BPA Studies Using Composite Load Model – Portland Metro Area

2015 NERC-DOE FIDVR Conference

Presented by

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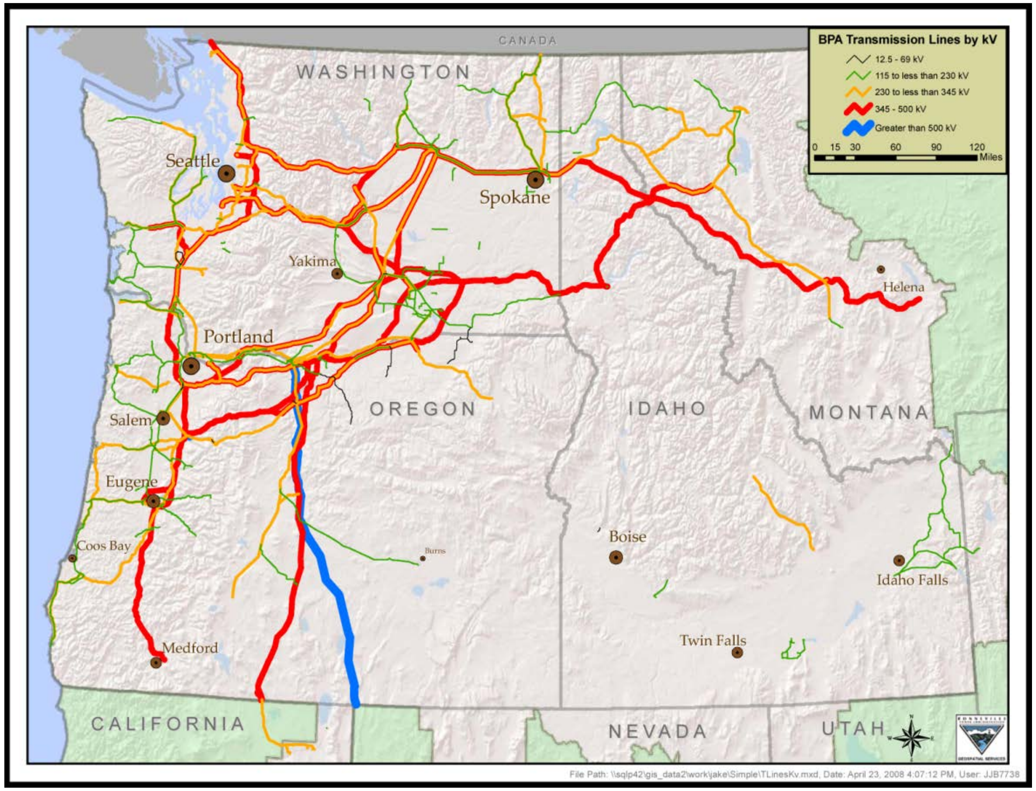
BPA Overview



- 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)

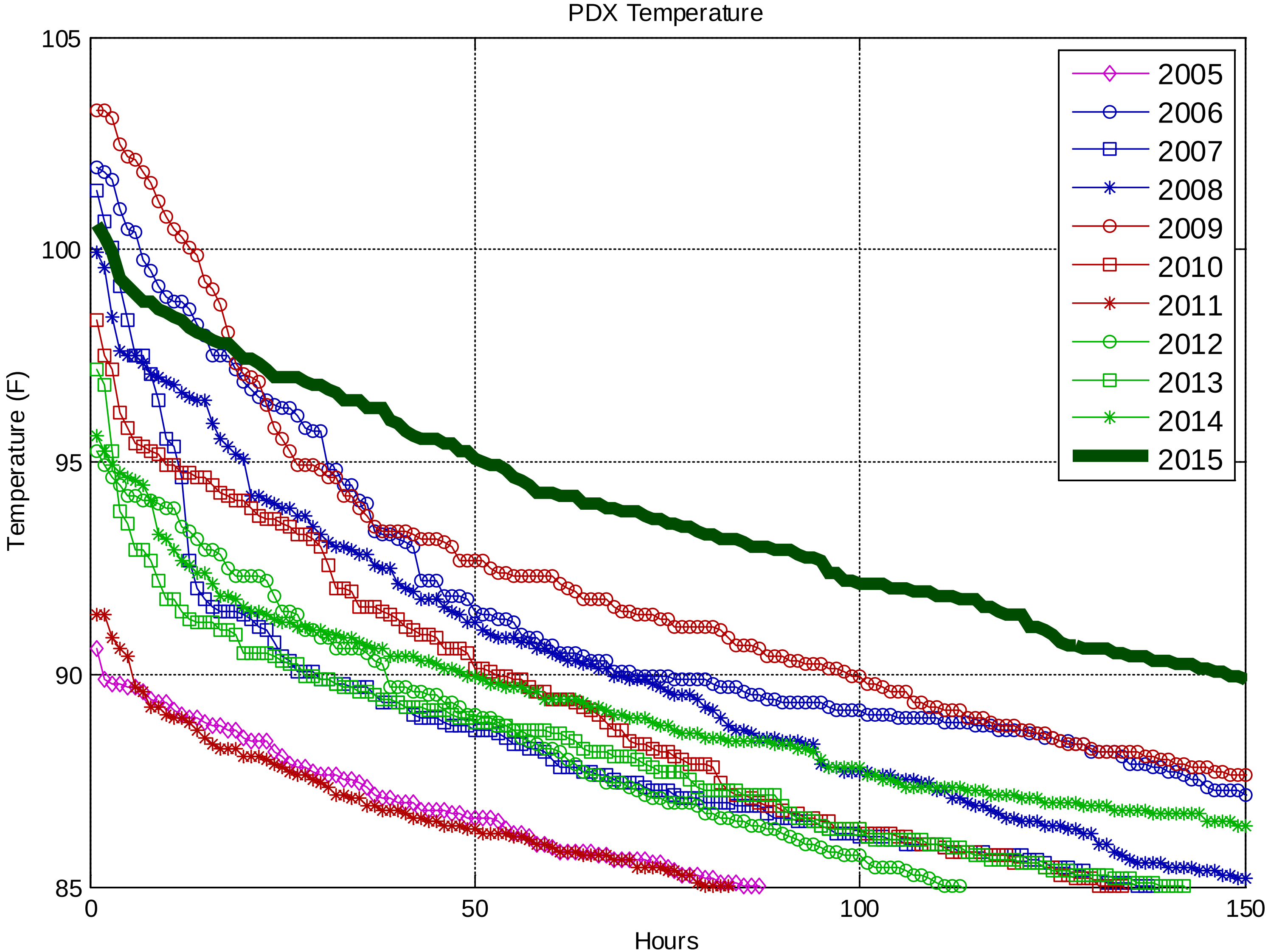
Portland Area Study

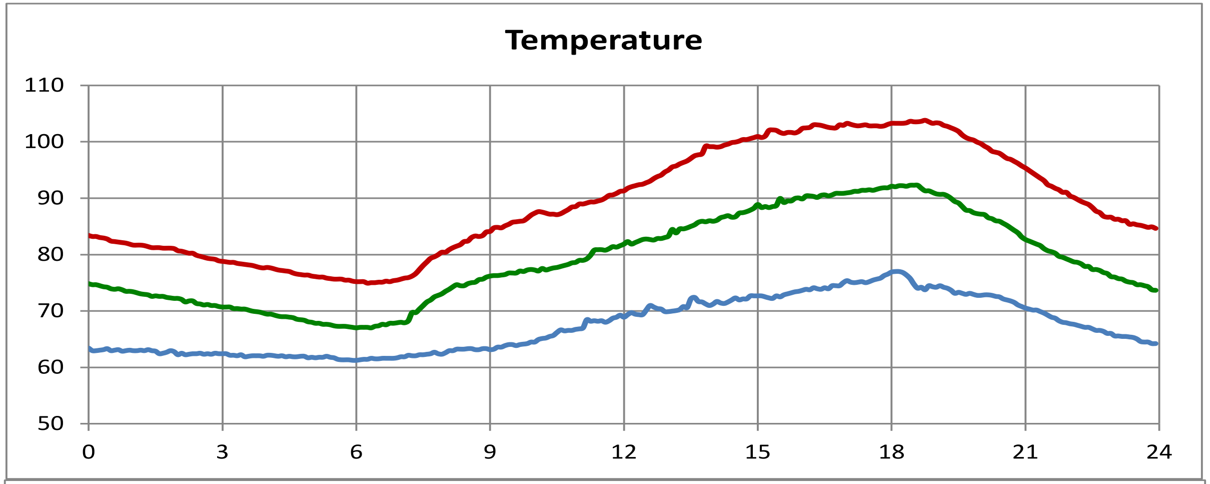
The study has multiple objectives:

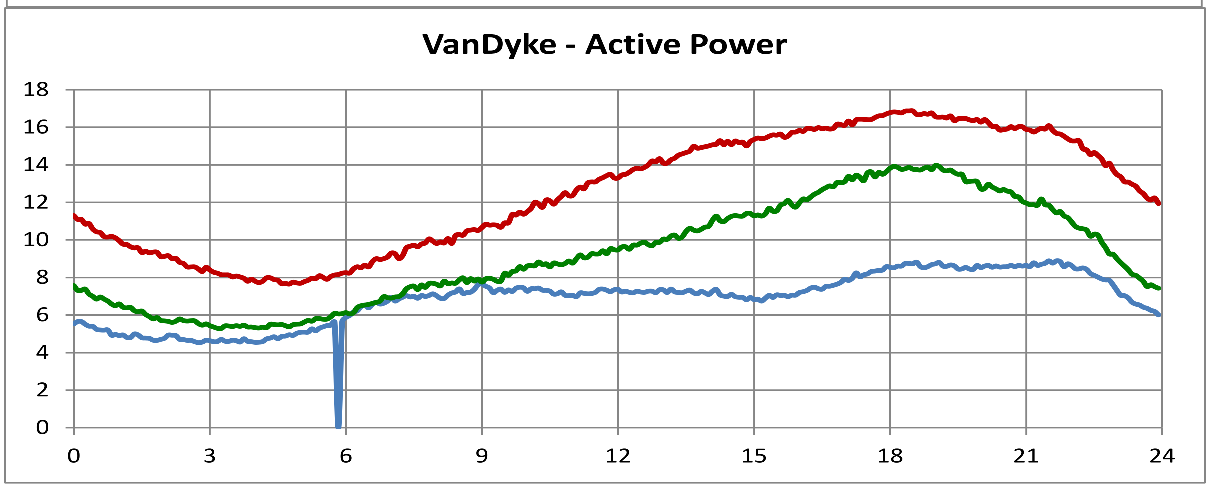
- Modeling
  - One of the first large scale studies using phase 2 load models (air-conditioner stalling is enabled)
- Reliability Assessment
    - What types of faults and under what conditions can cause load-induced voltage instability or delayed voltage recovery in Portland Metro area?
    - Should a wide-spread load-induced voltage instability or delayed voltage recovery occur in Portland Metro area, what are the risks of it cascading in other parts of the system?
    - What solutions can be used to mitigate FIDVR phenomenon and limit its propagation?
- Regulatory Support (NERC TPL-001-4 Standards R5)

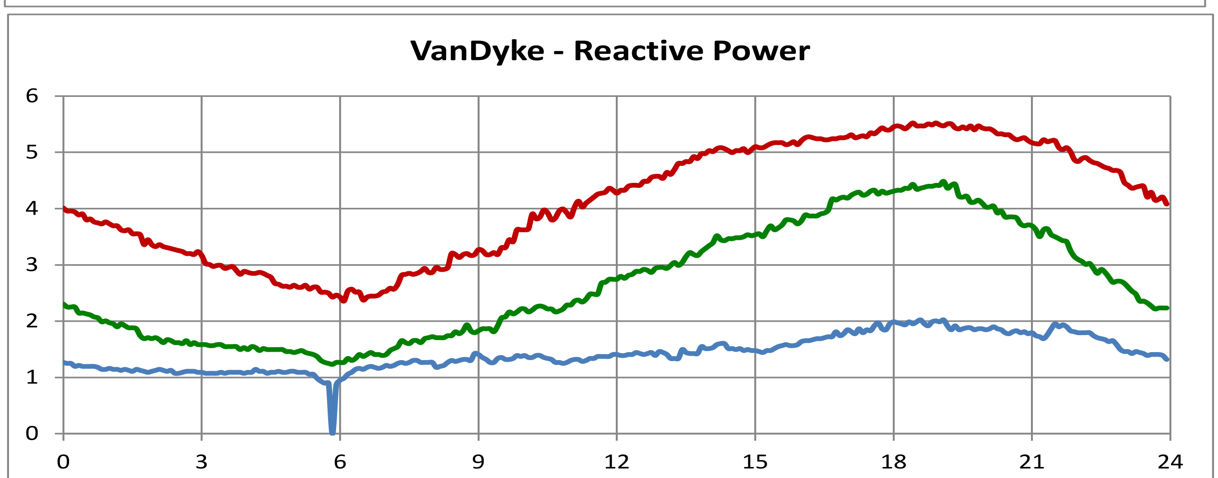
It does get hot in Portland

… but not very often





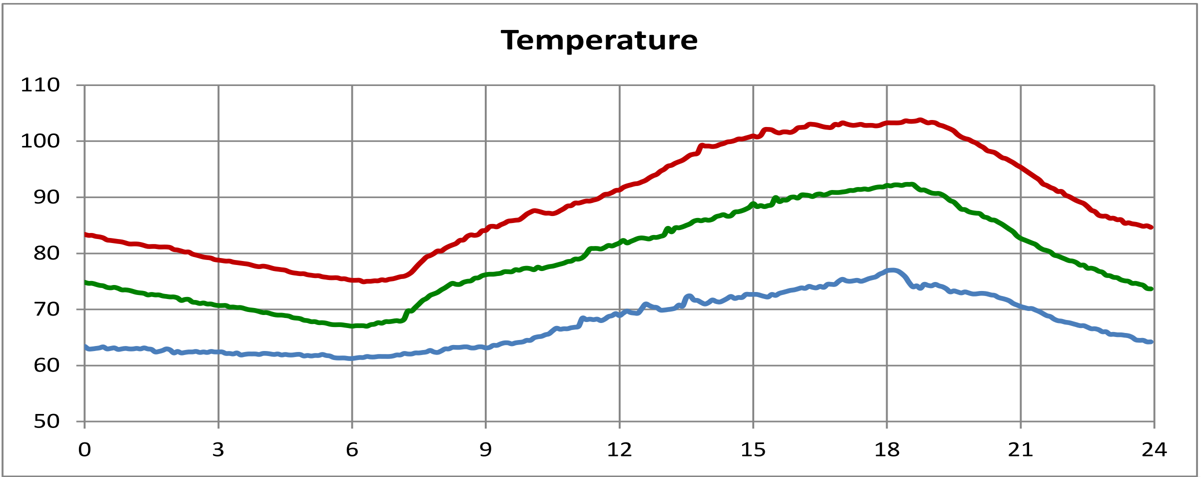


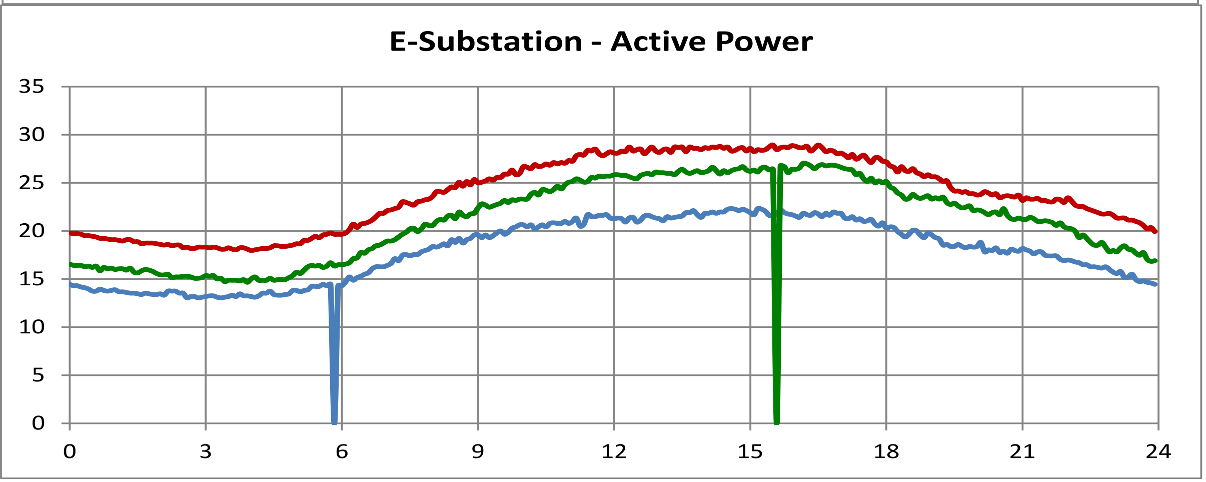


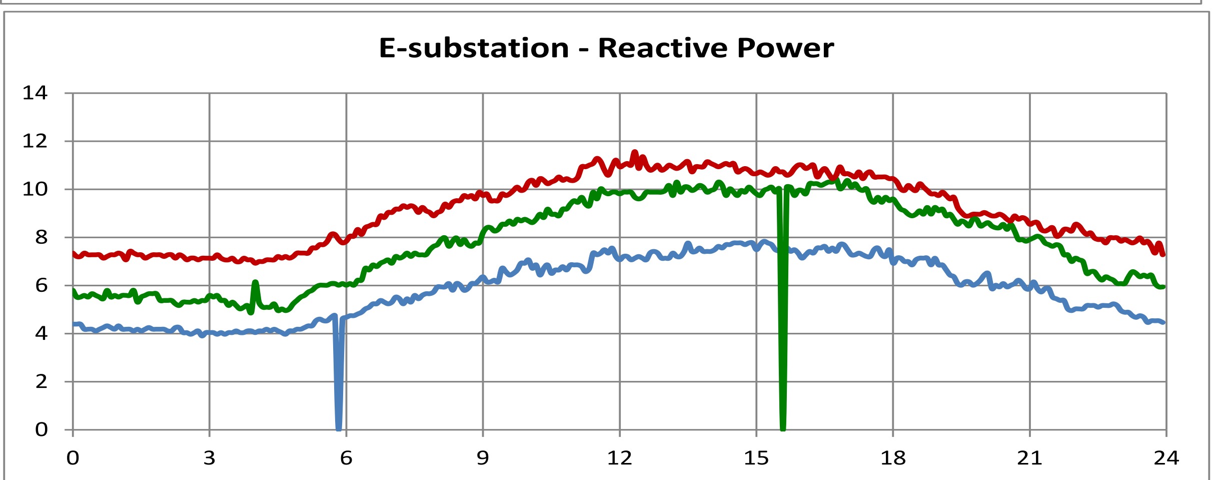
Sub-urban residential neighborhood (newer construction)

Air-conditioning load accounts for 40 to60% of total summer load

Downtown commercial

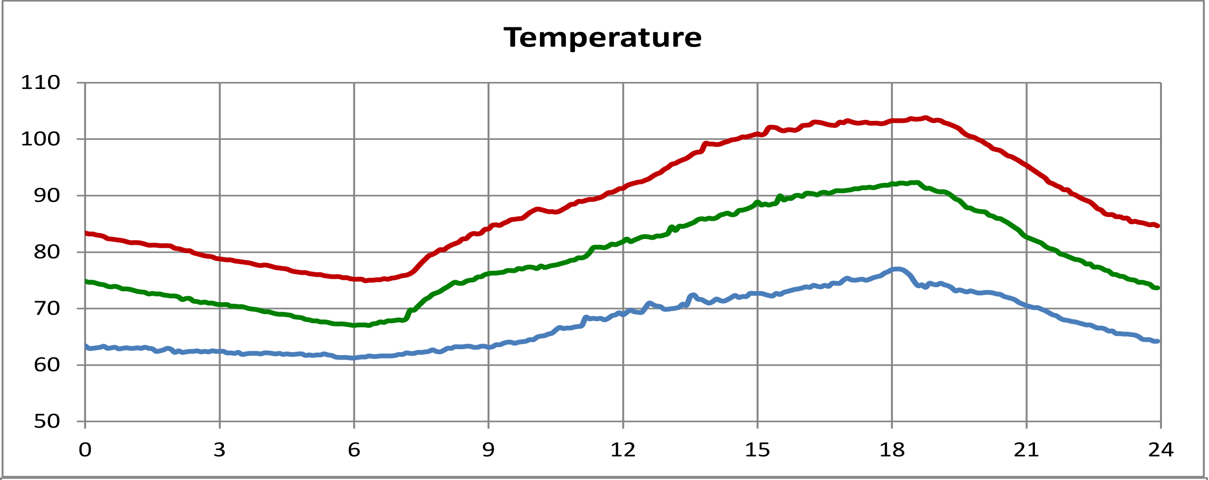


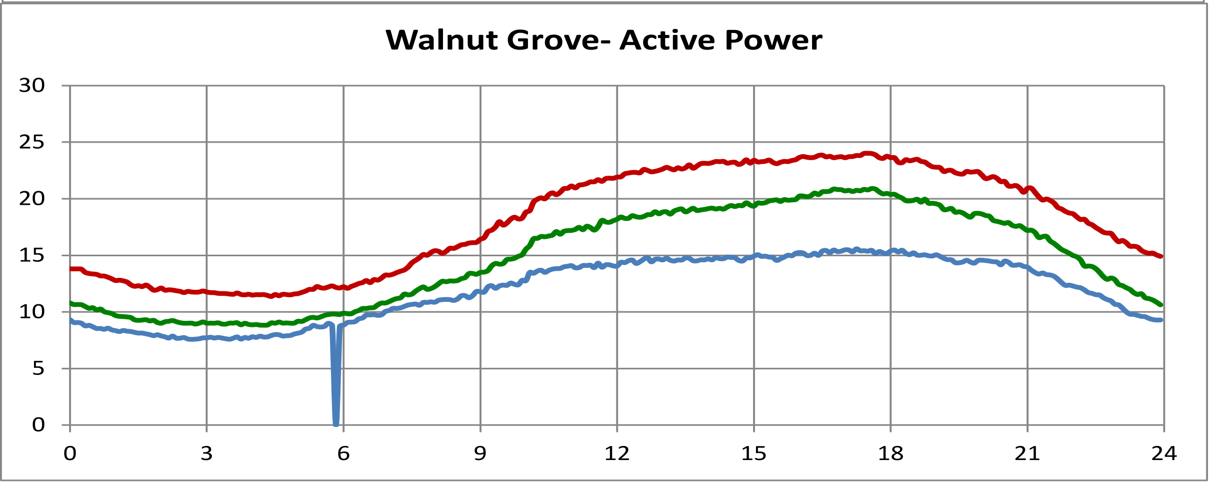


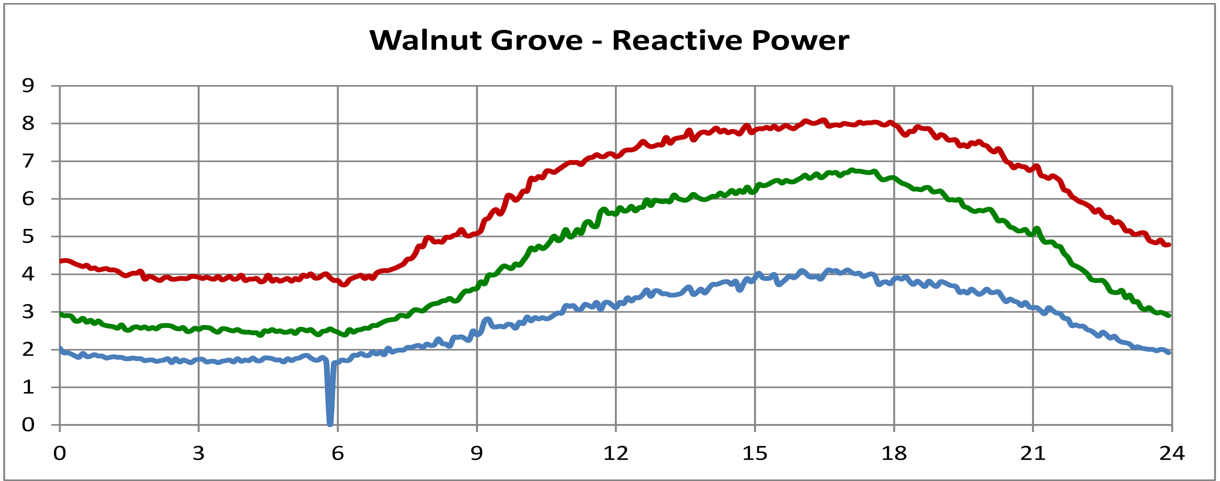


Commercial loads show less temperature sensitivity

Mixed Loads


Temperature
110
100
90
80
70
60
50
0
3
6
9
12
15
18
21
24


Walnut Grove- Active Power
30
25
20
15
10
5
0
0
3
6
9
12
15
18
21
24


Walnut Grove - Reactive Power
9
8
7
6
5
4
3
2
1
0
0
3
6
9
12
15
18
21
24

Portland Area Study

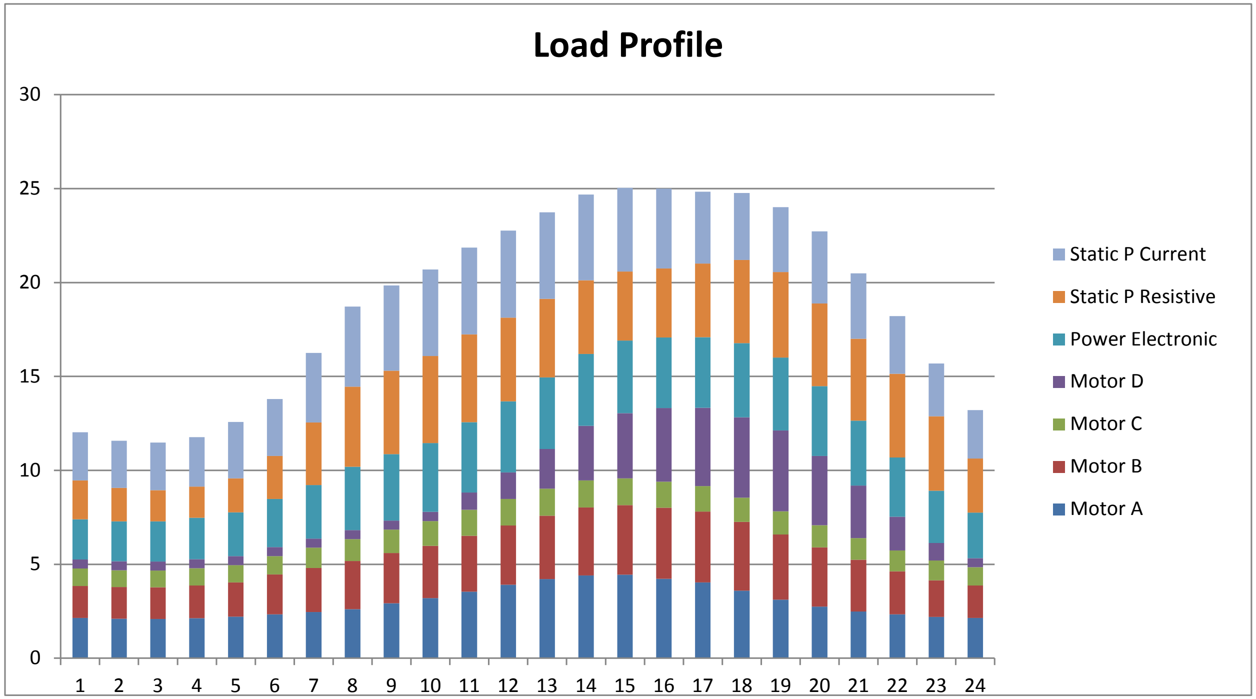
High-volume of transient simulations is performed:

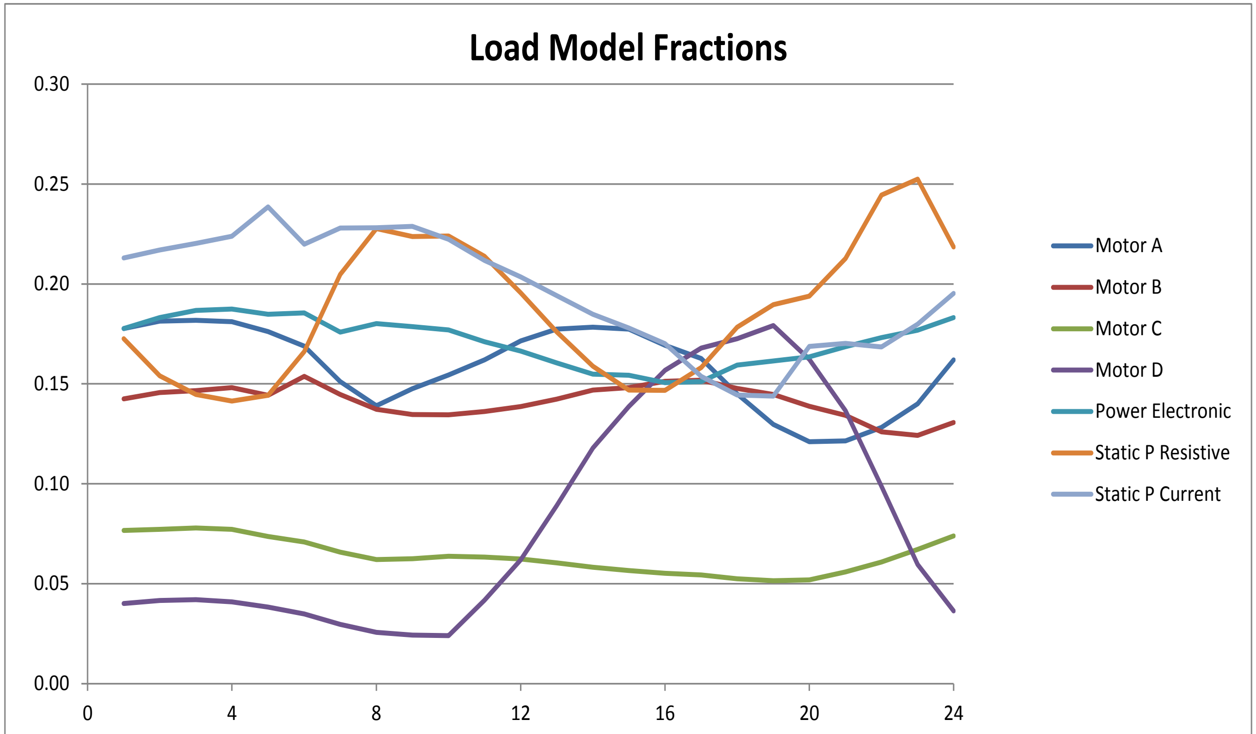
- Base Case scenarios = 3
- Hours (14:00 to 18:00) = 5
- Contingencies = 132
- Temperature sensitivities = 2
- Total Runs = 3,960

In addition to composite load model, we modeled shunt capacitors and reactor relays (Ryan Quint), and line distance relays

We also run scenarios of generation tripping during a contingency

WECC Load Composition Model





Modeling Assumptions (for HE 17:00)

Normal Summer

Load	MA	MB	MC	MD	Electronic	Static - R	Static - I
Mixed	**0.16**	0.15	0.05	**0.17**	0.15	0.16	0.15
Residential	**0.08**	0.13	0.03	**0.31**	0.13	0.23	0.09
Commercial	**0.21**	0.14	0.03	**0.12**	0.19	0.12	0.19

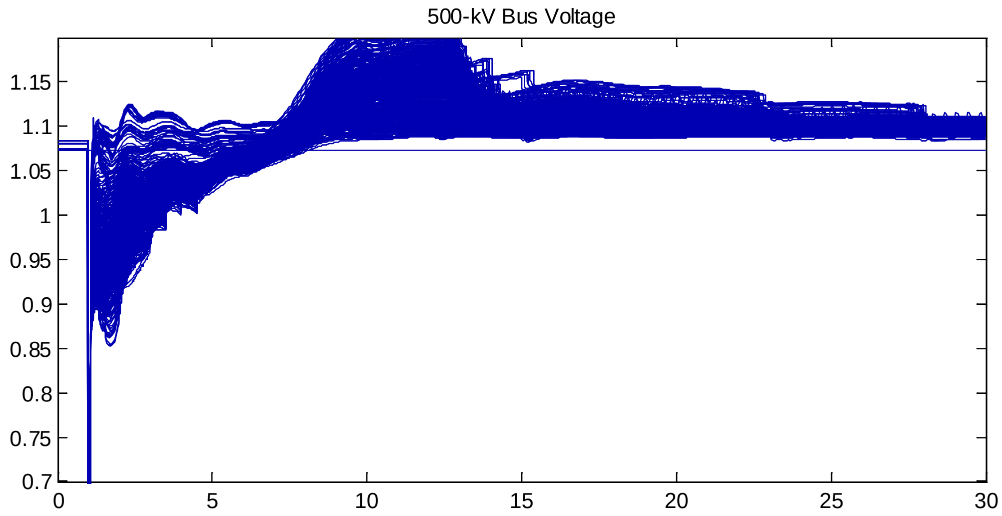
AC stalls if voltage drop below 54% for 3 cycles

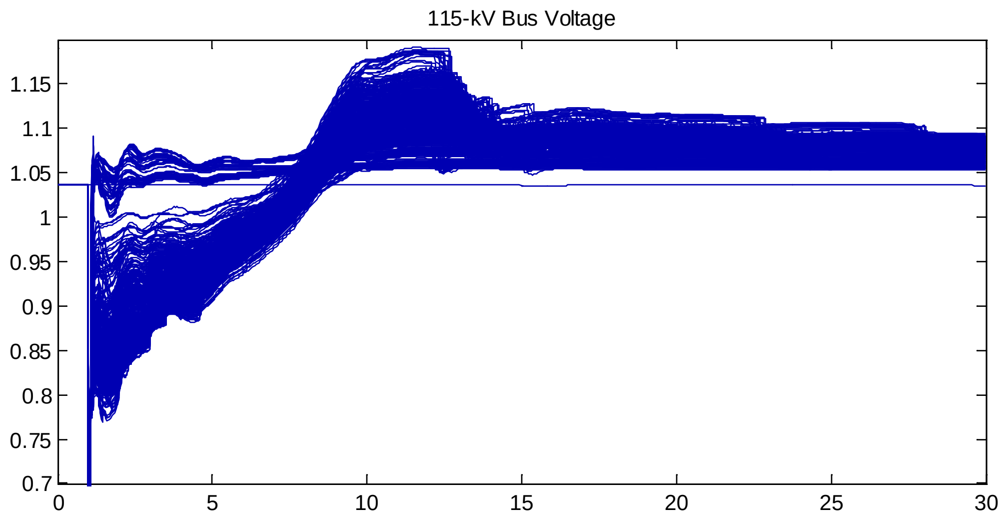
Hot Summer (95+ F)

Load	MA	MB	MC	MD	Electronic	Static - R	Static - I
Mixed	**0.17**	0.15	0.05	**0.24**	0.13	0.13	0.13
Residential	**0.06**	0.15	0.02	**0.42**	0.10	0.20	0.05
Commercial	**0.25**	0.15	0.04	**0.13**	0.14	0.09	0.20

AC stalls if voltage drop below 60% for 3 cycles

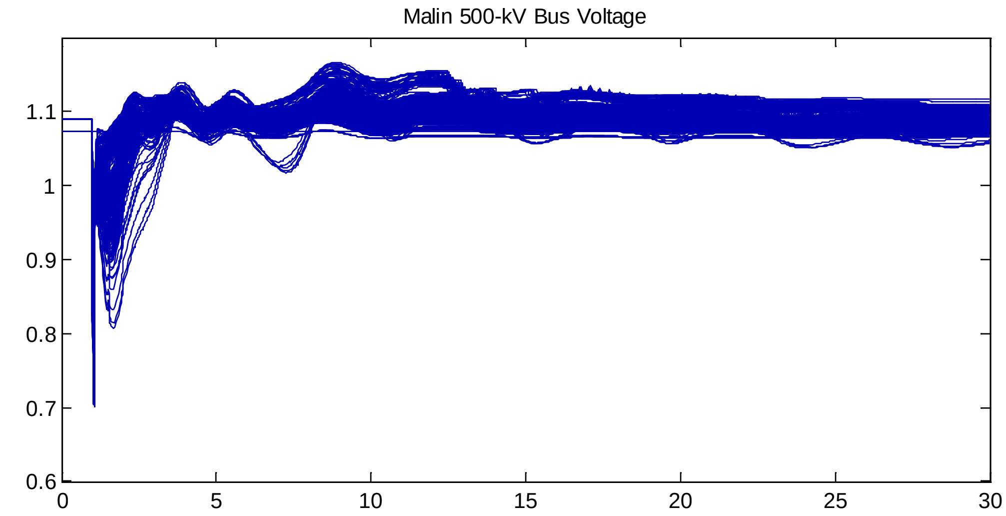
Portland Area Voltages

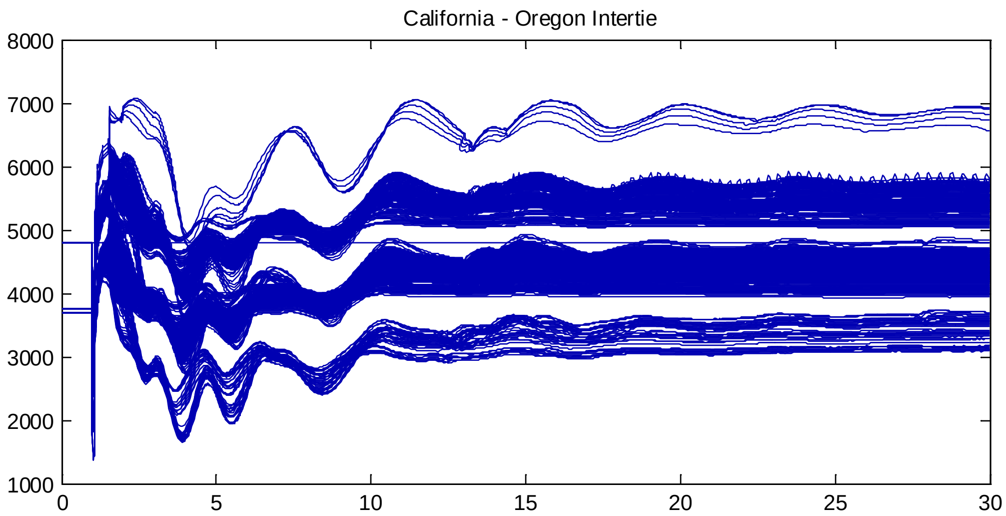




3-phase faults
500-kV and 230-kV
normal clearing

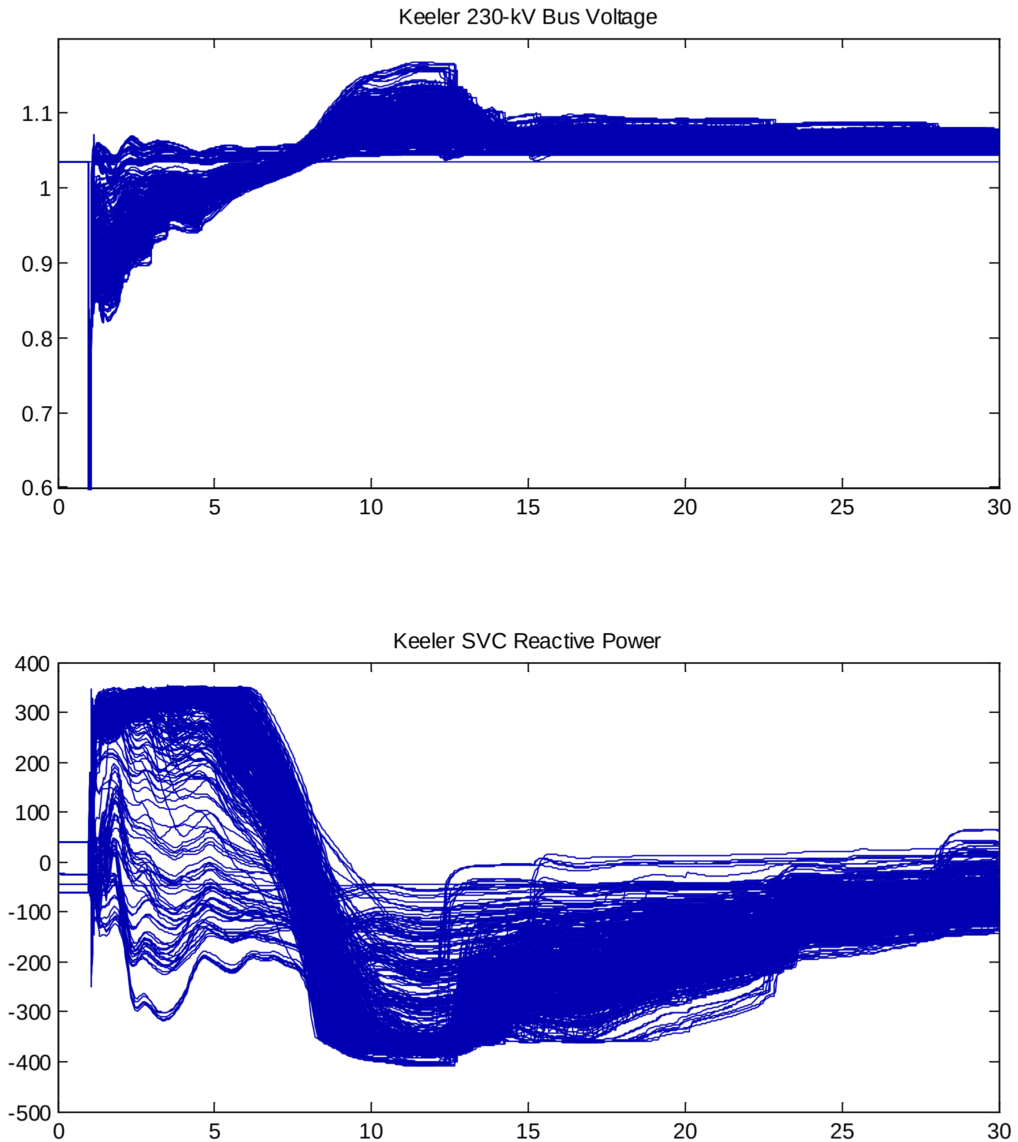
California – Oregon Intertie





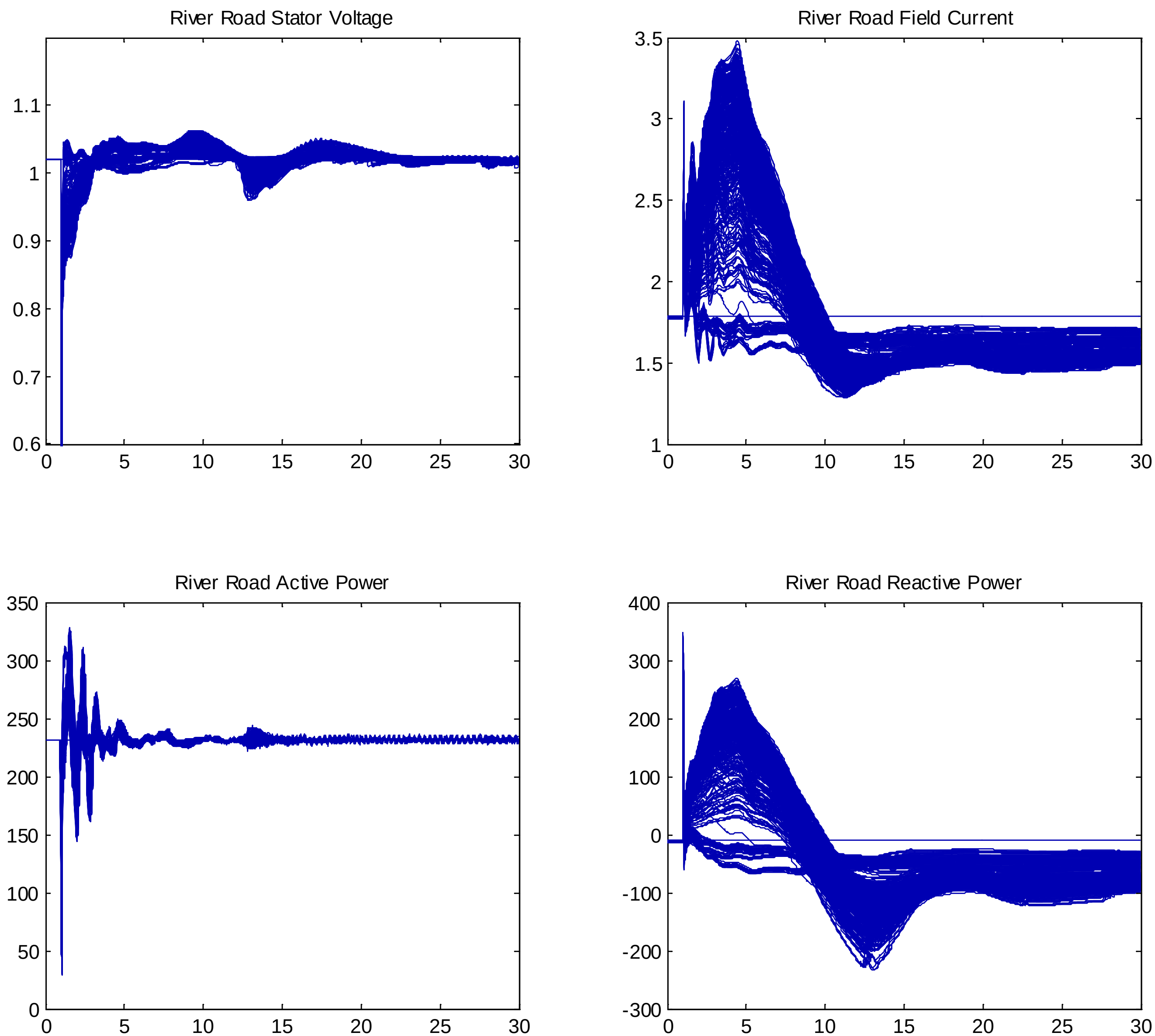
3-phase faults
500-kV and 230-kV
normal clearing

Portland Area SVC



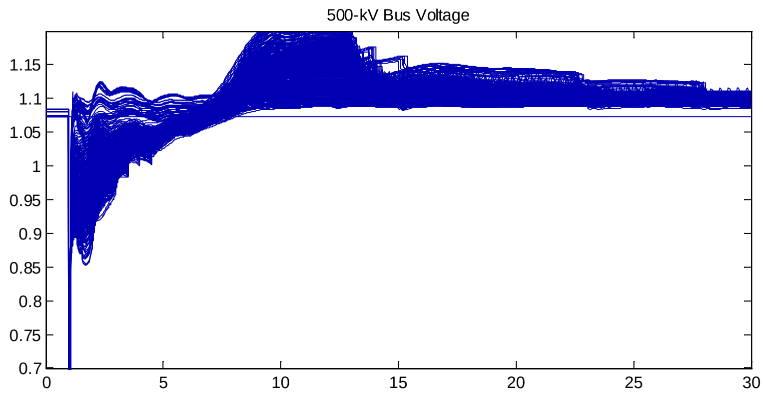
3-phase faults
500-kV and 230-kV
normal clearing

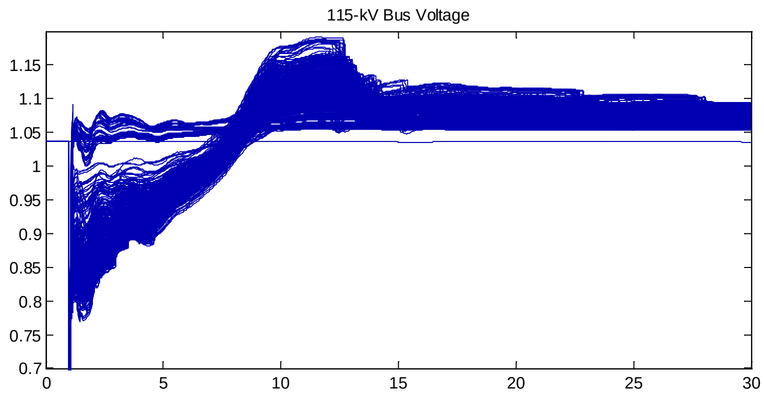
Portland Area Generation



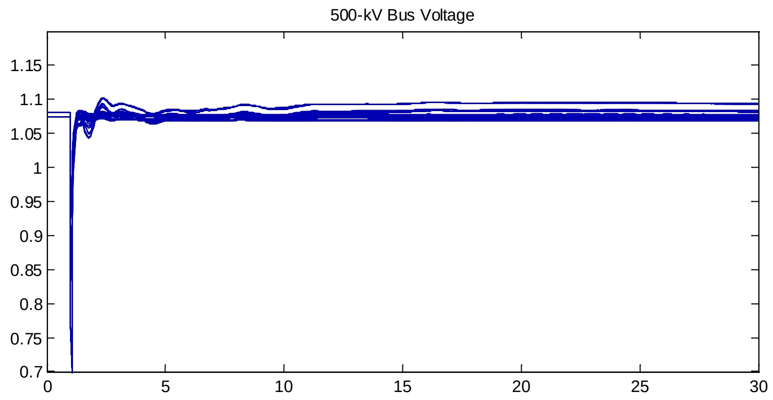
Fault Type Matters

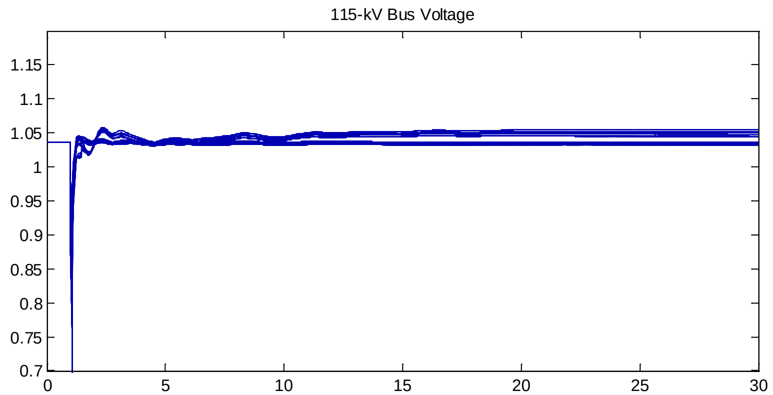
3-phase fault, normal clearing





1-phase fault, normal clearing

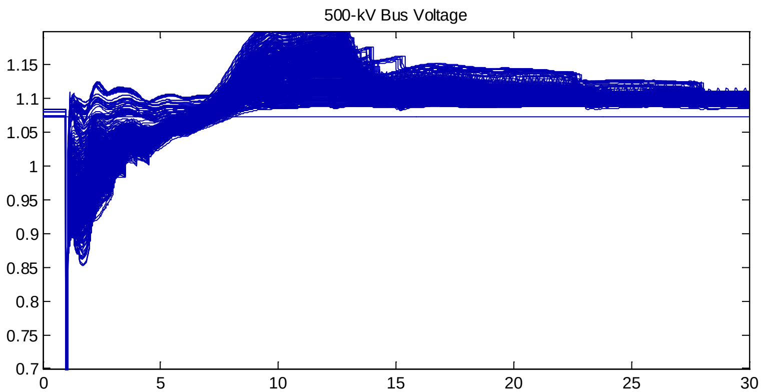


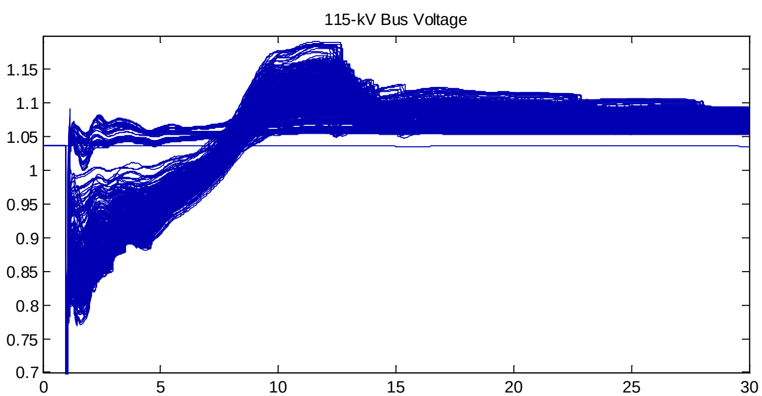


Portland area voltages

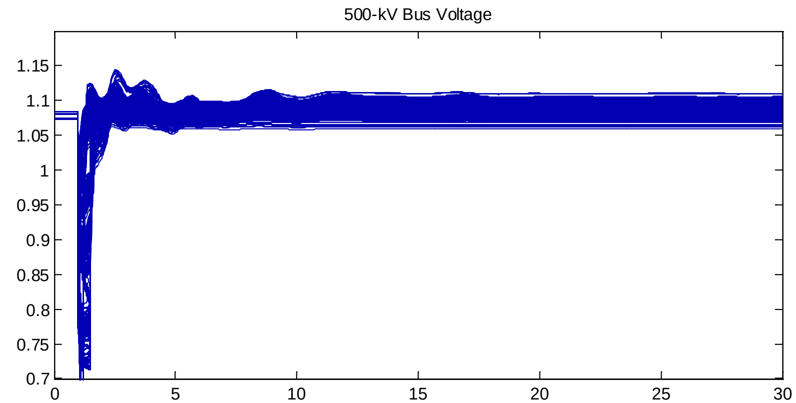
Fault Type Matters

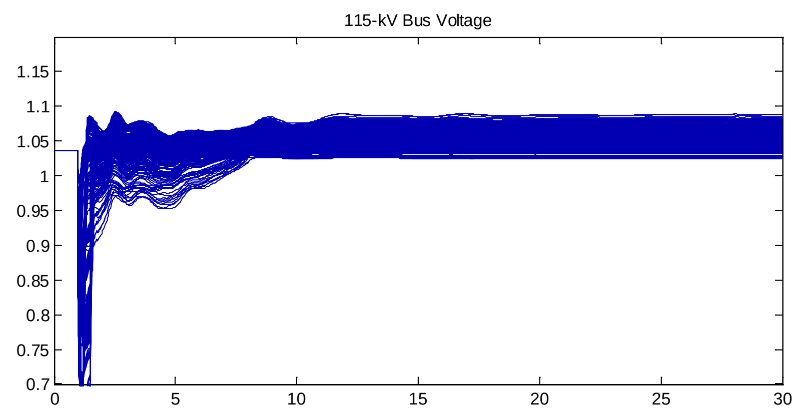
3-phase fault, normal clearing





1-phase fault, delayed clearing





Portland area voltages

Observations

Modeling:

- Phase 2 Composite Load Modeled performed well numerically in 4,000 runs, results look credible
- Further review of high voltages is required
  - Whether transformer saturation needs to be modeled (Carson Taylor)
  - Whether restart of air-conditioners needs to be modeled (Richard Bravo)
- Generators step-up transformers must be modeled, cannot have generators connected at 115-kV level
- Shunt reactor and capacitor relays need to be modeled
- Generator OEL and UEL need to be modeled

Observations

System Performance:

- 3-phase faults are likely to cause FIDVR in Portland area under hot temperatures
- 1-phase faults are not likely to result in FIDVR
- Should a FIDVR event occur, it does not cascade outside Portland area
- High voltages are possible after FIDVR due to loss of load
- High voltages are aggravated by shunt capacitor switching, many of the switching occur during voltage recovery

Next Steps – Portland Area Studies

- Monitoring
  - BPA has good PMU coverage of 500-kV grid and main 230-kV substations in the area
  - Continue expansion of synchronzied measurements down to sub-transmission and distribution levels (work with LSEs)
- Model Improvements
  - Re-run the studies after the revised AC model is implemented – results are expected to get better
  - Continue risk-based scenario planning to ensure robustness with respect to unexpected generator control actions and trips during FIDVR

Thank You