



California ISO
Shaping a Renewed Future

How PI System Supports CAISO Operations and Grid Reliability

Presented by

Jim McIntosh

Director – Operations Executive Advisor

California ISO

Agenda

- CAISO Overview
- Current & Future Challenges
- PI System Display Examples
 - Reliability Displays
 - Transmission Displays
 - Generation Displays
 - Renewables Displays
- Current & Future PI System Projects at CAISO
 - Synchro-Phasor Integration
 - Demand Response
- Questions and Comments

California ISO by the numbers

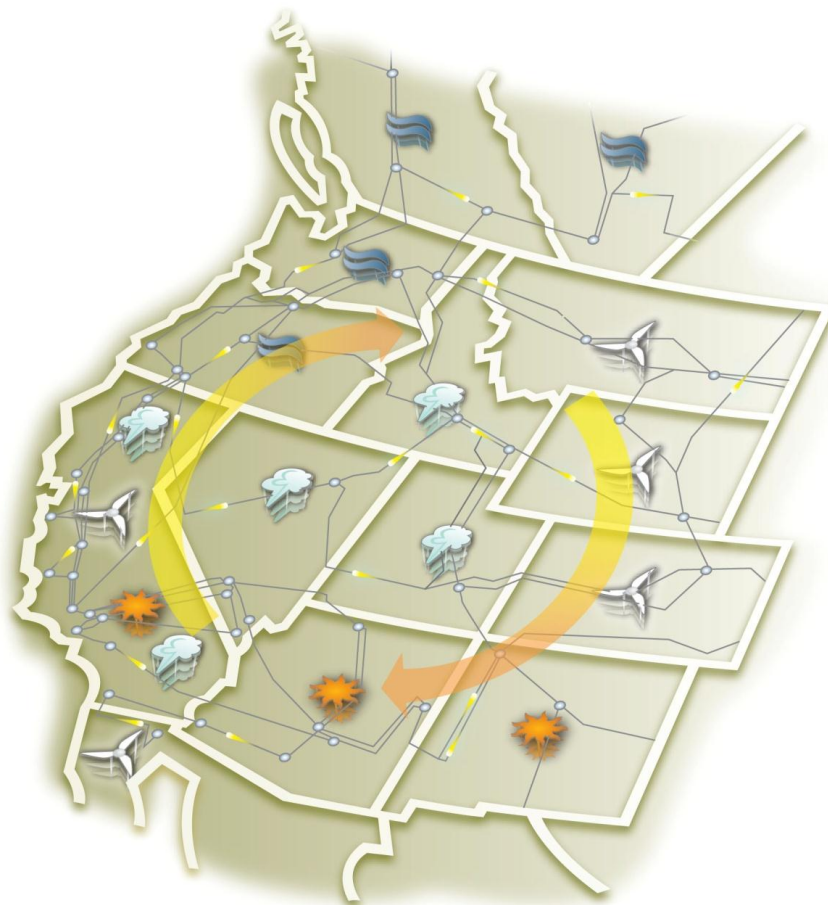


- **55,027** MW of power plant capacity
- **50,270** MW record peak demand (July 24, 2006)
- **30,000** market transactions per day
- **25,526** circuit-miles of transmission lines
- **30 million** people served
- **286 million** MW hours of electricity delivered annually

Resource reciprocity

Welcome to the Western Grid

- CA is one of 14 states within **Western Electricity Coordinating Council**
- Resource sharing enhances reliability, helps achieve renewable targets and manages cost
- A quarter of all the electricity that keeps the lights on during the summer comes from other parts of the west including parts of Canada and Mexico



The power mix

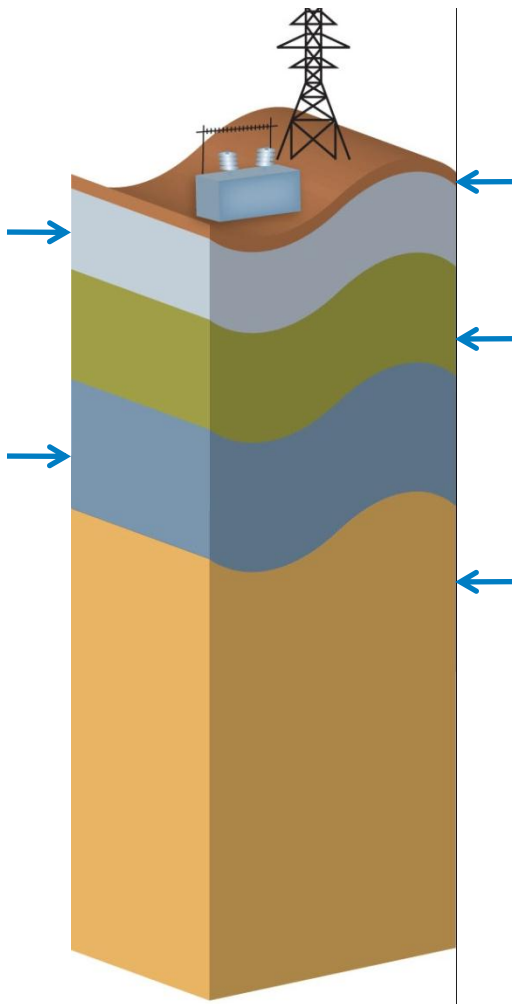
12.2% - large hydro

15.3% - nuclear

1.8% - coal

13.9% - hydro, geothermal,
biomass, wind, solar

56.7% - natural gas



CAISO current & future challenges

- Forecasting
- Generation fleet characteristics
- Ramping requirements
- Ambitious environmental goals
- Reliability with fewer gas powered plants
- Cost containment

We need to strike a balance between reliability, renewables and reasonable cost.

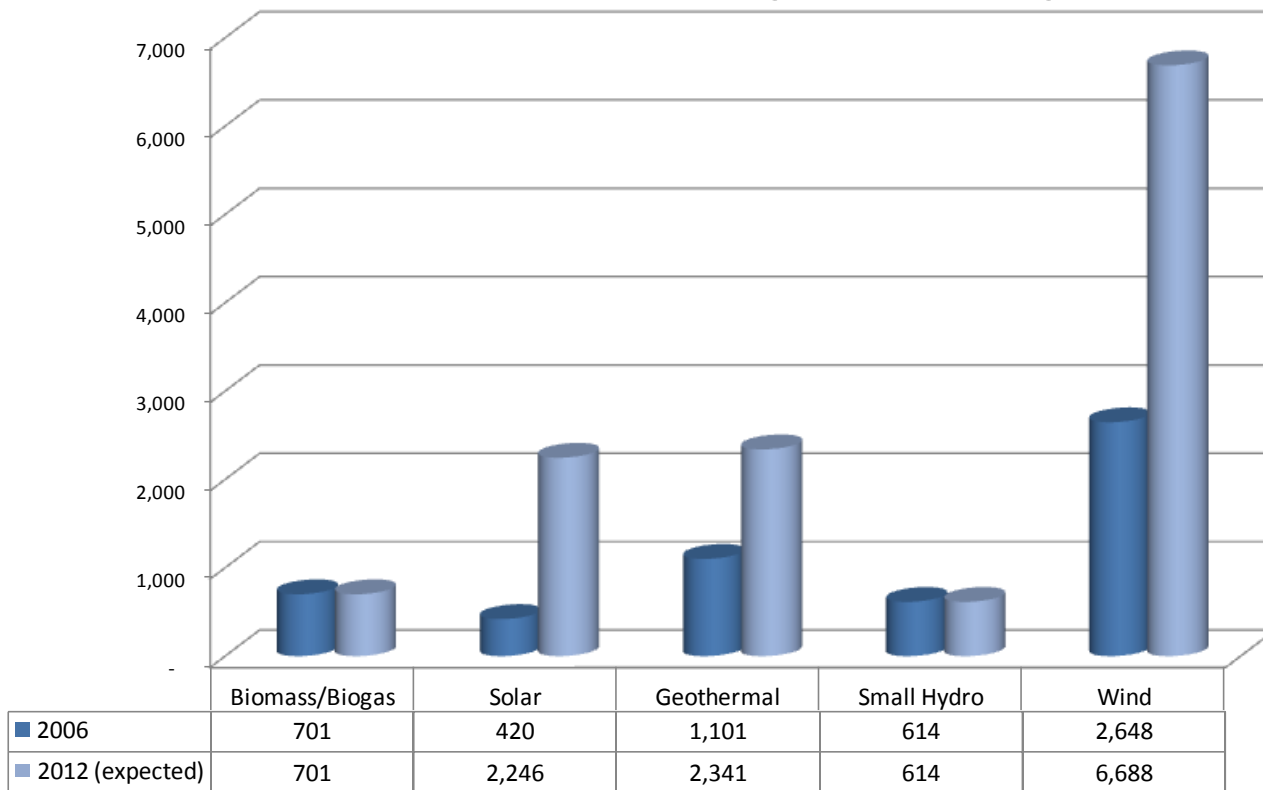
The ISO grid control room faces significant short- and long-term challenges

- Uncertainty of grid infrastructure development
- Ramping requirements significantly increased
- Continued development of control room tools
- Load and wind forecasting accuracy
- Rapid changes in grid generation fleet, especially wind and solar technologies

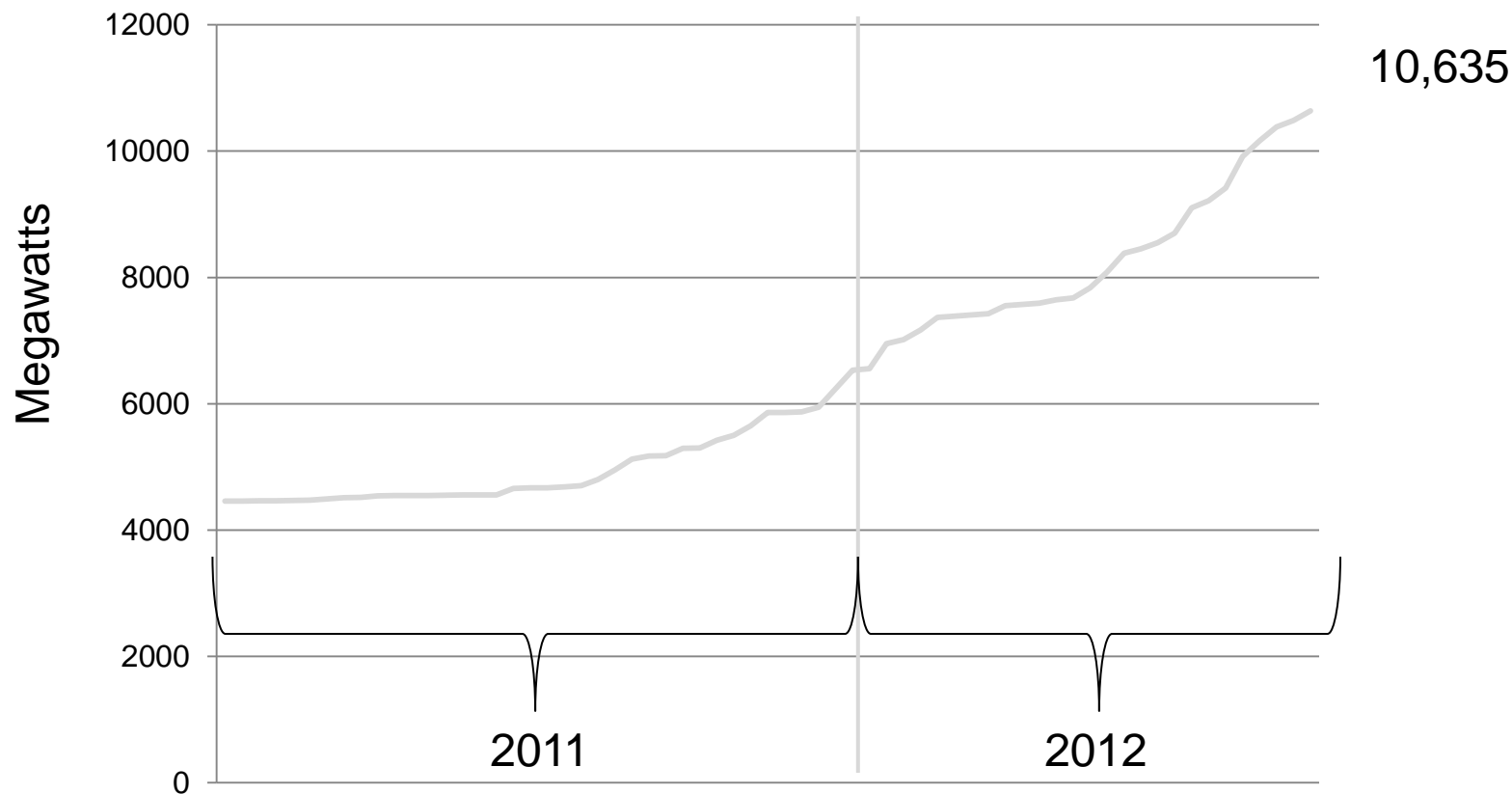
1. Wind and solar variability will be a significant issue by 2012-2013.

2. Synchrophasors are the most significant advancement in control center technology in the last 30 years.

The 2-3 year look-ahead: renewable resource portfolios in 2006 and 2012 (20% RPS), by capacity (MW)

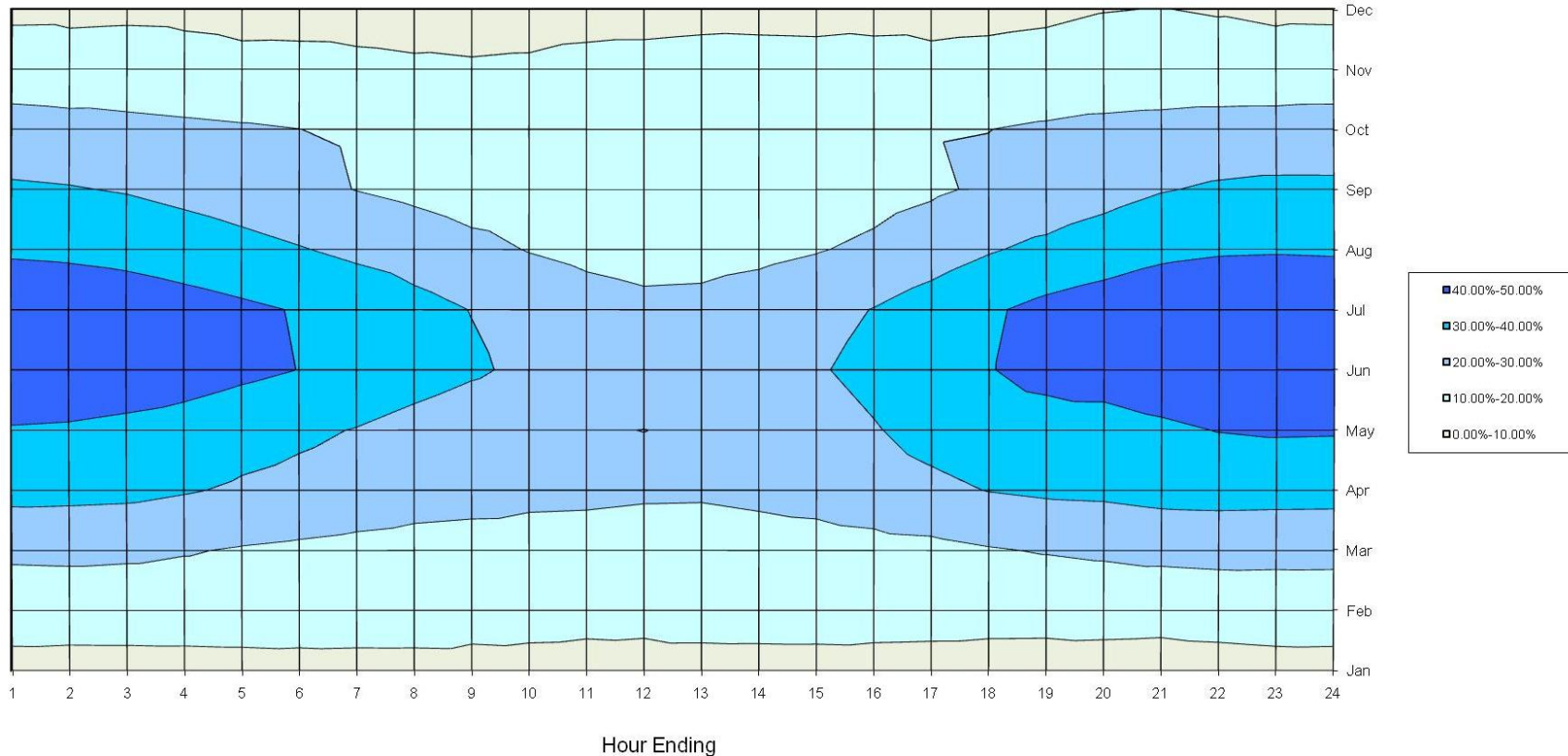


Projected renewable growth



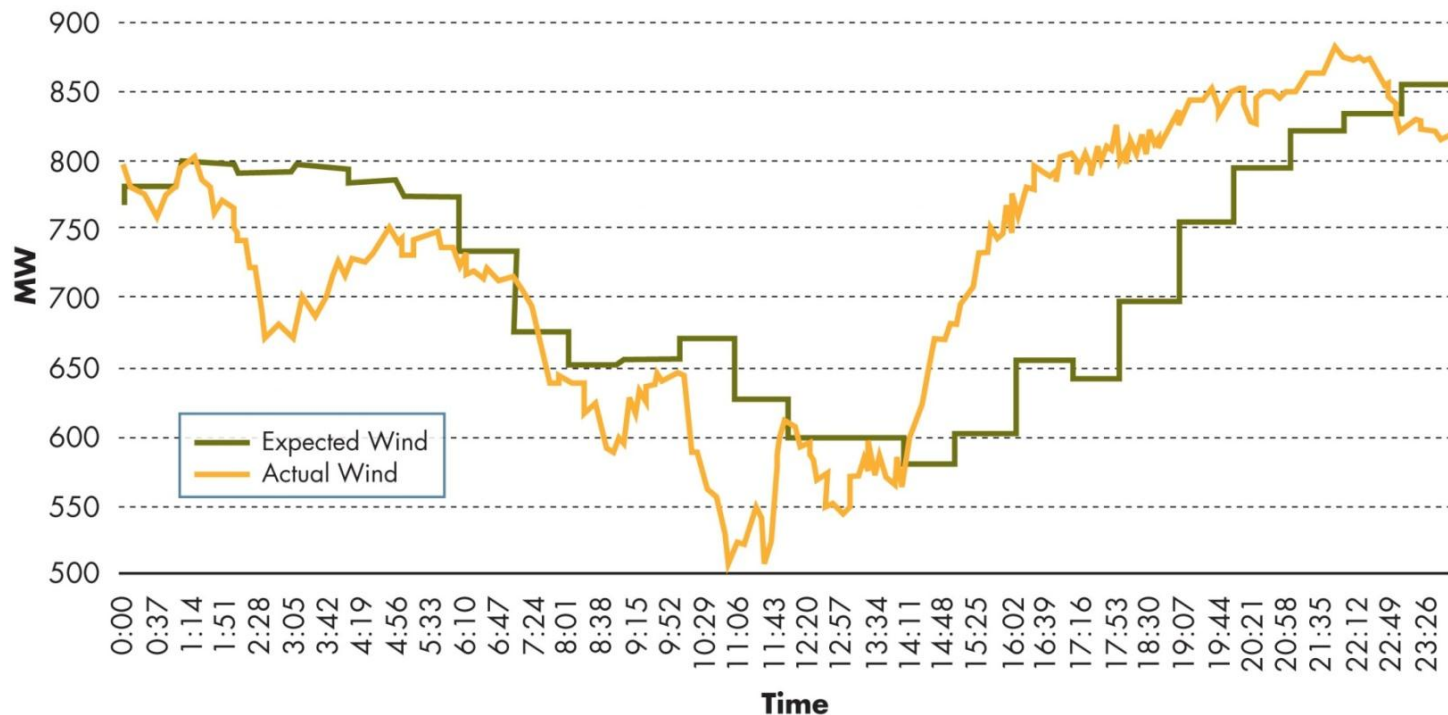
2009 CAISO wind profile –

Adjusted for monthly installed capacity average capacity factor = 22.2%



Forecasted vs. actual wind output

Simulated spring day in 2012

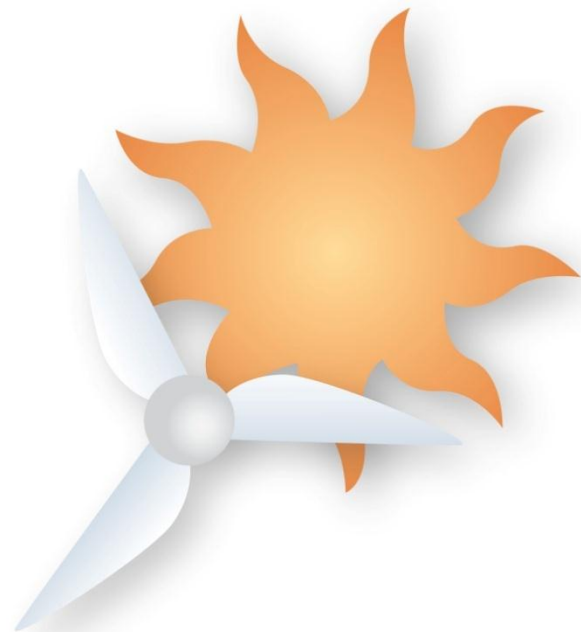


Source: 2010 Integration of Renewable Resources
Operational Requirements and Generation Fleet Capability at 20% RPS

Variable power resources

Electricity fueled from the wind and the sun

- Wind power often increases overnight, when demand is low
- Some natural gas-fired power plants **must** continue to produce power at night to be ready for morning spike in electricity demand
- Resulting overnight oversupply of electricity from wind power and conventional plants causes utilities to sell power at low prices or even pay generators to dispose of megawatts
- Surplus power mean consumers can pay twice for electricity



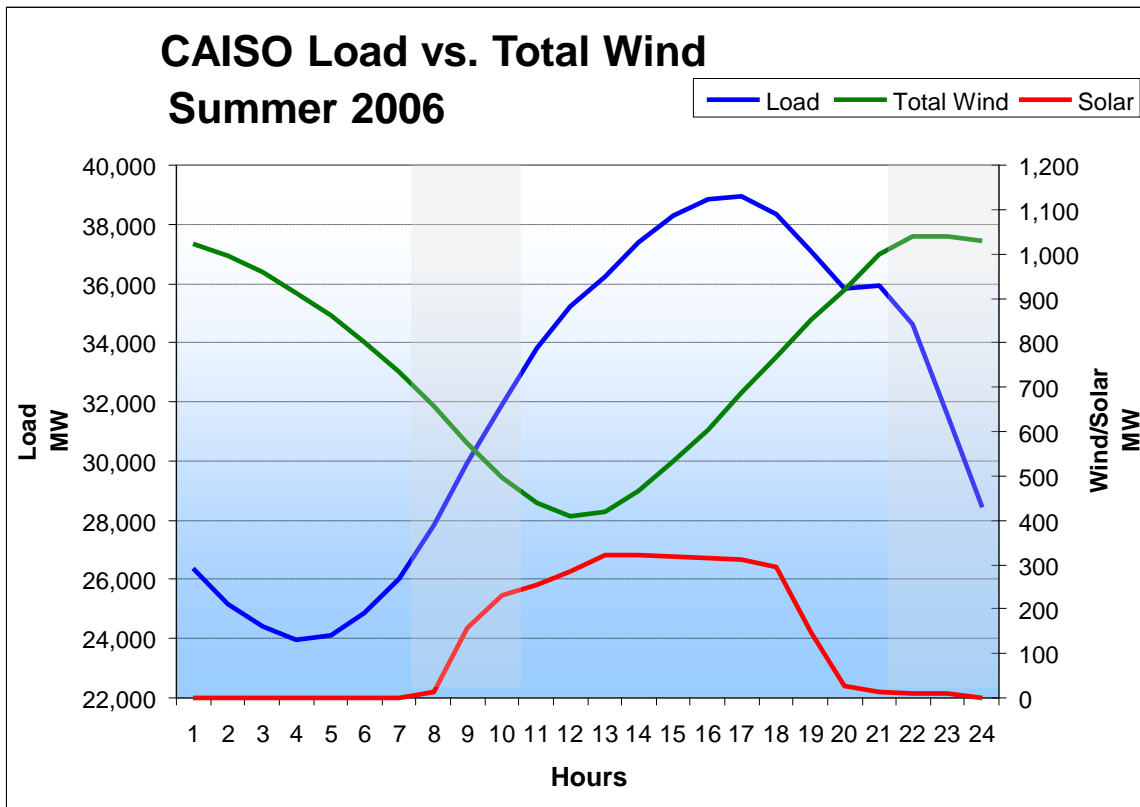
The Big Question:

How do we prevent over-generation while maintaining grid reliability?

These challenges can be addressed through improved control room tools (synchrophasors) and training

- Wind and solar modeling & production forecasting
- State estimator solution & accuracy
- Grid reliability & engineering studies
- Network and market modeling
- Awareness of regional disturbances (e.g. 1996 event)
- Dynamically assess the grid (EMS not sufficient)
 - 30 samples per second compared to once every four seconds
 - Can increase COI transfer by 1500 MW
 - Estimated reduction in congestions costs \$250 million
 - Better real time visualization

Wind generation tends to be inversely correlated to daily load curve, creating ramping impacts



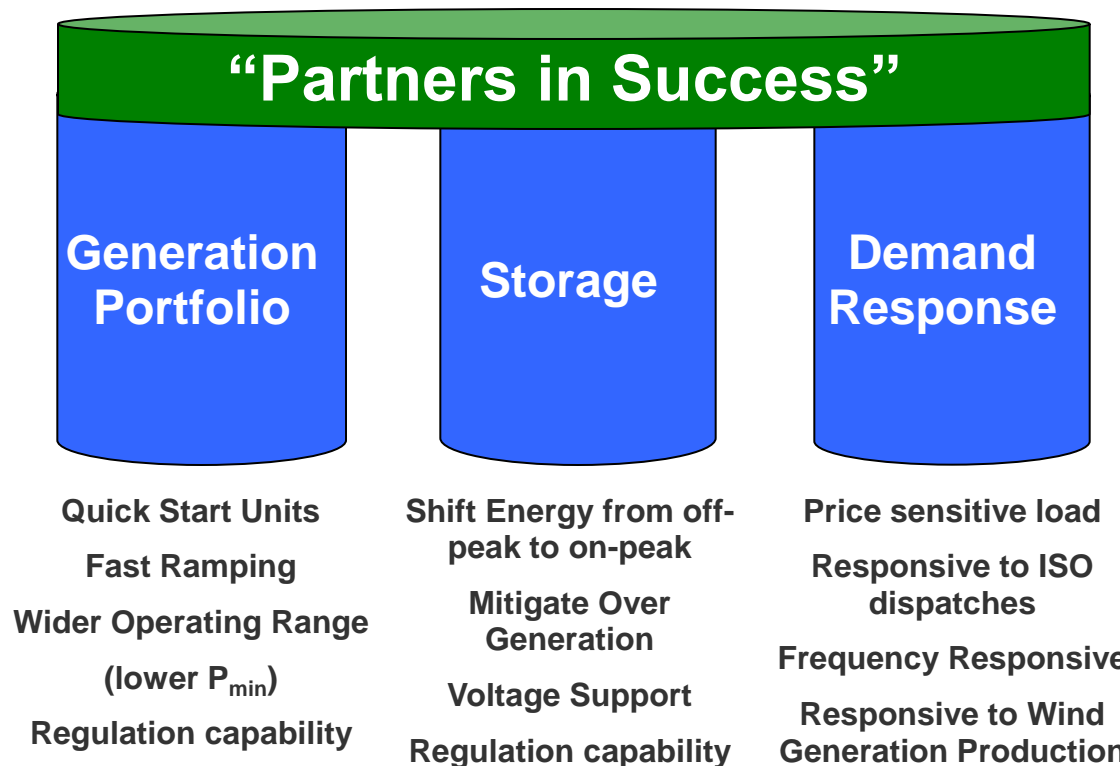
Resources required for renewables integration



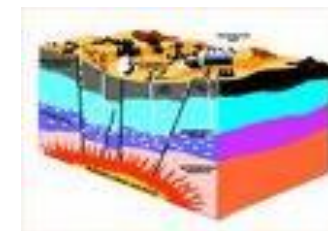
**Wind
Generation**



**Solar
Generation**



**Hydro
Generation**



**Geo-thermal
Generation**

Folsom, CA – Control Room



Alhambra, CA – Control Room





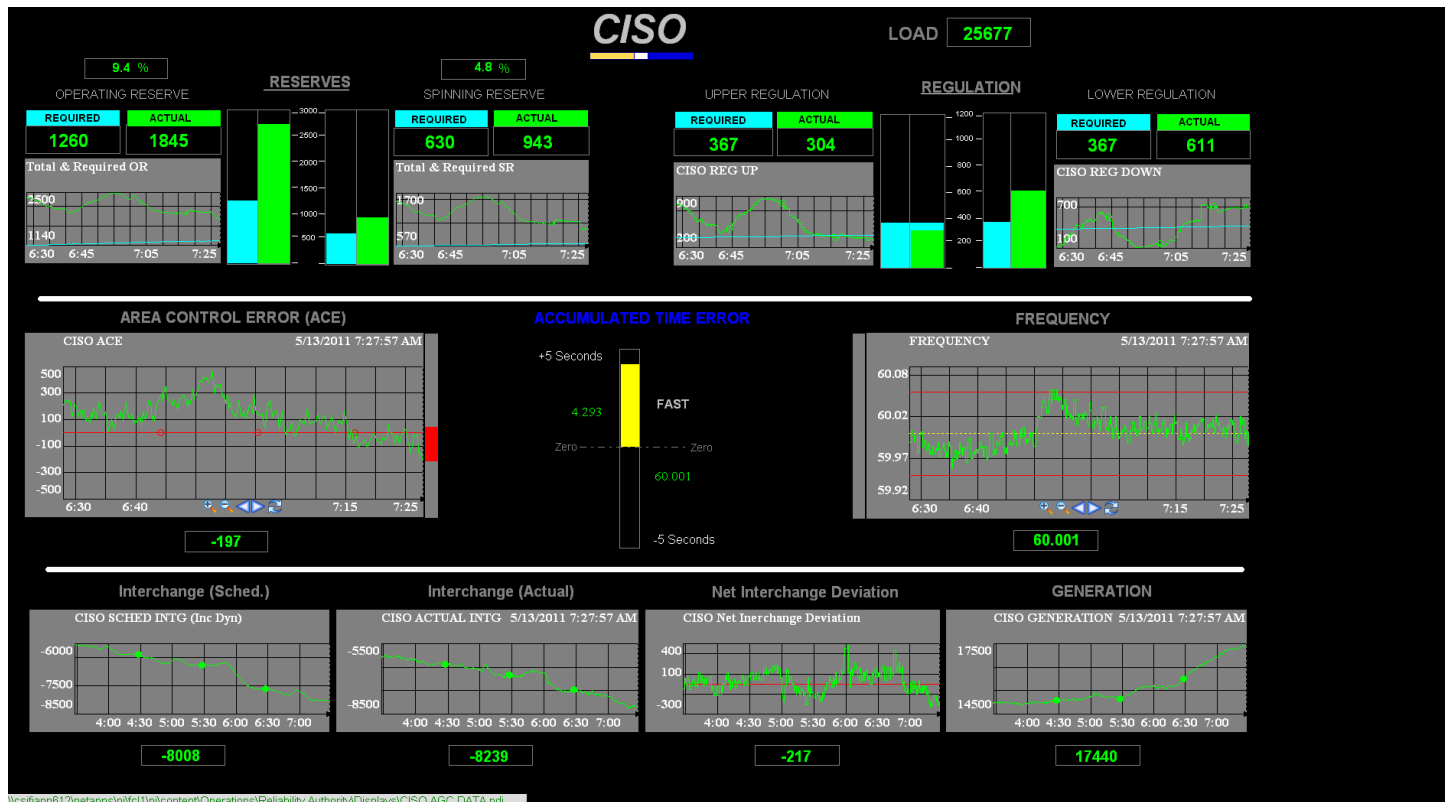
CAISO PI System Displays

Reliability

CAISO PI System Display – reliability back-up tie line display with ACE-Area Control Error/FREQ

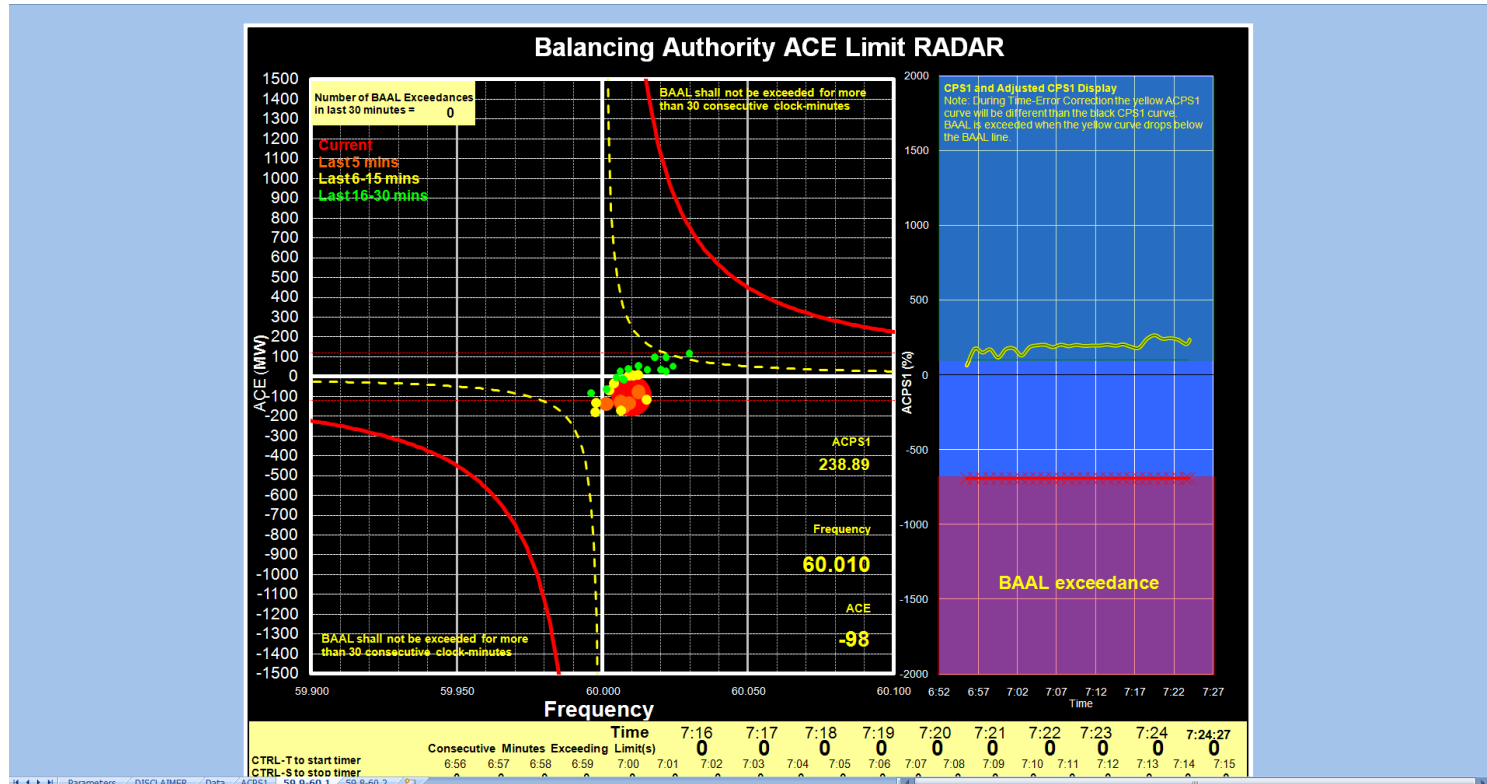


CAISO PI System Display – reliability CAISO AGC summary



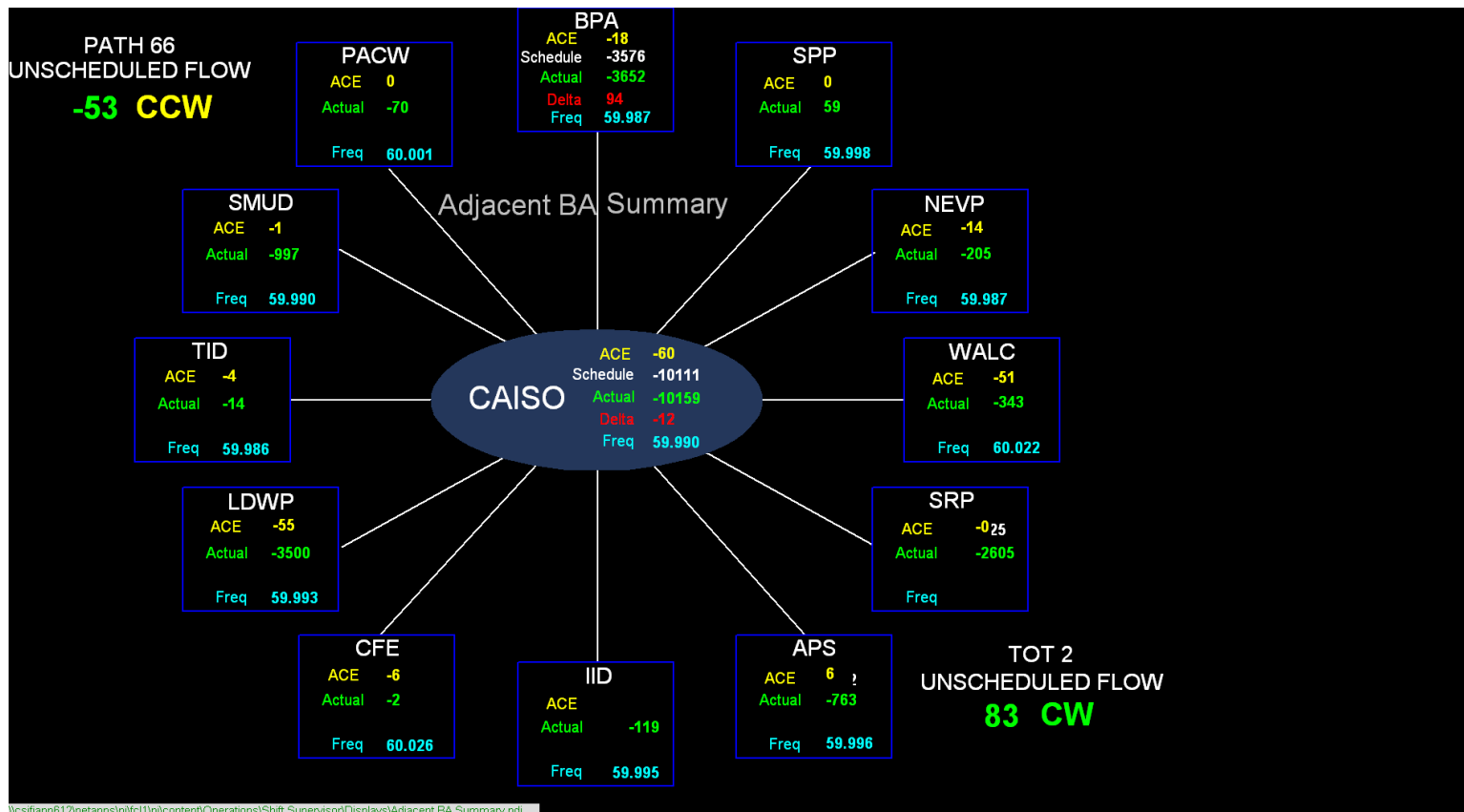
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CAISO PI System Display – reliability balancing authority ACE (Area Control Error) limit radar





CAISO PI System Display – reliability adjacent BA summary

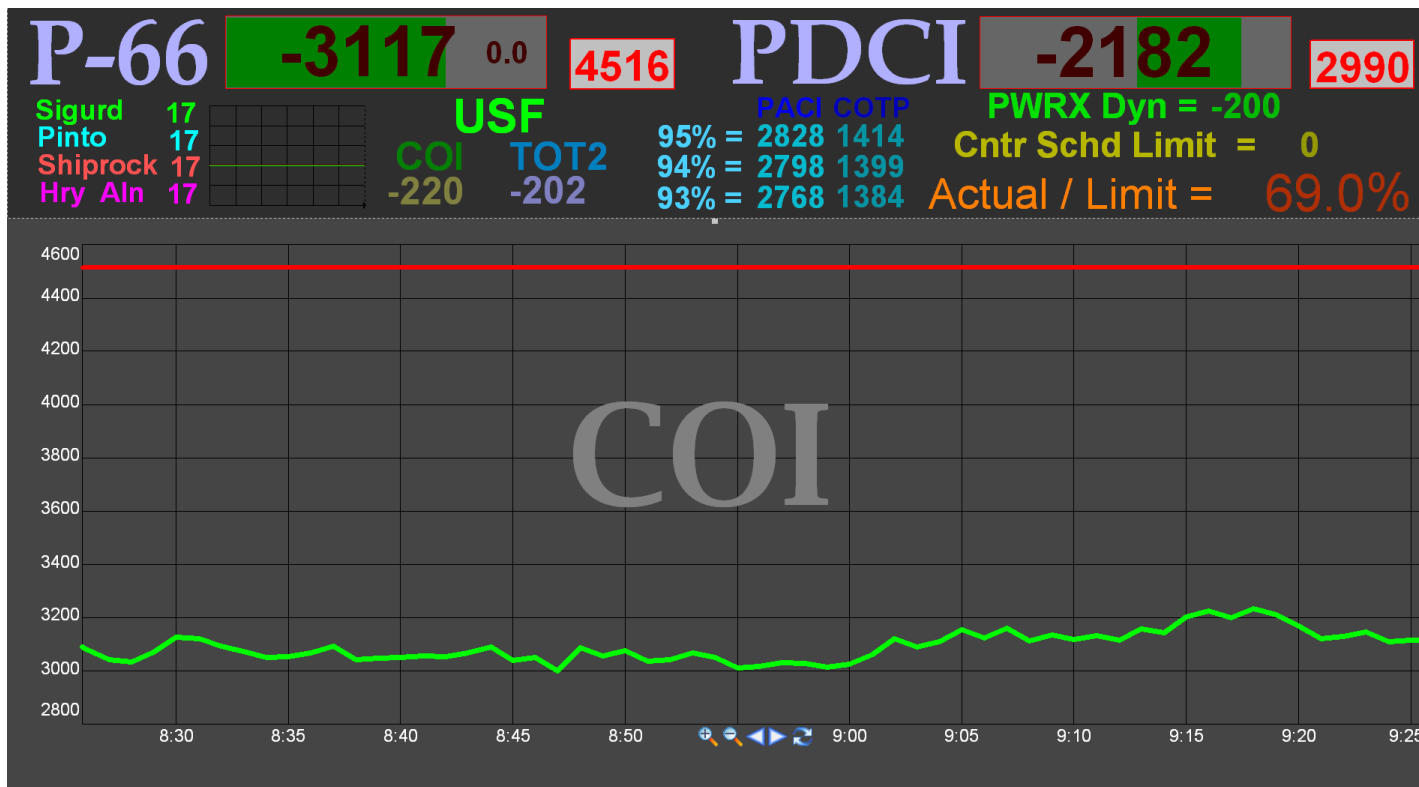




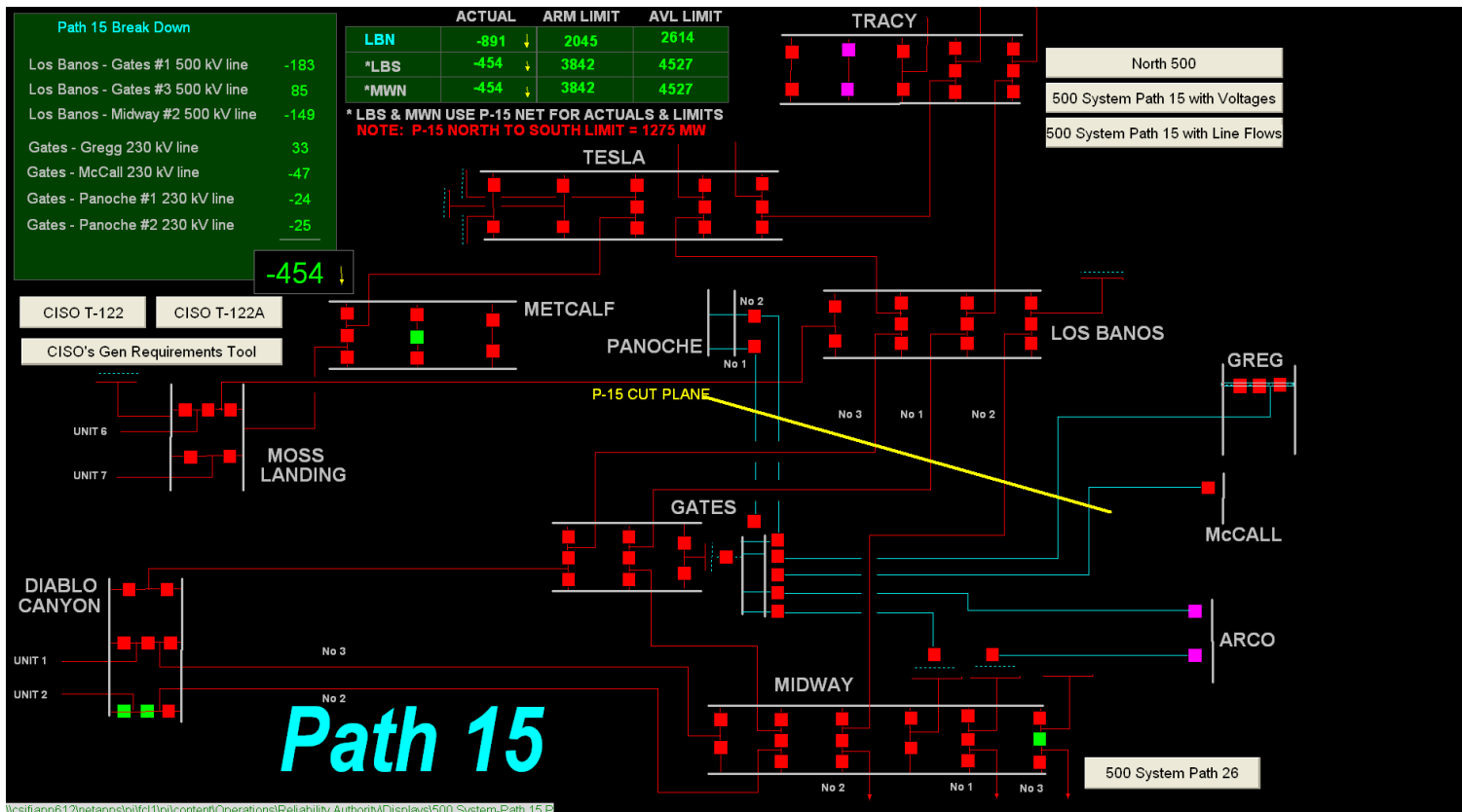
CAISO PI System Displays

Transmission

CAISO PI System Display – transmission California-Oregon Intertie (COI) summary

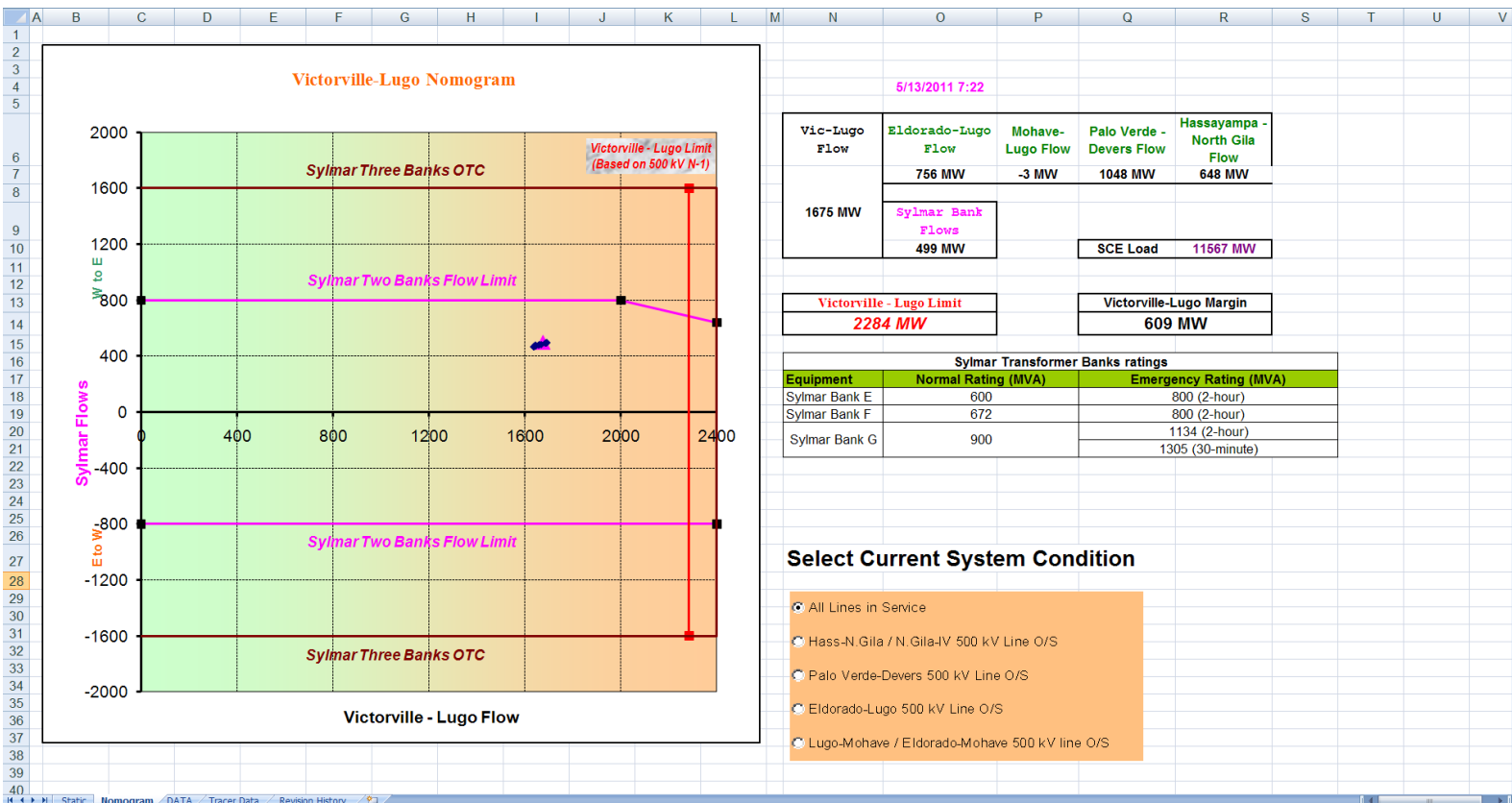


CAISO PI System Display – transmission path 15 summary



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CAISO PI System Display – transmission nomogram



CAISO PI System Display – transmission path monitor

California ISO Shaping a Renewed Future							TRANSMISSION PATH MONITOR							California ISO Shaping a Renewed Future						
PATH	DIR	ACT	LIM	▲	ACT VS. LIM	ALM	TIMER	PATH	DIR	ACT	LIM	▲	ACT VS. LIM	ALM	TIMER					
P-66 COI+RATS	↓	-3639	4670	1031				P-65 PDCI	↓	-2776	2990	214								
P-24 + MARBLE	→	67	100	33				P-58 ELD-MEAD	←	91	1140	1049								
P-15 LBN	↓	-1037	1881	859				P-15 IRAS	↓	946	2400	1454								
P-26 MID-VIN	↓	1591	2000	409				P-17 W. BORAH	←	572	2557	1985								
SDG&E IMPORTS	↓	2072	2650	578				SDG&E + CFE	↓	2078	2650	572								
P-23 FCORNR	←	772	840	75				P-45 SDGE/CFE	↑	-1	800	799								
P-46 WOR	←	5219	9426	4207				P-49 EOR	←	-4241	9300	5059								
P-43 N.SONGS	↑	1467	2440	973				P-44 S.SONGS	↓	803	2200	1397								
P-61 VIC-LUGO	↓	-1934	2400	466				SCIT	↓	11563	14829	3608								
SOUTH OF LUGO	↓	3247	4150	903				SCIT EOR	←	-4241	6645	2414								

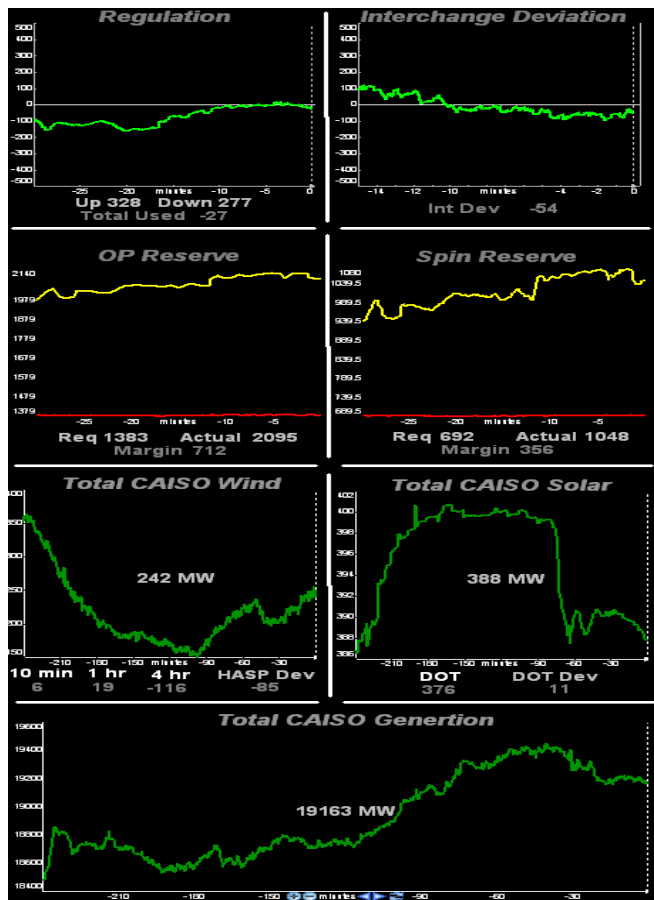
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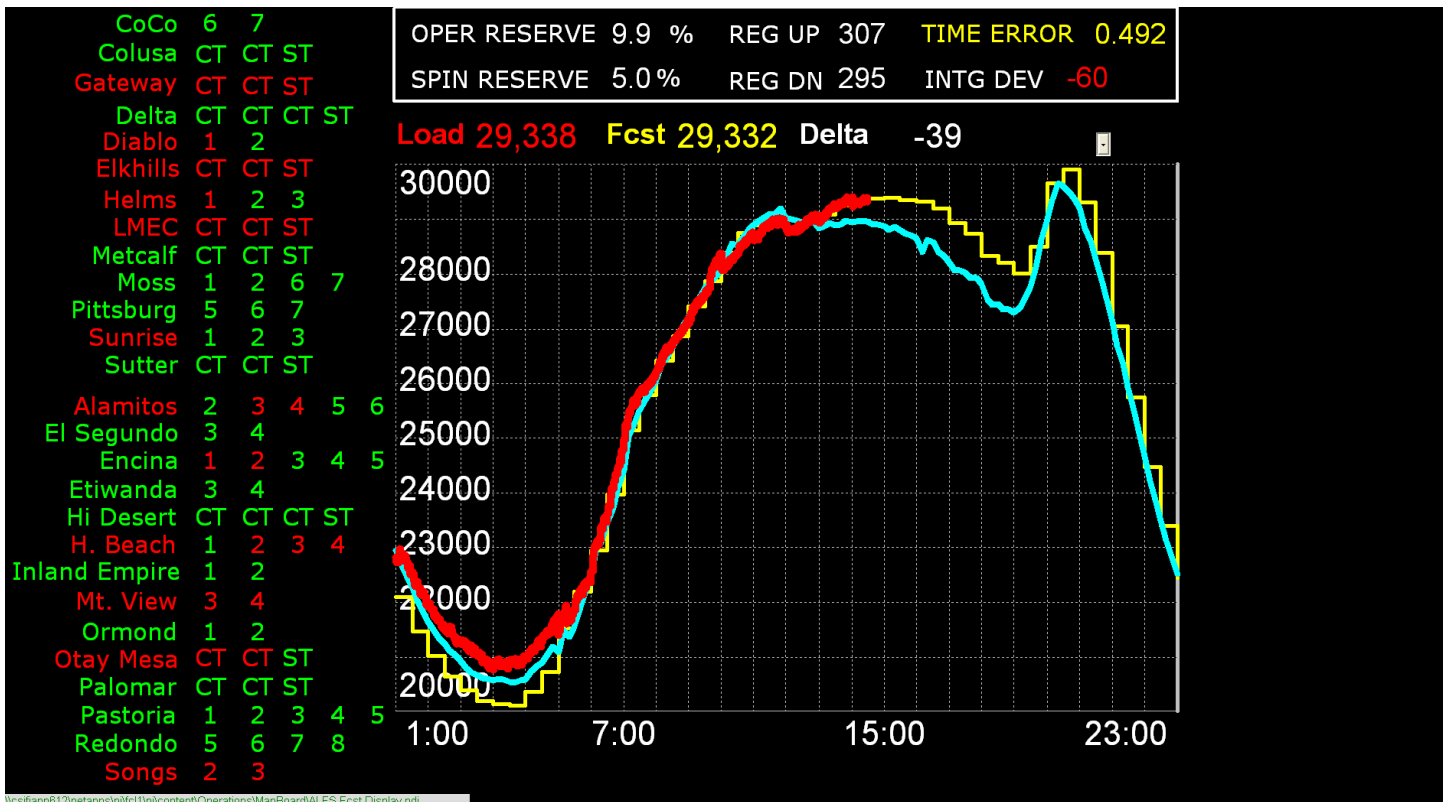
CAISO PI System Displays

Generation

CAISO PI System Display – generation regulation summary



CAISO PI System Display – generation load forecast and DCS generator status summary



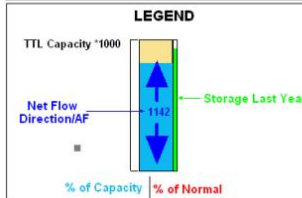
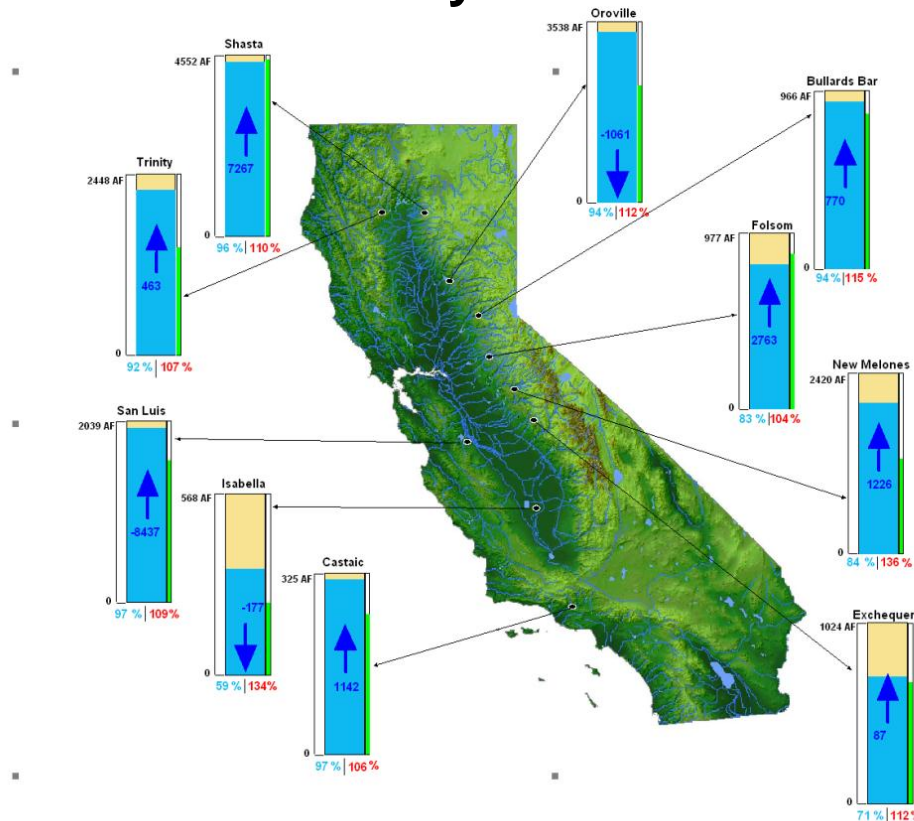
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CAISO STI/PI System Display – generation – AGC Summary using PI System data



CAISO PI System Display – generation hydro conditions summary

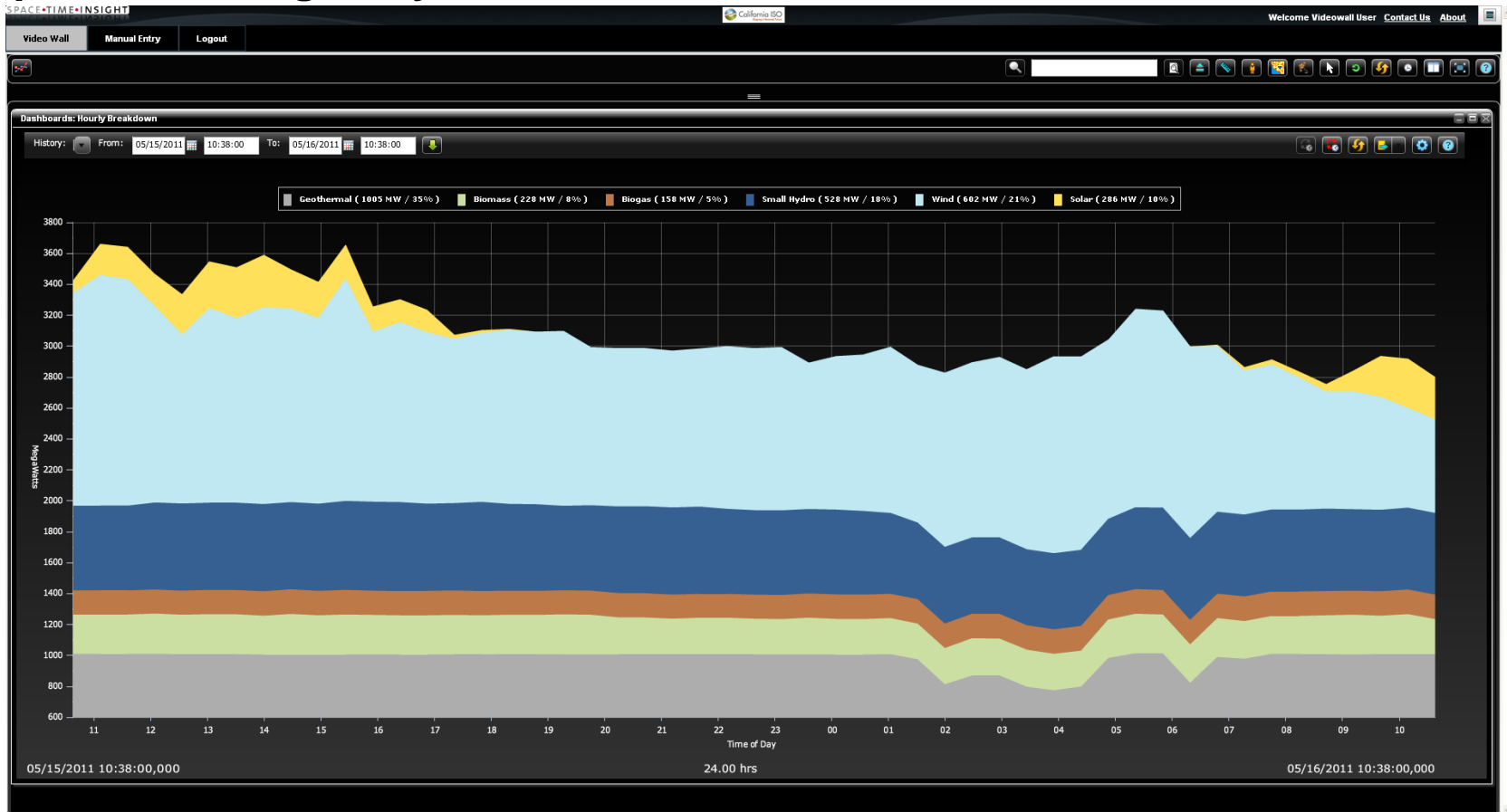




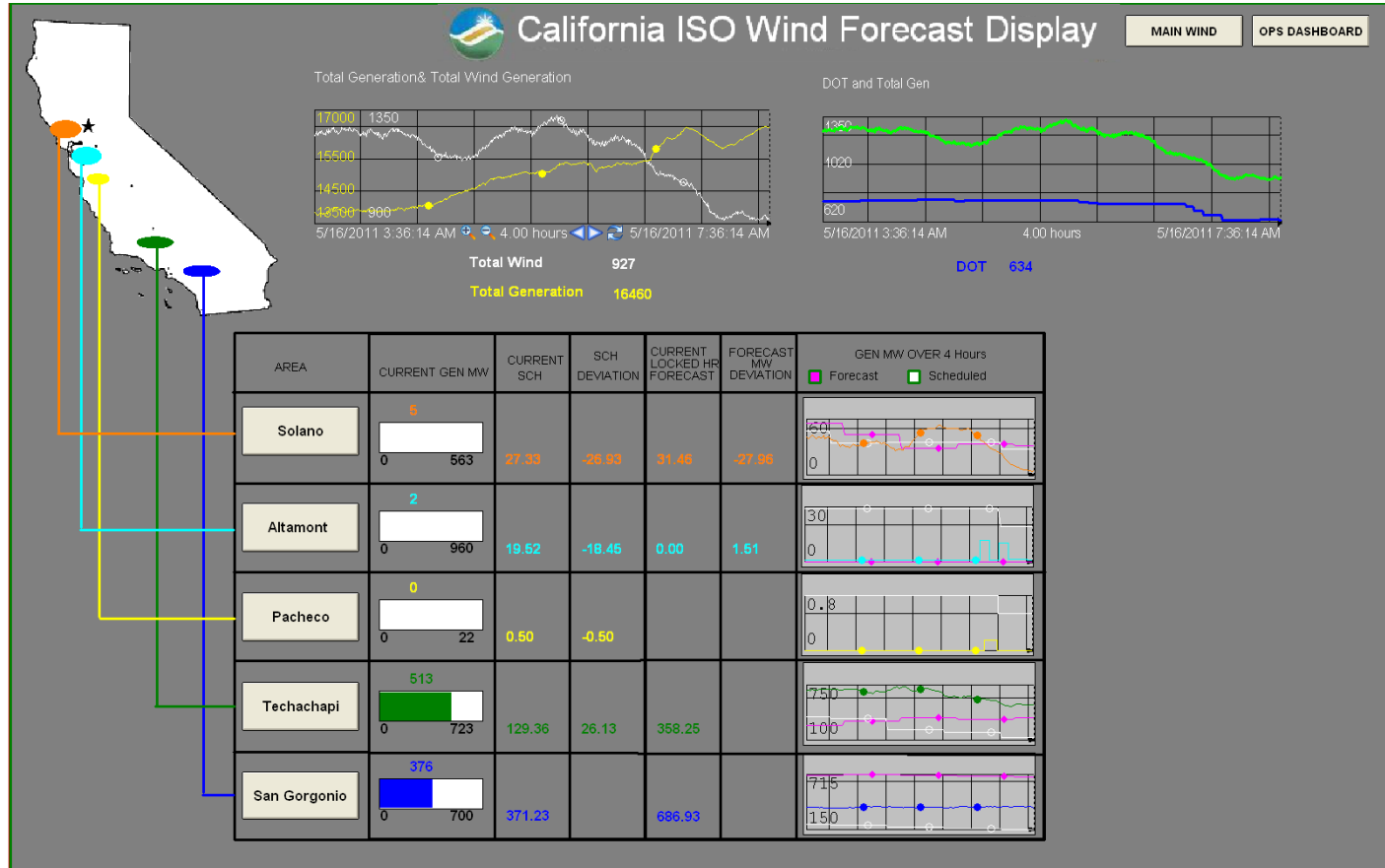
CAISO PI System Displays

Renewables

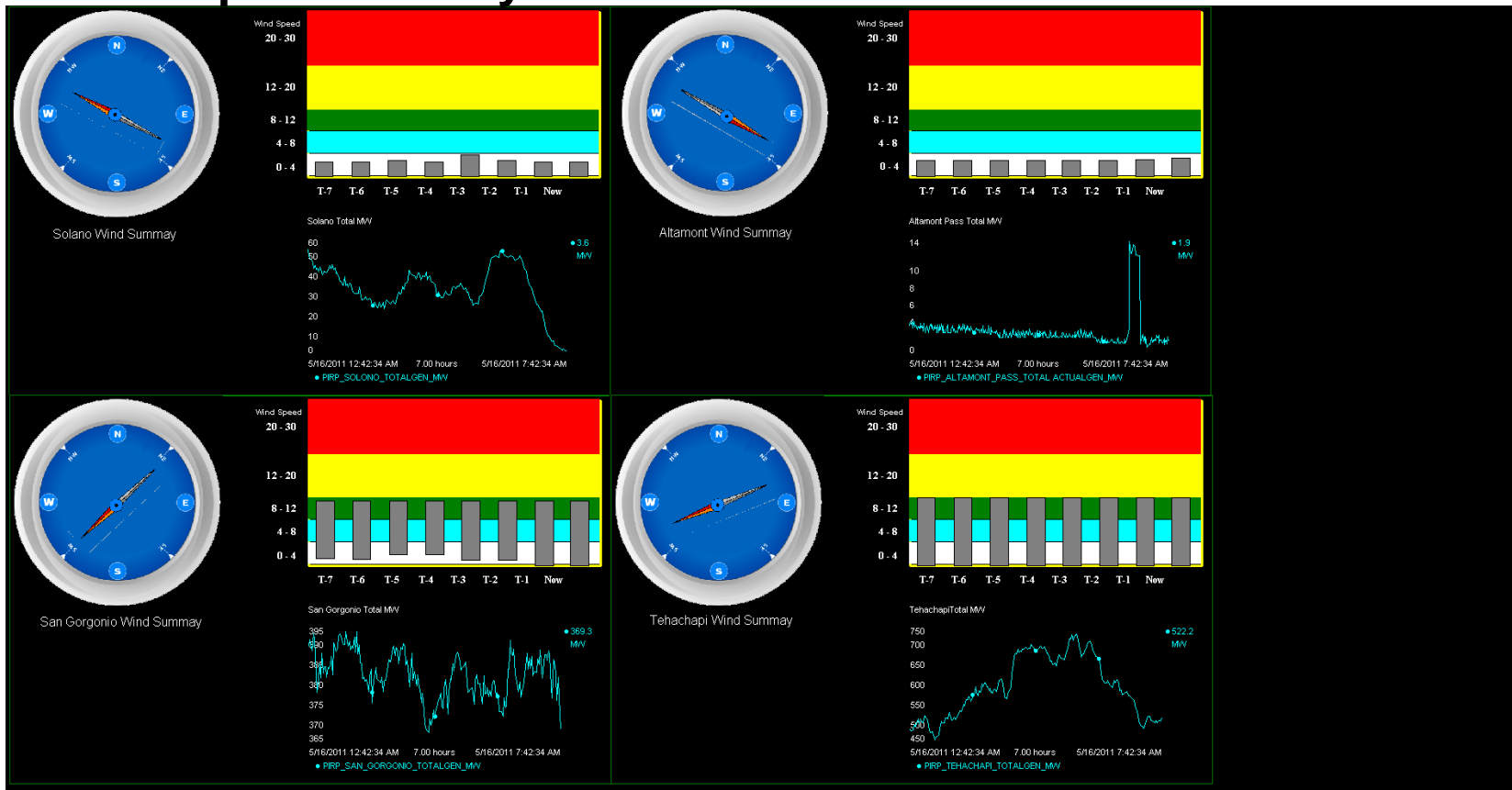
CAISO STI/PI System Display – 24 hr renewables portfolio using PI System data



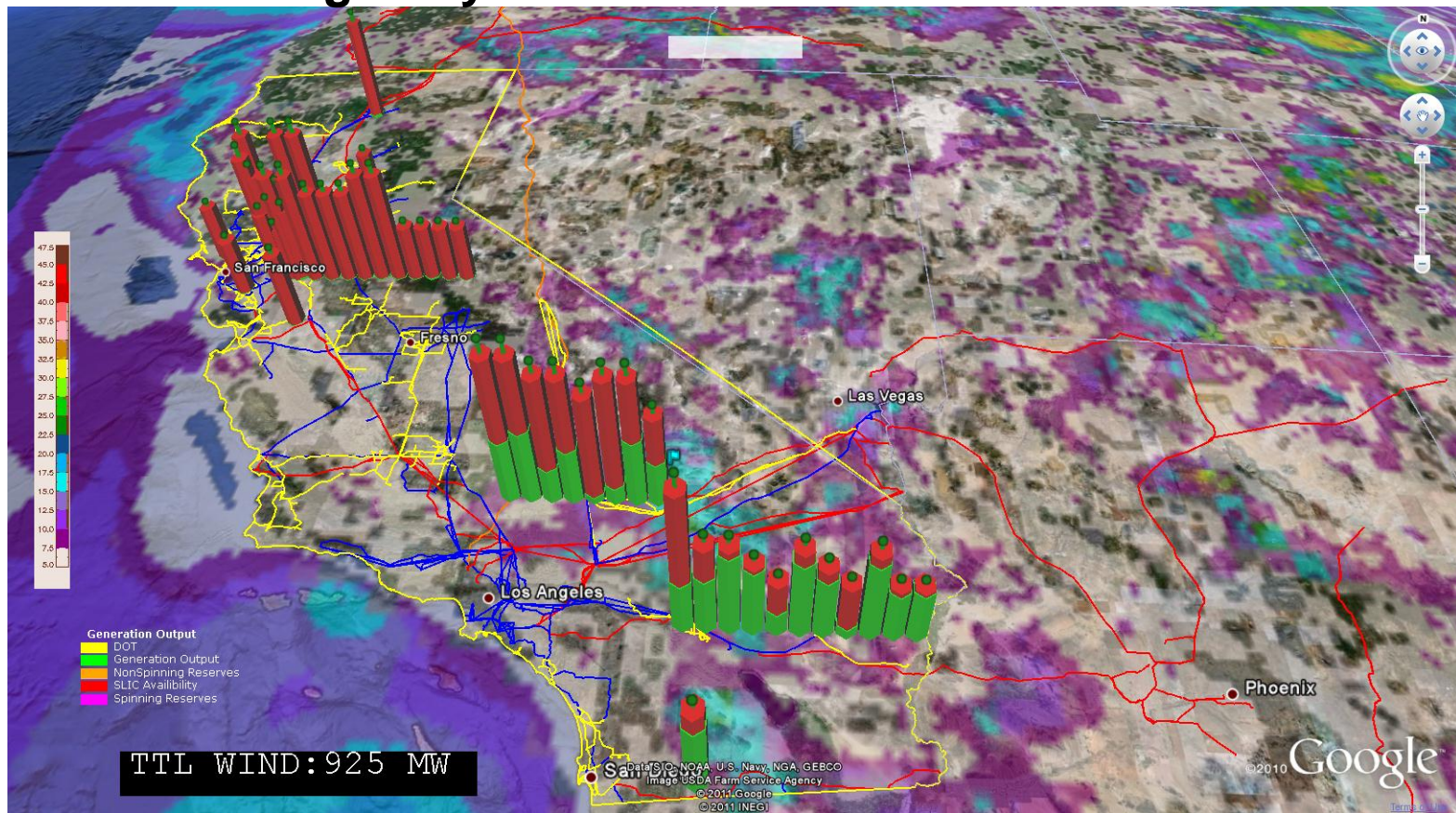
CAISO PI System Display – wind forecast and generation summary



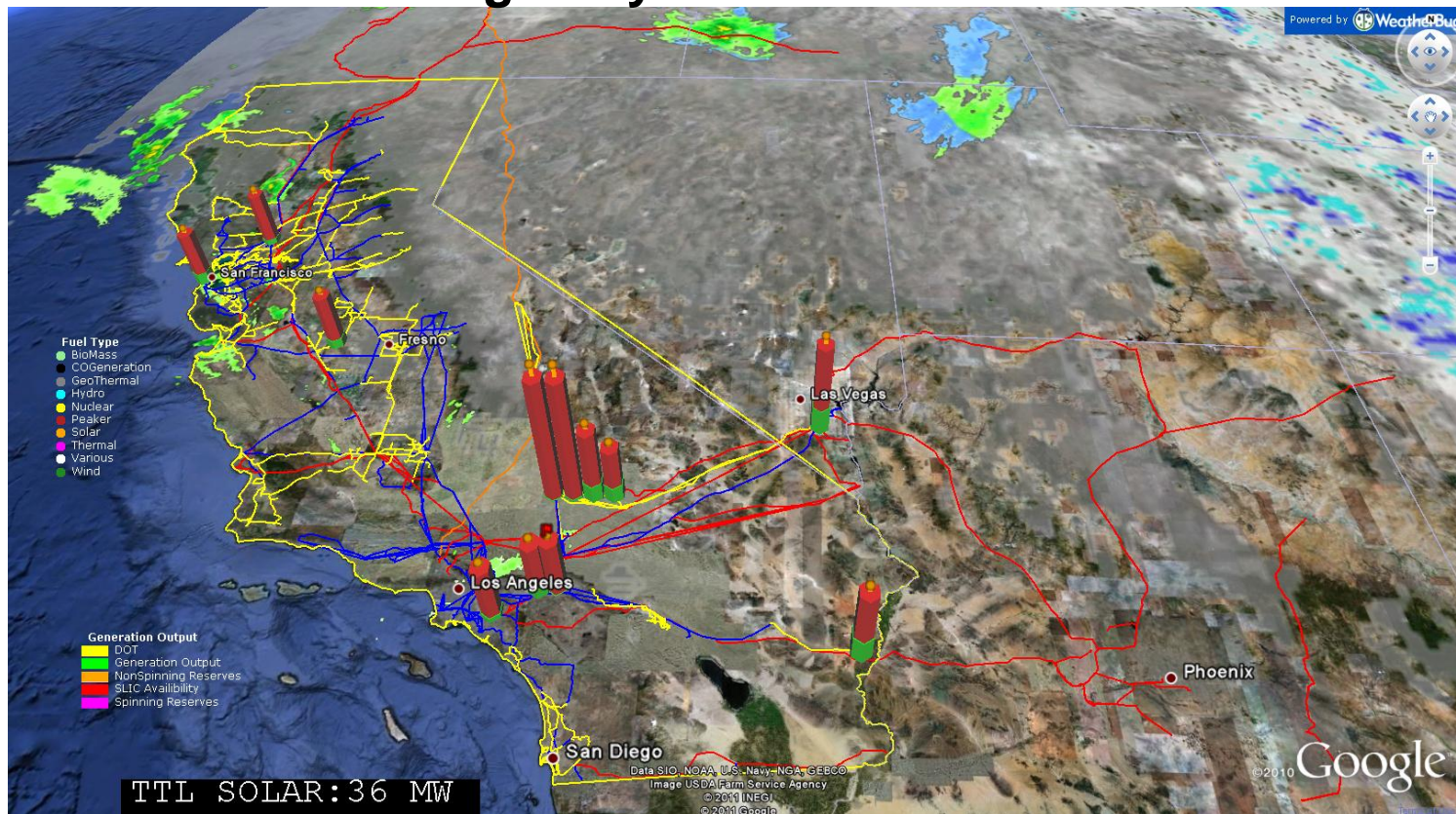
CAISO PI System Display – wind speed, directions and output summary



CAISO STI/PI System Display –wind speed contour and wind generation using PI System data



CAISO STI/PI System Display –solar generation summary with cloud cover using PI System Data



CAISO Current & Future PI System Projects

- Synchro-Phasor Integration
- Western Interconnection Synchrophasor Project
- 56 PMUs already sending data
- 100 PMUs estimated by December 2011
- 180 PMUs estimated by December 2012
- 250 – 300 PMUs estimated by December 2013



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Questions or Comments?



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Thank you