

Operating Impacts of Higher VG Penetrations – A Panel Discussion

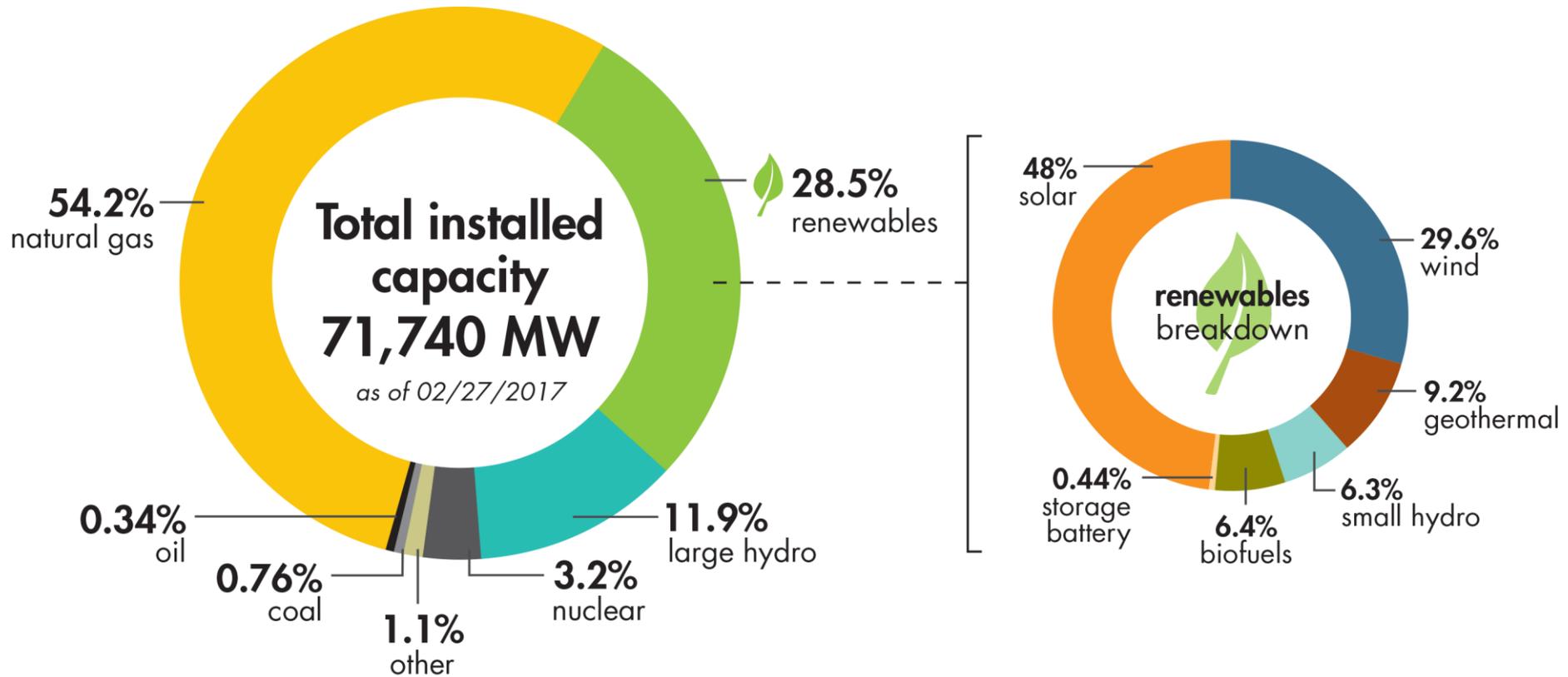
Clyde Loutan, Principal – Renewable Energy Integration

UVIG --- 2017 Fall Technical Workshop

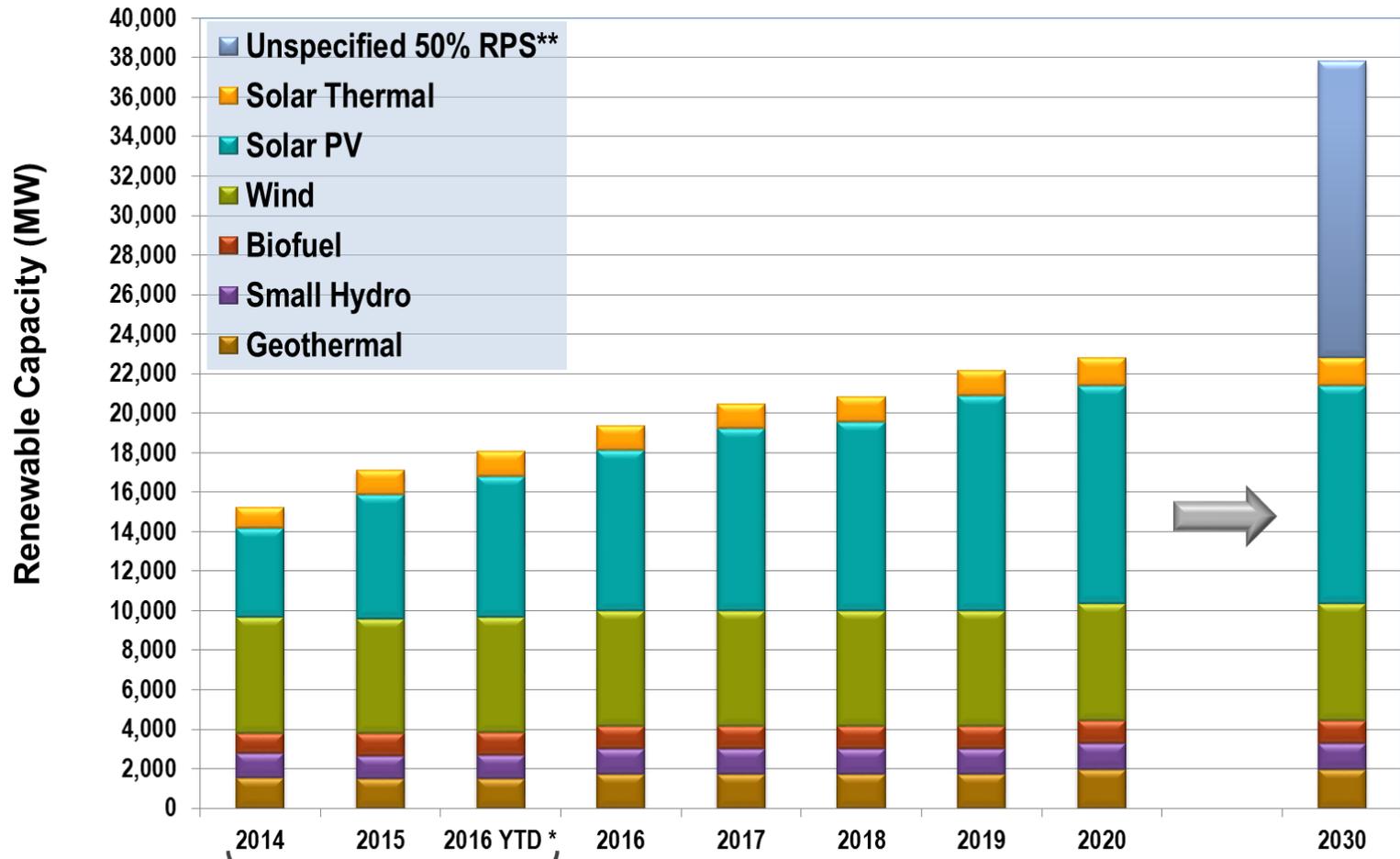
October 10-12, 2017

Nashville, TN

CAISO's Resource mix as of February 2017



Approximately 4,000 MW of additional transmission-connected renewables by 2020 and an additional 10,000 to 15,000 MW by 2030



(Existing generation)

*All online resources that are not in test mode are included in the 2016 YTD amounts, including those yet to achieve full commercial operation.
 **Approximate (IOU data through 2017 and RPS Calculator data 2018-2020)

Power industry transformation



Wind

- Unpredictable Output
- 4,985 MW Peak – May 16, 2017
- 6,087 MW Installed Capacity



Solar Thermal / Photo Voltaic

- Semi – Predictable Output
- 9,914 MW Peak – June 17, 2017
- \approx 10,000 MW Installed Capacity

* Simultaneous wind and solar has exceeded 13,000MW on April 23, 2017



Roof Top Solar

- Semi – Predictable Output
- Behind the meter – Residential
- 5,000+ MW Estimated Capacity

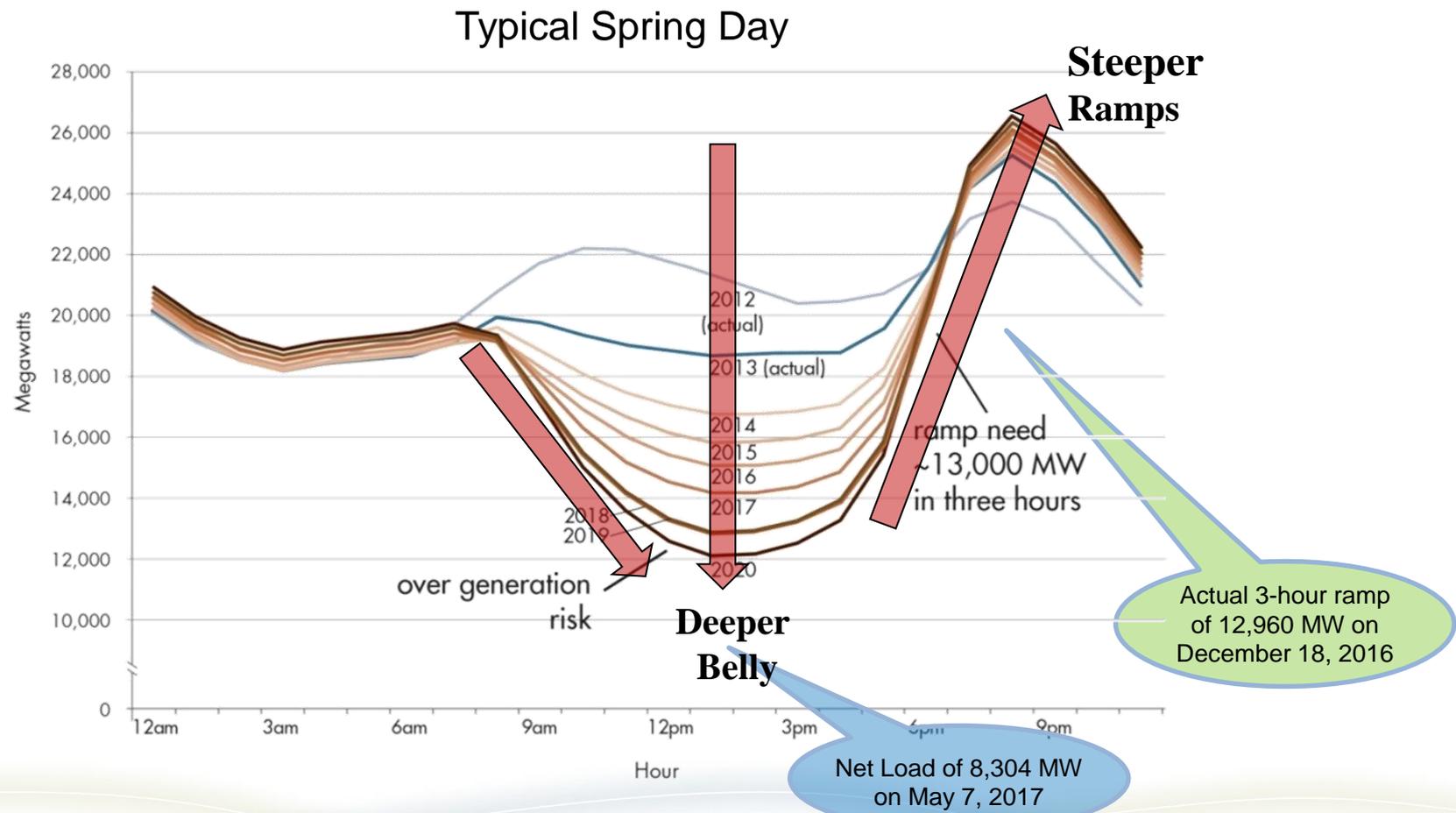
Main Drivers:

- ✓ California RPS
- ✓ GHG reduction
- ✓ Once-through-cooled plants retirement

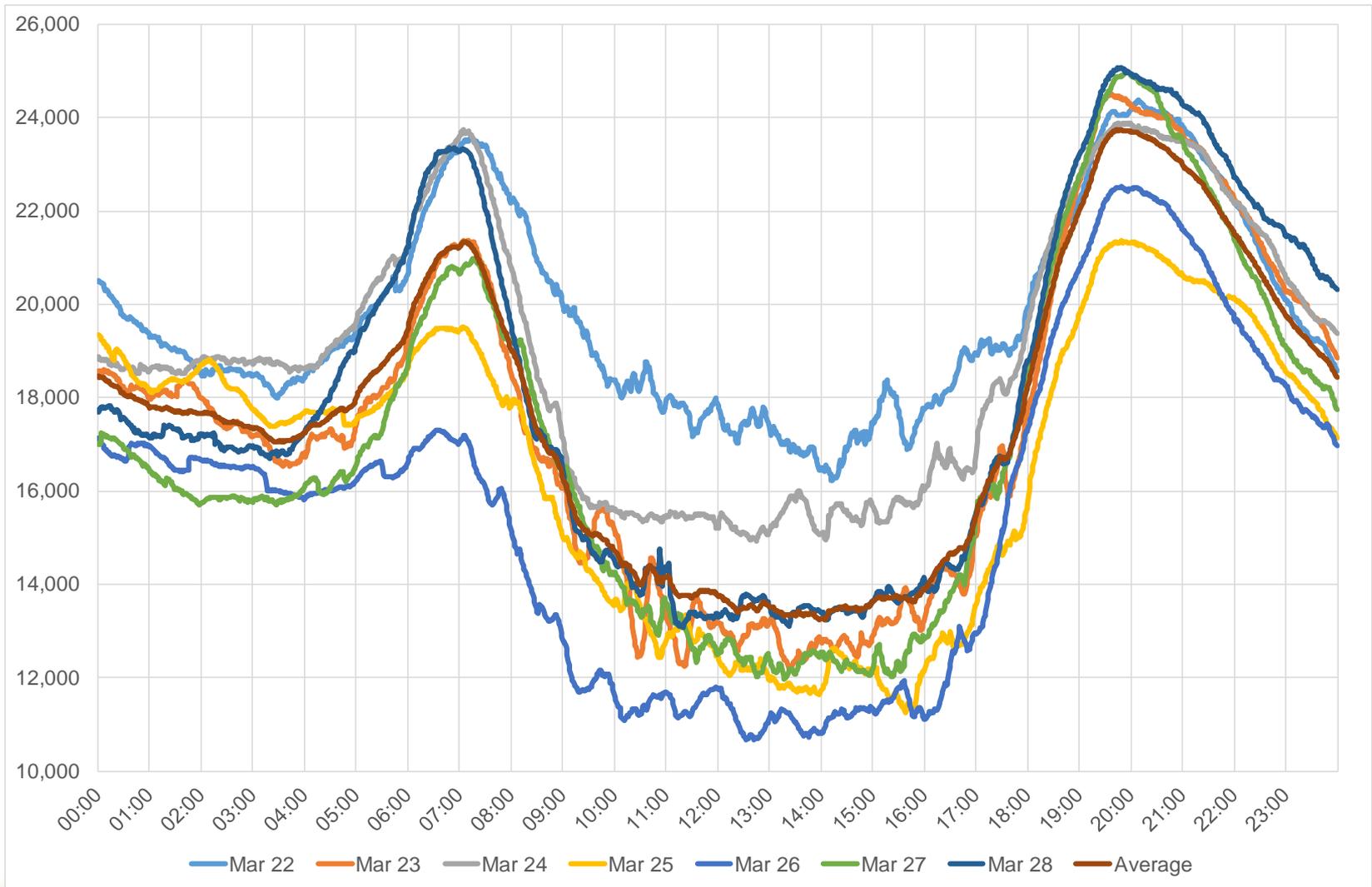
Goals:

- ✓ Higher expectation of reliability
- ✓ Higher expectation of security
- ✓ Smart Grid
- ✓ Situational awareness through Visualization

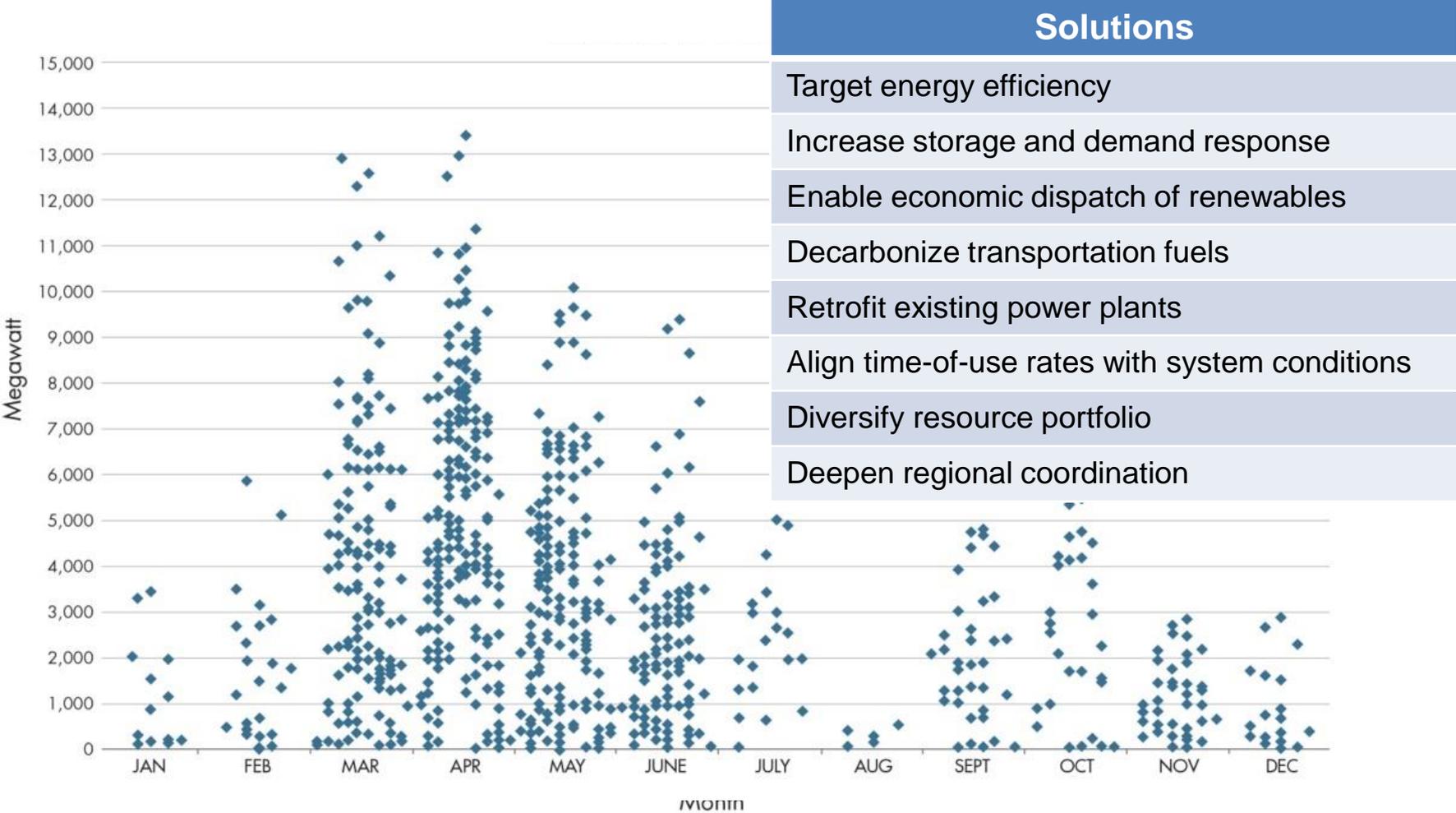
Actual net-load and 3-hour ramps are about four years ahead of ISO's original estimate



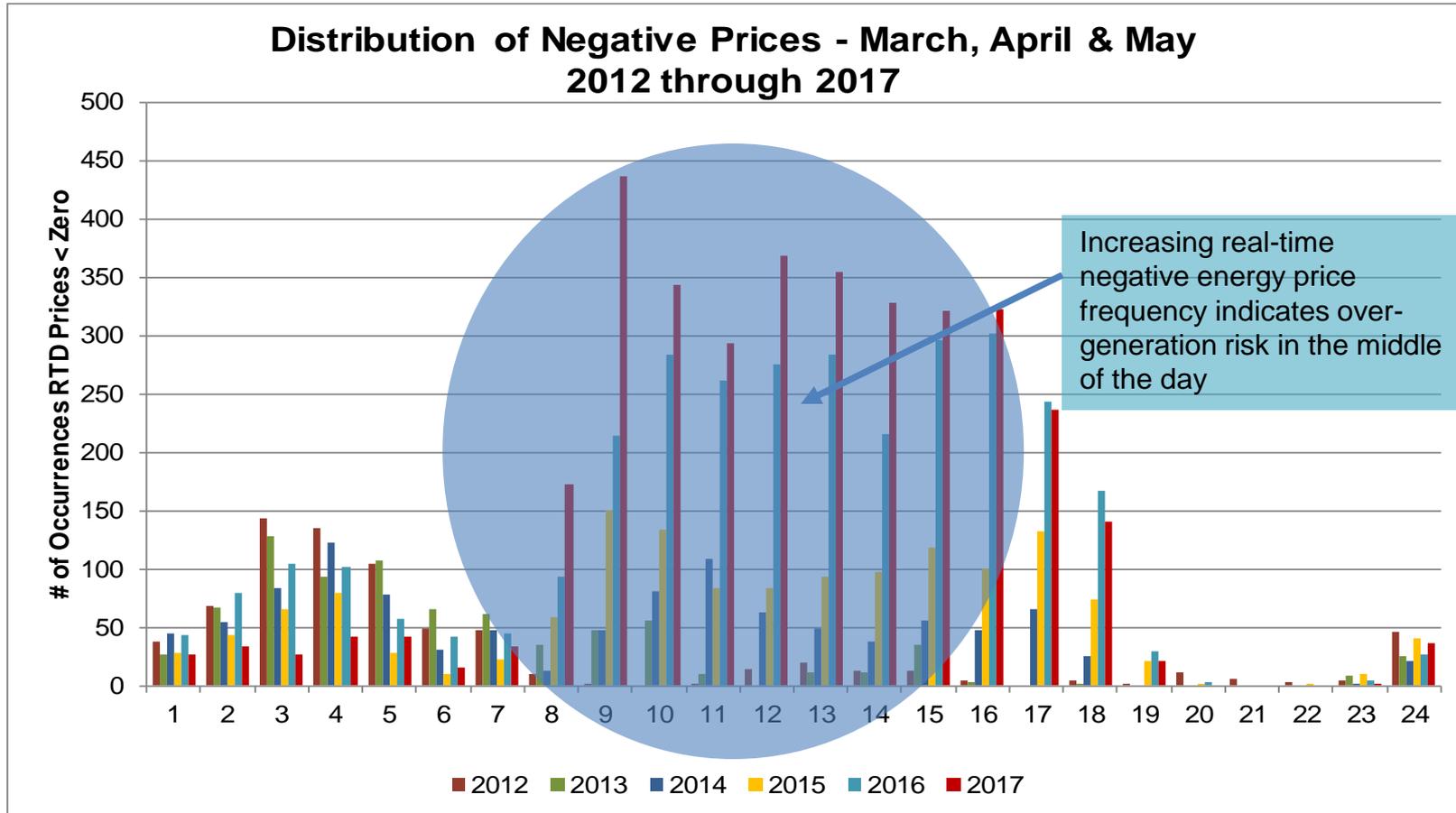
Net Load varies from one day to the next --- One week in March 2017



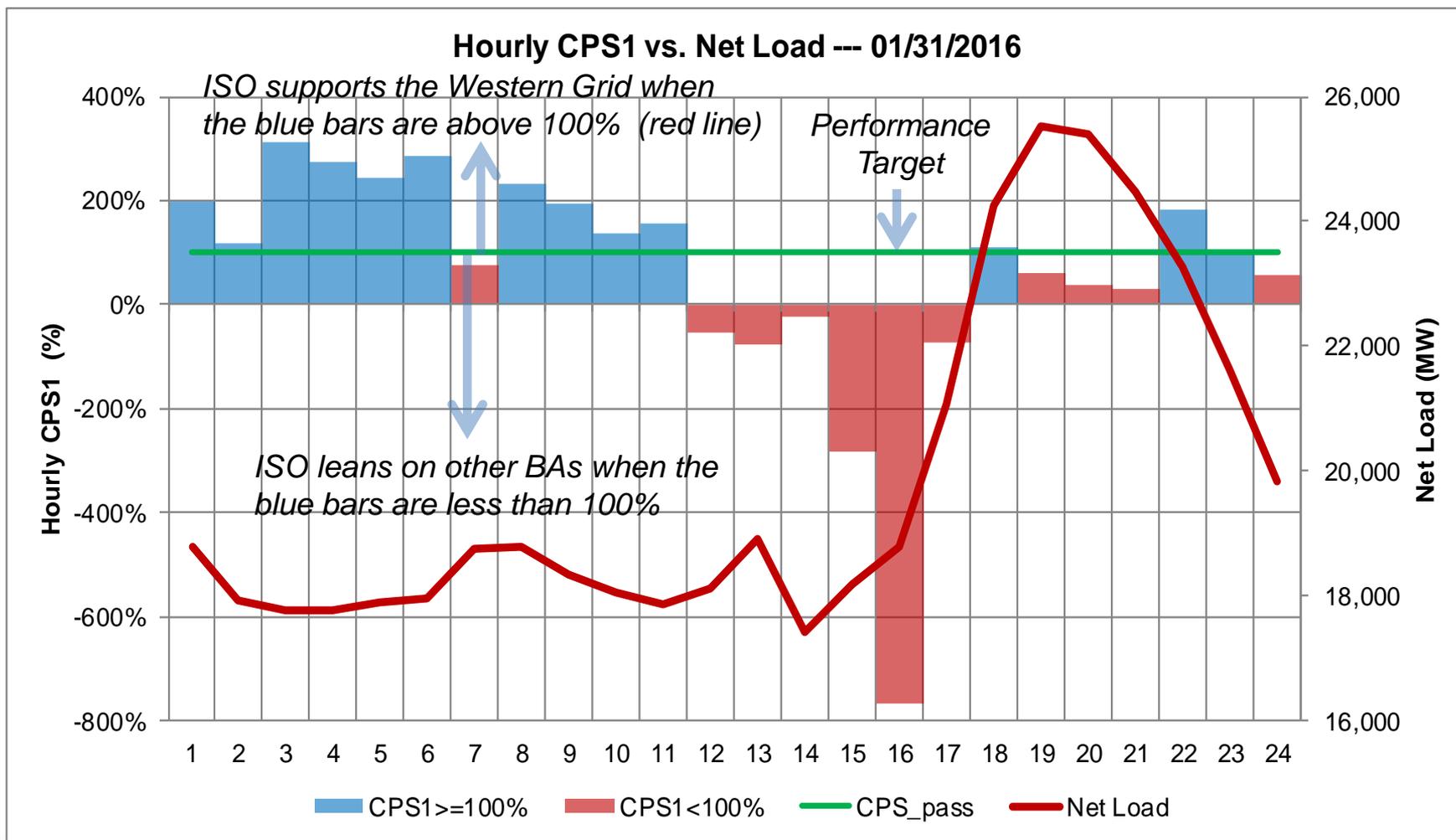
Renewable curtailment in 2024 at 40% RPS is significant



New price patterns incentivize innovation in responsive demand and storage

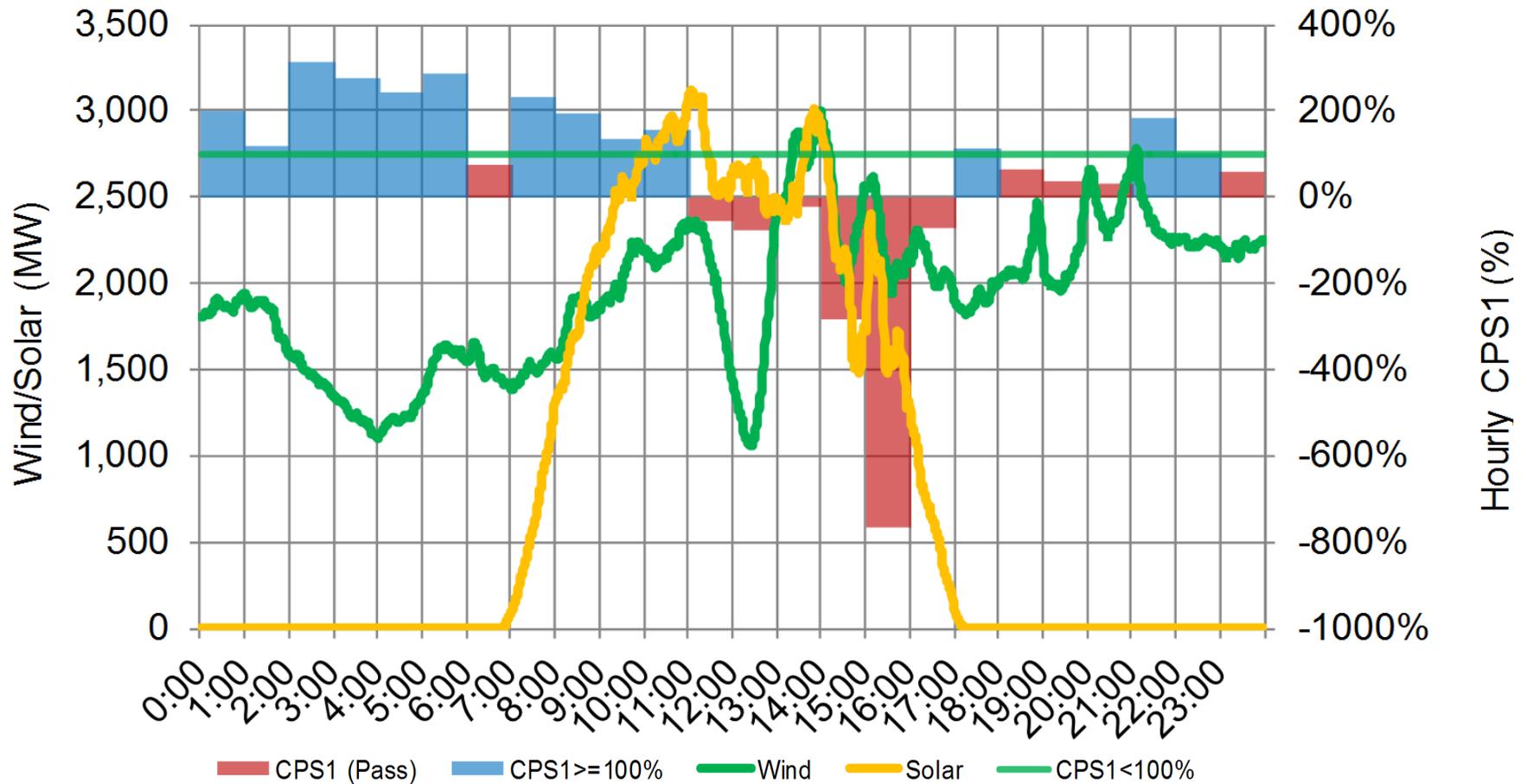


ISO tracks real-time supply and demand balance as a measure of operational effectiveness



Enhance operational performance during periods of increased supply variability

Wind/Solar vs. CPS1 --- 01/31/2016



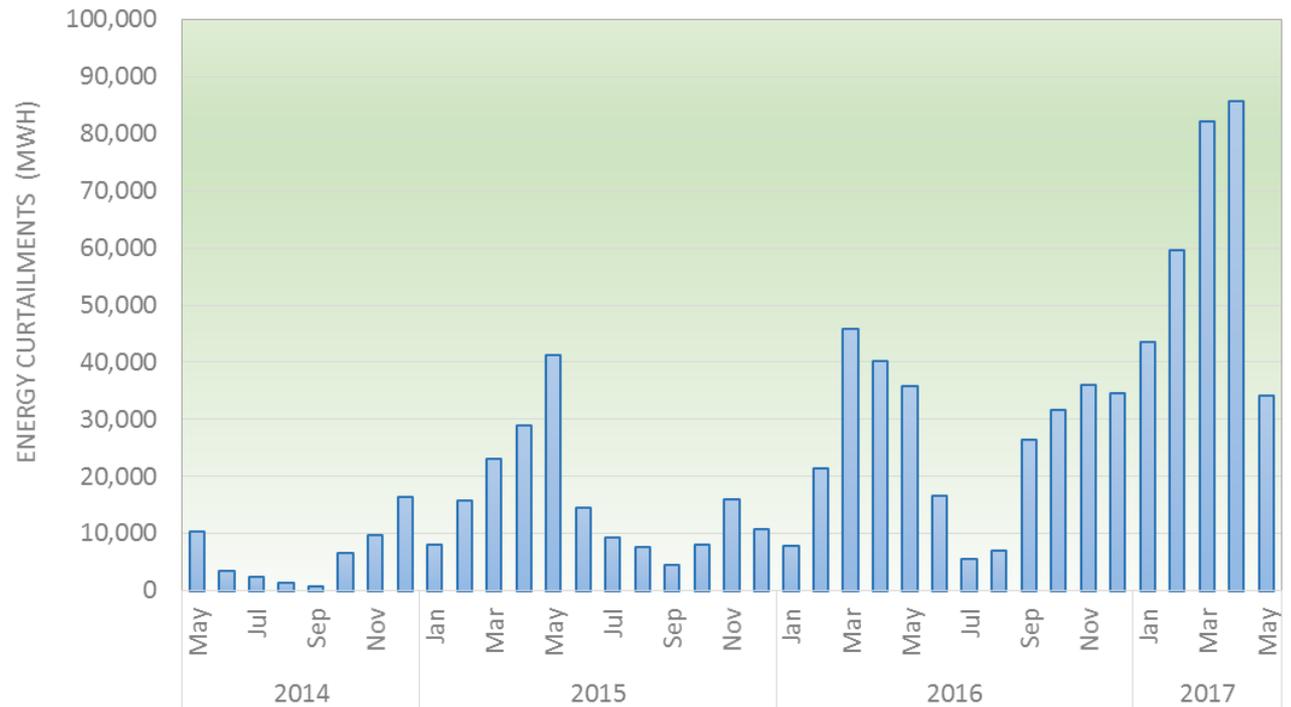
CPS1 is NERC Control Performance Standard which is evaluated on a rolling 12-month average. Over the past few years, the rolling average has been declining as a result of some poor daily performances.

Thus, the CAISO need to take measures to enhance daily performance on days with higher variability.

Opportunities

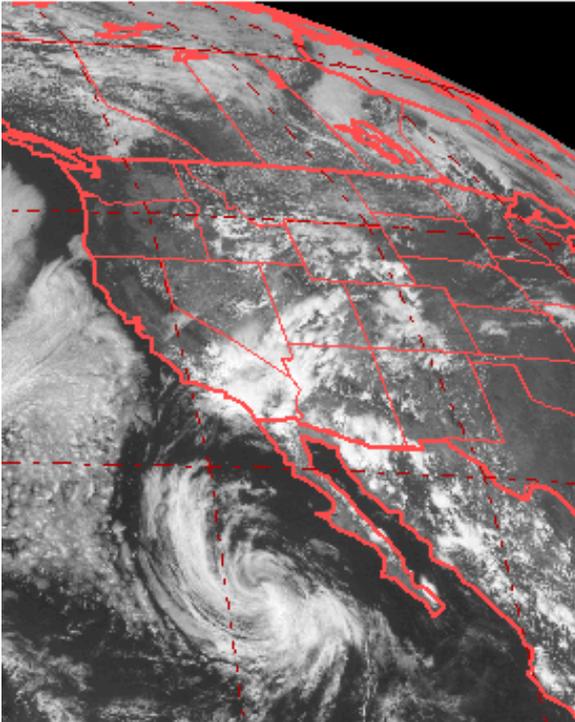
Manage oversupply and minimize curtailment to decarbonize and realize environmental goals

- In 2017, approx. 2.6% of potential solar production was curtailed (1.3% of potential renewable production)
- Spring curtailments ran up to 1,775 MW (approx. 8.8% of energy demand in that hour)
- Current curtailment is manageable. As we approach 50% RPS, curtailments will occur year round and become much larger unless a suite of strategies to contain curtailment are pursued

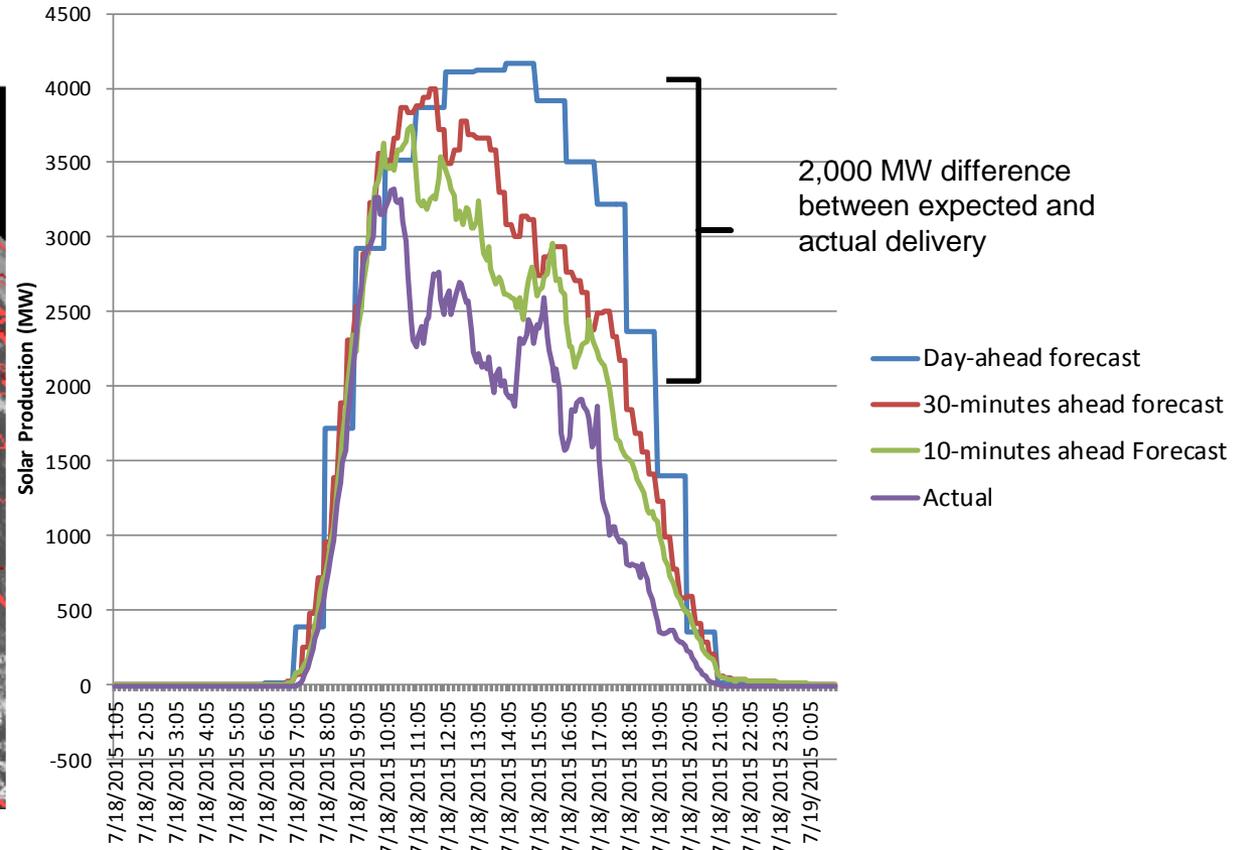


Enhance forecasting to manage supply uncertainty

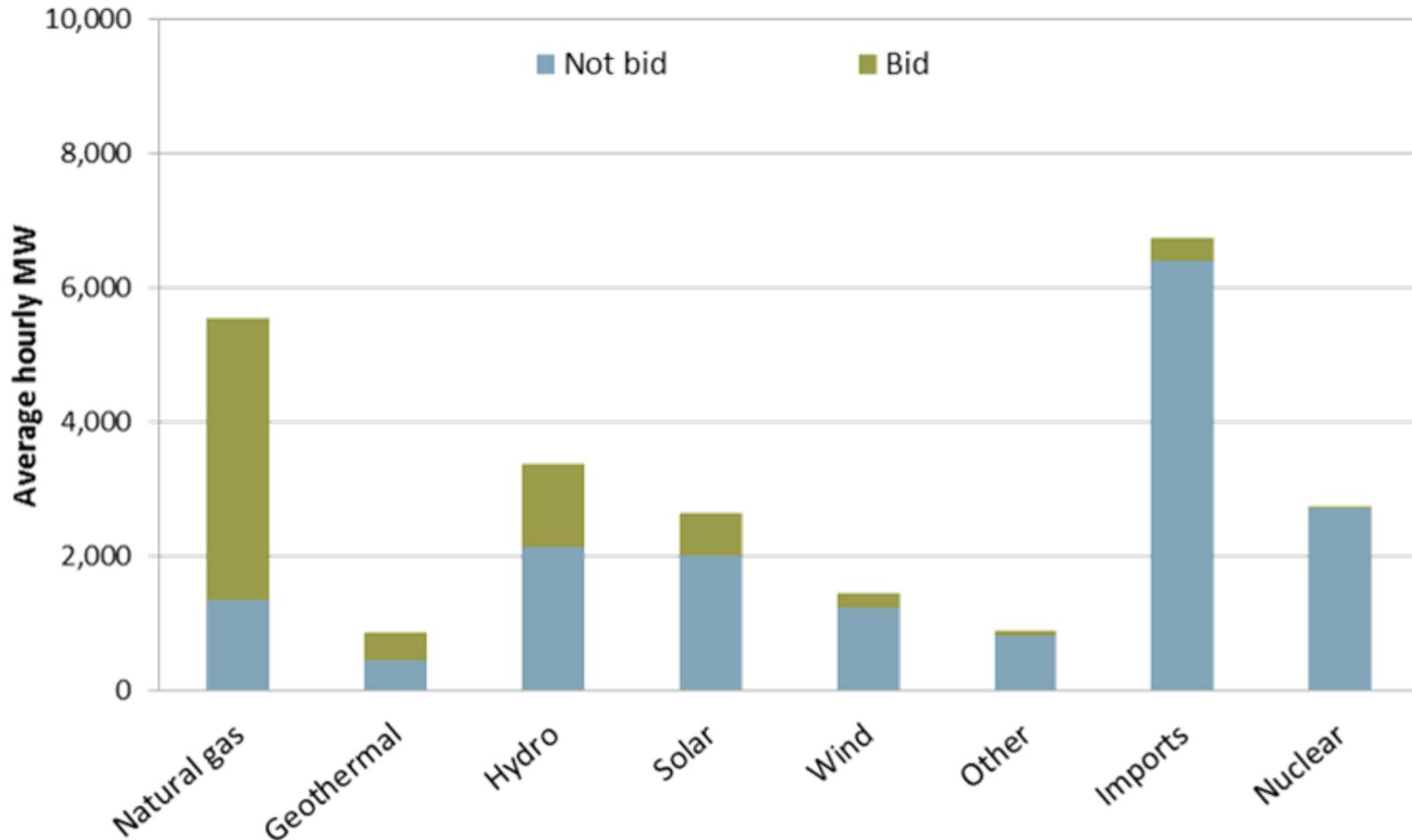
Example day with monsoonal conditions



CAISO – Solar Forecast & Actual July 18, 2015



Opportunity for renewables and imports to provide more real-time flexibility via bids



Source: DMM 2016 Annual Report

What can we do with that all excess supply.....?



Target energy efficiency



Increase storage and demand response



Decarbonize transportation fuels



Enable economic dispatch of renewables



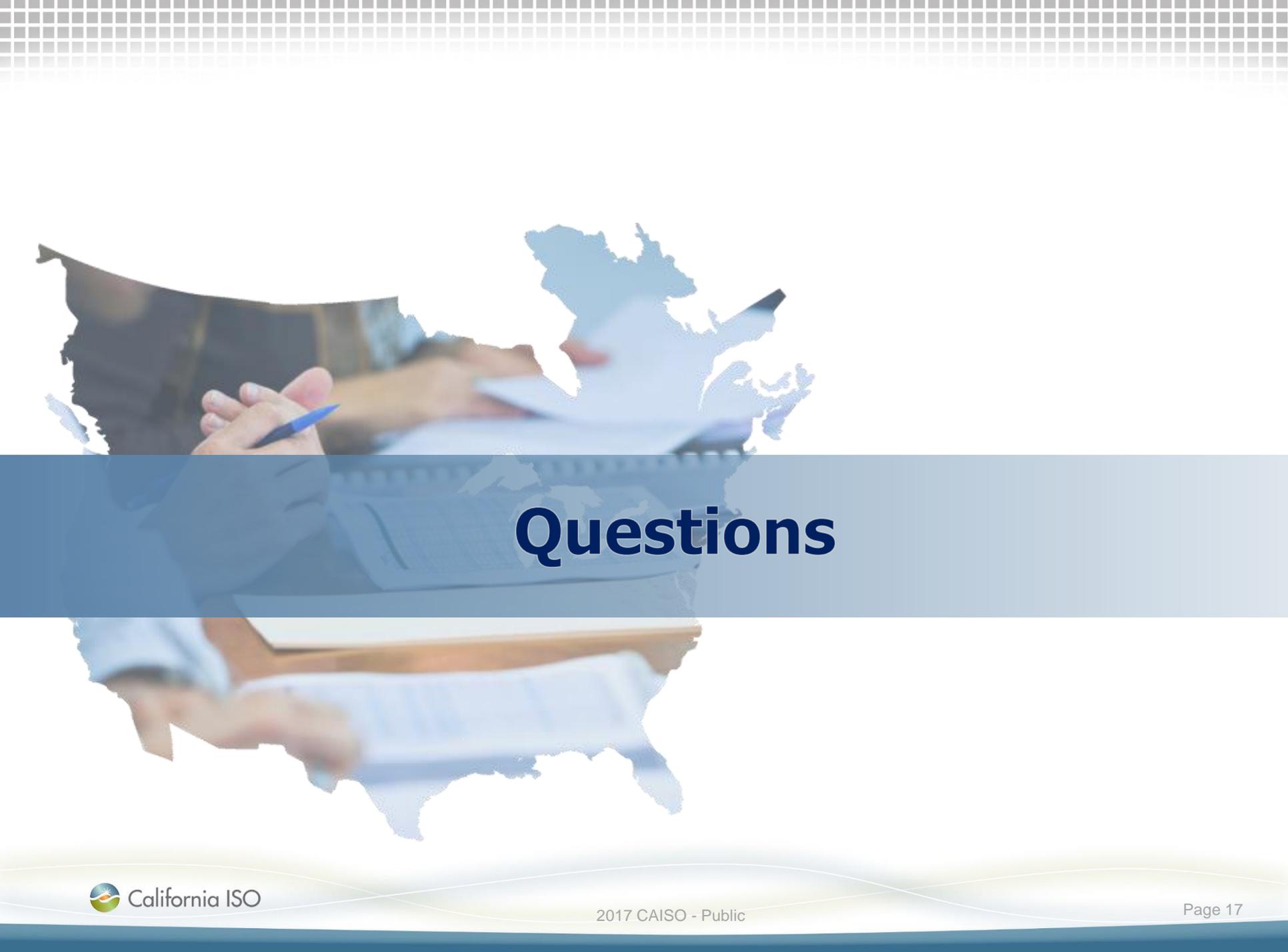
Retrofit existing power plants



Align time-of-use rates with system conditions

Can variable energy resources provide essential reliability services to reliably operate the grid?

- NERC identified three essential reliability services to reliably integrate higher levels of renewable resources
 - Frequency control
 - Voltage control
 - Active power management such as ramping capability or flexible capacity
- Advancement in smart inverter technology allows VERs to provide services similar to conventional resources
- VERs with the right operating characteristics are necessary to integrate higher levels of renewables and decarbonize the grid



Questions