



PMU-based application for power plant model validation (PPMV)

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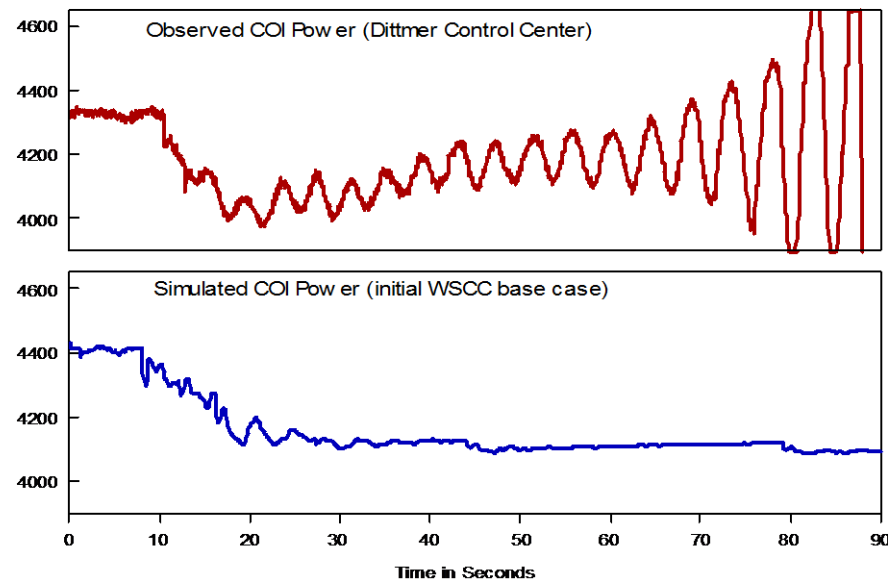
Steve Yang, BPA

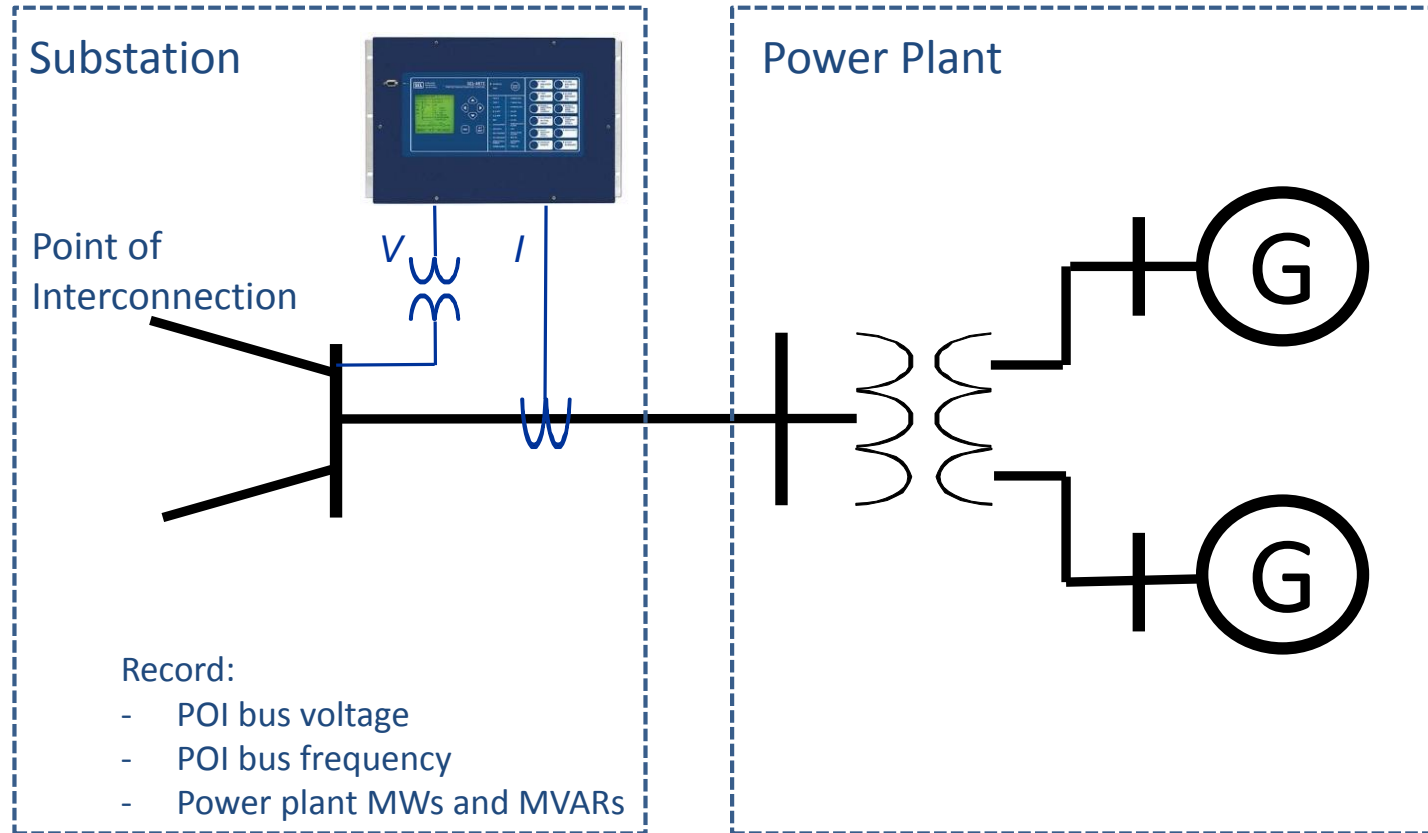
Pavel Etingov, PNNL

North American SynchroPhasor Initiative Working Group Meeting
March 23-24, 2015

- ▶ Accurate and up-to-date models are needed for reliable and economic grid operations and planning
- ▶ WECC required generators to be tested for model validation after 1996 system outages
- ▶ WECC established a formal Generating Unit Model Validation Policy in 2006:
 - Baseline model development, Periodic model validation
- ▶ NERC Reliability Standards MOD-026,-027:
 - Developed from 2007 to 2013
 - In effect starting July 1, 2014

August 10, 1996

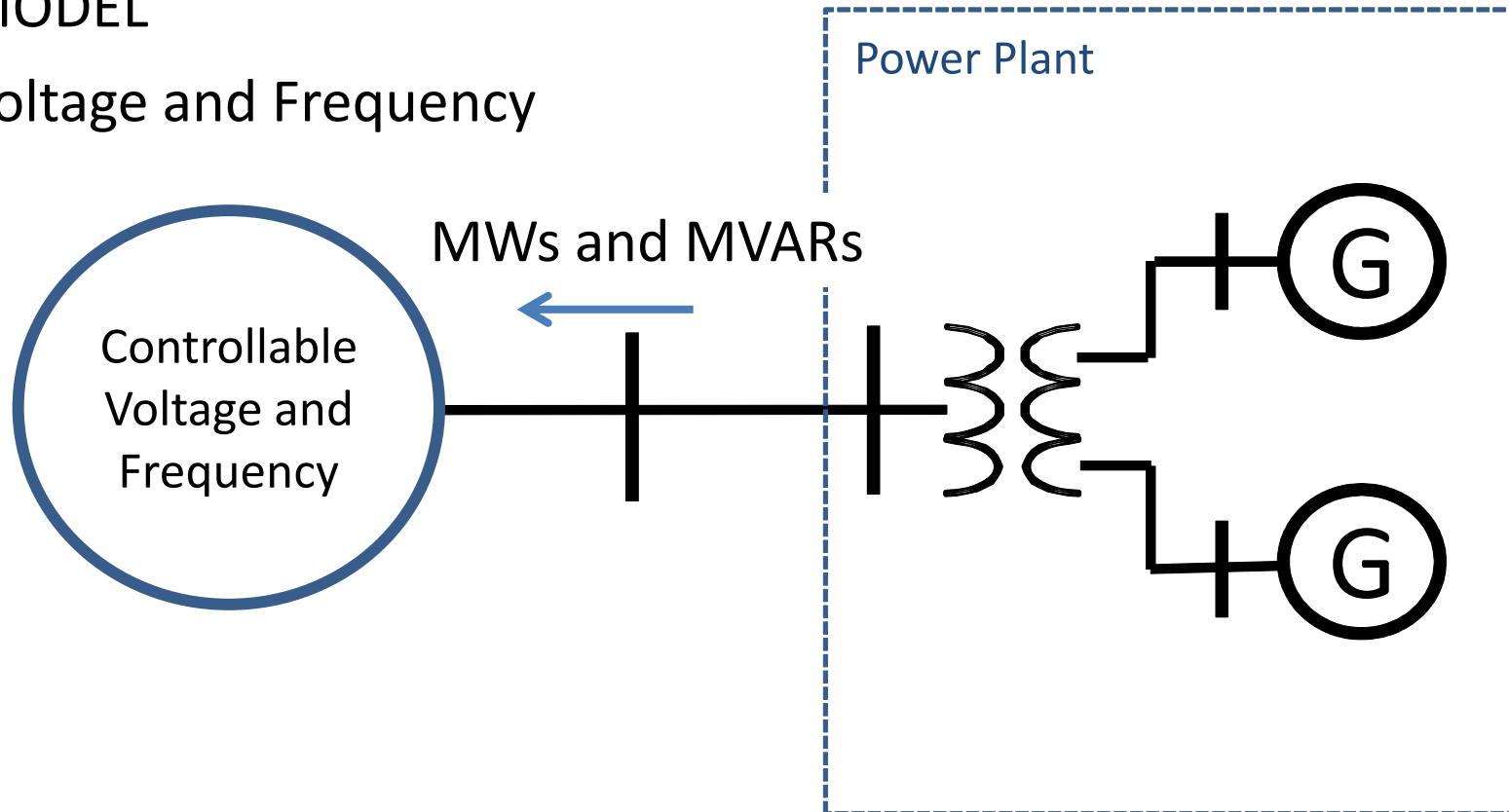




PMU needs to be placed at Power Plant POI

MODEL

Voltage and Frequency



Disturbance play-in capabilities are added to GE PSLF in 2001



Disturbance-Based Model Validation



Proudly Operated by **Battelle** Since 1965

BPA has PMU disturbance monitoring:

- ▶ Conventional –
 - 12 plants,
 - 130 generators,
 - 21,145 MW of generation
- ▶ Wind –
 - 11 plants
 - 1,200 MW of generation
- ▶ Review model performance annually



Disturbance-Based Model Validation



BPA PPMV

sequence of GE PSF EPCLs and MATLAB programs

PNNL-BPA PPMV

Stand-alone data management program

Idaho Power

Excel macro with PI data link and PSLF interfaces



PPMV Tool main features



Proudly Operated by **Battelle** Since 1965

- ▶ The tool automates the process of power plant model validation using disturbance recordings.
- ▶ Interacts with GE PSLF Play-In Function for generator model validation
- ▶ Database of projects (model validation studies)
- ▶ Database of the historic events.
- ▶ Database of the power plant
- ▶ Generating reports

The screenshot displays the PPMV 2.0 software interface. On the left, a 'Projects' panel lists various test cases, with '11Apr2010_event' selected. Below it, an 'Event Description' section shows '3 Phase Fault at bus yyyy' and selected 'DYD file(s)'. A 'DYD preview' window is open, displaying a text-based simulation file. On the right, a 'Plots' panel contains four stacked line graphs comparing 'Actual' data with two simulation models: 'MCNPH2-2012HS' and 'MCNPH2-2013HS-USA'. The graphs show Frequency (Hz), Active Power (MW), Voltage (kV), and Reactive Power (MVar) over a 45-second period.

List of Projects

- HPP_test
- MN4_2012HS_test
- JohnDay_test
- 11Apr2010_event
- 27Sept2010_event
- NewProject123
- MN2_2012HS_test

List of power plants

- HPP
- McNary_PH2
- McNary_PH4

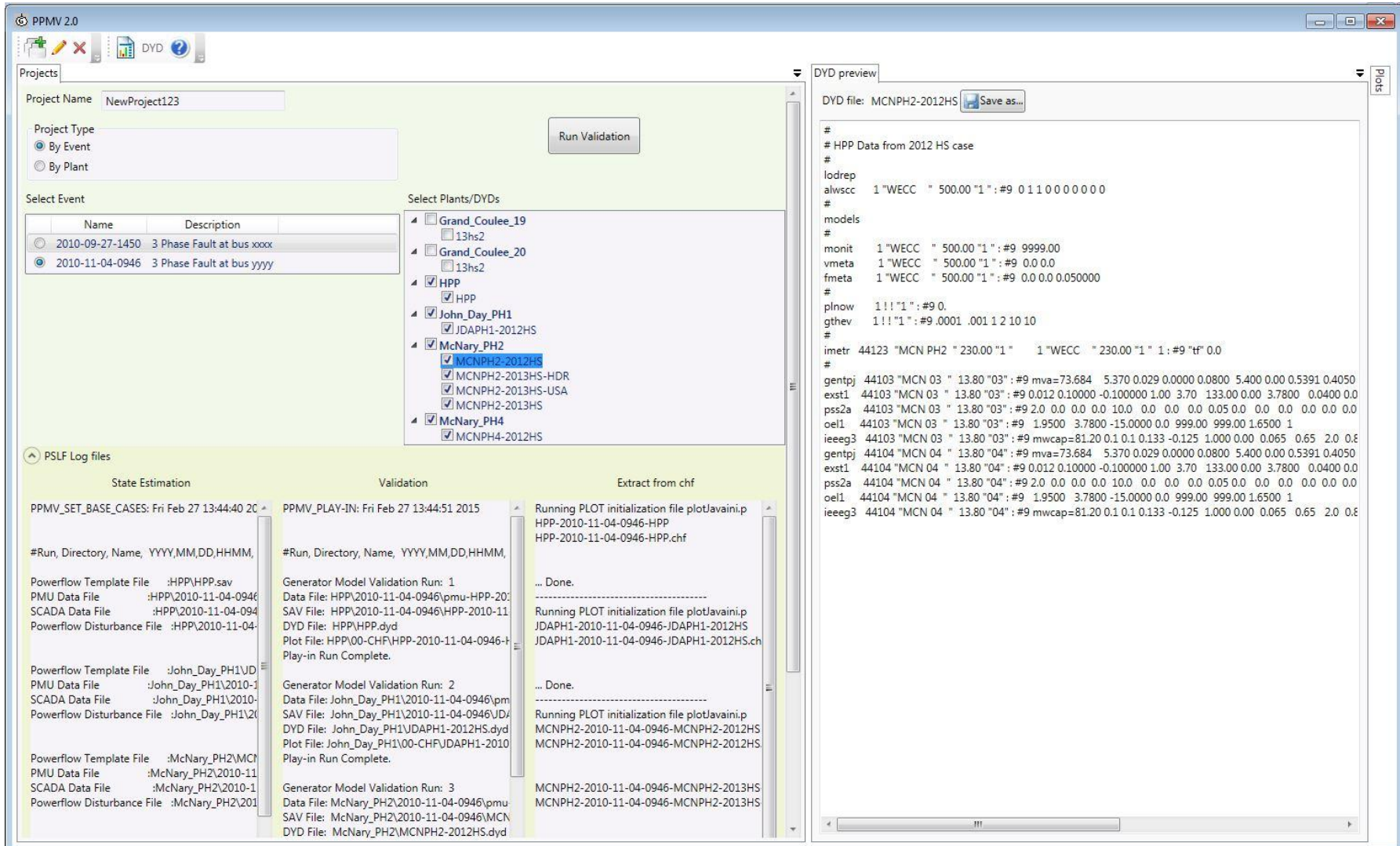
Event plots

DYDs

DYD preview

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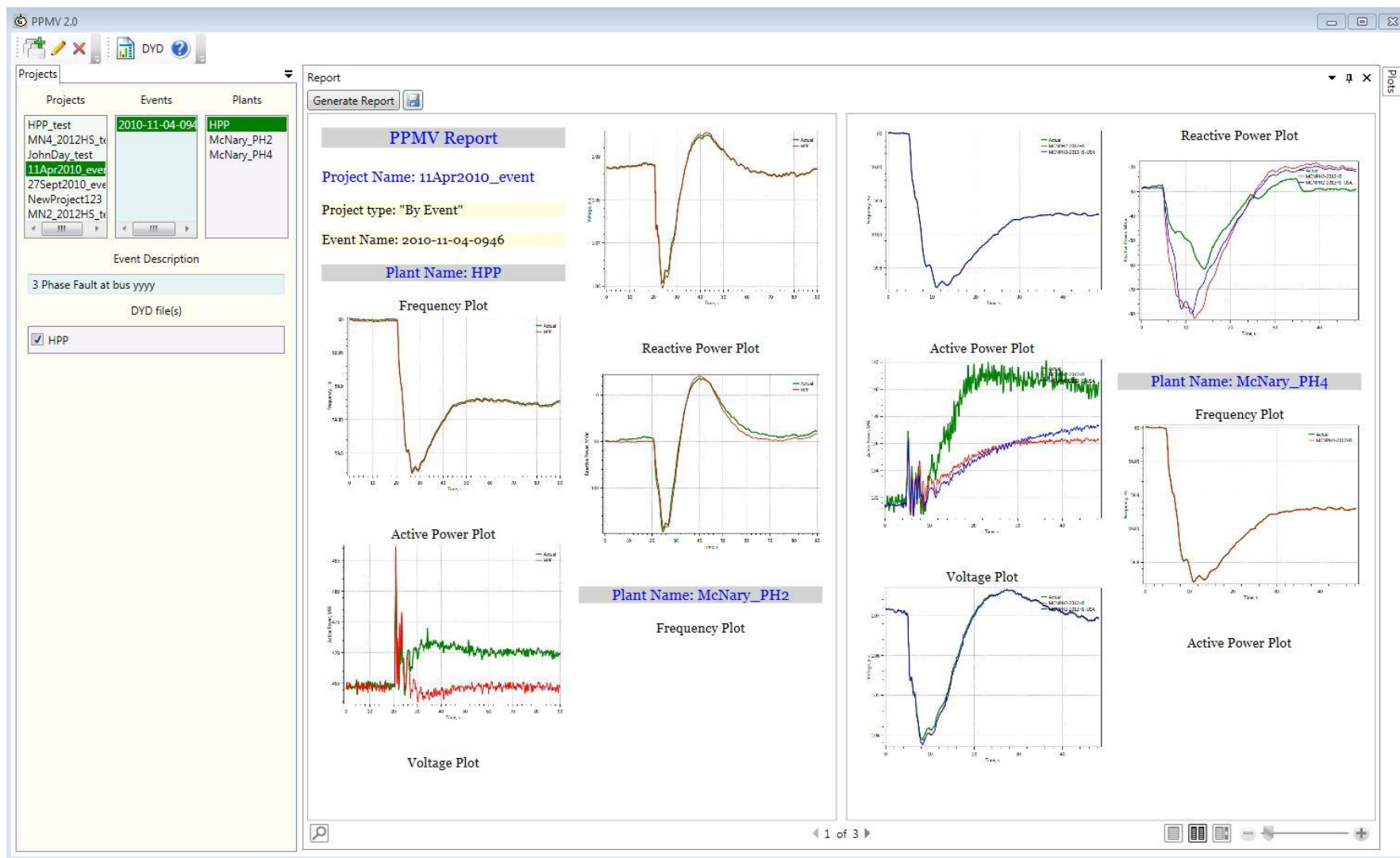
#
# HPP Data from 2012 HS case
#
lodrep
alwsc 1 "WECC " 500.00 "1":#9 0 1 1 0 0 0 0 0 0
#
models
#
monit 1 "WECC " 500.00 "1":#9 9999.00
vmeta 1 "WECC " 500.00 "1":#9 0.0 0.0
fmeta 1 "WECC " 500.00 "1":#9 0.0 0.0 0.050000
#
plnow 1 !! "1":#9 0.
gthv 1 !! "1":#9 0.001 .001 1 2 10 10
#
imetr 44123 "MCN PH2 " 230.00 "1" 1 "WECC " 230.00 "1" 1:#9 "t
#
gentpj 44103 "MCN 03 " 13.80 "03":#9 mva=73.684 5.370 0.029 0.0000
exst1 44103 "MCN 03 " 13.80 "03":#9 0.012 0.10000 -0.100000 1.00 3.70
ps2a 44103 "MCN 03 " 13.80 "03":#9 2.0 0.0 0.0 0.0 10.0 0.0 0.0 0.0
oel1 44103 "MCN 03 " 13.80 "03":#9 1.9500 3.7800 -15.0000 0.0 999.1
ieeeg3 44103 "MCN 03 " 13.80 "03":#9 mvcap=81.20 0.1 0.1 0.133 -0.125
gntc1 44104 "MCN 04 " 13.80 "04":#9 mva=73.684 5.370 0.029 0.0000
    
```

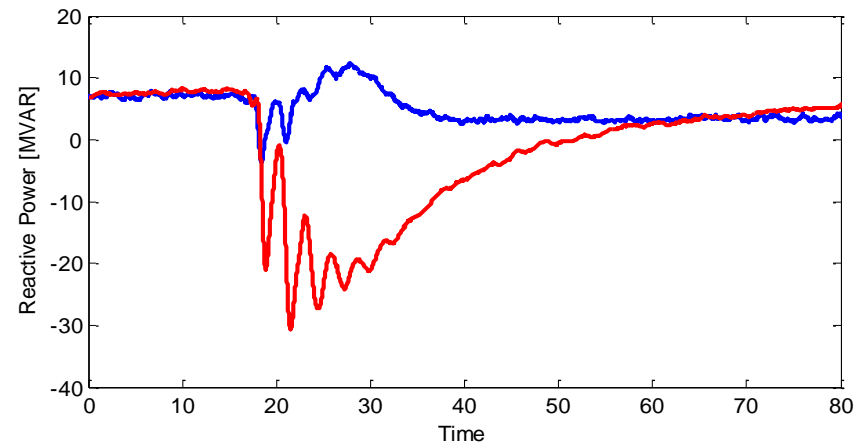
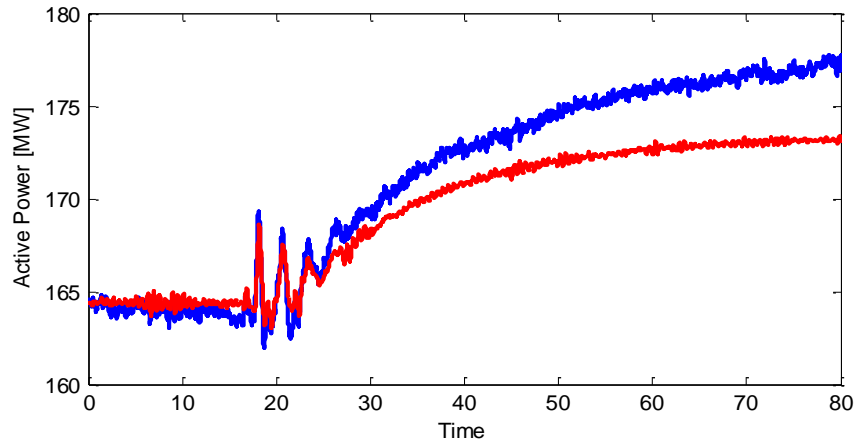
The screenshot displays the PPMV 2.0 software interface. The main window is titled "PPMV 2.0" and contains several panels:

- Projects:** A field for "Project Name" containing "NewProject123". Below it are radio buttons for "Project Type": "By Event" (selected) and "By Plant". A "Run Validation" button is visible.
- Select Event:** A table with columns "Name" and "Description".

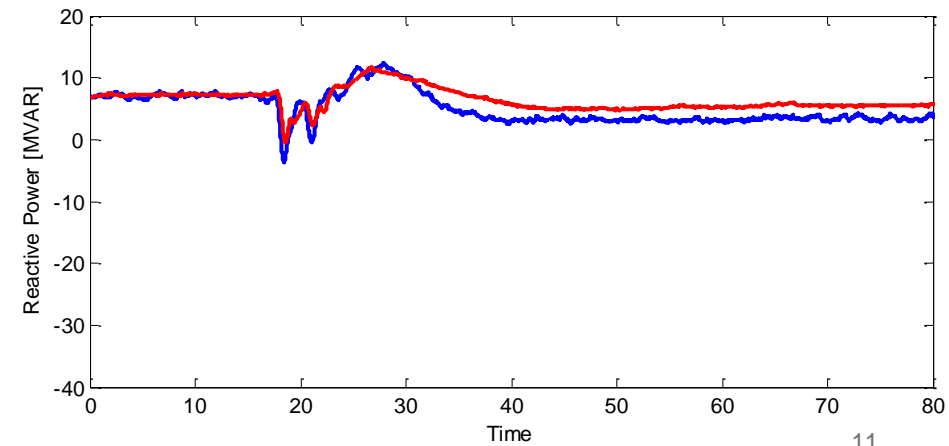
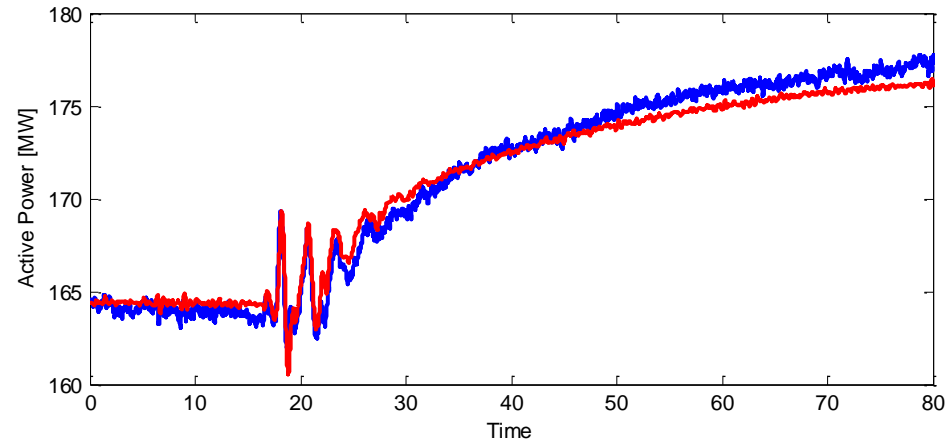
| Name | Description |
|-----------------|---------------------------|
| 2010-09-27-1450 | 3 Phase Fault at bus xxxx |
| 2010-11-04-0946 | 3 Phase Fault at bus yyyy |
- Select Plants/DYDs:** A tree view showing a hierarchy of plants and DYDs. The "McNary_PH2" plant is selected, and its "MCNPH2-2012HS" DYD is highlighted.
- PSLF Log files:** A section with three columns: "State Estimation", "Validation", and "Extract from chf". Each column contains log entries for different validation runs, including file paths and run details.
- DYD preview:** A panel on the right showing the "DYD file: MCNPH2-2012HS". It contains a list of parameters and their values, such as "lodrep", "alwsc", "models", "monit", "vmeta", "fmeta", "plnow", "gthev", "imetr", "gentpj", "exst1", "pss2a", "oe1", and "ieeg3".



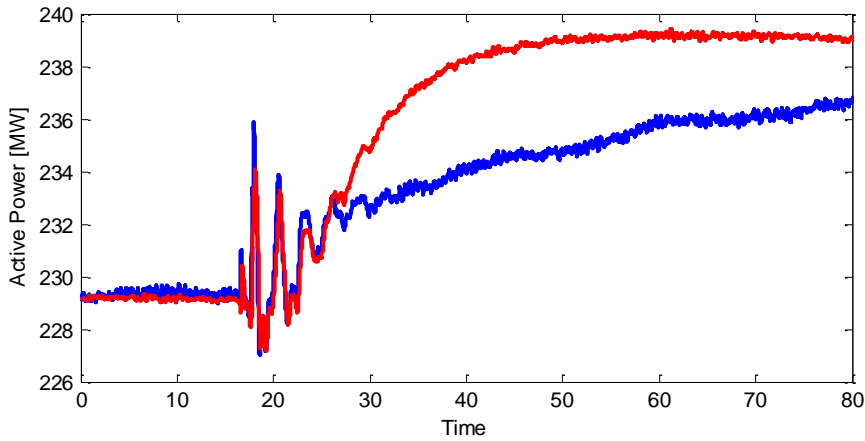
BEFORE-2014



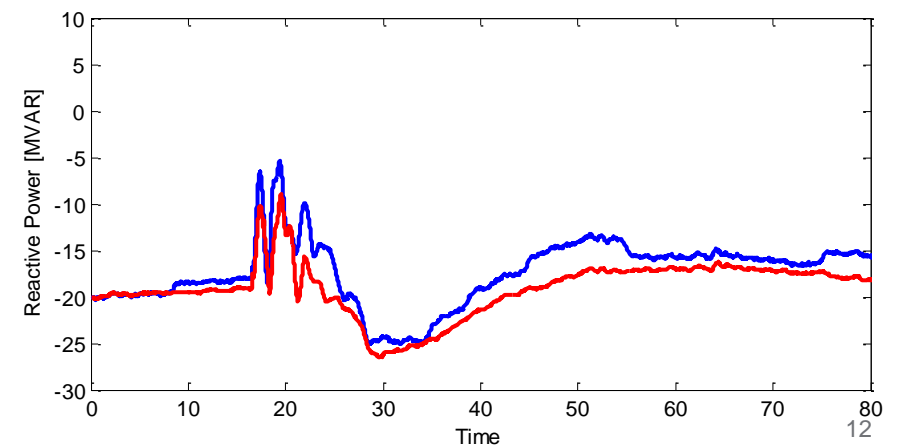
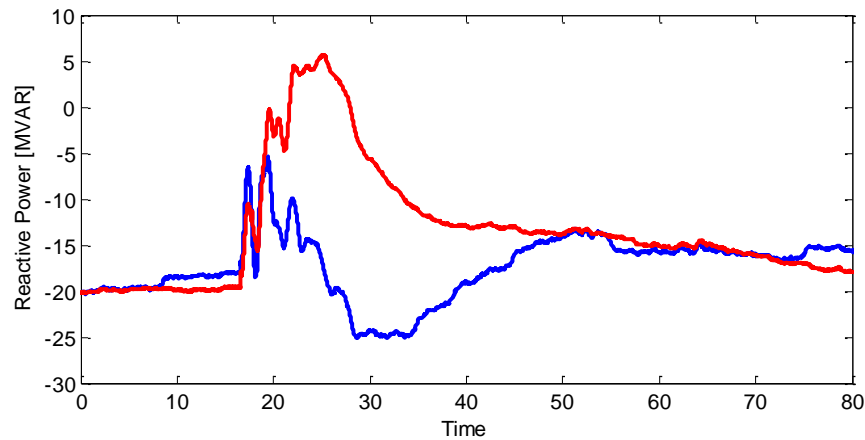
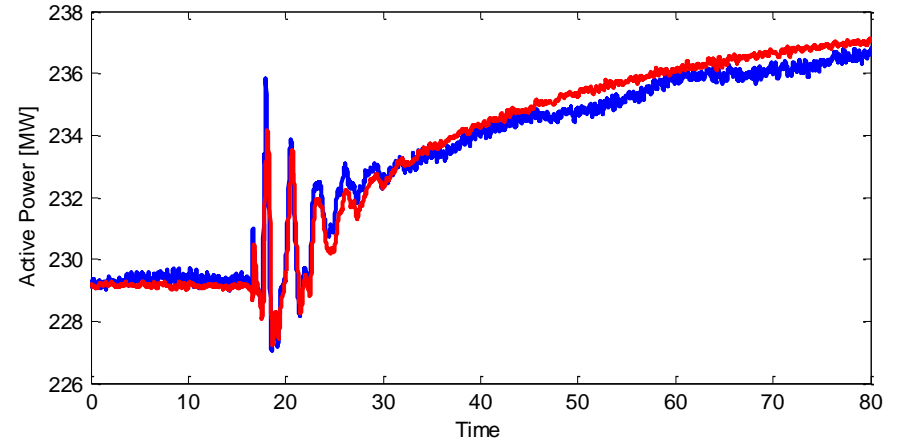
AFTER-2015



BEFORE-2014



AFTER-2015

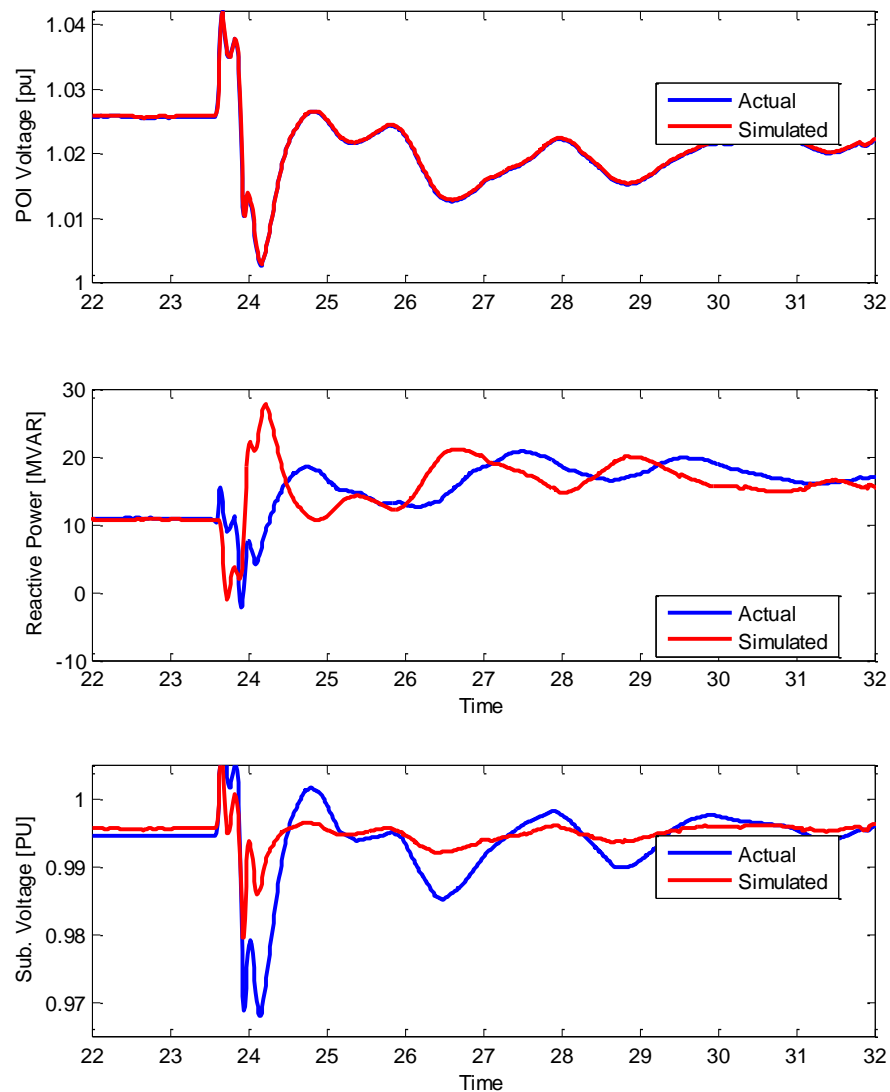
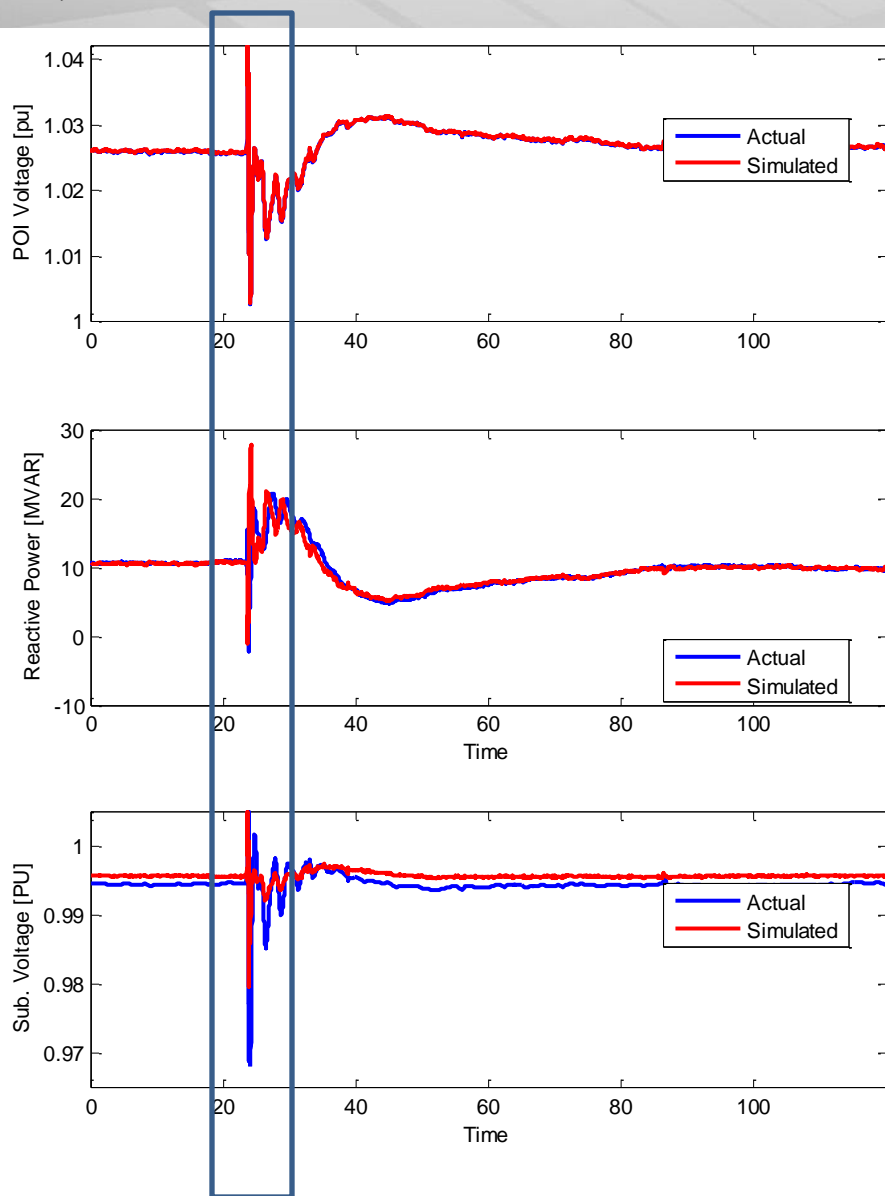


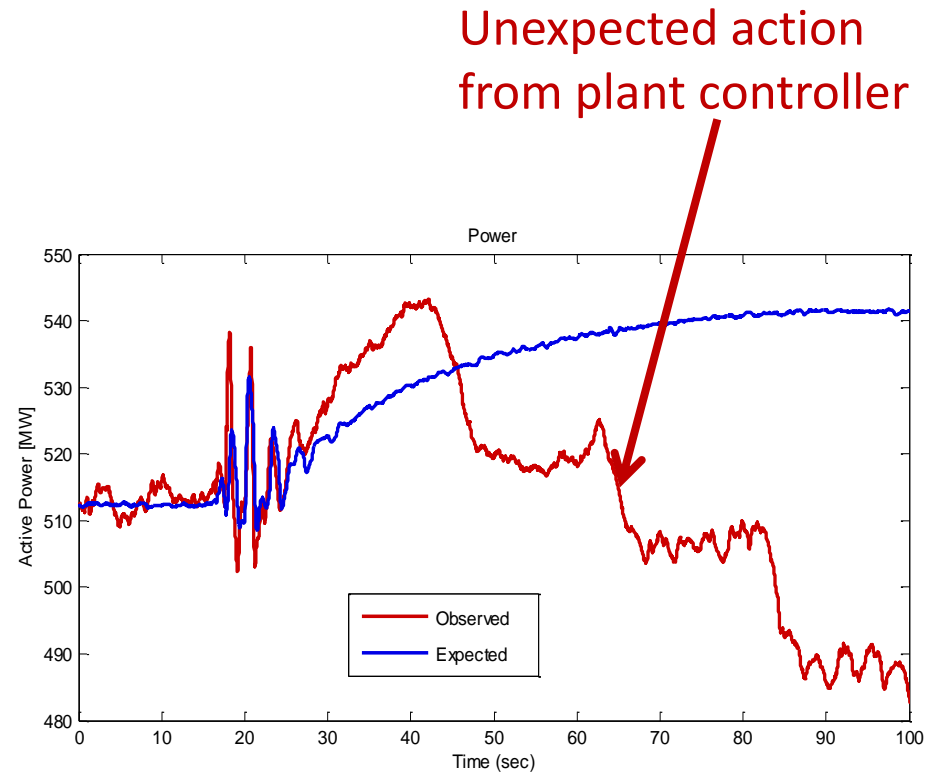
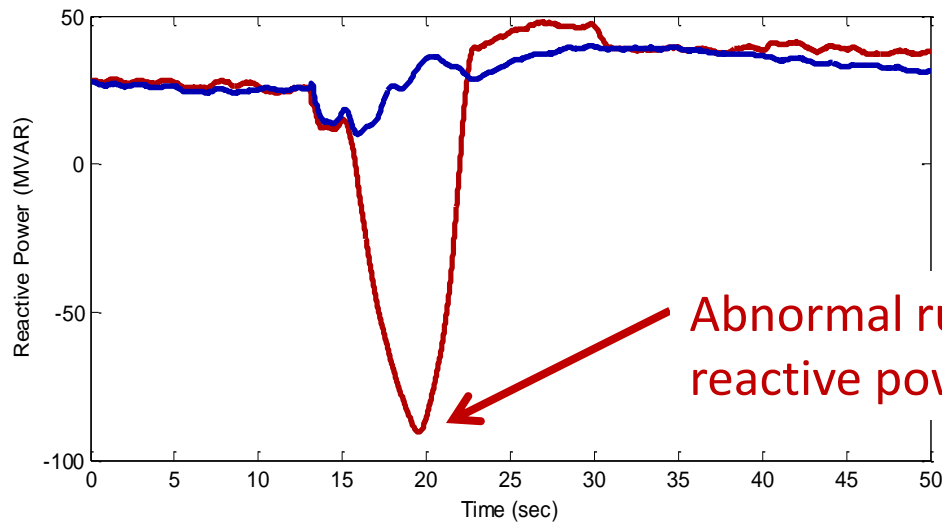
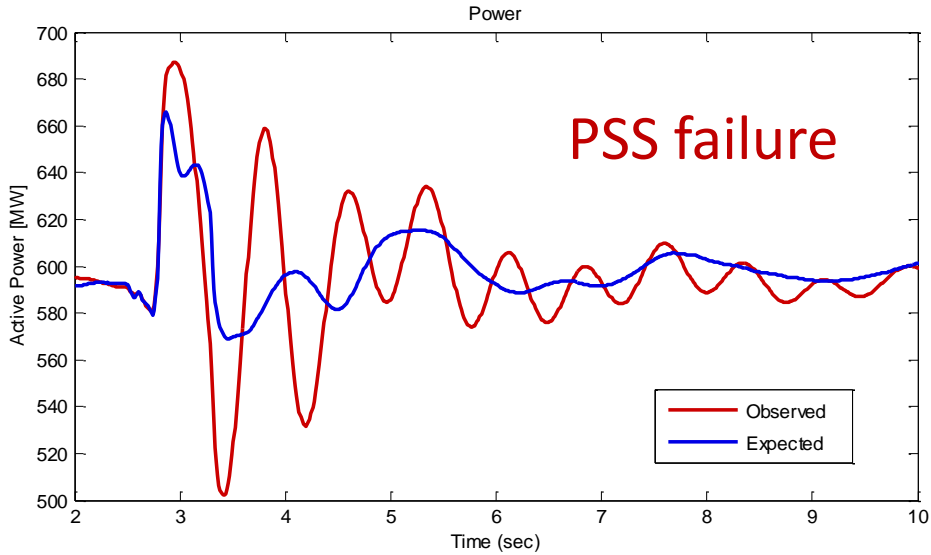


Wind Power Plant Model Validation



- ▶ BPA has nearly 4,900 MW of wind generation interconnected to its transmission system
- ▶ BPA prototyped PMU-based wind power plant validation set-up for multiple wind power plants
- ▶ BPA is collaborating with EPRI, UVIG, NREL research on wind power model validation using PMU data
- ▶ BPA implemented wind models in State Estimator







Future work

▶ New version of the PPMV tool is under development

- New advanced GUI
- New advanced functionality

- PPMV project page: <https://svn.pnl.gov/PPMV>
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