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UC2010

Real Time Information — Currency of the New Decade

Hilton San Francisco Union Square | San Francisco, CA

April 26-28, 2010

Phasor Measurements for Renewable Interconnections

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Center of Excellence

OSIsoft, LLC

AGENDA

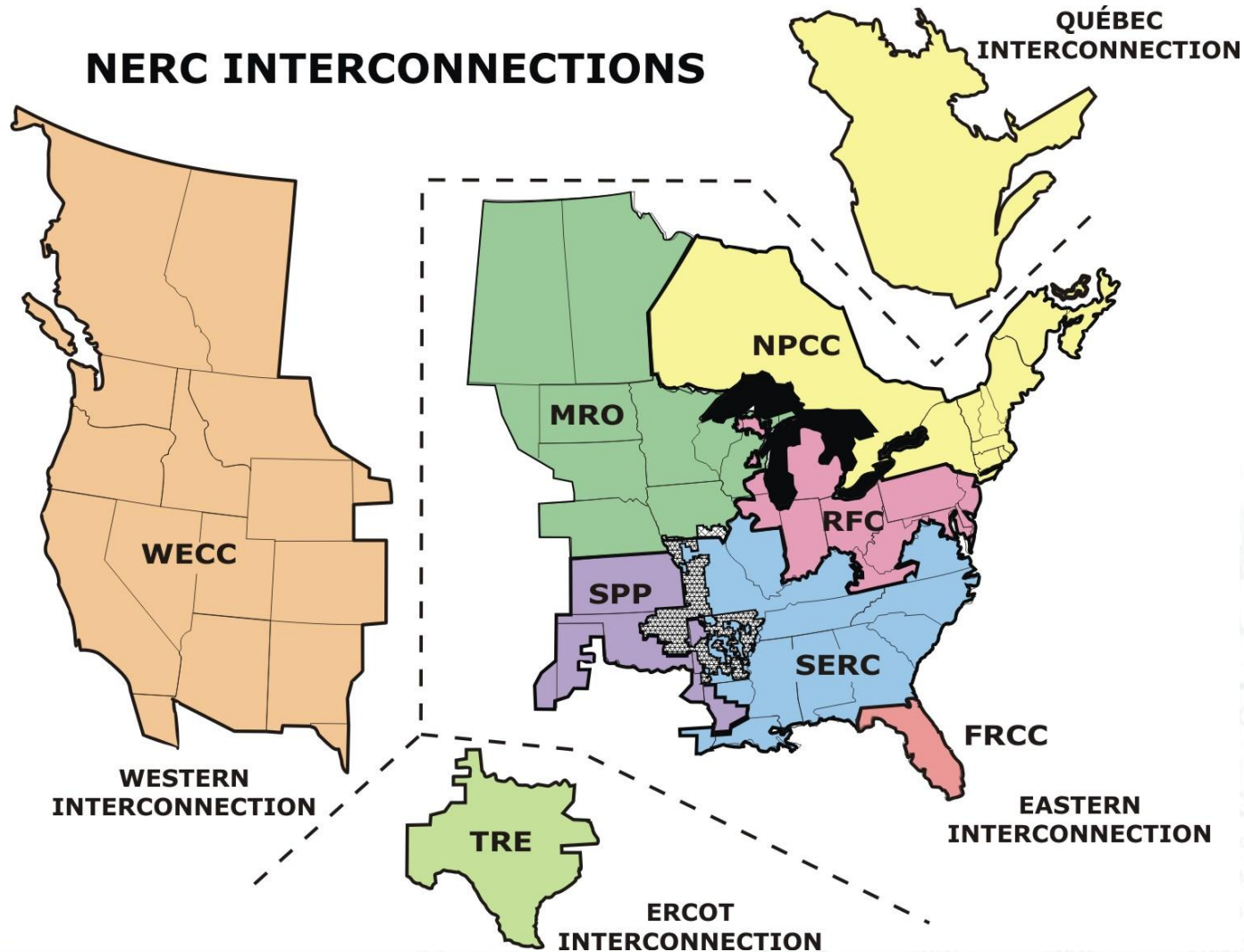
- **The Problem**

- Intermittency from renewable energy
 - More spinning reserves (NERC IGVTF)
- Renewable portfolios increasing
 - California 33 percent by 2020
- ERCOT Grid issues
 - Grid oscillations detected at high penetration

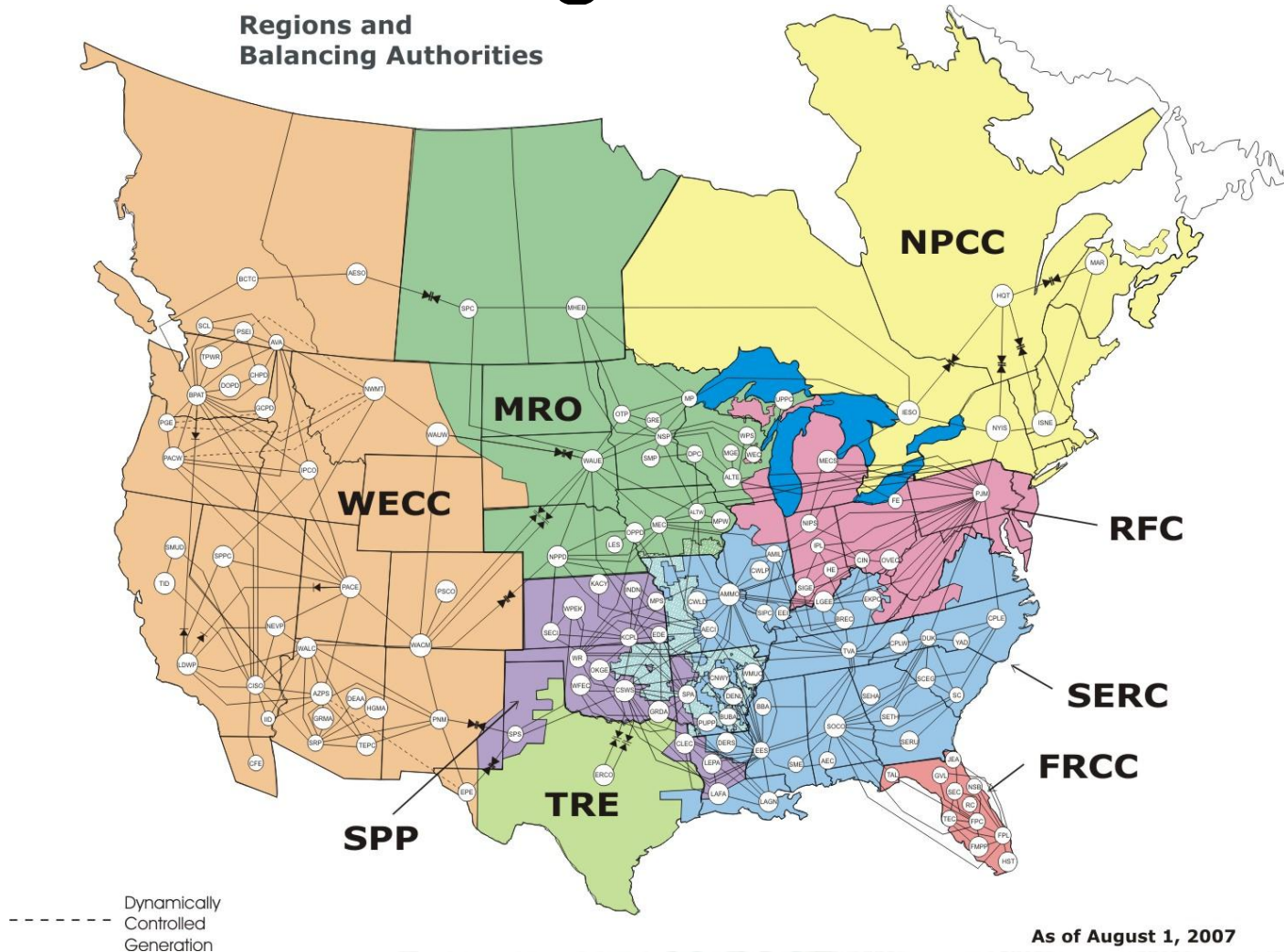
- **Solutions**

- Monitor grid performance
- Maximize efficiency of existing grid

The US Grid



Balancing Authorities



States with RPS

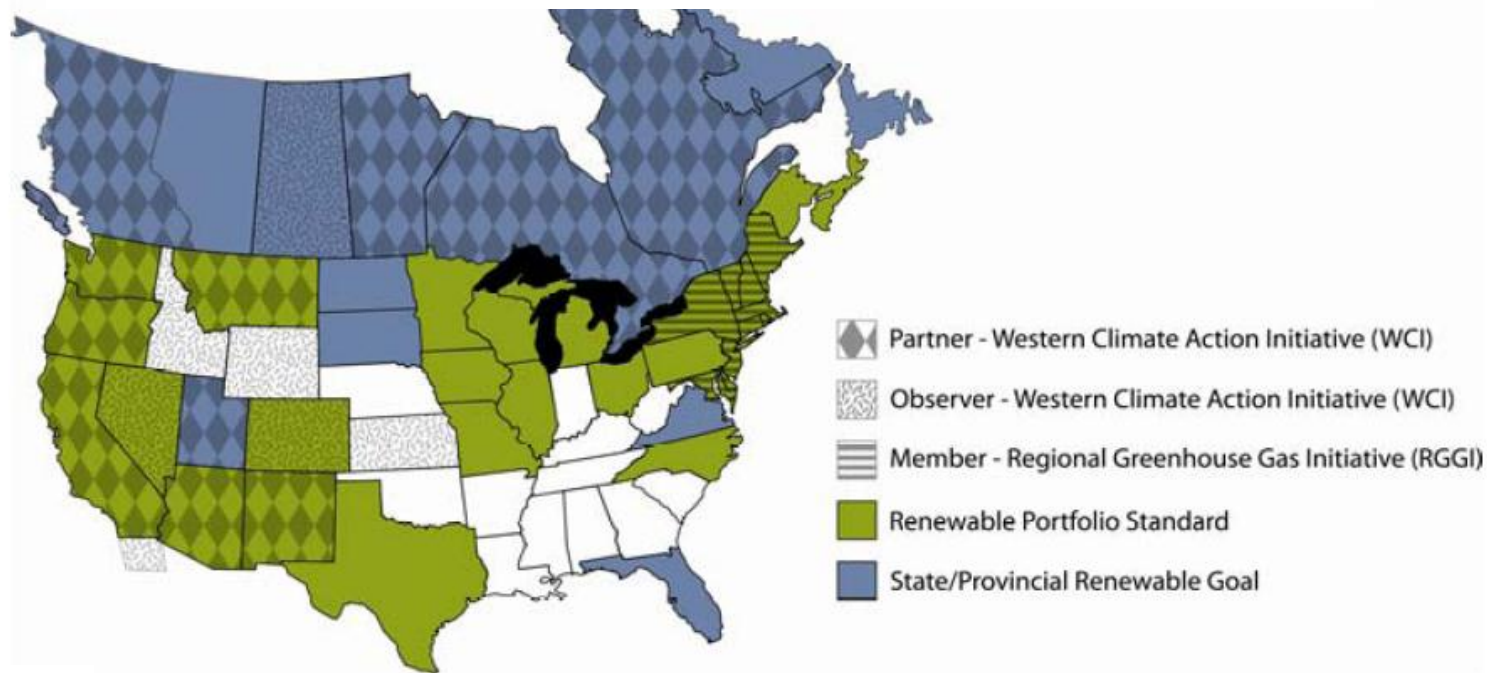
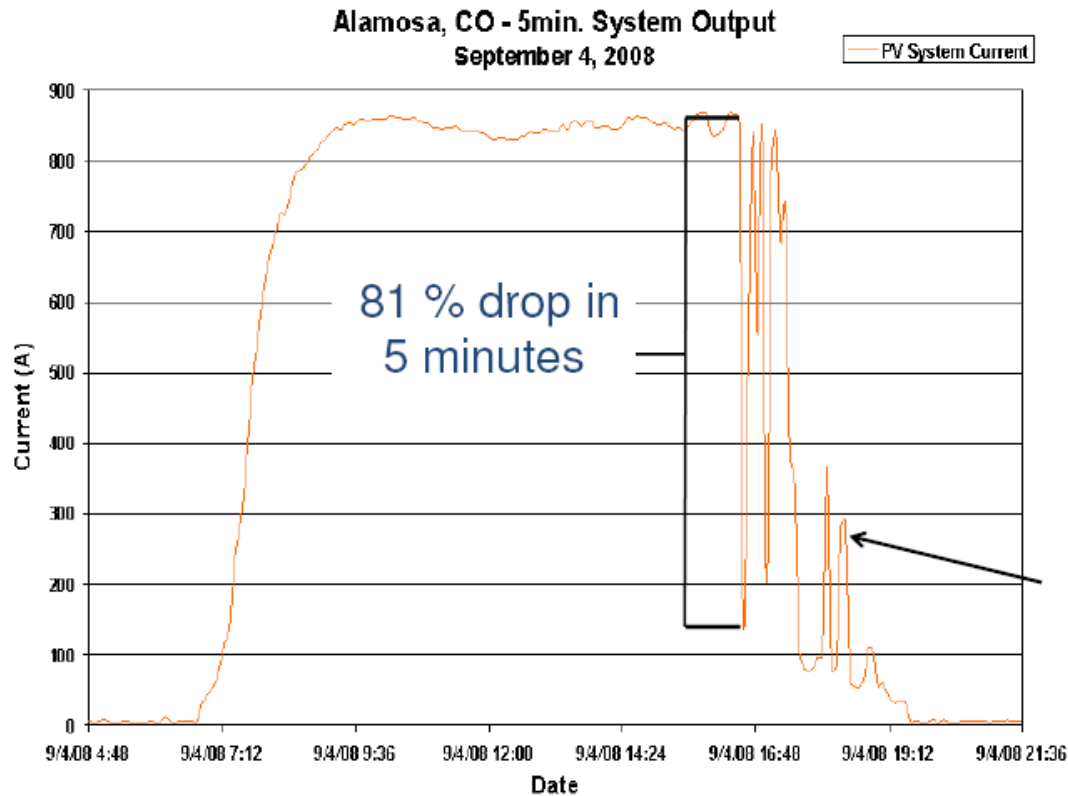


Figure 1.1: Snapshot of North American Climate Initiatives

Intermittency (Solar PV)

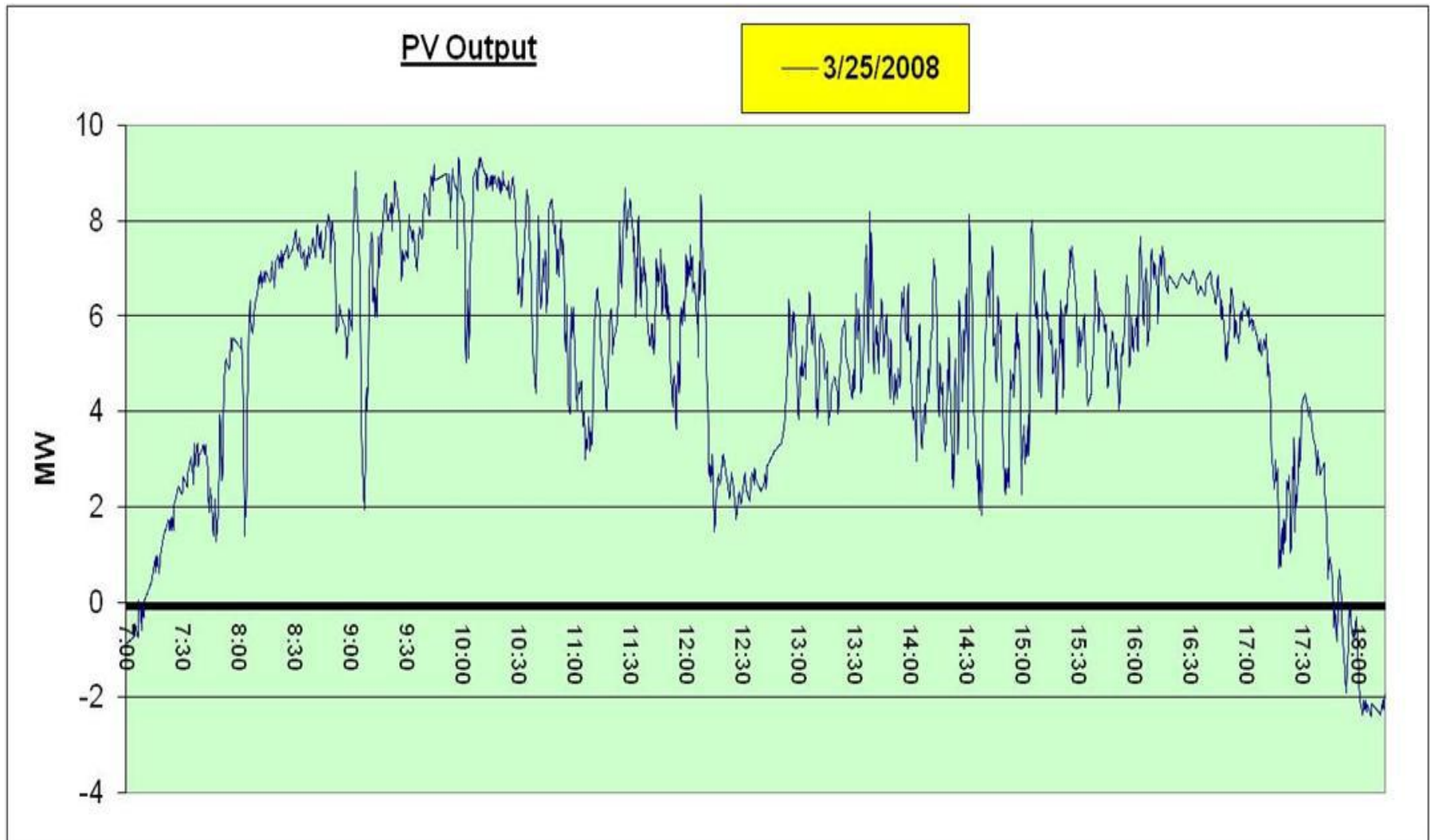
Solar energy sources are highly variable



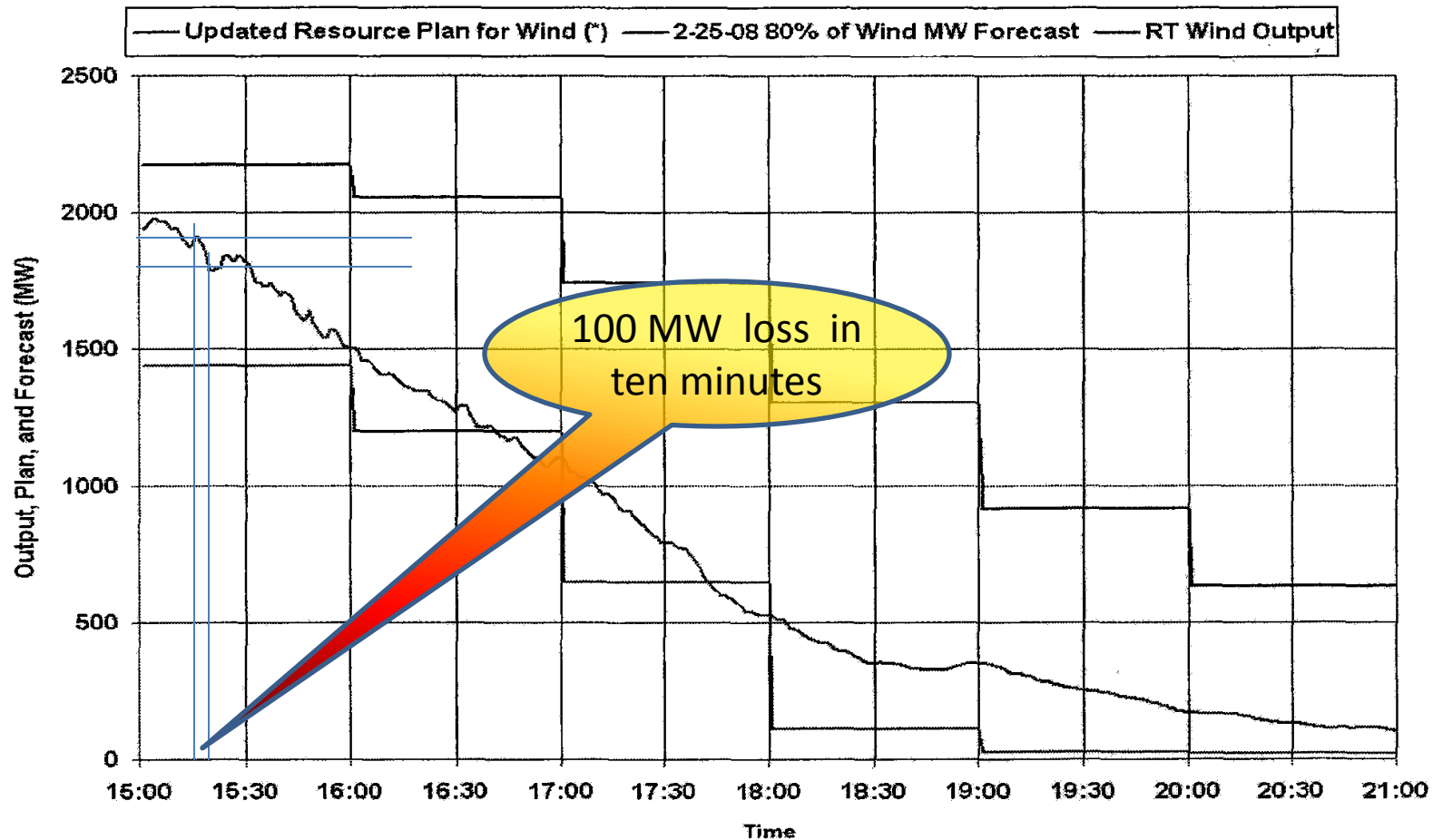
Output from
an 8MW
solar PV
panel in
Colorado on
9/4/08

**High
variability
due to
clouds**

Intermittency Solar (Partly Cloudy Day)



Intermittency Wind (ERCOT)



(*) Updated Resource Plans are hourly values captured during the operating hour.

Additional spinning reserves

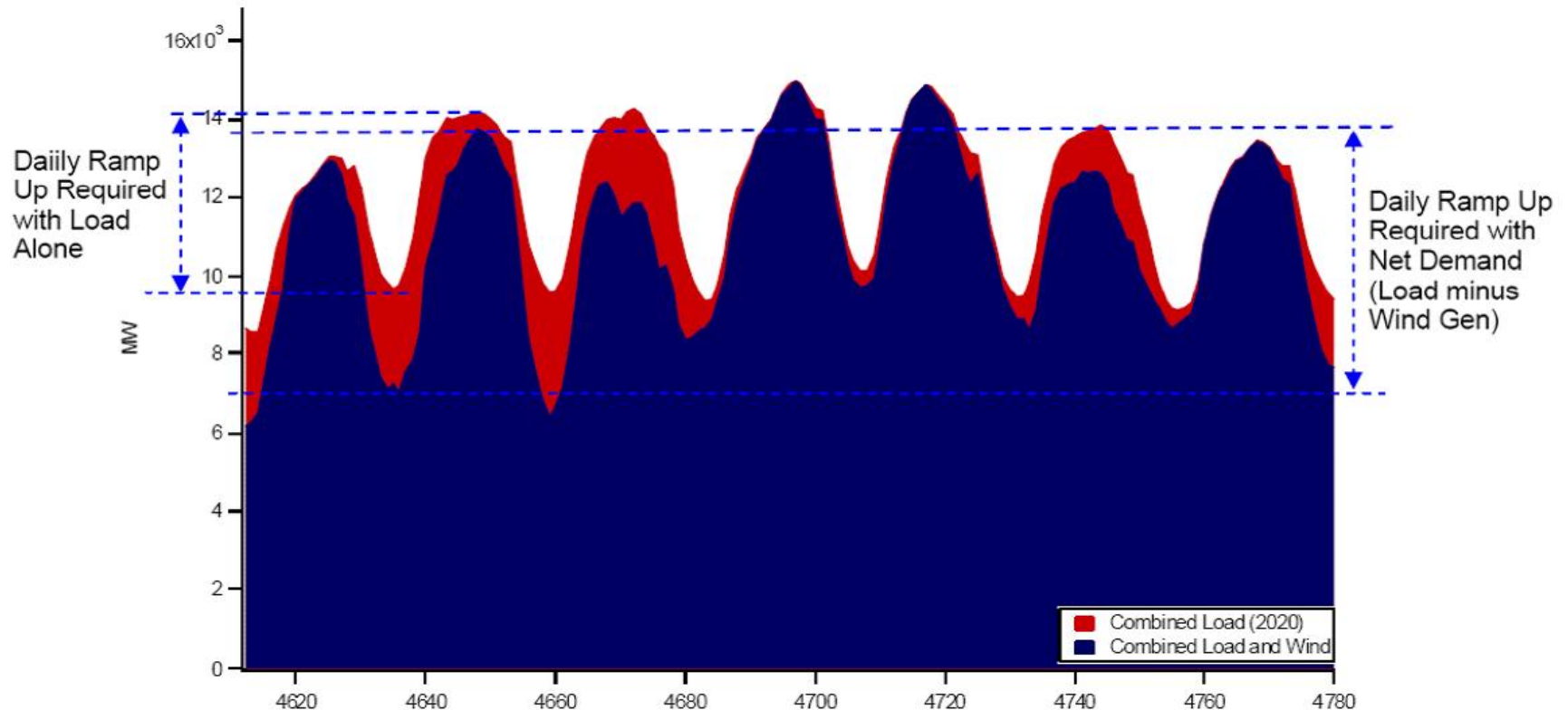


Figure 2.2: Variable Generation can Increase System Flexibility Needs

NERC IGVTF Report (p 8)

As shown in Figure 2.2, wind generation is significantly higher during the off peak load period than during the peak load period. Hence, the net demand during the day, shown in blue, varies from about 7,000 MW to 13,600 MW requiring the conventional generators to ramp from 7,000 MW to 13,600 MW (6,600 MW of ramping capability) which is approximately 45% greater than the ramping capability needed without wind generation.

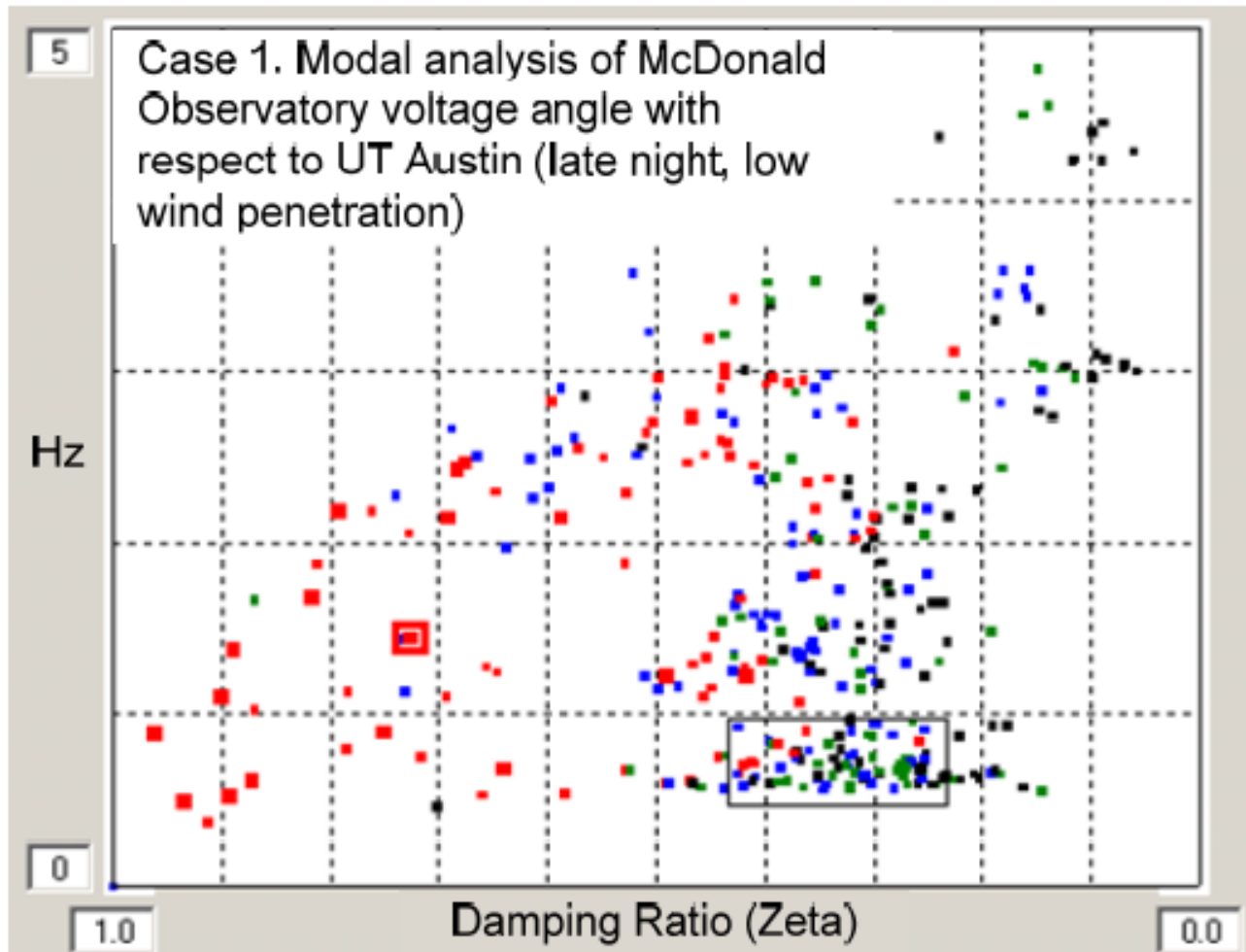
U of Texas PMU Network*



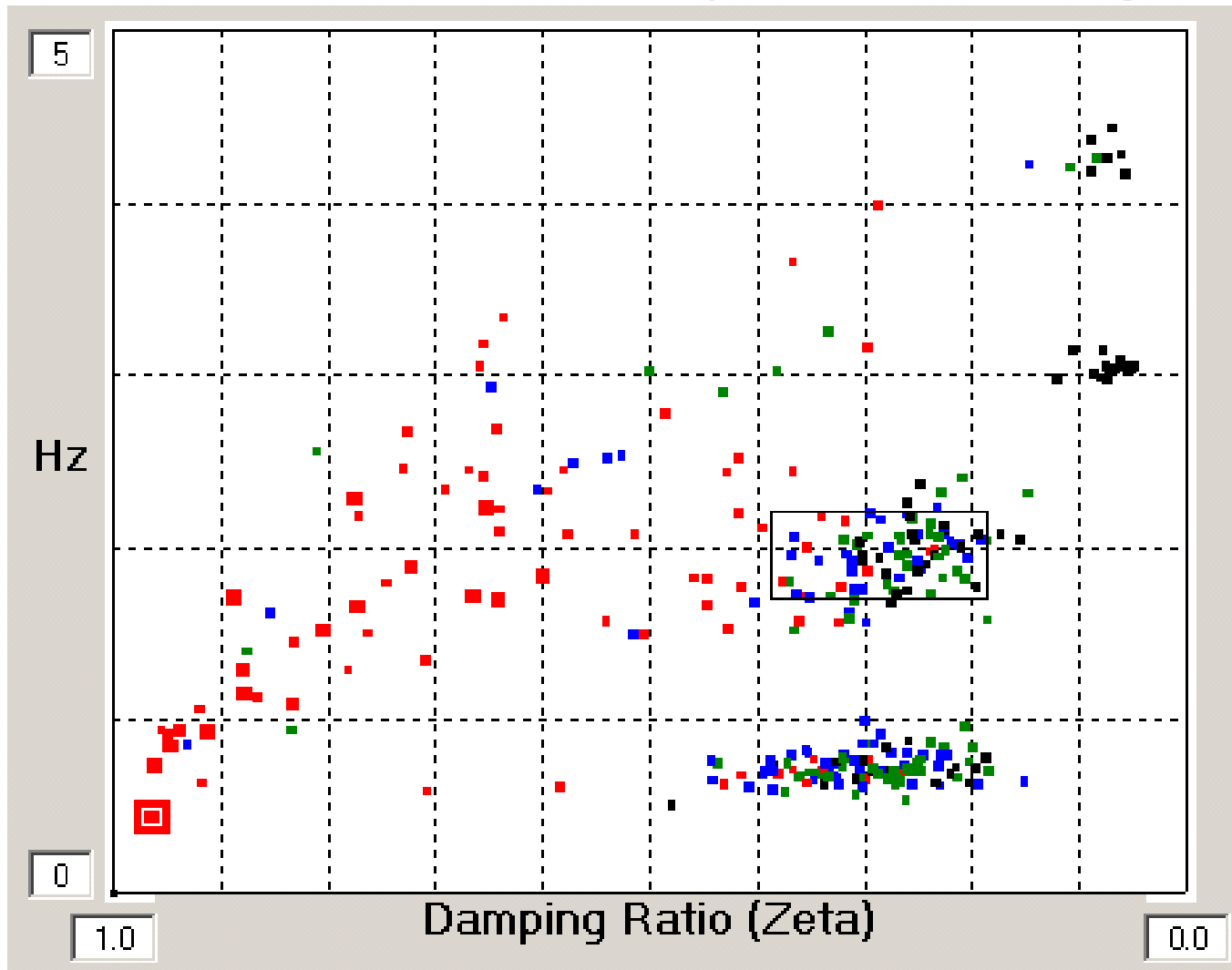
* With permission of
Prof. Mack Grady

Fig. 3. Map of ERCOT with existing and future PMU installations

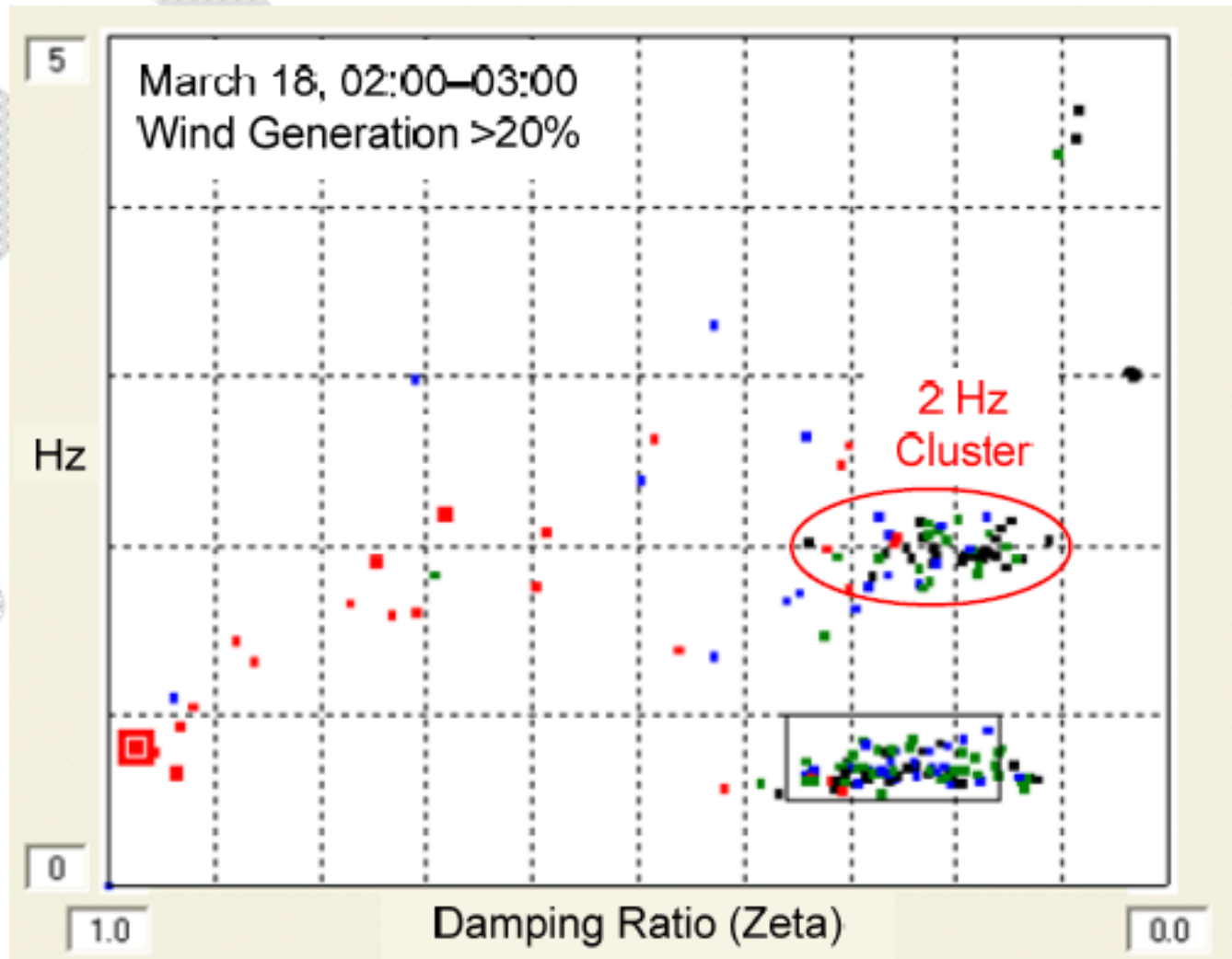
ERCOT (Wind < 1 percent)



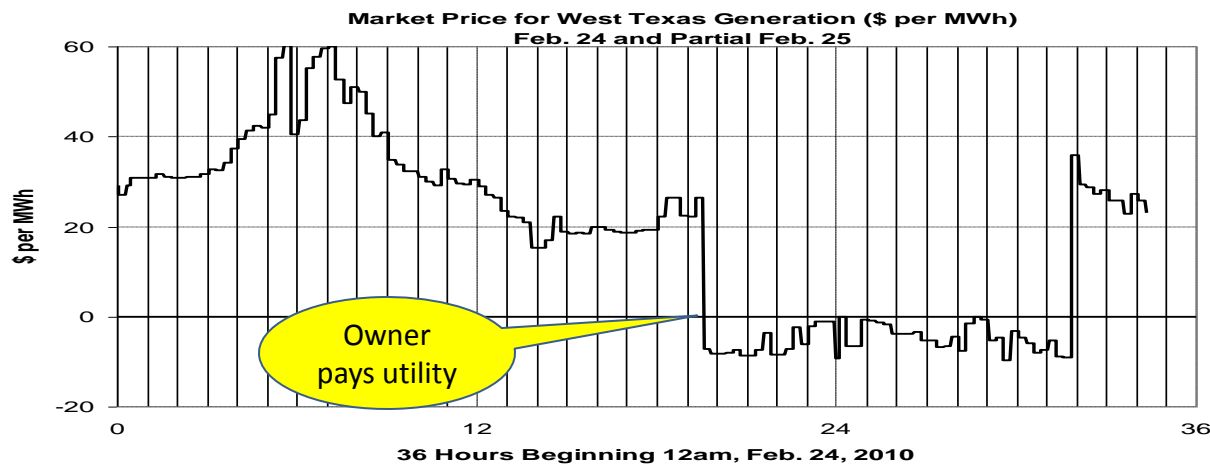
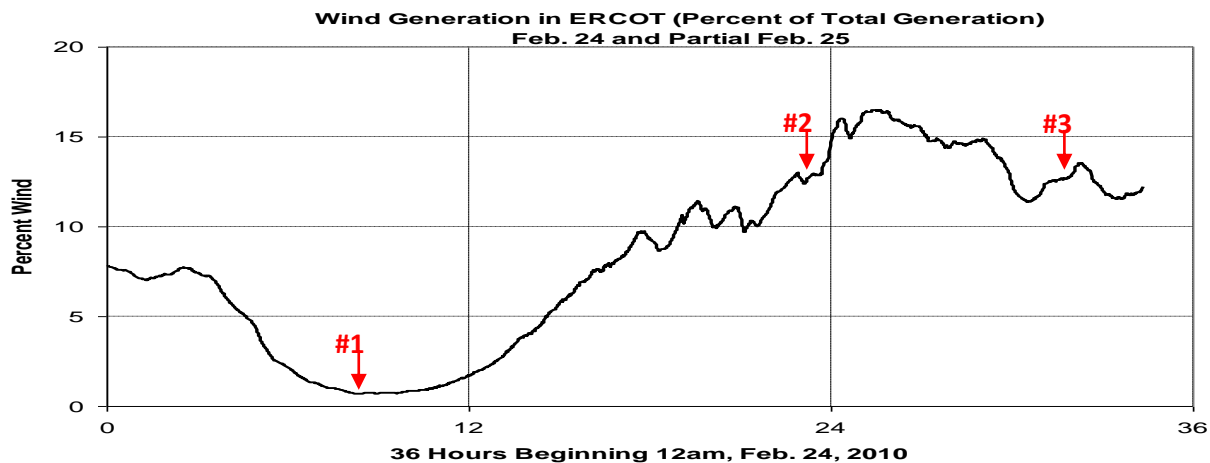
Results from ERCOT (wind > 13 percent)



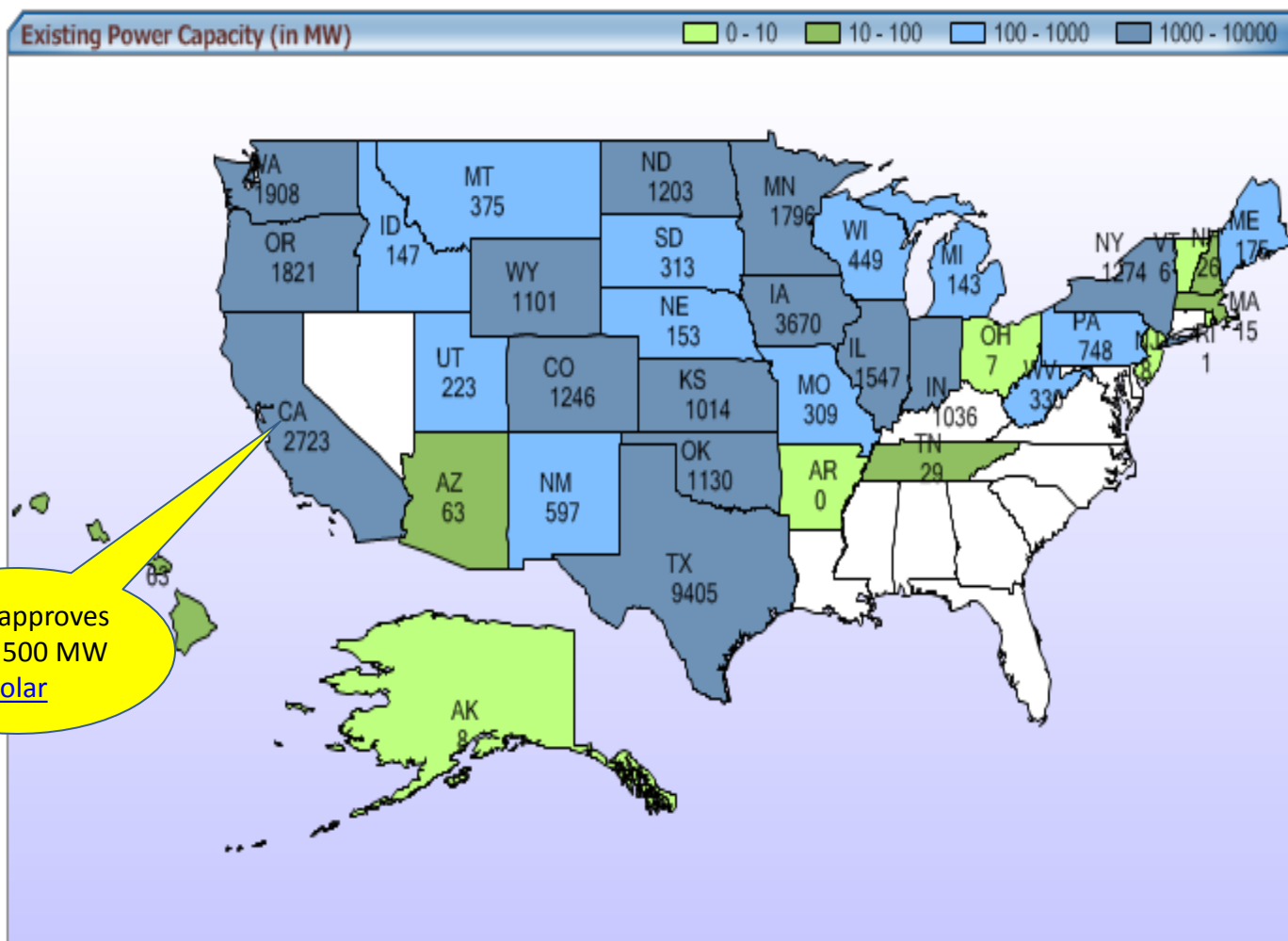
Wind > 20 percent



Financial impact



CHALLENGE

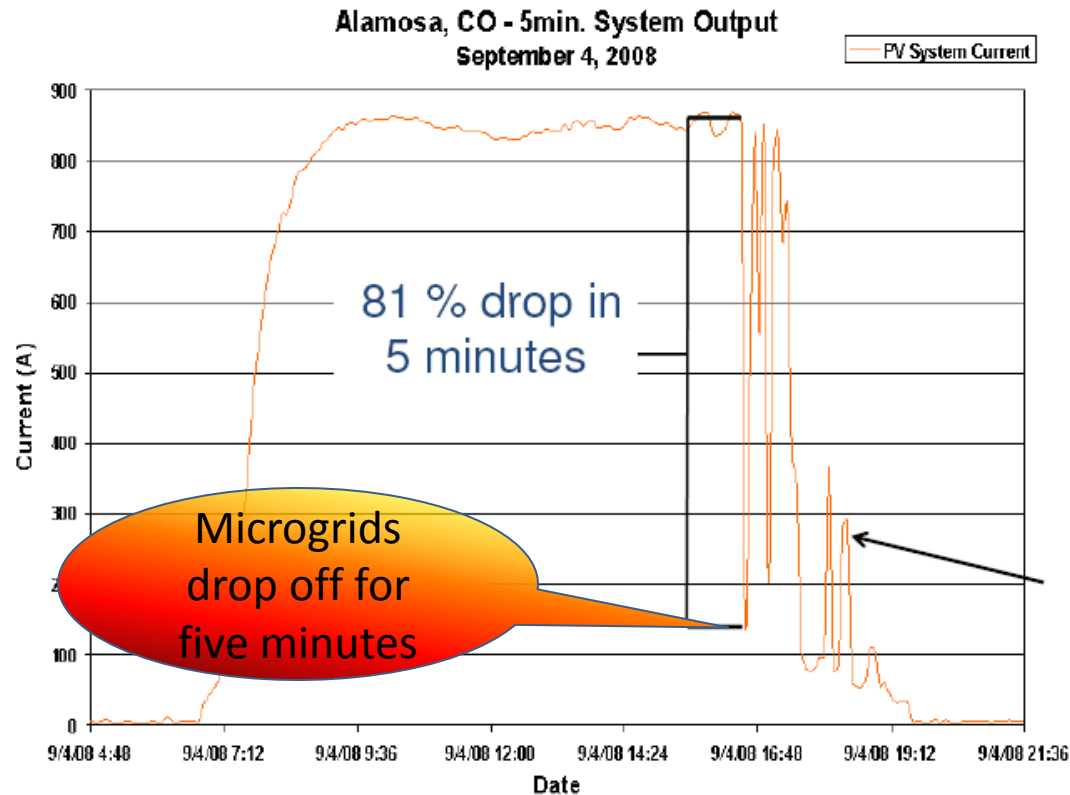


SOLUTION

- Accurately measure impact of renewables
- Compute real time capacity of transmission
- Compute stability margin of grid in real time
- Dispatch wind resources
- Improve wind and solar forecasting
- Implement demand response
 - Includes microgrid curtailments

Microgrid curtailment

Solar energy sources are highly variable



Output from
an 8MW
solar PV
panel in
Colorado on
9/4/08

High
variability
due to
clouds

BPA implementation

- All wind farms connected to BPA transmission grid must install PMUs and send real time phasor data to BPA

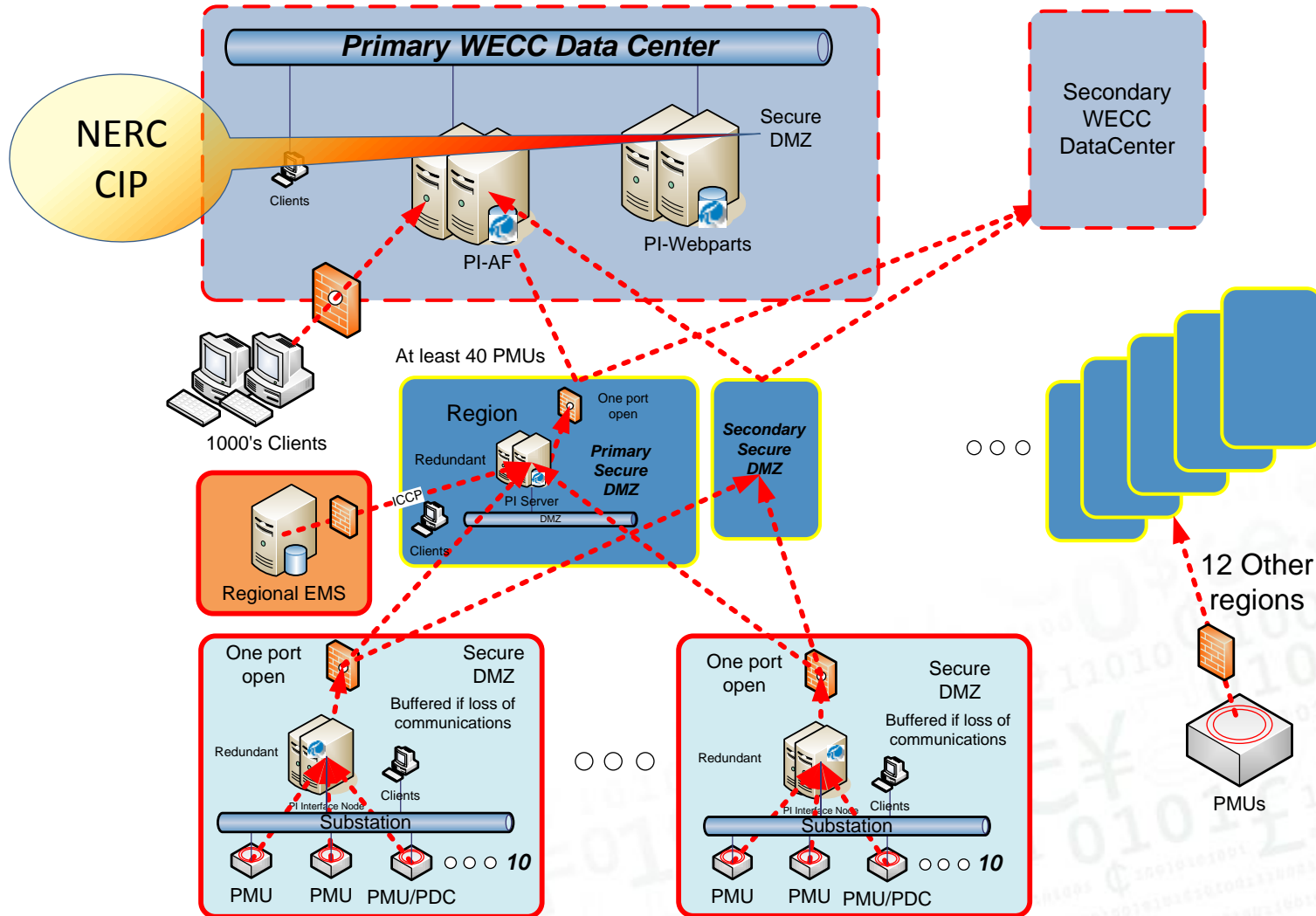
US DOE ARRA Projects

- WISP - \$108 million
- PG&E - \$50 million
- BPA - \$40 million
- SCE - \$80 million
- ERCOT - \$27 million
- MISO - \$34 million
- NYISO - \$76 million
- NE-ISO - \$18 million
- CAISO - \$5.4 million

OSIsoft SOFTWARE

- PI Servers
- PI Interfaces C37.118
- PI Interfaces INT-FFT
- PI WebParts
- PI DataLink
- PI ProcessBook
- PI-SDK

PI SYSTEM ARCHITECTURE



RESULTS

Entergy PMU System

- Installed in 2005
- Re-built after Katrina (2006)
- Full HA in 2006 (22 PMUs)
- Gustav Hurricane Power Island detection and control (savings \$2 million) (2008)

Others in

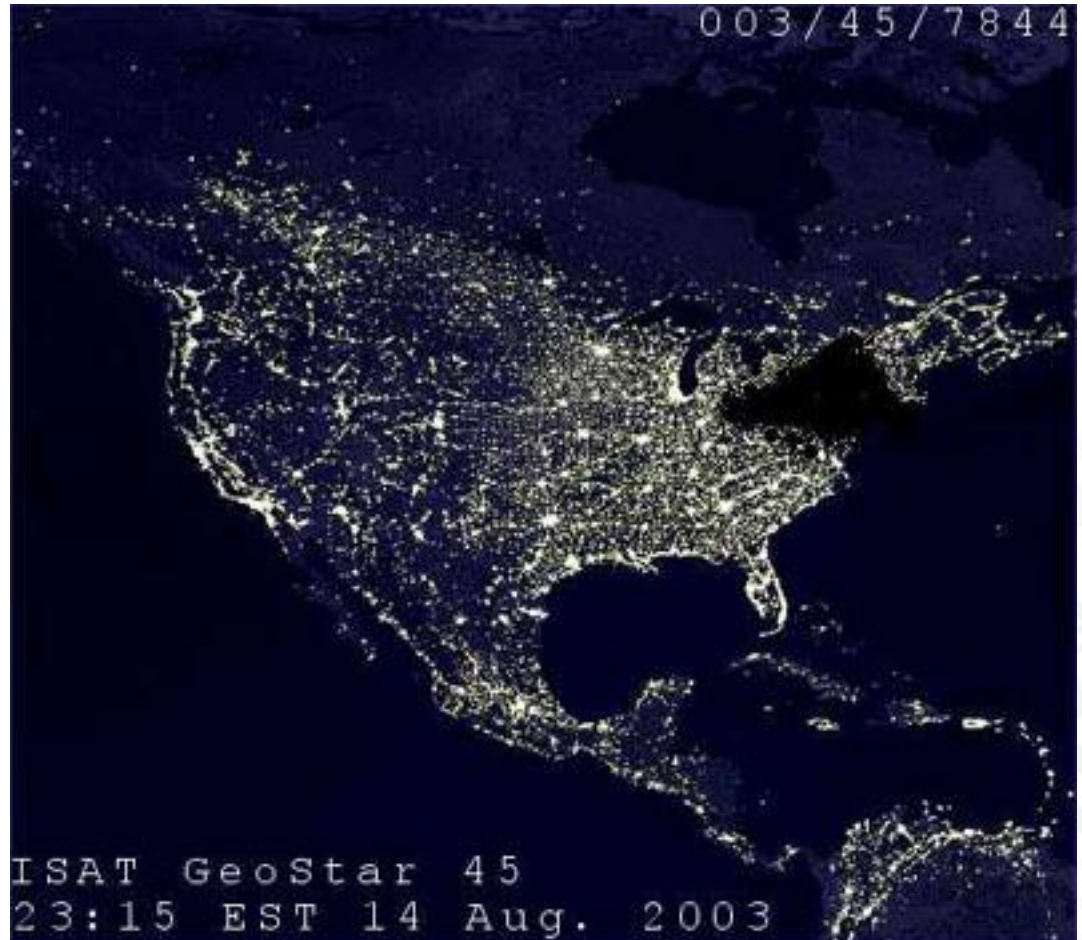
China (six systems using PI for PMU data) (July 1 Blackout detection)

Malaysia (Tenaga) (Negative sequence detection of exciter failure)

Mexico (CFE) (Harmonics in southern Mexico)

TANGIBLE BENEFITS

- Entergy reports \$2-3 million in saving due to PMUs for Island management
- 2003 Northeast Blackout prevention
 - Savings = \$10 billion (DOE Task Force)



Hurricane Gustav

- It is estimated that approximately 200,000-250,000 customers, and 50 transmission substations were kept in service by virtue of the island being maintained
- Projected Savings for this islanding event is approximately 2-3 million dollars by maintaining the island. Additional societal benefits would also have been realized.

INTANGIBLE BENEFITS

Increase capacity factor for renewables
Increase efficiency of transmission lines
Accommodate more Utility scale renewable
Accommodate city microgrids
Early warning of grid stress
Increase in grid reliability

FUTURE PLANS / NEXT STEPS

- DOE Funded WAMS projects
 - Begin implementation
 - Document benefits
- Other implementations
 - Transformer condition monitoring
 - Large motor condition monitoring
 - Generator exciter control
 - Transmission protection and control



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Thank you

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