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10 Year Anniversary 1998–2008

NASPI Working Group Meeting

February 24 & 25, 2010 – Austin, Texas

California's Experience

on

Integrating Wind Generation

Jim Mcintosh

Director, Renewable Resource Integration

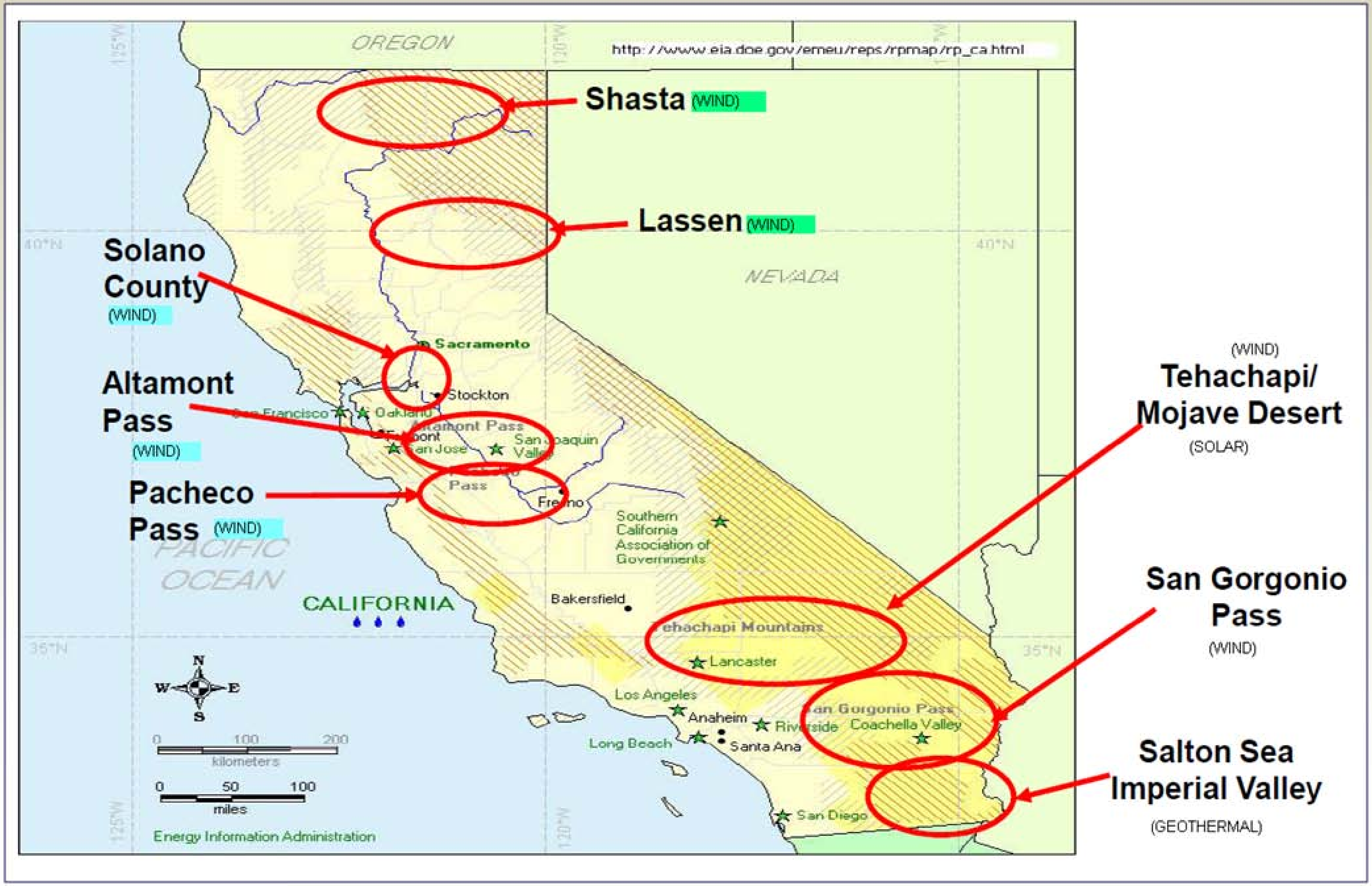
California ISO

VISION

- **New renewable technologies**
  - Wind, Solar, Geothermal, Biomass, Biogas, Tidal/wave
- **Need to integrate large volumes of renewables**
  - Western Interconnection Synchrophasor Project (WISP)
  - NASPI & WECC – Proposed Guidelines & Rules

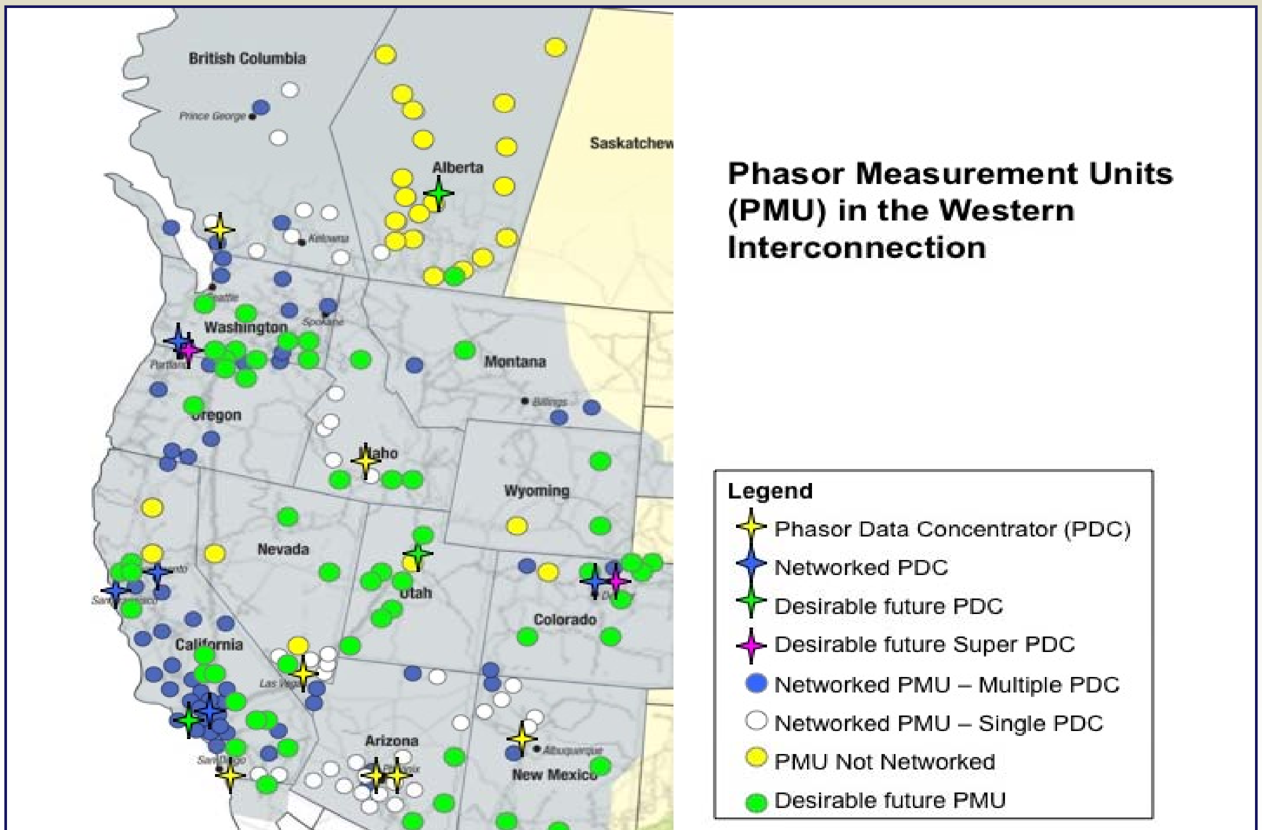
  PMU data promises the ability to manage the intermittent nature of renewable resources**.** PMU data will also deploy the ancillary services needed to firm the changing nature of the West's generation fleet. Currently 56 PMUs and in 3 years could go to 200. PMU data will significantly improve system models.
- **Missing design elements**
  - Power System Stabilizers
  - Low Voltage Ride Through
  - Governor Response
  - Inertia

VARIABLE GENERATION LOCATIONS



CALIFORNIA MAP – EXISTING PMUs
– NEW & PROPOSED PMUs

GOAL – ALL 500 KV SUBSTATIONS, RENEWABLES AND KNOWN CONGESTION POINTS



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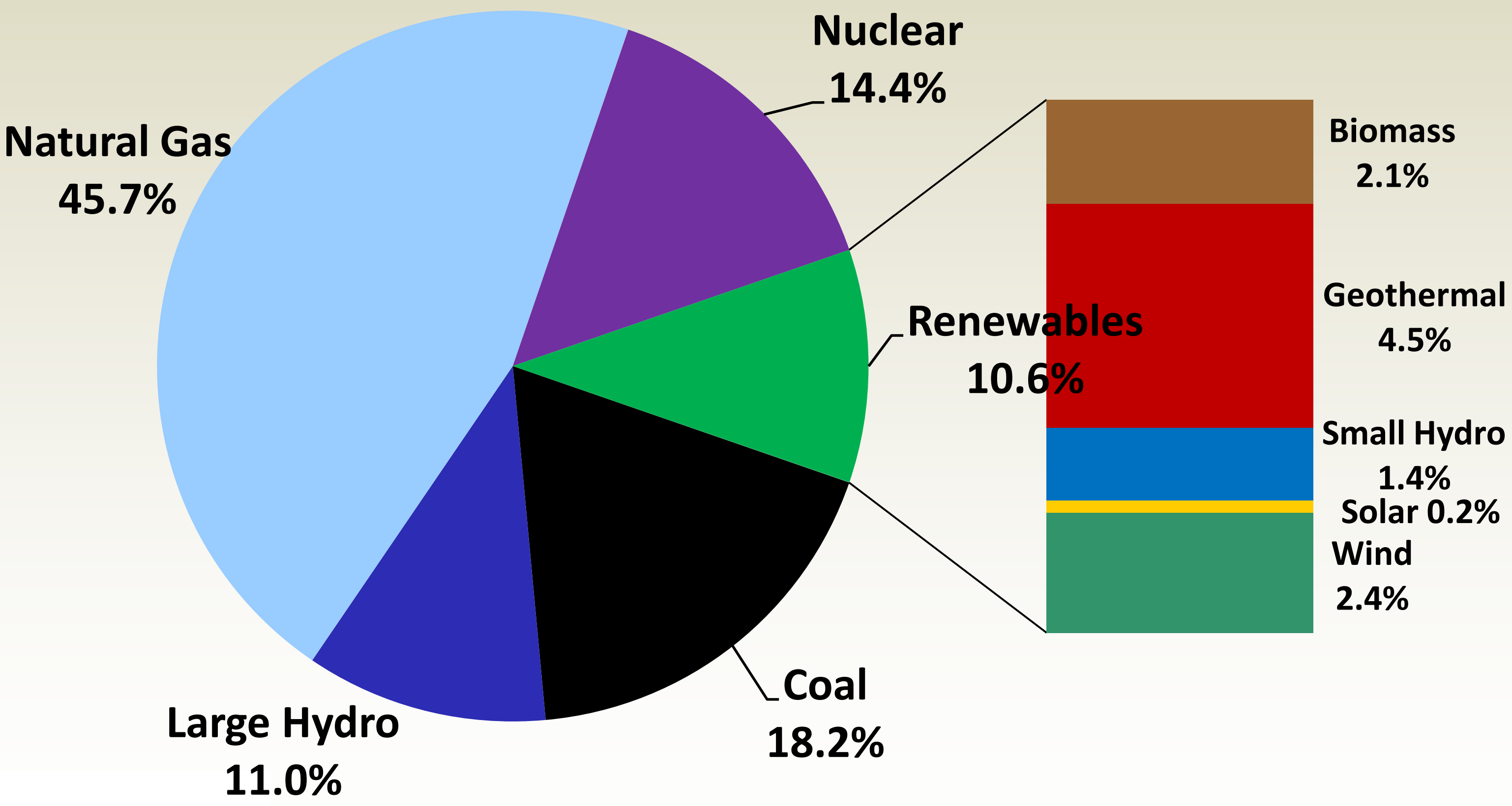
Total System Electric Energy in Gigawatt Hours

In 2008 at – 10.6% in achieving the 20% RPS goal.



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GRID RELIABILITY OPERATIONAL CHALLENGES

FORECASTING	**– Short Term & Long Term**
Wind	**– Variability and predictability**
Concentrated Solar	**– Large ramps and variability**
PV Solar	**– Variability & predictability & visibility**
	– PV Solar buried in "distribution cloud"

With rapid penetration of wind-turbine generation, reactive reserves measurement has become a challenge. Additional synchrophasor measurement at wind sites is necessary to ensure system operators know of the

(i) Availability of Reactive Reserves.

(ii) Deliverability of the Reactive Reserves during a disturbance.

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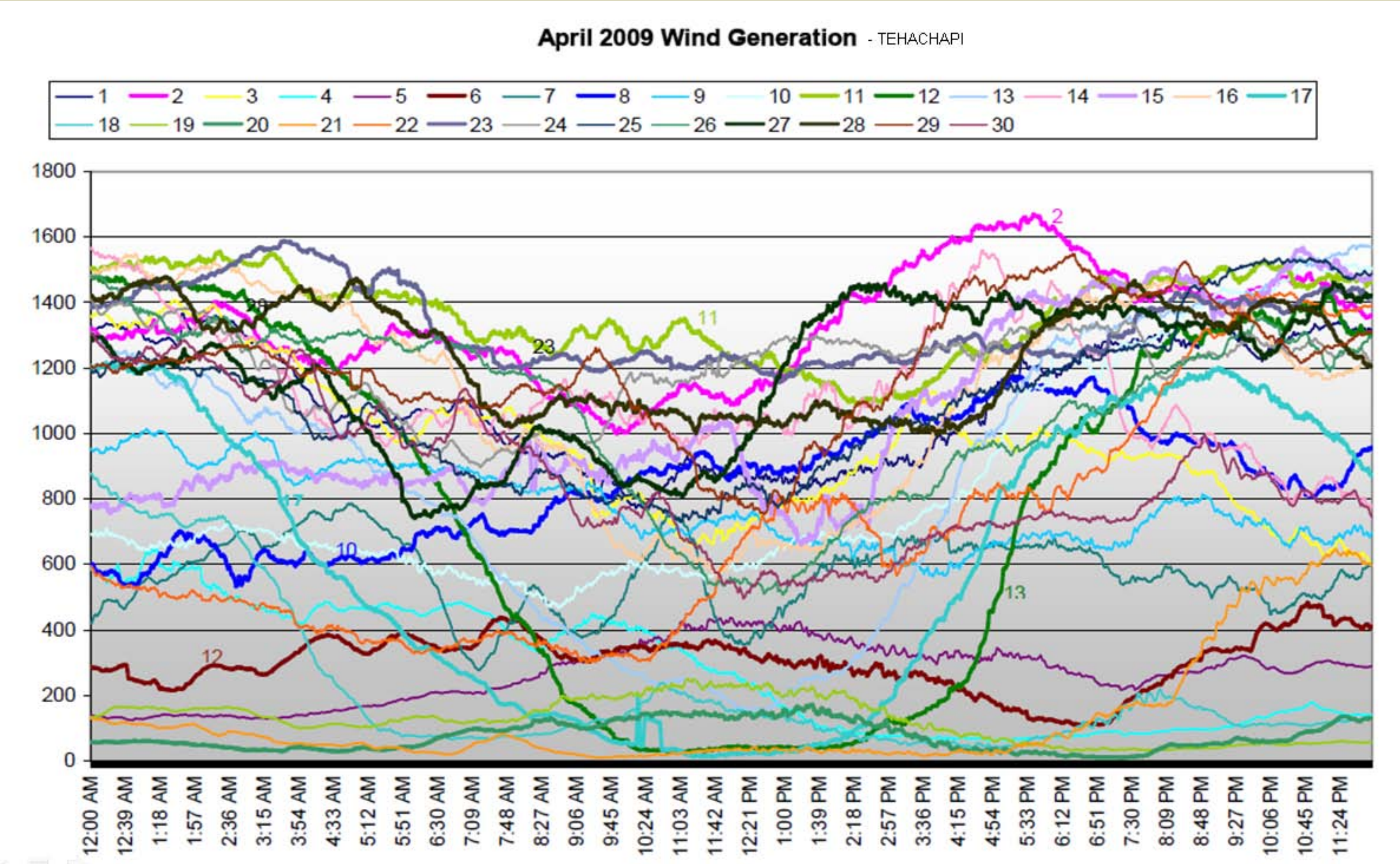
CALIFORNIA RESOURCE FLEET CHARACTERISTIC CHALLENGES

Potential Portfolio of Renewables for 20% & 33%

	Plant Capacity in Megawatts		
Year	2009 (Existing)	20% Additions	33% Additions
PV	400	830	3,234
Solar thermal	400	996	7,297
Wind	3,000	5,917	10,972
Geothermal	900	1,298	2,400
Small Hydro	844	37	844
Biomass/Biogas	900	358	1000
OTC Impacts		?	?
GHG Impacts		?	?

Wind energy is a challenge to forecast



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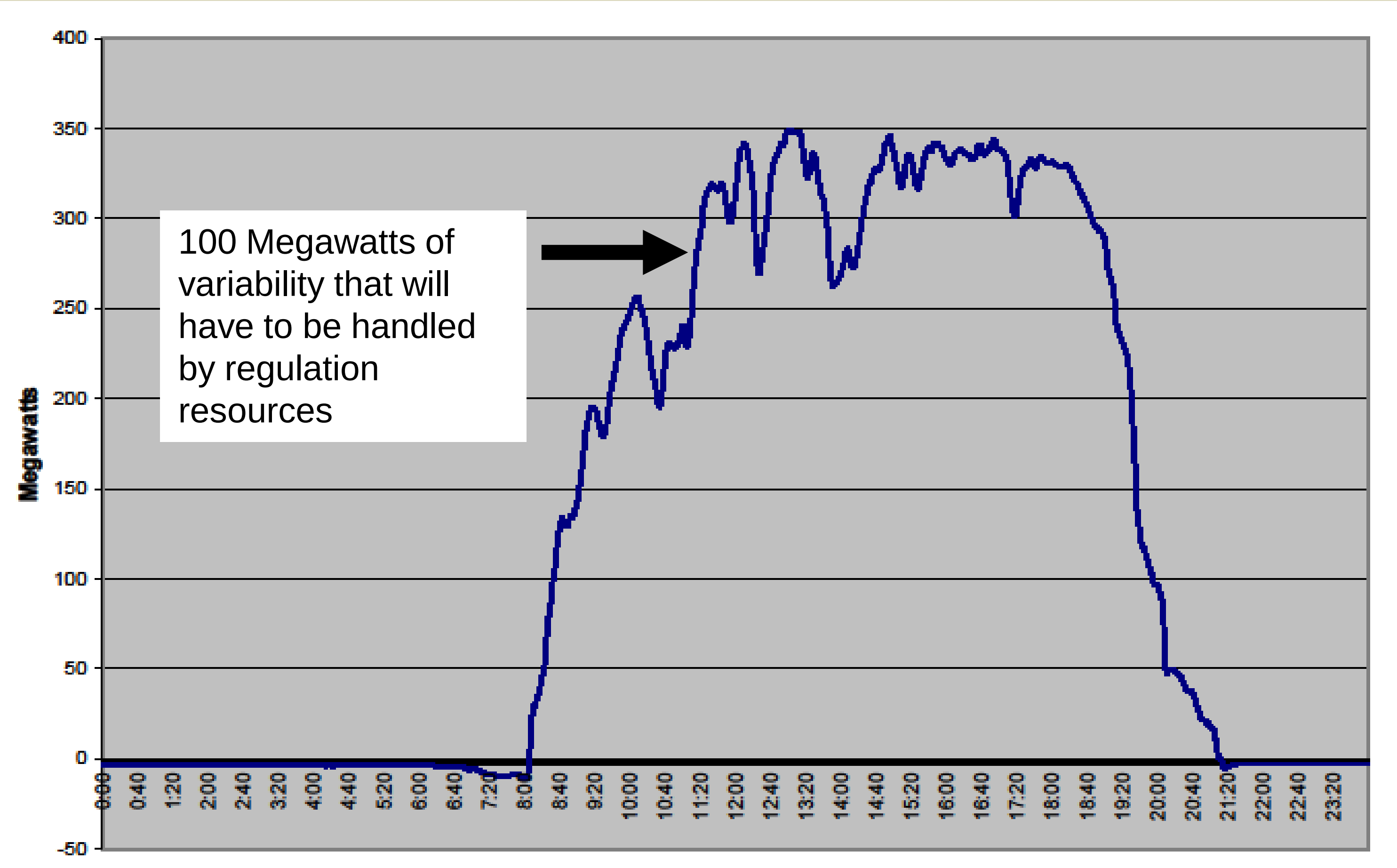
Variable Energy Production from Concentrated Solar
PARTLY CLOUDY DAY – June 01 2009



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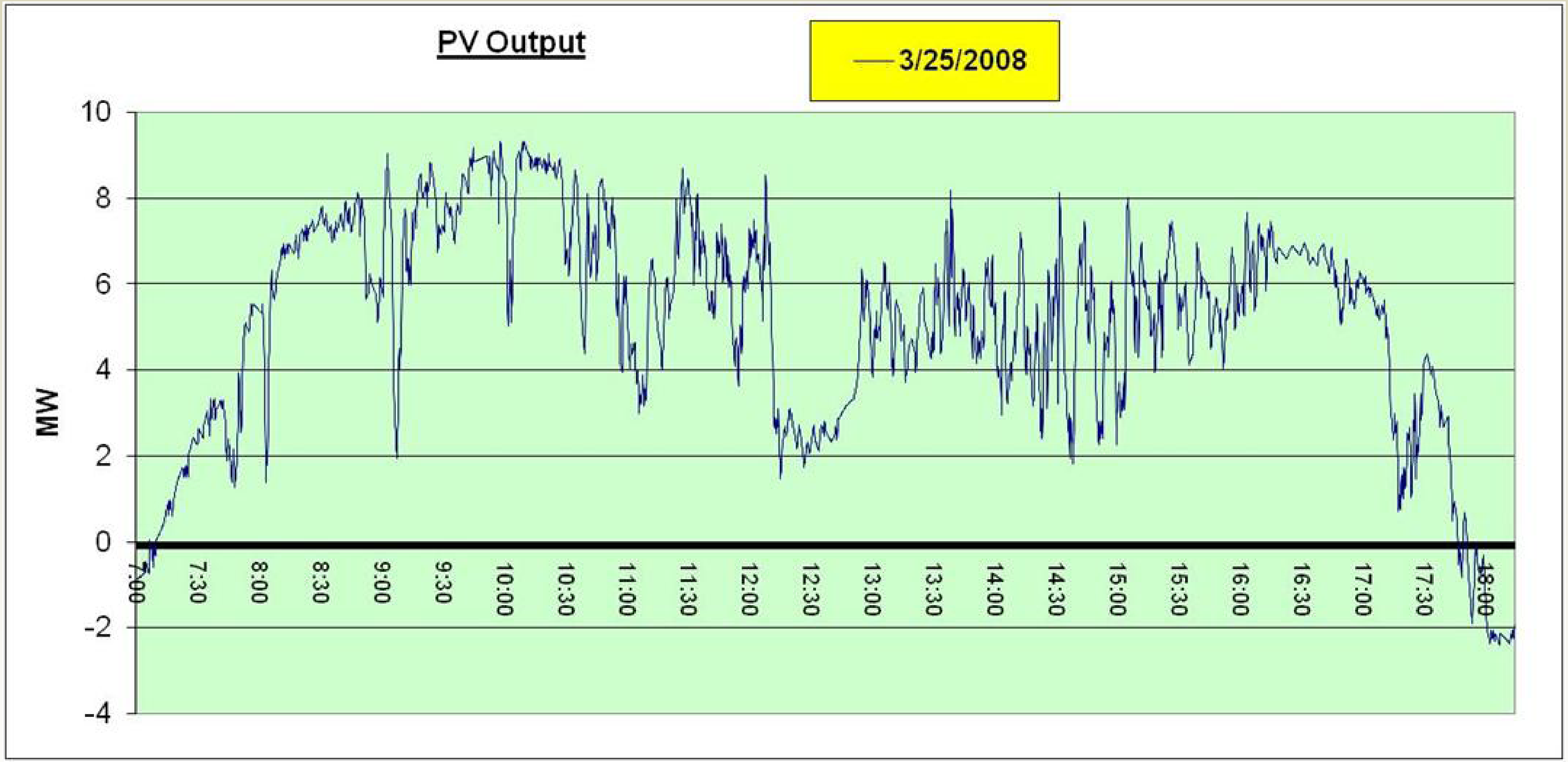
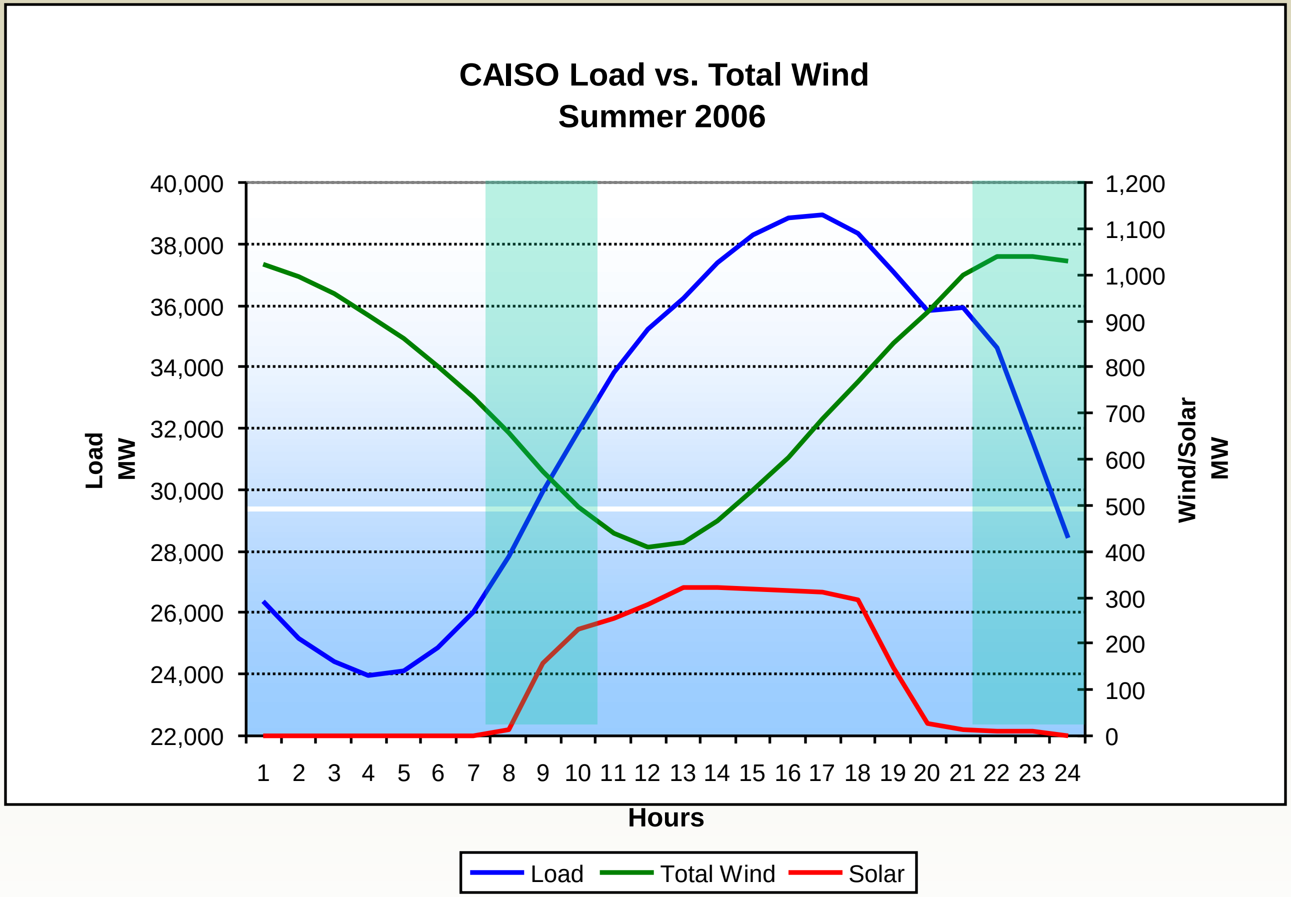
Solar PV plant output variability
Partly-cloudy day, 10-second time-step



% OF PRODUCTION SWINGS THAT NEEDS A PARTNER

Regulating & Ramping Challenges

Inverse Correlation for WIND & Ramp Up and Down Issues for SOLAR



Wind generation tends to be inversely correlated to daily load curve, creating ramping impacts. 70 % of the Wind is generated at night and 28% of the solar is generated on weekends.

STRATEGIES for INTEGRATING RENEWABLES

- 1st line of defense
  - Markets and interconnection standards
- 2nd line of defense
  - Operational tools and procedures
  - See Timeline for Synchrophasor Projects
- 3rd line of defense
  - Hard limits
  - Must Maintain System Stability and Grid Reliability

Markets and interconnection standards

- Stay connected through off-nominal frequency over- and under-frequency events, including coordination with utilities' Under-Frequency Load Shedding programs.
- Stay connected through off-nominal voltage events, including coordination with utilities' Under-Voltage Load Shedding program
- Intelligent reconnection - do not automatically restart/reconnect if **over-frequency** or severe **under-voltage** conditions exist or North-South separation scheme has been triggered.

Markets and interconnection standards

Adequate reactive power capabilities

- Evaluate deliverability of reactive reserves to the grid
- Ensure capability of fast cycling of shunt discharge

Voltage control mode

- Provide primary voltage control for transient stability
  – ability to survive power system disturbances
- Provide secondary control for post-transient stability
  – ability to recover from a disturbance

Markets and interconnection standards

Have capability of providing primary frequency control:

- Response characteristics – structure, time constants, gain are to be defined by grid code

Governor control mode:

- Upward direction for arresting system frequency deviations as required by TO, part of the wind will be spilled to provide Frequency Responsive Reserves.
- Downward direction for over-frequency at all times

Capability to measure Frequency Responsive Reserves.

TIMELINES - CAISO SYNCHROPHASOR PROJECTS

2010 to 2013

1. PRODUCTION QUALITY ARCHITECTURE (2010)
2. INTEGRATION WITH PI DATA HISTORIAN (2010)
3. VISUALIZATION IN THE CONTROL ROOM WITH RTDMS & GOOGLE EARTH APPS (2010)
4. SMALL SIGNAL STABILITY WITH ALARMING
5. STATIC MODEL BASELINING/BENCHMARKING

2010 to 2015 and Beyond

6. VOLTAGE STABILITY MONITORING
7. REAL TIME OSCILLATION CONTROL
8. STATE ESTIMATION & SYNCHROPHASORS
9. DYNAMIC MODEL BENCHMARKING
10. PSS VALIDATION & VERIFICATION

Red	Necessary and Critical
Blue	Critical with Added Benefits
Green	Moderate Needs & Requires more Investigation

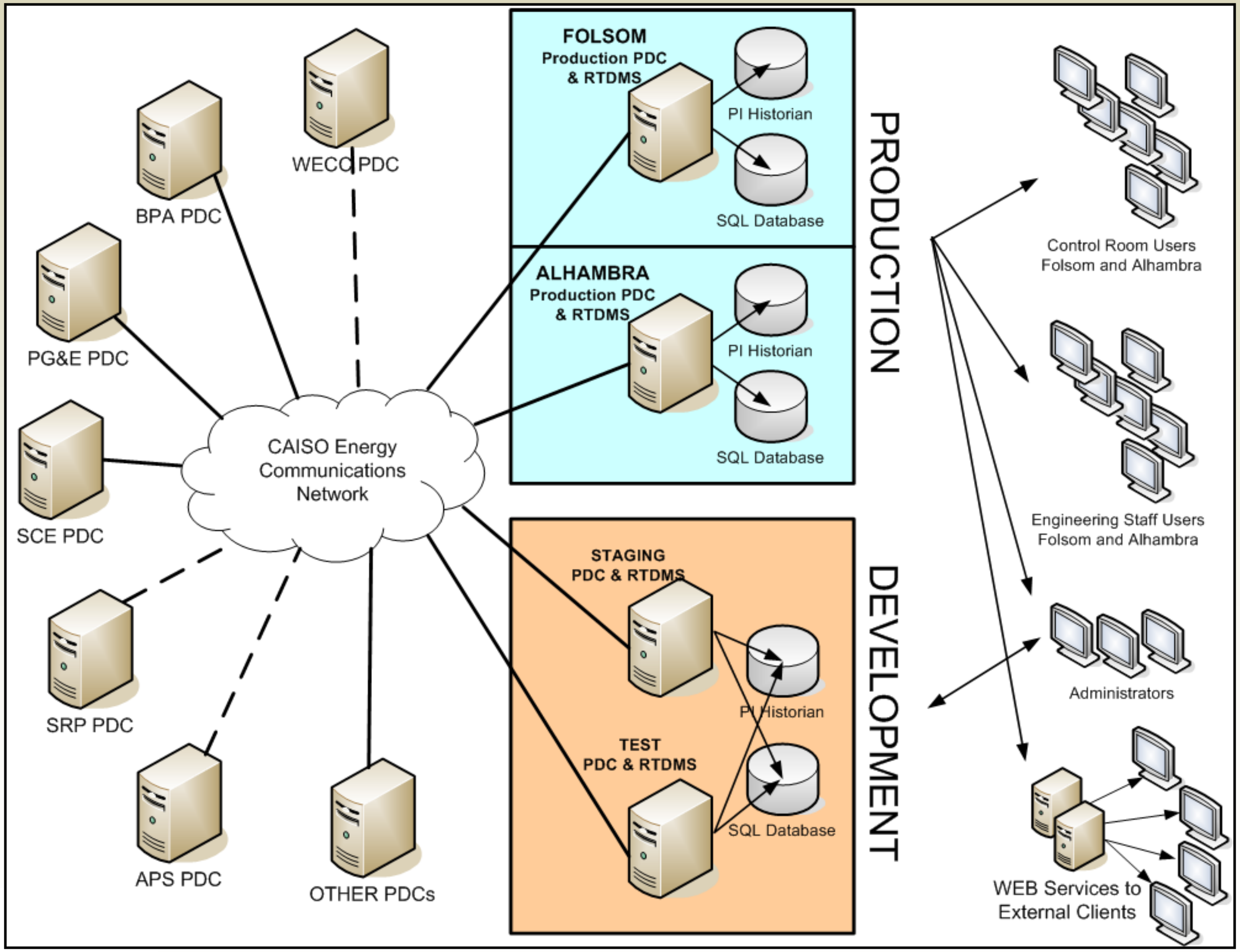
DELIVERABLES for CEC/EPG/CAISO PROJECTS

- PHASE I - $1.7 million
  - Task 1 – Administrative Tasks
  - Task 2 – Voltage Stability Monitoring using Phasor
  - Task 3 – Small Signal Stability Monitoring
  - Task 4 – Phasor Visualization and Alarming
  - Task 5 – Stability Nomograms and Alarming
  - Task 6 – Operational Integration of Renewables

DELIVERABLES for CEC/EPG/CAISO PROJECTS

- PHASE II - $1 million
  - Task 1 – Procure & install production quality hardware at CAISO
  - Task 2 – Integrate Phasor data with CAISO Pi Historian
  - Task 3 – Automatic Event Analyzer
  - Task 4 – Transition RTDMS Visualization to production grade quality
  - Task 5 - CAISO Phase Angle Baseline Analysis

Production Quality CAISO Phasor System Architecture



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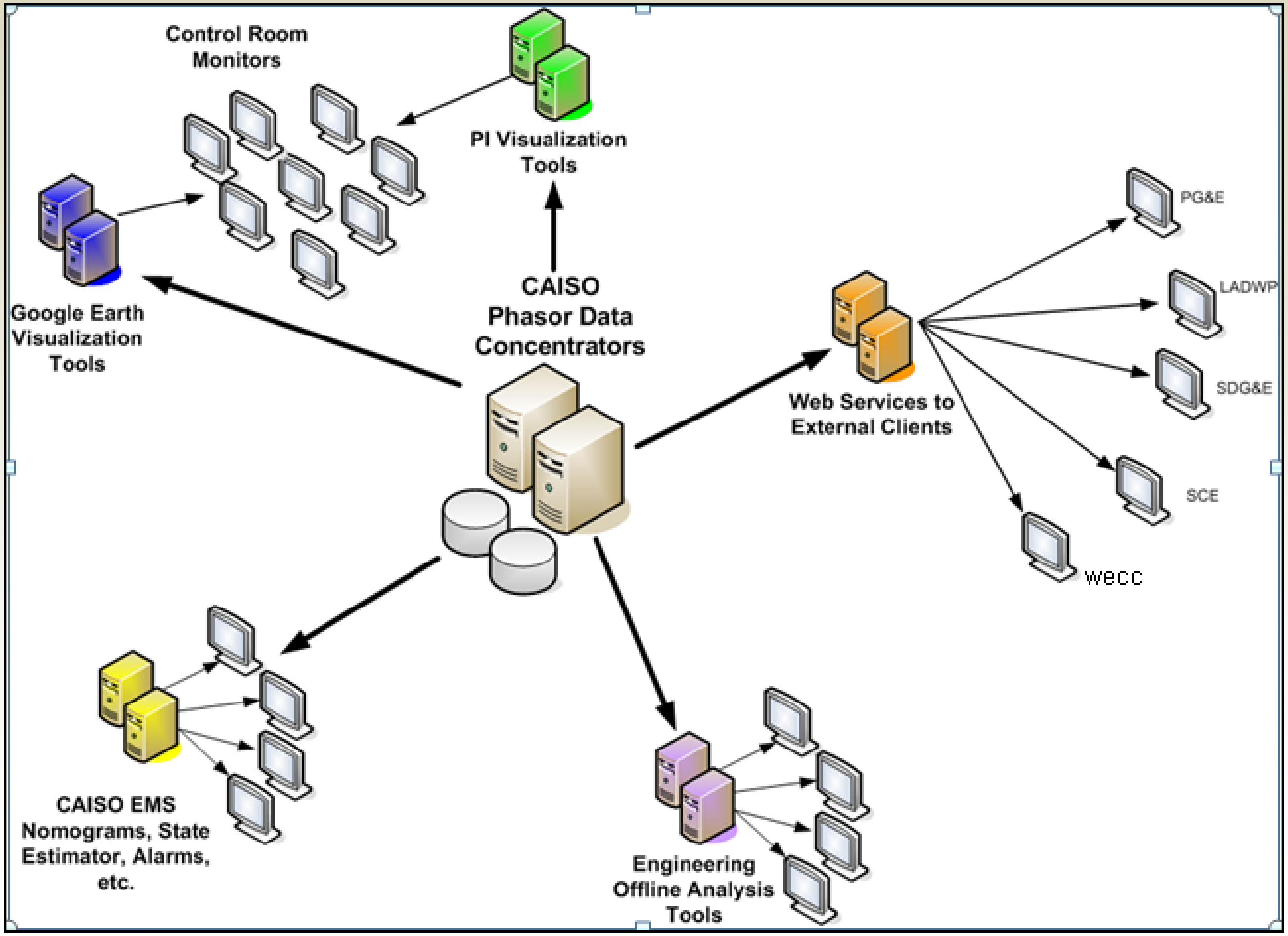
Phasor System – Visualization and Tools



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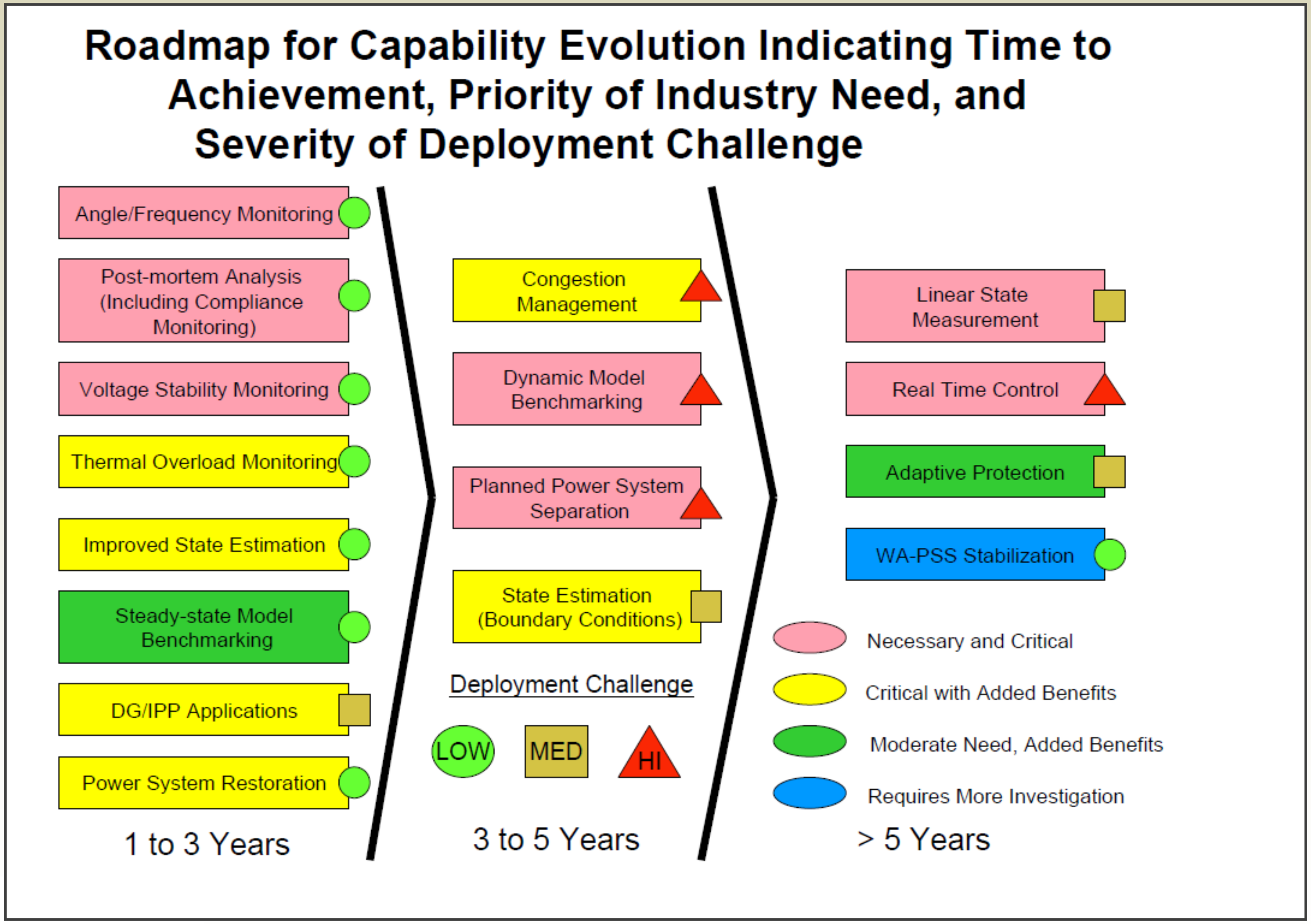
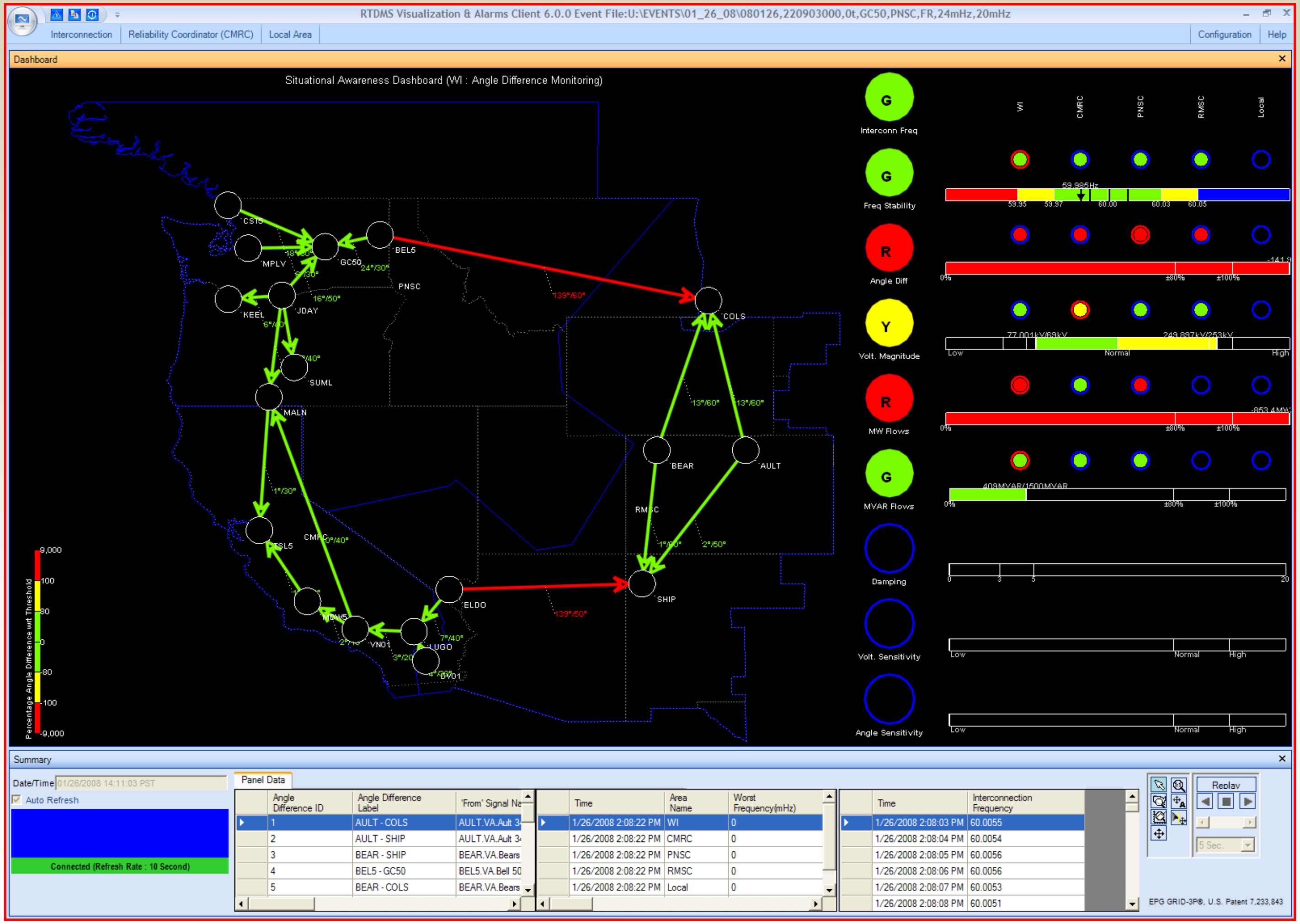
WISP Timeline



CAISO OPERATIONAL TOOLS
RTDMSV6 WIDE AREA MONITORING SYSTEMS



JAN 26 2008 PDCI event
RTDMSV6 WIDE AREA MONITORING SYSTEMS

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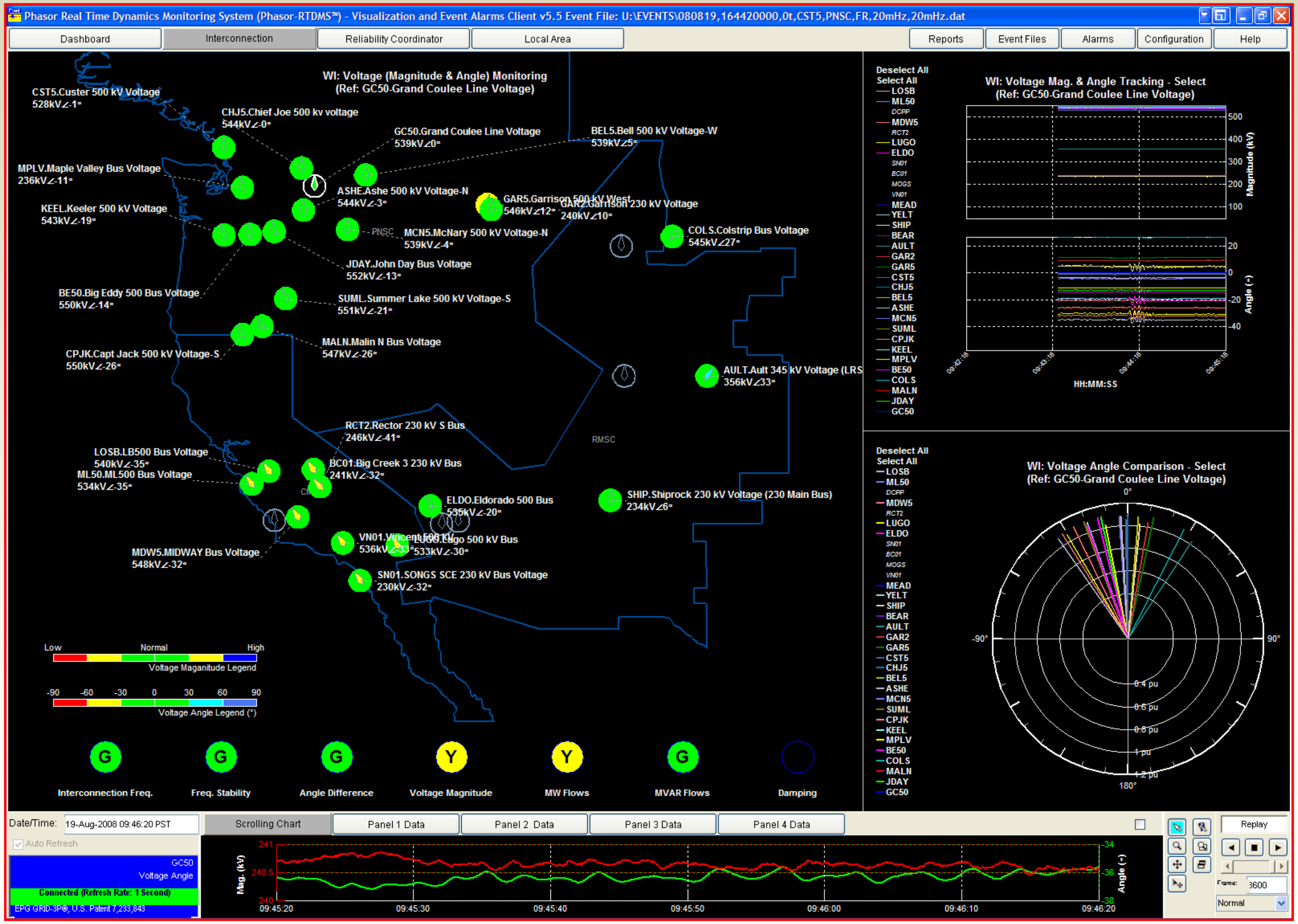
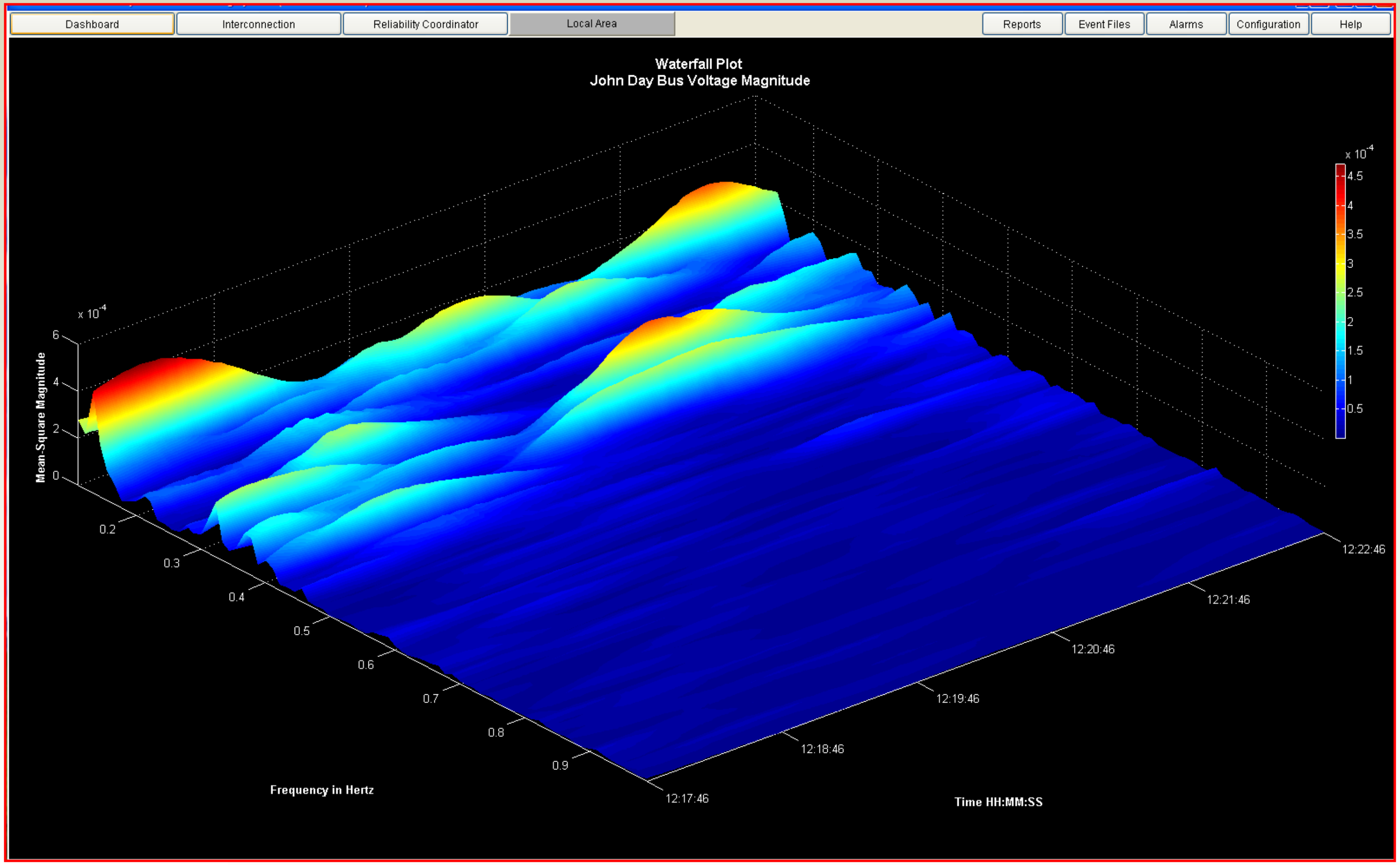
DASHBOARD STYLE ALARMING
RTDMS WIDE AREA MONITORING SYSTEMS



TIME & FREQUENCY WATERFALL PLOTS

ENERGY OF OSCILLATION for INTELLIGENT ALARMING



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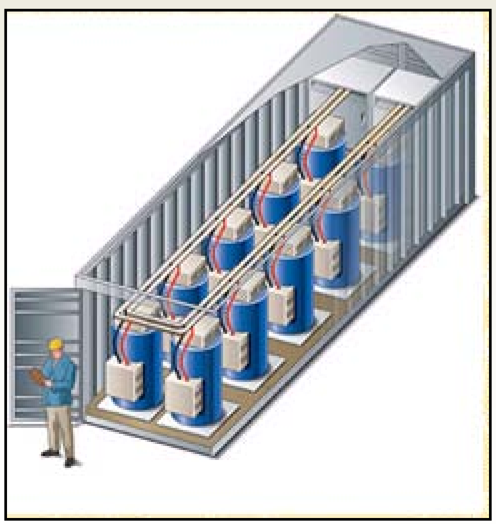
Operational tools and procedures

Reactive power supply or absorption for voltage regulation
Real power injection for frequency regulation
Power flow stabilization during intra-hour fluctuation
Load following
Peak shaving

THYRISTOR INJECTIONS
SUPERVAR APPLICATIONS



Operational tools and procedures

- Governor action
- Frequency response
- Inertia Unit Commitment
- Load Following & Regulation
- Automatic Generation Control
- Market Demands and Compliance

Operational tools and procedures

- Develop automatic corrective measures
  - Grid Damping

- Energy Storage Devices
  - Mitigation of Transmission Overloads & Reactive Power Sources
  - Ramp and Imbalance Energy Control
  - Ancillary Operating Reserves and Regulation Services

- Dynamic Security
  - Challenges in Path/Flow gate limits.