

*I skate to where the puck is going
to be, not where it has been.*

Wayne Gretzky



NASPI Conference

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Applications

- **Planning Applications**
 - Reliability starts with good planning – understanding the system and making the right investment decisions
- **Wide-Area Situational Awareness (WASA)**
 - Give power system dispatchers and tech staff greater visibility of electric power grid
- **Improvements of the existing EMS applications**
 - State estimation
 - **Stability Controls (WACS)**
 - Unlock transmission capacity, provide “defense in depth” against blackouts

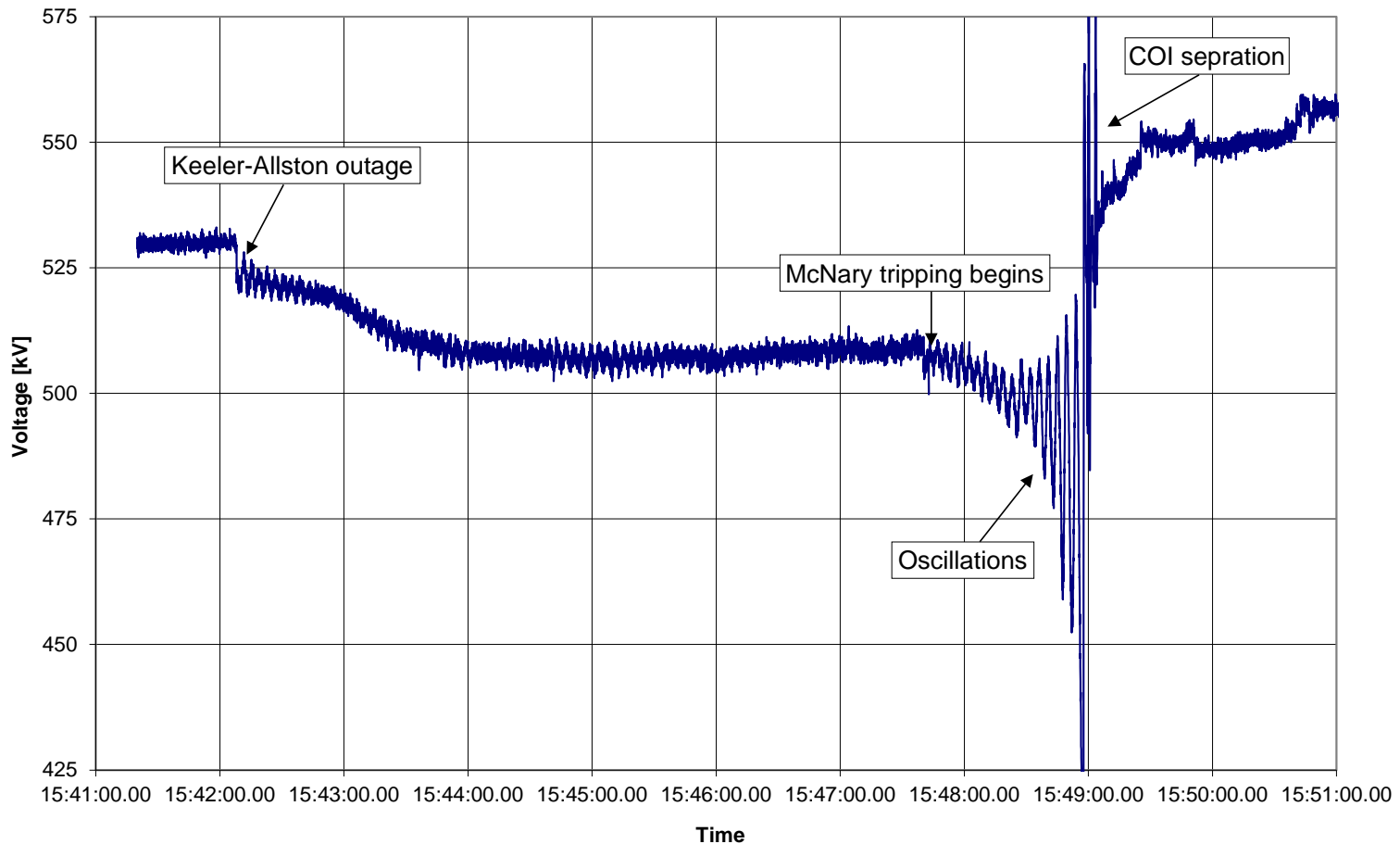


Notice & Wonder

August 10 1996 Outage

“Those who forget the past are condemned to repeat it”

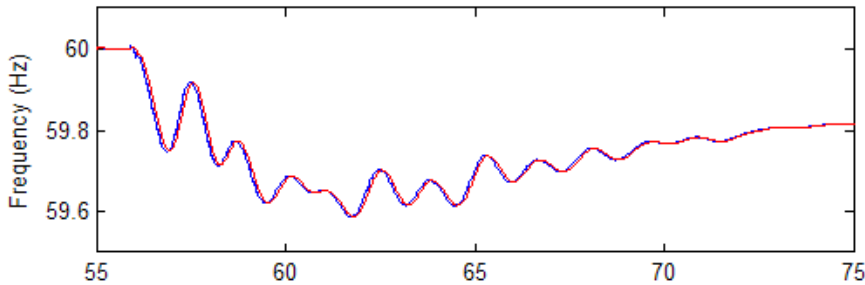
Slatt Voltage



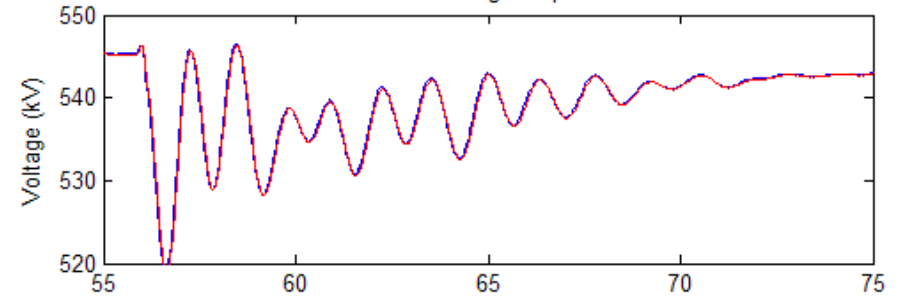
Power Plant Model Validation

- What a bad model looks like (800 MW steam-turbine unit)

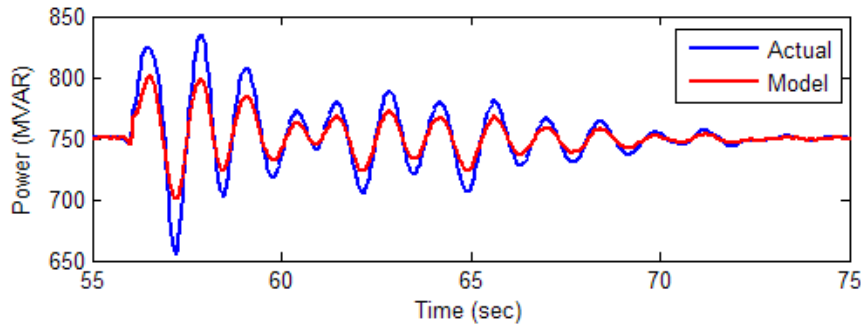
POI Frequency - Input



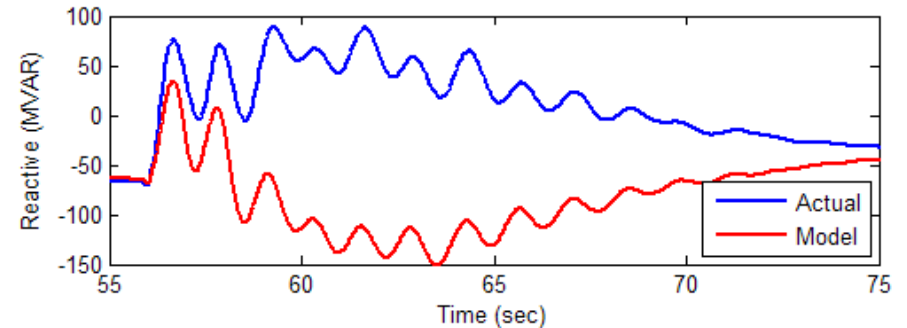
POI Voltage - Input



Active Power



Reactive Power



Voltage and frequency are inputs

Active and reactive power are “measures of success”

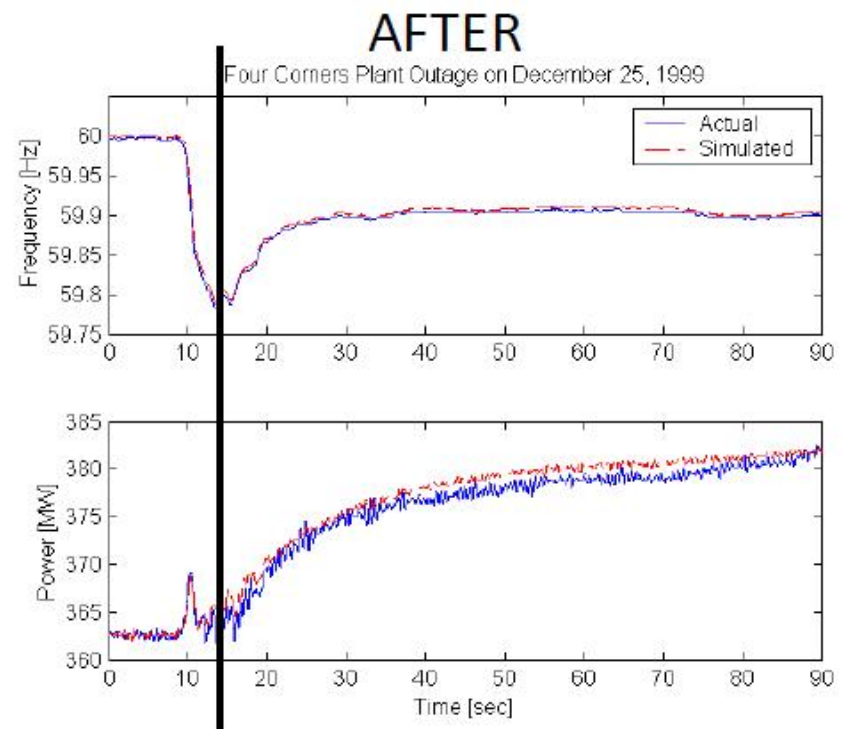
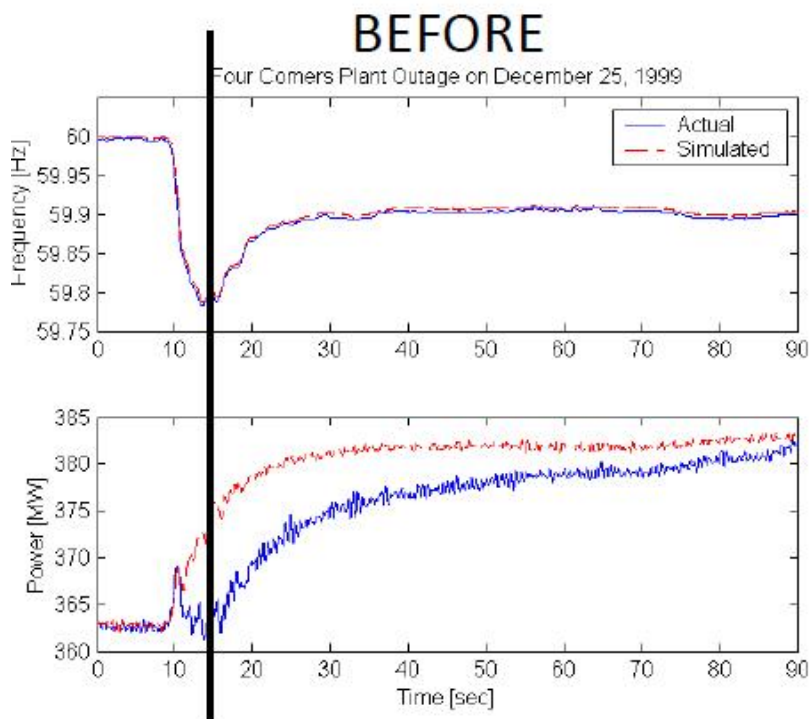
Blue line = actual recording

Red line = model

Modeling Governor Response Validation

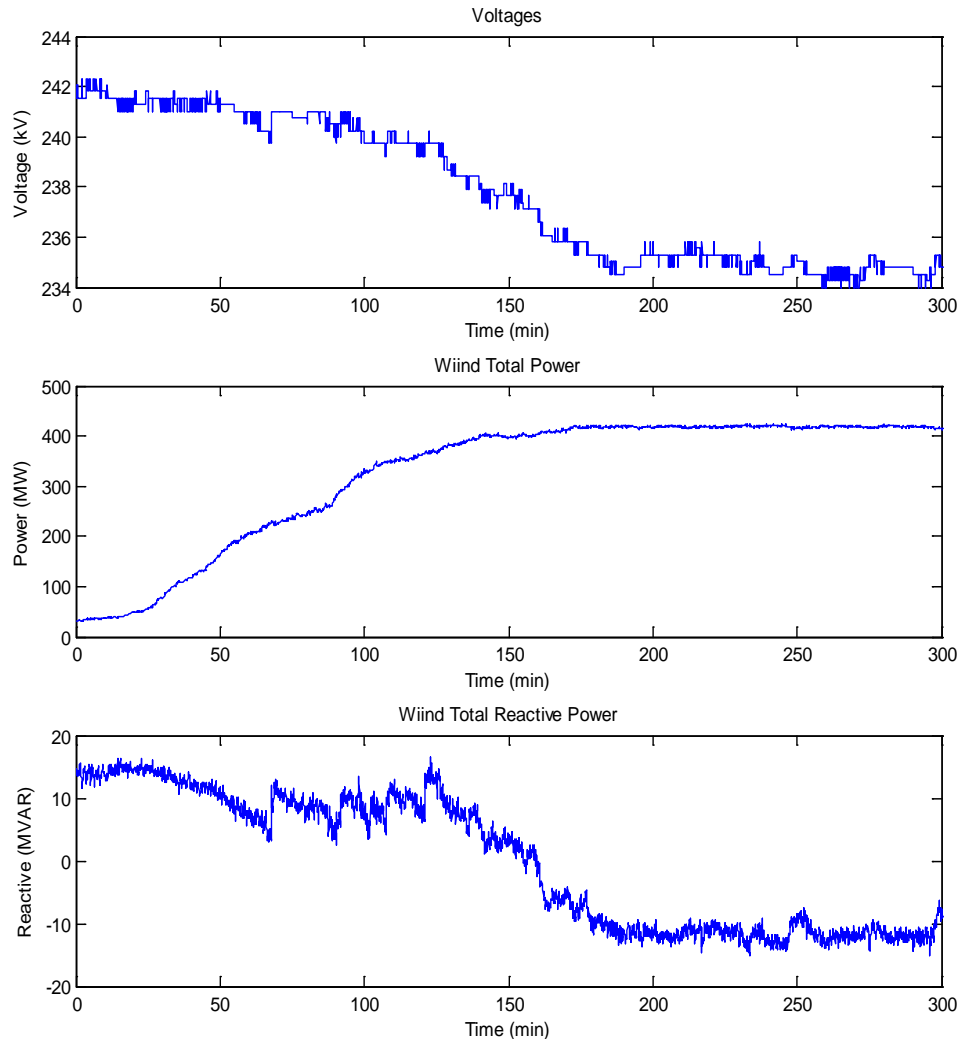
- PMU data was very instrumental in identifying which power plants are responsive, under load control or base-loaded
- Several model improvements were made – gas turbine models, Kaplan hydro-turbine models

Transactions on Power Systems, vol.19, no.2, pp.1144-1149, May 2004.



Blue = actual, Red = model

no Dynamic Voltage Control

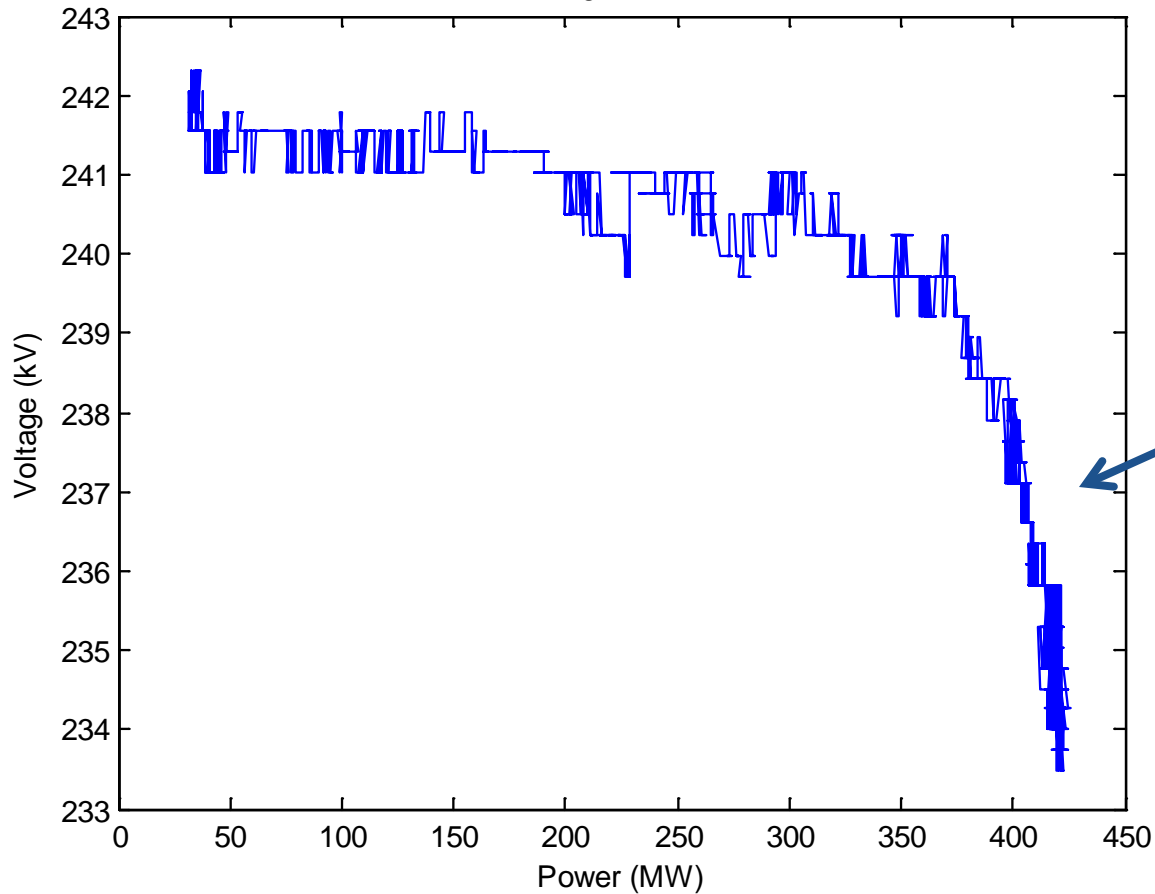


This is actual data, not simulations
Same plant
All lines in service
Wind ramping up event
Wind power plants are in **power factor control** mode

no Dynamic Voltage Control

PV-Curve for same event

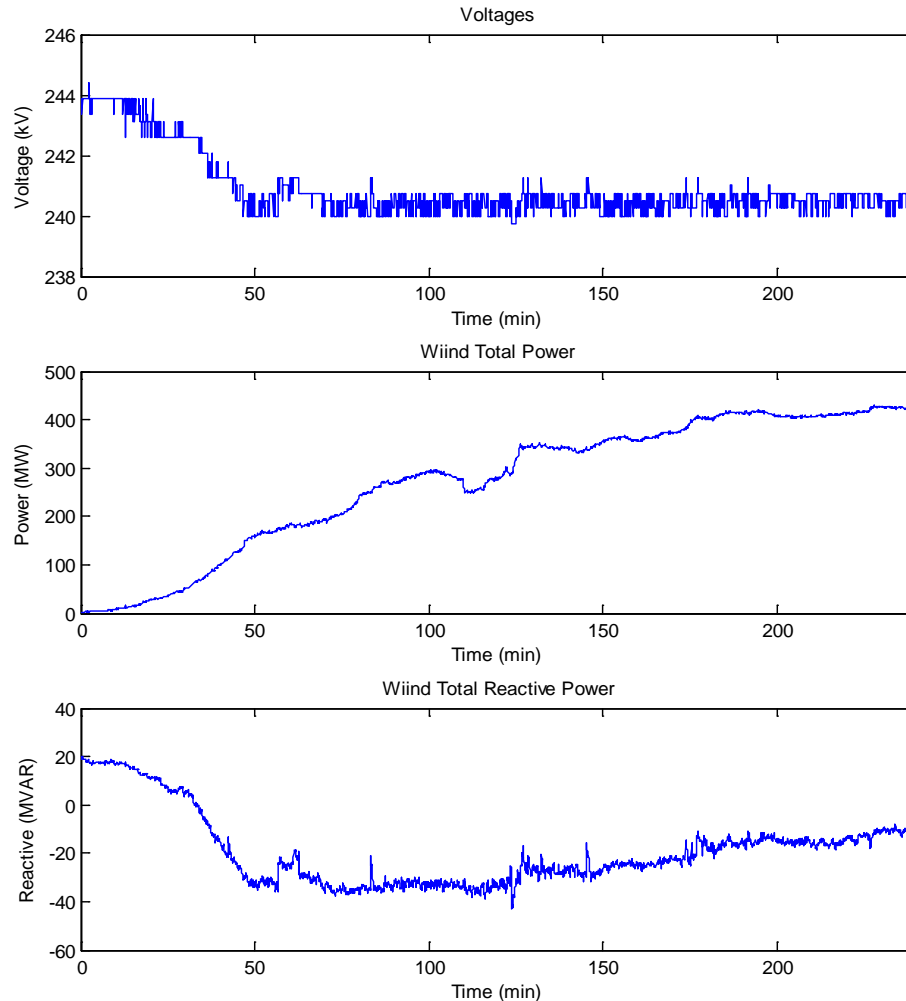
PV Plot - Voltage versus Wind Total



The edge



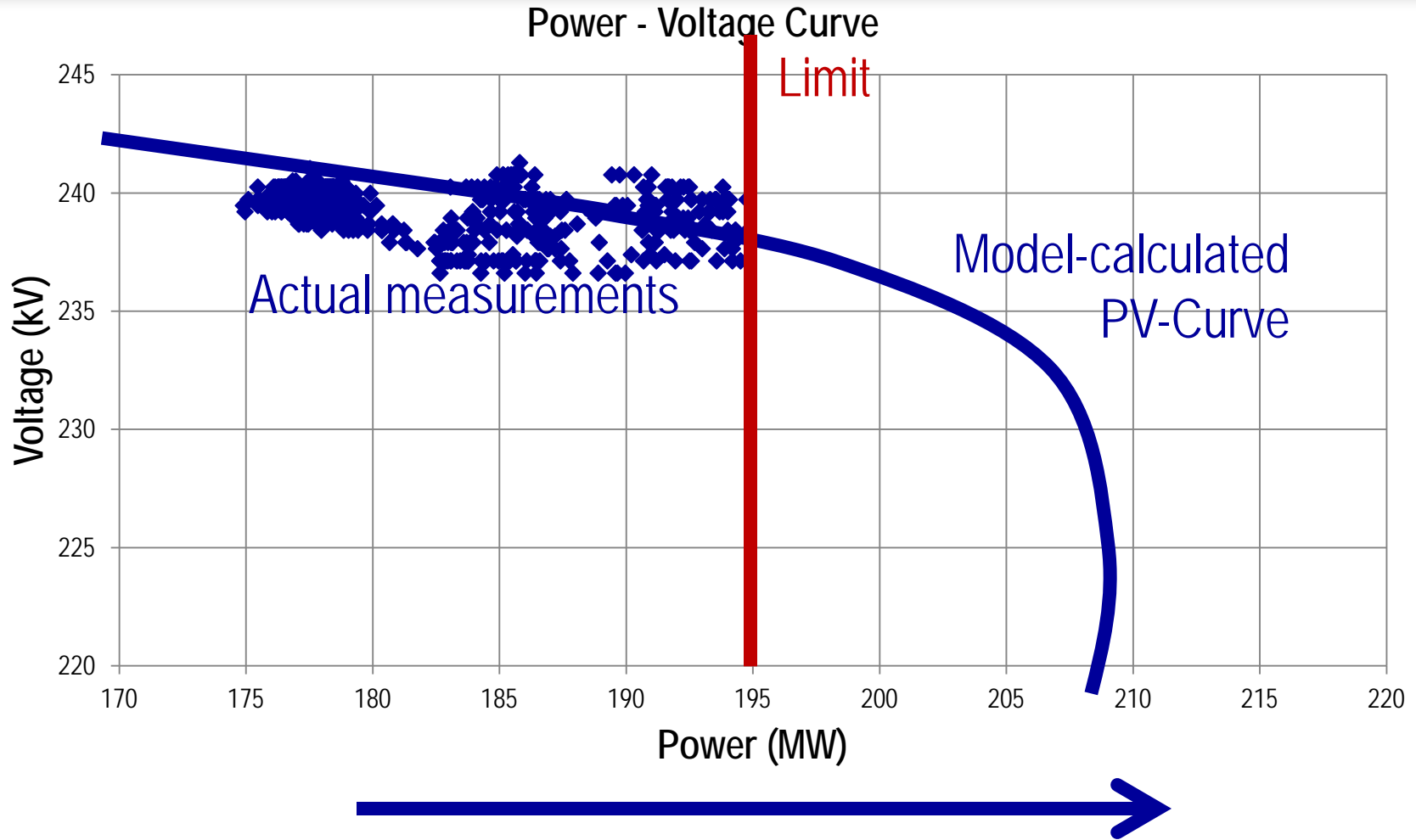
Voltage Control



This is actual data, not simulations
Same plant a couple of weeks later
All lines in service
Wind ramping up event
Two wind power plants are under **voltage control**



Had we had Model-Based Stability Analysis

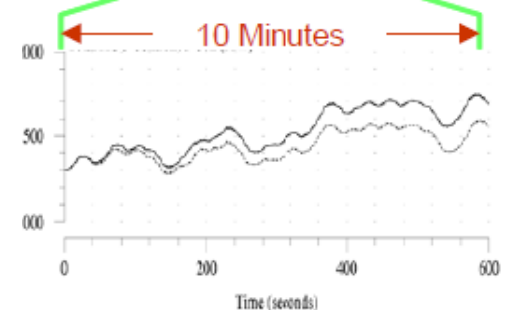
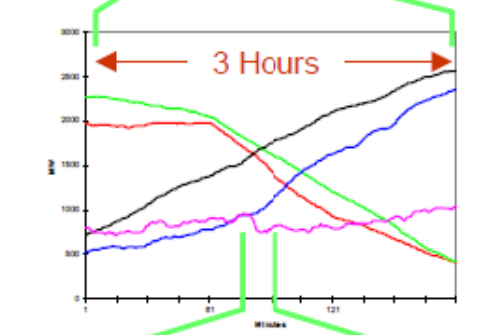
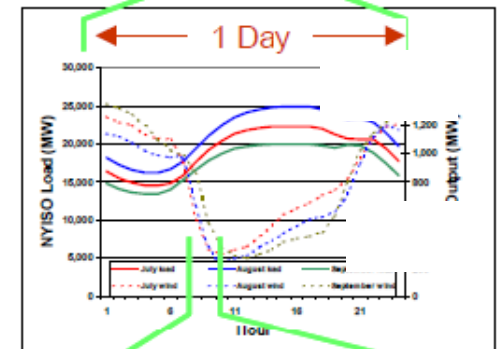
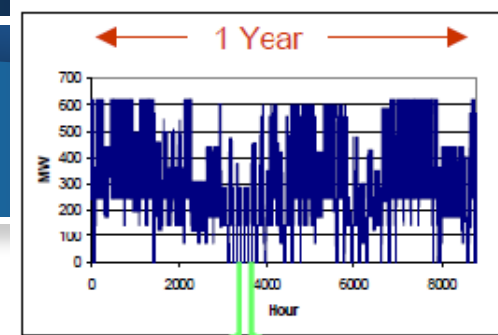


Limits are set using model-based stability analysis



Variability: how to lower the uncertainty

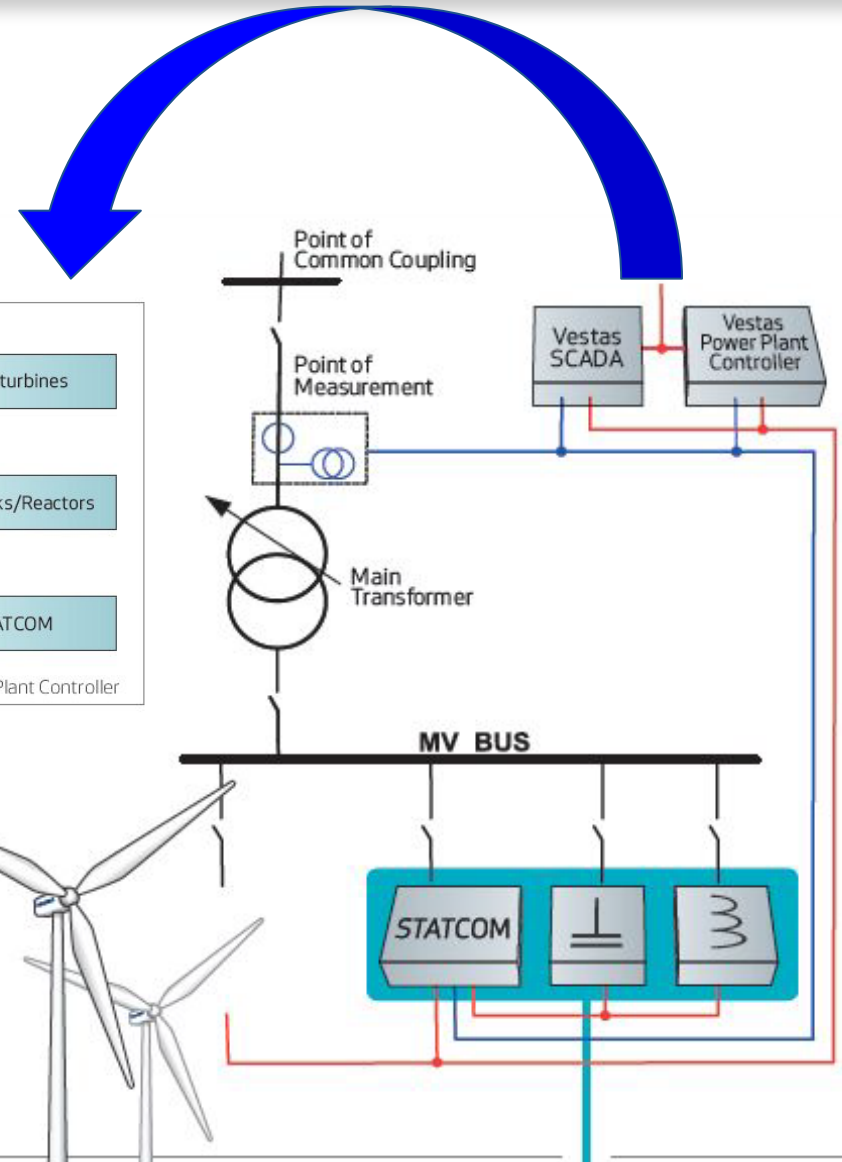
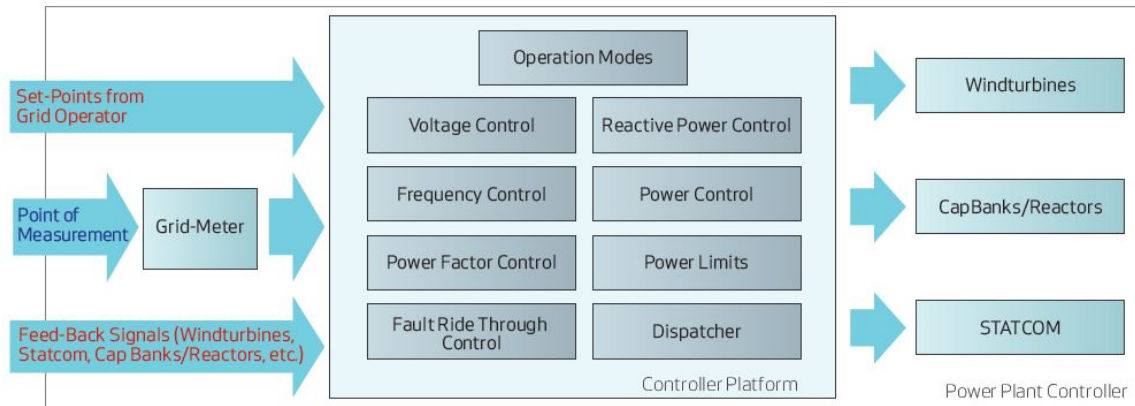
- Operations & geography mitigate variability & cost
 - Smaller scheduling and dispatch intervals
 - Optimizing existing balancing resources
 - Improving wind forecasting
 - Load shaping
 - Geo-diversity and transmission
- As Wind grows, demand for flexibility increases
 - Not flexible: coal & nuclear
 - Environmental and political pressure
- New generation resources a better fit, more flexible
 - Solar: offsetting diurnal pattern
 - Steam turbine gas plants (CCGT) = flexibility for load changes
 - Gas turbine plants (SCGT) = most flexibility for regulating/peaks
- Variability decreasing as wind integration evolves
- Need to accelerate the evolution





Power Plant architecture & controls

- Voltage, Frequency & Reactive Power control
- Dynamic & integrated plant response capability





Utility Drivers

- 1990's – Deregulation
- 2000's – Incentive based maintenance
- 2003/current – Compliance

- How much R&D was included in these industry trends?
- Have any of these industry trends created innovation?

WHEN IS THE
LAST TIME THIS DEVICE WAS
UPGRADED? IT REALLY NEEDS TO
BE MORE USER FRIENDLY.
WHO'S IN CHARGE
OF INNOVATION
UP HERE? IS THIS
AVAILABLE IN
OTHER
COLORS?



STEVE JOBS
1955-2011

FILZ SIMMONS ©
THE ARIZONA DAILY STAR 2011
CASPER CARTOONS.COM



“Being the richest man in the cemetery doesn’t matter to me. Going to bed at night saying, I’ve done something wonderful. That’s what matters.”

“It’s the intersection of technology and liberal arts that makes our hearts sing.” What makes your heart sing?

Steve Jobs 1955-2011