



California ISO

# Briefing on renewables and recent grid operations

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## Sample of operationally notable days with high renewable production

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

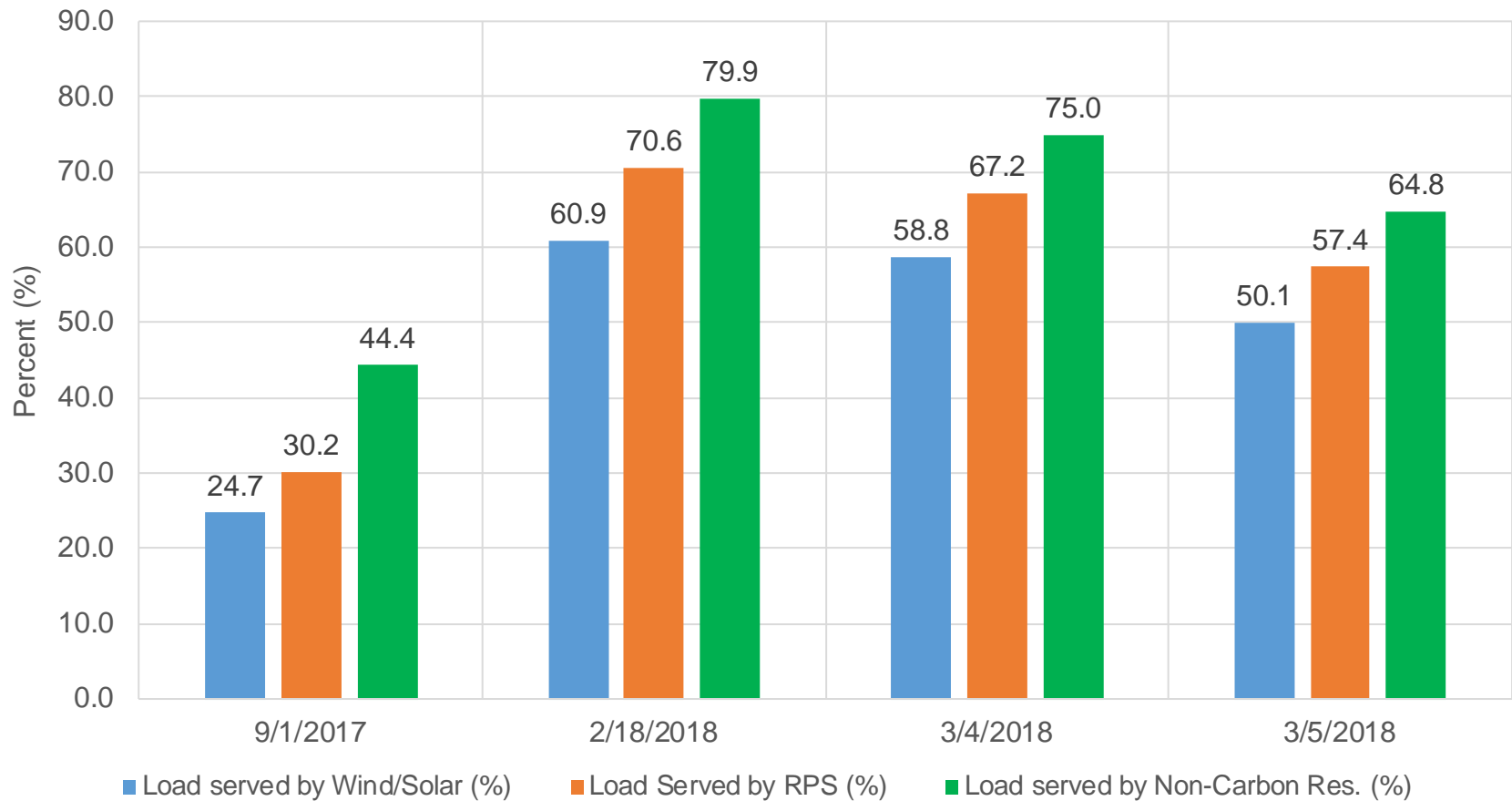
February 18, 2018: Minimum net load 7,149 MW

March 4, 2018: Maximum 3-hour upward ramp 14,777 MW  
Maximum 1-hour upward ramp 7,545 MW

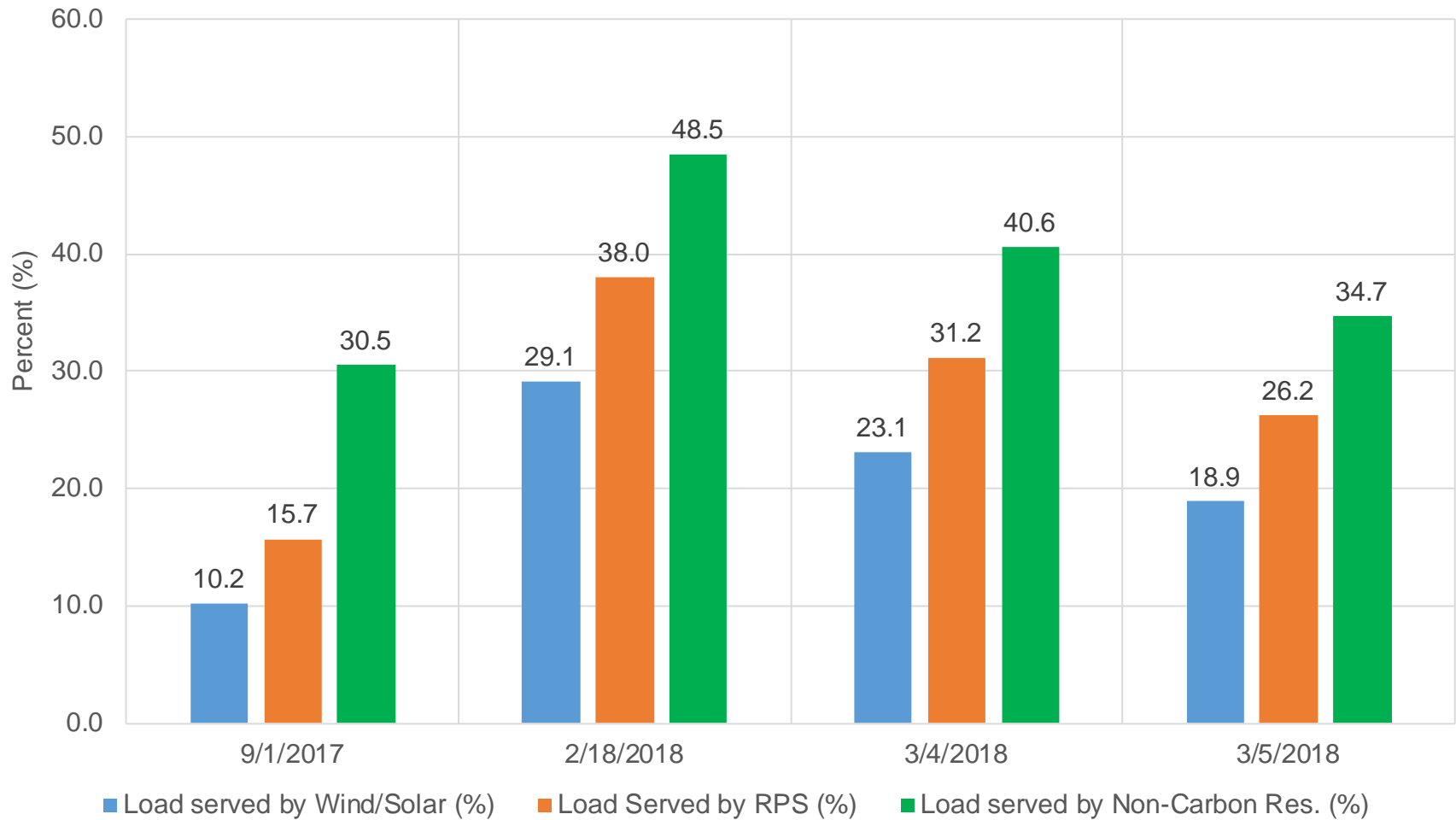
March 5, 2018: Maximum solar production 10,409 MW

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

## Comparison of Load Served by Different Combinations of Resources

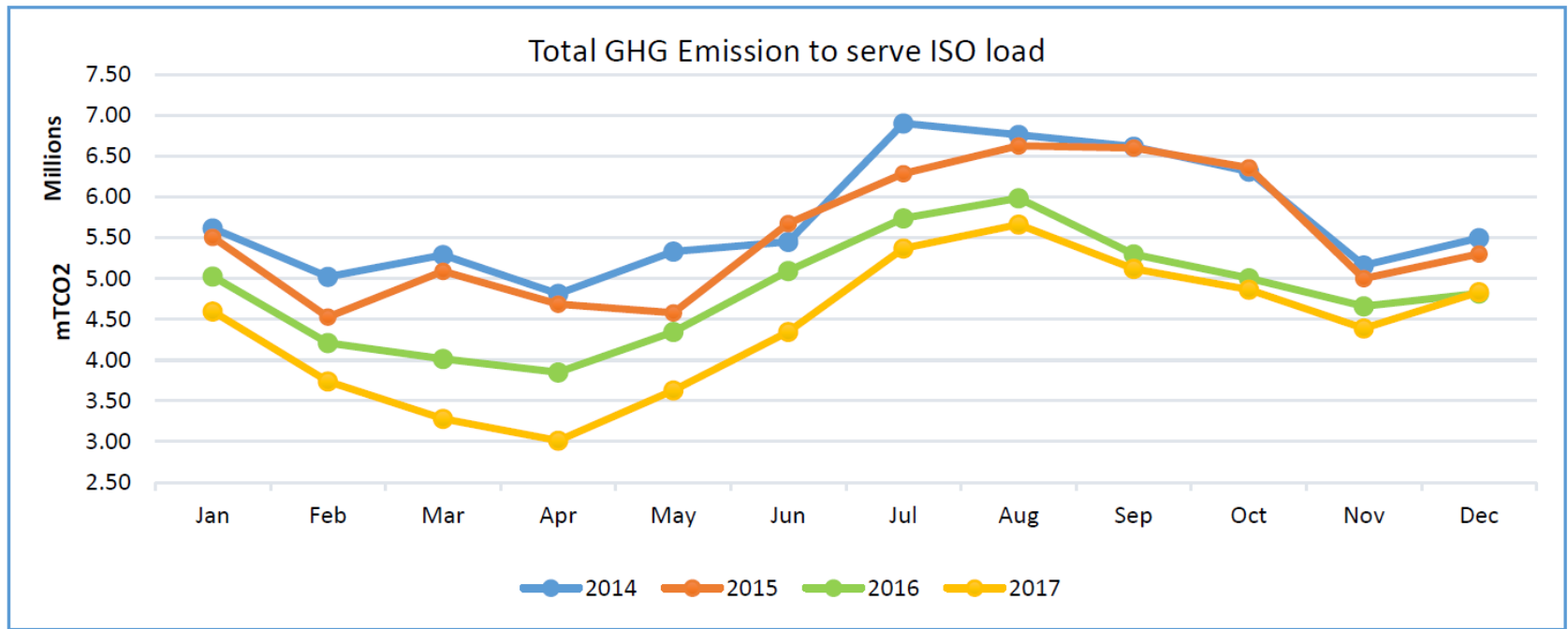


# Percentage of daily load served by wind/solar, total RPS and non-carbon resources



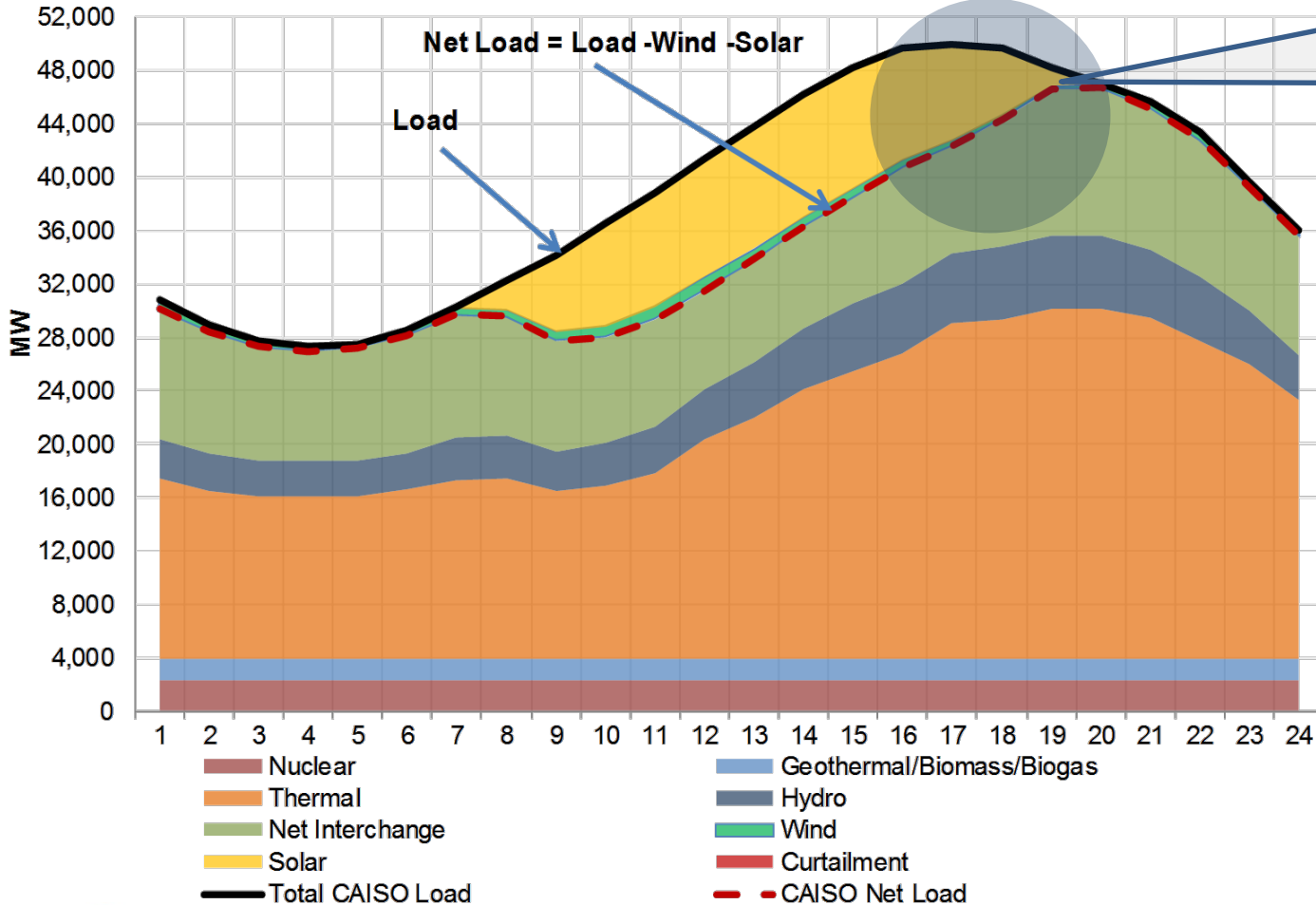
# ISO GHG emissions reduced by 23% since 2014

YTD (January - December) million mTCO <sub>2</sub>	2014	2015	2016	2017
GHG Emission to serve ISO load	68.78	66.24	58.05	52.85



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

**Generation Breakdown --- 09/01/2017**

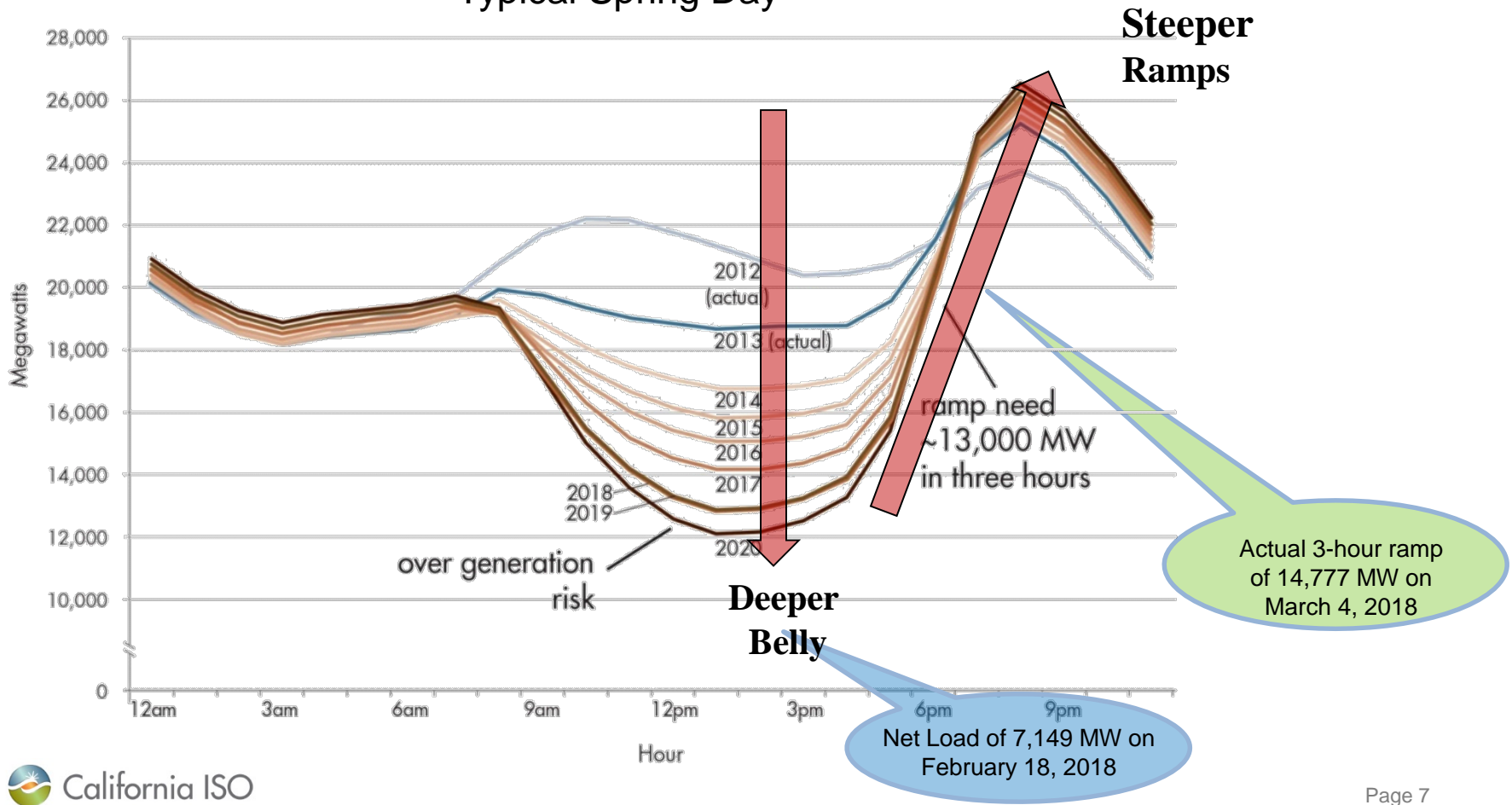


Max net-load of 47,168 MW served by:  
 Imports: 24%  
 Hydro: 11%  
 Thermal: 56%  
 Other: 9%

- 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

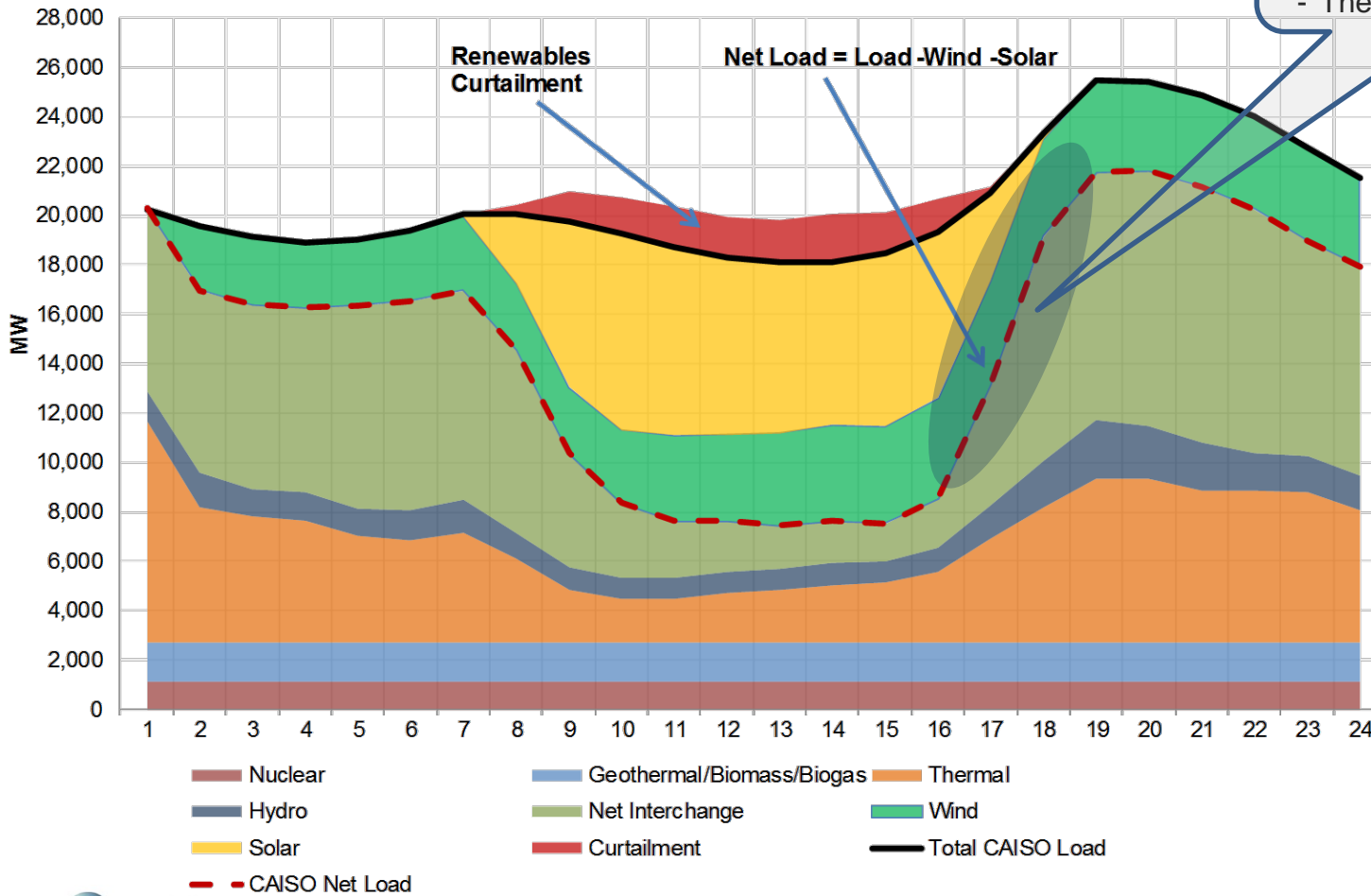
# Actual net-load and 3-hour ramps are about four years ahead of the ISO's original estimate primarily due to under forecasting roof-top solar PV installation

## Typical Spring Day



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

Generation Breakdown --- 02/18/2018



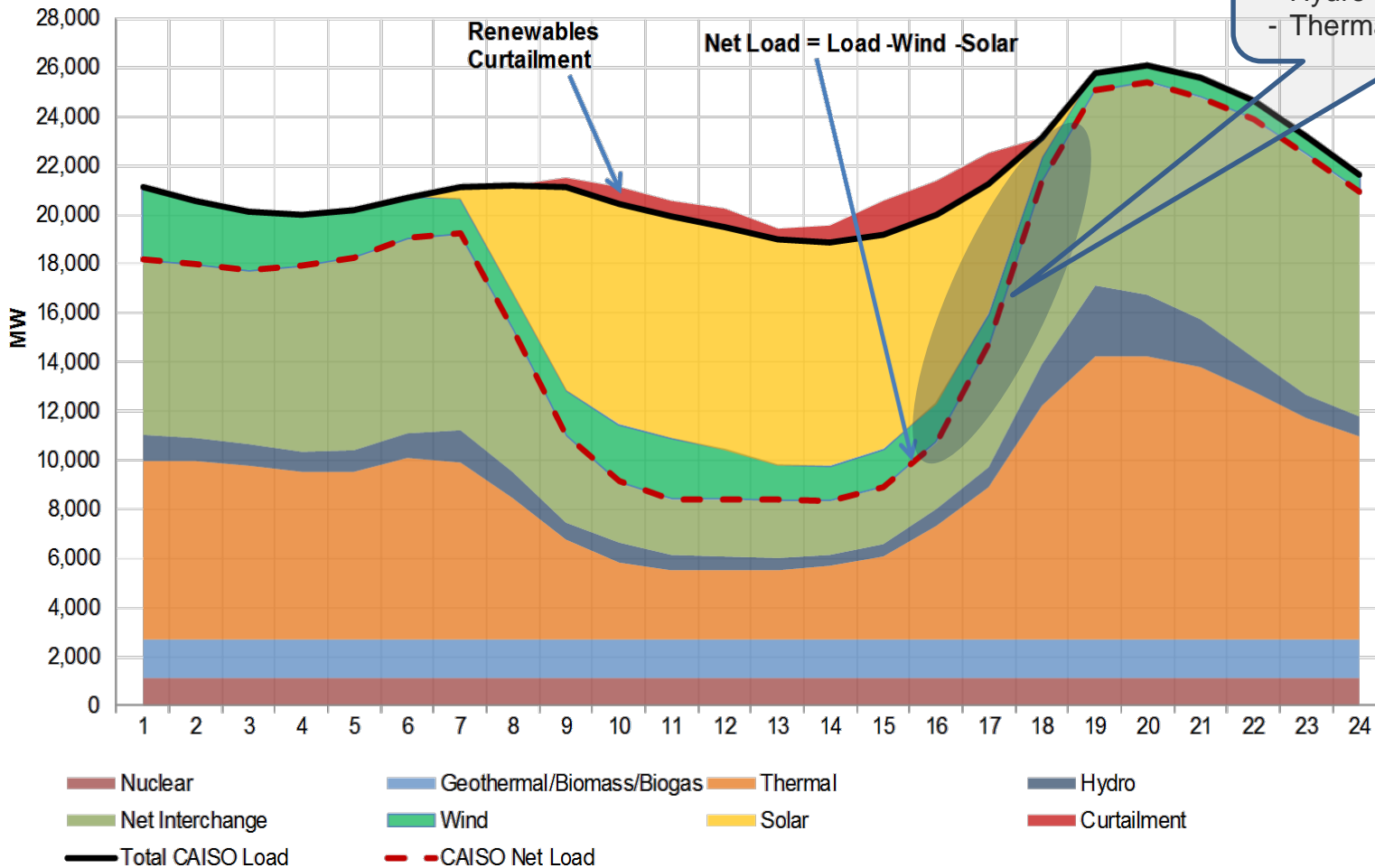
- Max renewables curtailed 1,905 MW
- Total curtailment was 9,070 MWh
- Max EIM Export was 2,338 MW
- Diablo Unit 2 was off-line
- One of the biggest challenges during low minimum net-load is the capability to commit internal resources to meet the evening ramp and other AS requirements
- Rely on imports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



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

Generation Breakdown --- 03/04/2018

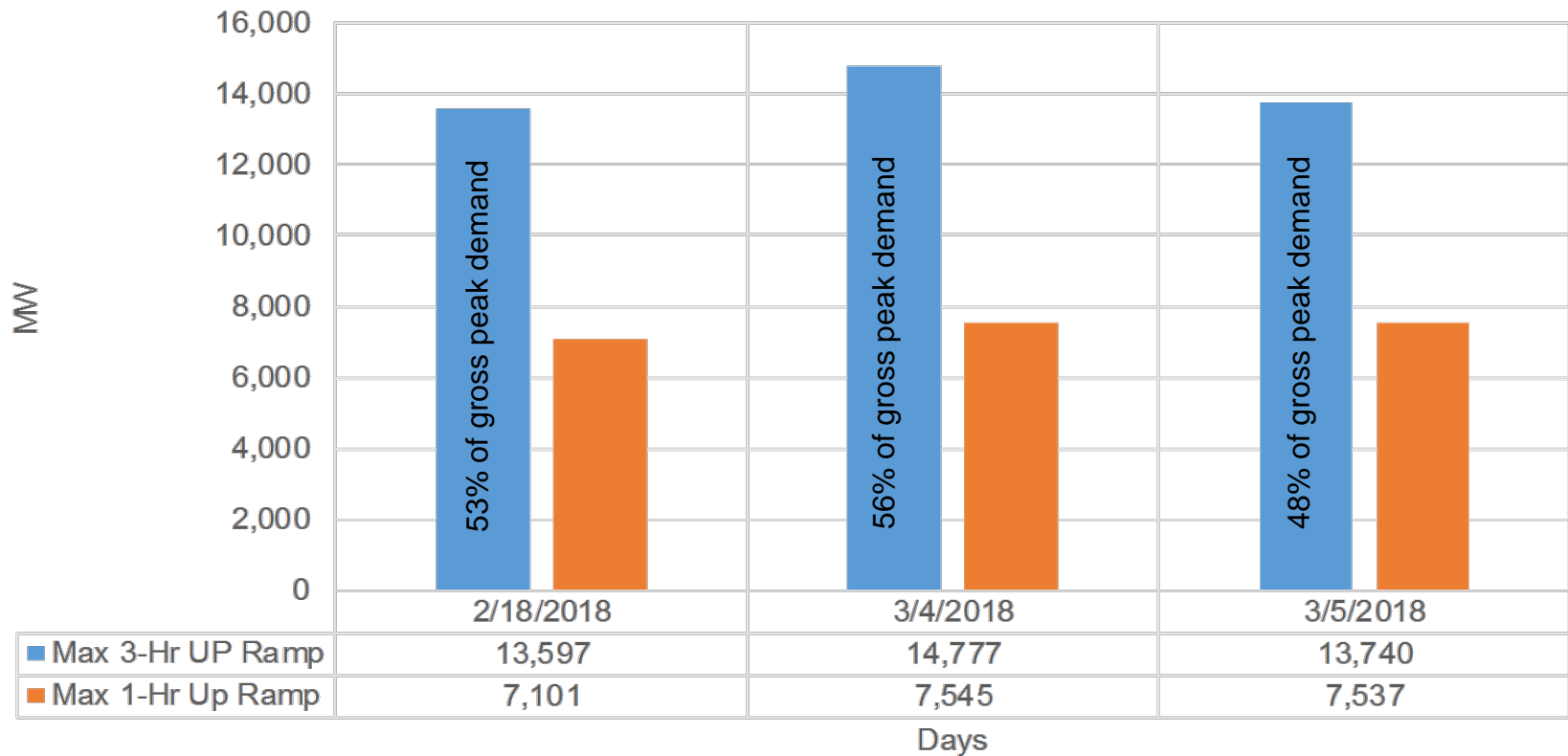
3-hr, 14,777MW ramp met by:  
 - Import ~ 36%  
 - Hydro – 15%  
 - Thermal – 49%



- The ISO 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

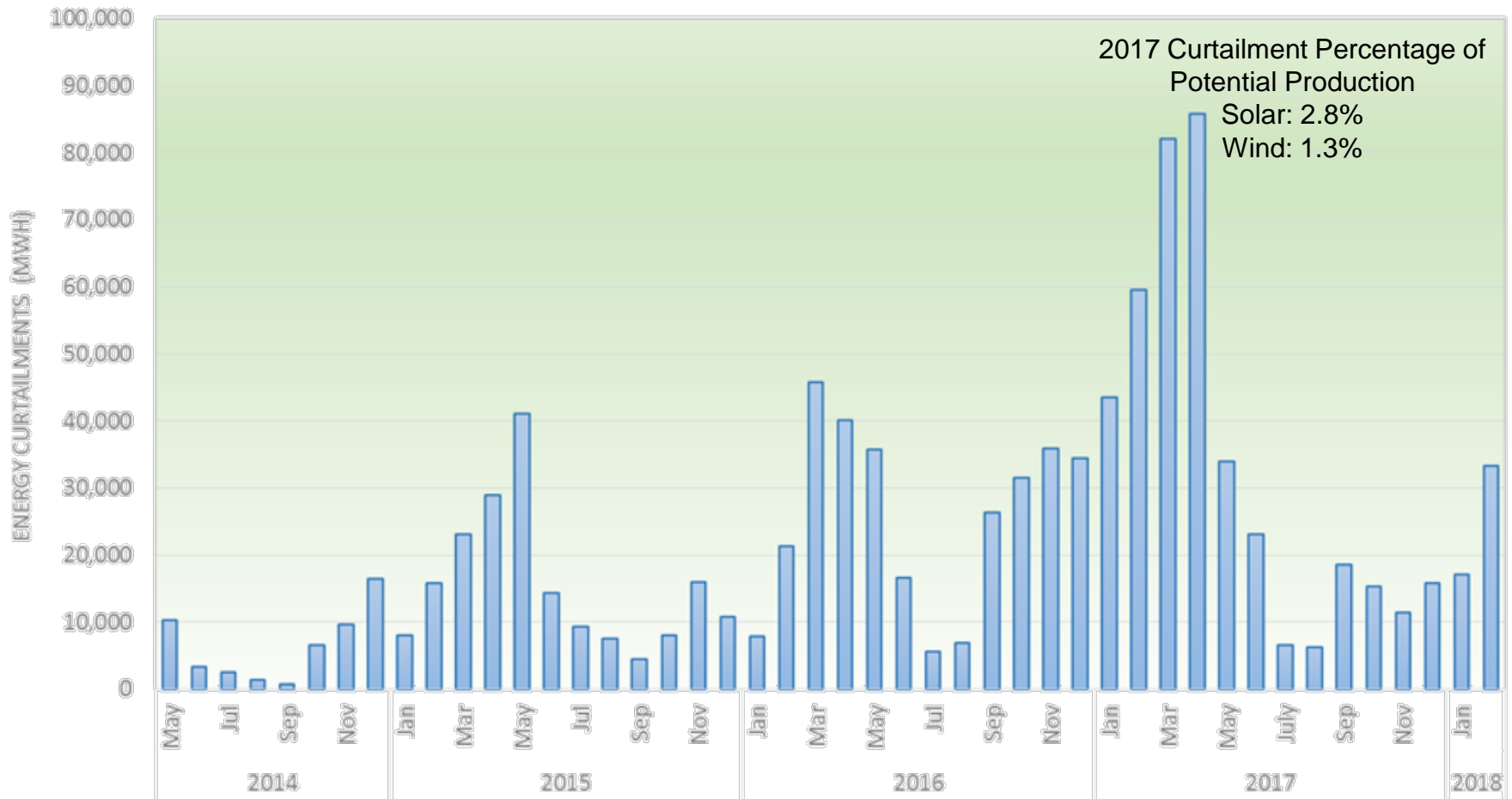
The 1-Hour upward ramps are more than 50% of the three hour ramps, which indicates the need for faster ramping resources

**Comparison of 3-Hour and 1-Hour upward Ramps**



■ Max 3-Hr UP Ramp    ■ Max 1-Hr UP Ramp

# Increasing trend of renewable curtailment varies with seasonal and hydro conditions



# Summary/Observations

- Load reliably served by renewable resources continue to grow
- GHG associated with serving the ISO load has decreased 23% 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 rapidly
- 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 ISO 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 ISO relies on internal resources to meet its ramps