



# Intelligent Transmission

Presented  
by

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# Background for Intelligent Transmission

- **Aug. 2003 Blackout: Northern US and Central Canada**
  1. **Aging Grid**
  2. **Competitive Market – Though under N-1 or N-2 Planning but Economic Operation and Generation Market – Walking Closer to The Edge : Cascading Failure**
  3. **Forecasting Operational Data**
  4. **Special Protection System(SPS) and Remedial Action Scheme(RAS) – Hypothetical Scenarios**

# Intelligent Transmission

1. **PMU data vs SCADA data**
2. **Measurement Based vs Model Based**
3. **Substation SE – ms / PMUs – ms**
4. **Wide Area Monitoring and State Estimation(WAMSE)**
5. **Fast Time – Domain Dynamic Simulation – Cascading and Islanding**
6. **Visualization, On-line Prediction**

Reference: J. Giri, D. Sun and R, Avila-Rosales, Wanted: A More Intelligent Grid, IEEE Power and Energy Magazine, Vol. 7, No. 2, March/April 2009

### SCADA Data

Refresh Rate 2–5 Seconds

Latency and Skew

“Older” Legacy Communication

Responds to Static Behavior

Freq Change Means:  
Generation-Load Imbalance

X Ray

### Phasor Data

Refresh Rate 30 Samples/s

Time Tagged Data, Minimal Latency

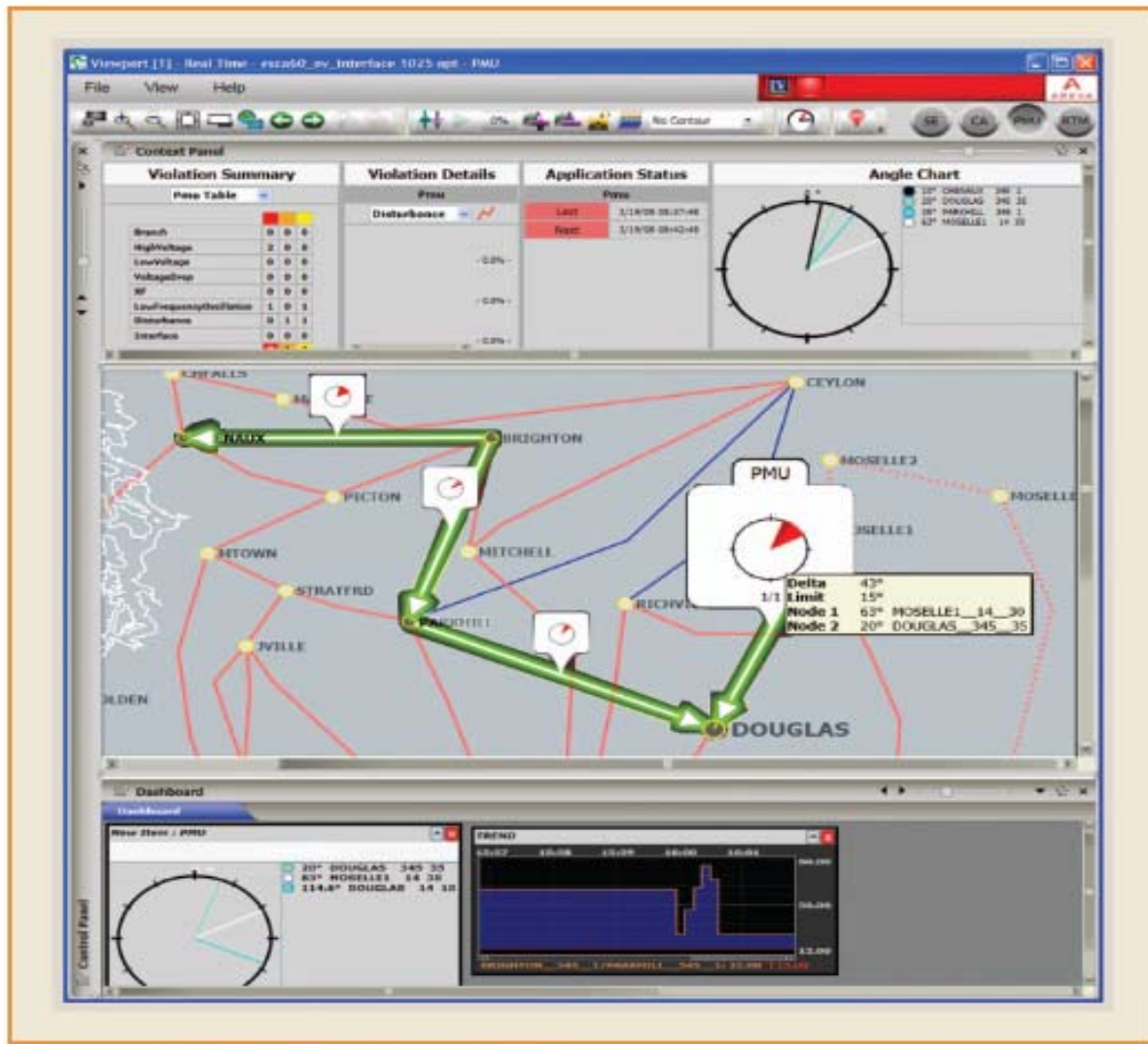
Compatible with Modern Communication  
Technology

Responds to System Dynamic Behavior

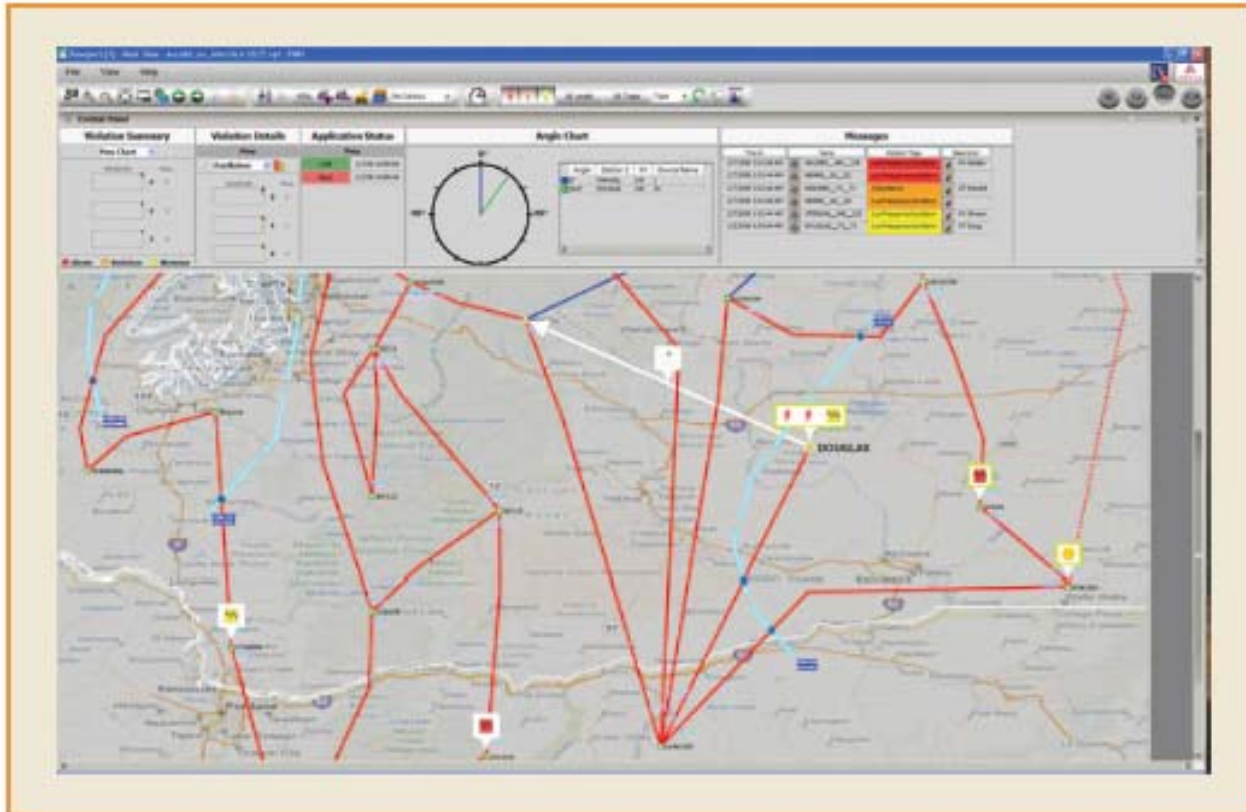
Angle-Pair Change Means:  
MW Change or “Electrical Distance  
Change”

MRI

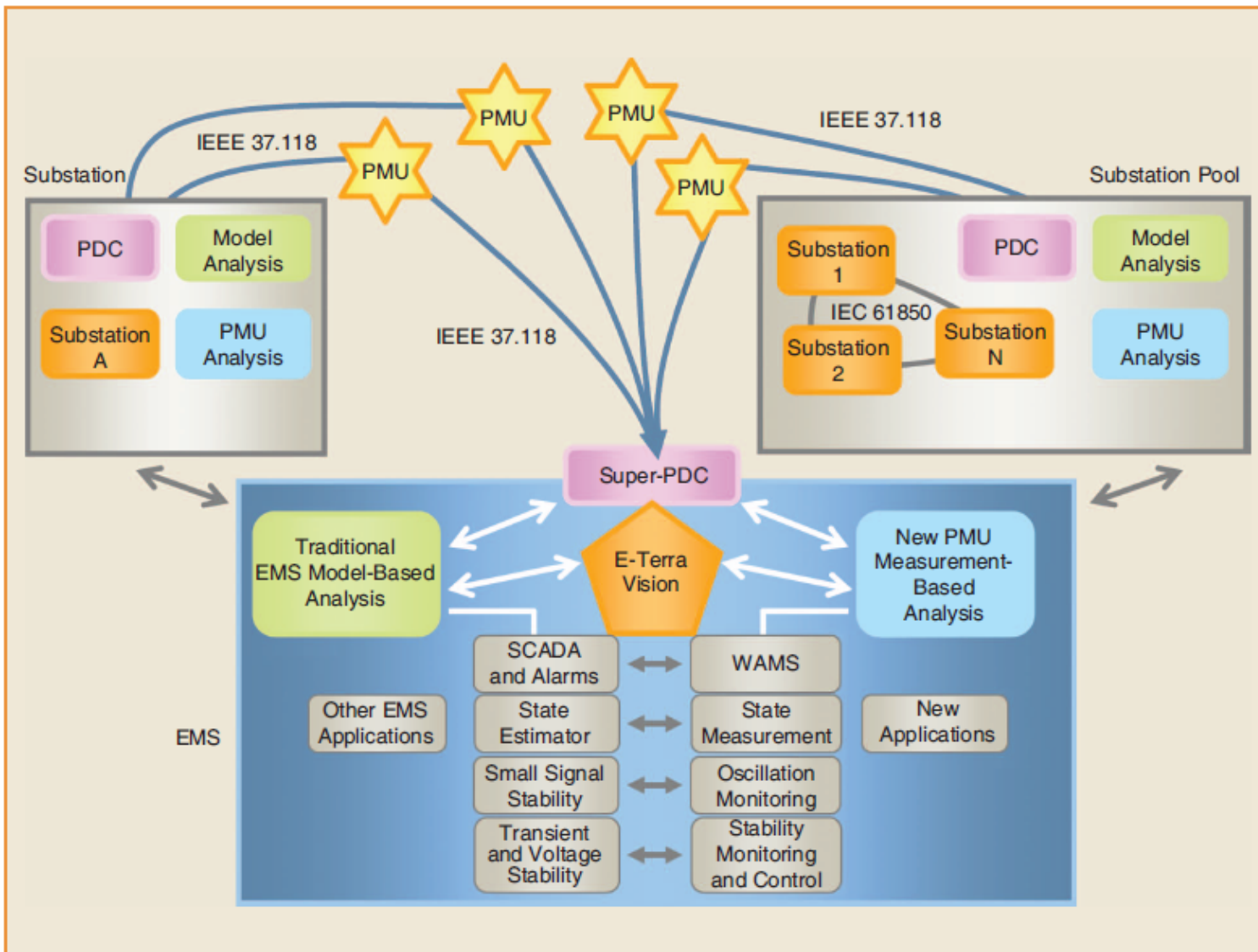
SCADA versus PMU measurements.



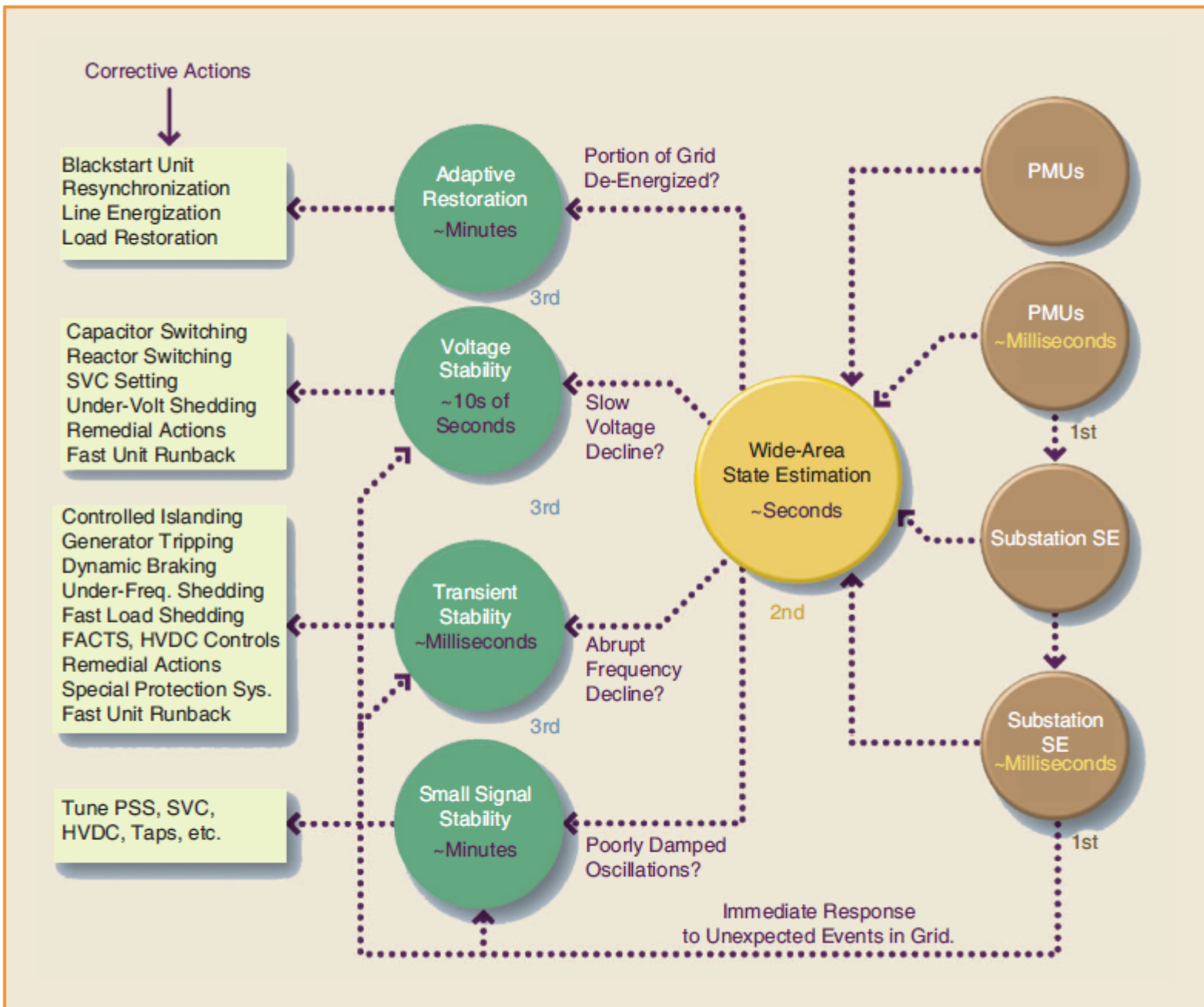
PMU visualization and trends.



PMU angle differences and oscillation modes.

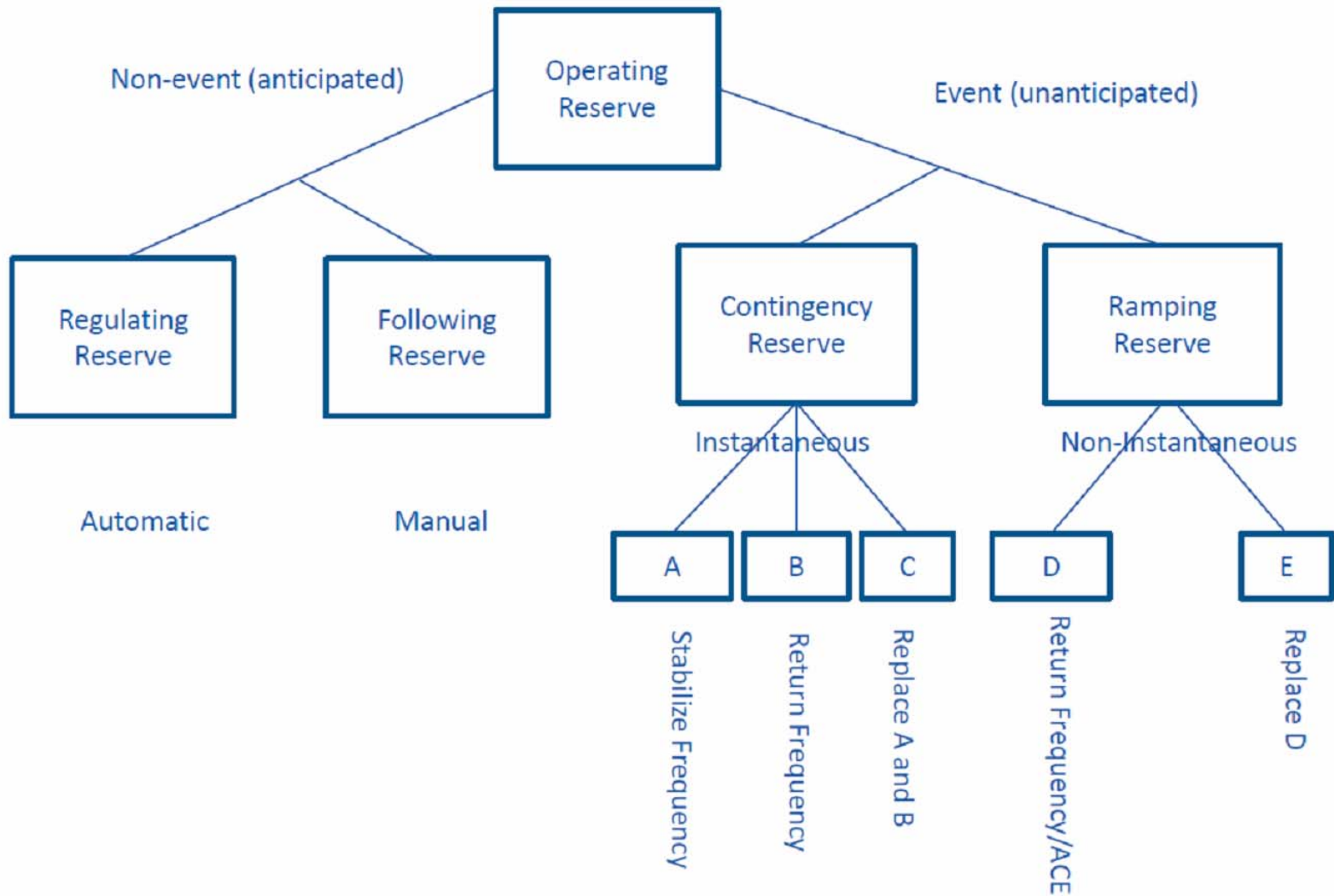


The new grid security analysis paradigm.

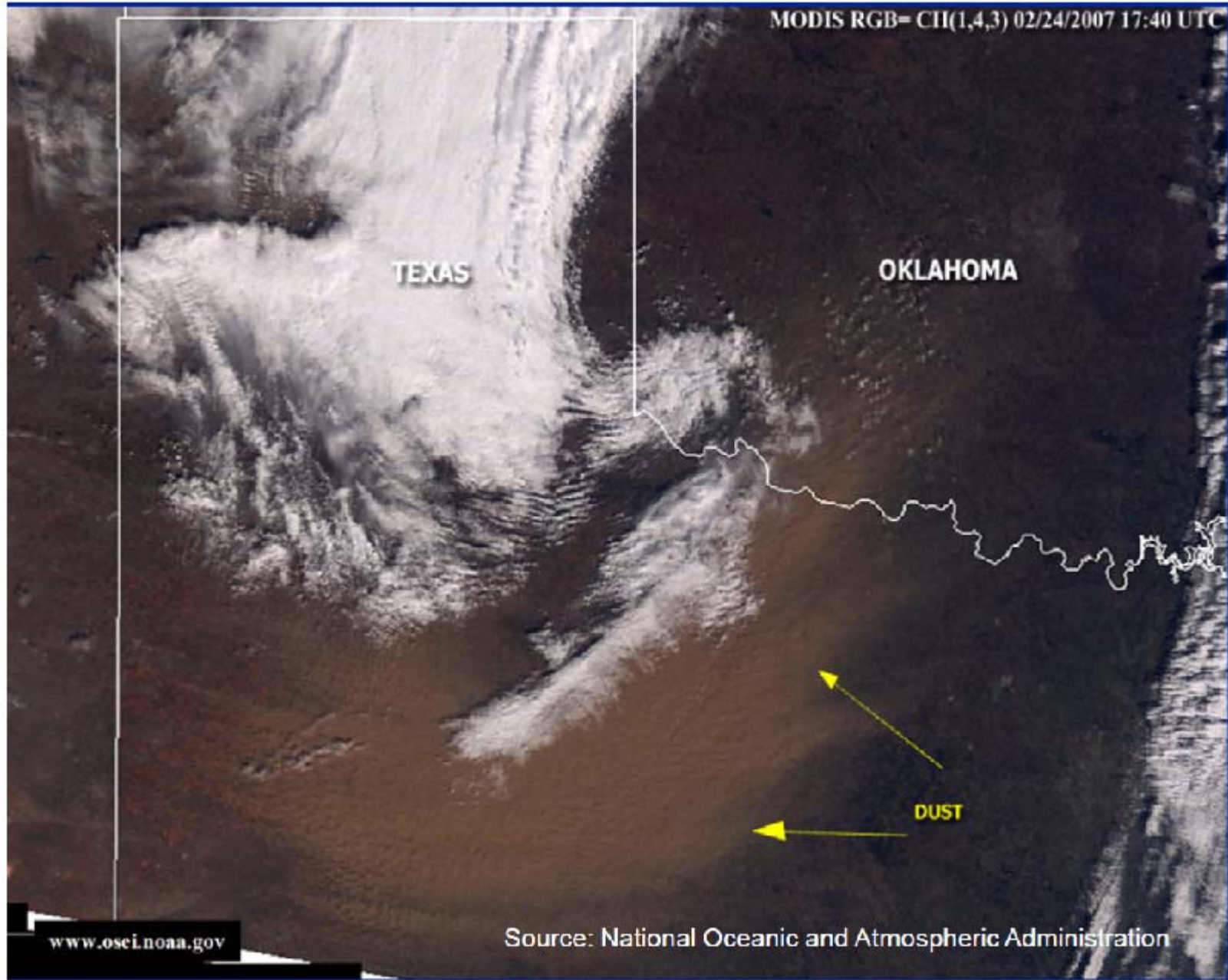


Intelligent grid control.





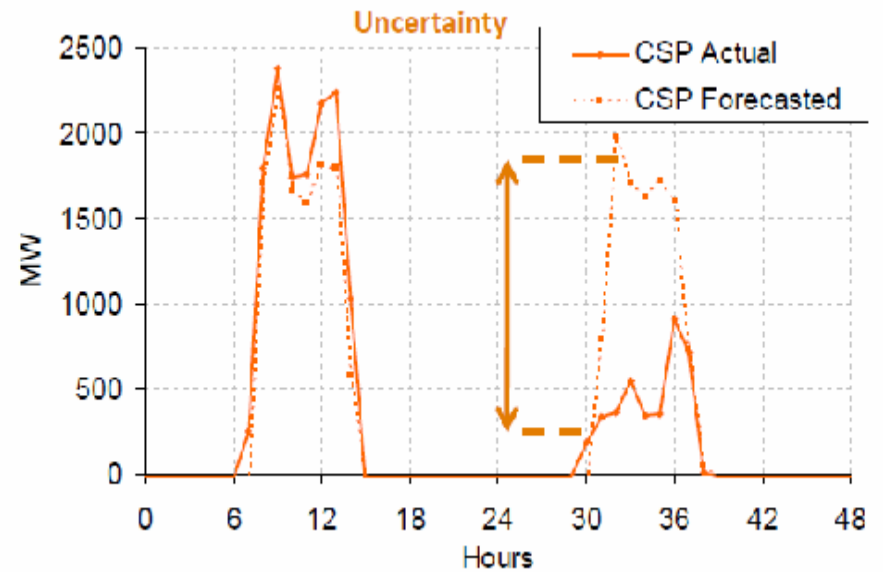
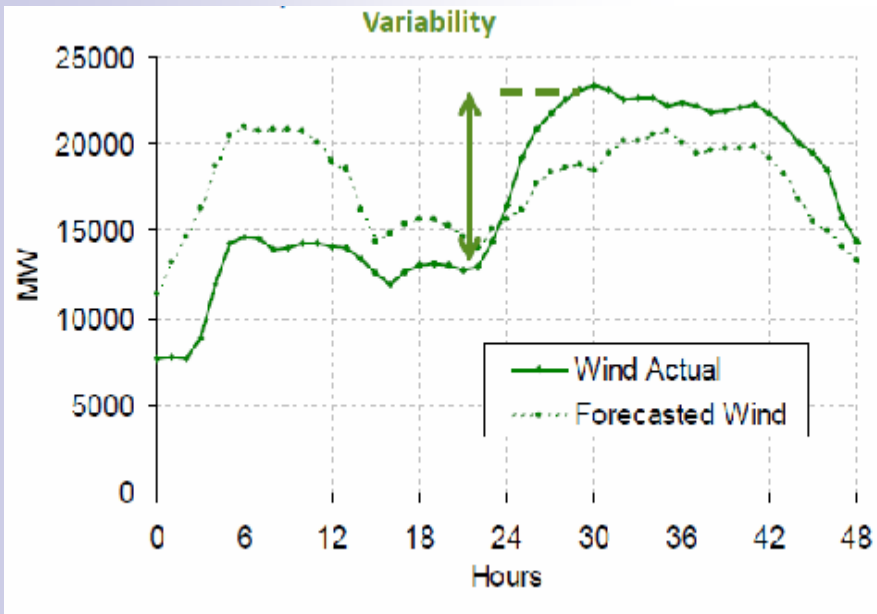
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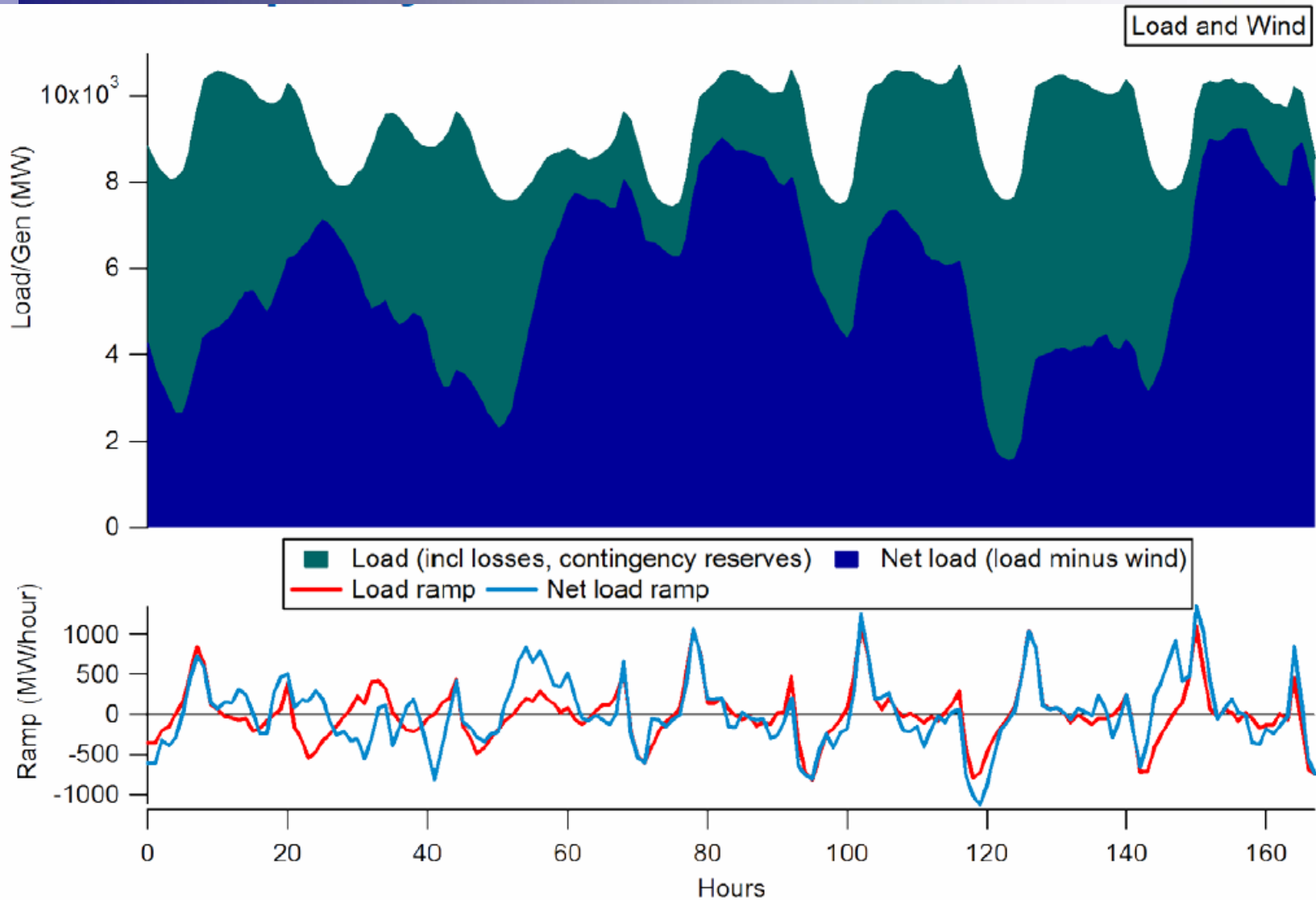


www.osci.noaa.gov

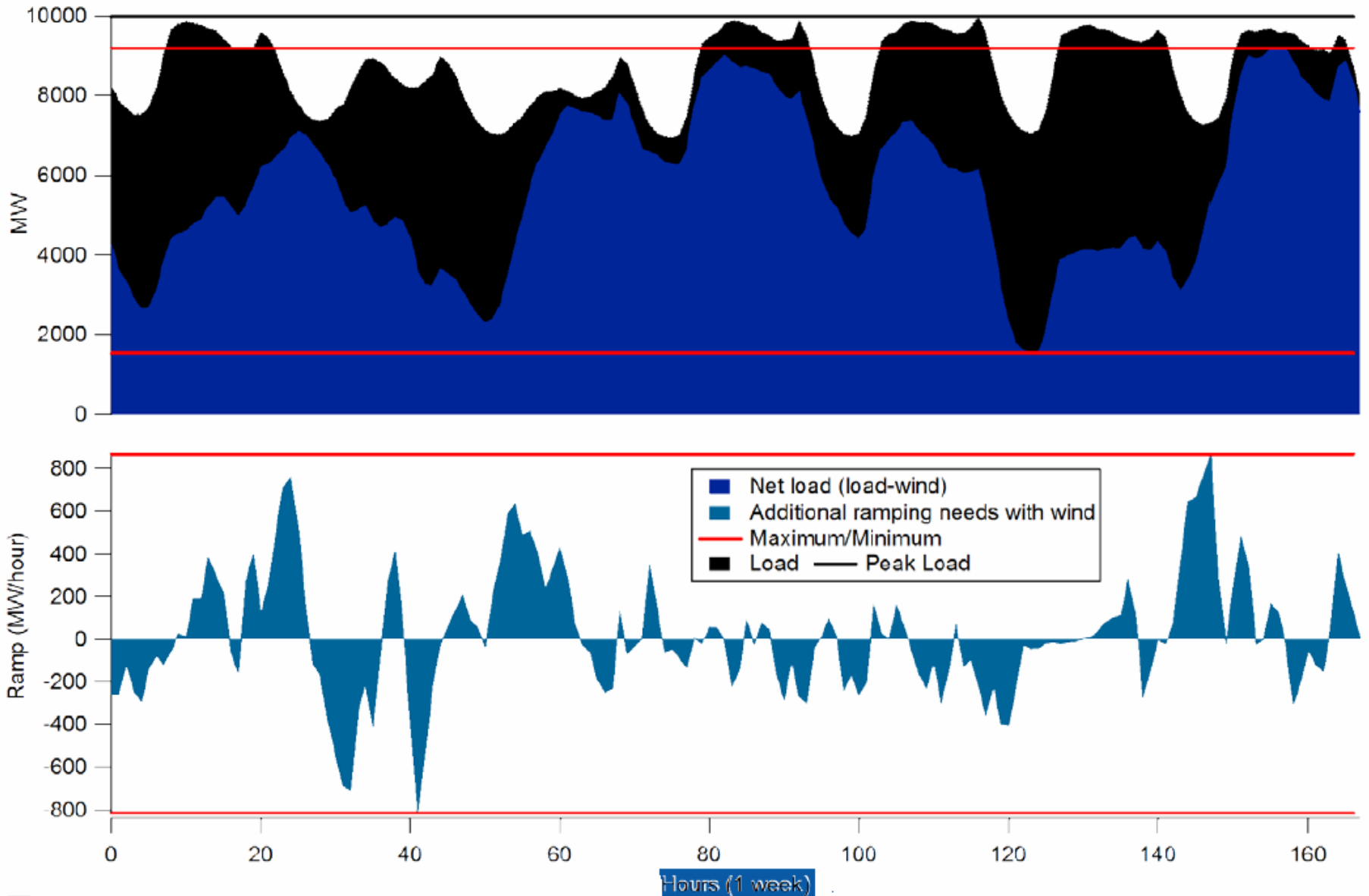
Source: National Oceanic and Atmospheric Administration

M. Milligan, Ph.D, Variable Renewable Generation Impact on Operating Reserves, RMEL 2011 SMEPP Conference, May 17, 2011.

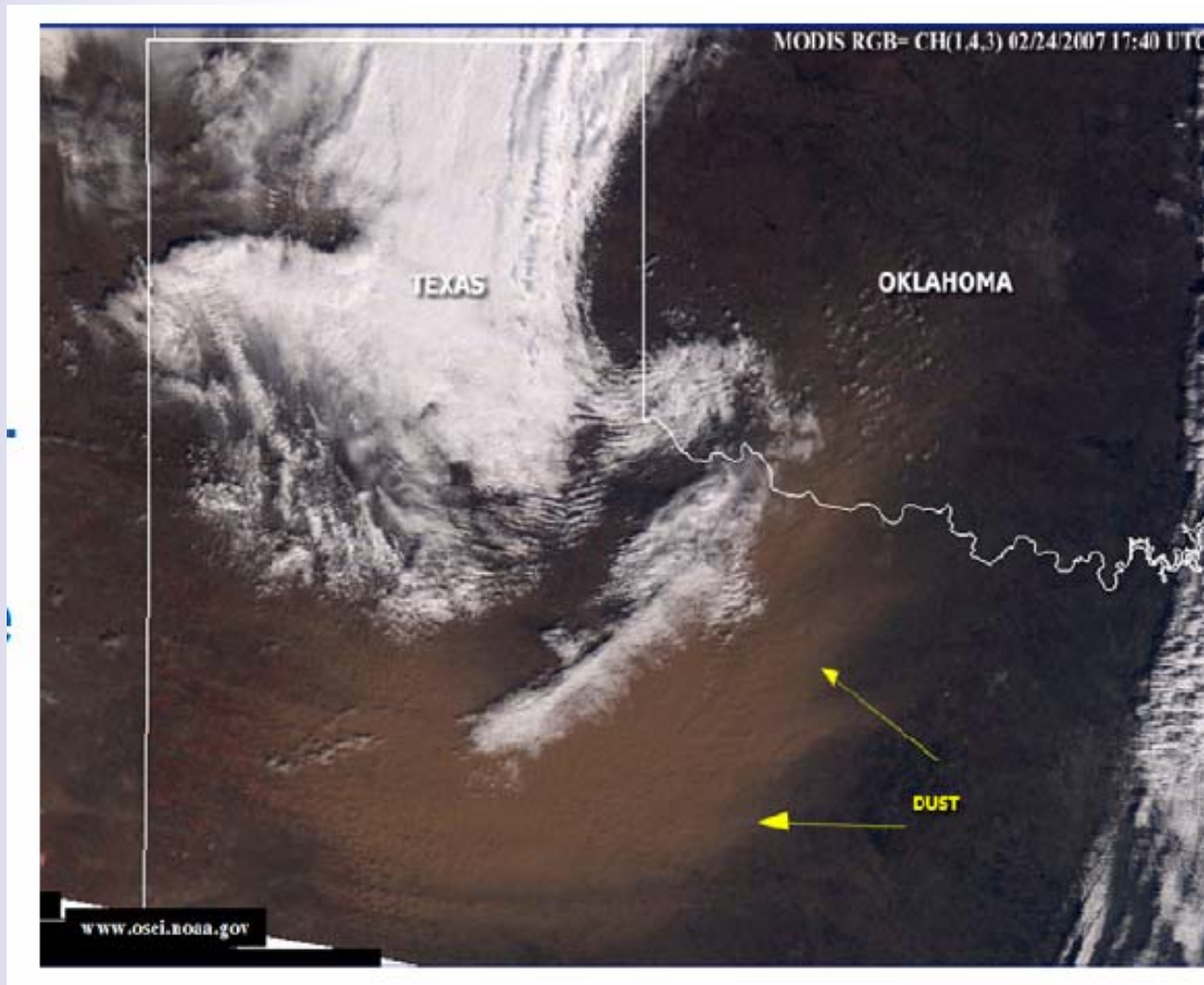




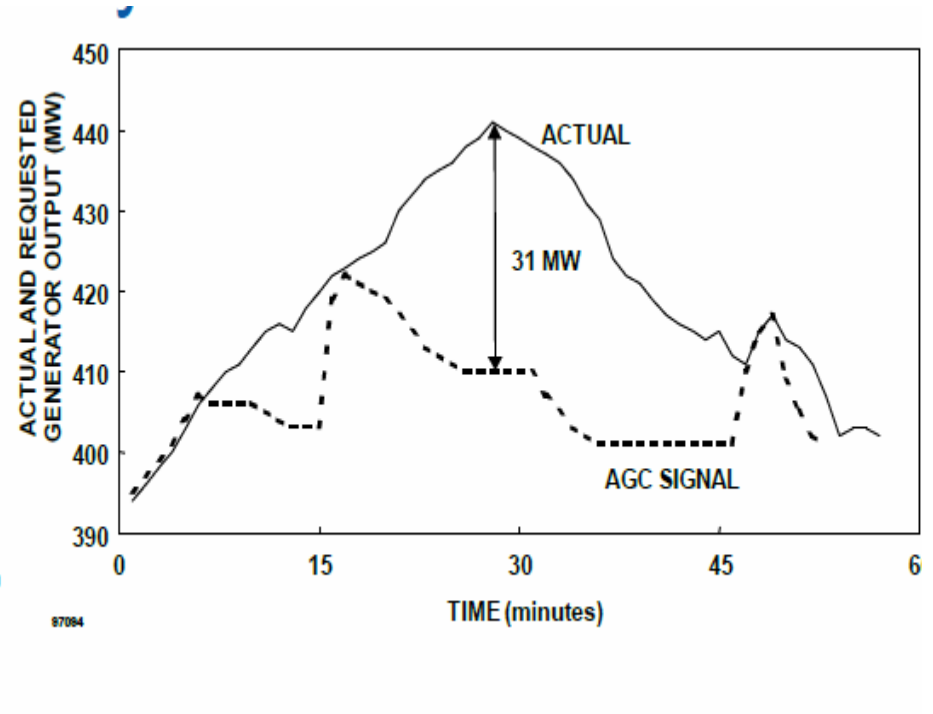
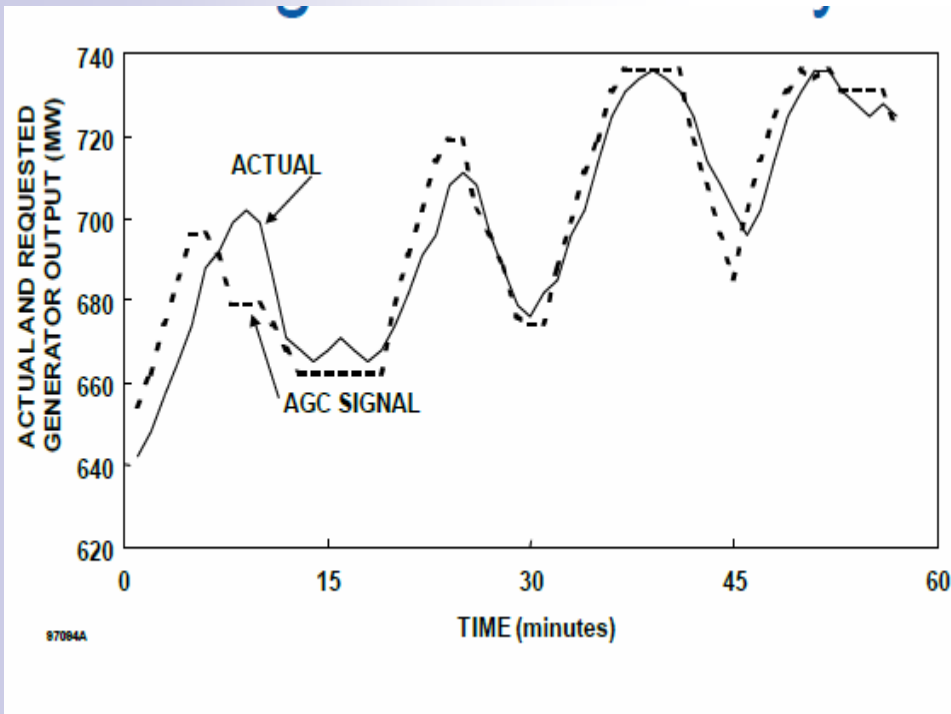
M. Milligan, Ph.D, Variable Renewable Generation Impact on Operating Reserves, RMEL 2011 SMEPP Conference, May 17, 2011.

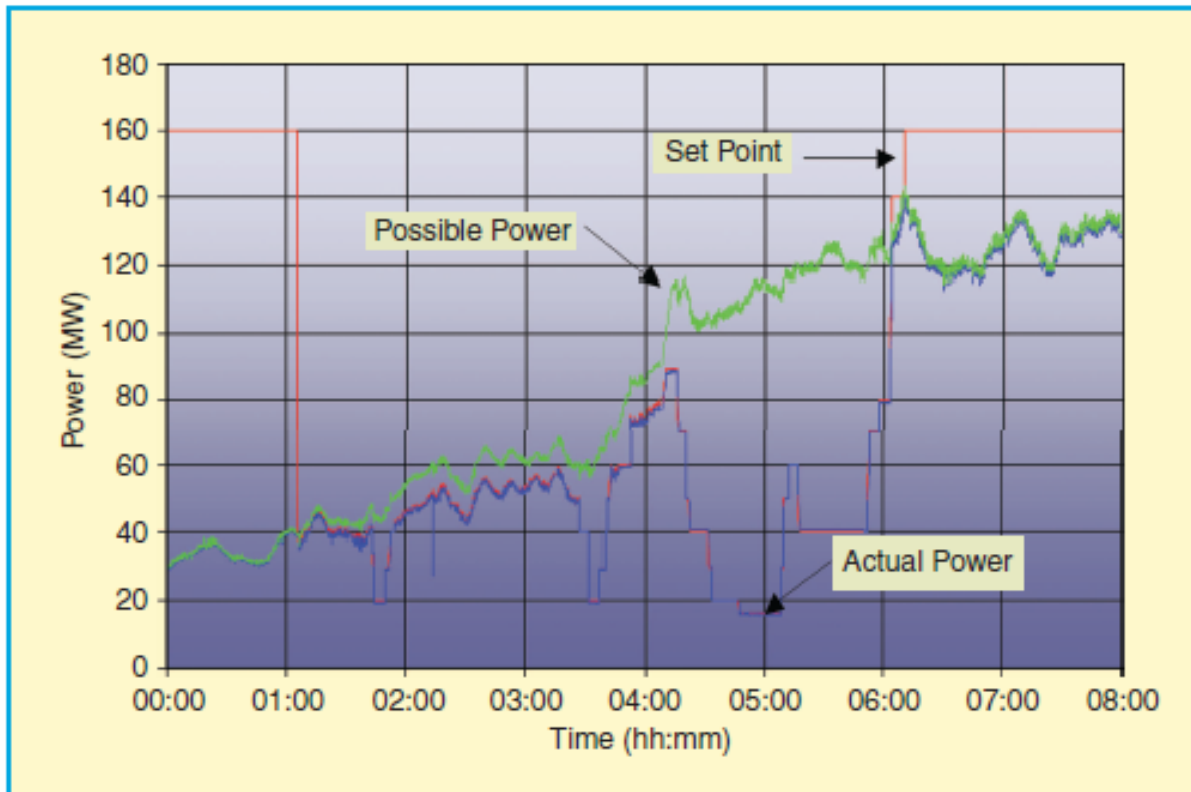


M. Milligan, Ph.D, Variable Renewable Generation Impact on Operating Reserves, RMEL 2011 SMEPP Conference, May 17, 2011.



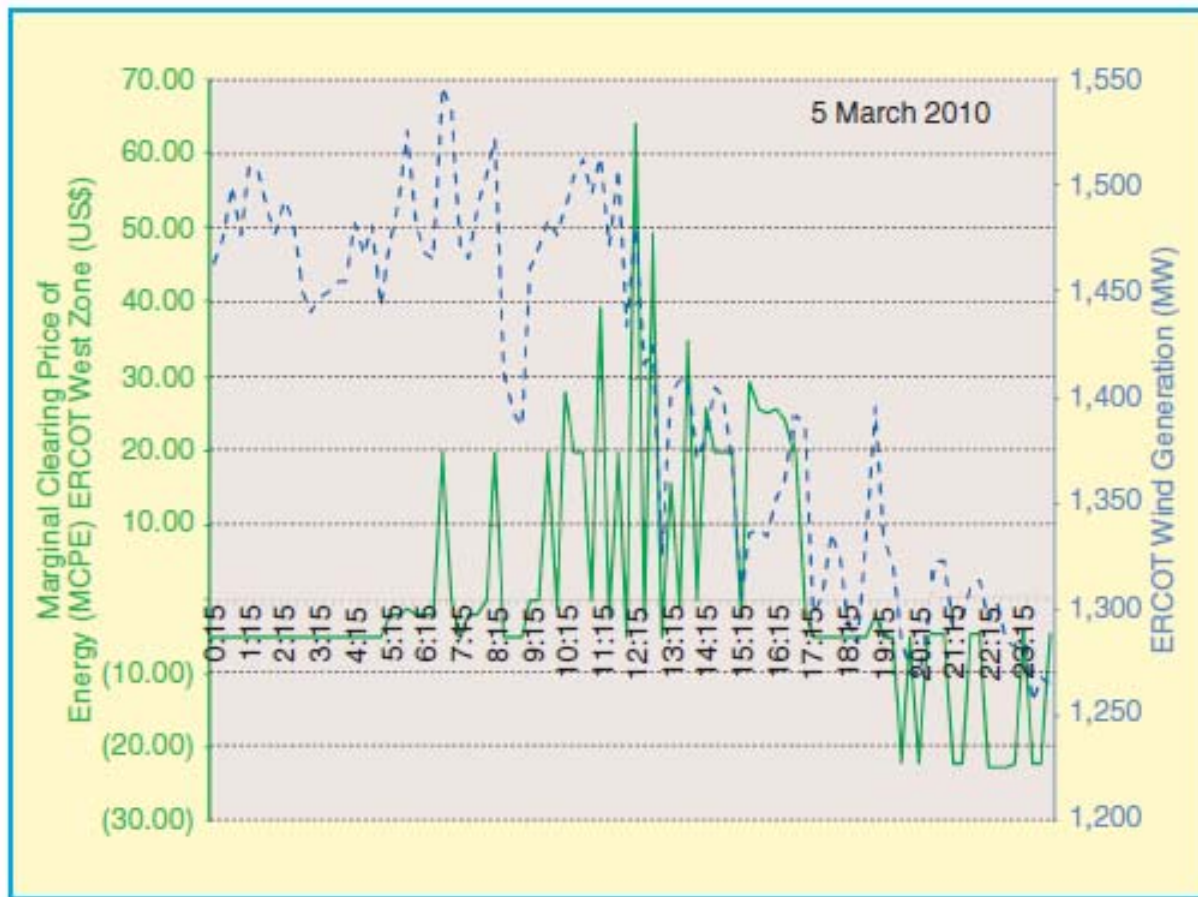
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Example of reserves carried on the Danish Horns Rev wind plant.





Market price volatility.