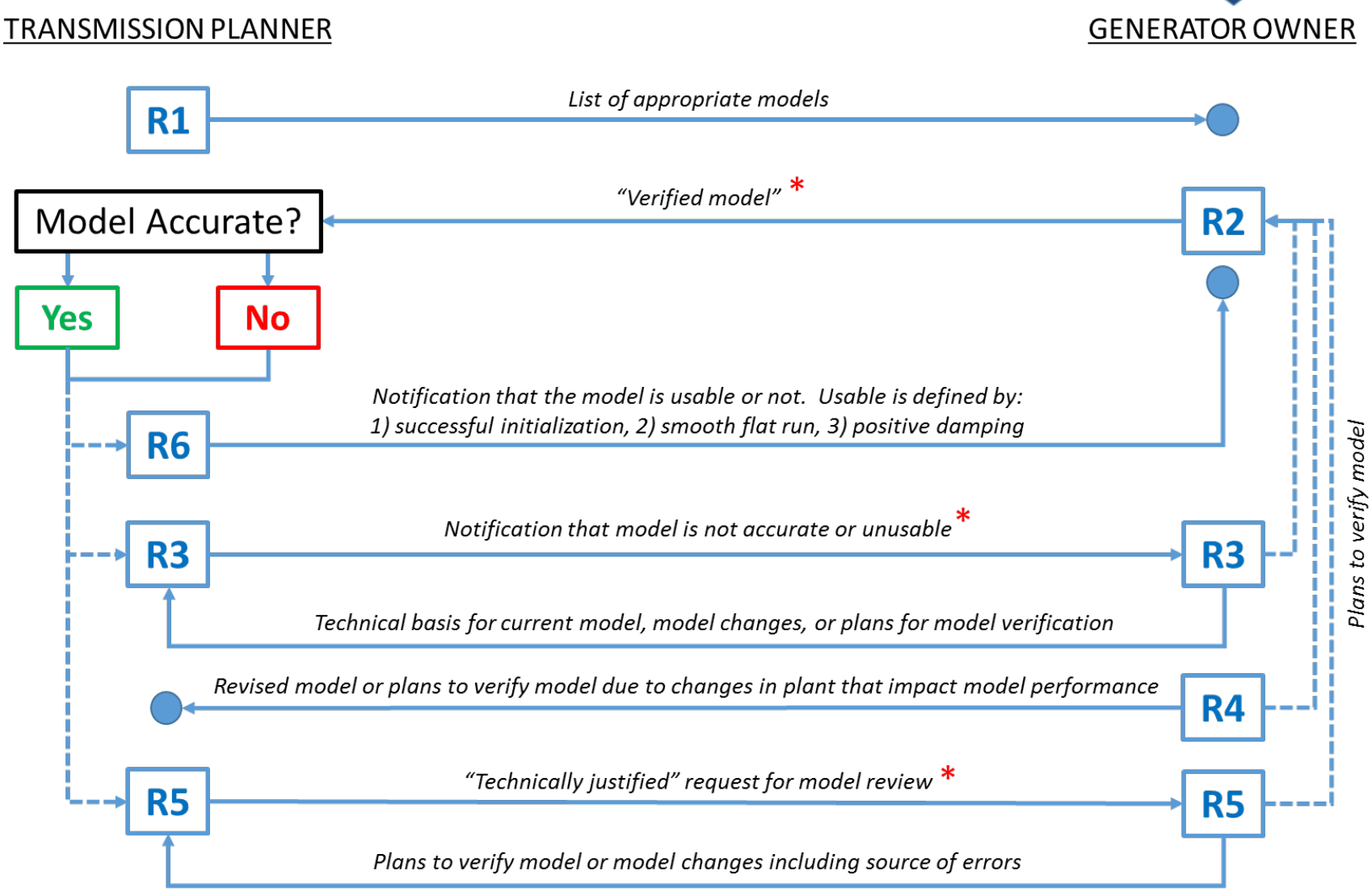
MOD-026-1 & MOD-027-1: Verification of Models and Data

- **MOD-026:** Generator excitation control system or plant volt/var control functions
- **MOD-027:** Turbine/governor and load control or active power/frequency control functions
- Applicability:
  - Individual units greater than 100 MVA
  - Generating plants consisting of multiple units directly connected at a common BES bus with total generation greater than 100 MVA
- Process:
  - R1. TP provides instructions and model data to GO
  - R2. GO provides verified model back to TP
  - R3. TP can provide oversight of model and performance
  - R4. GO provides revised model/plans upon any changes made

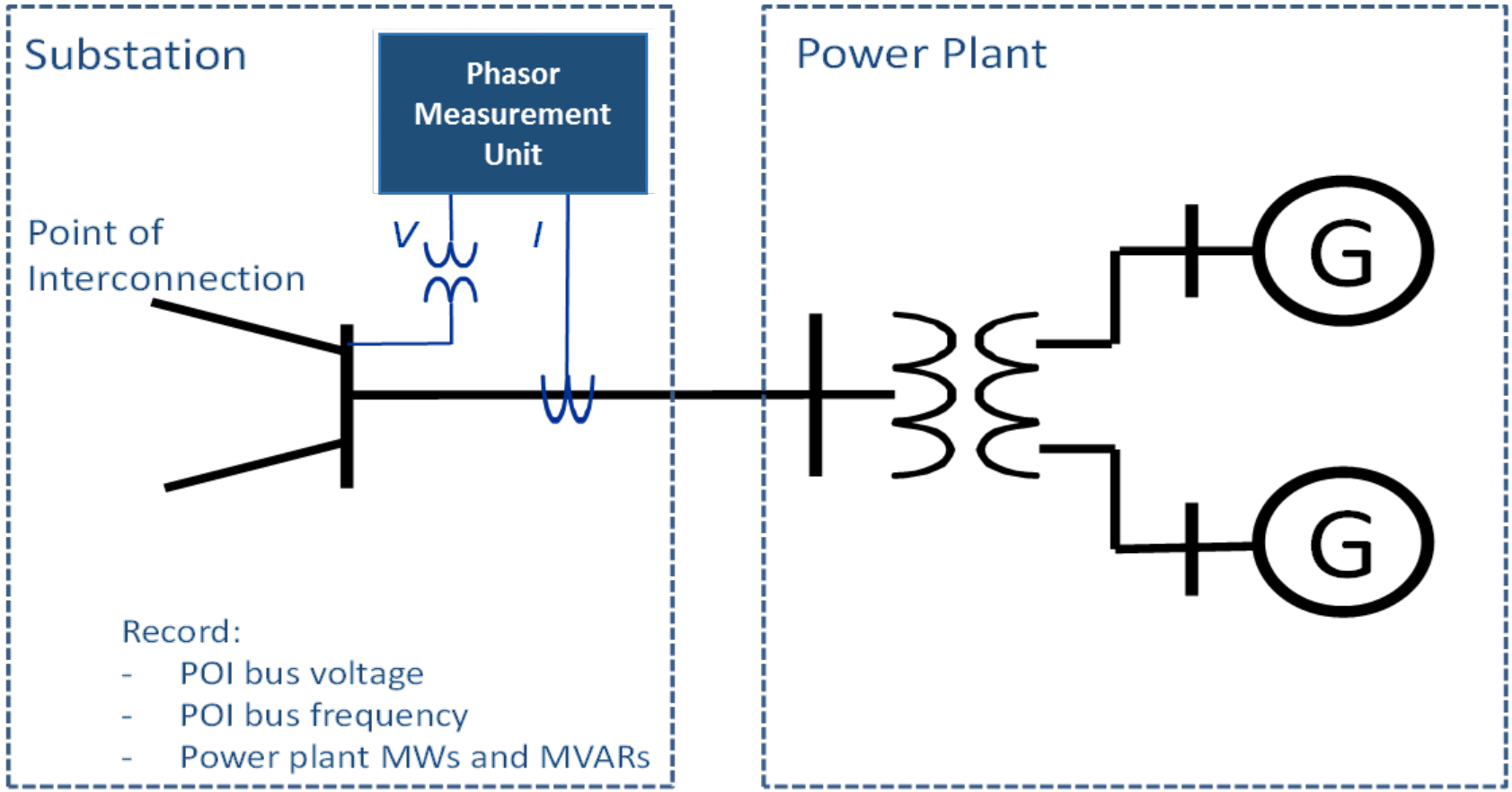
MOD-026-1 & MOD-027-1: Verification of Models and Data

- Requirement R3: "…receiving one of the following items for an applicable unit:"
  - "Written comments and supporting evidence from its Transmission Planner indicating that the simulated excitation control system or plant volt/var control function model response did not match the recorded response to a transmission system event."
- Requirement R5: "Each [GO] shall provide a written response to its Transmission Planner…following receipt of a technically justified* unit request from the [TP] to perform a model review of a unit or plant…"
  - "Corrected model data including the source of revised model data…"
  - ***technical justified**: achieved by the [TP] demonstrating that the simulated unit or plant response does not match the measured unit or plant response.

NERC Standards



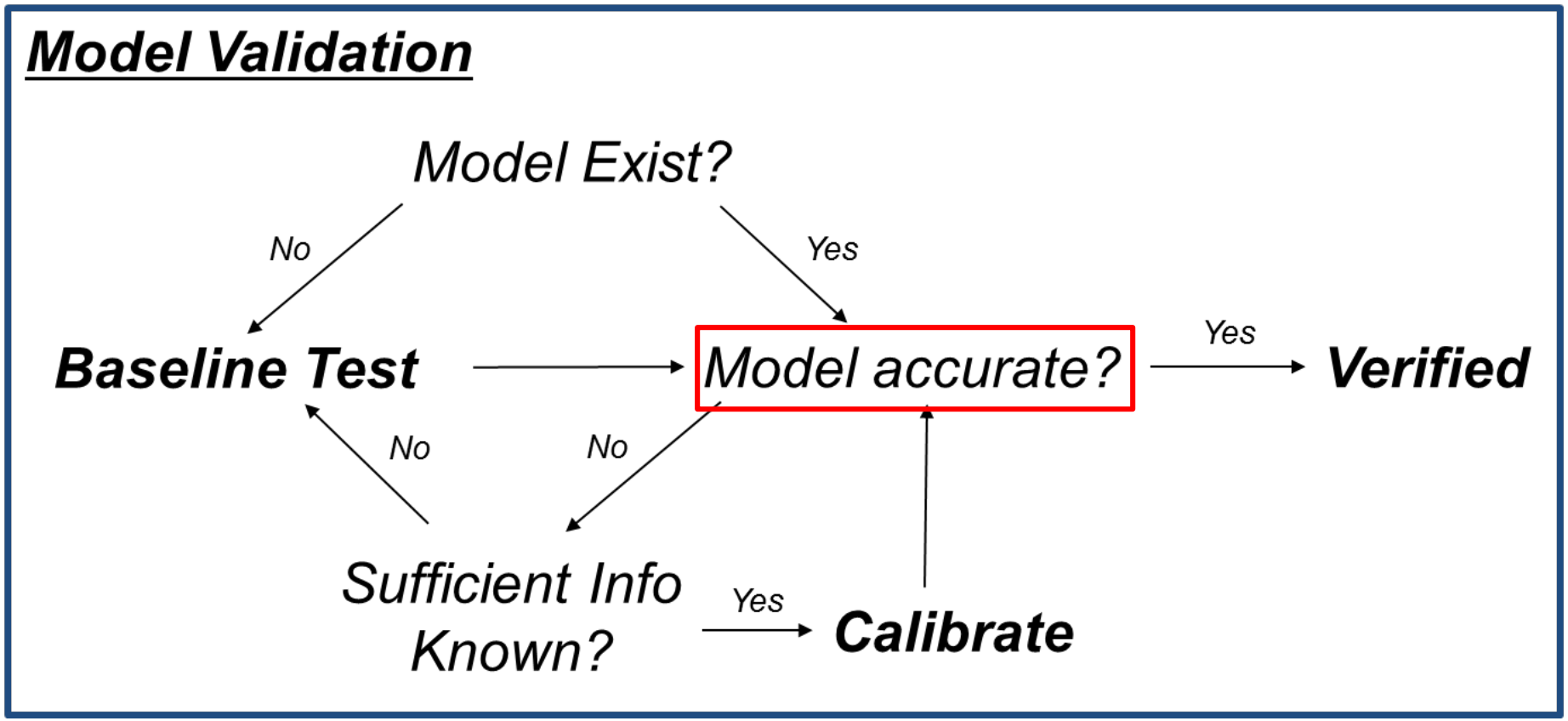
PMU Disturbance-Based PPMV



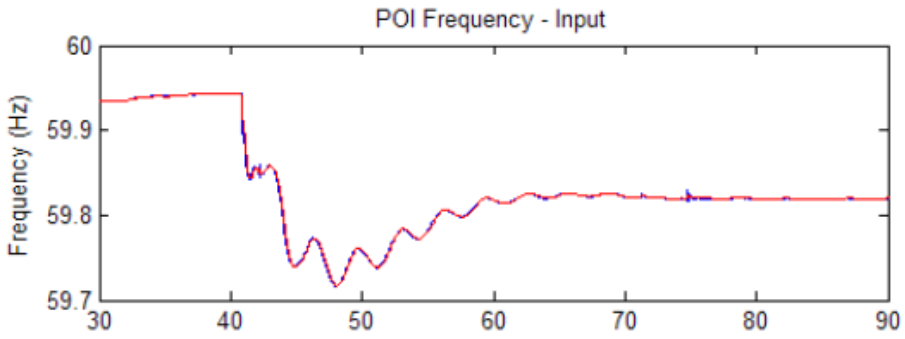
Measurement and Modeling Considerations

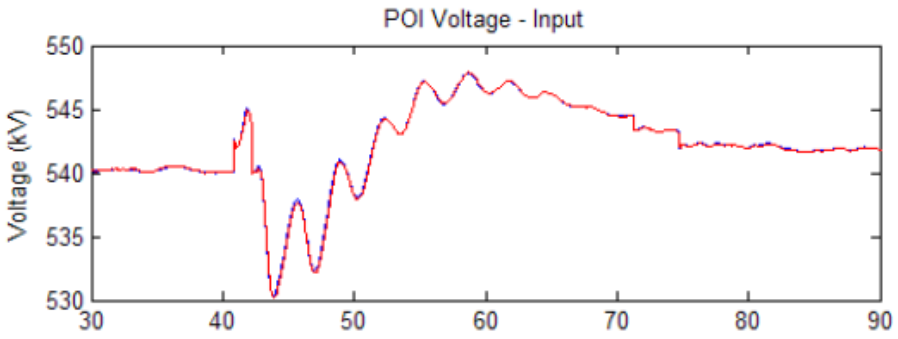
- PMU measurement data quality – watch out for archived data!
- Measurement Location – is flexible! high- or low-side of GSU, POI of power plant (radial connection)
- Signals – V, F, P, Q, (δ, I)
- Measurement duration – at least 10 seconds pre- and 30 seconds post-disturbance
- Events:
  - Local or nearby fault events
  - Major line or shunt switching
  - Underfrequency events (interconnection-wide) – generator tripping
- Must perform disturbance-based verification for ***multiple events***

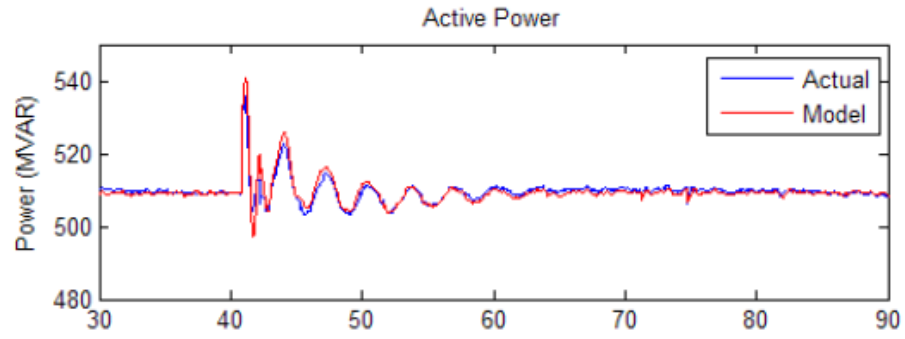
Model Validation Process

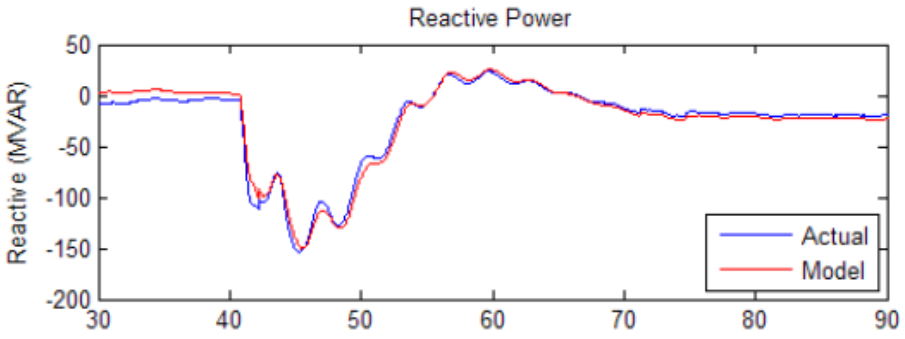


Disturbance-Based Verification









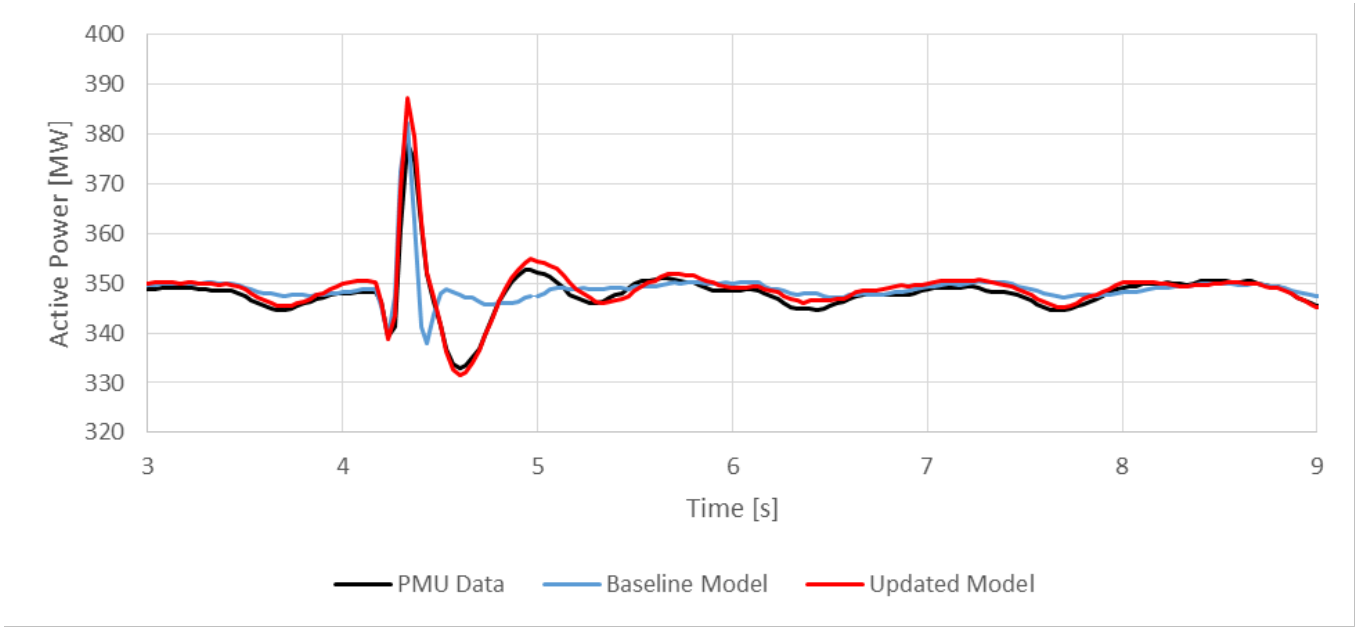
- **Play In:** Voltage and Frequency Signals (V & *f*)
- **Measures of Success:** Active and Reactive Power (P & Q)

Tools

- The following tools all have playback models and capability to perform disturbance-based model verification:
  - GE PSLF
  - PTI PSS®E
  - Powertech TSAT and ModV
  - PowerWorld Simulator
  - EPRI PPPD
  - BPA-PNNL PPMV
  - MATLAB® and Simulink®
  - EPG GPV

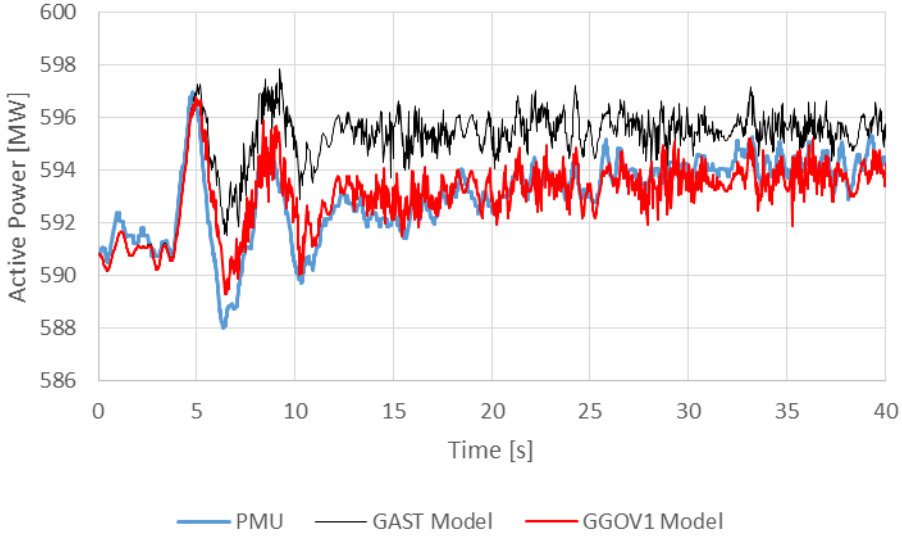
- NERC SMS supporting industry use of vetted tools – user forum to share experience, code, examples, etc.

Calibration

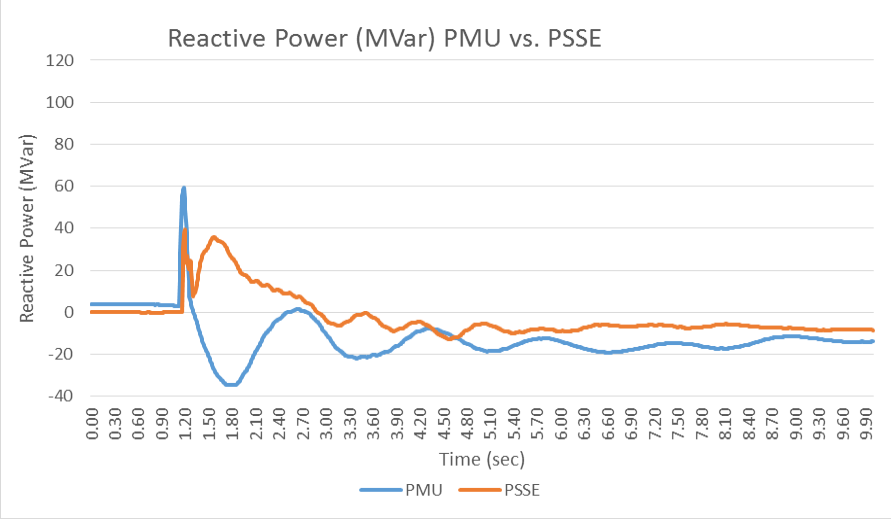


- NERC *advocated* using *Engineering Judgment* for any calibration
- ***Avoid*** numerical curve fitting methods
- Consider controller failures for very poor matches
- Understand parameter sensitivities – run example playbacks!
- A matching response does ***not*** mean a verified model

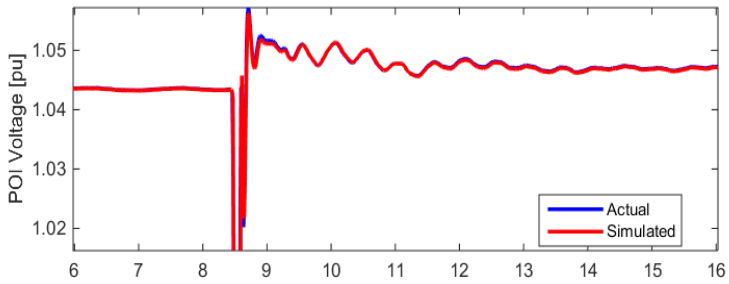
Industry Efforts

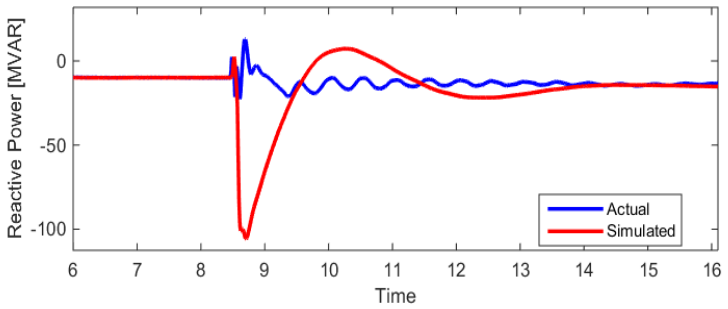


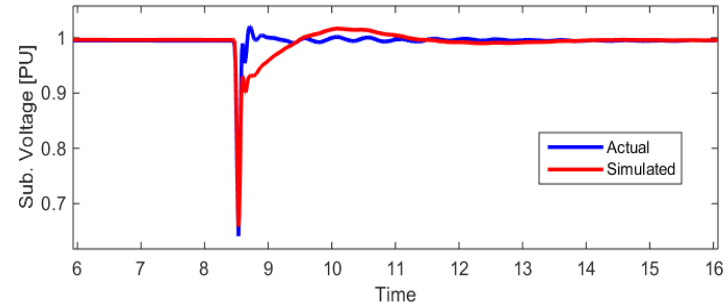
Gas Turbine Modeling



Combined Cycle Verification

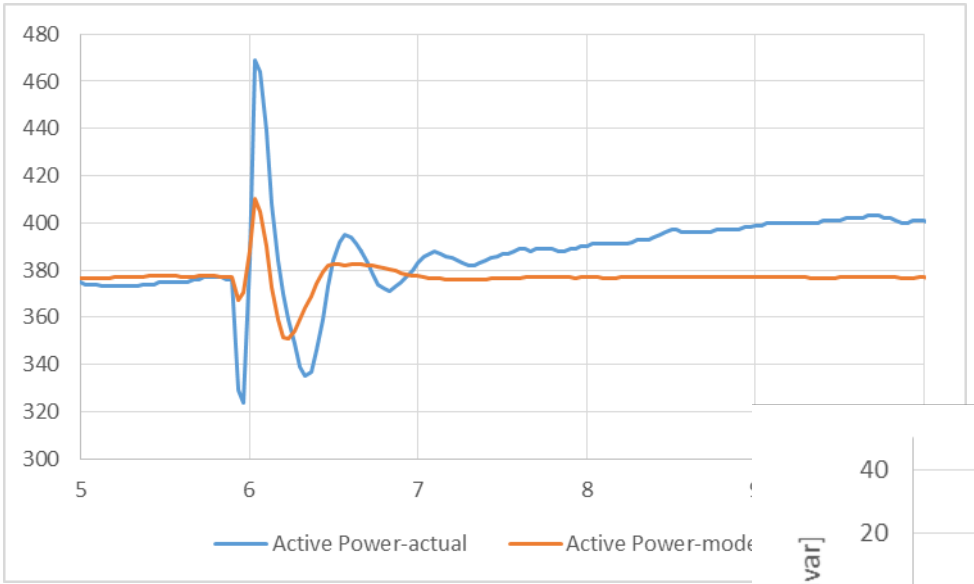




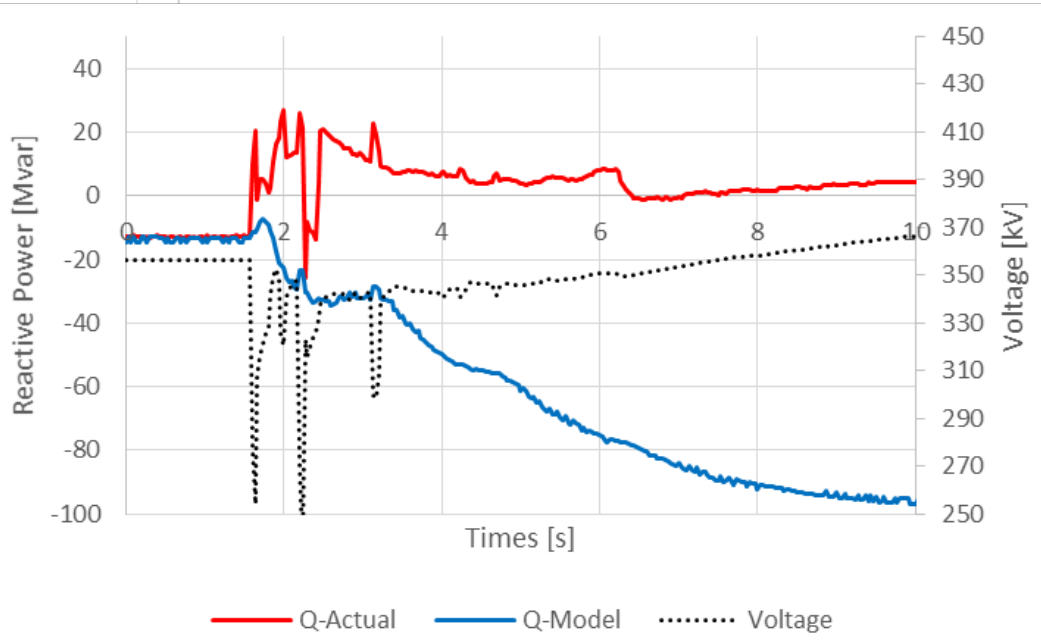


Wind Plant Modeling

Industry Efforts

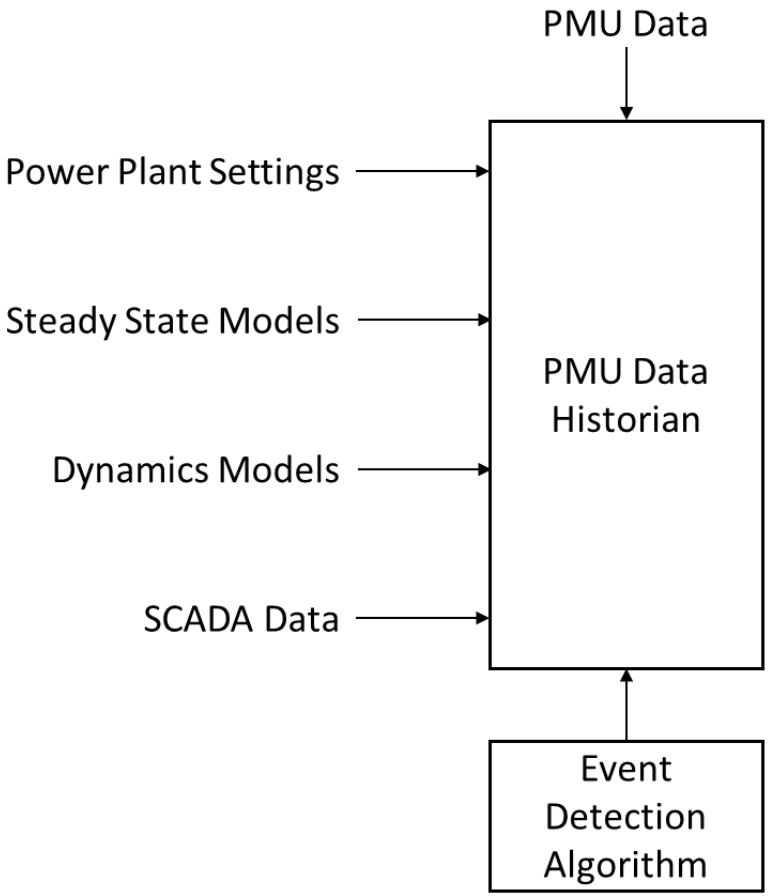


Hydro Machine Modeling



Generic Wind Model Testing

Power Plant Performance Monitoring



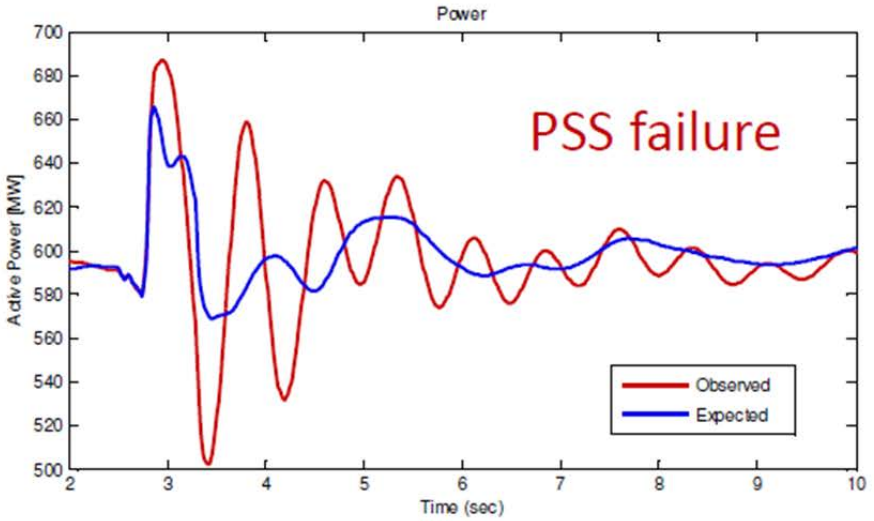
Automated Power Plant Model Verification

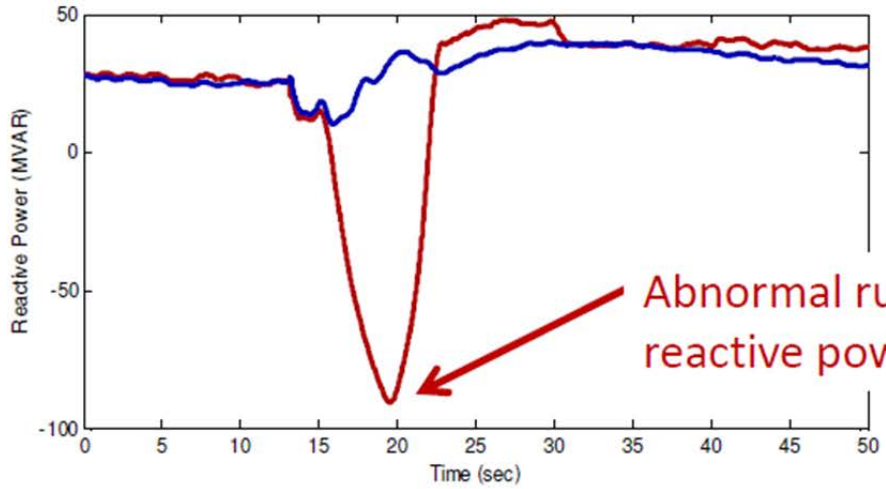
- Data Extraction
- Base Case Setup
- Stability Simulation

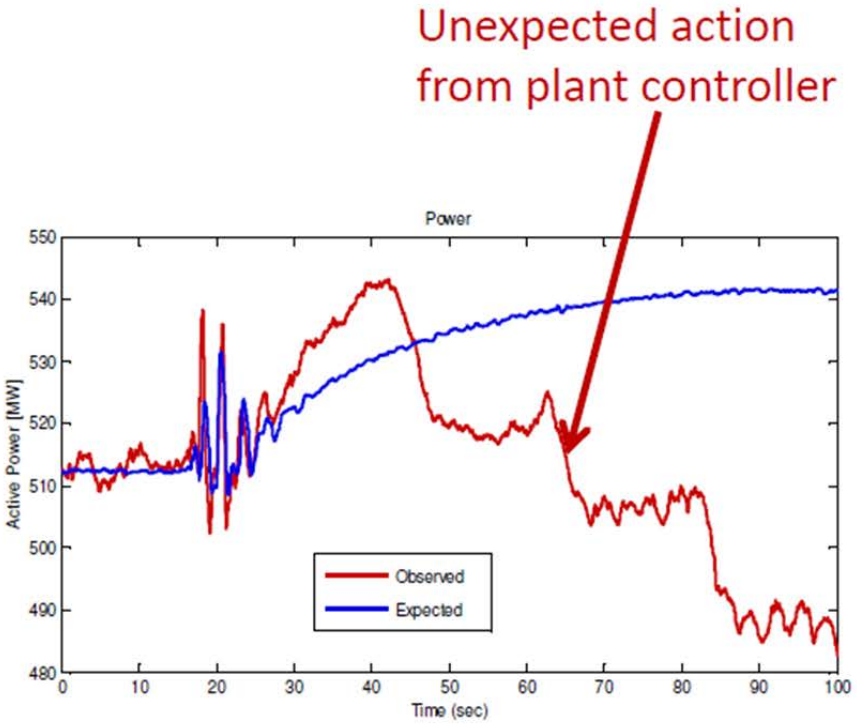
Intelligent Model Characterization

- Model Comparison
- Report Generation
- Automated Model and Control Issue Detection

Mitigating and Detecting Failures or Control Issues







Takeaways

- Disturbance-based PPMV is becoming a mainstream Planning function
  - Does not necessarily require advanced programs or functions – commonly used tools have playback capability for PPMV

- NERC SMS building user forum for PPMV – sharing experiences
- NERC Staff supporting development of industry capabilities

- Testing thus far has shown that ***majority*** of models are "wrong"
  - *Let's work together to correct them!*
- Encourage all Transmission Planners, Planning Coordinators, and Generator Owners to get involved

Questions and Answers

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