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Renewable Integration Update

Clyde Loutan

Principal, Renewable Energy Integration

2018 IEPR Commissioner Workshop on Renewable Integration and Electric System Flexibility, California Energy Commission

June 20, 2018

STATUS

Industry in the midst of unprecedented change

- Driven by fast-growing mix of interrelated issues

Federal Election Impacts

Existing 50% goal

Gas Storage Challenges

NEW 100% goal

Community Choice

Grid Modernization

Regional Collaboration

Consumer-owned Power

Fossil Plant Retirements

Transmission & Distribution Systems Interface

Sample of operationally notable days with high renewable production

September 1, 2017: Peak demand of 50,116 MW

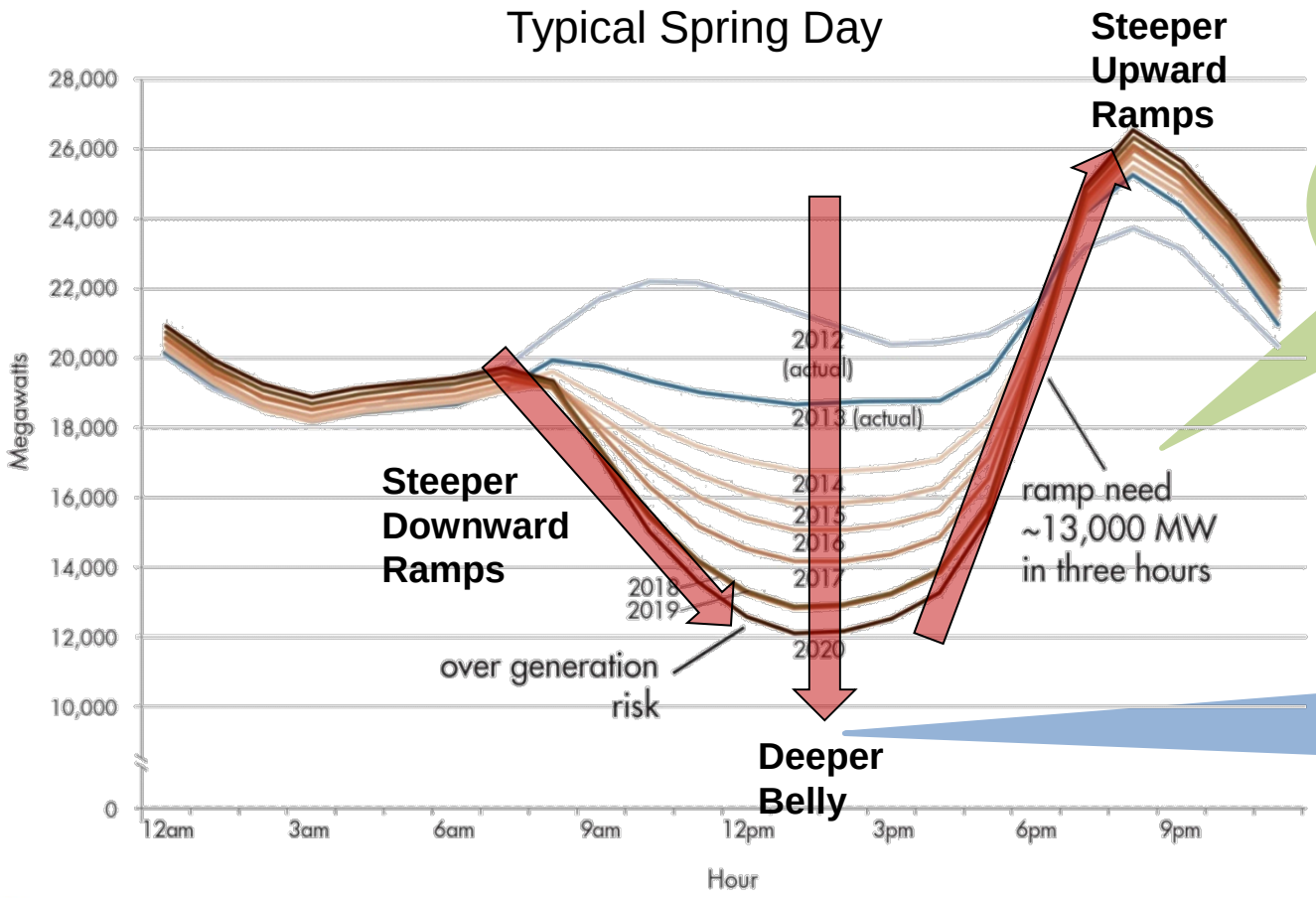
February 18, 2018: Minimum net load 7,149 MW

March 4, 2018: Maximum 3-hour upward ramp 14,777 MW

Maximum 1-hour upward ramp 7,545 MW

May 25, 2018: Maximum demand served by wind/solar was 13,726 MW or 64%

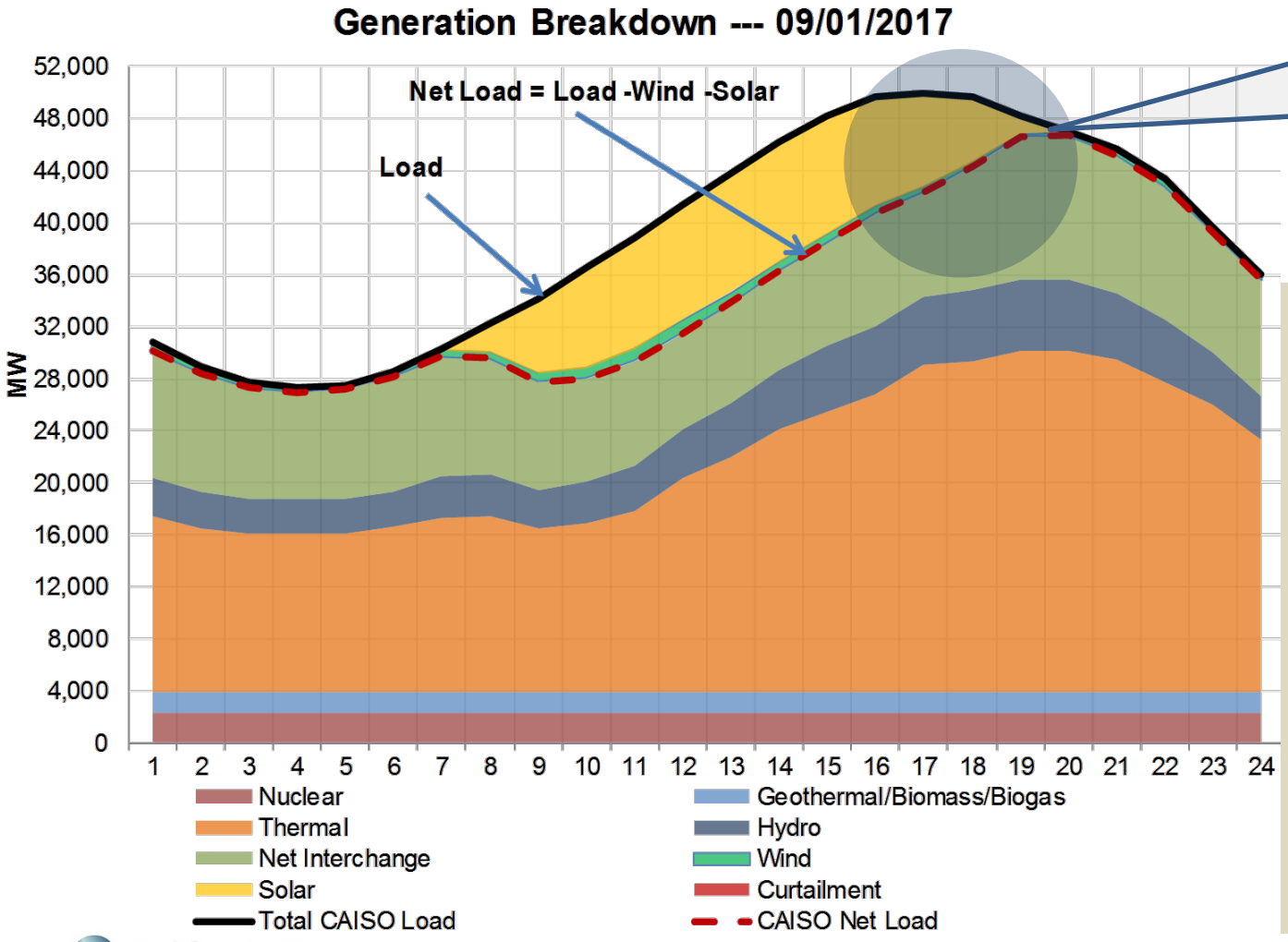
Actual net-load and 3-hour ramps are approximately four years ahead of the ISO's original estimate



Actual 3-hour ramp of 14,777 MW on 3/4/18 *(last year this was 12,960 MW on 12/18/16)*

Net load of 7,149 MW on 2/8/18 *(last year this was 9,187 MW on 4/23/17)*

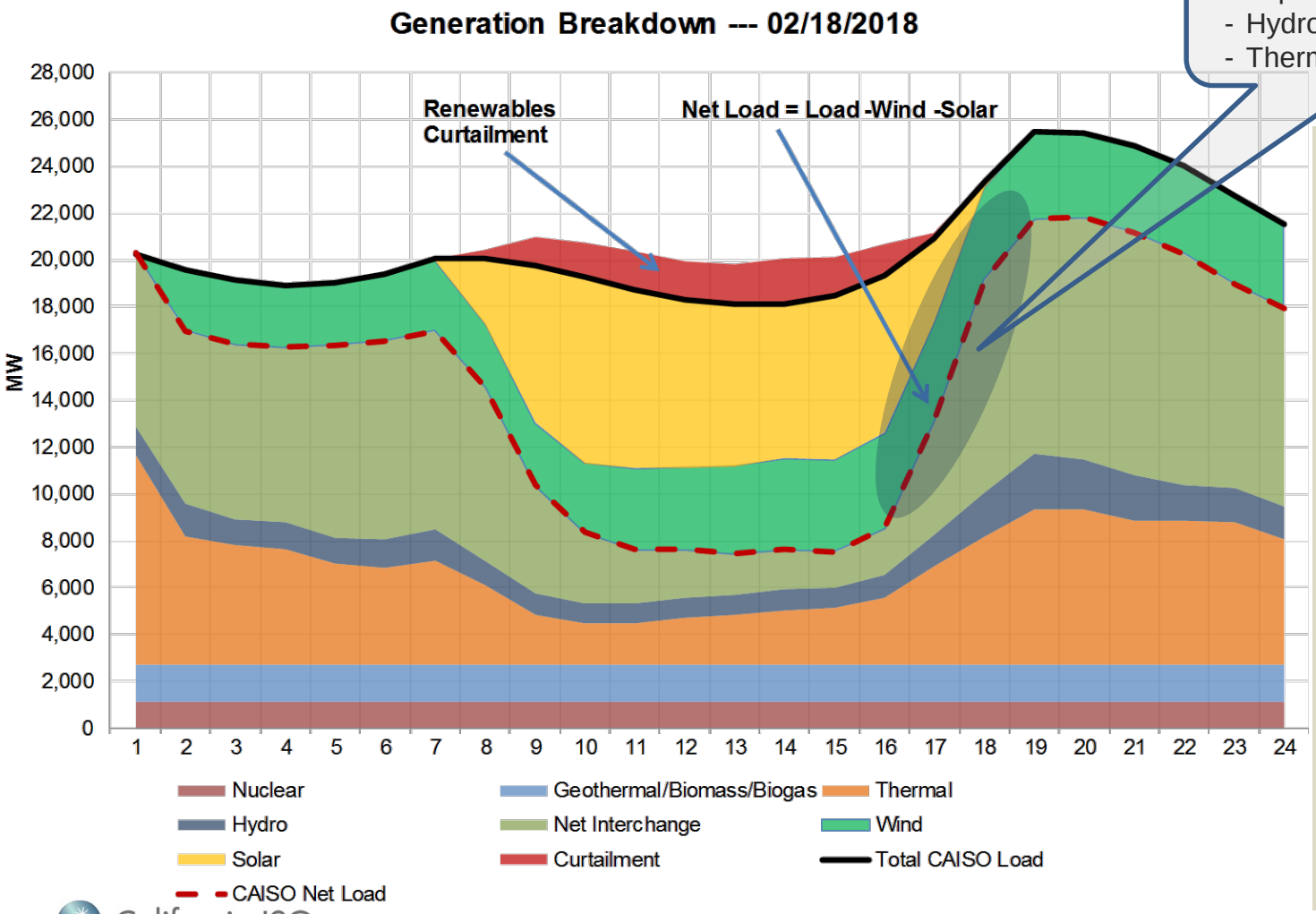
In 2017, the CAISO peak load was 50,116 MW and occurred at 15:58:24 on Friday, September 1



Max net-load of 47,168 MW served by:
Imports: 24%
Hydro: 11%
Thermal: 56%
Other: 9%

- High temperatures along the coast
- Peak Load: 50,116 MW
- Peak net-load: 47,168 MW
- Peak load decreased by 2,948 MW
- Solar production decreased by 7,199 MW
- Net Load increased by 5,301 MW
- Essentially no wind

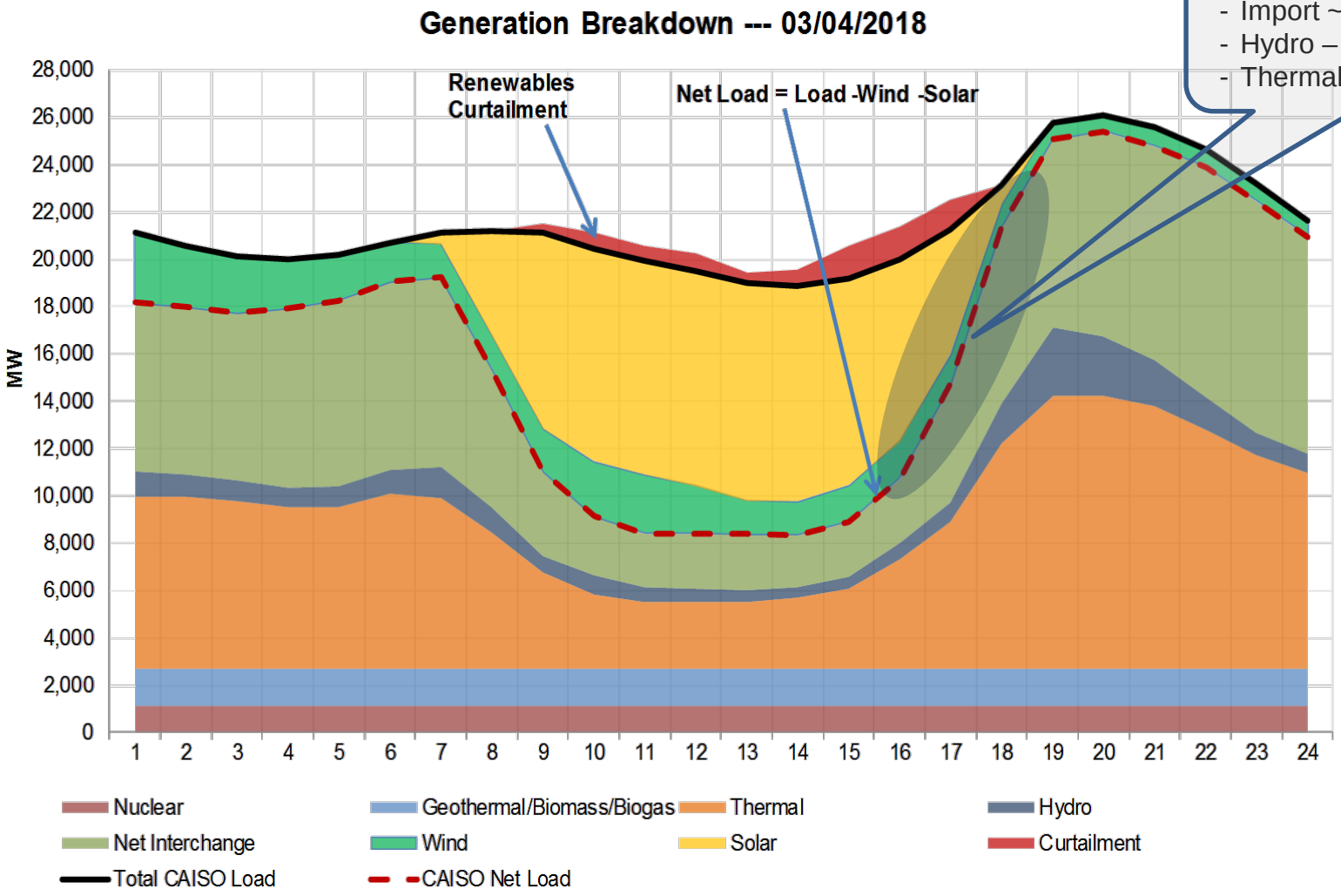
On Sunday, February 18, 2018, the ISO experienced a minimum net-load of 7,149 MW @ 14:06



3-hr, 13,597 MW ramp met by:
- Import ~ 62%
- Hydro – 10%
- Thermal – 28%

- Max renewables curtailed 1,905 MW
- Total curtailment was 9,070 MWh
- Max EIM Export was 2,338 MW
- Diablo Unit 2 was off-line
- One of the biggest challenges during low minimum net-load is the capability to commit internal resources to meet the evening ramp and other AS requirements
- Rely on imports on low net-load days to meet ramps

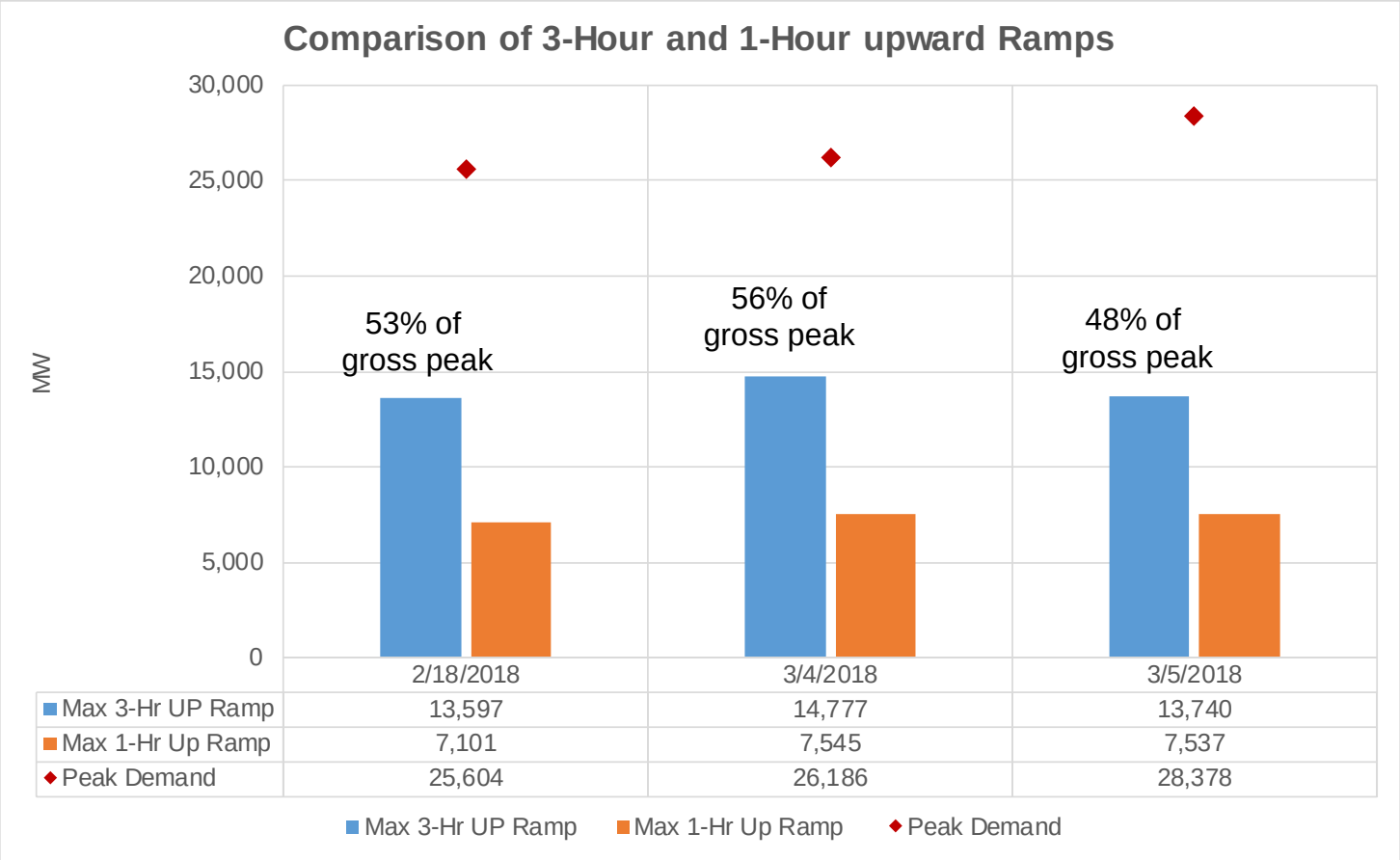
On Sunday, March 4, 2018 the maximum 3-hour upward ramp was 14,777 MW



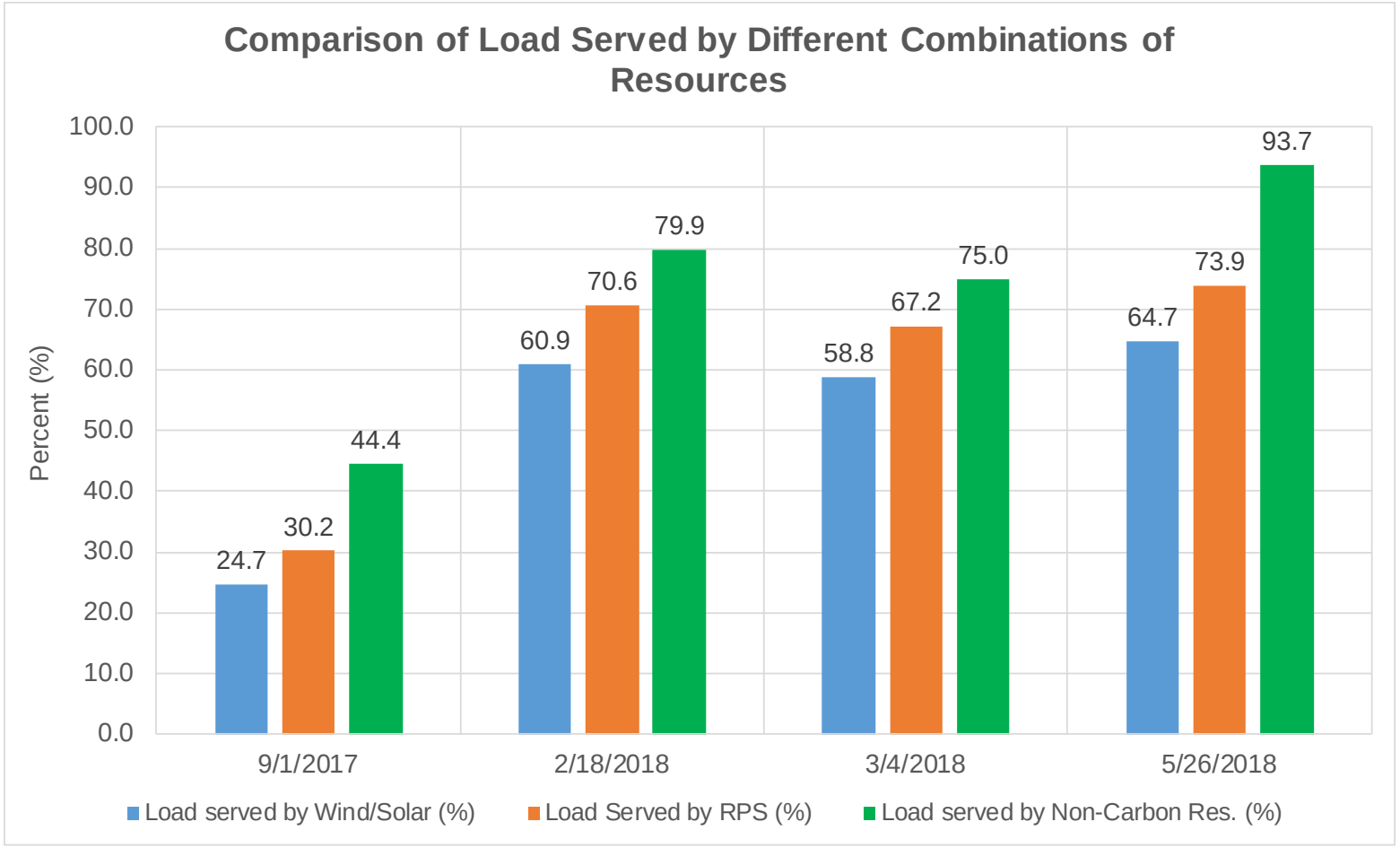
3-hr, 14,777MW ramp met by:
- Import ~ 36%
- Hydro – 15%
- Thermal – 49%

- The CAISO markets economically optimized resources both internally and externally to meet demand
- Imports may or may not be available when needed to meet evening ramps
- Internal resources makes up about 64% of ramp
- Cannot rely on wind to meet ramps

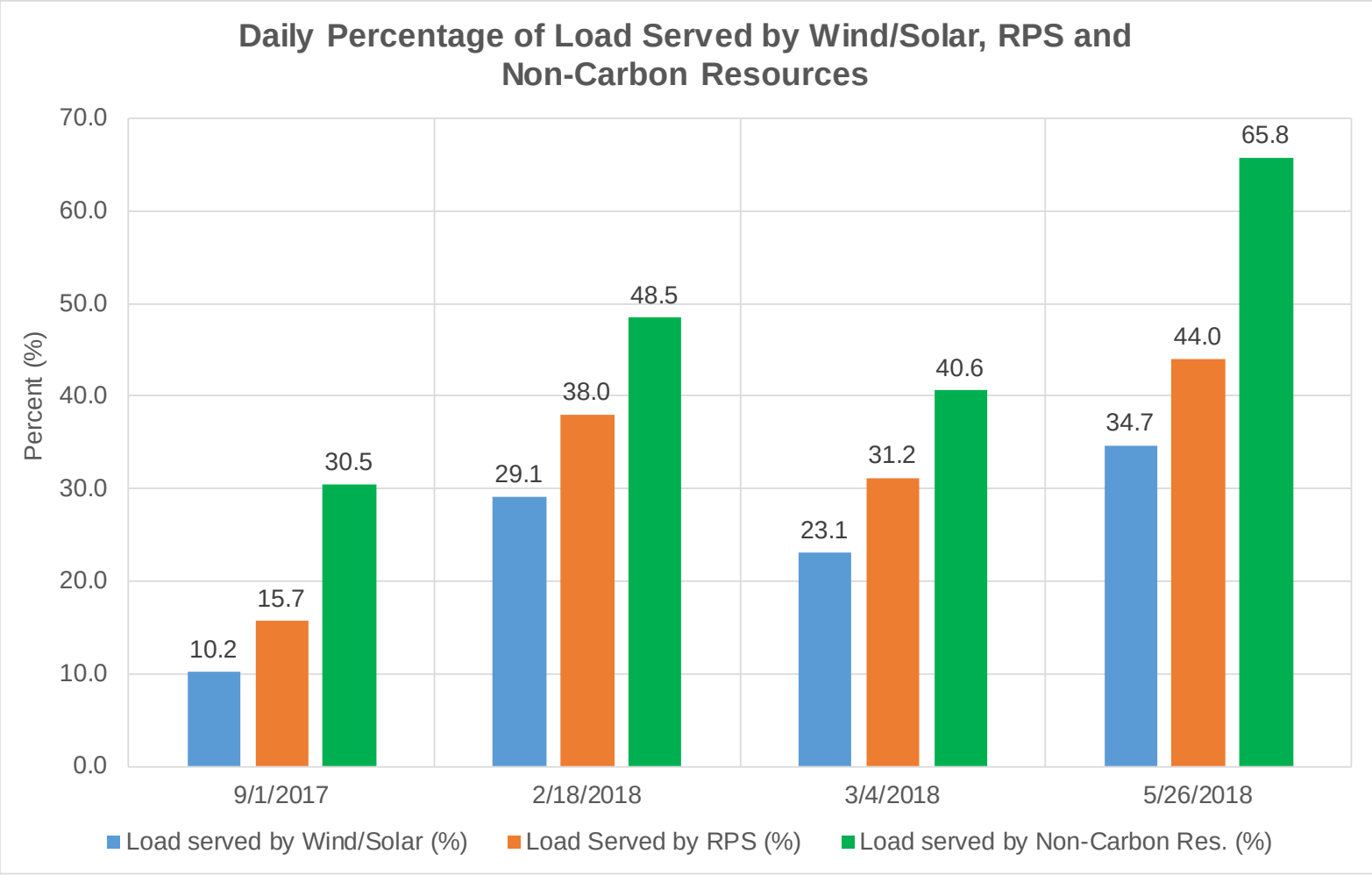
The 3-Hour upward ramps are more than 50% of the daily peak demand, which indicates the need for faster ramping resources



Maximum percentage of 1-minute load served by wind/solar, total RPS and non-Carbon resources

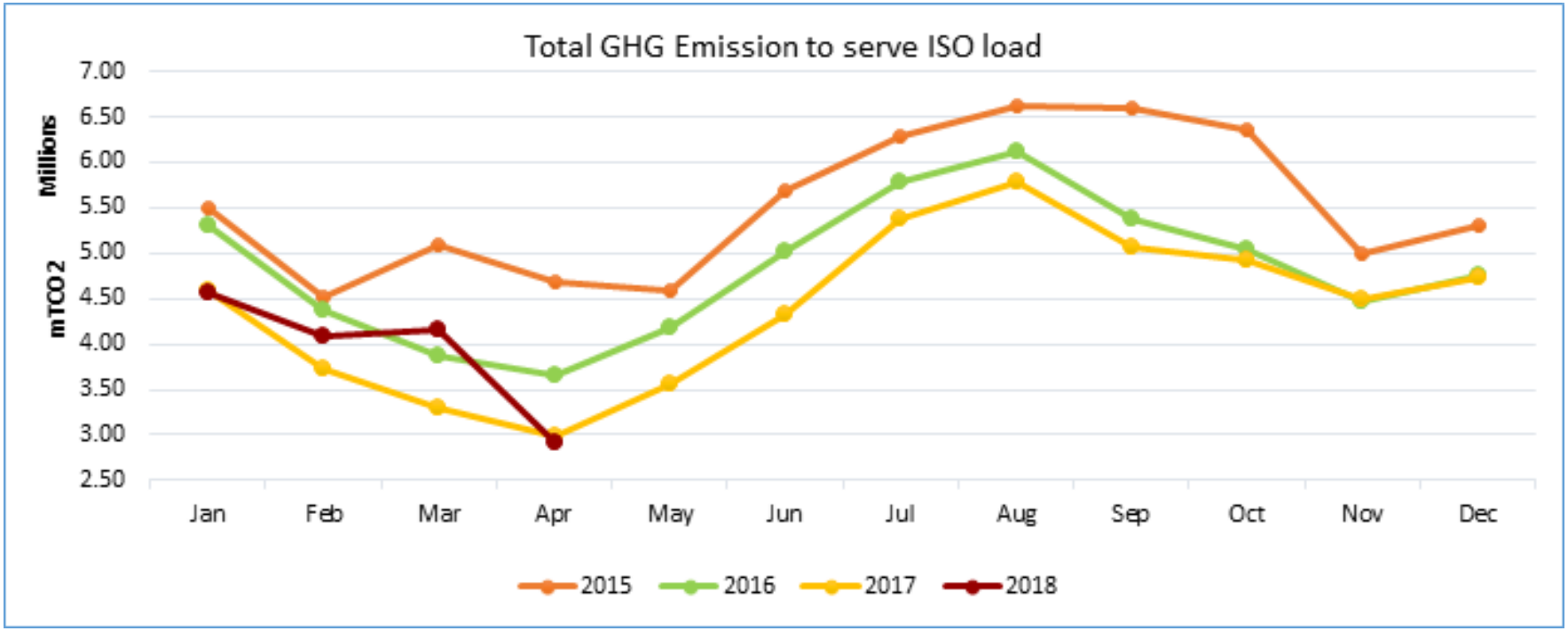


Percentage of daily load served by wind/solar, total RPS and non-carbon resources



Greenhouse gas reductions are occurring as renewables increase

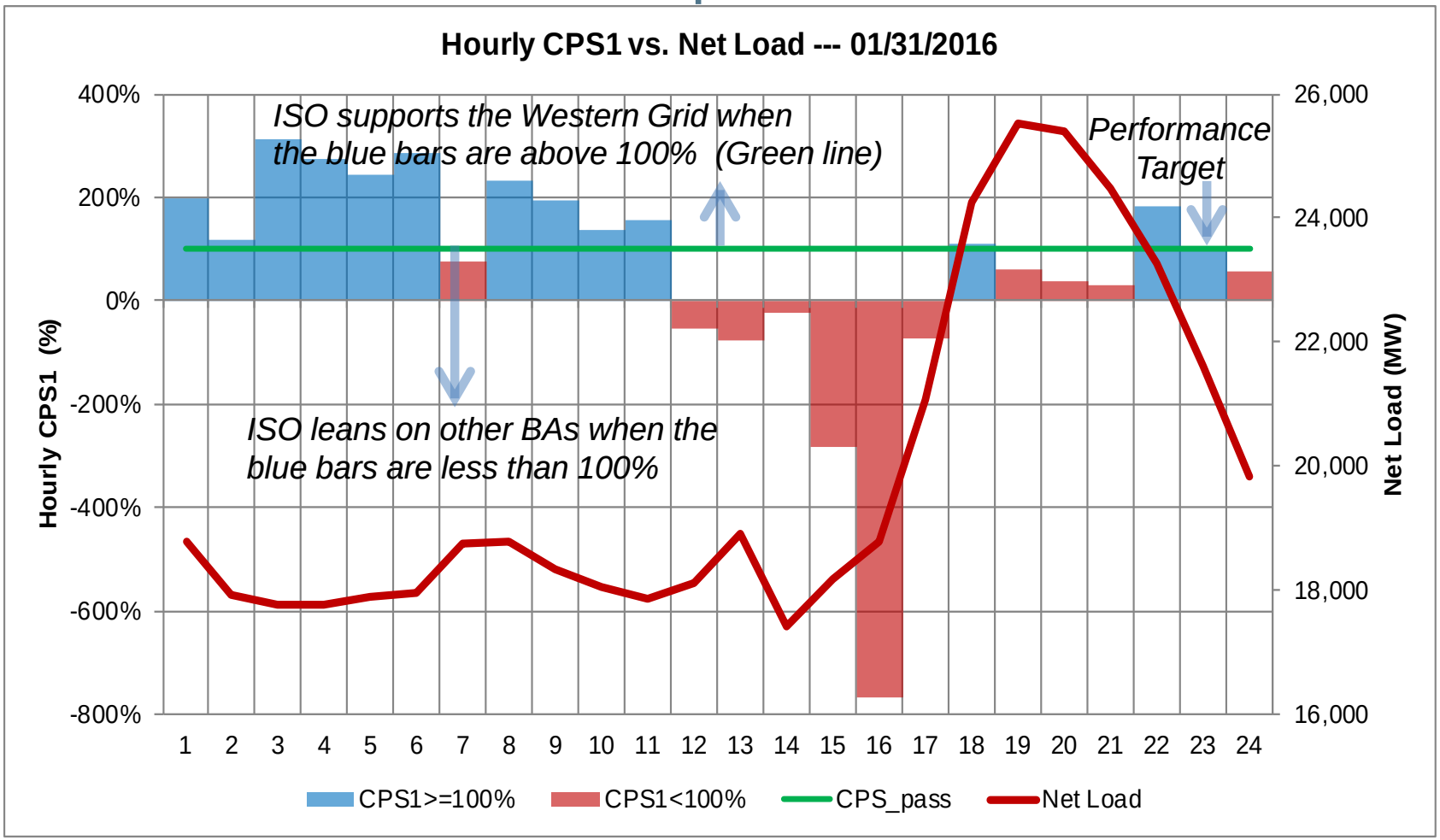
YTD (January - March) million mTCO2	2015	2016	2017	2018
GHG Emission to serve ISO load	19.81	17.22	14.60	15.73



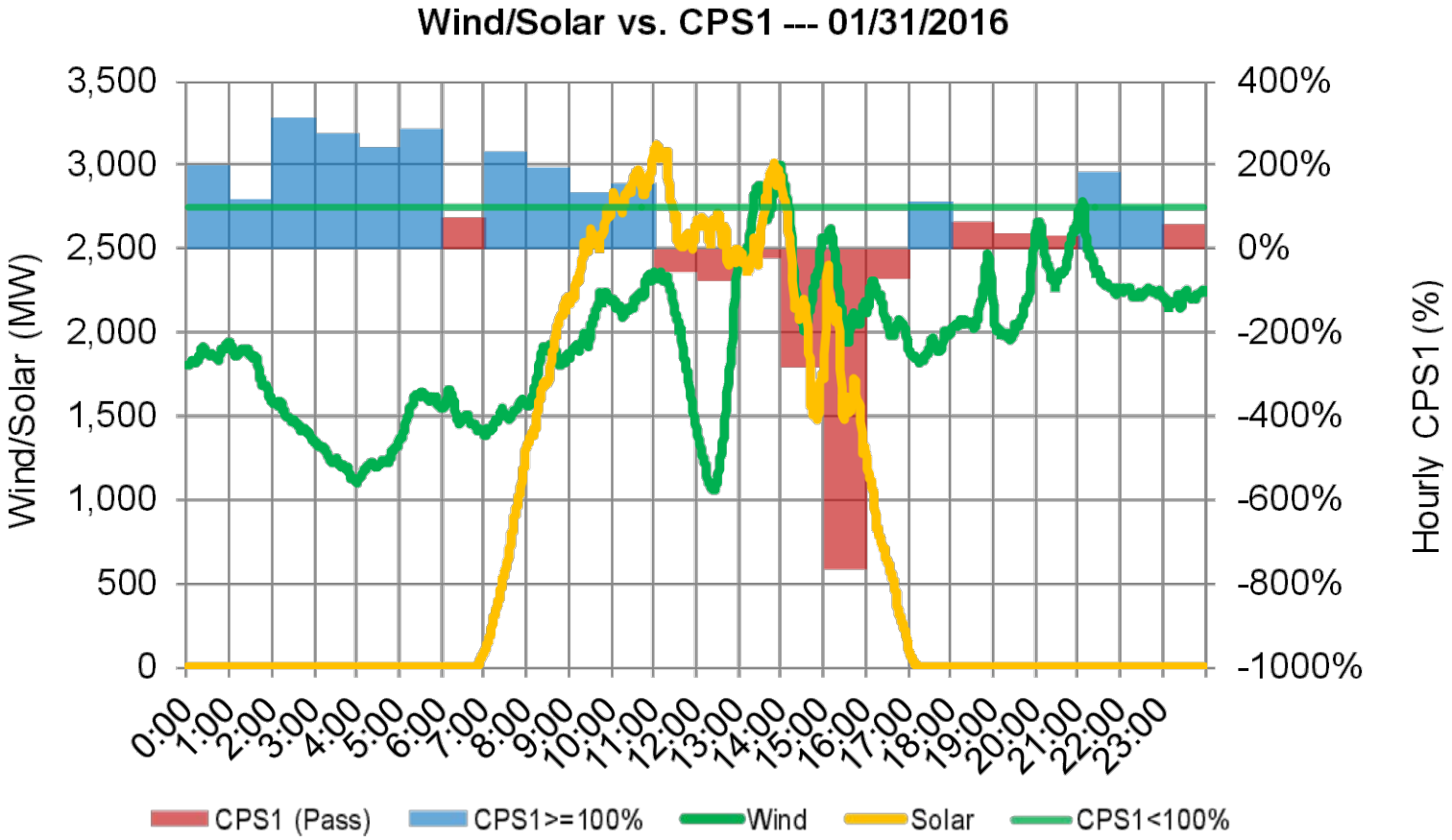
Summary/Observations

- Load reliably served by renewable resources continue to grow
- GHG associated with serving the CAISO load has decreased 24% over the last four years
- Minimum net load continues to drop lower than expected
- Curtailment of renewable resources although low relative to total production is increasing
- Ramps are increasing and present a risk going forward if sufficient ramping capability does not exist
- During spring our reliance on imports and internal gas resources to meet the ramps is significant and creates opportunities for solutions
  - The CAISO relies heavily on imports to meet its ramps during days with low loads and high renewable production
  - During the spring months, at higher net-load levels, the CAISO relies on internal resources to meet its ramps

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

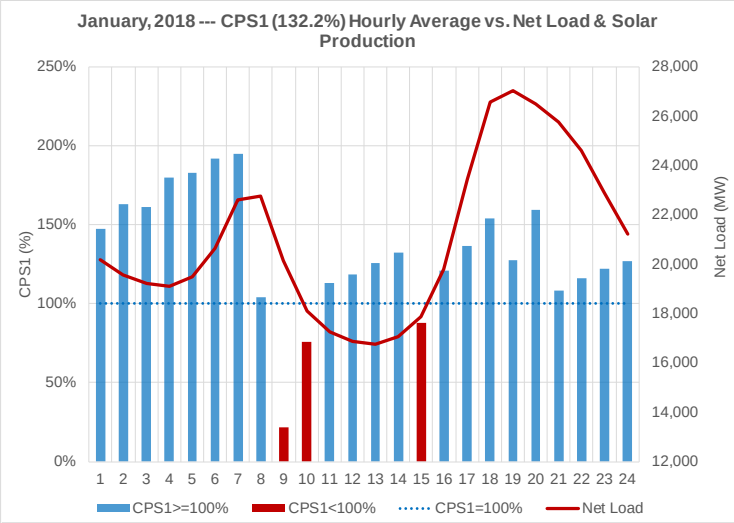


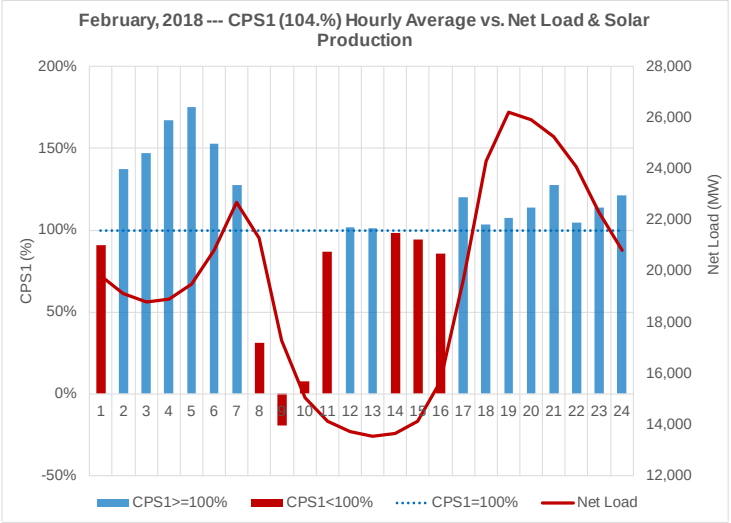
Need to enhance operational performance during periods of increased supply variability

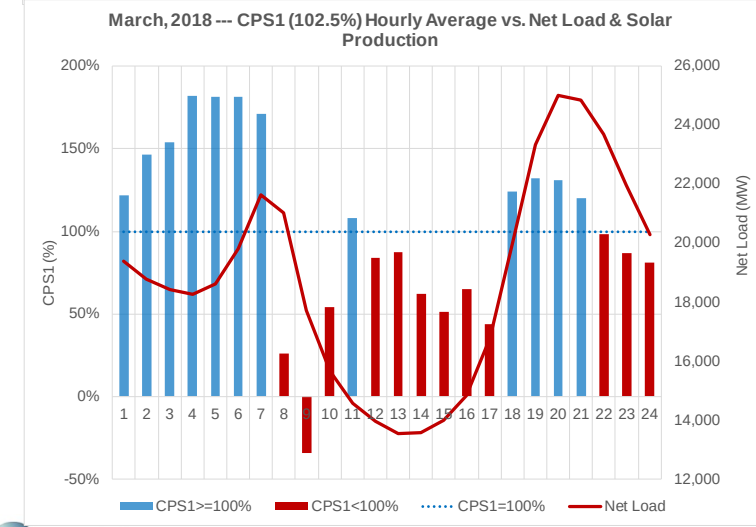


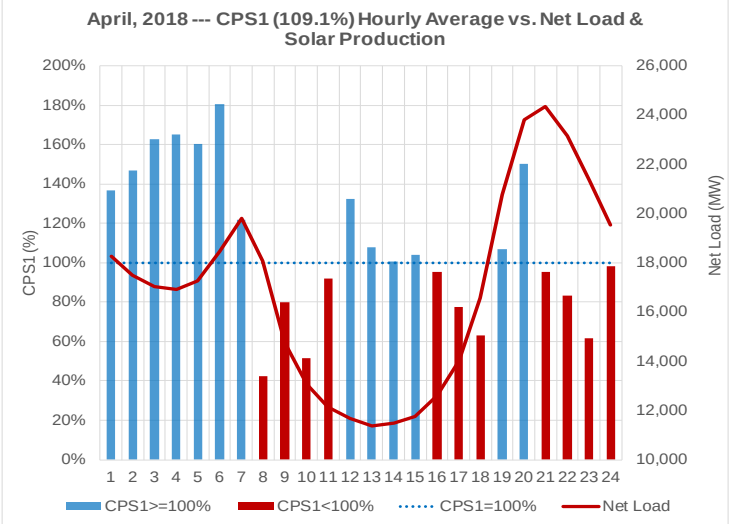
CPS1 is NERC Control Performance Standard 1, which is evaluated on a rolling 12-month average. Over the past few years, the rolling average has been declining as a result of some poor daily performances. Thus, the CAISO need to take measures to enhance daily performance on days with higher variability.

CAISO's average hourly CPS1 for the first four months of 2018 shows operational challenges during net-load ramps



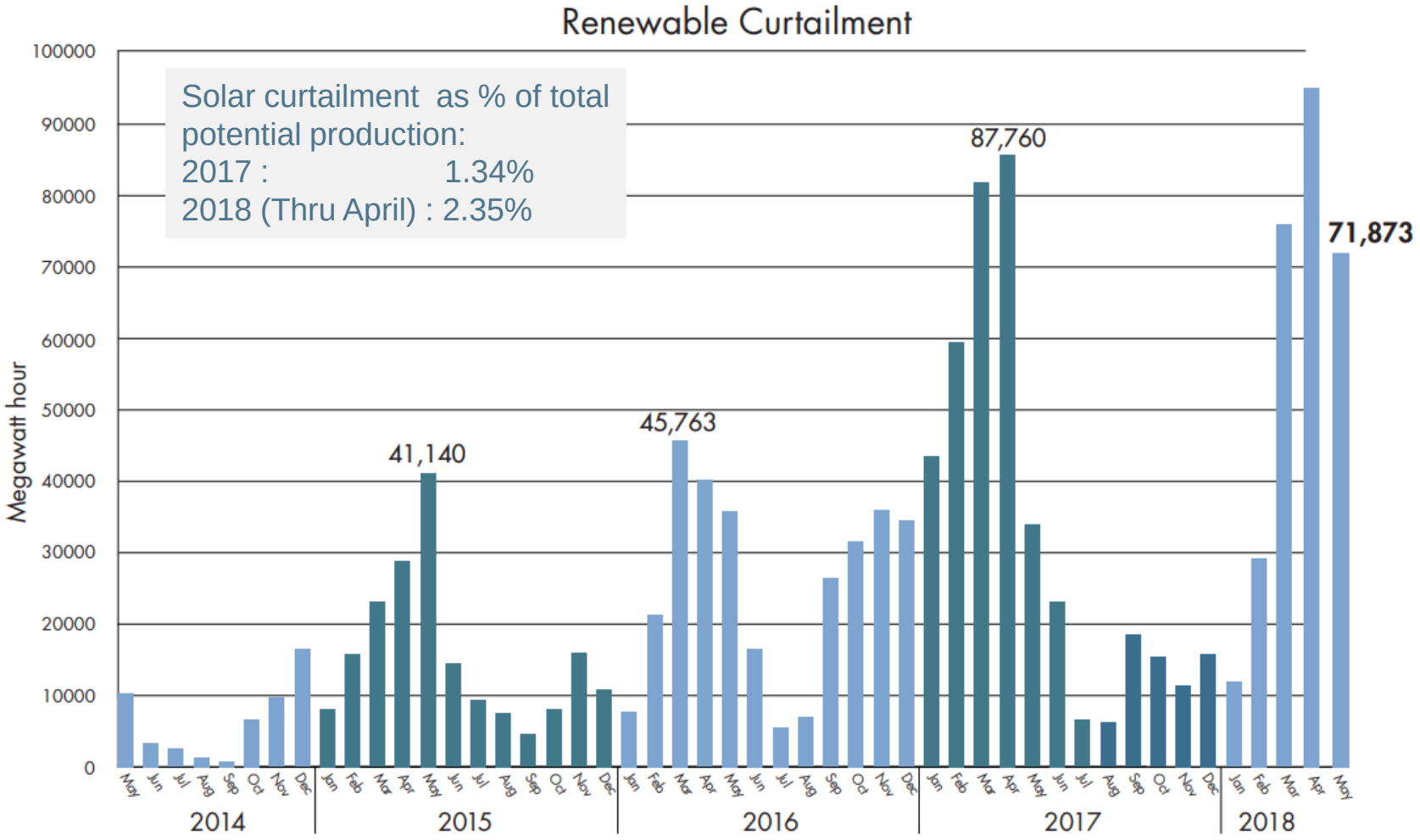




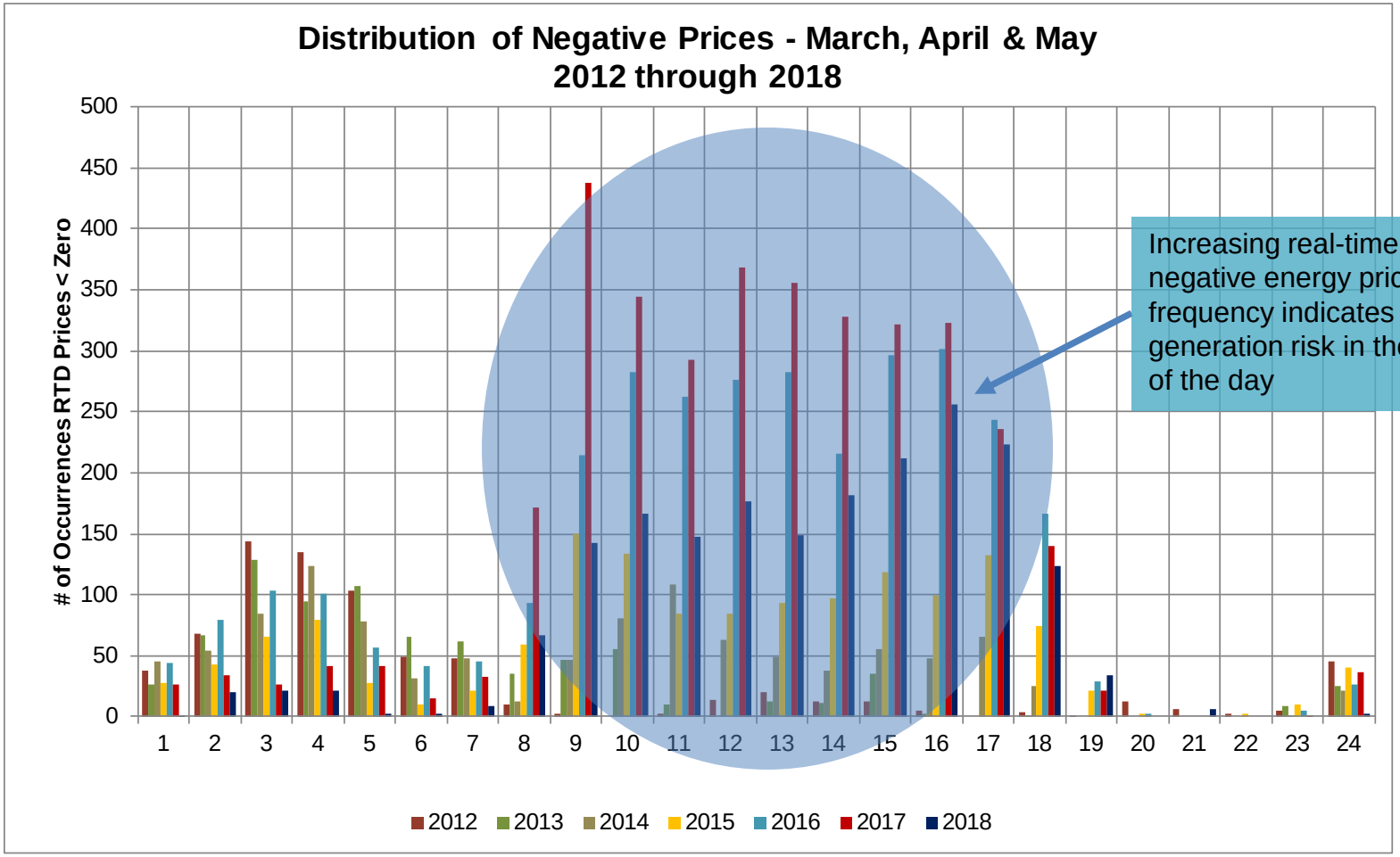


OPPORTUNITIES

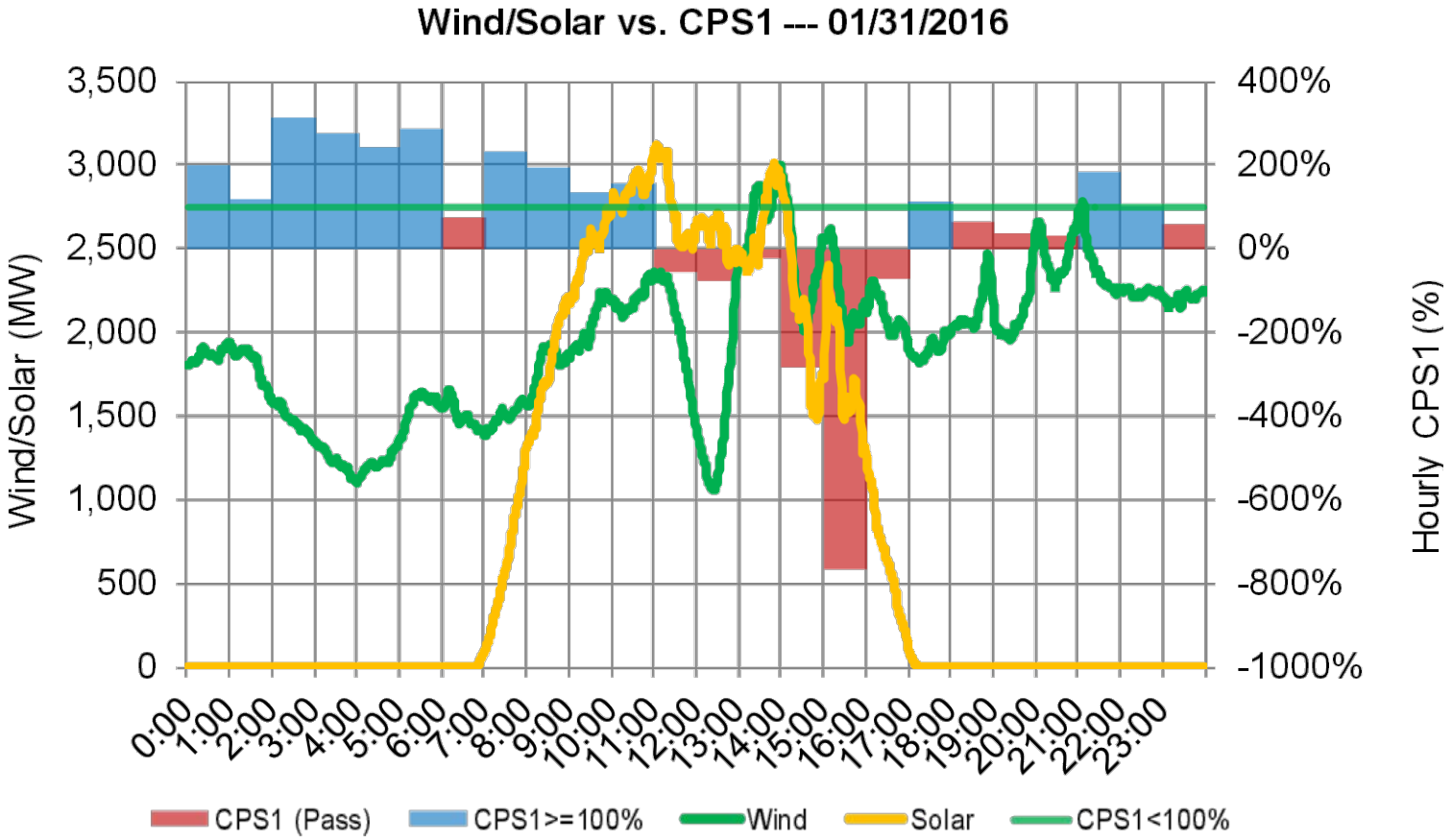
Opportunity 1: Manage oversupply and minimize curtailment



Opportunity 2: New price patterns incentivize innovation in responsive demand and storage



Opportunity 3: Enhance operational performance during periods of increased supply variability



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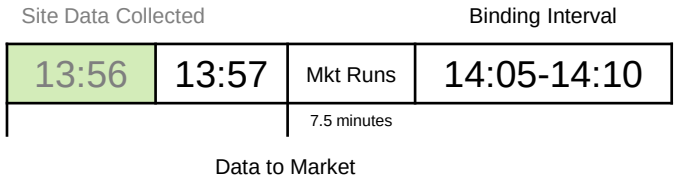
Opportunity 4: Enhance forecasting to manage supply uncertainty

Current:

Persistence Method:

- More recent actuals are used in forecast
- 6+ minutes are eliminated from lag



Forecast calculated in market, eliminating ALFS & processing time needed outside of CAISO

Opportunity 5: Utilizing grid connected VERs to provide essential reliability services

- The CAISO is working with SCE and a solar developer to use an existing solar facility to participate in regulation up/down service
- The CAISO is tentatively scheduled to test a 131 MW wind plant in July 2018 for:
  - Regulation up/down capability
  - Voltage Control
  - Active Power Management Capability,
  - Frequency response
  - Inertia Capability

SOLUTIONS

A suite of solutions including VERs will be necessary

Storage – increase the effective participation by energy storage resources.

Western EIM expansion – expand the western Energy Imbalance Market.

Demand response – enhance DR initiatives to enable adjustments in consumer demand, both up and down, when warranted by grid conditions.

Regional coordination – offers more diversified set of clean energy resources through a cost effective and reliable regional market.

Time-of-use rates – implement time-of-use rates that match consumption with efficient use of clean energy supplies.

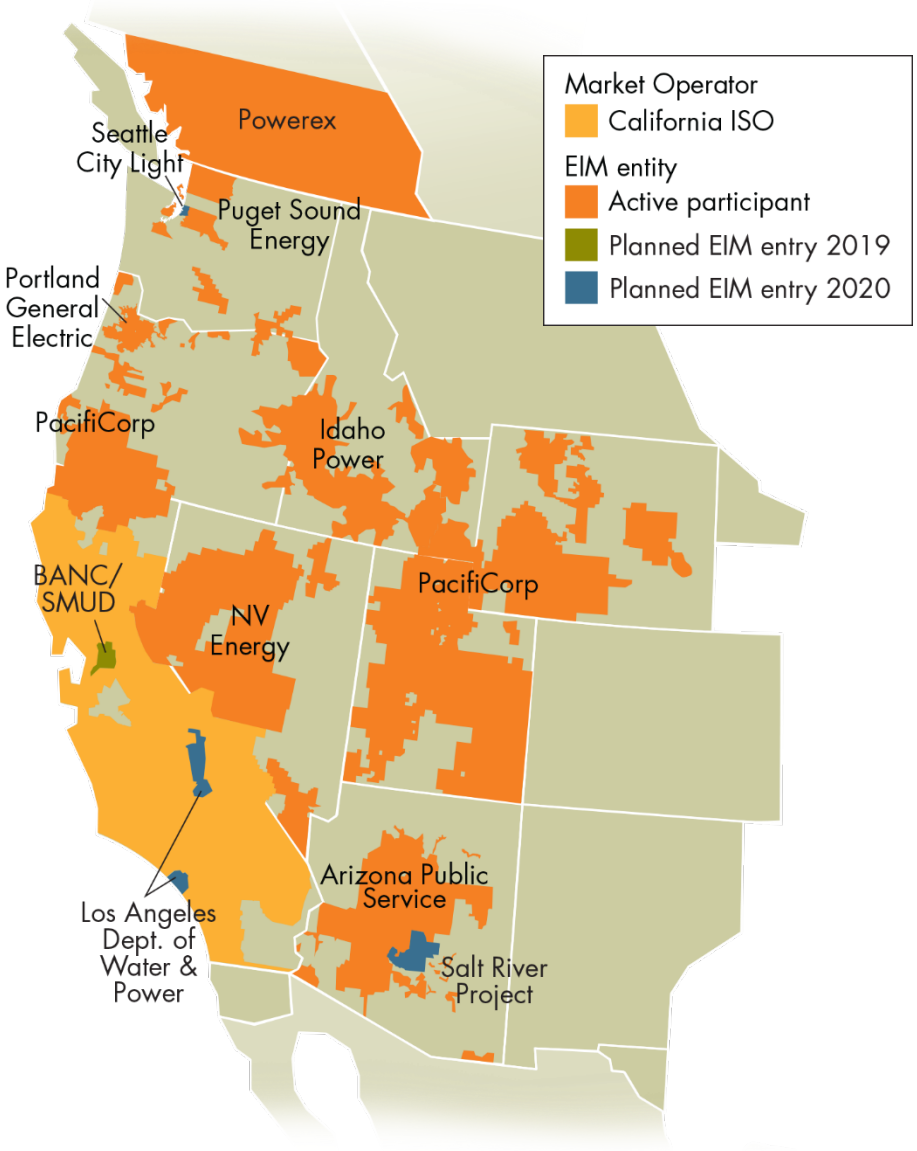
Electric vehicles – incorporate electric vehicle charging systems that are responsive to changing grid conditions.

Minimum generation – explore policies to reduce minimum operating levels for existing generators, thus making room for more renewable production.

Flexible resources – invest in modern, fast-responding resources that can follow sudden increases and decreases in demand.

Western Energy Imbalance benefits: $331 million

- Entities now in the implementation phase
  - ~ BANC/SMUD & Seattle City Light – Spring 2019
  - ~ Salt River Project, Seattle City Light, Los Angeles Department of Water & Power (LADWP) – Spring 2020
- Entities exploring future entry
  - ~ CENACE, Baja California, Mexico



Energy imbalance market helps avoid curtailment