



Wind Power Plant Model Validation Success Stories and Challenges

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Motivation and Regulatory Landscape

- Accurate and validated models are required for reliable and economic power system operations
 - Power system dynamic response will change as renewable resources increase
 - California is committed to serving 33% of its load with renewable resources by 2020
- NERC Reliability Standards are developed
 - NERC MOD-032 requires Generator Owners to provide powerflow and dynamic models for their power plants and generating equipment
 - NERC MOD-026 and -027 require Generator Owners to perform verification of generator excitation control and governor control models respectively
 - NERC MOD-025 requires Generator Owners to perform verification of generator active and reactive power capabilities
 - Applies to Wind and Solar!



WECC Wind Model Development

- WECC Renewable Energy Modeling Task Force (REMTF) led a multi-year effort in developing models for wind and solar power plants
- REMTF developed WECC Wind and Solar Power Plant Dynamic Modeling Guide in 2014
 - A methodology for calculating collector system equivalent was developed, and typical data sets
 - REMTF guidelines have been adopted by most wind power plants operators in WECC
 - BPA made their EMS and state estimator models consistent with planning models. Powerflow models of wind power plants are proven to work and fairly mature
 - Development of wind generation dynamic models was done in phases. Initial implementation of type 3 and 4 wind generation models (wt3x, wt4x) represented a limited set of wind generation manufacturers



Phase II Wind Dynamic Models

- Recently developed second phase is more modular and has capabilities to capture a wider group of wind generation turbine makes and models
- However, the second phase of wind generation dynamic models is not well understood outside WECC REMTF, very few planners understand the model, or its parameter sensitivity
- WECC PPMVDTF developed “Roadmap for Wind Power Plant Model Data and Validation”



Wind PPMVDTF Roadmap

- Compile List of Wind and Solar Power Plants in WECC
- Validate Powerflow models
- Conversion from Phase I to Phase II models
- Survey typical voltage control practices and develop a methodology and tools for validating wind power plant voltage control
- Validate Dynamic models using PPMV tools with support from REMTF

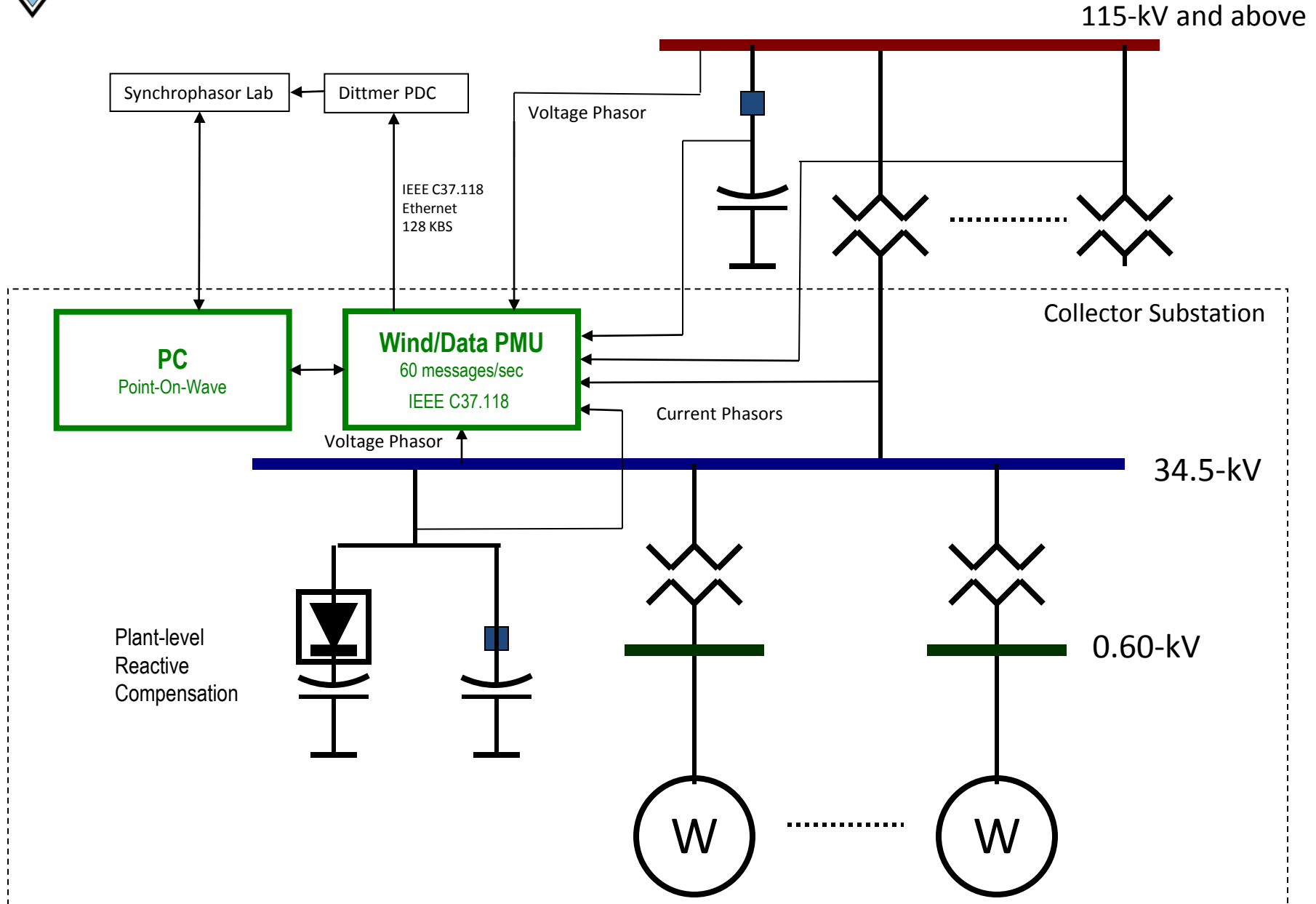


BPA's WIND PMU Coverage

- 14 wind power plants (out of 32 plants)
- Totaling more than 1,500 MW of generation (out of 4,900 MW)
- Mandatory PMU installation on any new generation connecting to BPA



BPA's WIND PMU



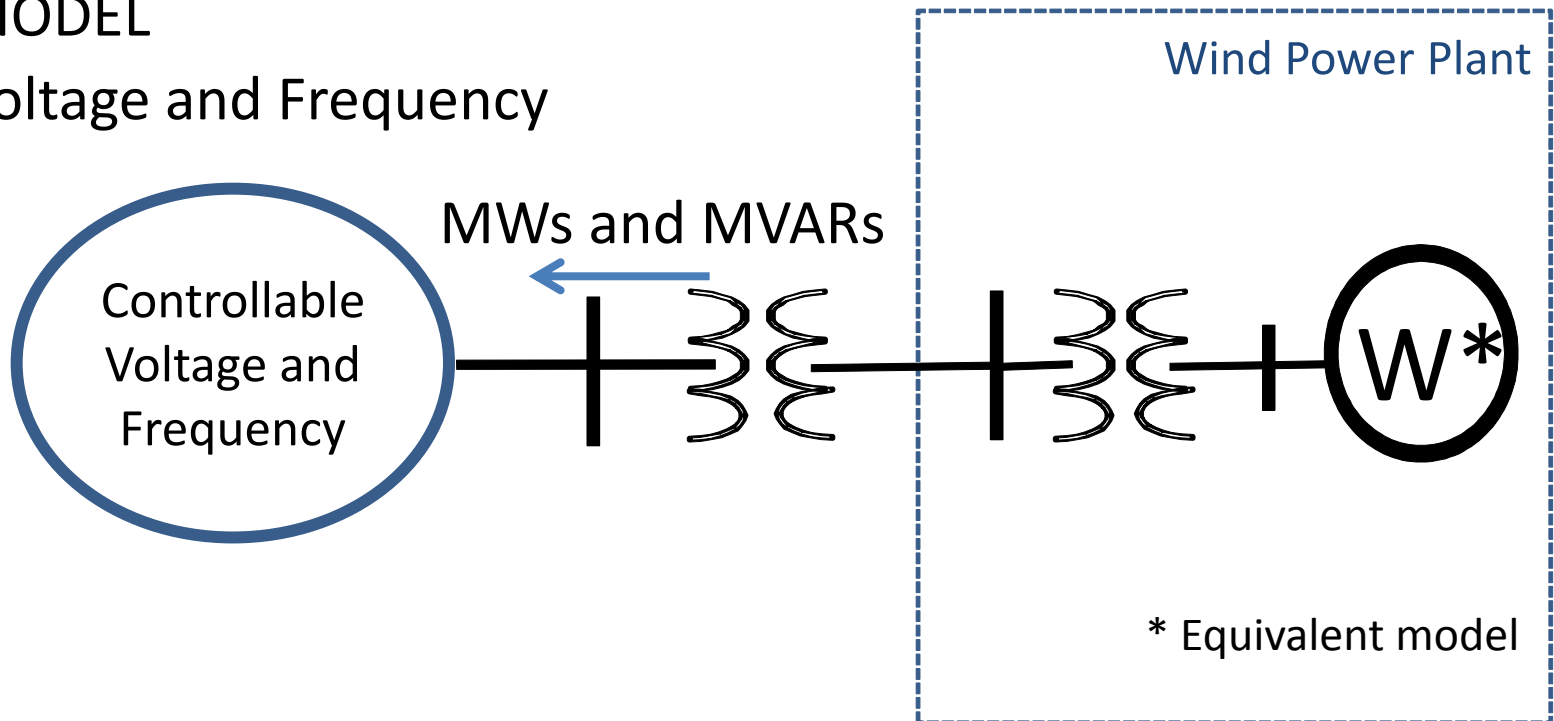


BPA Wind PPMV Process

- Same as conventional PPMV
 - EPCL script method
 - BPA-PNNL PPMV tool

MODEL

Voltage and Frequency



- Measured and responded MWs and MVARs are compared for measures of success



Validating Siemens Default Model Data for Type 4 Wind Turbine Generators

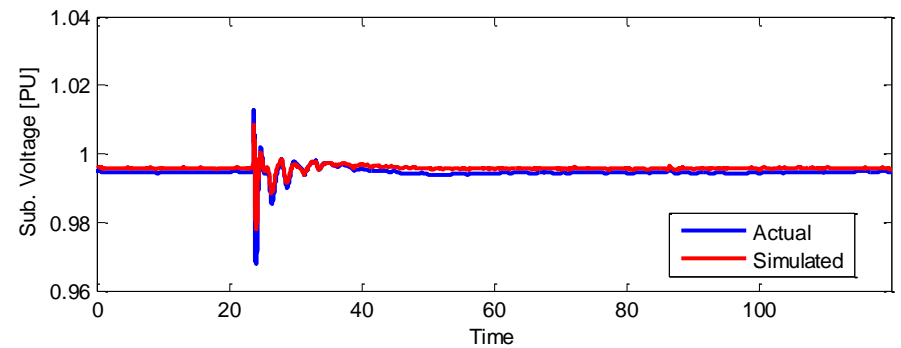
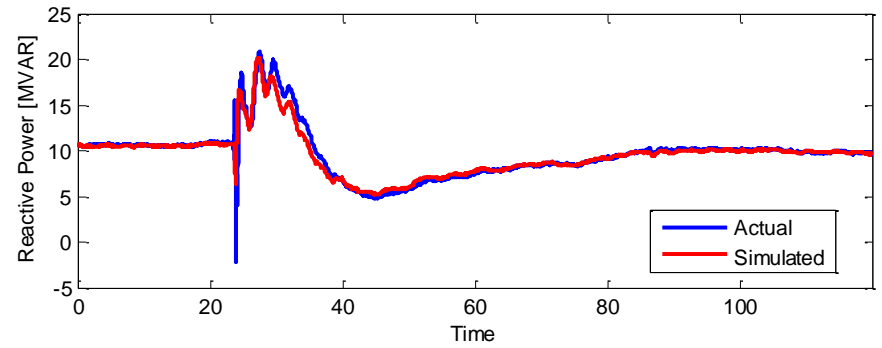
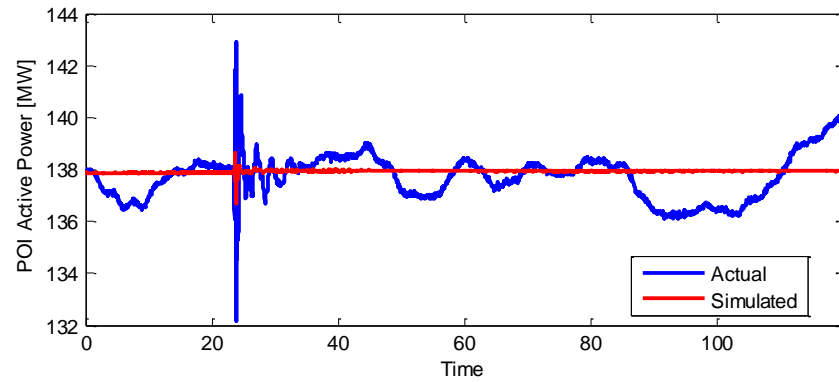
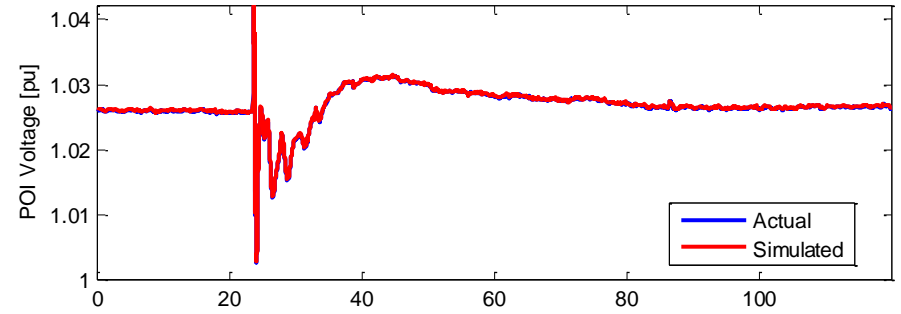
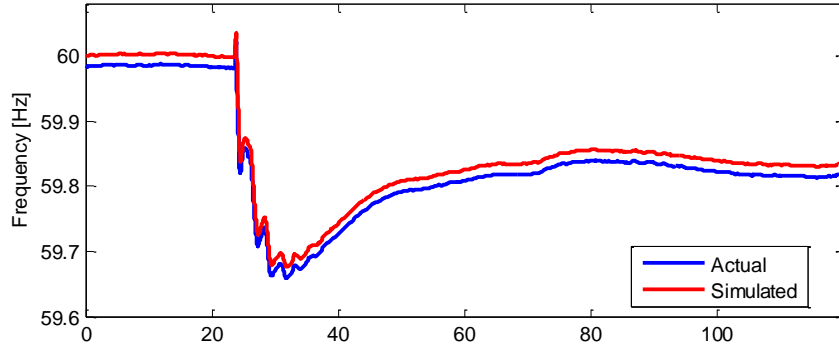
- regc_a : Generator/converter model
- wtgt_a : Drive train model
- reec_a : Renewable energy electrical control model
- repc_a : Power Plant Controller

Example Dynamic files:

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"lvpnt1" 0.8 "lvpnt0" 0.4 "qmin" -1.3 "accel" 0.7 "tg" 0.02 "tfltr" 0.02 "iqrmax" 50. "iqrmin" -50. "xe" 0.0
#
wtgt_a xxxxxx "WIND W1" 0.69 "Z4" :#9 "mvab" 0.00 "ht" 5.3 "hg" 1.0 "dshaft" 0.92 "kshaft" 1.85 "wo" 0.05
#
reec_a xxxxxx "WIND W1" 0.69 "Z4" :#9 "mvab" 0.00 "vdip" 0.90 "vup" 1.20 "trv" 0.00 "dbd1" -0.05 "dbd2" 0.05 "kqv"
0.0 "iqh1" 1.05 "iq1" -1.05 "vref0" 0.0 "iqfrz" 0.0 "thld" 0.00 "thld2" 0.00 "tp" 0.05 "qmax" 0.40 "qmin" -0.40
"vmax" 1.10 "vmin" 0.90 "kqp" 0.0 "kqi" 0.10 "kvp" 2.0 "kvi" 10.0 /"vref1" 0.00 "tiq" 0.02 "dpmax" 99.0
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"vp1" 0.05 "ip1" 0.19 "vp2" 0.2 "ip2" 0.6 "vp3" 0.35 "ip3" 0.52 "vp4" 0.7 "ip4" 1.0
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"tp" 0.25 "fdbd1" 0.00 "fdbd2" 0.00 femax" 999. "femin" -999. "pmax" 999. "pmin" -999. "tlag" 0.10 "ddn"
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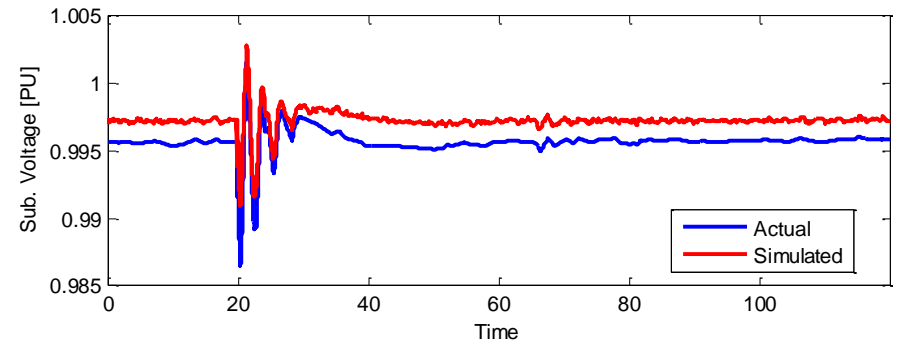
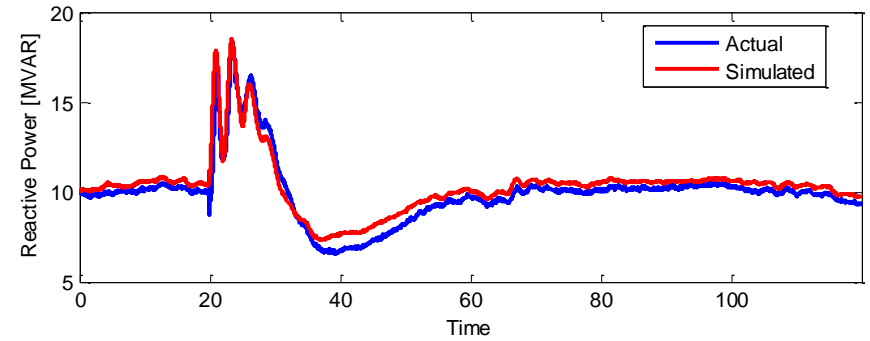
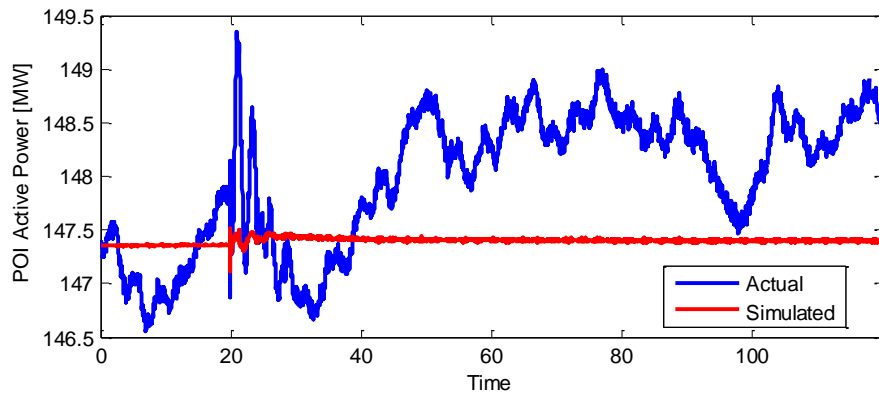
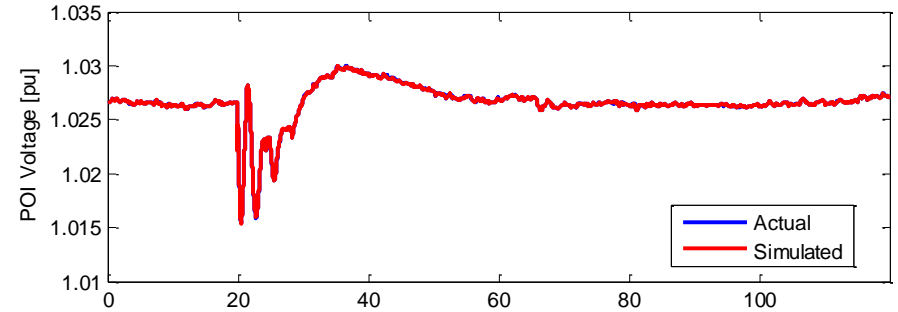
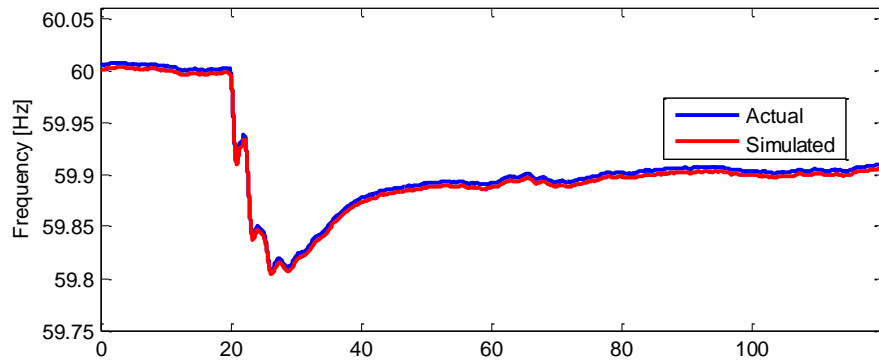


Event 1



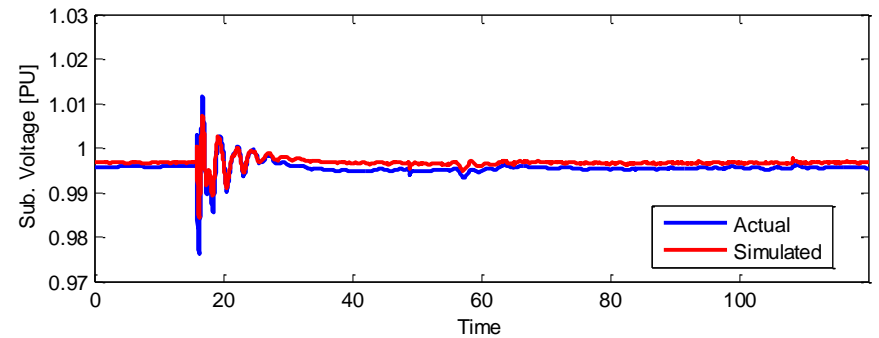
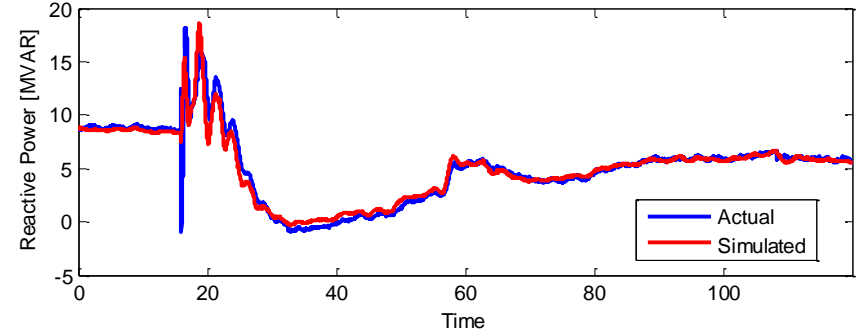
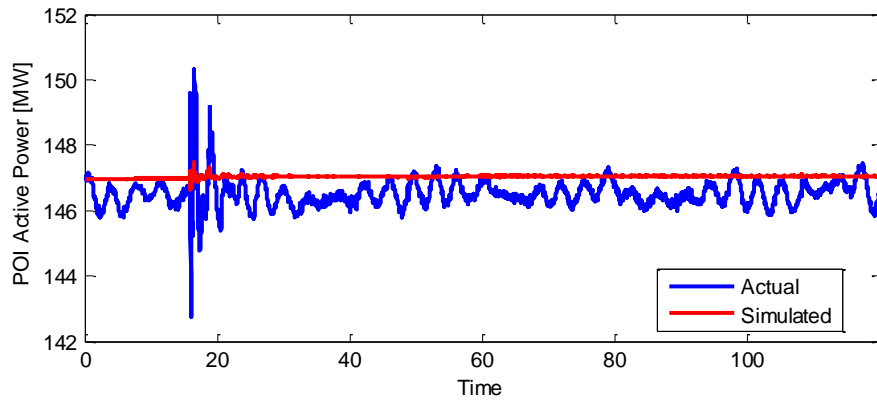
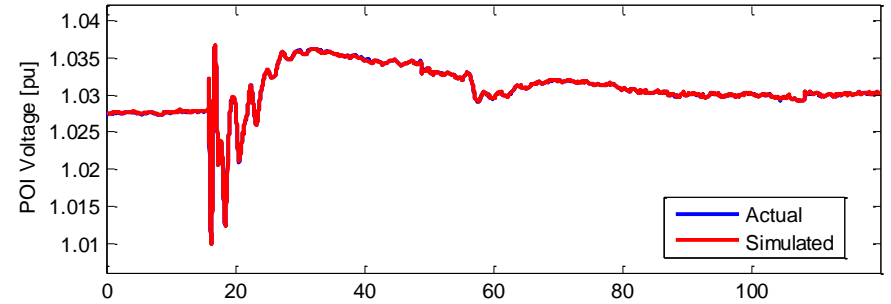
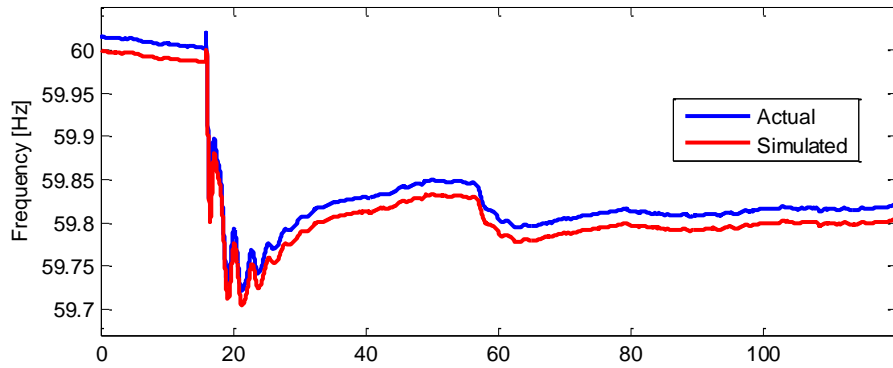


Event 2





Event 3





Validating GE Default Model Data for Type 3 Wind Turbine Generators

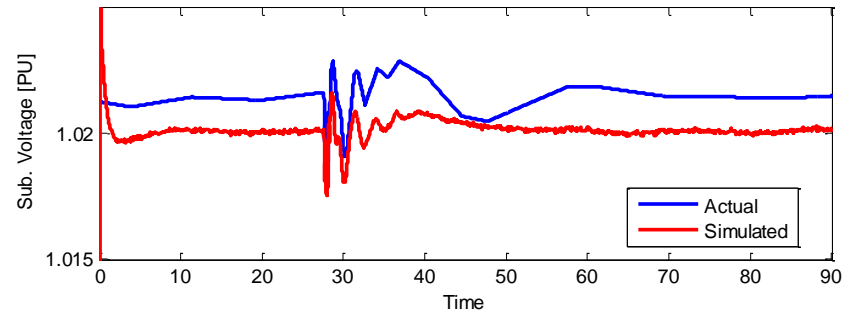
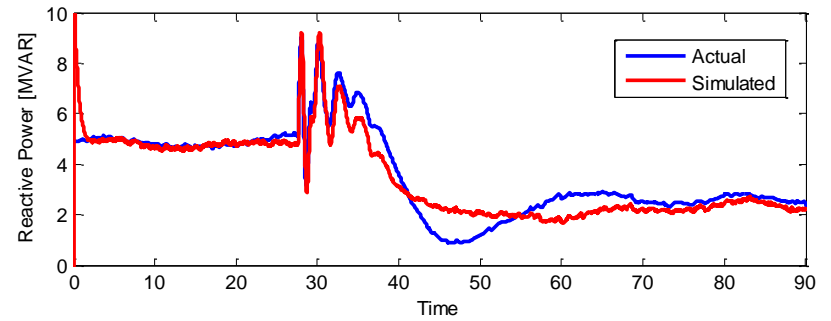
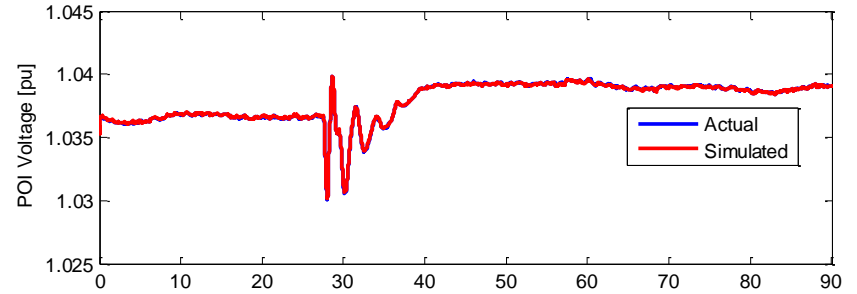
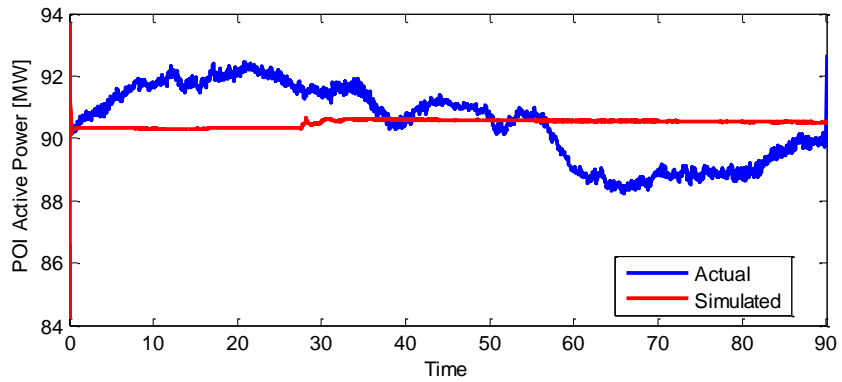
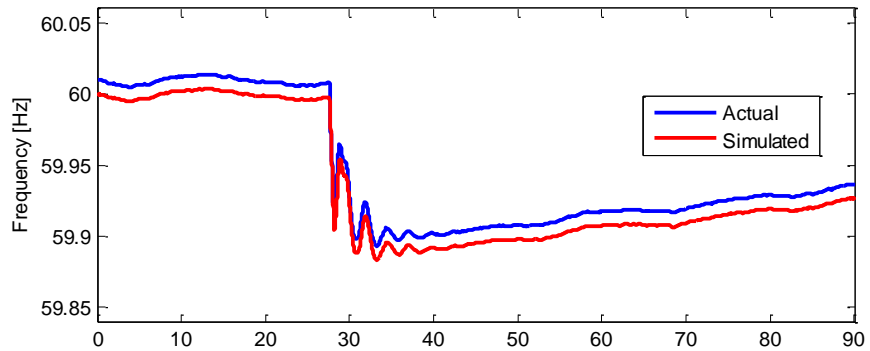
- regc_a : Generator/converter model
- reec_a : Renewable energy electrical control model
- wtgq_a : WTG Torque controller model
- wtgt_a : Drive train model
- wtga_a : Simple aerodynamic model
- wtgp_a : WTG Pitch controller
- repc_a : Power Plant Controller

Example Dynamic files:

```
regc_a      xxxxx "WIND W3A  " 0.60 "Z1" :#9 mva=80.6  "lvplsw" 1.000000 "rrpwr" 10.0000 "brkpt" 0.900000 "zerox" 0.400000 "lvpl1"
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"iqrmin" -99.0000 "xe" 0.800000
reec_a      xxxxx "WIND W3A  " 0.60 "Z1" :#9 "mvab" 0.0 "vdip" -99.0 "vup" 99.0 "trv" 0.0 "dbd1" -0.05 "dbd2" 0.0 "kqv" 0.0 "iqh1" 1.0500
"iql1" -1.0500 "vref0" 0.0 /
"iqfrz" 0.150000 "thld" 0.0 "thld2" 0.0 "tp" 0.050000 "qmax" 0.400000 "qmin" -0.400000 "vmax" 1.1000 "vmin" 0.900000 "kqp" 0.0 "kqi" 0.100000
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wtgp_a      xxxxx "WIND W3A  " 0.60 "Z1" :#9 "mvab" 0.0 "kiw" 25.0000 "kpw" 150.00 "kic" 30.0000 "kpc" 3.0000 "kcc" 0.0 "tpi" 0.300000
"pimax" 27.0000 "pimin" 0.0 "piratmx" 10.0000 "piratmn" -10.0000
repc_a      xxxxx "WIND W3A  " 0.60 "Z1" YYYYYY!!!! YYYYYY "WINDD 3A  " 34.50 ZZZZZ "WIND  " 230.00 "1" 1 :#9 "mvab" 0.0 "tfltr"
0.020000 "kp" 1.0000 "ki" 10.0000 "tft" 0.0 "tfv" 0.500000 "refflg" 1.000000 "vfrz" 0.0 "rc" 0.0 "xc" 0.0 "kc" 0.050000 "vcmpflg" 1.000000 "emax"
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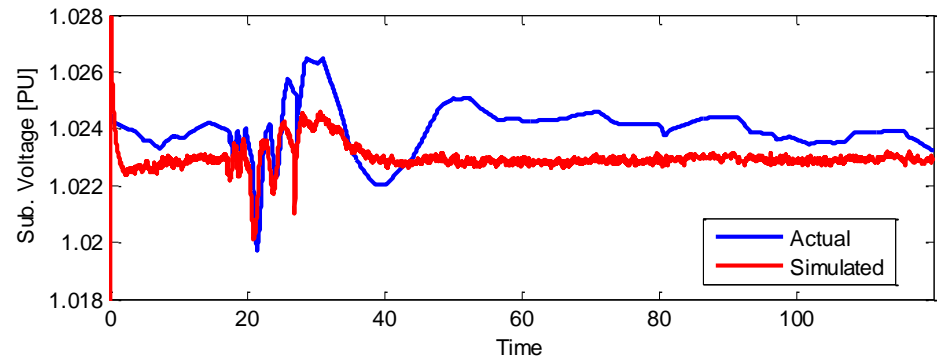
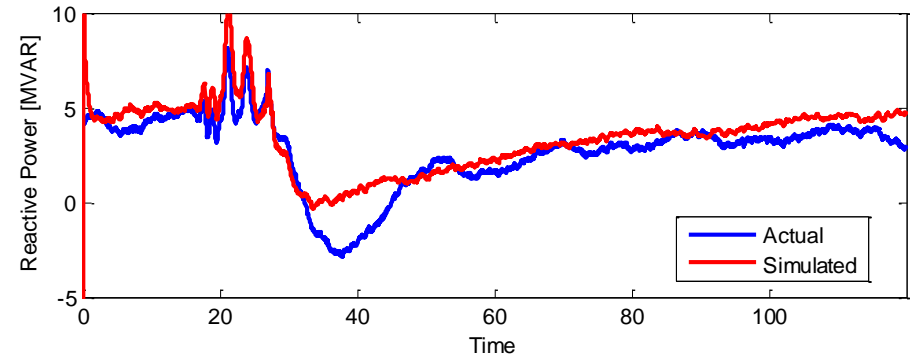
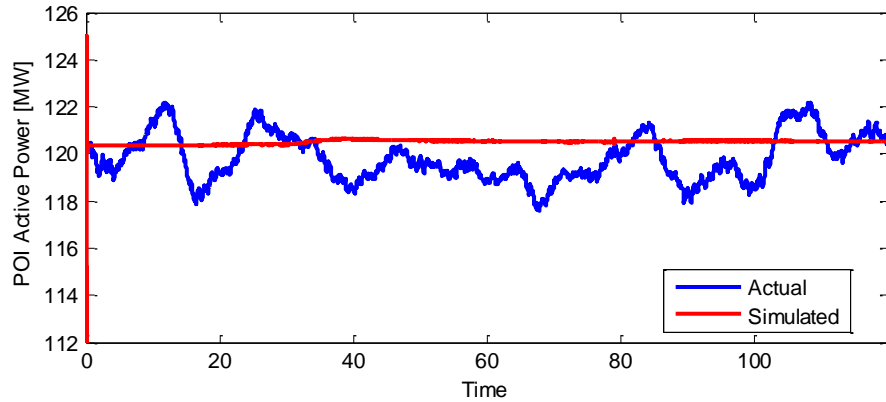
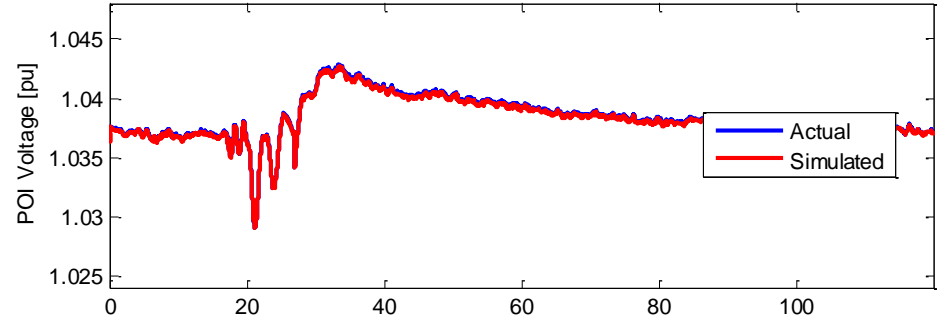
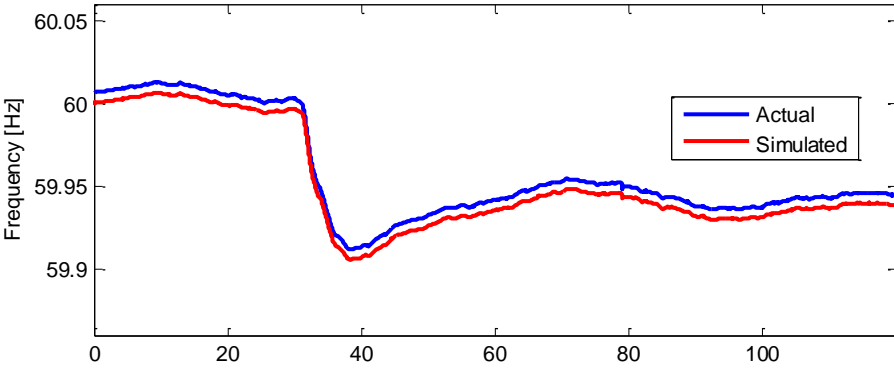


Event 1



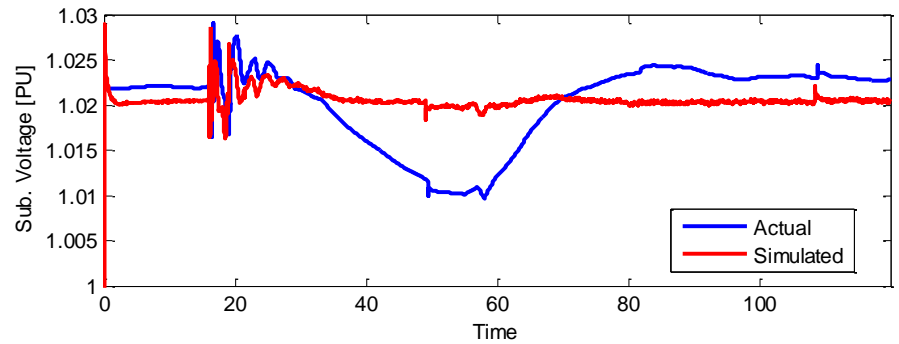
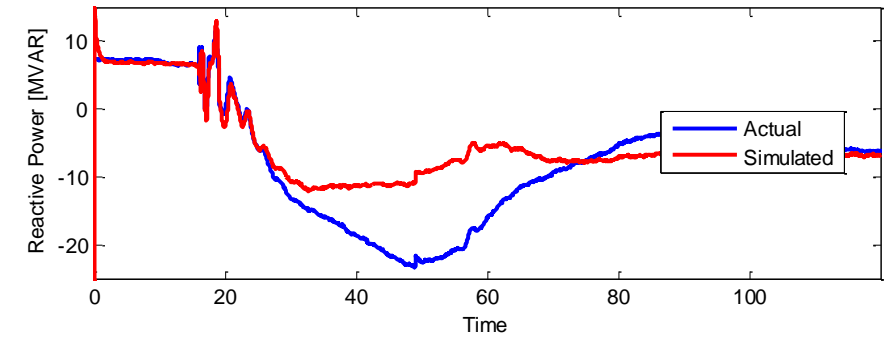
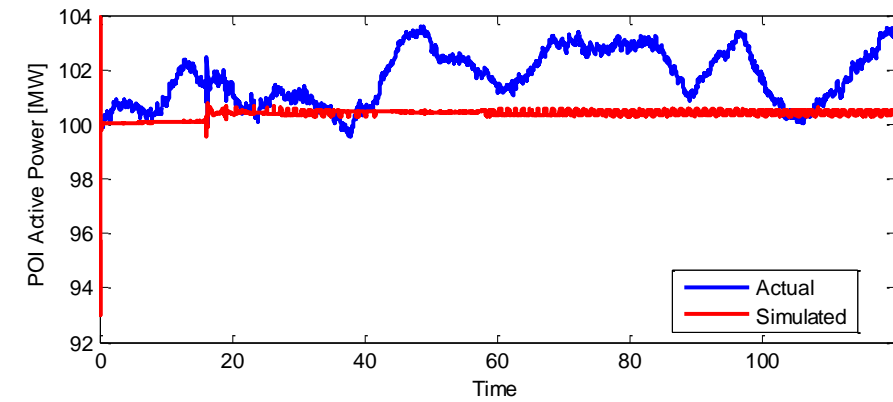
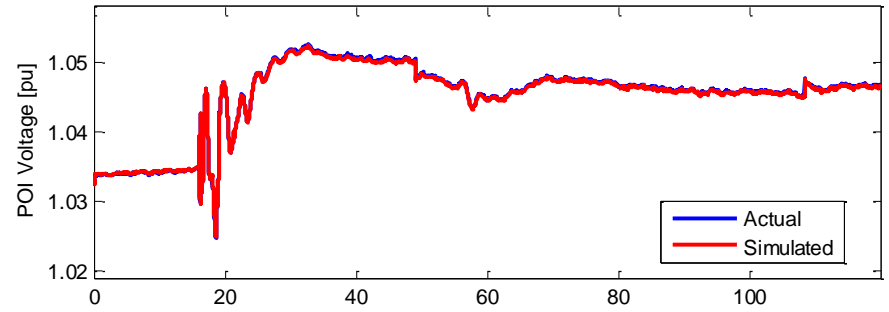
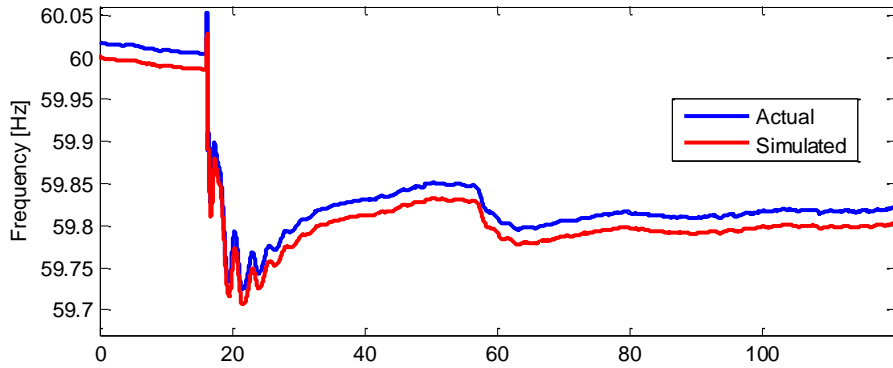


Event 2





Event 3





Summary

- Initial results are very good
 - Continue to work with manufactures and owners
 - Solar power plant validation are done in same fashion
- Encouraging owners to install PMU
 - Getting more attraction – NERC Reliability Standards
 - Cost saving
- WECC MVWG REM and PPMVD collaboration
 - Roadmap for wind and solar power plant model data and validation
 - Participation and collaboration is a key to success
- EPRI's Wind PPPD
 - Continue to work with EPRI
 - EPRI's looking for more data



Thank You!

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