Planning and Operations Data Requirements

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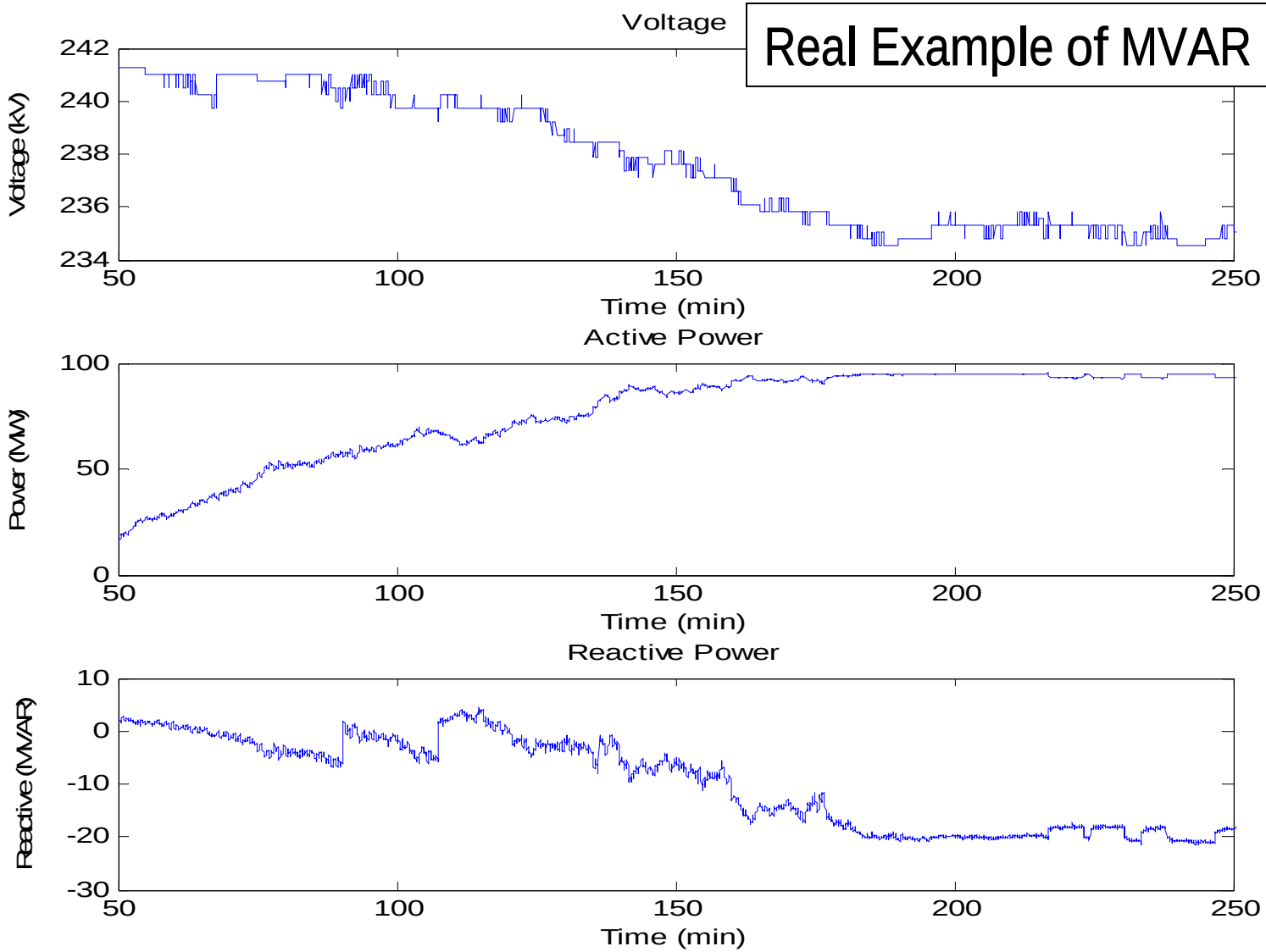
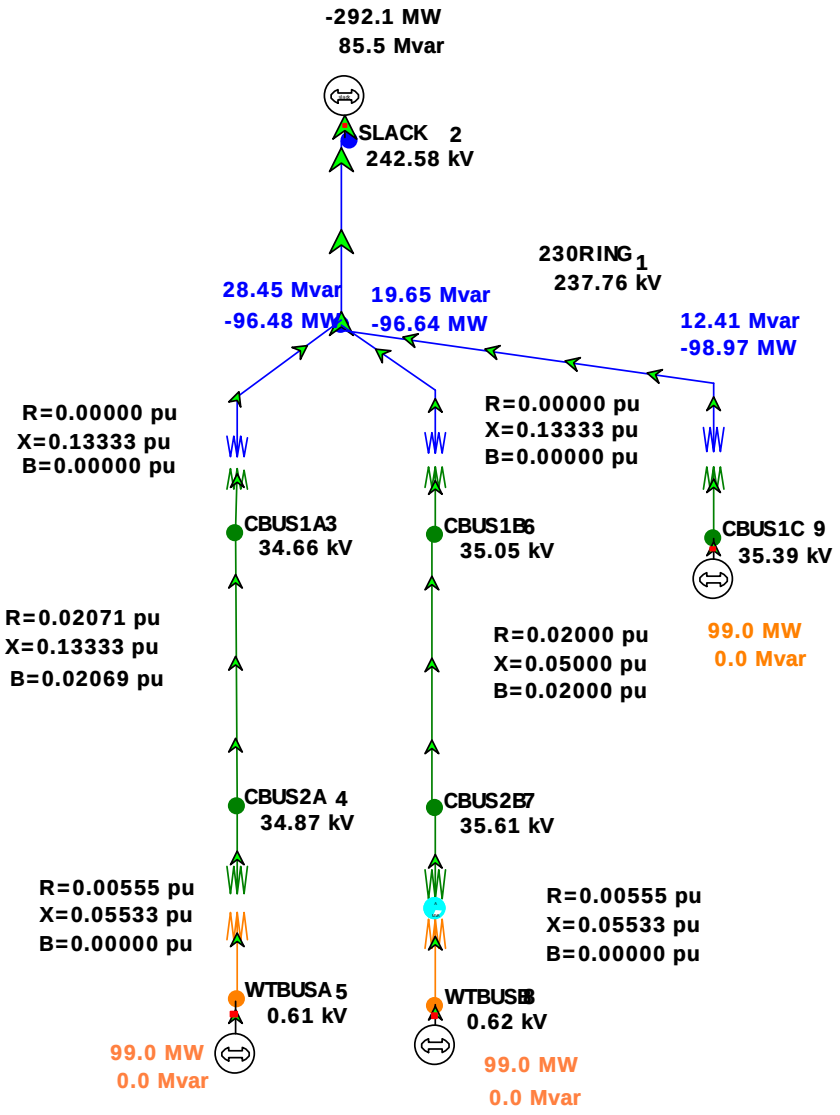
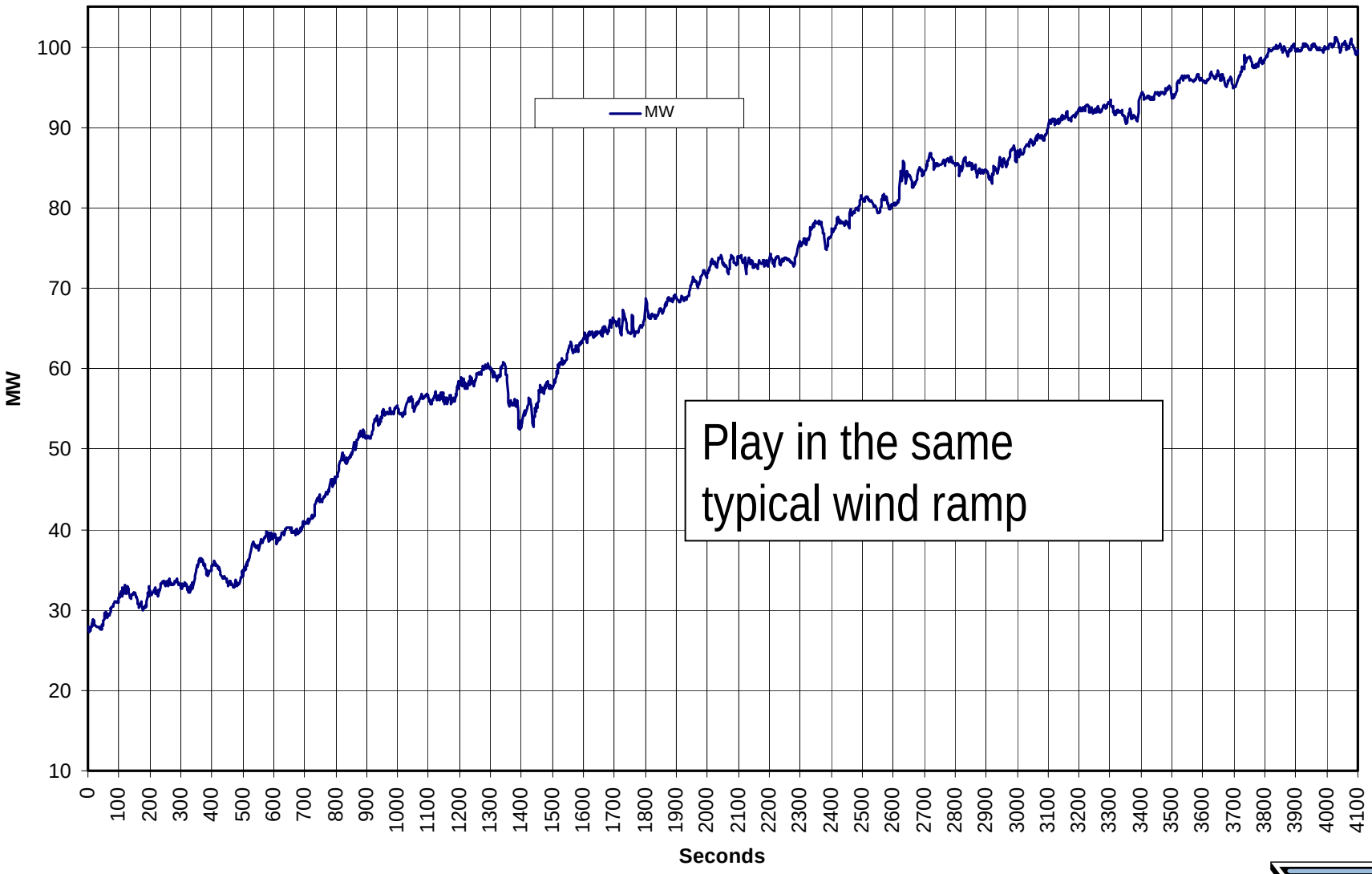
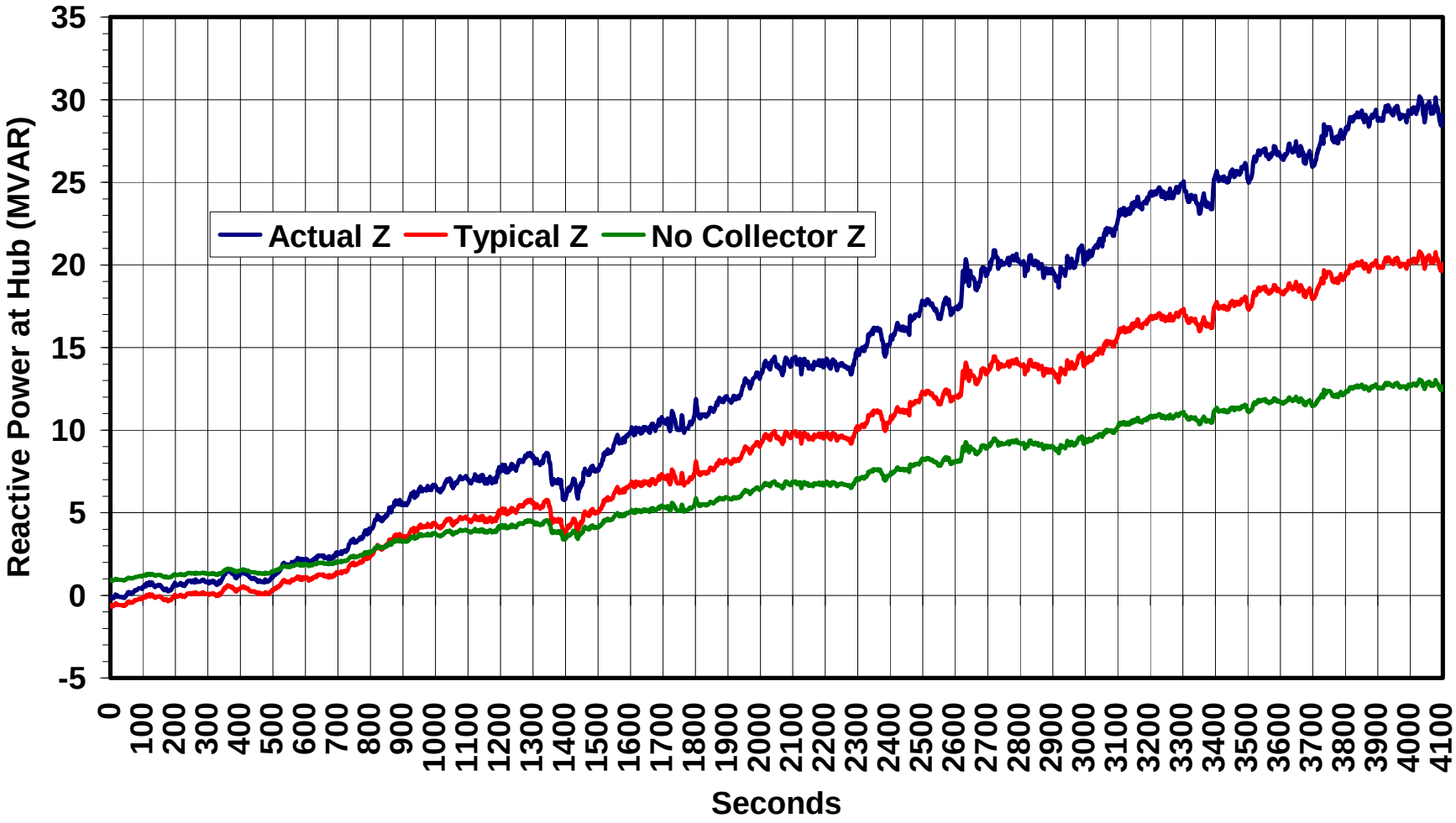
Real Example of MVAR Flows




-292.1 MW
85.5 Mvar
SLACK 2
242.58 kV
230RING 1
237.76 kV
28.45 Mvar
-96.48 MW
19.65 Mvar
-96.64 MW
12.41 Mvar
-98.97 MW
R=0.00000 pu
X=0.13333 pu
B=0.00000 pu
R=0.00000 pu
X=0.13333 pu
B=0.00000 pu
CBUS1A3
34.66 kV
CBUS1B6
35.05 kV
CBUS1C 9
35.39 kV
R=0.02071 pu
X=0.13333 pu
B=0.02069 pu
R=0.02000 pu
X=0.05000 pu
B=0.02000 pu
99.0 MW
0.0 Mvar
CBUS2A 4
34.87 kV
CBUS2B7
35.61 kV
R=0.00555 pu
X=0.05533 pu
B=0.00000 pu
R=0.00555 pu
X=0.05533 pu
B=0.00000 pu
WTBUSA 5
0.61 kV
WTBUSB8
0.62 kV
99.0 MW
0.0 Mvar
99.0 MW
0.0 Mvar


MW
100
90
80
70
60
50
40
30
20
10
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
3100
3200
3300
3400
3500
3600
3700
3800
3900
4000
4100
Seconds
Play in the same typical wind ramp

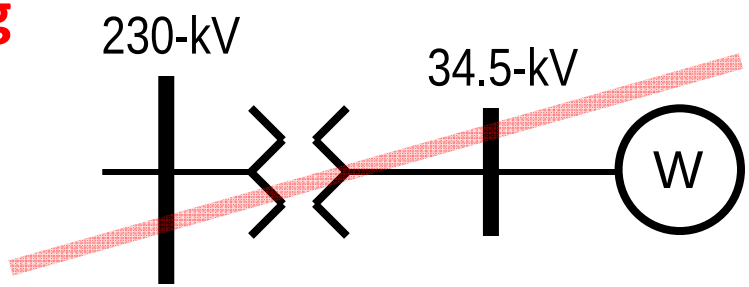
Collector System Example



Powerflow Modeling (Lesson Learned)

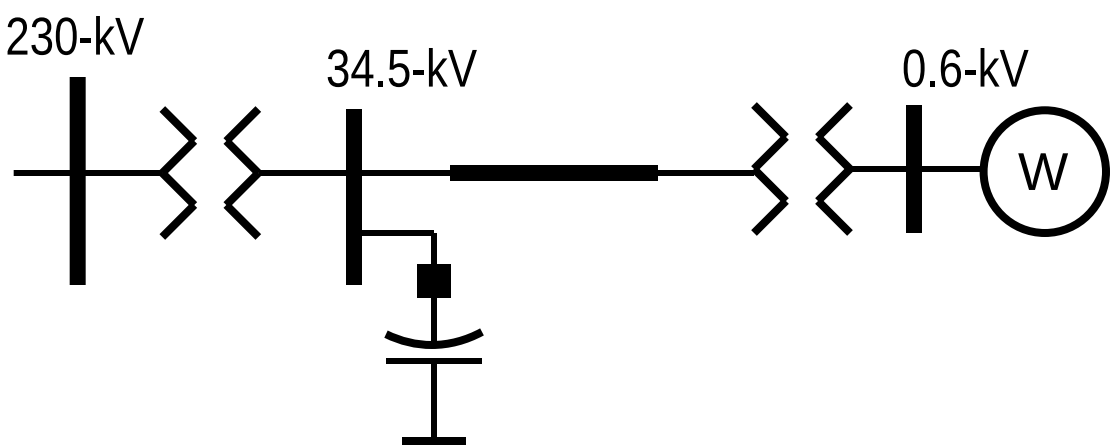
- Collector system equivalent must include shunts to properly model for voltage stability studies

Wrong



Optimistic assessment of reactive requirements

Right



Internal PF caps and external caps impacted by voltage squared (V^2/X)

Planning and Operations Modeling Data Overview

- As built data for the plant (turbines, transformers, any transmission lines to the POI, collector system)
- Most accurate model equivalent data
  - Collector system impedance
  - Reactive capability curve
  - Best available dynamic model type and parameters (Bob Zavadil)
- Operating studies determine seasonal and real time limits – inaccurate results may cause unnecessary, costly transmission limits or in the other extreme system failures due to undetected system limits.
- Planning studies will direct future reinforcements – accurate results help direct effective investments in the grid.
- NERC Modeling, Data, and Analysis (MOD) require accurate model data for generation

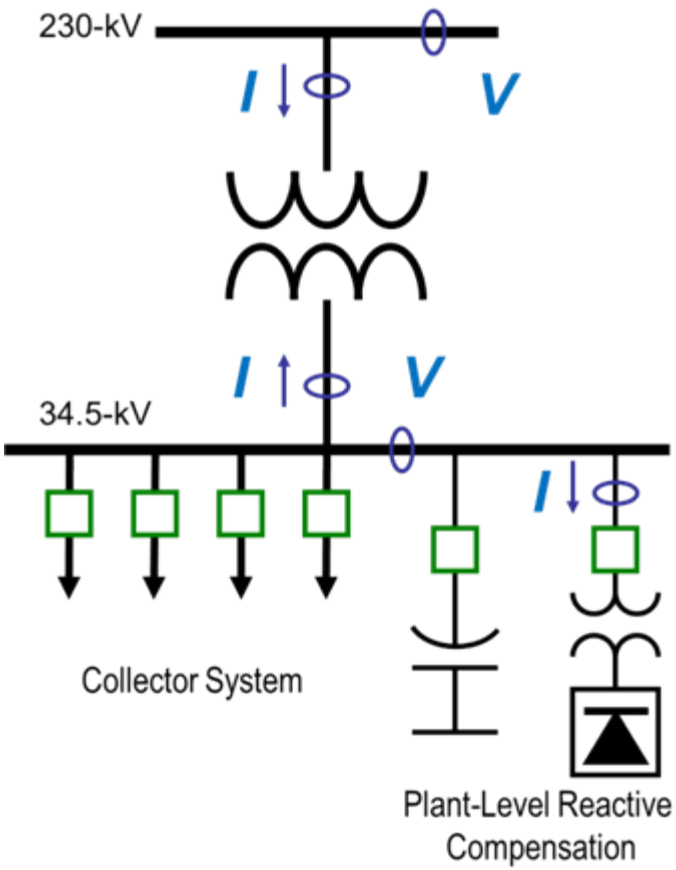
What are Phasor Measurements ?

- A PMU looks just like a relay
- Takes 3-phase voltages and currents
- Has a clock synched with GPS
- Calculates signal magnitude and angle – called “phasor”
- Streams the calculated “phasors” at the rate of 30 to 60 times per second
- Compared to traditional 4-second SCADA data –
  - measurements are <u>time-synchronized</u>,
  - better signal resolution
  - reported at <u>higher rate of 30 to 60 times per second</u>

PMUs enable observation of power system dynamic performance over a wide area

PMU Monitoring

- Wind Power Plant PMUs will measure:

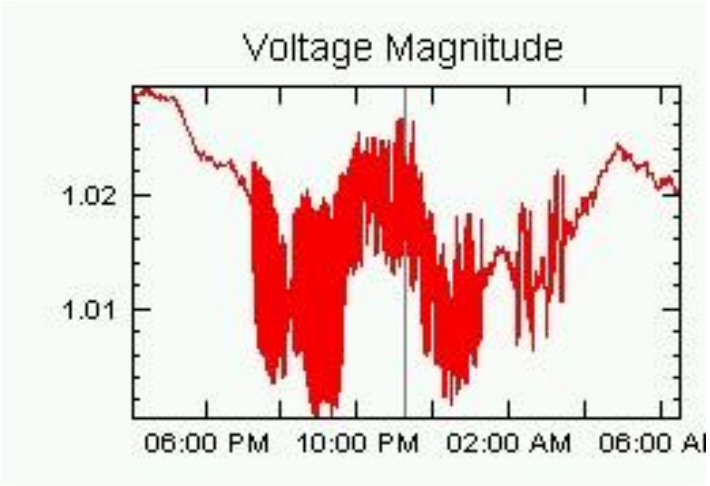


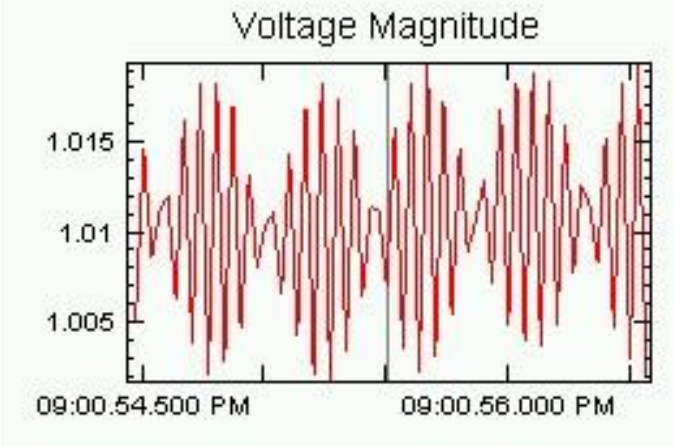
Data to be used in:

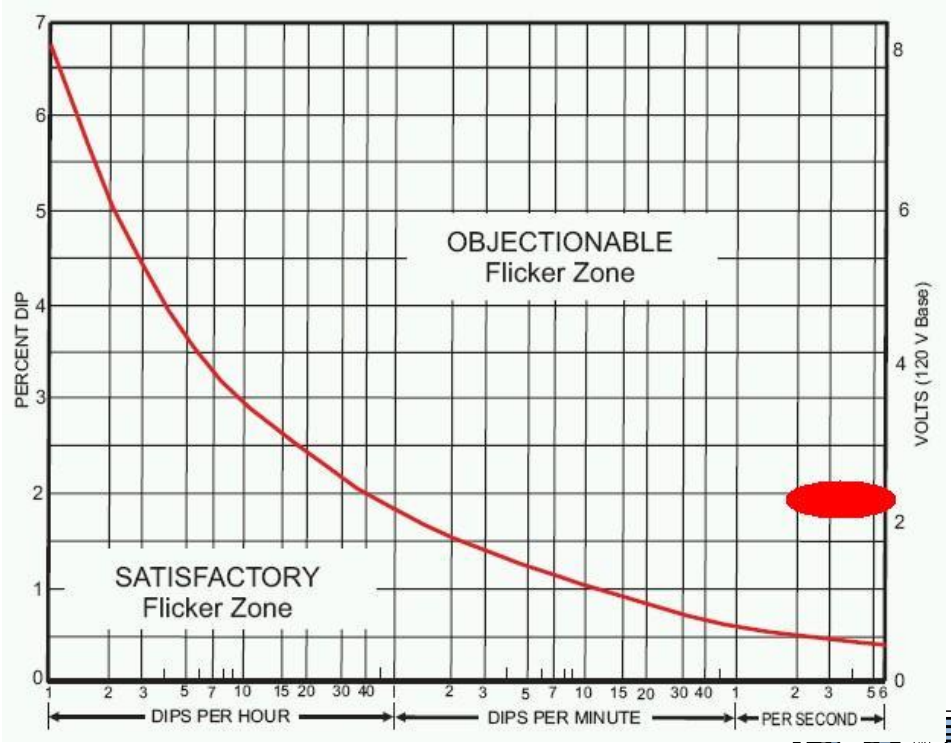
- Model validation
- Control performance analysis
- State estimation

PMU Monitoring

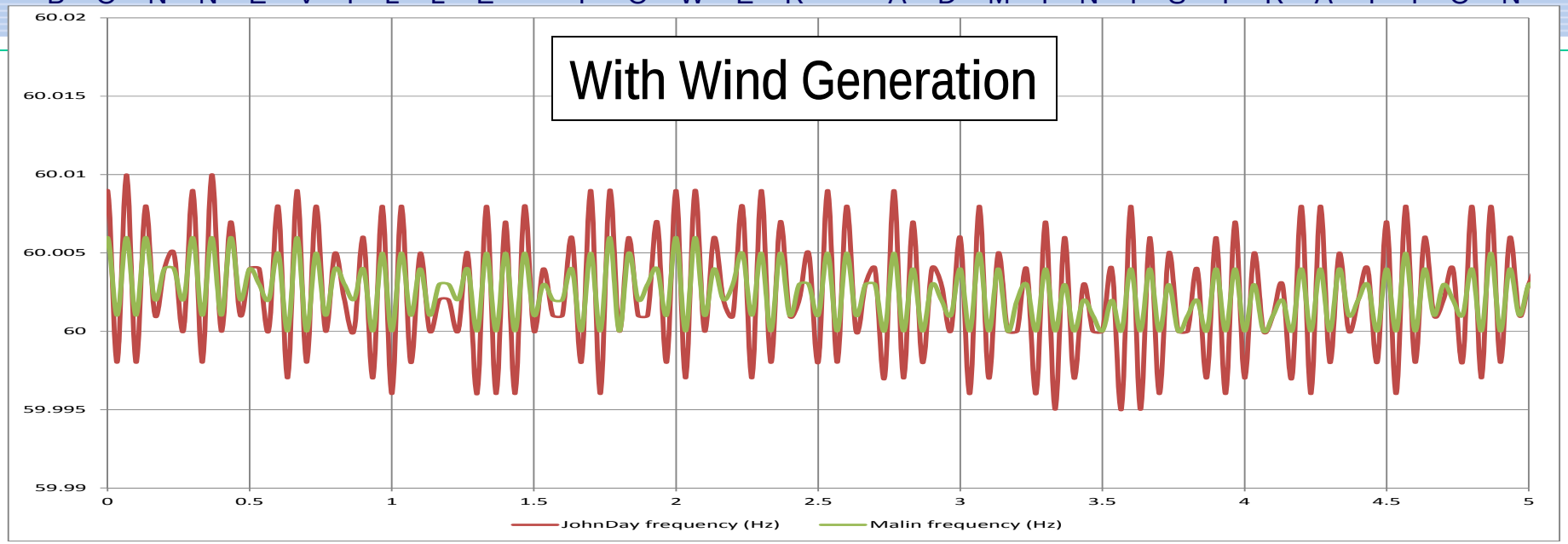
- PMU detected control issues at WPPs with Type 4 turbines in the Eastern Interconnection

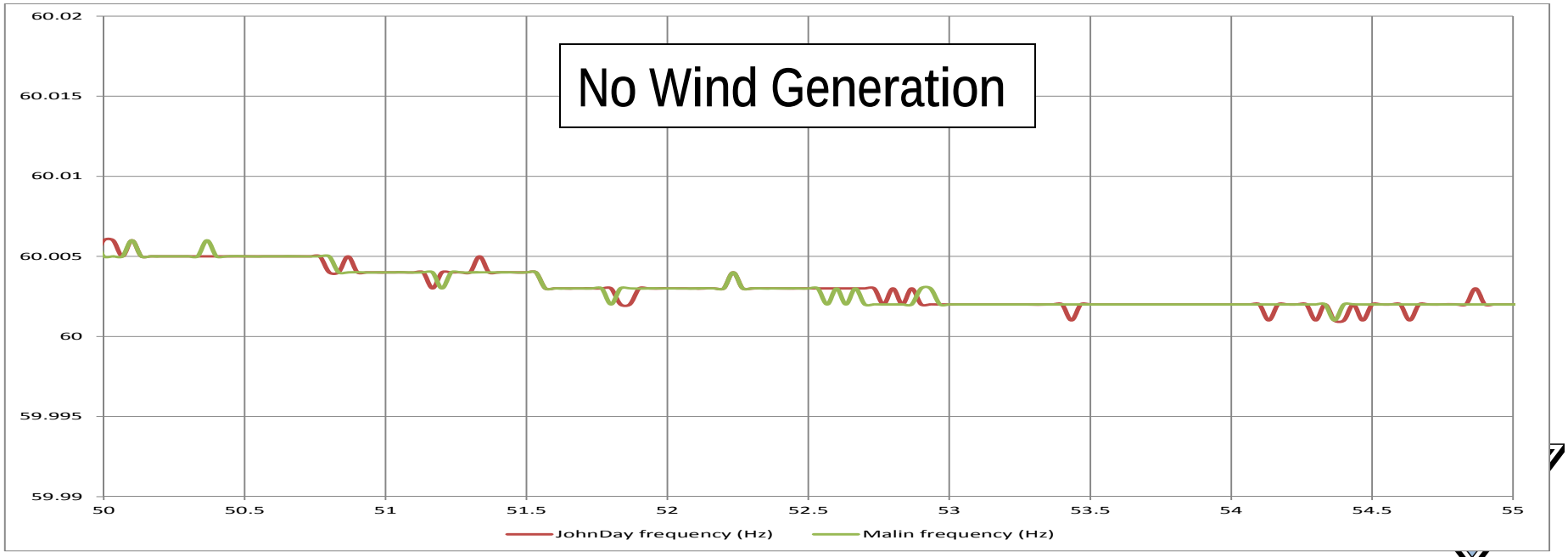






Provided by Austin White, OGE

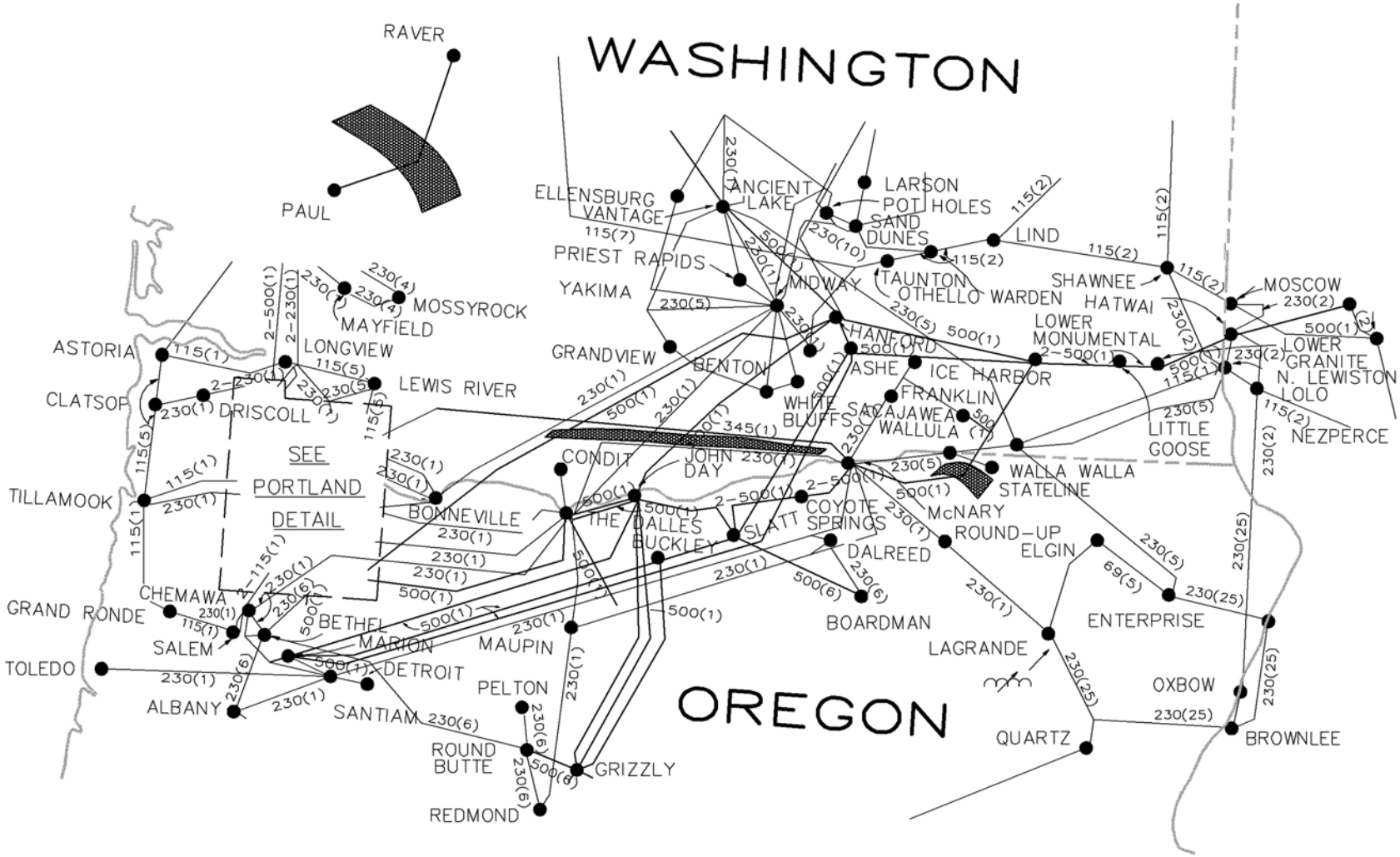

With Wind Generation
60.02
60.015
60.01
60.005
60
59.995
59.99
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
JohnDay frequency (Hz)
Malin frequency (Hz)


No Wind Generation
60.02
60.015
60.01
60.005
60
59.995
59.99
50
50.5
51
51.5
52
52.5
53
53.5
54
54.5
55
JohnDay frequency (Hz)
Malin frequency (Hz)

Dynamic Modeling

- Major effort under way in WECC and UWIG to develop generic dynamic models for wind generation:
  - All four types of wind models are developed and implemented in GE PSLF and PTI PSS®E
    - Model revisions are expected over the next few years
  - Data sets are being developed for most common WTG makes and models – Bob Zavadil is the lead on DOE project
  - Model validation remains the issue (CEC funded a project with NREL in the past)
    - Need more PMU data, BPA is the only one today
  - BPA uses generic models (huge thanks to Ed Muljadi at NREL for providing data sets and advising on model use)

North of John Day – MVAR Reserves



Main Grid Transmission Limits MVAR Reserves are Required

- Reactive reserves that support transfers on the California/Oregon intertie and the PDCI are totaled.
- Transmission limits on North of John Day require specified reactive reserves.
- Wind generation must be part of the reactive reserves monitored for main grid paths.

Operational Data Requirements Overview

- Real time operations of the transmission system requires:
  - Visual displays for the dispatchers (Operational Awareness)
  - Sufficient system monitoring of reactive reserves and other operating parameters
  - Accurate state estimation cases for real time studies
- System event diagnostics
- Model validation (more from Dmitry Kosterev/Stephanie Lu)

Questions ?