BPA PPMV Success Story

NASPI Workshop
October, 2016

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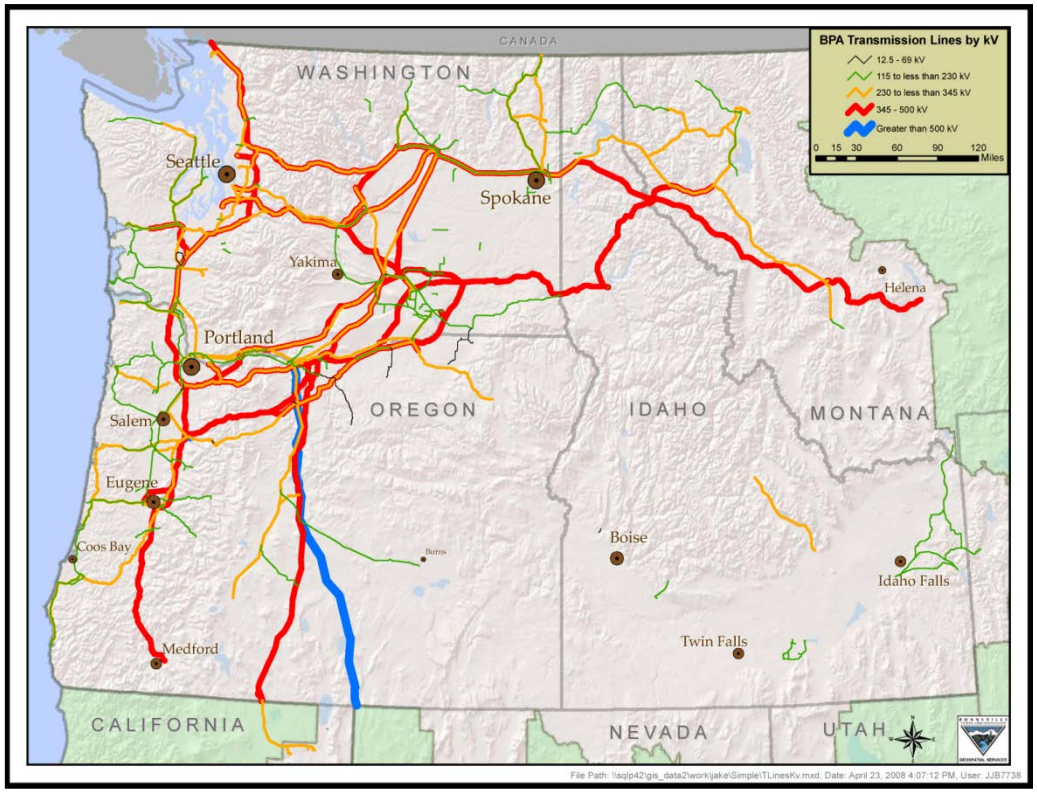
Bonneville Power Administration

Outline

- Dynamic Disturbance Recorders for PPMV at BPA
- PPMV2.0 tool and process
- WECC Certification
- CGS Calibration Success Story
- Going Beyond PPMV
- Summary

BPA Overview



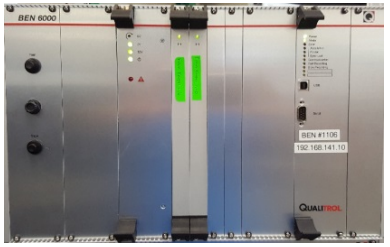
- Bonneville Power Administration (BPA) is a federal Power Marketing Agency in Pacific Northwest
- BPA markets power from 31 Federal dams and the Columbia Generating Station Nuclear Plant
- BPA operates more than 15,000 miles of transmission, including 4,735 miles of 500-kV lines

- BPA operates several large paths in the Western Interconnection – California Oregon AC Intertie (4,800 MW), Pacific HVDC Intertie (3,100 MW), Northern Intertie (3,100 MW), and Montana Intertie (2,200 MW)

Dynamic Disturbance Recorders (DDRs) for Model Validation at BPA

- Phasor Measurement Unit (PMU)
  - Output voltage and current phasors, calculated frequency, active and reactive power
  - Data can be archived locally and streamed to a control center in real time
  - Minimum filtering is preferred for model validation

- Point on Wave Recorders
  - Technologies:
    - DFRs with continuous recording capabilities (BEN6000)
    - Portable Power System Monitor (PPSM)
  - Output: point on wave voltages and currents
  - Data is archived locally, retrieved via FIN network
  - Phasor calculations are done off-line
  - Preferred technology for electronically connected equipment



Modern DDRs can combine Phasor and Point on Wave recording

BPA's DDR Coverage at POI

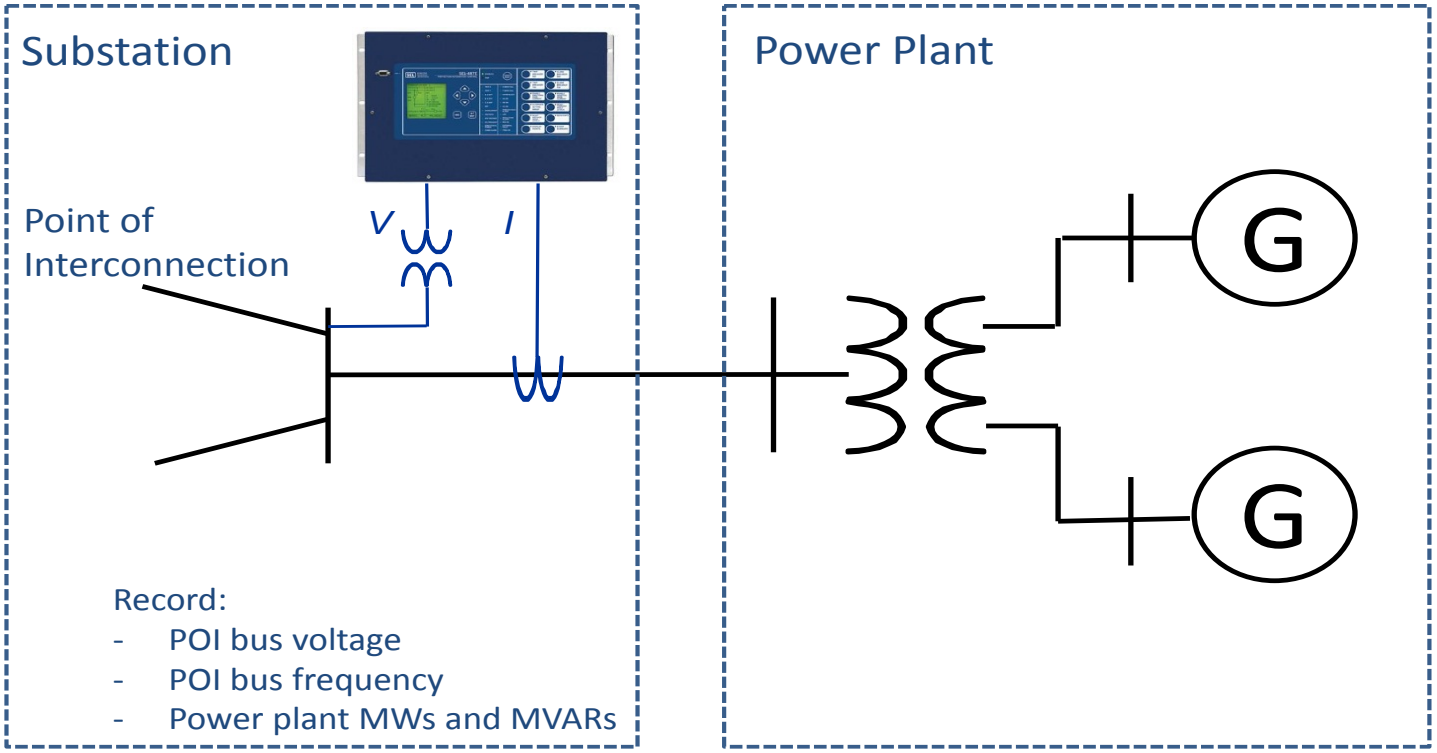
- Conventional –
  - 14 plants,
  - 133 generators,
  - 21,345 MW of generation

- Wind –
  - 12 plants
  - 1,200 MW of generation

- More to be added

DDRs at Point-of-Interconnection (POI)

- BPA has installed DDRs at power plant POIs since 1996
- BPA developed Power Plant Model Validation (PPMV) application using DDR data and GE PSLF play-in function (added in 2001)
- BPA requires PMU installation for all new generation including the wind

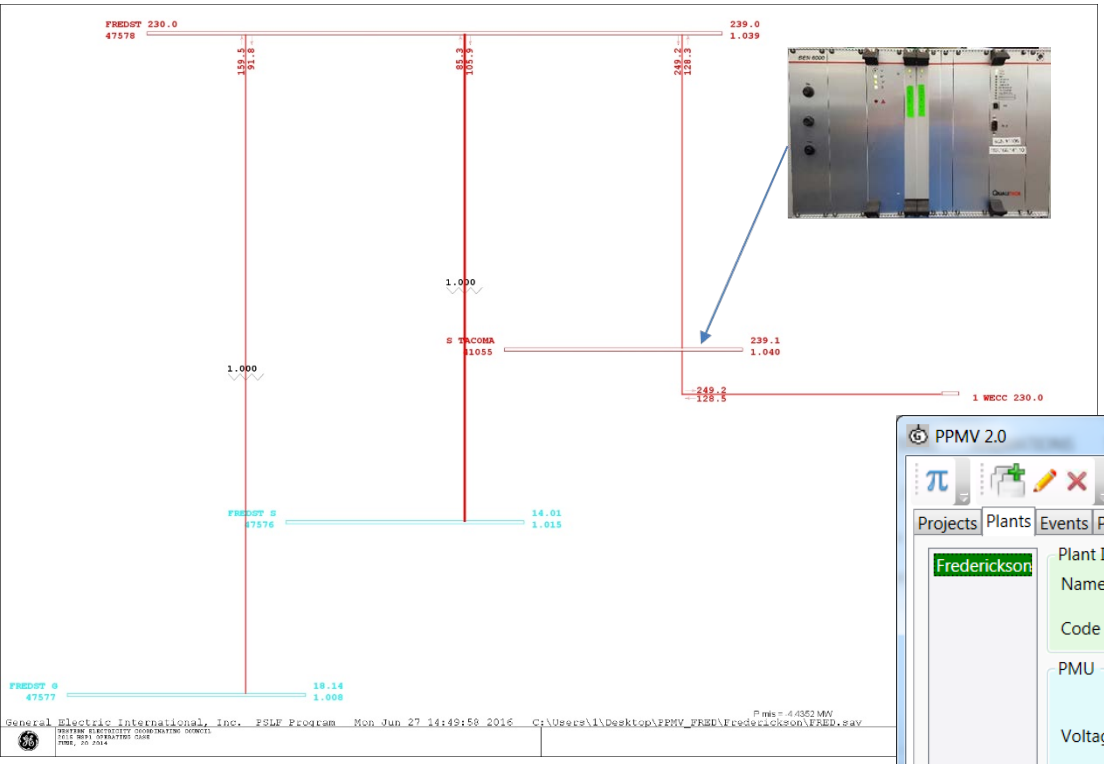


DDR needs to be placed at Power Plant POI

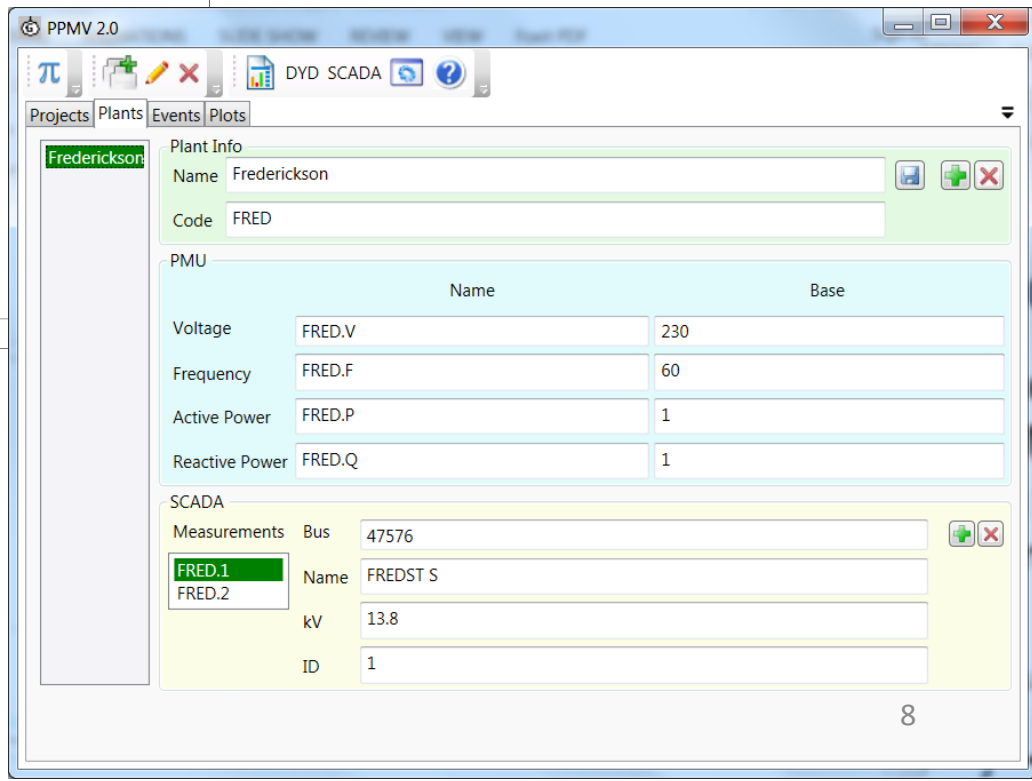
BPA PPMV Tools

- BPA PPMV
  - Sequence of GE PSLF EPCLs and MATLAB programs
- **BPA-PNNL PPMV 2.0**
  - Stand-alone data management program and automated PSLF interfaces (now works with PSSE)
- EPRI PPPD
  - Stand-alone MATLAB based software

PPMV Process: Initial Set-up



Extract power plant data from WECC basecase and build a sub-system

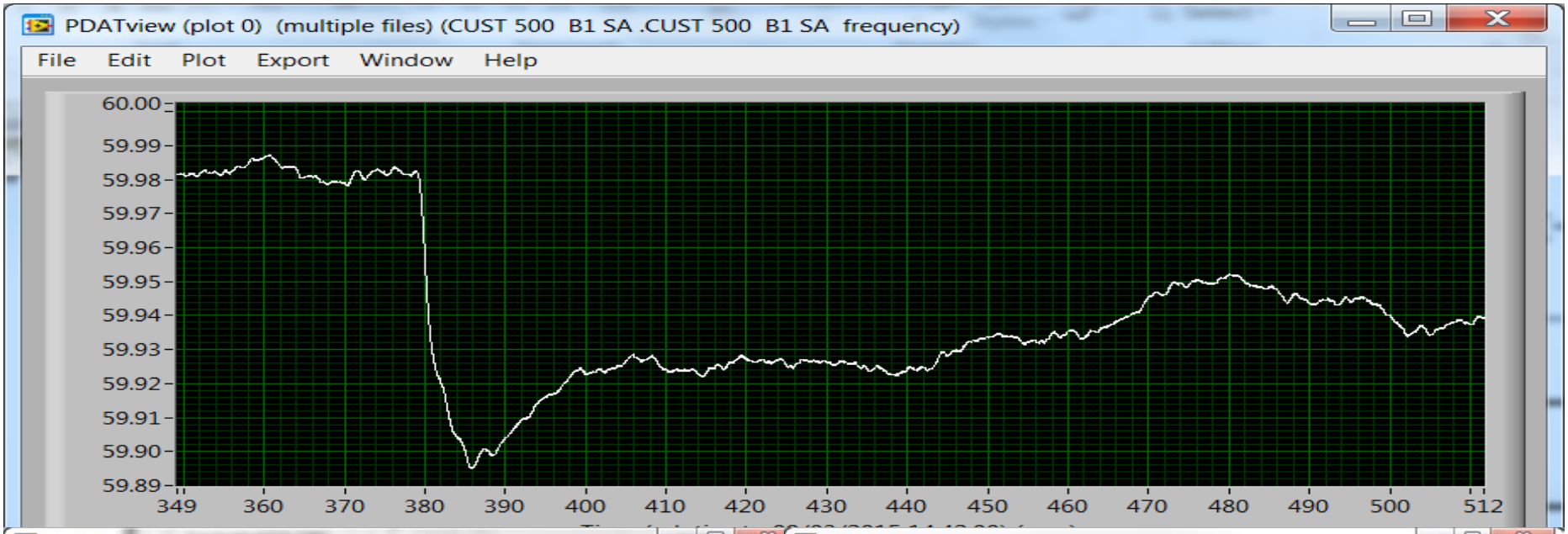


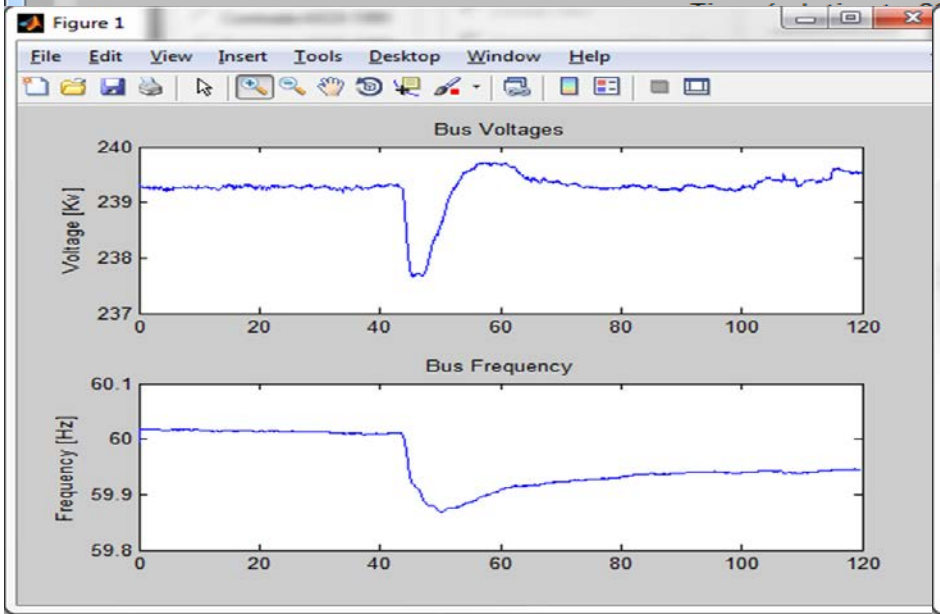
Enter plant information

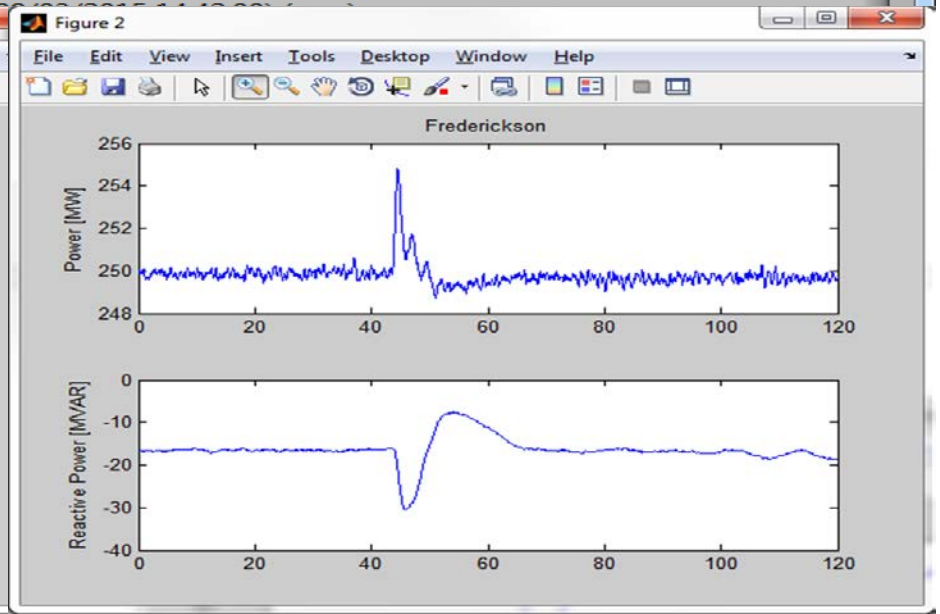
PPMV Process: Event Notifications

- BPA frequency event detection program
- BPA event detector
- WECC JSIS event alerts
- DFR triggers
- StreamReader trending displays

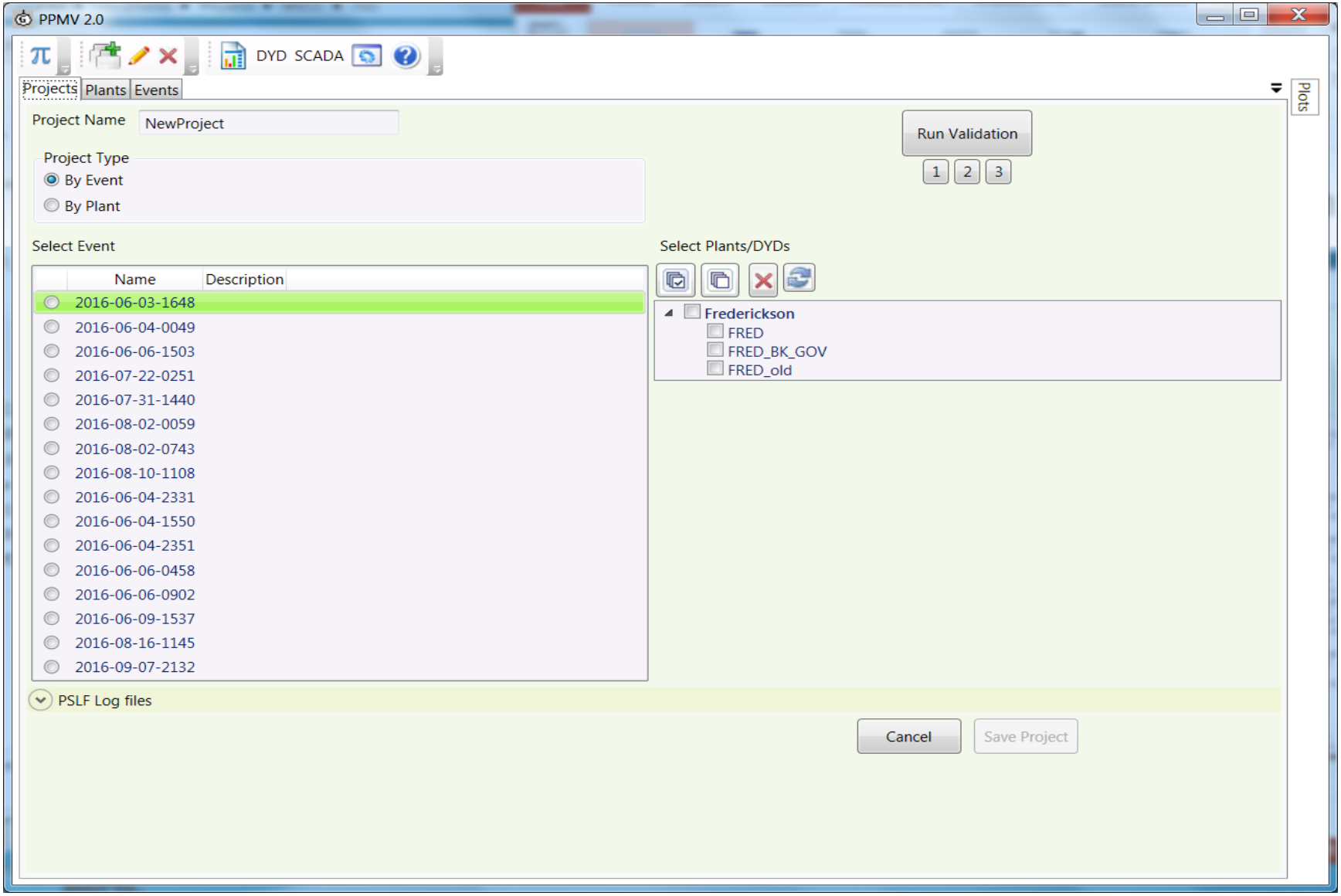
PPMV Process: Collect and Review Data



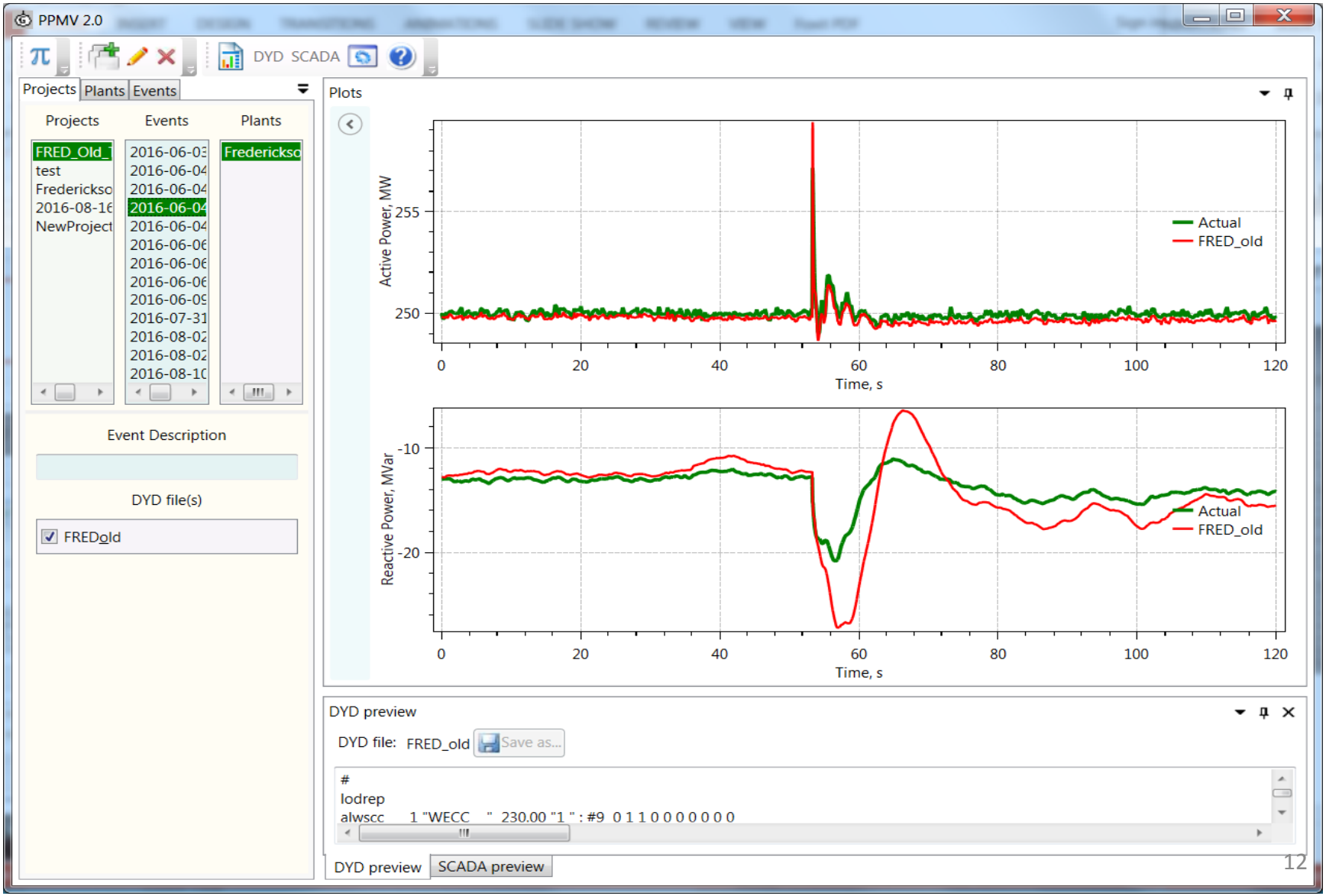




PPMV Process: Run Validation



PPMV Process: Initial Results

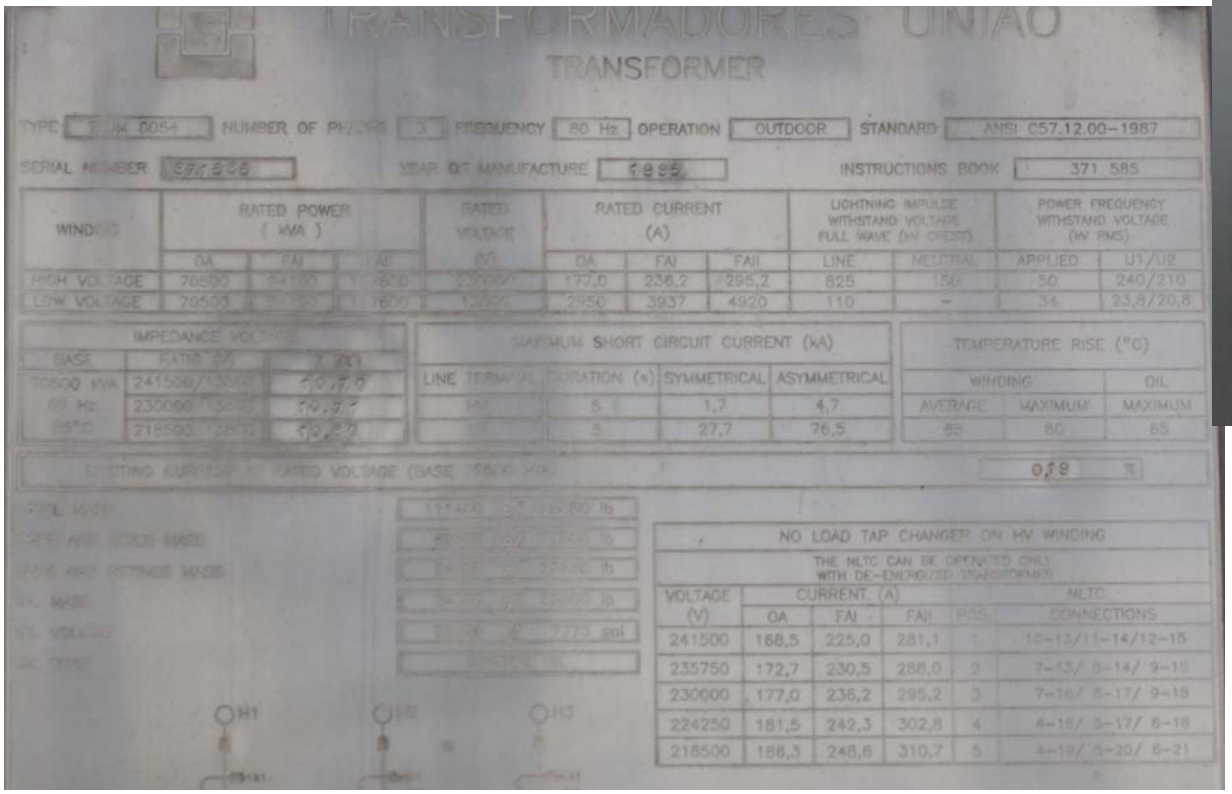


PPMV Process: When models and reality don't agree

- Model validation studies need to be done over several events
- It is very rare to get a good match for all events because operating mode can be different (e.g. generator is ramping, generator on AGC responding to a contingency)
- Frequent reasons for systemic model mismatch include:
  - **Wrong powerflow data**
  - PSS status / gain
  - Inertia time constant
  - AVR gain

PPMV Process: Transformer Name Plate and Tap Setting

Check transformer impedances and taps


TRANSFORMER

TYPE NUMBER OF PHASES 3 FREQUENCY 60 Hz OPERATION OUTDOOR STANDARD ANSI C57.12.00-1987

SERIAL NUMBER YEAR OF MANUFACTURE 1995 INSTRUCTIONS BOOK 371 585

WINDING	RATED POWER (kVA) OA	FA	AF	RATED VOLTAGE (V)	RATED CURRENT (A) OA	FA	FAF	LIGHTNING IMPULSE WITHSTAND VOLTAGE FULL WAVE (kV CREST) LINE	NEUTRAL	POWER FREQUENCY WITHSTAND VOLTAGE (kV RMS) APPLIED	U1/U2
HIGH VOLTAGE	70500				177,0	236,2	295,2	825	150	50	240/210
LOW VOLTAGE	70500				2950	3937	4920	110	–	34	23,8/20,8

IMPEDANCE VOLTAGE BASE	RATIO (kV)	Z (%)
70500 kVA	241500/13800	10,70
60 Hz	230000/13800	10,71
65°C	218500/13800	10,72

MAXIMUM SHORT CIRCUIT CURRENT (kA) LINE TERMINAL	DURATION (s)	SYMMETRICAL	ASYMMETRICAL
H1	5	1,7	4,7
	5	27,7	76,5

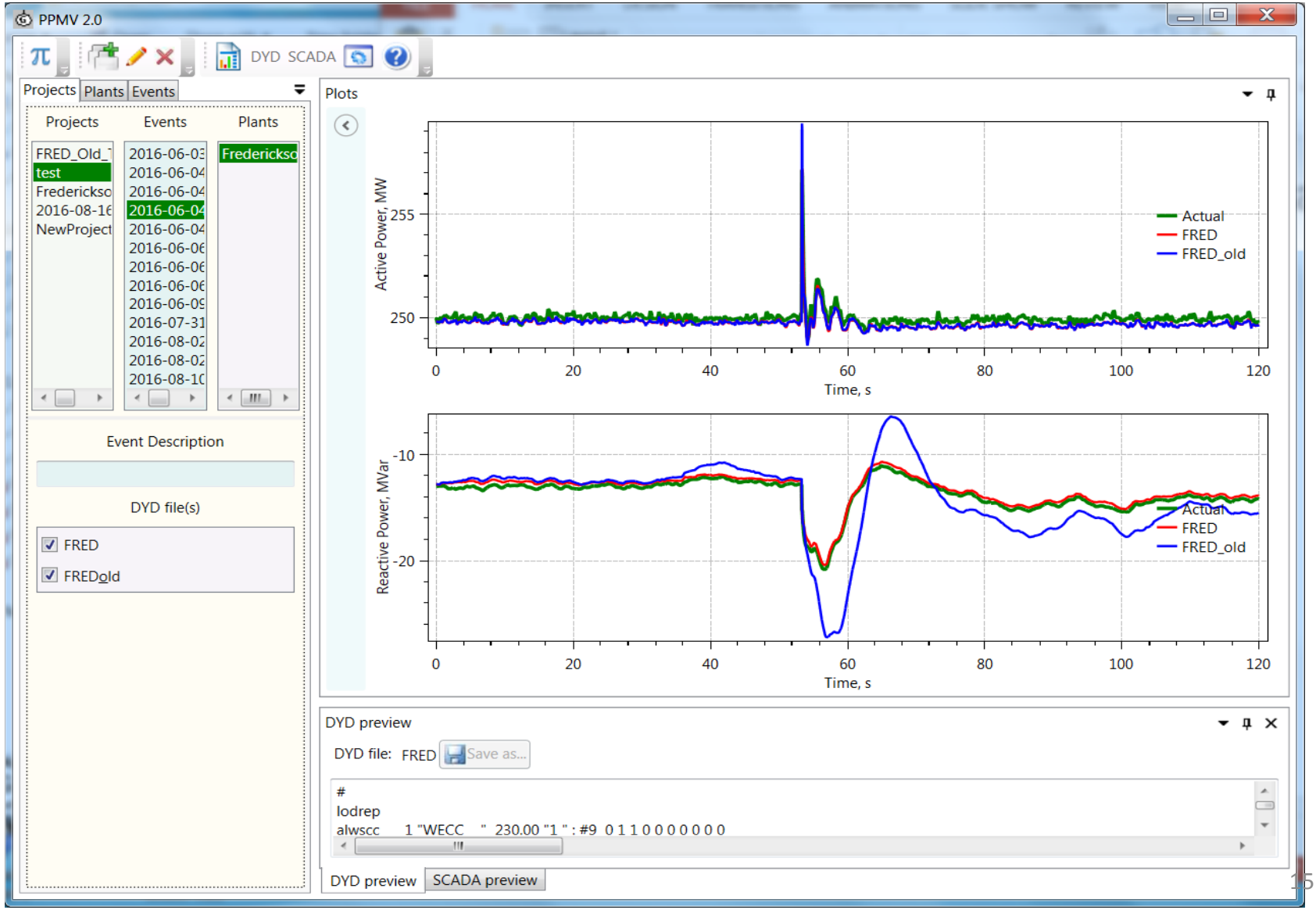
TEMPERATURE RISE (°C) WINDING AVERAGE	WINDING MAXIMUM	OIL MAXIMUM
65	80	65

LIFTING DURING AT RATED VOLTAGE (BASE 70500 kVA) 0,58 %

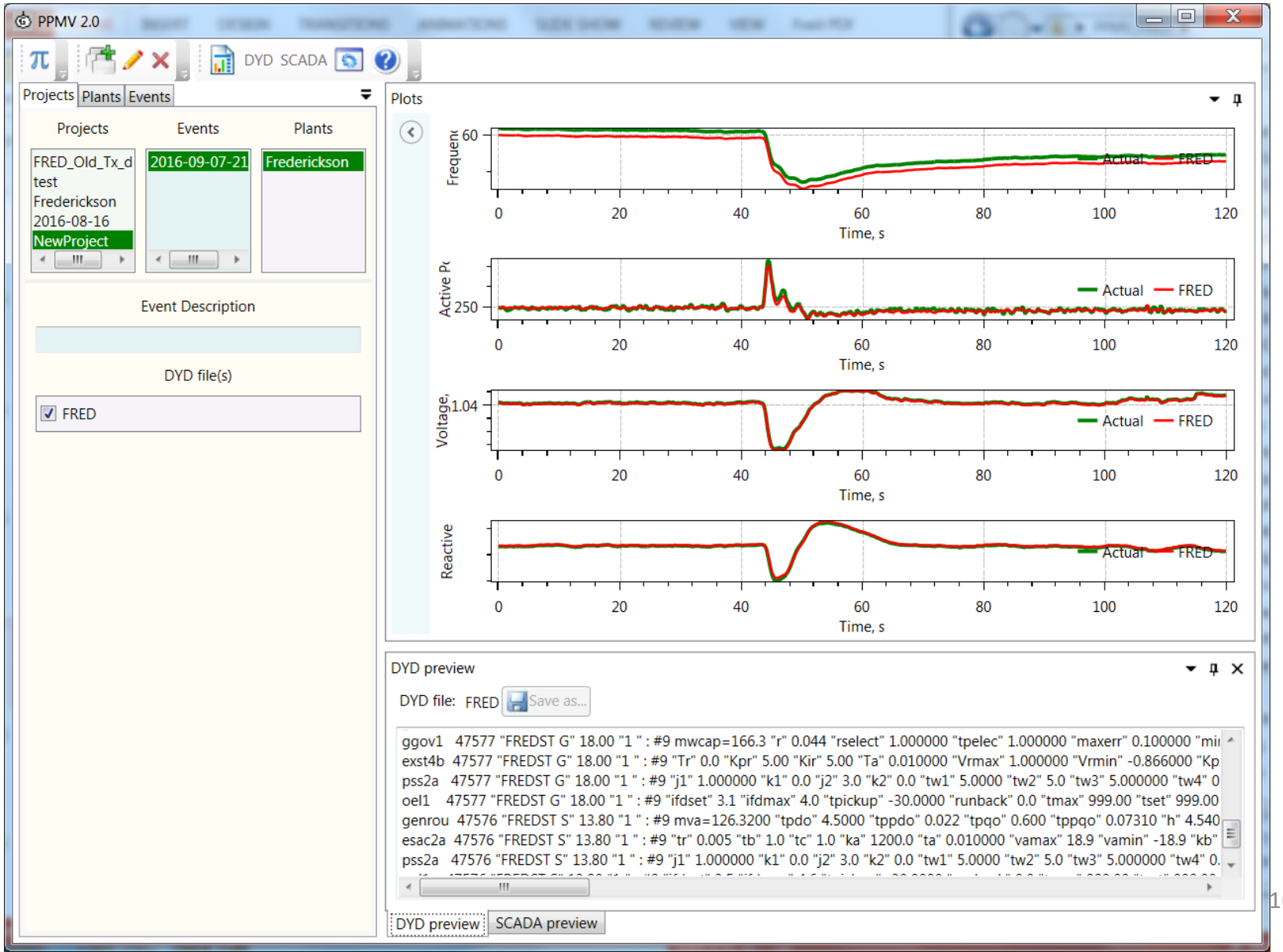
NO LOAD TAP CHANGER ON HV WINDING — THE NLTC CAN BE OPERATED ONLY WITH DE-ENERGIZED TRANSFORMER					
VOLTAGE (V)	CURRENT (A) OA	FA	FAI	POS.	NLTC CONNECTIONS
241500	168,5	225,0	281,1	1	10-13/11-14/12-15
235750	172,7	230,5	288,0	2	7-13/ 8-14/ 9-15
230000	177,0	236,2	295,2	3	7-16/ 8-17/ 9-18
224250	181,5	242,3	302,8	4	4-16/ 5-17/ 6-18
218500	186,3	248,6	310,7	5	4-19/ 5-20/ 6-21

H1 H2 H3

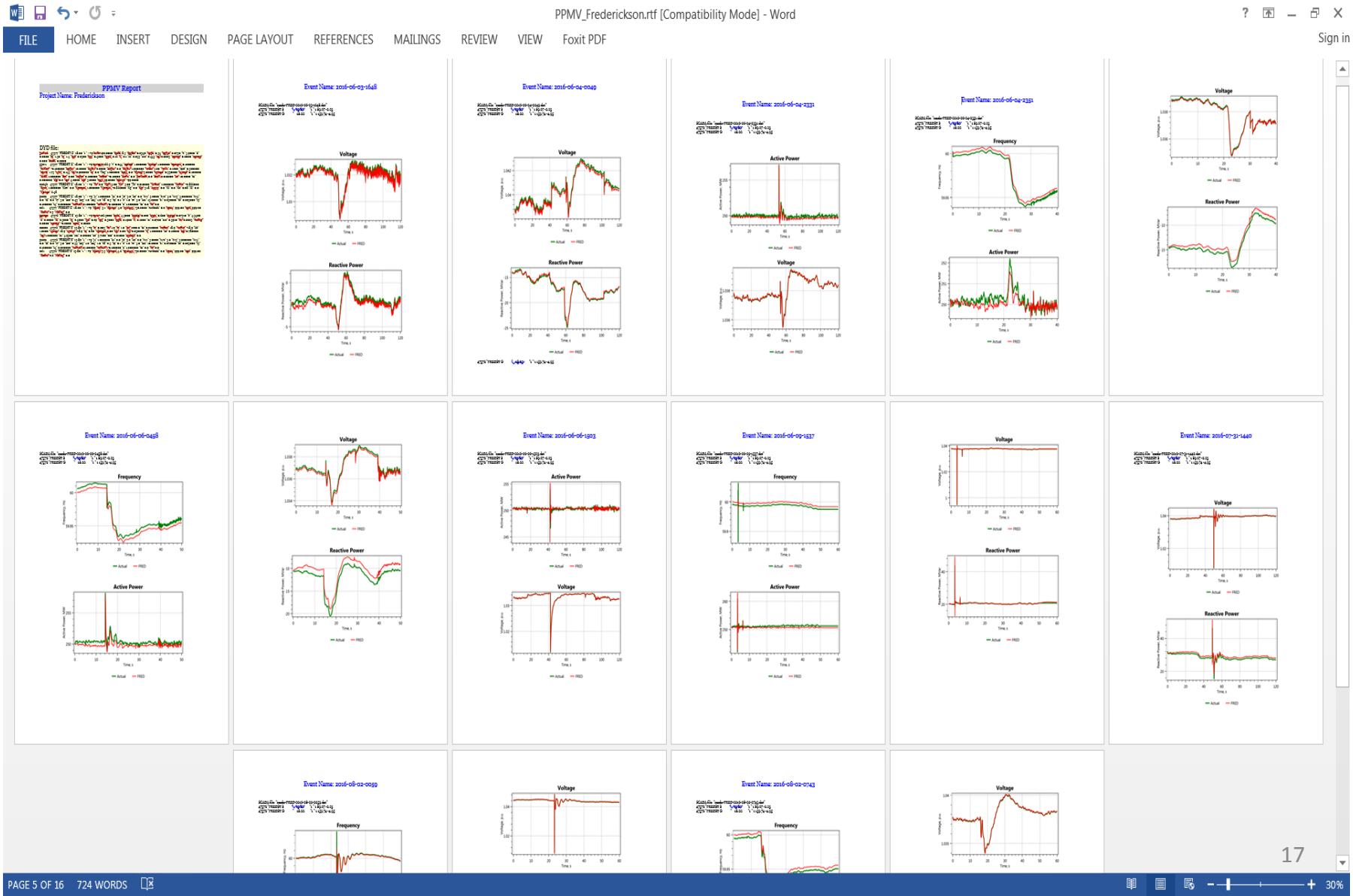
PPMV Process: New Transformer Data



PPMV Process: Review Results



PPMV Process: Generate Report



WECC Re-Certification of Centralia Power Plant

WECC

WECC GENERATOR TESTING AND VALIDATION PROGRAM

CERTIFICATE OF TESTING

Centralia Units 1 & 2

TransAlta Centralia Generation, LLC

have complied with the WECC *Generating Unit Model Validation Policy* and the *Synchronous Machine Reactive Limits Verification* guidelines.

Date of Issue — April 30, 2016
Date of Expiration — April 30, 2021

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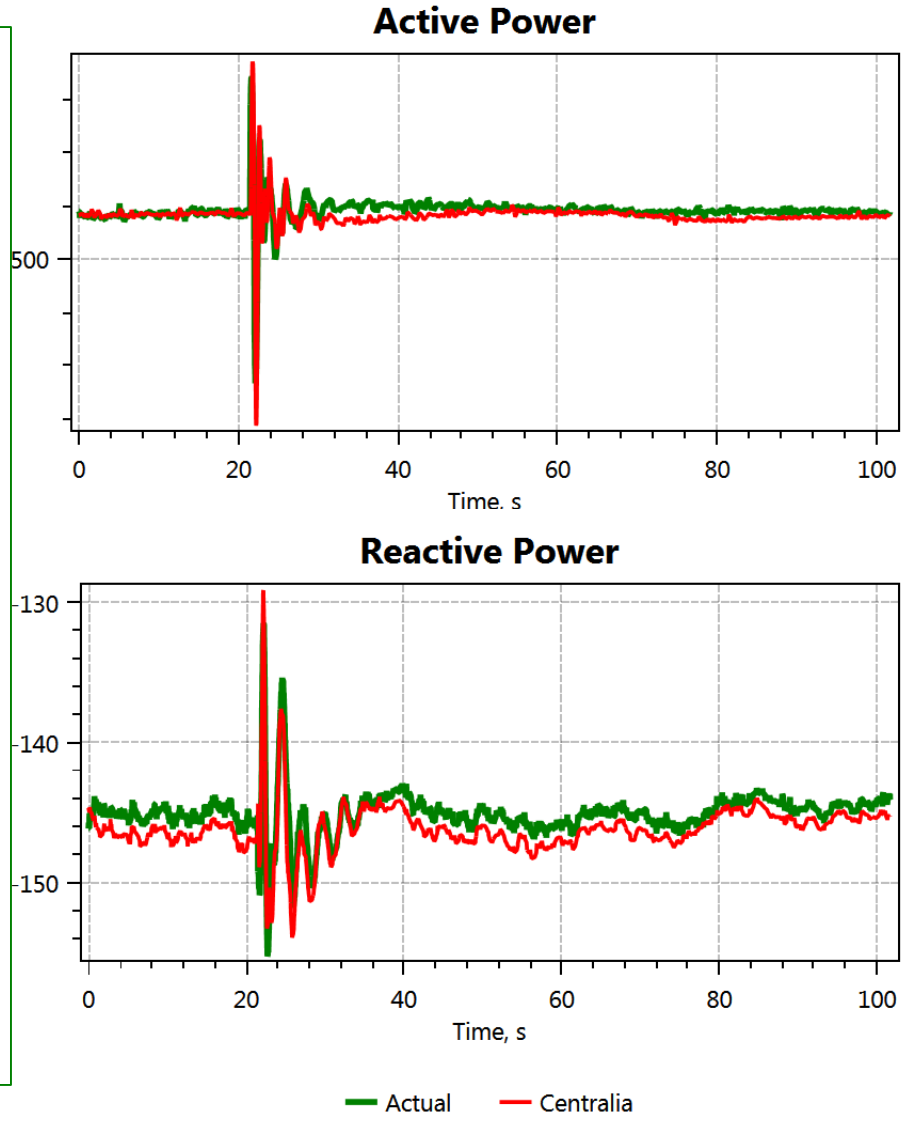
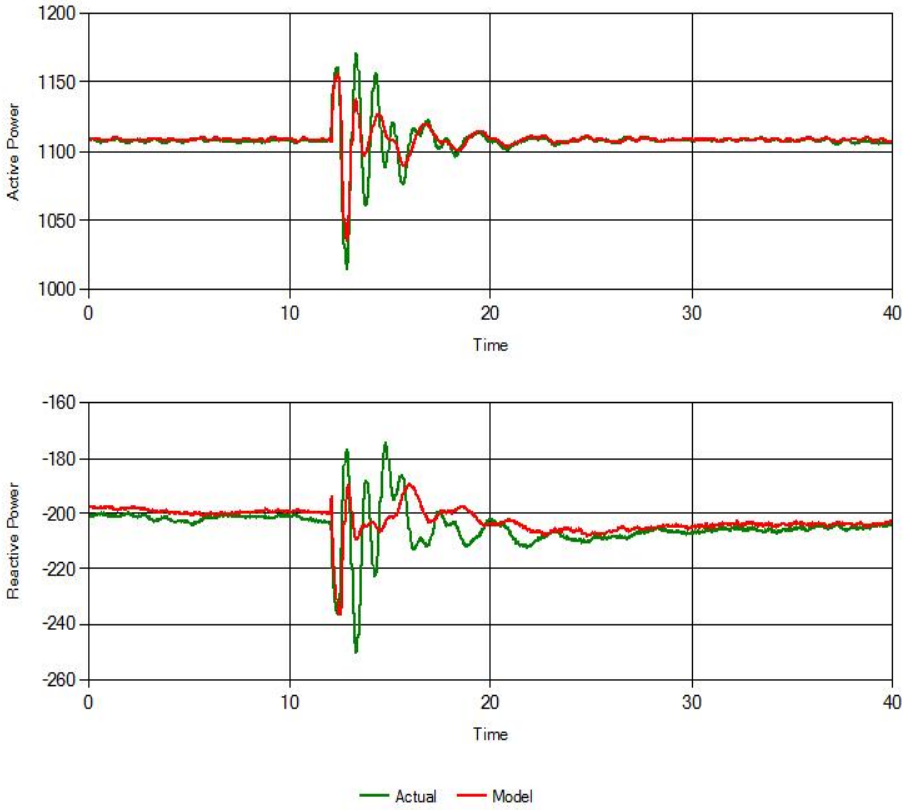
WESTERN ELECTRICITY COORDINATING COUNCIL

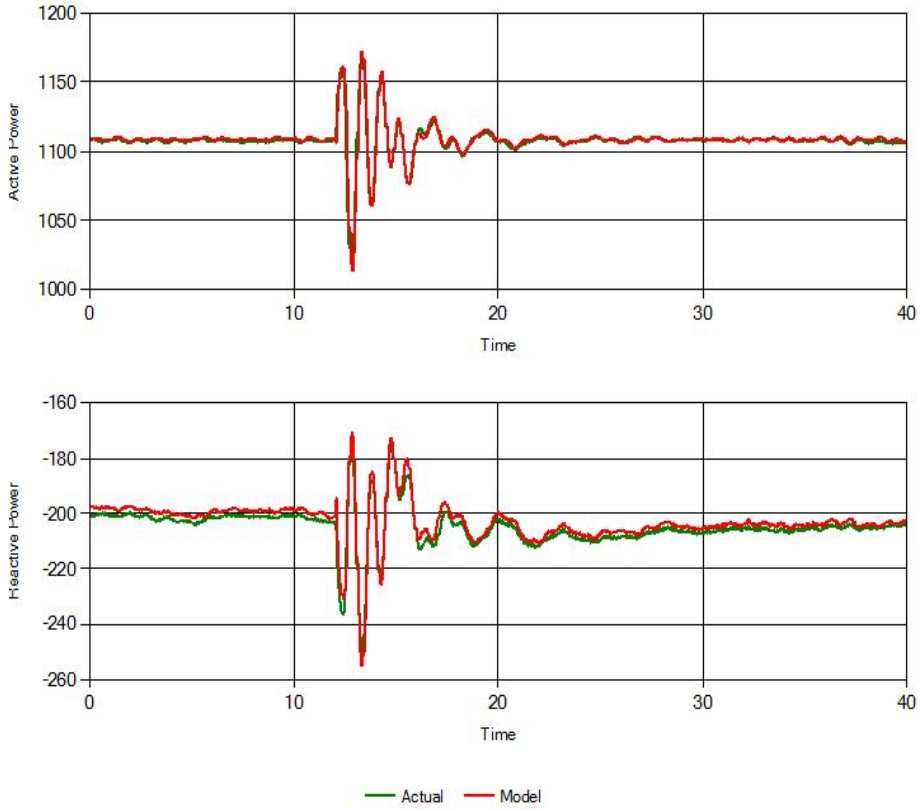


CGS Calibration

Before calibration



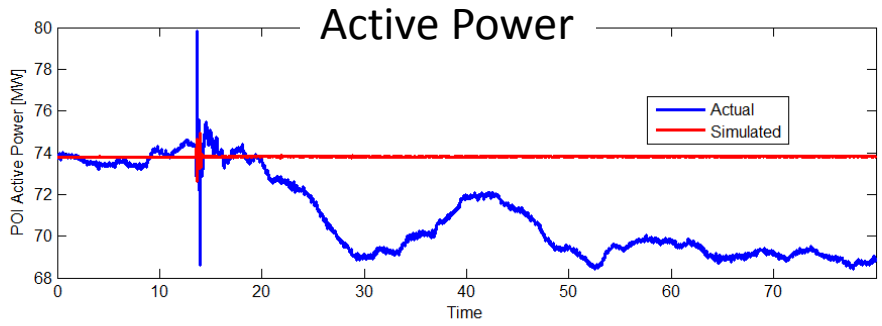
After calibration

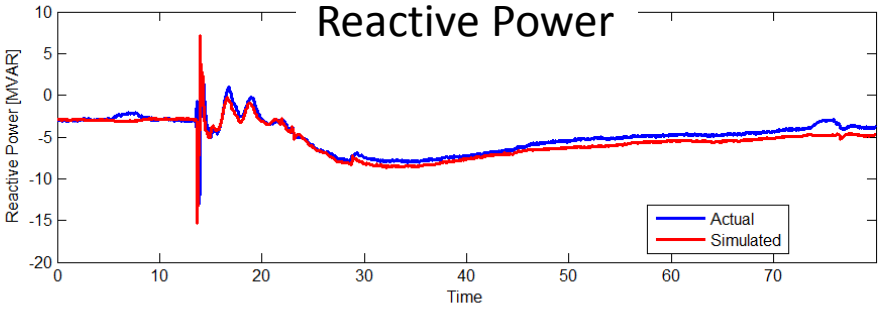


- Collaboration with Bernie Lesieutre (University of Wisconsin)
- We ran more than 30 events and counting
- PPMV can *complement* model development and calibration, there are successful case studies. However, engineering expertise and knowledge of generator controls are essential. Beware of curve fitting exercises

Wind Power Plant Model Validation

- BPA installed PMUs at 12 wind power plants
- BPA is working with wind power plant operators, wind turbine manufacturers on model
- Initial results are very encouraging

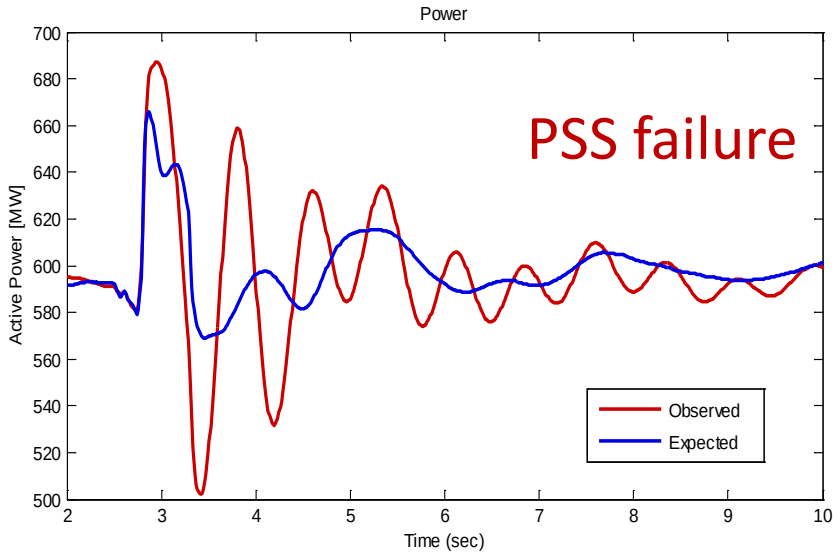


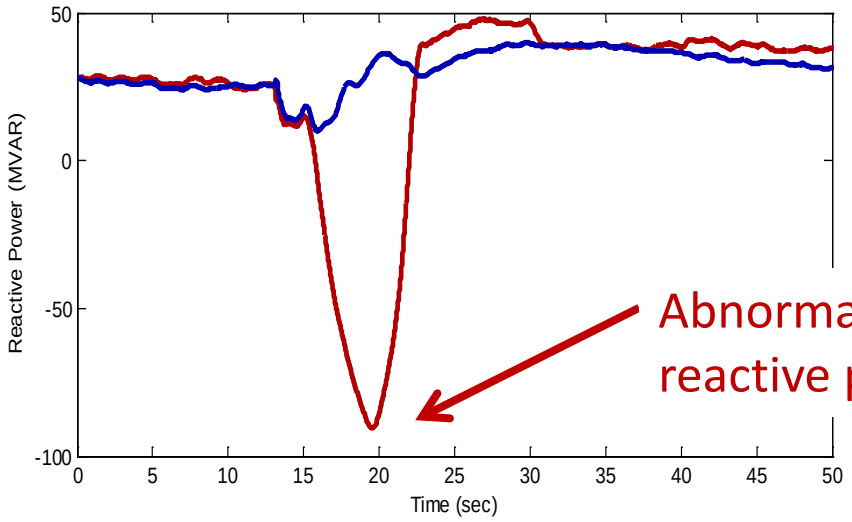


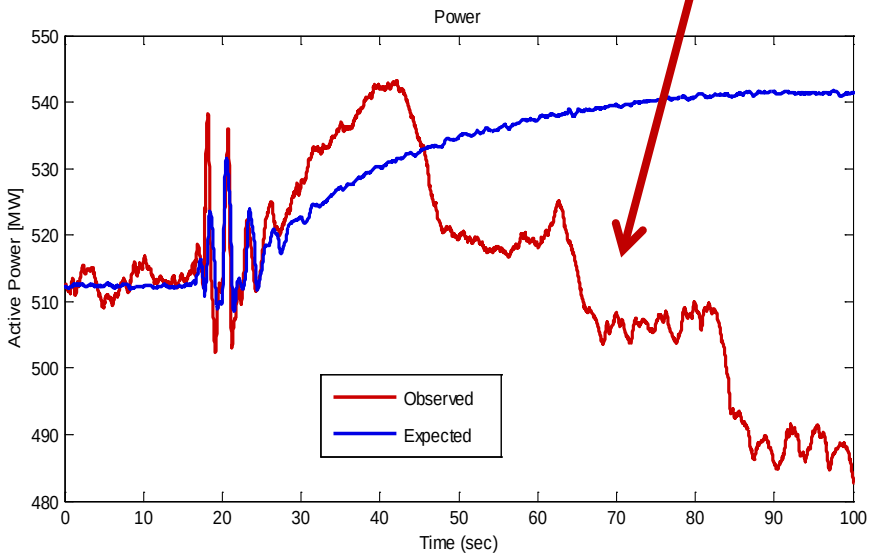
White Creek Power plant: Reasonable agreement between actual and simulated reactive power for a grid disturbance

Performance Monitoring and Detection of Control Failures

- PMU monitoring provides detection of generator abnormalities







Summary

- PPMV using Dynamic Disturbance Recorders
  - Provide a cost-effective approach for periodic model verification as required by MOD-026,MOD-027 and WECC policy
  - Give Transmission Planners independent way to validate power plant dynamic performance and models
  - Can be used in real-time performance monitoring
- Several technology solutions are available
- Model validation tools are mature and well-developed
  - A number of success stories
  - Disturbance model validation is a part of regular business process at BPA

Thank You!

Contact information:

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