



California ISO
Your Link to Power

Energy Storage in California ISO Markets and other ISO/RTO Markets

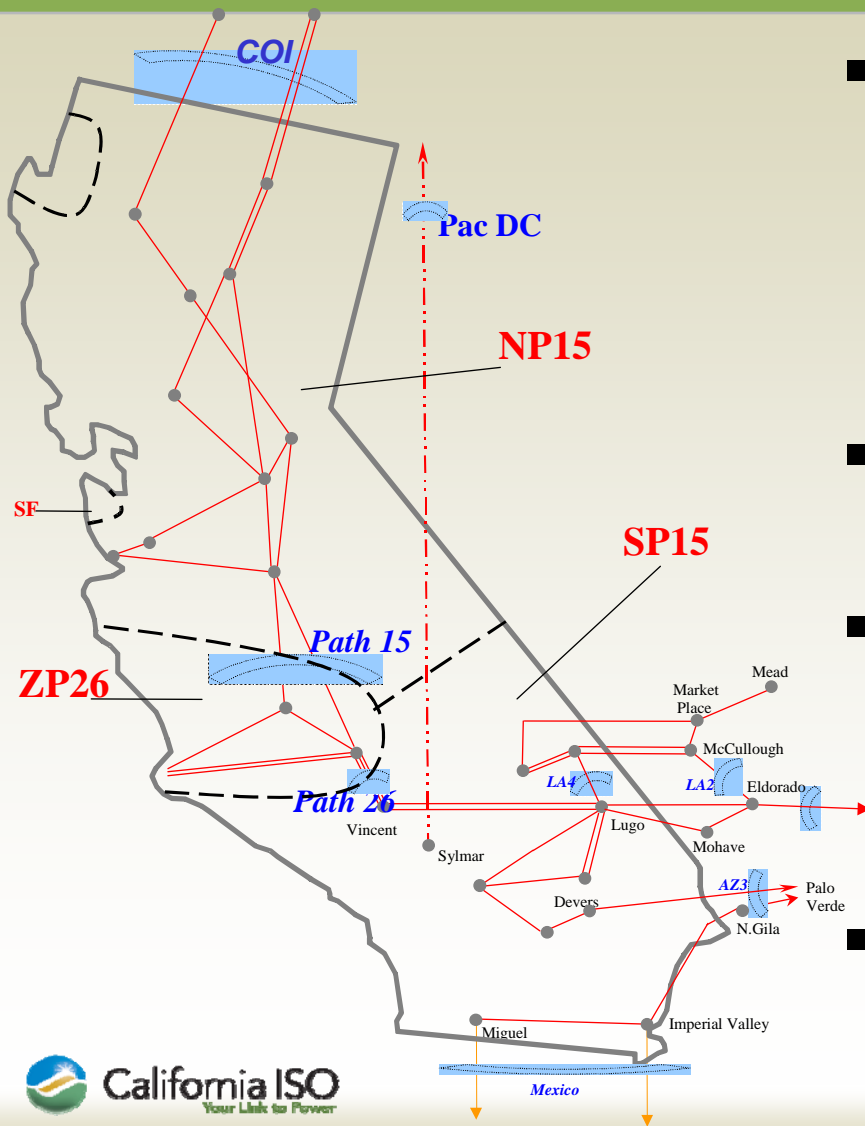
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NARUC, February 15, 2009

Overview

- ISOs and RTOs provide a market environment conducive to storage technology development and deployment
- ISOs and RTOs are working to support participation of storage resources in ancillary service markets (as required under FERC Order 890)
- Renewable integration needs and greenhouse gas policy should improve the need for and market viability of various storage technologies over time

Overview of California ISO Balancing Authority



- Serves about 75% of California load. Includes 30 million consumers in PG&E, SCE, and SDG&E and many municipal utilities
- Peak load of 50,270 MW during heat storm on July 24, 2006
- 43,000 MW of available generation capacity at peak after derates for hydro, wind and outages
- 9,260 MW net imports on peak hour

Typical Features of ISO and RTO markets*

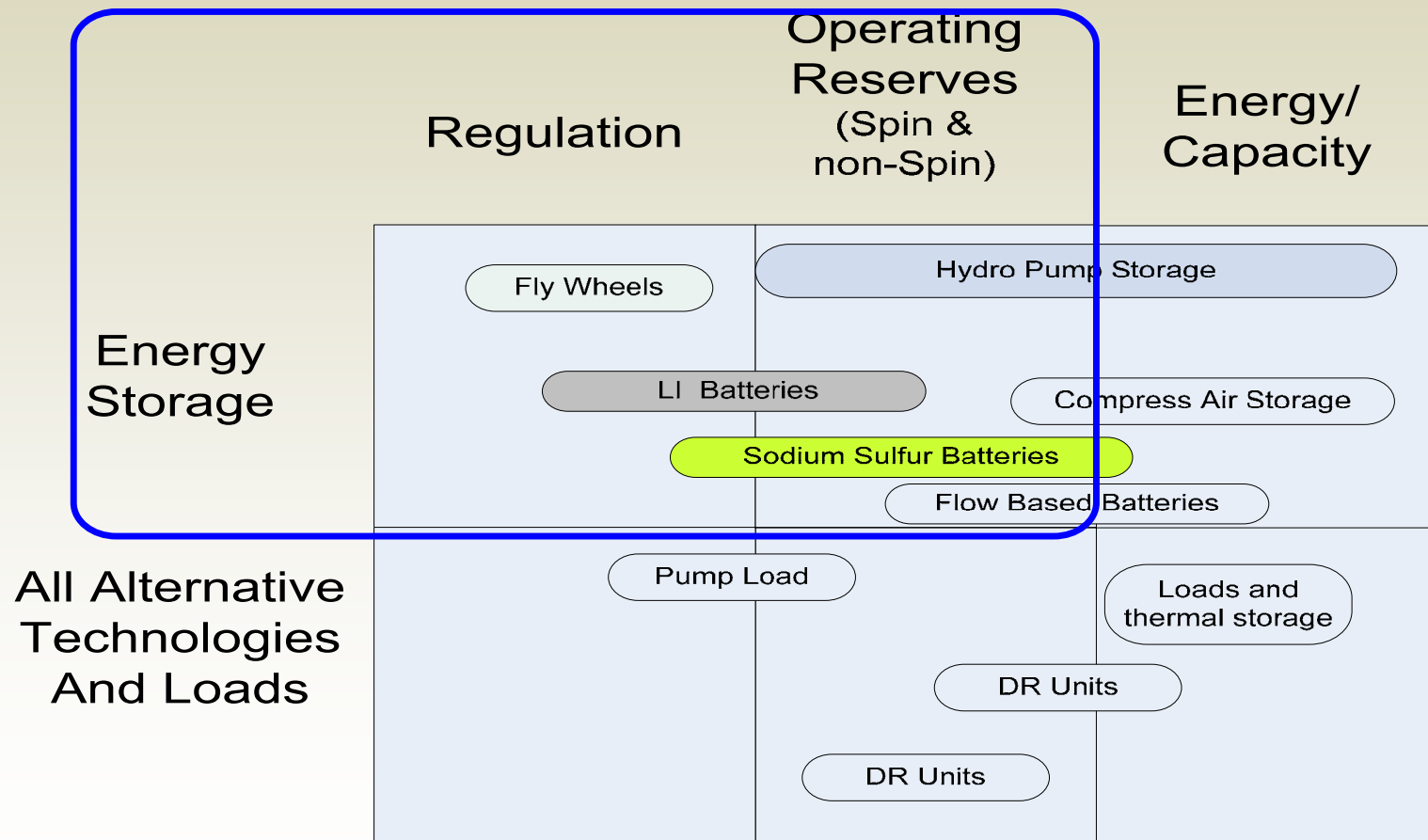
- Day-ahead and Real-Time Markets for Spot Energy and certain Ancillary Services (Regulation and Operating Reserves)
 - Two financial settlements; real-time settles at deviations from day-ahead schedules
- Locational Marginal Pricing (Nodal Pricing) of Energy
 - Reflects congestion and losses
- Appropriate Substitutions among Market-Based Offers for Energy and Ancillary Services
 - Means that resource capabilities are put to their most cost-effective use
 - Ensures that suppliers are indifferent between product markets

* *Including the CAISO market redesign scheduled for April 2009*

Typical Features of ISO and RTO markets (*cont.*)

- Scarcity Pricing
 - Administratively increases the Energy and, depending on the market, the price for Regulation and Operating Reserves during shortage conditions
- Annual or Multi-Year Markets for Capacity
 - California RA market is bilateral with Resource Adequacy requirements set by CPUC; MISO market is also bilateral
- Allocate and/or Auction Point-to-Point Financial Transmission Rights
 - Can be used to hedge congestion charges
- Market Power Monitoring and Mitigation
- Transparency
 - Market prices and quantities
 - Market design and operational decisions (to stakeholders/FERC)

Market Opportunities for Storage and other non-generation resources



ISO/RTO Efforts to Integrate Storage Technologies into Regulation and Operating Reserves

- Compliance with FERC Order 890
 - Revise ISO/RTO tariffs to allow “non-generation resources” to participate in Ancillary Service markets
- Efforts to reduce operational barriers to limited energy storage
 - Changes to AGC and dispatch systems
- Efforts to reduce market barriers to limited energy storage technologies, particularly in Regulation
 - Changes to tariffs and operating procedures to reduce minimum duration required to provide Operating Reserves and Regulation
 - Proposed changes to market software
 - Pilot programs to evaluate Regulation market performance (ISO-New England; CAISO under consideration)

Milestones in ISO/RTO Limited Energy Storage Integration into Regulation Markets

- California ISO/California Energy Comm. (2005) – pilot with Beacon flywheel to test ACE “smoothing” signal (subdivides signal to faster and slower regulating resources to improve efficiency)
- PJM (2008) – AES 1 MW Lithium Ion battery approved for commercial participation in Regulation market
- ISO-New England (Nov. 2008) – Alternative Technologies Pilot Program for Regulation – operational and market performance evaluation, Beacon 1 MW flywheel is initial participant
- Midwest ISO (2008) – “Stored Energy Resource” included in tariff to provide Regulation and Operating Reserves
- New York ISO (2008) – has proposed “Limited Energy Storage Resource” included in tariff to supply Regulation
- California ISO (2009-10) evaluation of storage technology pilot

Market Pricing for Regulation

- Pricing rules vary by ISO and RTO
- Generally, there is a market clearing price for Regulation Capacity (\$/MW)
 - May reflect opportunity costs with respect to providing Energy when Energy and Regulation are co-optimized (e.g., NYISO, MISO, PJM, CAISO MRTU)
 - May not include opportunity costs (e.g., ISO-New England)
- ISO-New England includes “mileage” payment
 - Resources that spend more time on Regulation are paid more
- Resources that provide Energy Offers are paid for their Energy output
 - Would not apply to limited energy storage technologies that only provide Regulation

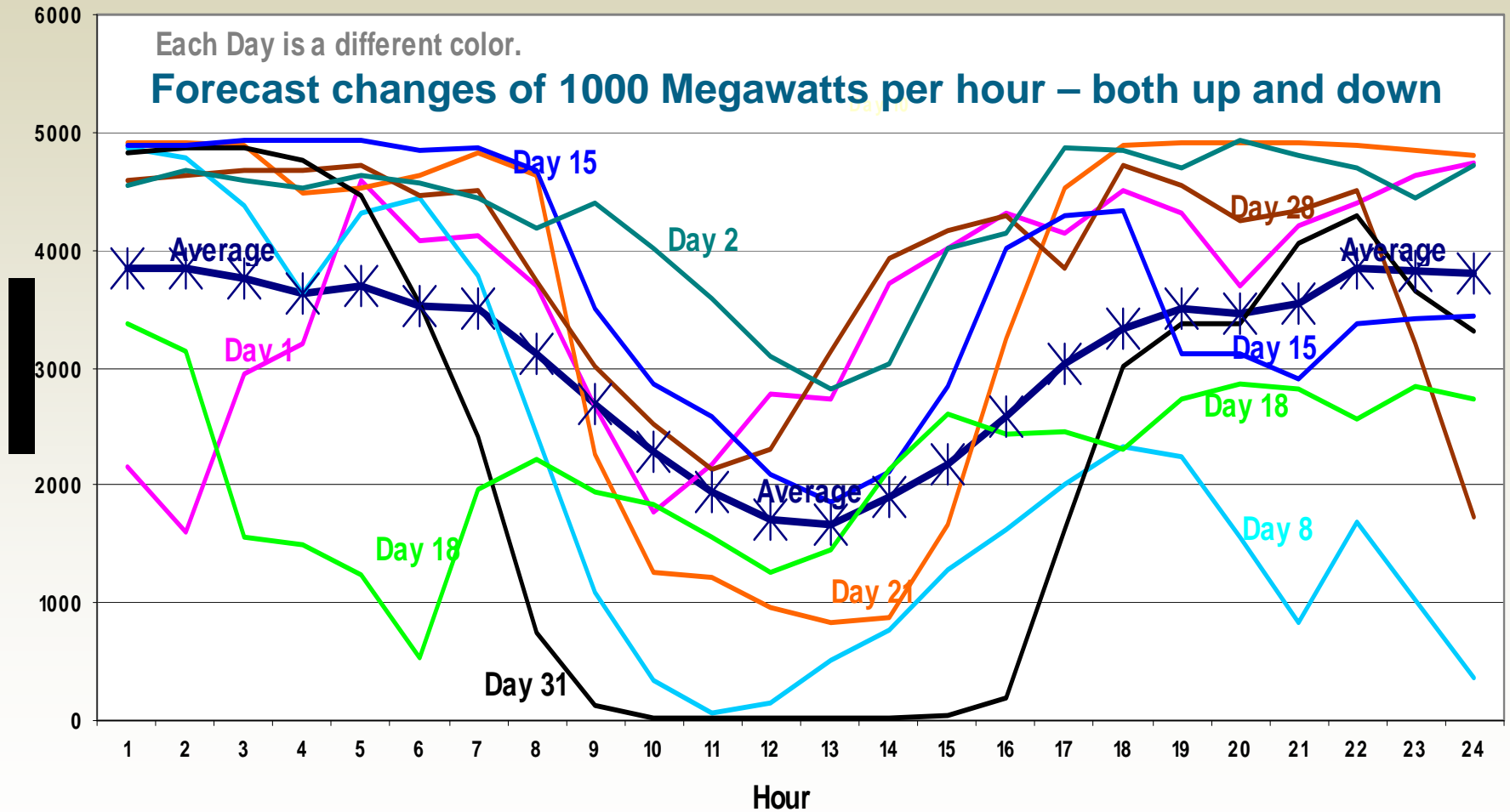
Average Hourly Clearing Prices for Regulation (\$/MWh) in Selected ISO/RTO Markets

	2004	2005	2006	2007
California ISO Reg Up	\$17.95	\$20.94	\$18.94	\$16.81
California ISO Reg Down	\$10.95	\$16.05	\$17.01	\$9.97
PJM	\$42.75	\$49.73	\$32.69	\$36.86
New York ISO (Day-Ahead Market)	\$22.60	\$39.21	\$51.30	\$56.35
ISO New England	\$28.92	\$30.22	\$24.03	\$12.67

Looking Ahead: Major Policy and Regulatory Drivers for Storage in California to 2020

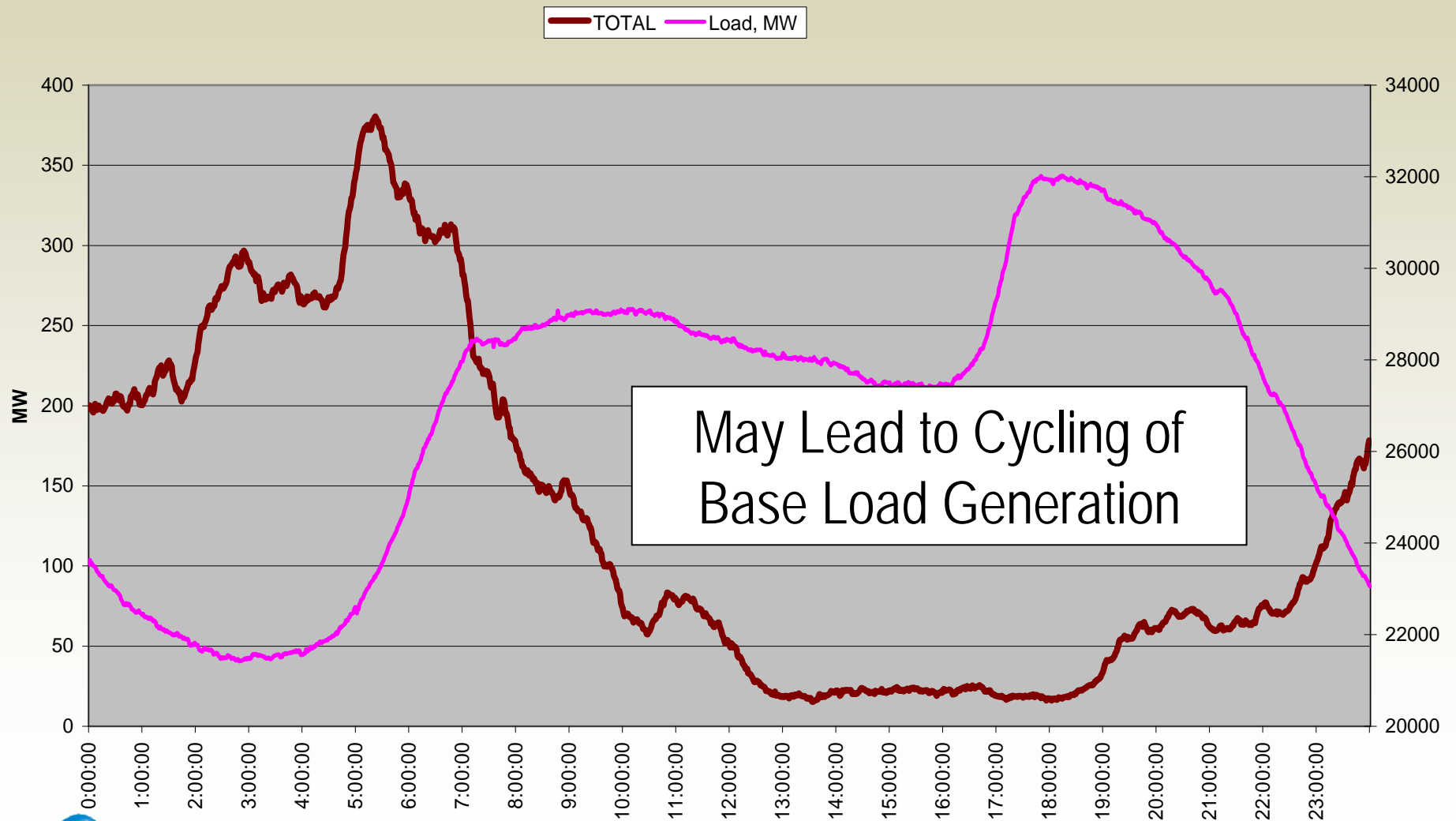
- Renewable Portfolio Standard
 - 20% RPS by 2010 (likely achieved by 2012); 33% by 2020
 - Increased need for load-following capability and Regulation to support integration of wind and solar
- Once-through cooling regulations (~2012-2022)
 - Proposed rules for repowering or retirement of 22 GW of thermal plants with once-through cooling in California
 - Will adversely affect ramping and Regulation capability of generation fleet
- Greenhouse Gas Policy (AB32 compliance begins in 2012; target is 1990 emissions by 2020)
 - Will increase costs of carbon emitting thermal plants used for Energy and Ancillary Services

20% RPS -- Forecast Variability in Tehachapi (Southern California) with 5200 Megawatts of wind



California Wind Generation Output may Peak During Off-peak Periods

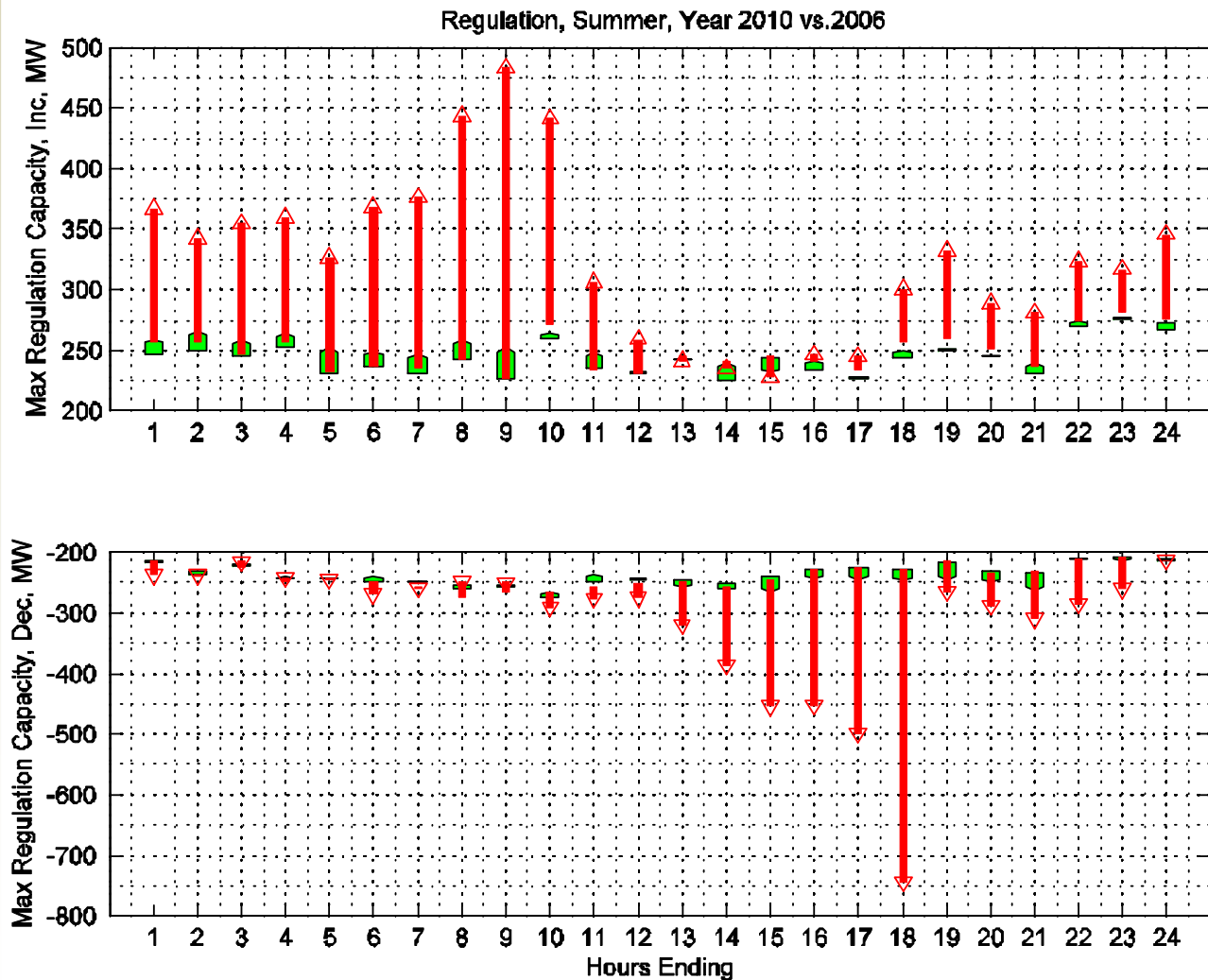
January 6, 2005 California Wind Generation



20% RPS --The CAISO regulation capacity requirements would increase noticeably during certain hour ranges

The maximum increase of 230 MW occurs during HE9 (480 MW – 250 MW)

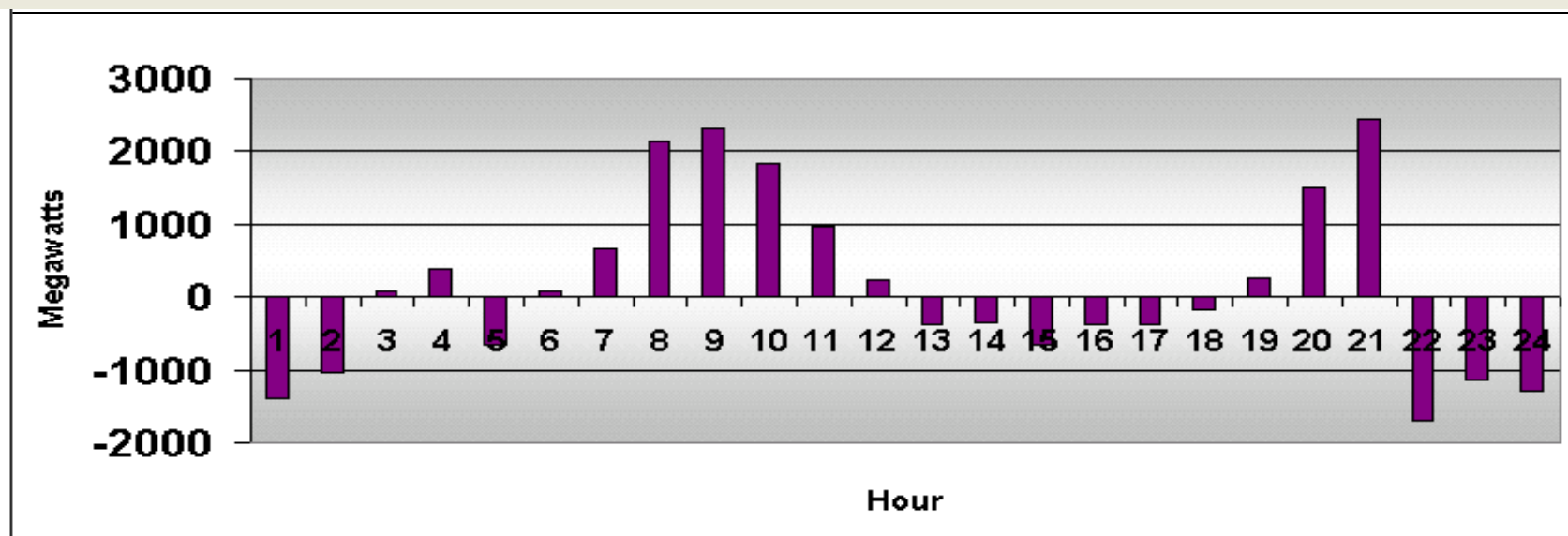
The maximum downward increase of 500 MW (750 MW - 250 MW) occurred in HE18



20% RPS -- Ramping issues

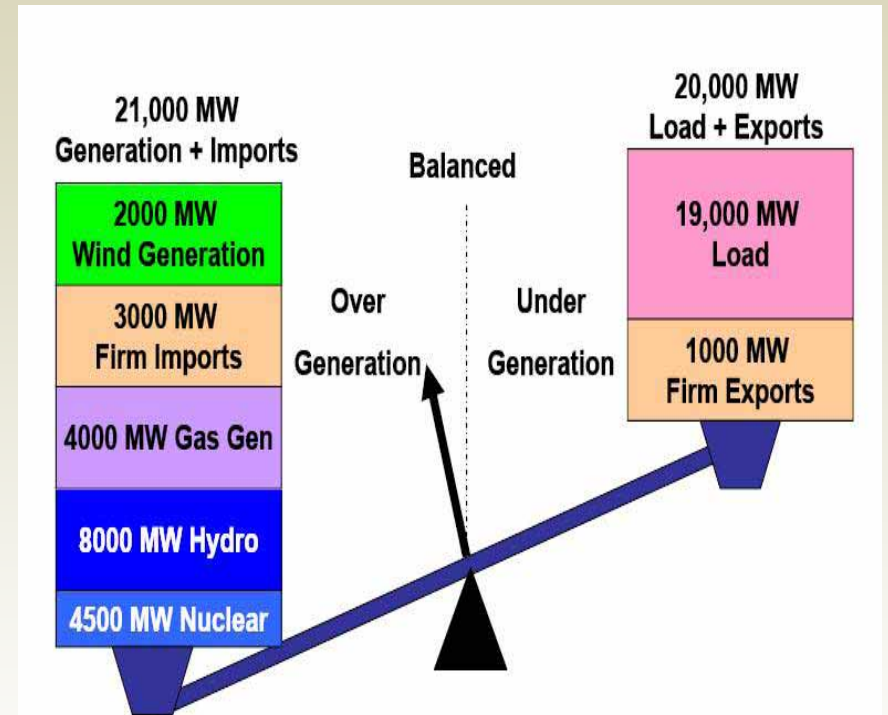
- In California, the wind generation energy production tends to be inversely correlated with the daily load curve. The wind energy production peaks during the night and falls off during the morning load pick up. The net result will be morning ramps of 2000 to 4000 MW per hour for 3 hours – a total of 6000 to 12,000 MW over 3 hours.

Forecasted Hourly Ramps due to Additional Wind Generation



Typical Oversupply Conditions - CAISO

- Light load conditions – loads around 22,000 MW or less,
- All the nuclear plants on-line and at maximum production,
- Hydro generation at high production levels due to rapid snow melt in the mountains,
- Long start thermal units on line and operating at their Pmin levels because they are required for future operating hours,
- Other generation in a “Must Take” status, QF, or required for local reliability reasons, and
- Wind generation at high production levels.



Imbalance between Generation and Load

From 20% to 33% RPS

Case	GWh	Avg. Mw	Nameplate Mw
20% RPS	55,657	6,353	13,614
33% RPS	~ 93,000	10,500	26,000

- Achieving 33% requires CA to meet two times load growth with renewables between now and 2020
- The increase in need for capacity, ramping and Regulation to achieve 33% RPS will likely be non-linear; Study by California IOUs show higher levels of Regulation and overgeneration frequency; CAISO analysis of 33% RPS integration needs expected in 2009-2010
- Regional diversification is important technically and economically

CAISO considers all Resource Capabilities for Integration of Renewables

Generation



Quick Start Units
Fast Ramping
Wider Operating Range (lower P_{\min})
Regulation capability

Storage



Shift Energy from off-peak to on-peak
Mitigate Over Generation
Voltage Support
Regulation capability

Demand Response



Price sensitive load
Responsive to ISO dispatches
Frequency Responsive
Responsive to Wind Generation Production

Conclusions

- ISO and RTO markets offer transparent pricing of Energy, Ancillary Services and also Capacity services that can be offered by storage technologies
- ISO and RTO markets present substantial commercial opportunities for storage technologies alongside other resources
- Renewable integration requirements and greenhouse gas policy could substantially improve these opportunities over time
- Appropriate tariff changes, software and operational adaptation, and pilot projects are proceeding and will accelerate