



Integrating variable energy resources at the California ISO

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Lode Chapter

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What does an ISO do?

- Operate the grid reliably and effectively
- Operate efficient spot markets for energy and reserves
- Provides fair and open transmission access and scheduling
- Plan and identify future grid infrastructure needs
- Manage new generation interconnections



ISO Vision: What we can do to ensure grid reliability and efficiency while leading the transition to a low carbon grid



California ISO Overview

- Nonprofit public benefit corporation
- Part of Western Electricity Coordinating Council: 14 states, British Columbia, Alberta and parts of Mexico
- 71,000 MW of power plant capacity
- 50,270 MW record peak demand (July 24, 2006)
- 26,000 circuit-miles of transmission lines
- ISO is governed by the Federal Energy Regulatory Commission, which has jurisdiction over transmission lines that cross state borders.



Two-thirds of the United States is served by independent system operators (ISO/RTOs)

Western Electricity Coordinating Council (WECC):

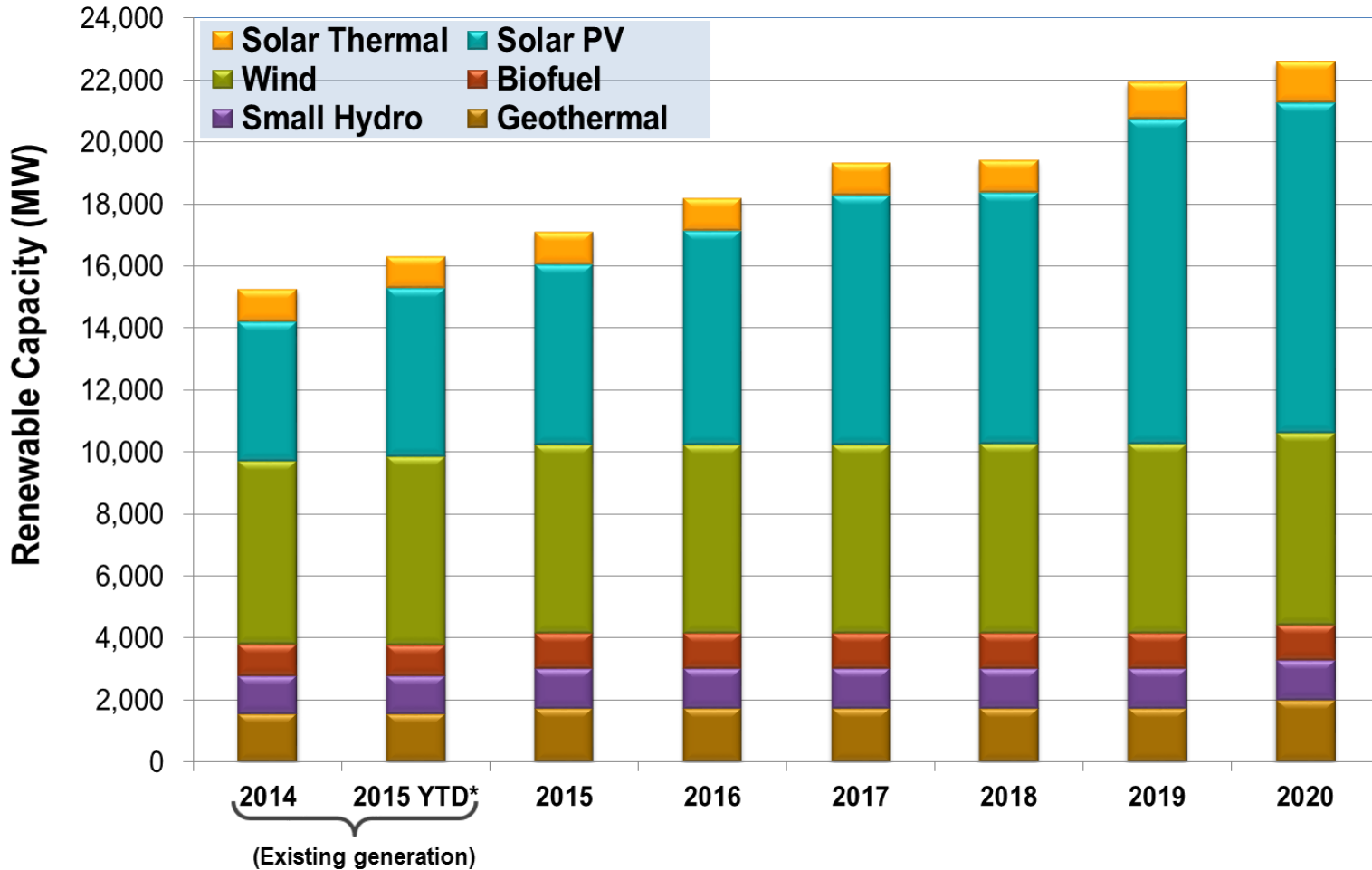
- 38 of 76 balancing authorities are in WECC
- Serves a population of approximately 82.2 million
- Spans more than 1.8 million square miles in all or part of 14 states
- In 2014, the BAs reported a nameplate capacity of 275,400 MW



California energy and environmental policies drive renewable integration and transmission needs

- Greenhouse gas reductions to 1990 levels by 2020
- 33% of load served by renewable generation by 2020
- 12,000 MW of distributed generation by 2020
- Ban on use of once-through cooling in coastal power plants
- Less predictable load patterns – rooftop solar, electric vehicles, and smart grid
- SB 350 requirements by 2030:
 - 50% renewables
 - Double energy efficiency
 - Greenhouse gas reductions to 40% below 1990 levels
 - Promote transportation electrification

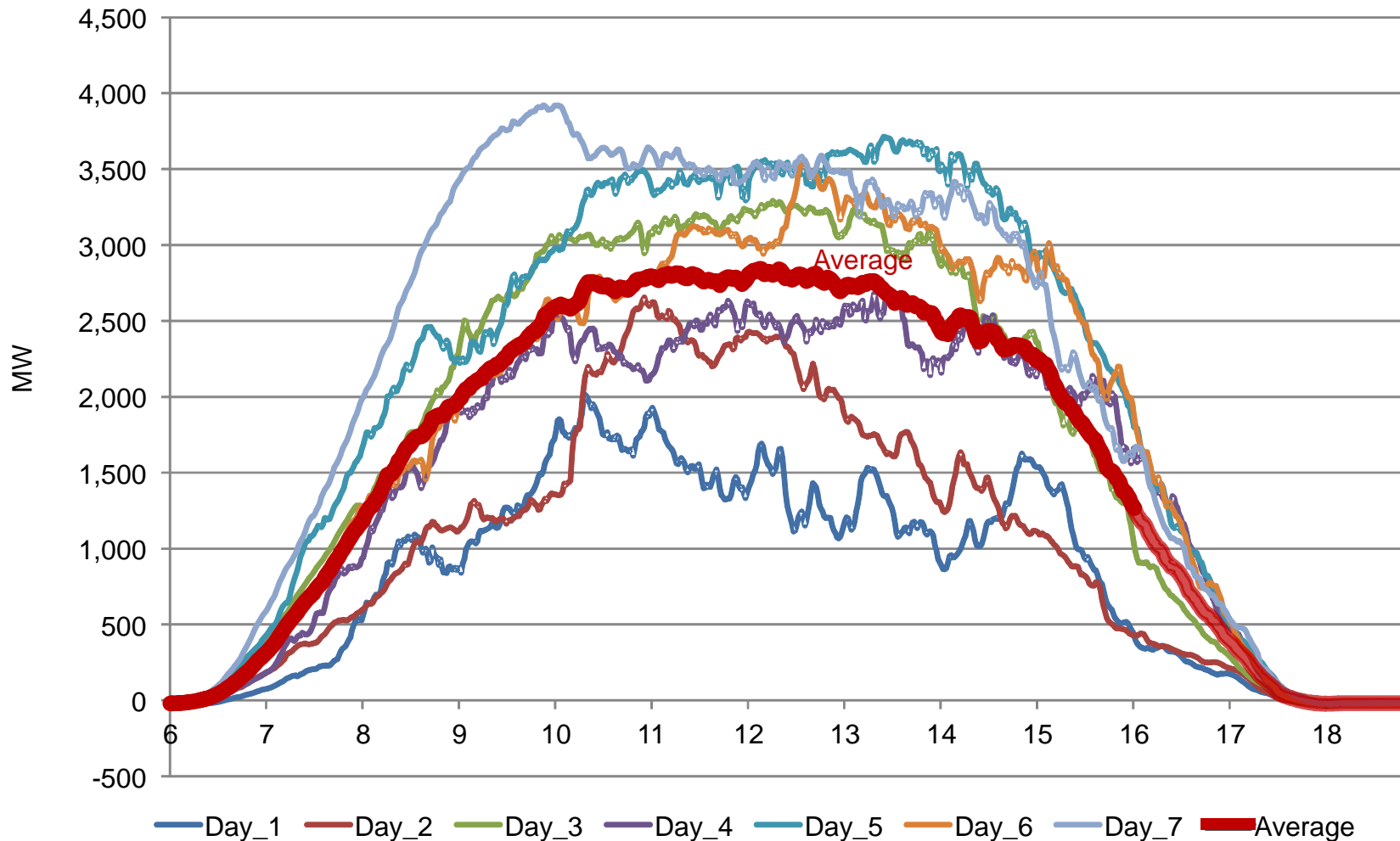
Expected renewable generation growth through 2020



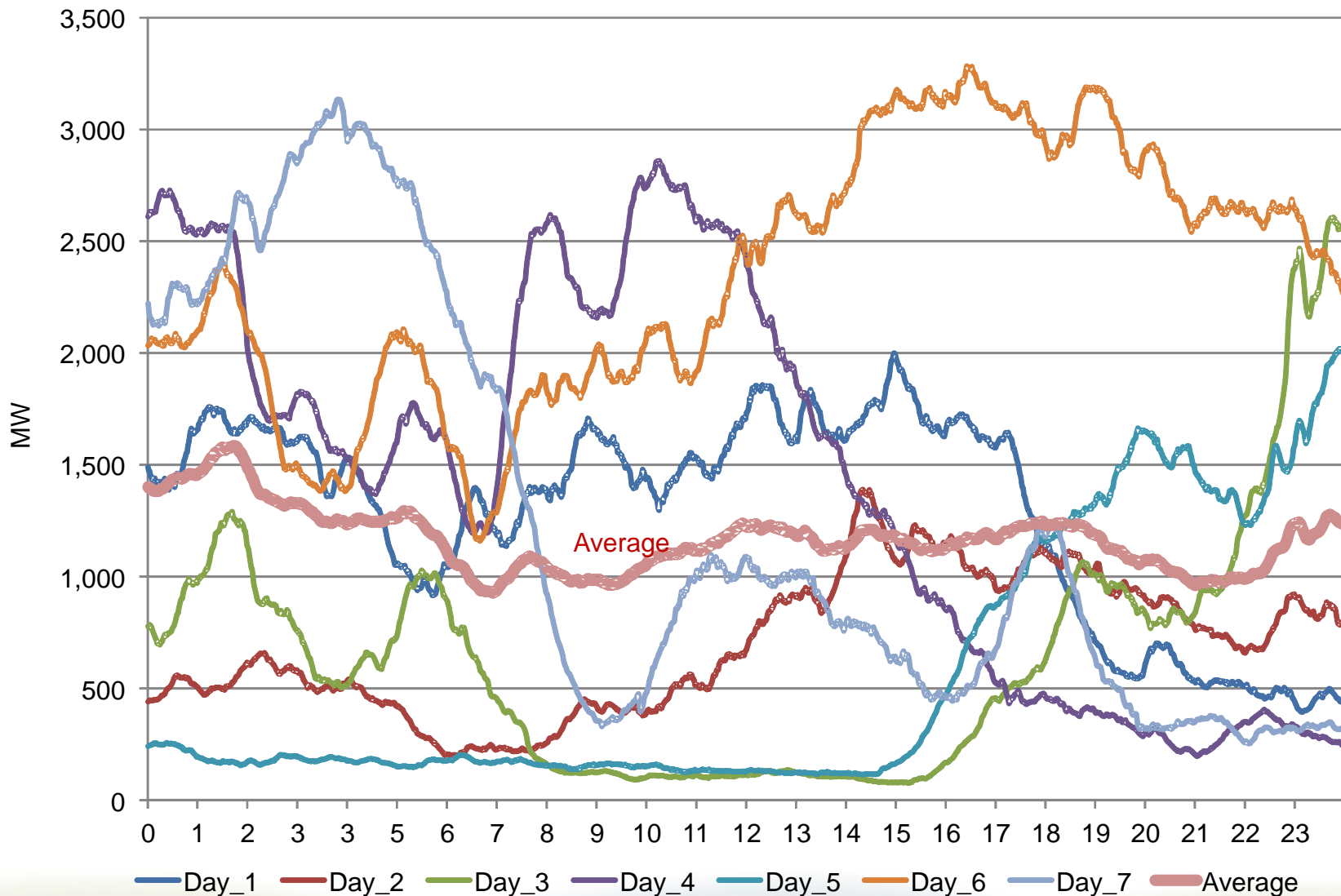
*All online resources are included in the 2015 YTD amounts, including those yet to achieve full commercial operation.

(IOU data through 2017 and RPS Calculator data 2018 – 2020)

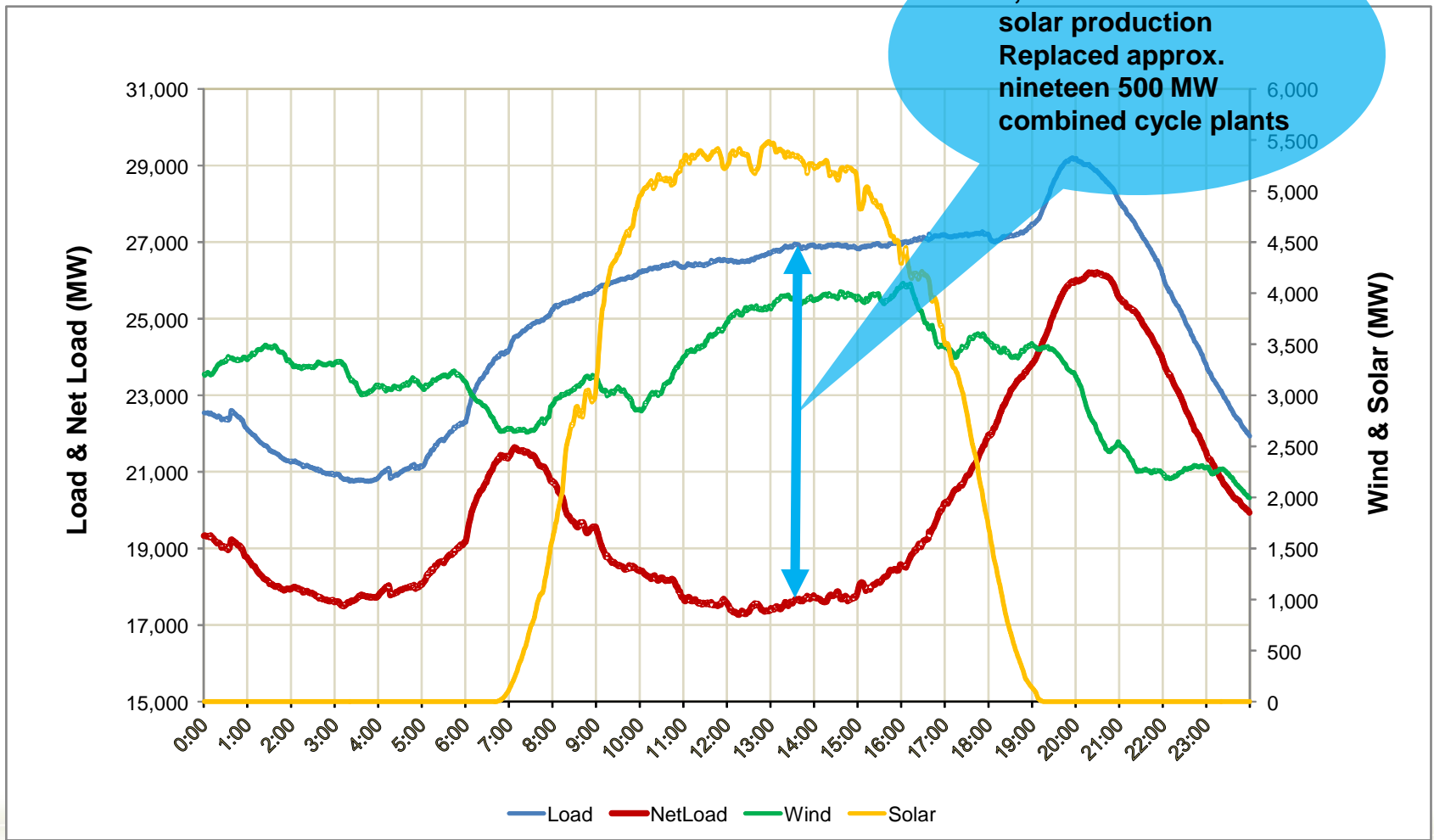
Solar production varies from one day to the next --- first week of March 2014



Wind production varies from one day to the next --- first week of March 2014

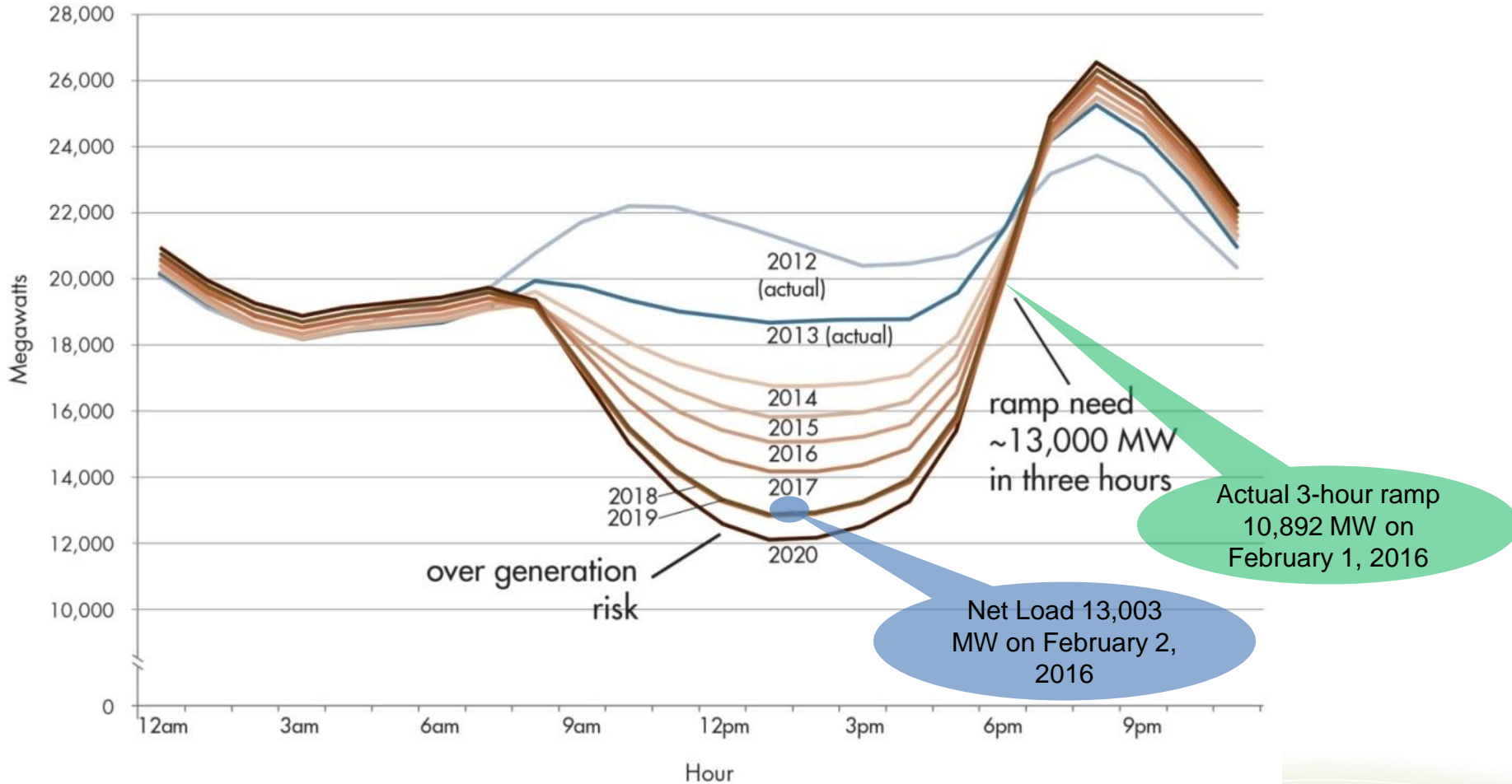


VERs production results in significant reduction of conventional resources to meet demand --- March, 31, 2015

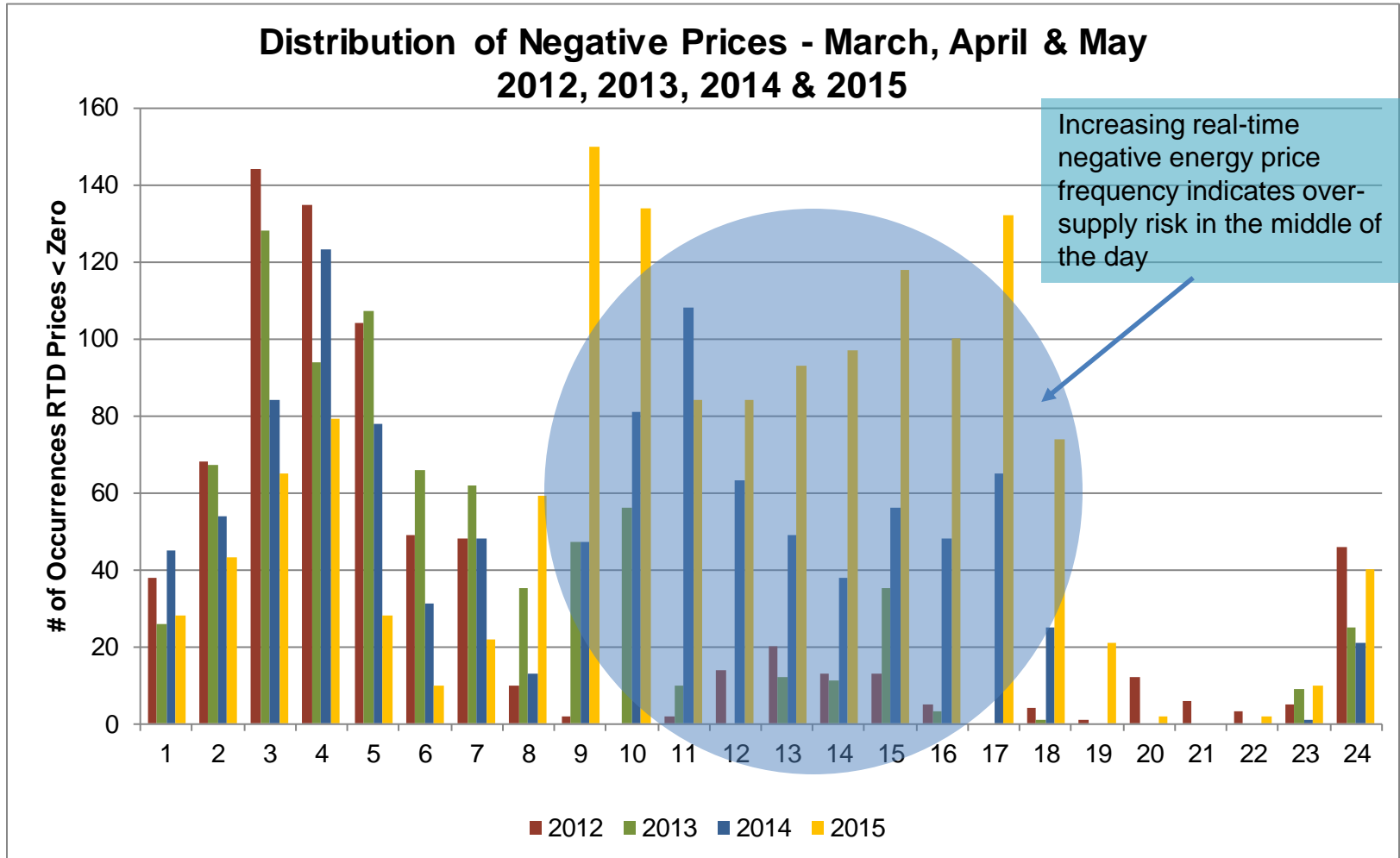


Original estimate of net-load as more renewables are integrated into the grid

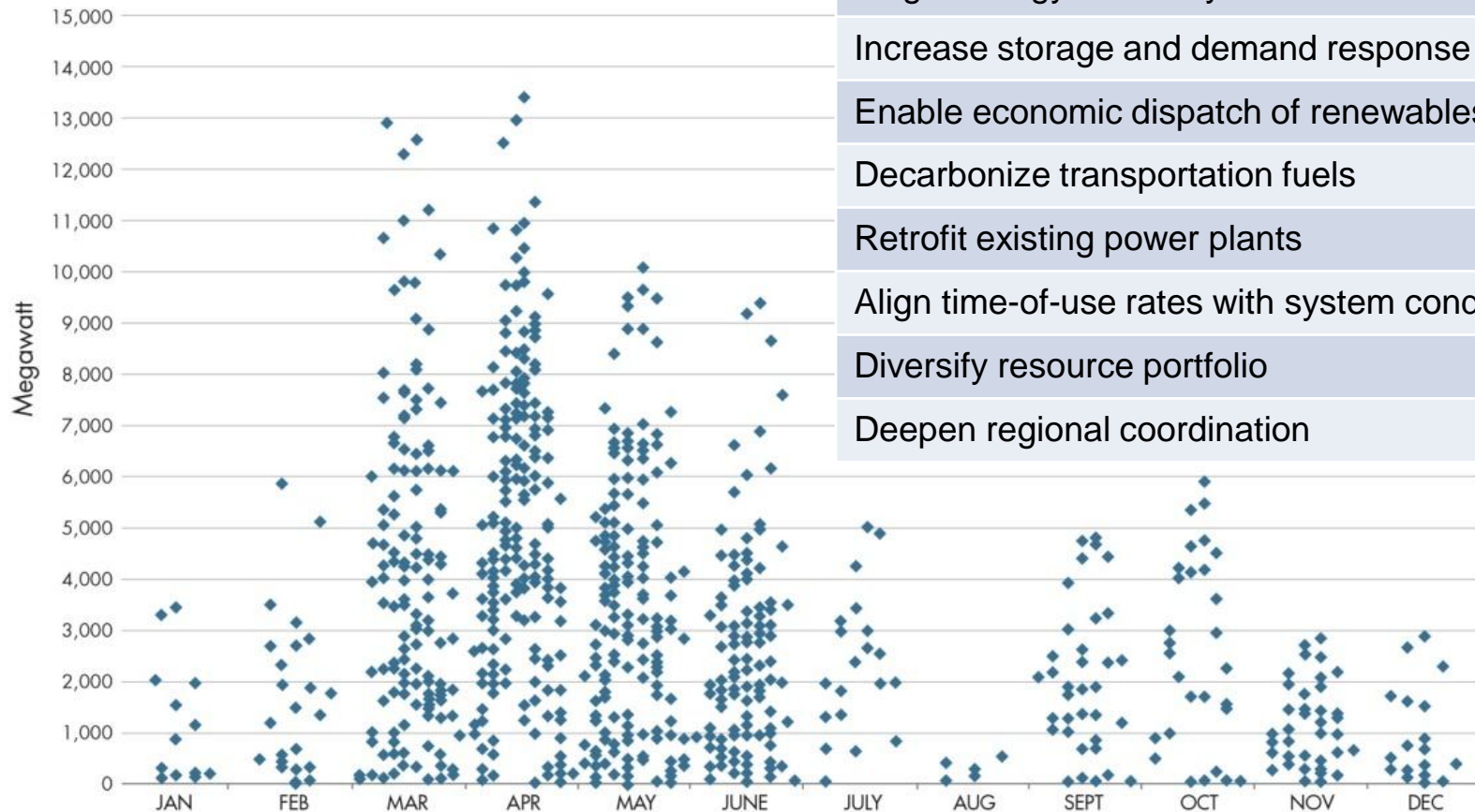
Typical Spring Day



Negative energy prices indicating over-supply risk start to appear in the middle of the day



Renewable curtailment in 2024 at 40% RPS is significant



Solutions

Target energy efficiency

Increase storage and demand response

Enable economic dispatch of renewables

Decarbonize transportation fuels

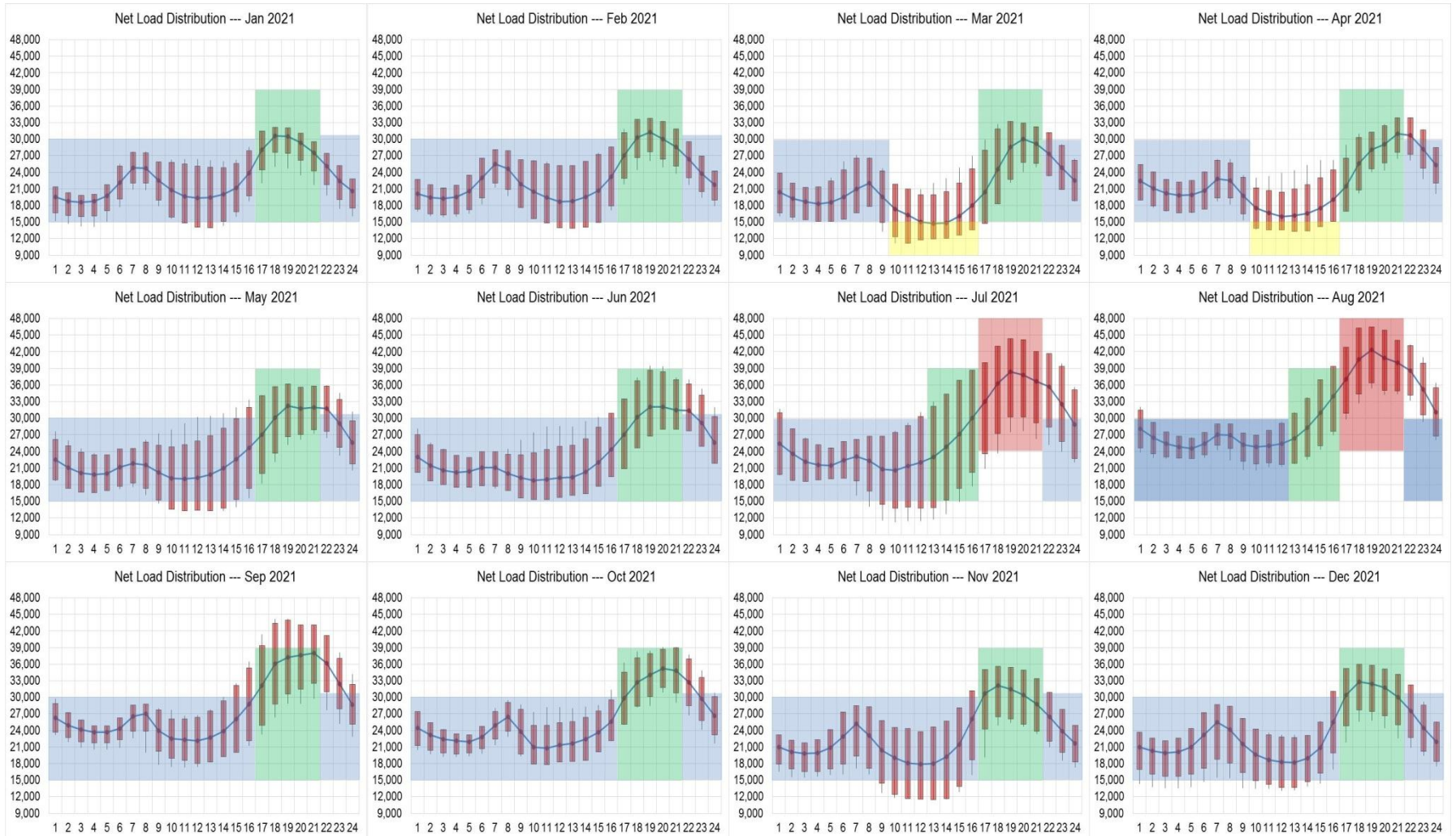
Retrofit existing power plants

Align time-of-use rates with system conditions

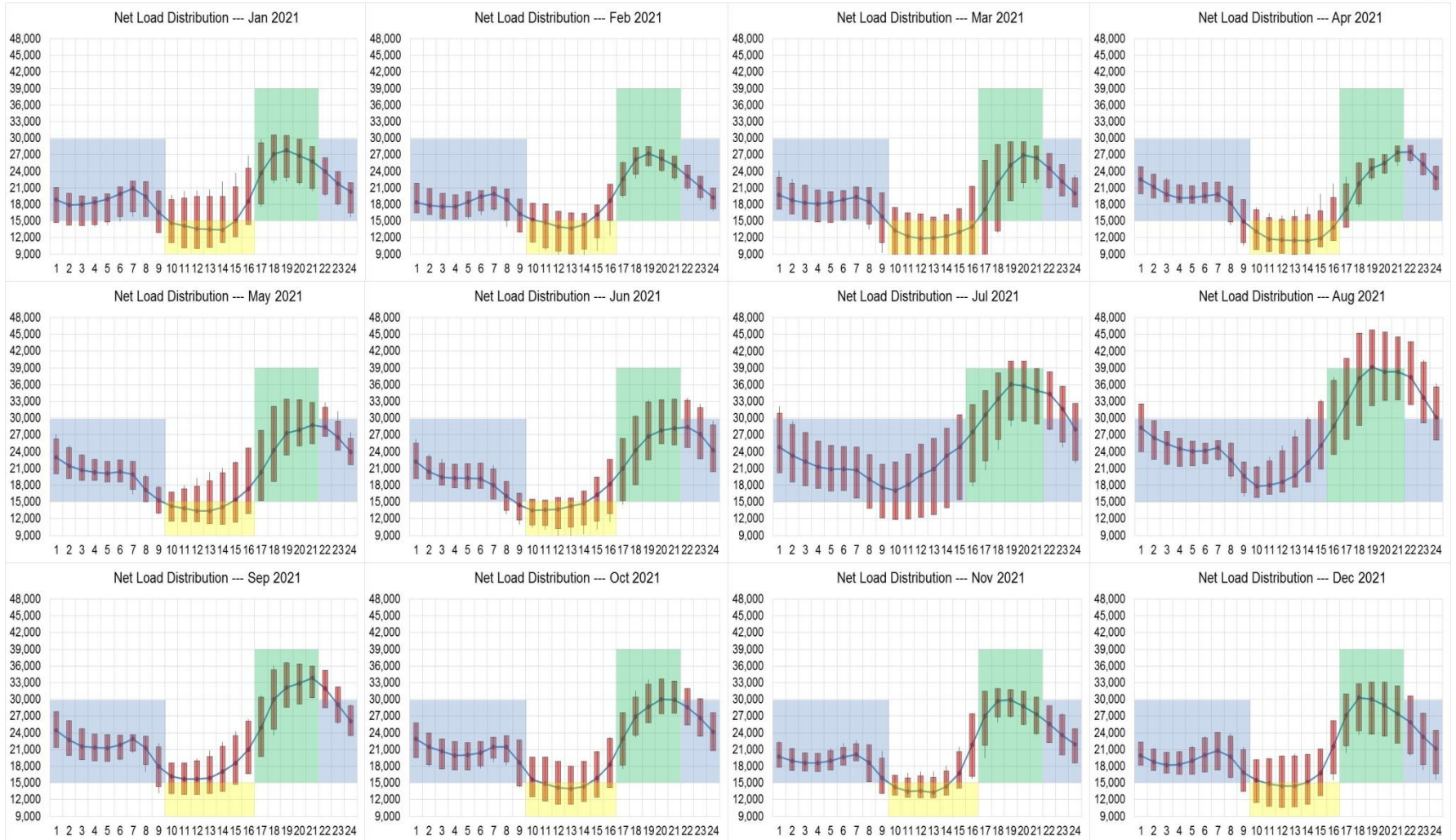
Diversify resource portfolio

Deepen regional coordination

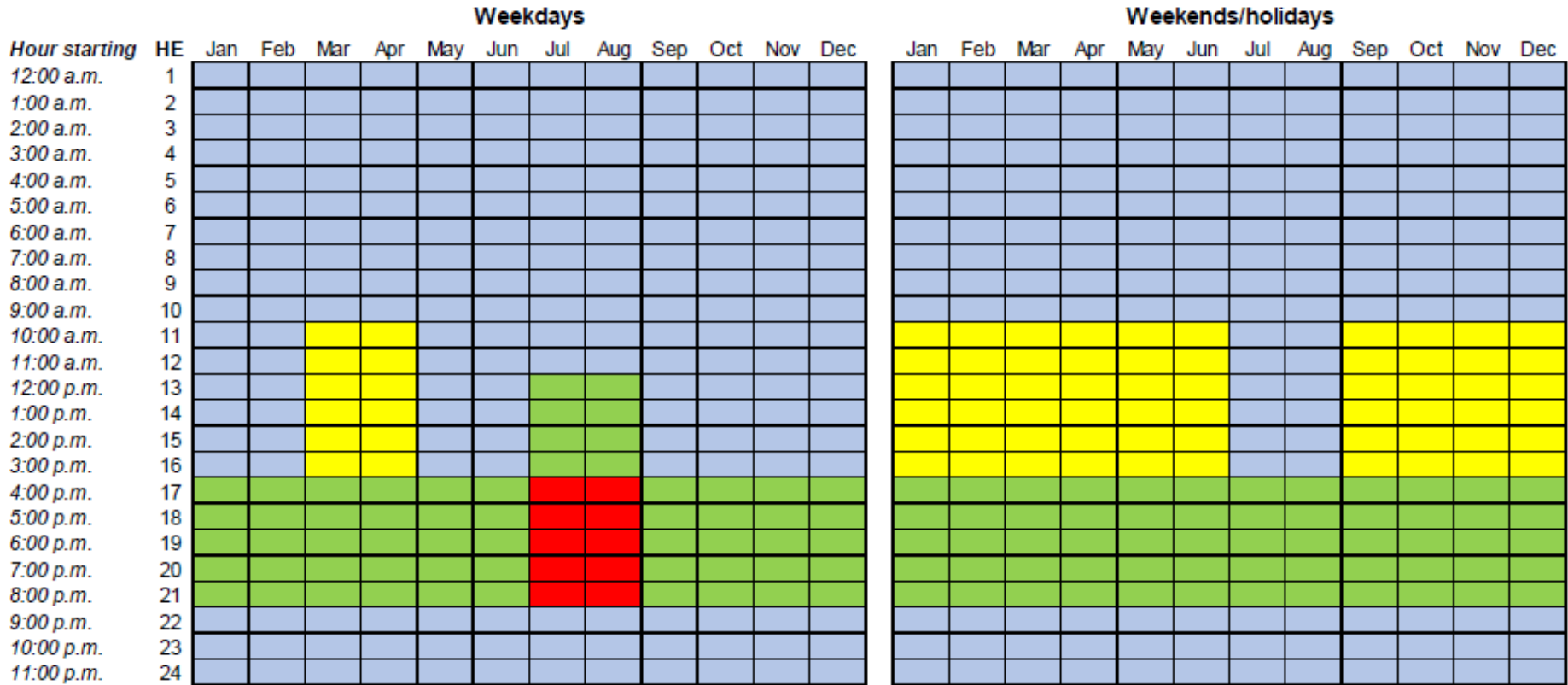
2021 Monthly Net Load Distribution --- Weekdays



2021 Monthly Net Load Distribution --- Weekends



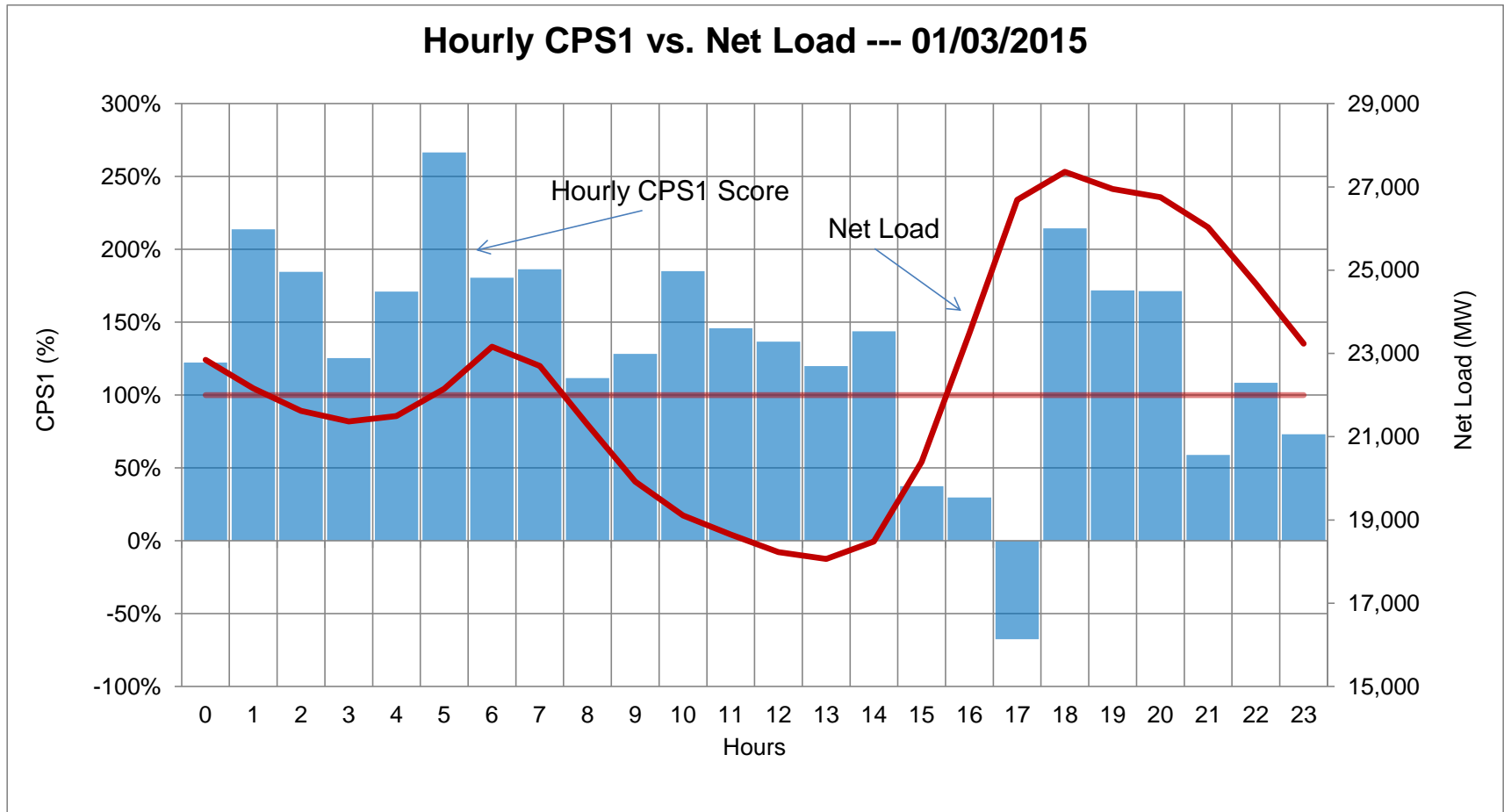
Proposed Weekday and Weekend TOU Periods



■ Super peak
 ■ Peak
 ■ Super off-peak
 ■ Off-peak

Periods were simplified to provide a CAISO system-wide uniform approach and limit variation in peak and off-peak periods.

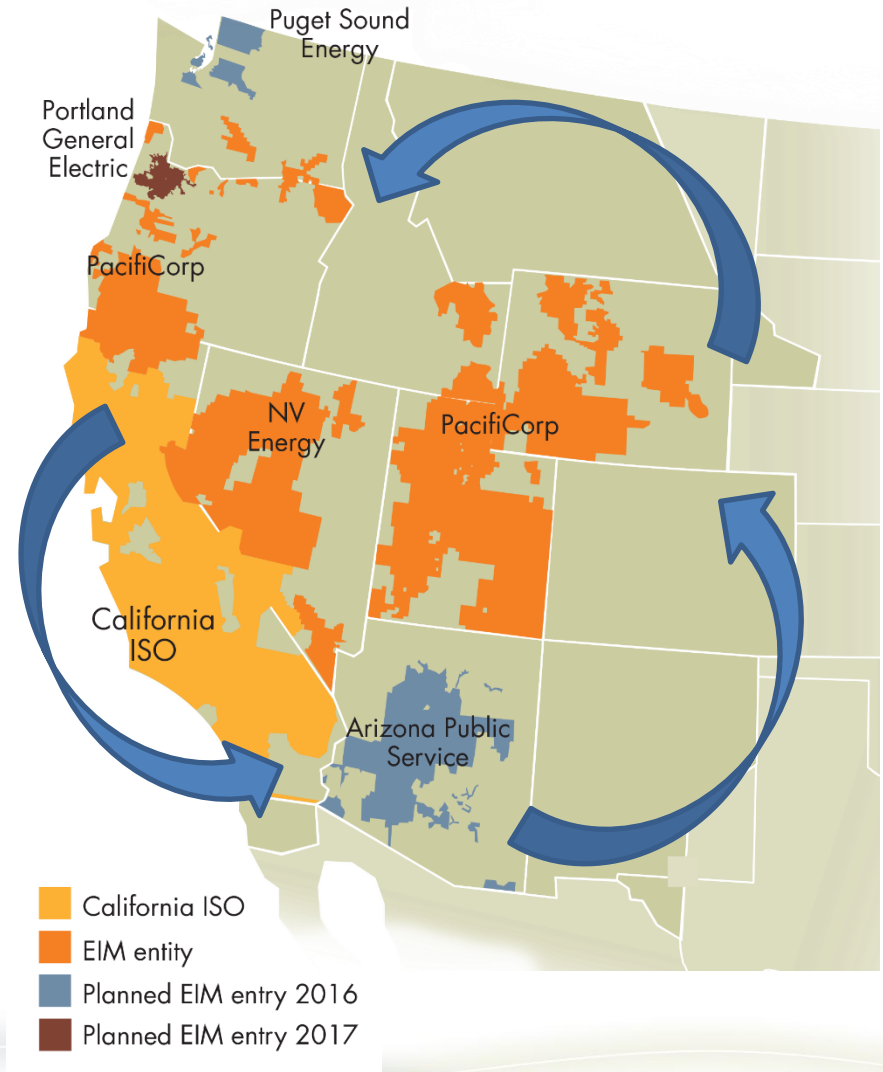
CAISO monitors CPS1 score on an hourly basis to determine hours when CPS1 score drops below 100%



The daily CPS1 score for January 3, 2015 was 134.2%, however it was a challenge meeting the 3-hour net-load ramp beginning hour ending 15

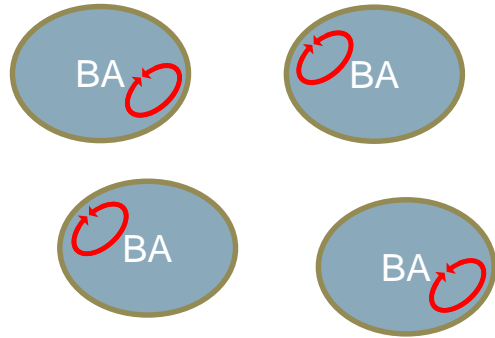
Energy imbalance market (EIM) is an easily-scalable extension of the real-time market to broader region

- Total savings of \$45.69 million through year ending 2015
- 17,776 MWh curtailment avoided, displacing 7,521 metric tons of CO₂.
- Integration of renewables across a larger geographical area
- Enhances reliability with improved situational awareness
- Reduces costs through automatic economic dispatch
- Balancing authorities maintain control and reliability responsibilities



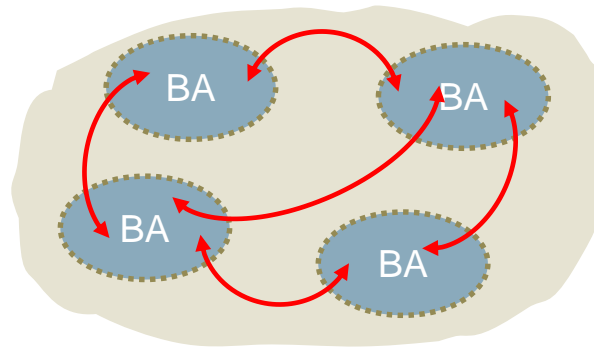
Full participation provides significant benefits beyond those of EIM

Without an EIM:
Each BA must balance supply and demand only within its borders



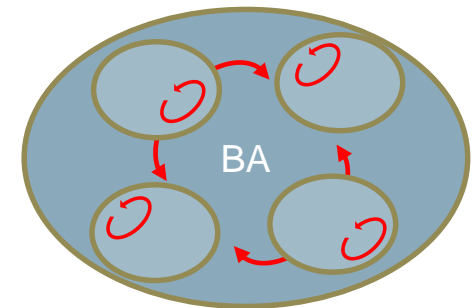
- limited pool of resources to leverage
- decreased flexibility
- must carry more reserves
- limited opportunities to use lowest cost energy
- increased costs to interconnect wind & solar

With an EIM:
Real-time 5- and 15-minute balancing across multiple BAs with lowest cost energy, enables more efficient renewable integration, reduces carbon emissions



- leverages geographic diversity of resources
- increased flexibility
- lower levels of reserves
- more economically efficient
- decreased interconnection costs

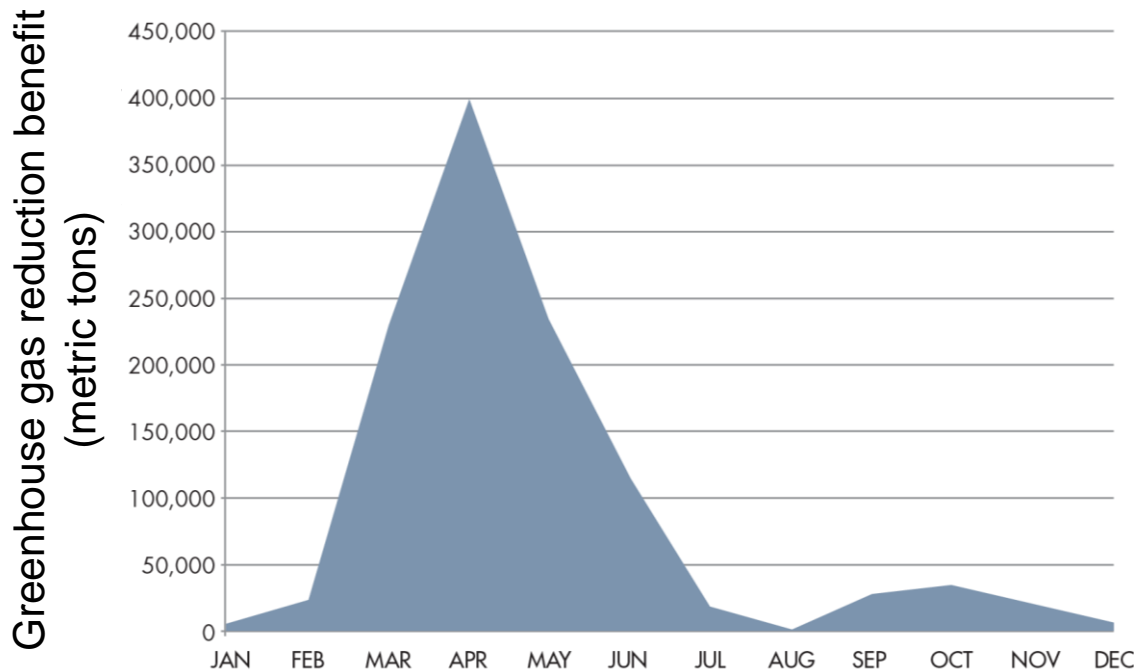
Full Day Ahead Participation:
Advanced planning finds lowest cost resources, renewables in one BA supports demand in another, reduces even more carbon emissions



- reduces costs in all grid operations including renewable integration
- excess generation shared across larger area
- regional planning identifies effective transmission investments
- increases flexibility to meet demand, which strengthens overall grid reliability

A regional grid means power that would have been curtailed can reach customers in other states, which lowers costs and reduces carbon emissions

Carbon Benefit of Eliminating Curtailment At 40% Renewable Portfolio Standard in 2024



- Eliminating 2024 renewable curtailment at a 40% renewable portfolio standard reduces carbon emissions by 1.1 million metric tons per year.
- West-wide coordination at a 50% renewable portfolio standard lowers carbon emissions by an estimated 1.5 million metric tons/year.

SB 350 requires the ISO to prepare proposed governance modifications and to study impacts to a regional market.

- Regional market impact studies (benefits, job impacts, disadvantaged community impacts)
- ISO proposes revised governance structure
- Inter-agency public workshops
- New legislation before governance change may take effect



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<http://www.caiso.com/Pages/TodaysOutlook.aspx>



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