



BPA PPMV Success Story

NASPI Workshop
October, 2016

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Bonneville Power Administration

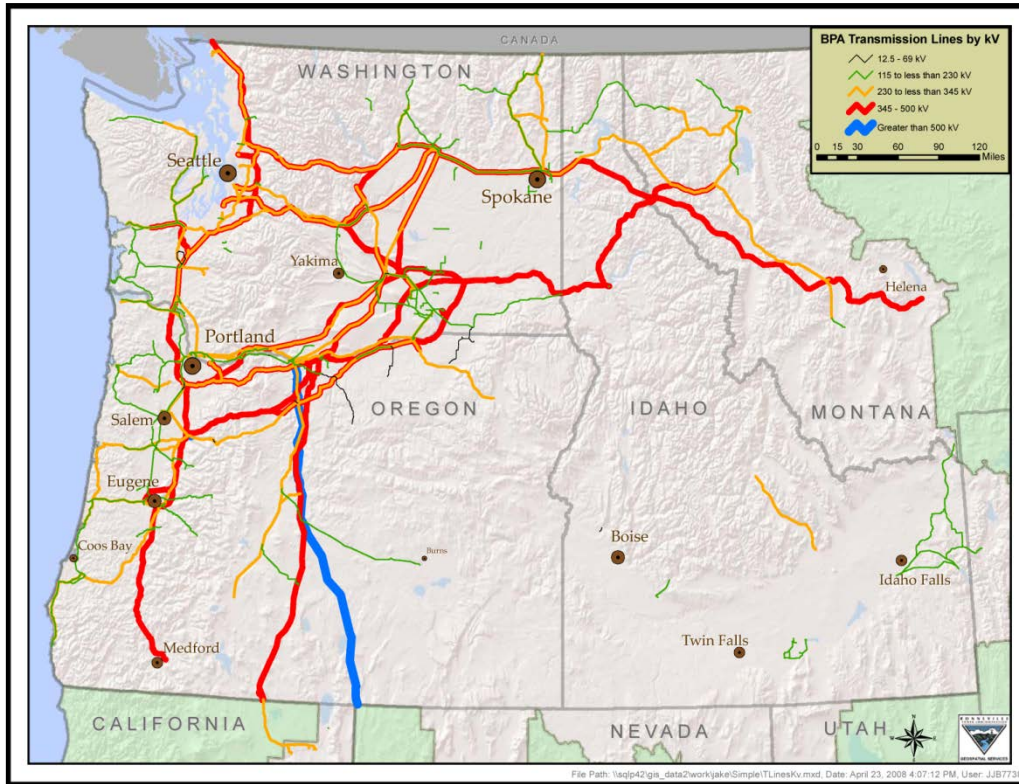


Outline

- 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



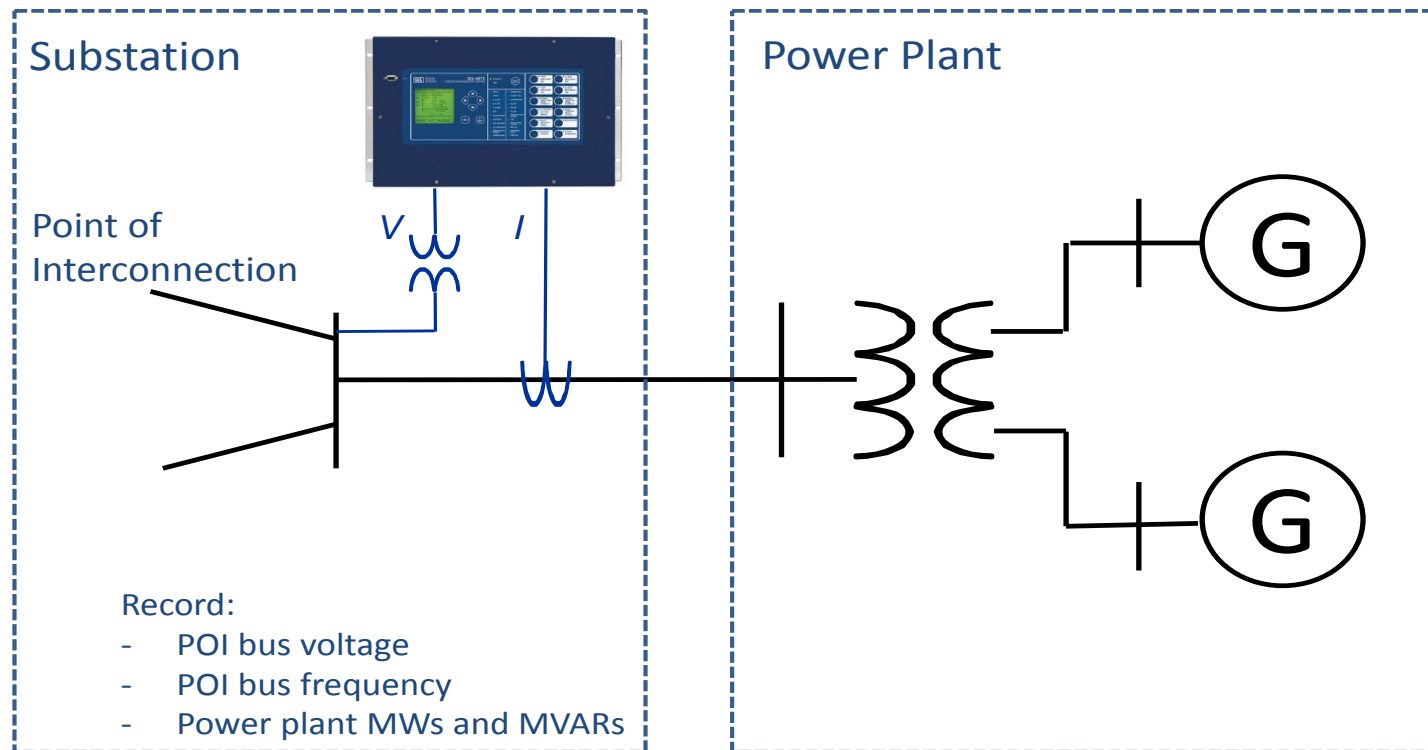
BPA's DDR Coverage at POI

- 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

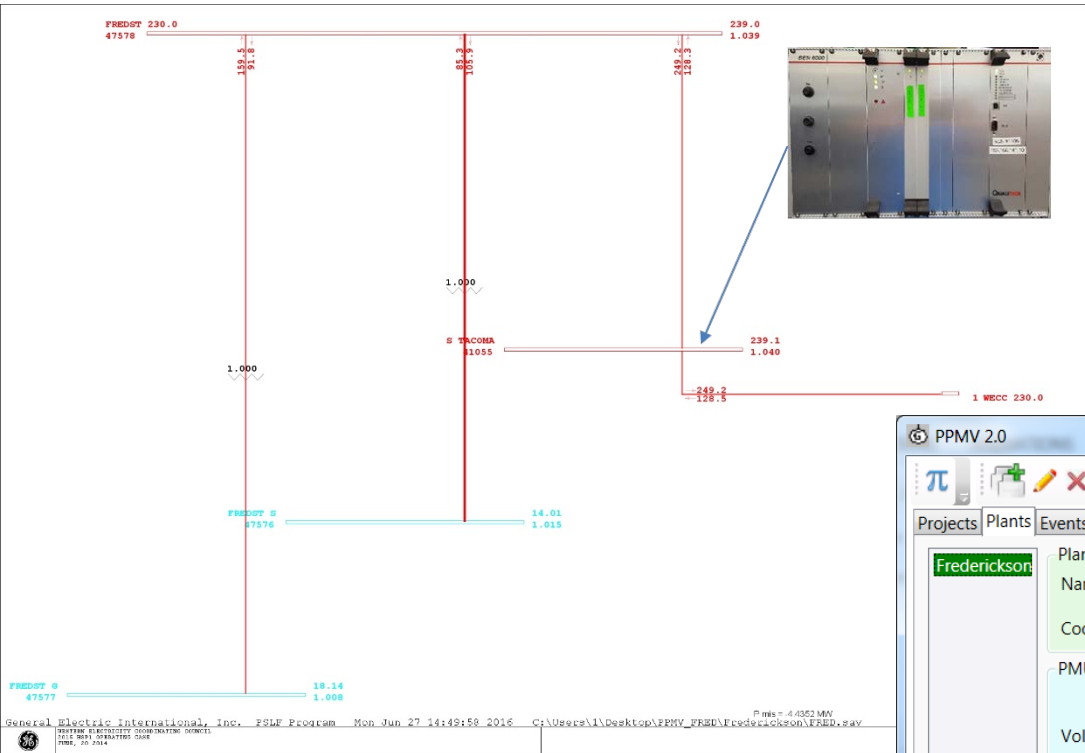


BPA PPMV Tools

- 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 2.0

Projects Plants Events Plots

Frederickson

Plant Info

Name Frederickson

Code FRED

PMU

	Name	Base
Voltage	FRED.V	230
Frequency	FRED.F	60
Active Power	FRED.P	1
Reactive Power	FRED.Q	1

SCADA

Measurements Bus 47576

FRED.1 Name FREDST S

FRED.2 kV 13.8

ID 1

8

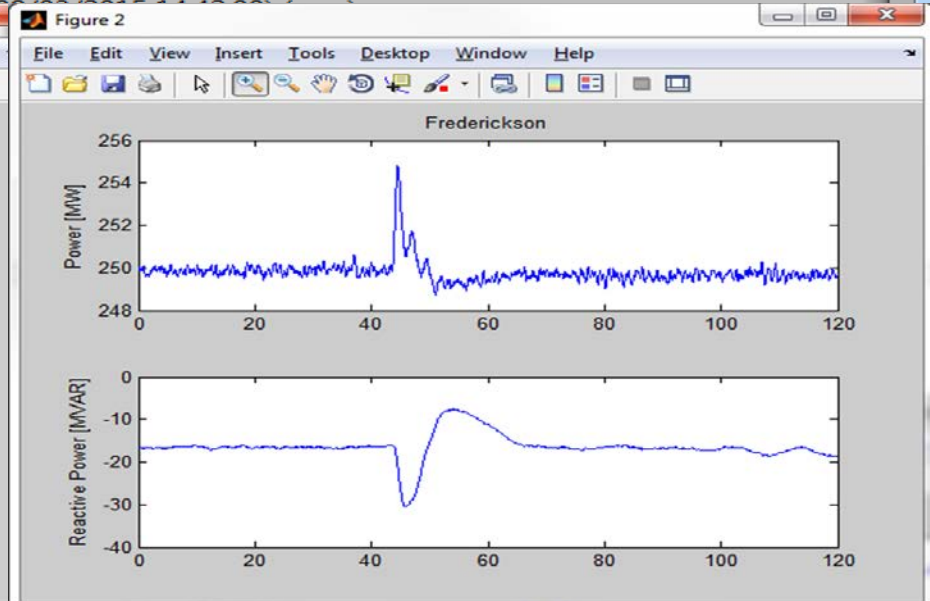
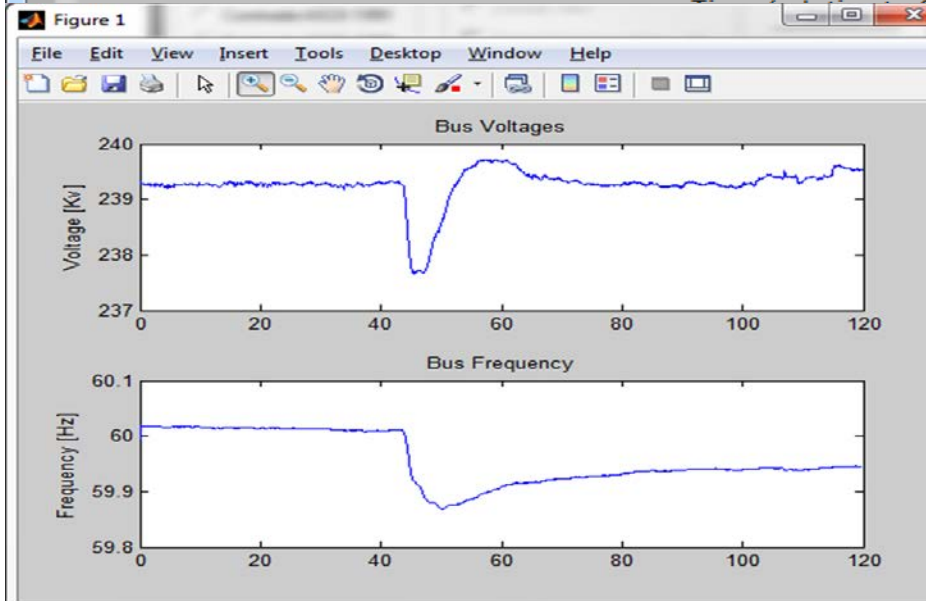
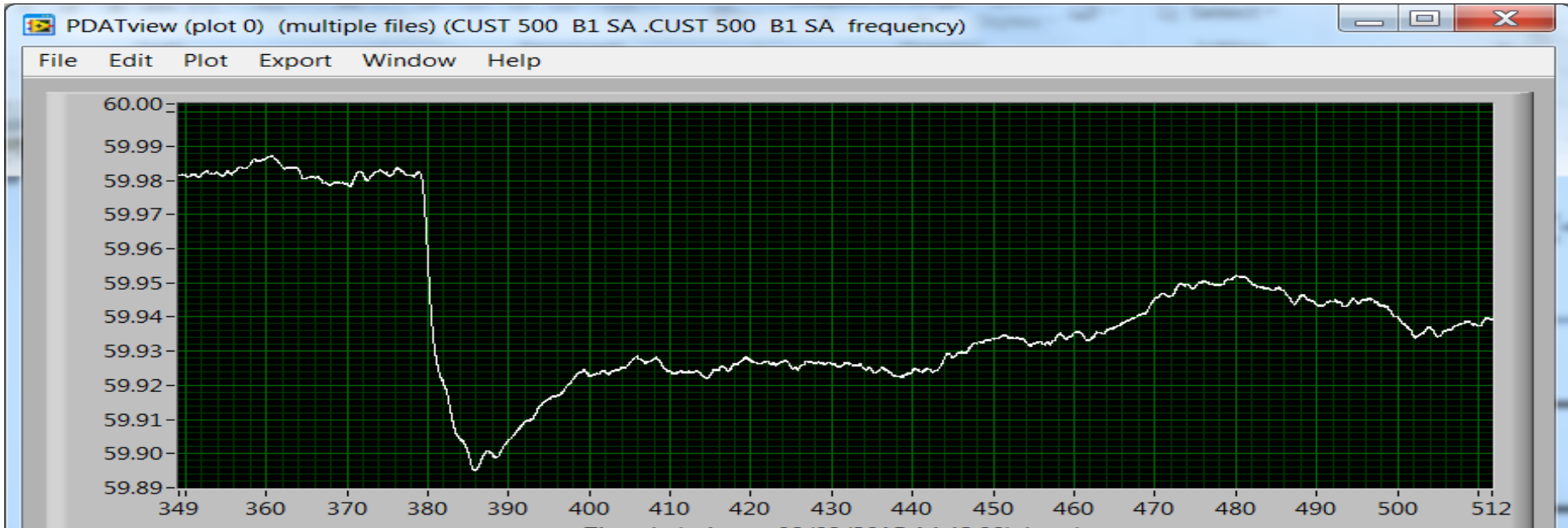


PPMV Process: Event Notifications

- 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 2.0

Projects Plants Events

Project Name:

Project Type:
 By Event
 By Plant

Run Validation
1 2 3

Select Event

	Name	Description
<input checked="" type="radio"/>	2016-06-03-1648	
<input type="radio"/>	2016-06-04-0049	
<input type="radio"/>	2016-06-06-1503	
<input type="radio"/>	2016-07-22-0251	
<input type="radio"/>	2016-07-31-1440	
<input type="radio"/>	2016-08-02-0059	
<input type="radio"/>	2016-08-02-0743	
<input type="radio"/>	2016-08-10-1108	
<input type="radio"/>	2016-06-04-2331	
<input type="radio"/>	2016-06-04-1550	
<input type="radio"/>	2016-06-04-2351	
<input type="radio"/>	2016-06-06-0458	
<input type="radio"/>	2016-06-06-0902	
<input type="radio"/>	2016-06-09-1537	
<input type="radio"/>	2016-08-16-1145	
<input type="radio"/>	2016-09-07-2132	

Select Plants/DYDs

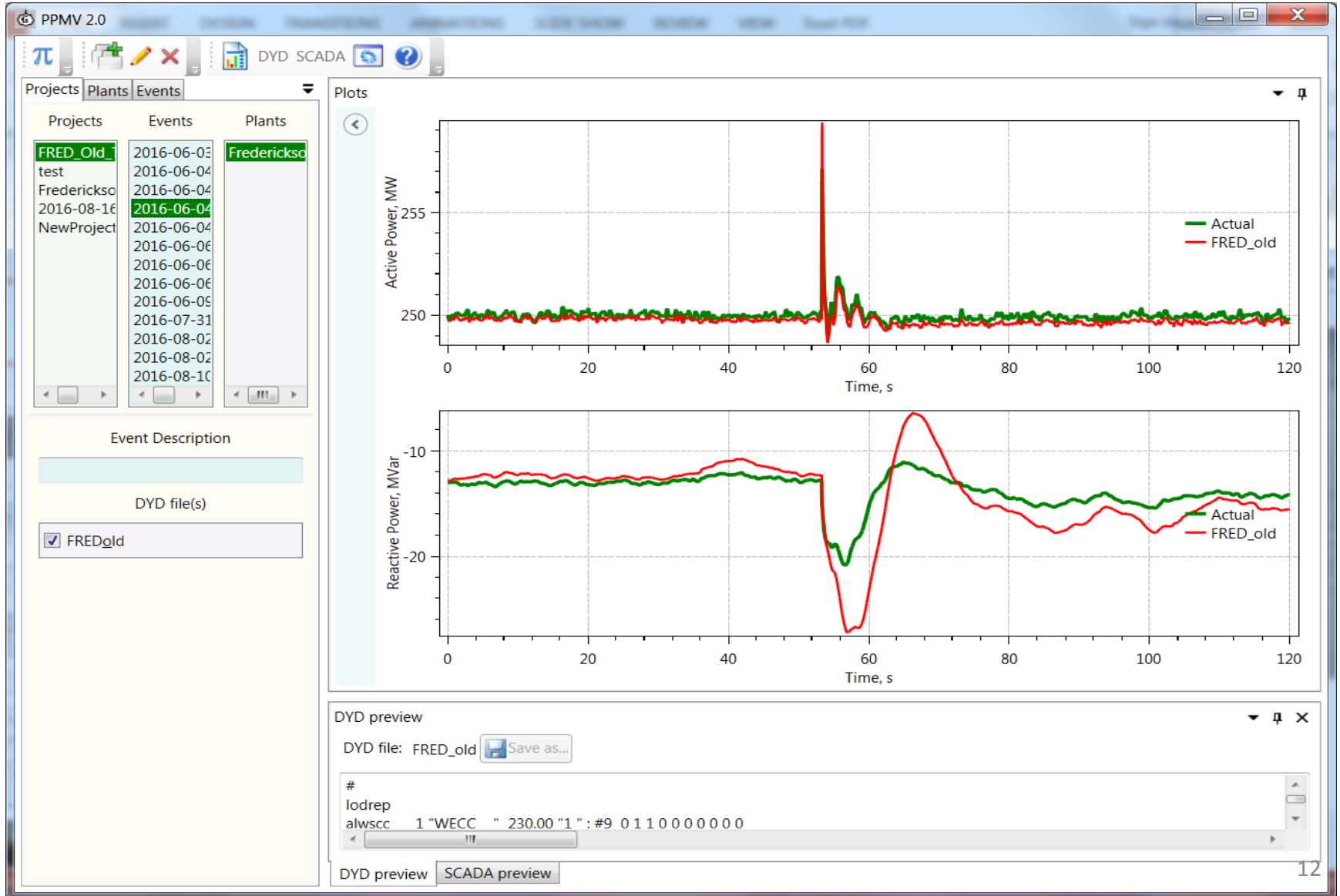
Frederickson
 FRED
 FRED_BK_GOV
 FRED_old

PSLF Log files

Cancel Save Project



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

TRANSFORMADORES UNIAO
TRANSFORMER

TYPE TJW 0054 NUMBER OF PHASES 3 FREQUENCY 60 Hz OPERATION OUTDOOR STANDARD ANSI C57.12.00-1987

SERIAL NUMBER 592506 YEAR OF MANUFACTURE 1995 INSTRUCTIONS BOOK 371 585

WINDING	RATED POWER (kVA)			RATED VOLTAGE (V)	RATED CURRENT (A)			LIGHTNING IMPULSE WITHSTAND VOLTAGE FULL WAVE (kV CR10/50)	POWER FREQUENCY WITHSTAND VOLTAGE (kV RMS)		
	OA	FAI	FAI		LINE	NEUTRAL	APPLIED		U1/U2		
HIGH VOLTAGE	20500	24100	17800	23000	177,0	236,2	295,2	825	150	50	240/210
LOW VOLTAGE	20500	24100	17800	12500	2950	3937	4920	110	-	34	23,8/20,8

BASE	IMPEDANCE (%)		MAXIMUM SHORT CIRCUIT CURRENT (kA)		TEMPERATURE RISE (°C)		
	RATIO (V)	Z (%)	LINE TERMINAL	ASYNMETRICAL	WINDING		OIL
20500 kVA	241500/13500	10,80	5	1,7	AVERAGE		MAXIMUM
60 Hz	230000/13500	10,97	5	27,7	MAXIMUM		MAXIMUM
85°C	218500/13500	10,80	5	27,7	65	80	85

LISTING SURPLUS AT RATED VOLTAGE (BASE 100% VA) 0,8 %

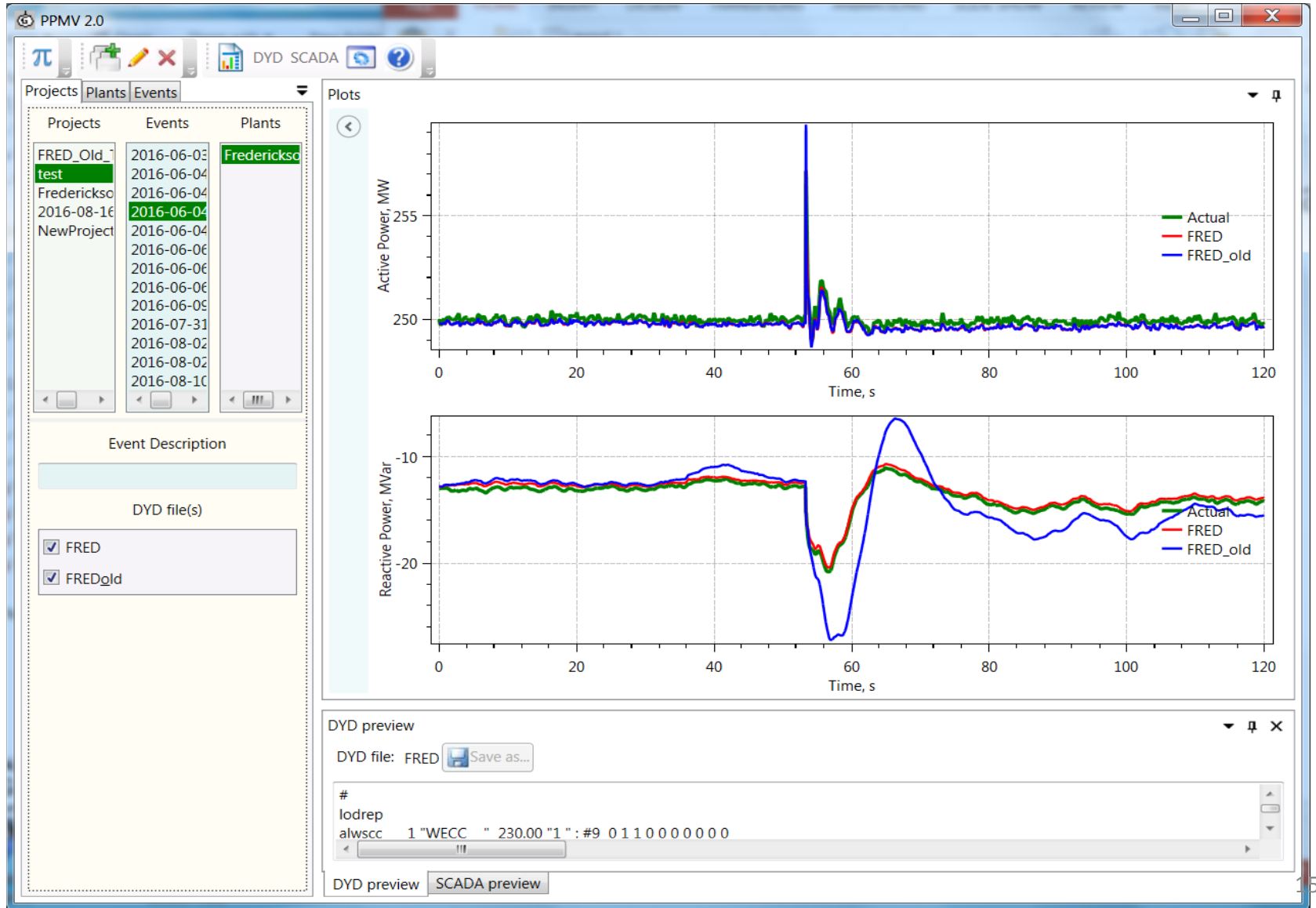
NO LOAD TAP CHANGER ON HV WINDING
THE NLTC CAN BE OPERATED ONLY WITH DE-ENERGIZED TRANSFORMER

VOLTAGE (V)	CURRENT (A)			NLTC CONNECTIONS
	OA	FAI	FAI	
241500	168,5	225,0	281,1	10-13/11-14/12-15
235750	172,7	230,5	286,0	7-13/ 8-14/ 9-15
230000	177,0	236,2	295,2	7-16/ 8-17/ 9-18
224250	181,5	242,3	302,8	4-16/ 5-17/ 6-18
218500	186,3	248,6	310,7	4-19/ 5-20/ 6-21





PPMV Process: New Transformer Data





PPMV Process: Review Results

PPMV 2.0

Projects Plants Events

Projects: FRED_Old_Tx_d test, Frederickson 2016-08-16, NewProject

Events: 2016-09-07-21

Plants: Frederickson

Event Description

DYD file(s): FRED

Plots

DYD preview

DYD file: FRED [Save as...](#)

```
ggov1 47577 "FREDST G" 18.00 "1" : #9 mwcap=166.3 "r" 0.044 "rselect" 1.000000 "tpelec" 1.000000 "maxerr" 0.100000 "mi  
exst4b 47577 "FREDST G" 18.00 "1" : #9 "Tr" 0.0 "Kpr" 5.00 "Kir" 5.00 "Ta" 0.010000 "Vrmax" 1.000000 "Vrmin" -0.866000 "Kp  
pss2a 47577 "FREDST G" 18.00 "1" : #9 "j1" 1.000000 "k1" 0.0 "j2" 3.0 "k2" 0.0 "tw1" 5.0000 "tw2" 5.0 "tw3" 5.000000 "tw4" 0  
oel1 47577 "FREDST G" 18.00 "1" : #9 "ifdset" 3.1 "ifdmax" 4.0 "tpickup" -30.0000 "runback" 0.0 "tmax" 999.00 "tset" 999.00  
genrou 47576 "FREDST S" 13.80 "1" : #9 mva=126.3200 "tpdo" 4.5000 "tppdo" 0.022 "tpqo" 0.600 "tppqo" 0.07310 "h" 4.540  
esac2a 47576 "FREDST S" 13.80 "1" : #9 "tr" 0.005 "tb" 1.0 "tc" 1.0 "ka" 1200.0 "ta" 0.010000 "vamax" 18.9 "vamin" -18.9 "kb  
pss2a 47576 "FREDST S" 13.80 "1" : #9 "j1" 1.000000 "k1" 0.0 "j2" 3.0 "k2" 0.0 "tw1" 5.0000 "tw2" 5.0 "tw3" 5.000000 "tw4" 0
```

DYD preview SCADA preview

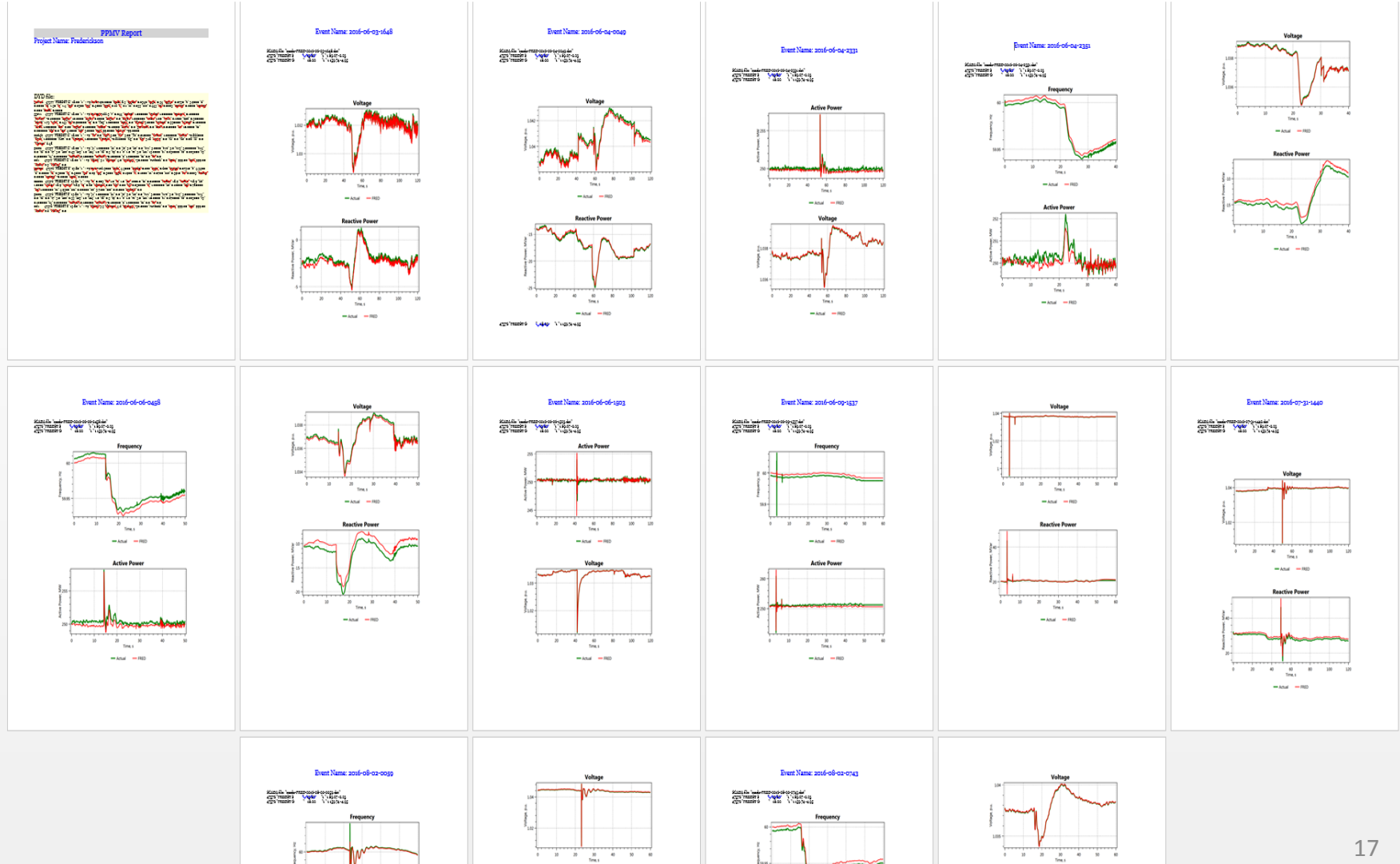


PPMV Process: Generate Report

PPMV_Frederickson.rtf [Compatibility Mode] - Word

Sign in

FILE HOME INSERT DESIGN PAGE LAYOUT REFERENCES MAILINGS REVIEW VIEW Foxit PDF





WECC Re-Certification of Centralia Power Plant



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

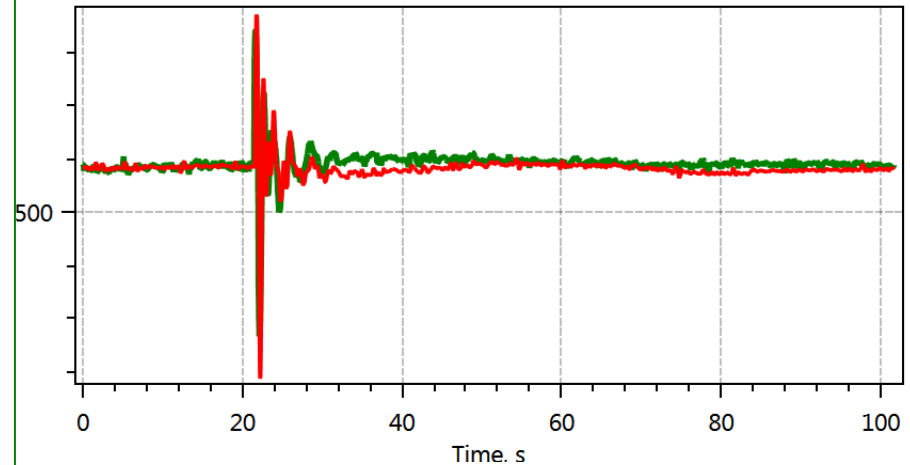
Date of Expiration — April 30, 2021

Branden Sudduth
Director, Reliability Planning
Western Electricity Coordinating Council

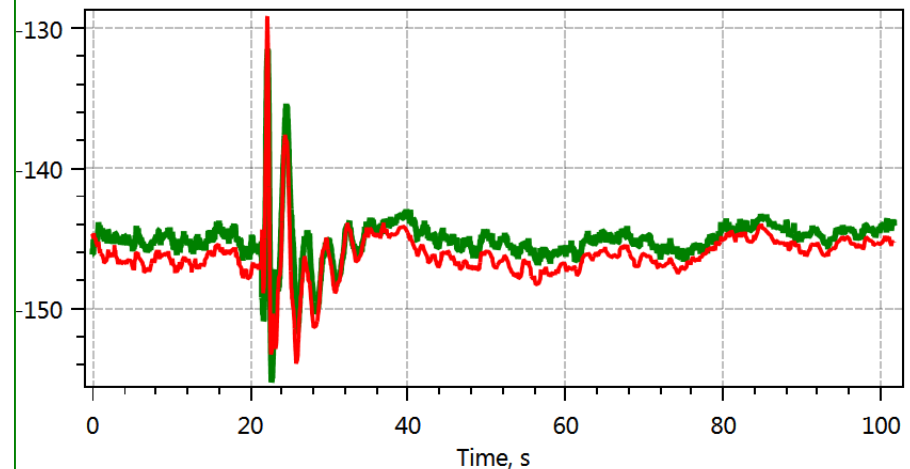
Melanie Frye
Vice President, Reliability Planning and Performance Analysis
Western Electricity Coordinating Council

WESTERN ELECTRICITY COORDINATING COUNCIL

Active Power



Reactive Power

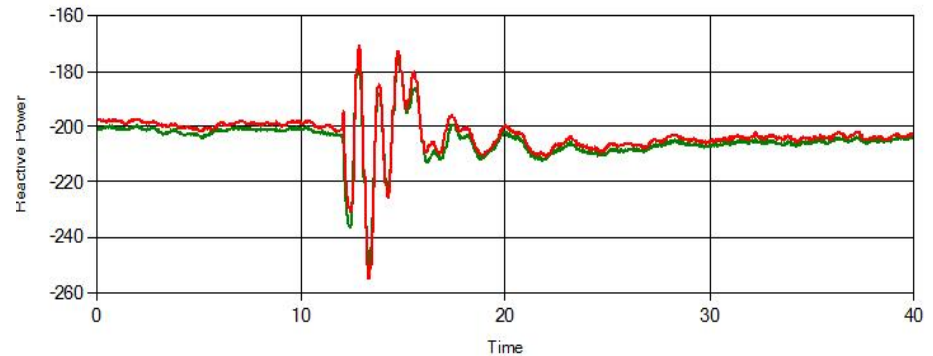
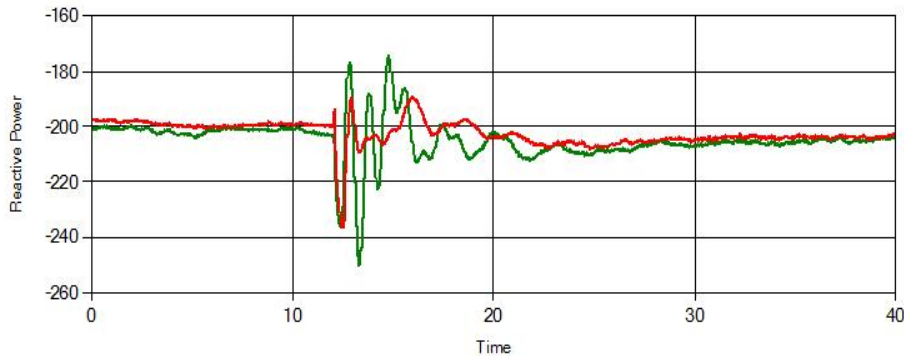
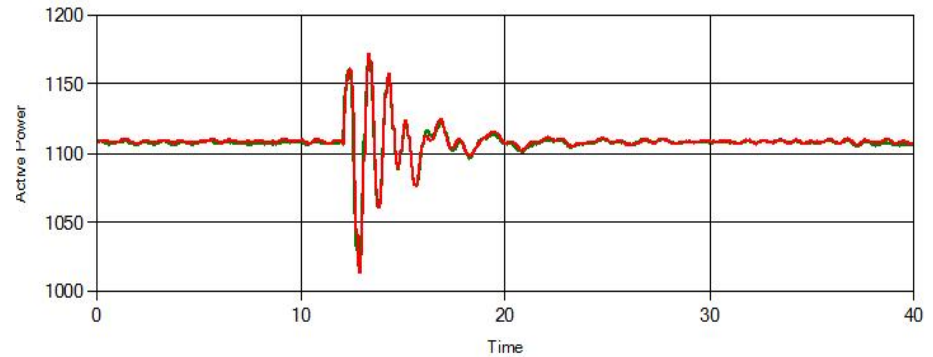
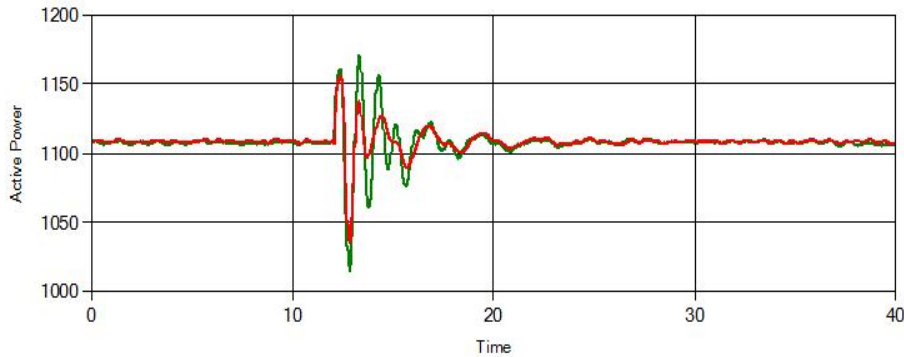


— Actual — Centralia



CGS Calibration

Before calibration



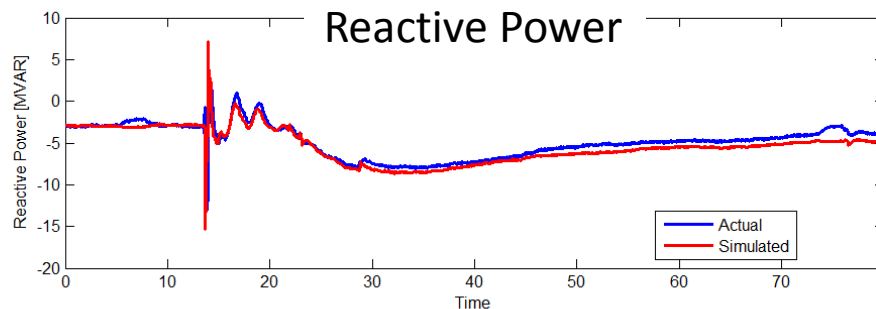
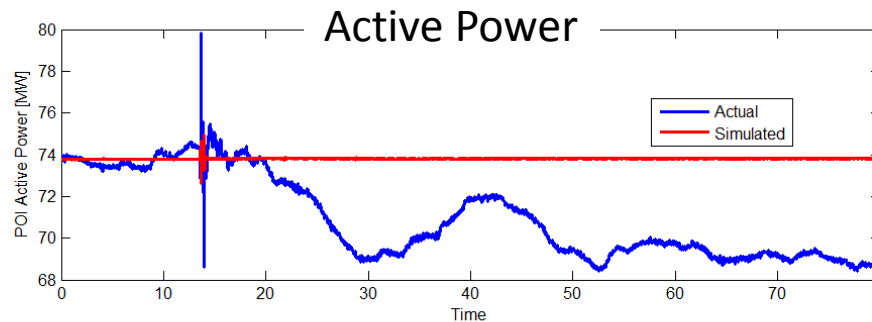
— Actual — Model

— Actual — Model

- 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

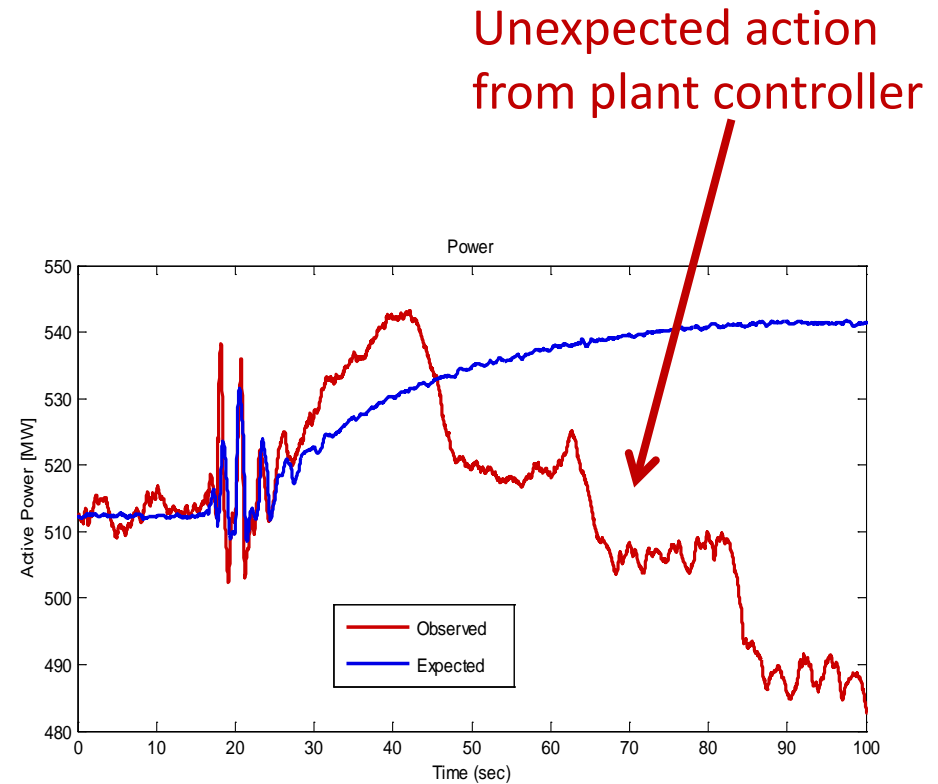
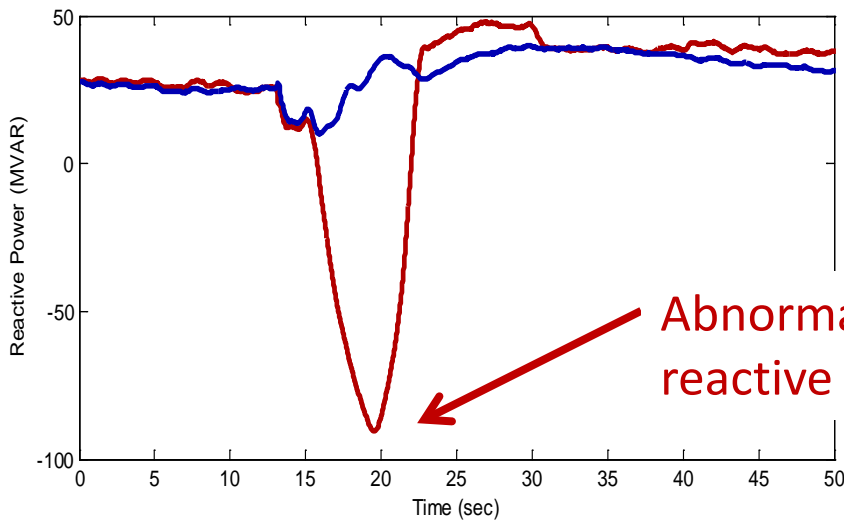
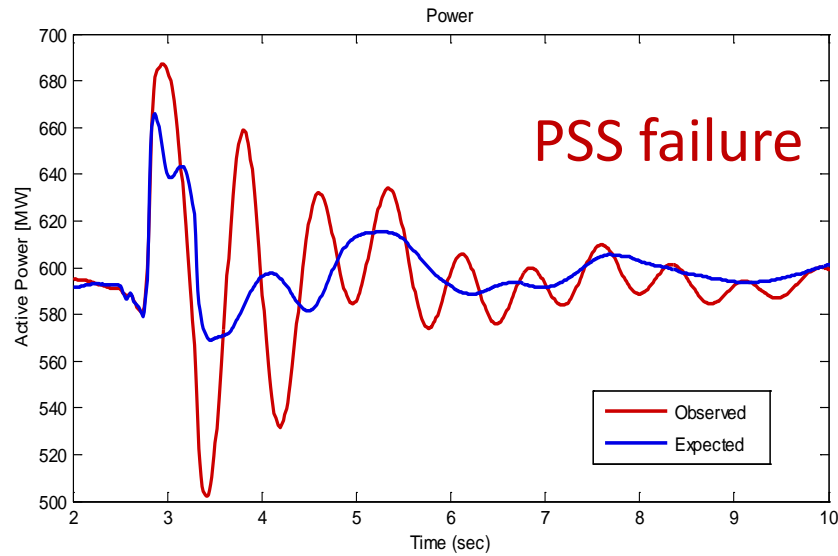


White Creek Power plant:
Reasonable agreement between
actual and **simulated** reactive
power for a grid disturbance



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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