California ISO
Shaping a Renewed Future

CEC IEPR Committee Workshop
Energy Storage for Renewable Integration

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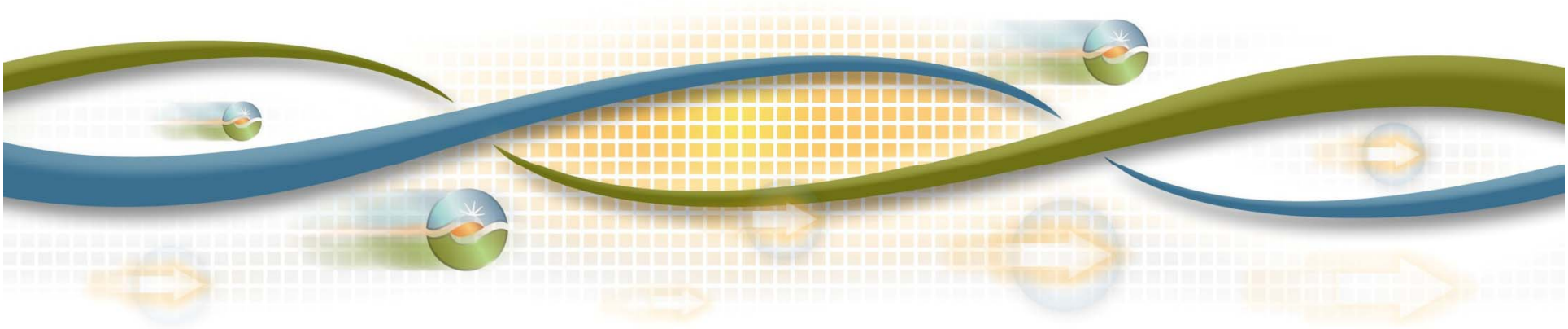
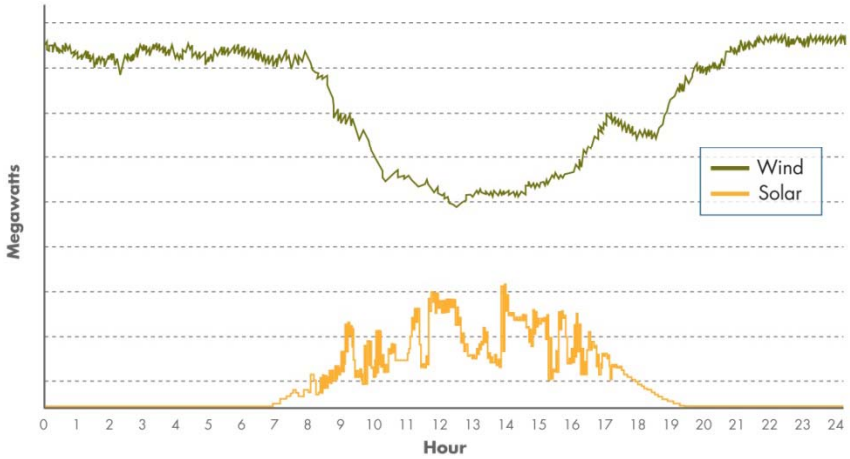


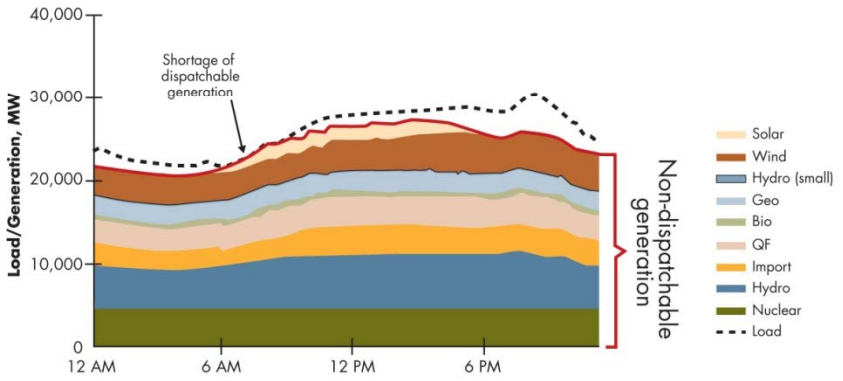
Renewable Integration From 2012 to 2020

- The ISO is committed to helping CA achieve its renewable policy objectives
- We must understand the potential effects on grid operations and wholesale markets
- ISO is preparing an analysis of alternative 33% RPS portfolios in cooperation with CPUC and an advisory 33% RPS modeling working group
- The work will help bound the level of uncertainty about many factors, including the make-up of utility procurement and technological developments that could affect integration capabilities such as storage and demand response

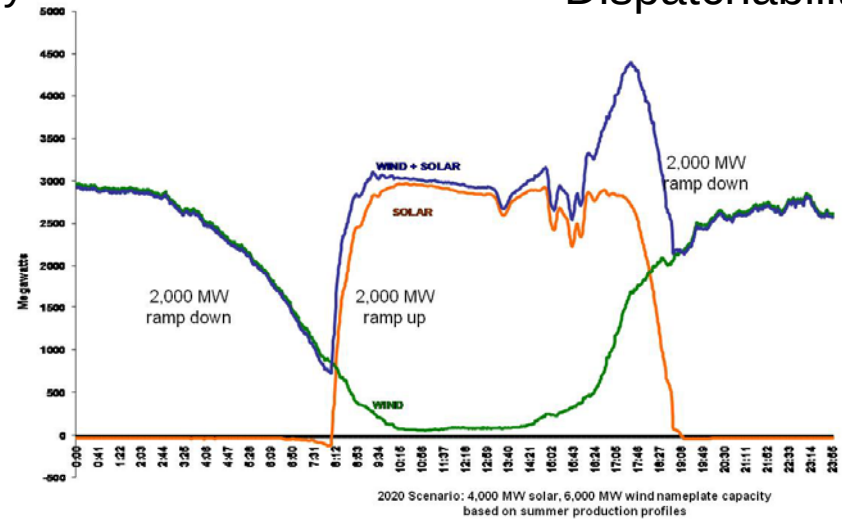
The ISO faces several challenges in maintaining reliability cost effectively.



Variability and uncertainty



Dispatchability and Overgeneration



Increased ramping needs

Step 1: Determining Operational Requirements based on load and renewable supply **variability** and **uncertainty**

- **Step 1: Operational Requirements**
  - Statistical Analysis of the **variability** and **uncertainty** is performed to quantifies the amount of "regulation" and "load-following" capability needed to maintain system balance
  - **Regulation**: A measure of system balancing between the 5 minute dispatch schedule and actual net load
  - **Load following**: a measure of system balancing requirements between hour-ahead and the 5 minute dispatch
- **Step 2: Production Simulations**
  - Incorporates regulation and load following requirements calculated in Step 1
  - Simulates unit commitment and dispatch necessary to meet requirements
  - Model resource ramping and start-up characteristics
  - Output cost and emission results
  - Evaluate options for meeting identified need including alternatives
- **Operational Inventory and Assessments of Existing Fleet**

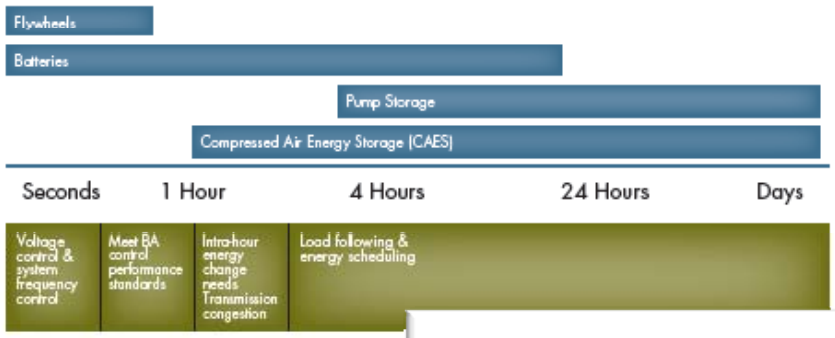
Initial Observations from 2010 CPUC – LTPP cases - Preliminary results to be released on April 29

- Assumptions include approximately 7,000MW of energy efficiency and 293MW of non-event demand response

- Assuming California meets these objectives:
  - Load following requirements have reduced
  - Little or no additional generic resource needs to meet regulation or upward load following requirement violations
  - As much as 1100 MW of load following down requirement shortages identified
  - The violations are only for a few hours and may be satisfied using alternatives such as storage or curtailment

Storage technology provides a flexible resource for maintaining reliability.

- Energy storage technology examples
  - Flywheel
  - Lithium Ion battery
  - Sodium Sulfur battery
  - Flow batteries
  - Compressed air energy storage
  - Pumped hydro
  - Electric Vehicles
- ISO market applications
  - Intermittent energy smoothing
  - Ramping
  - Over-generation mitigation



Storage Vision:

Facilitate cost-effective, comparable participation in ISO markets to fully utilize technology capabilities.

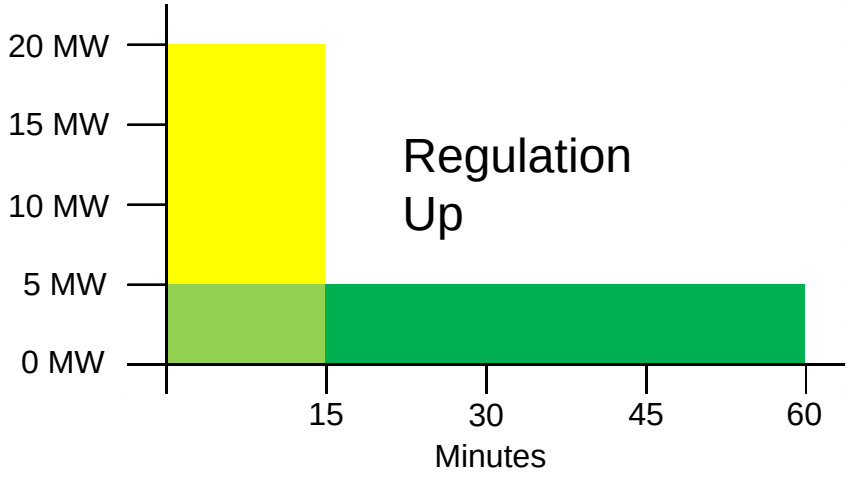
Regulation energy management provides additional functionality to address limitations of storage resources.

- Limited energy resources unable to participate in day-ahead regulation market at full capacity w/o REM
- Barriers to entry still existed even with March 2010 ancillary services modifications to support non-generation resources

Example: 20 MW / 5 MWh limited energy resource

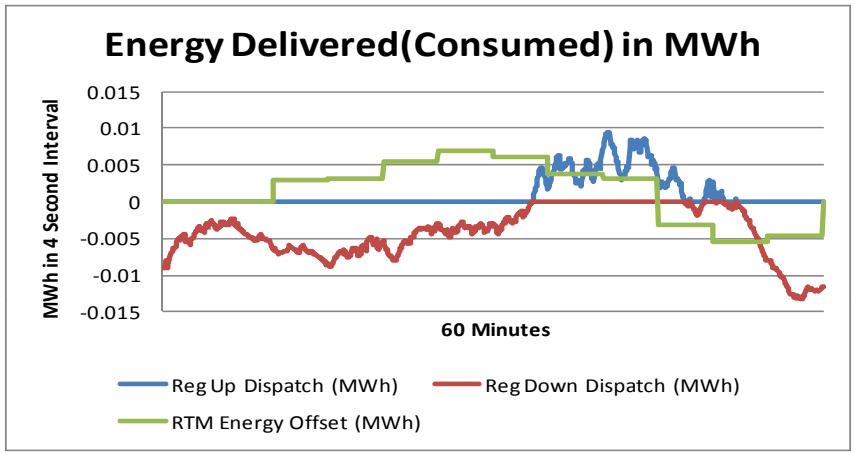
Green – prior requirement

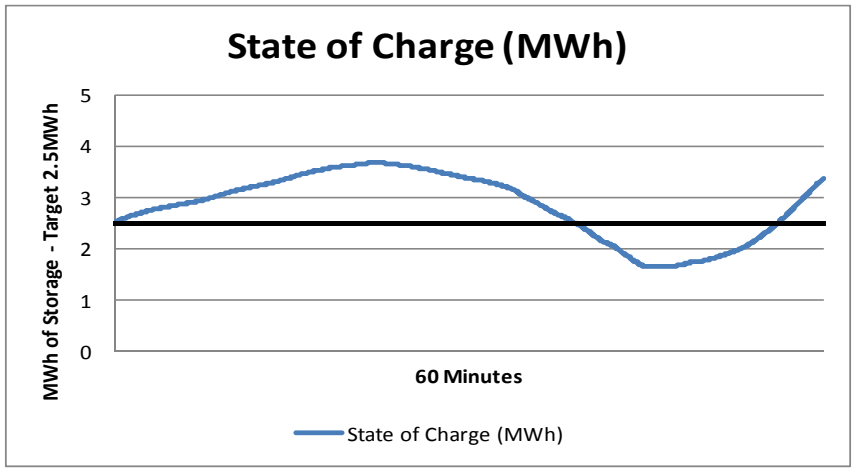
Yellow – regulation energy management



Approved by ISO Board February 2010. Implementation Spring 2012

Regulation energy management maintains resources state of charge to meet continuous energy requirement.





- Utilize real time energy market for energy offset
- Regulation and energy settlement similar to conventional generation
- Regulation dispatch and energy offset keep state of charge near midpoint
- Additional information at http://www.caiso.com/27be/27beb7931d800.html

ISO actively pursuing operational and market enhancements to support renewable integration

- Operational Enhancements
  - Wind & solar forecasting tools (output, ramping requirements)
  - More sophisticated grid monitoring systems
  - Over-generation mitigation procedures
  - Coordination with neighboring balancing areas
  - Generation interconnection standards
  - Pilot projects (storage, synchrophasors, demand response)
  - Intra-hour scheduling and dynamic transfers
- Market Enhancements
  - Regulation energy management – opportunity for storage to provide
  - New market products & changes to market rules
  - Increased regulation and reserve requirements
  - More sophisticated day-ahead unit commitment algorithms

Thank You

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