Briefing on the duck curve and current system conditions

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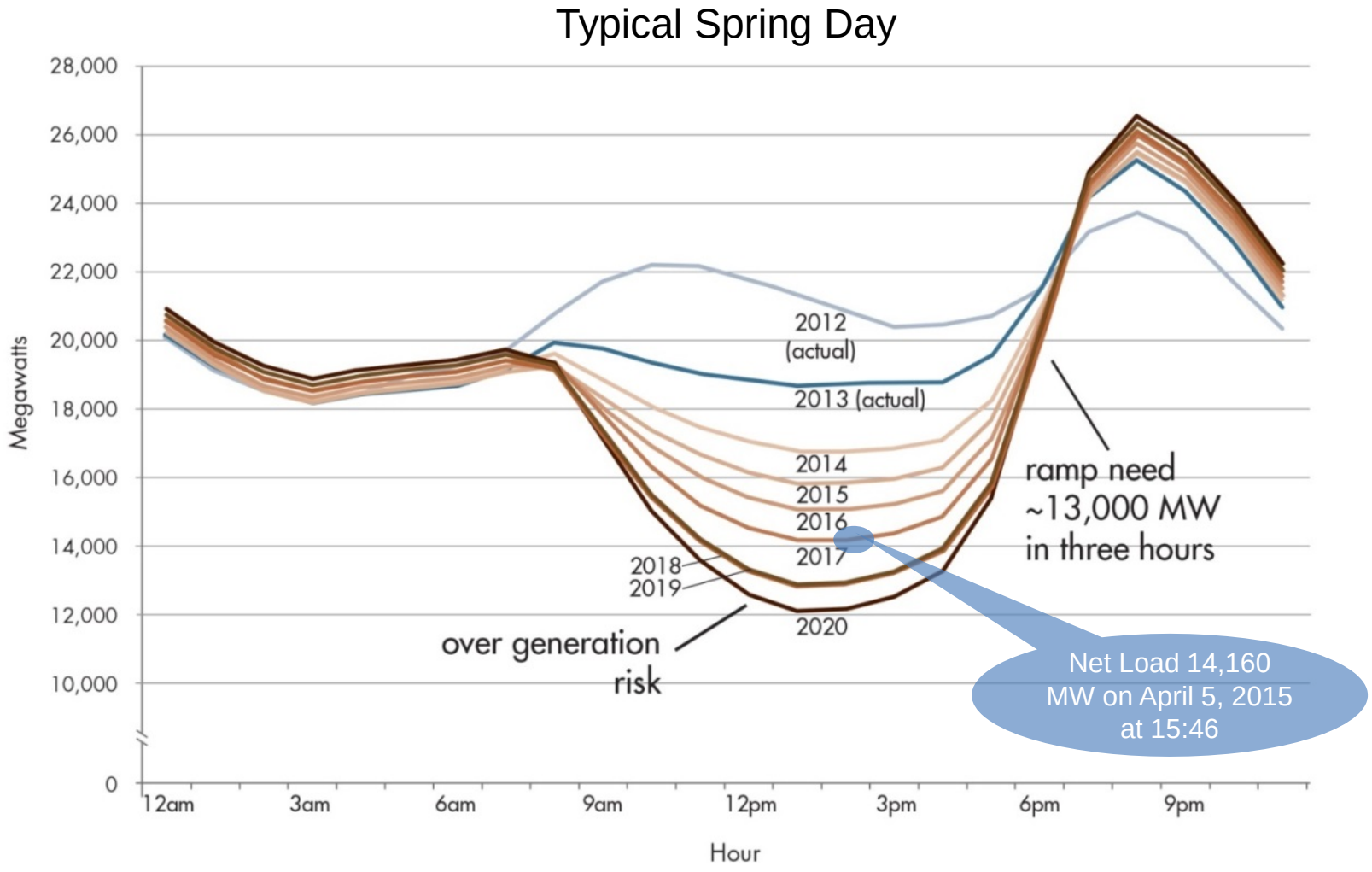
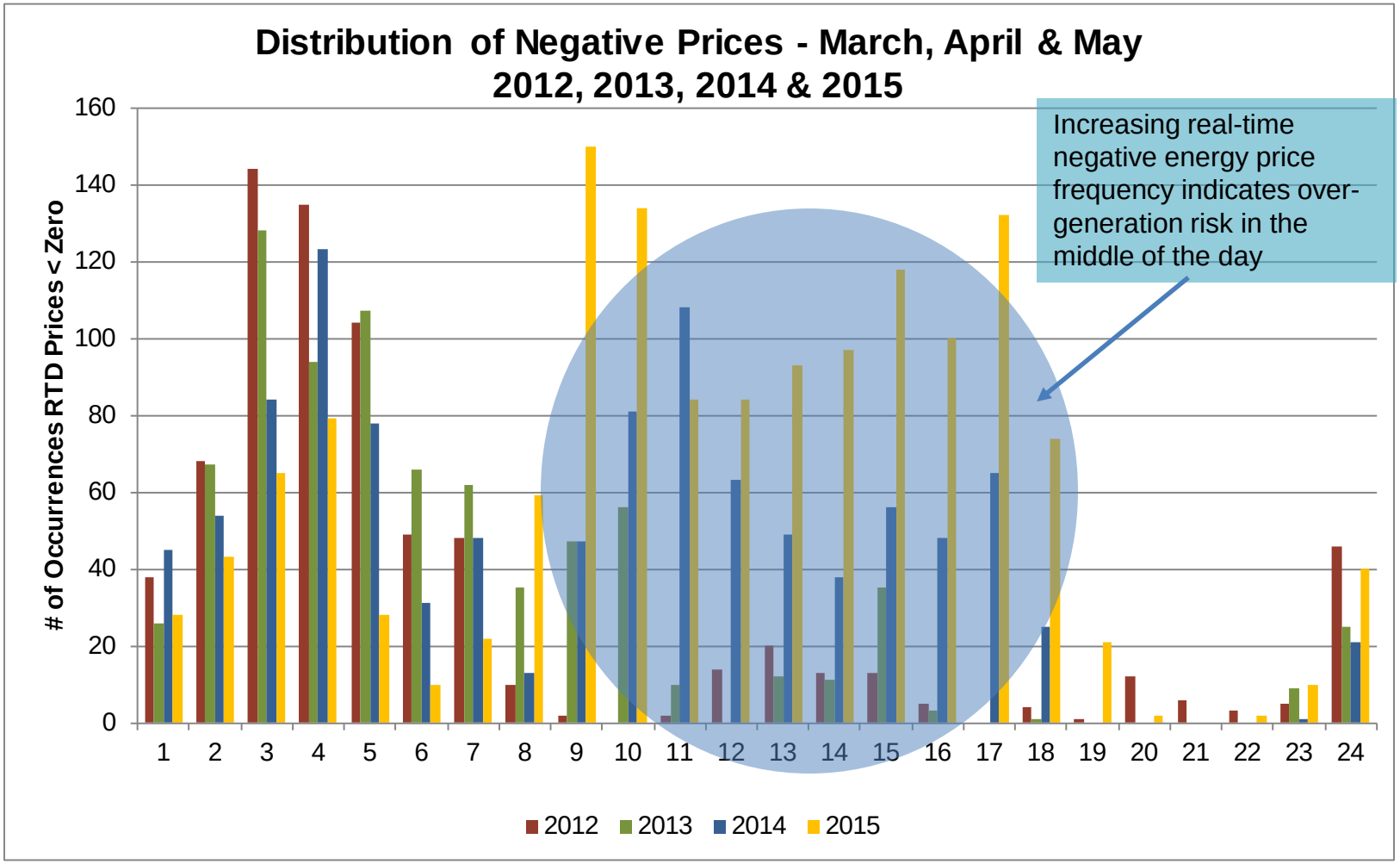
Market Surveillance Committee Meeting
General Session
July 15, 2015

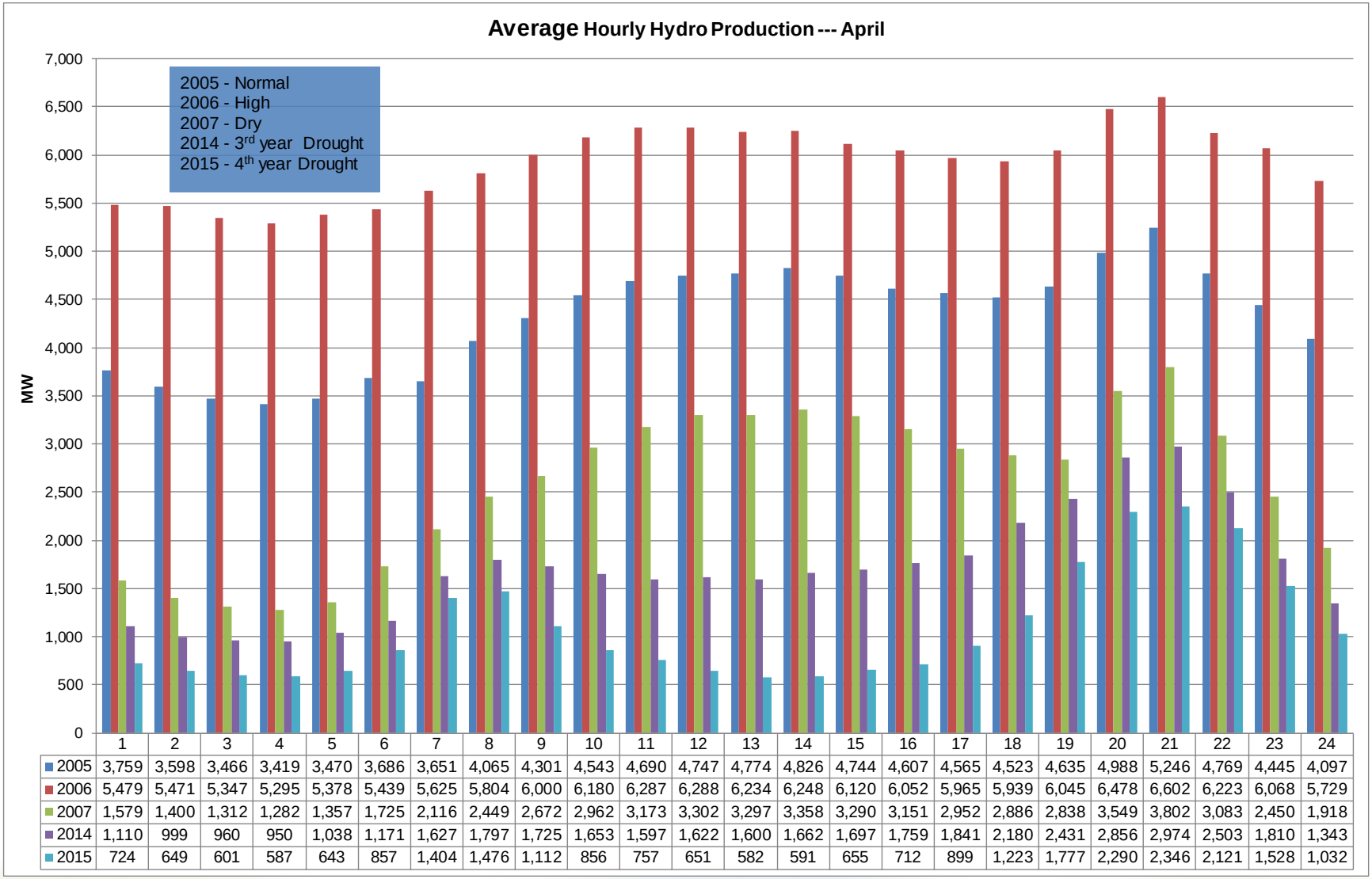
Original estimate of net-load as more renewables are integrated into the grid



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



Average hourly hydro production for high, low and average hydro years --- April



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
2005	3,759	3,598	3,466	3,419	3,470	3,686	3,651	4,065	4,301	4,543	4,690	4,747	4,774	4,826	4,744	4,607	4,565	4,523	4,635	4,988	5,246	4,769	4,445	4,097
2006	5,479	5,471	5,347	5,295	5,378	5,439	5,625	5,804	6,000	6,180	6,287	6,288	6,234	6,248	6,120	6,052	5,965	5,939	6,045	6,478	6,602	6,223	6,068	5,729
2007	1,579	1,400	1,312	1,282	1,357	1,725	2,116	2,449	2,672	2,962	3,173	3,302	3,297	3,358	3,290	3,151	2,952	2,886	2,838	3,549	3,802	3,083	2,450	1,918
2014	1,110	999	960	950	1,038	1,171	1,627	1,797	1,725	1,653	1,597	1,622	1,600	1,662	1,697	1,759	1,841	2,180	2,431	2,856	2,974	2,503	1,810	1,343
2015	724	649	601	587	643	857	1,404	1,476	1,112	856	757	651	582	591	655	712	899	1,223	1,777	2,290	2,346	2,121	1,528	1,032

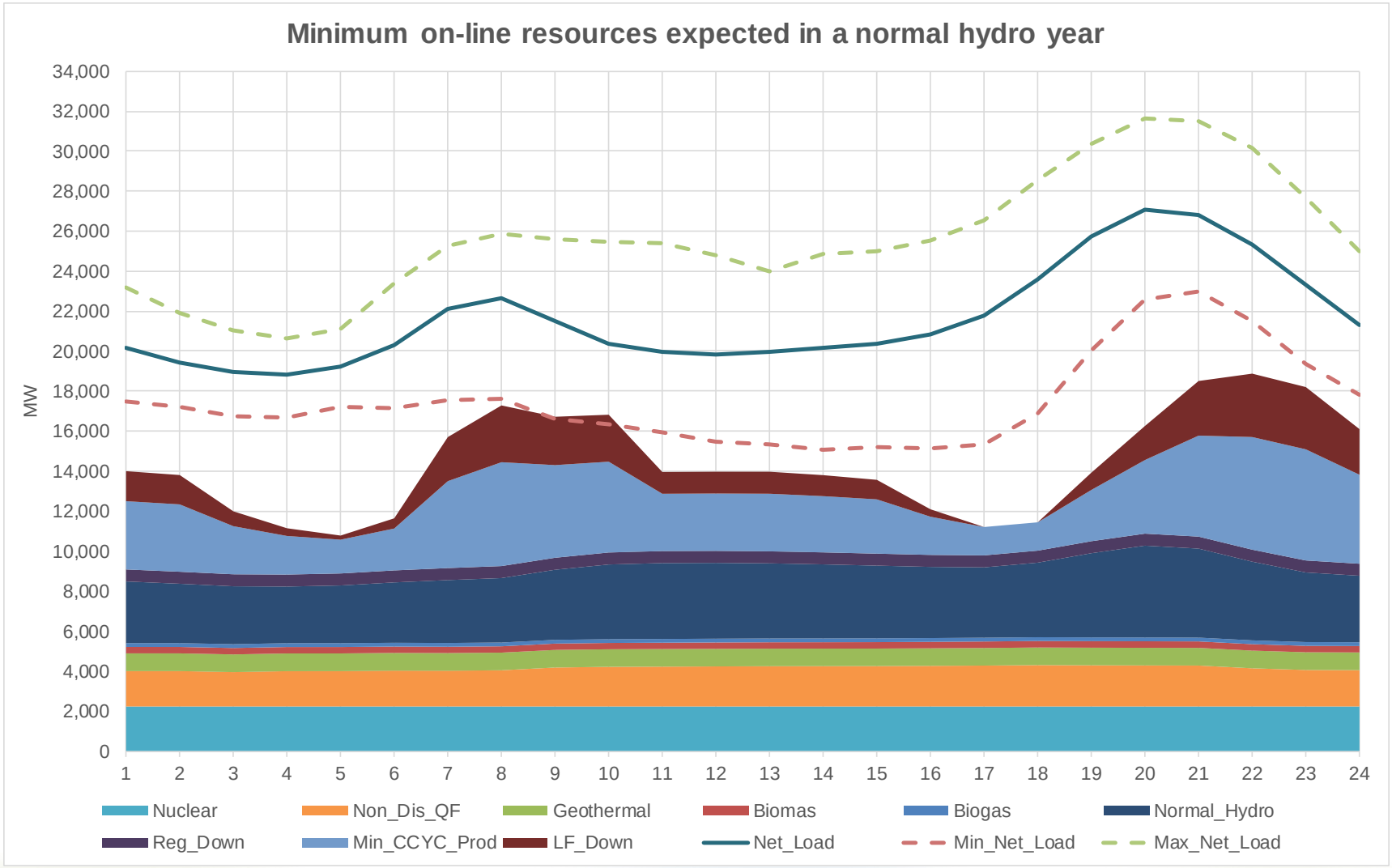
The assessment of a Balancing Authority control performance is based on three components

- **Control Performance Standard (CPS1) -** measures how well a BA's ACE performs in conjunction with the frequency error of the Interconnection measured as a 12 month rolling average
- **Balancing Authority Ace Limit (BAAL) -** is a real-time measure of area control error and system frequency which cannot exceed predefined limits for more than 30-minutes
- **Disturbance Control Standard (DCS) -** is the responsibility of a BA to recover its ACE to zero if its ACE just prior to the disturbance was greater than zero or to its pre-disturbance level if ACE was less than zero within 15 minutes
- ***New NERC operating standard (BAL-003-1 to be implemented in 2017)***
  - All BAs to support the interconnection frequency within 30 seconds following a disturbance greater than 500 MW anywhere in the interconnection

Control Performance Assessment

Pass is when CPS1 ≥ 100%; $BAAL_{Limit}$ ≤ 30 minutes & DCS = 100%

Minimum on-line generation expected in a normal hydro year



Assumptions for base-loaded/non-dispatchable resources and minimum system reliability needs

- ***Base Load & Non-Dispatchable Resources***

	Diablo 1 & 2:	2,243 MW
	Non-dispatchable QFs:	1,900 MW
RPS	Geothermal	880 MW
RPS	Biomas	320 MW
RPS	BioGas	190 MW
RPS	Small Hydro	250 MW
	Total Non-dispatchable resources	***5,783 MW***

Based on actual hourly average production for March 2015

- ***Reliability Needs from non-hydro resources***

Regulation Down	600 MW
Load-following Down (varies by hour – 3/2015 actual needs)	2,000 MW
Pmin of CCYC providing Frequency Response (4,844 * .33%)	1,600 MW
Minimum Generation on CCYC Resources	***4,200 MW***

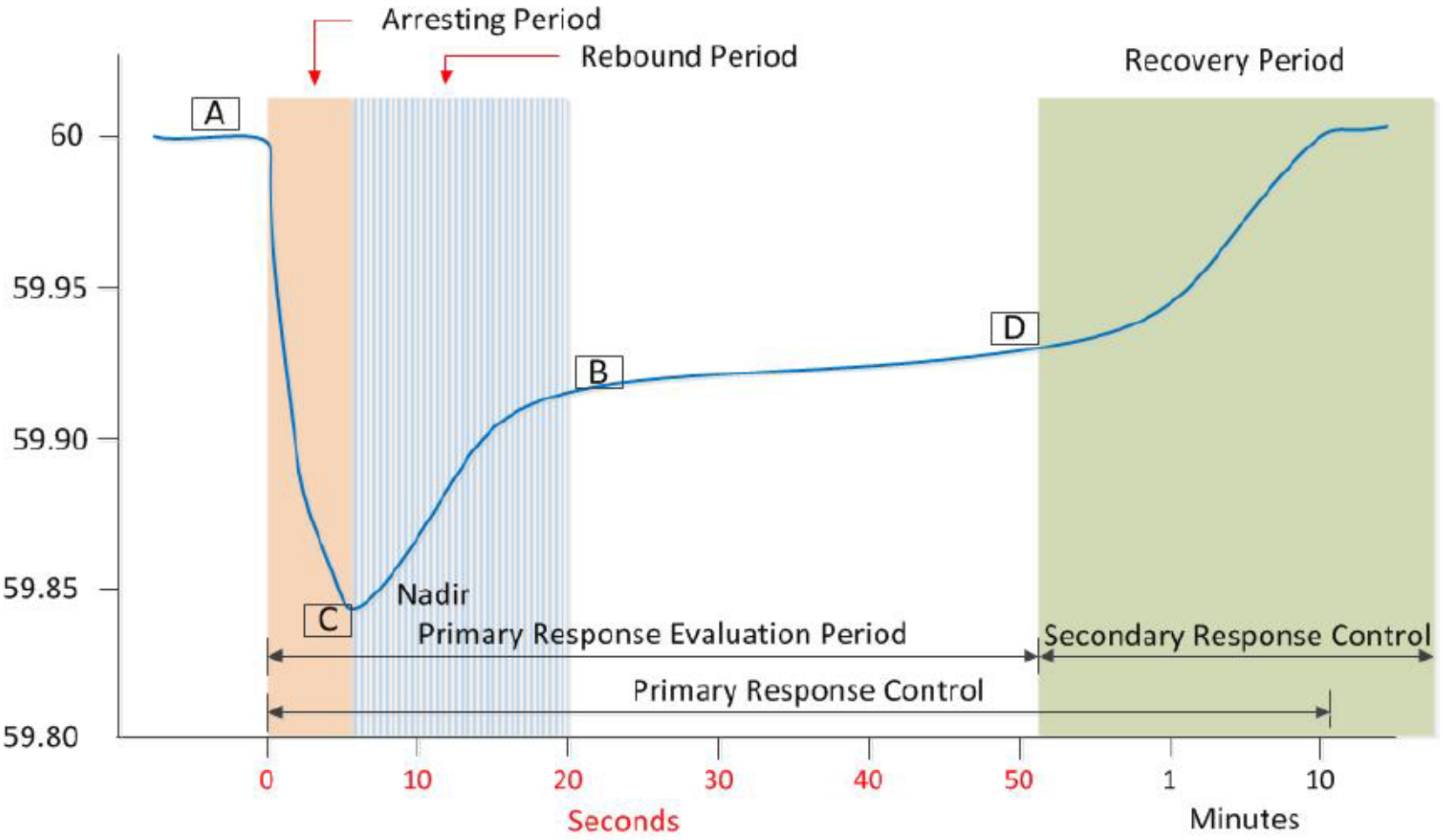
Approx. 4,844 MW* of capacity on CCYC is needed to provide about 387.5 MW of frequency response within 30 sec. (i.e. 387.5 / .08 = 4,844)

- ***Minimum Hydro for Dry Year (Avg. HE7 to HE16)*** ***3,000 MW***

- ***Other Assumptions***
  - Hydro resources can provide contingency reserve, regulation up and load-following and 50% of the ISO's Frequency Response Obligation (FRO)
  - No generation requirement for local constraints
  - Zero net imports (assumes the ISO can export approximately 3,600 MW of dedicated dynamic imports i.e. Palo Verde, Hoover, MUNI imports from LADWP and Geothermal from IID)

*WECC FRO is 907 MW/.1 Hz of which the ISO's share is about 30% or 272 MW/.1 Hz. This equates to about 775 MW based on the loss of two Palo Verde units. Typically, a conventional resource on governor control can provide about 5% to 10% of its Pmax as FR within 30 seconds. Assume CCYC resources can provide 8% of Frequency Response.

Typical frequency response recovery and potential need for ancillary services or capacity products



Source: NERC

As the grid transforms, existing ancillary service markets may not ensure the right resources with the right capabilities are available at the right time from all possible sources

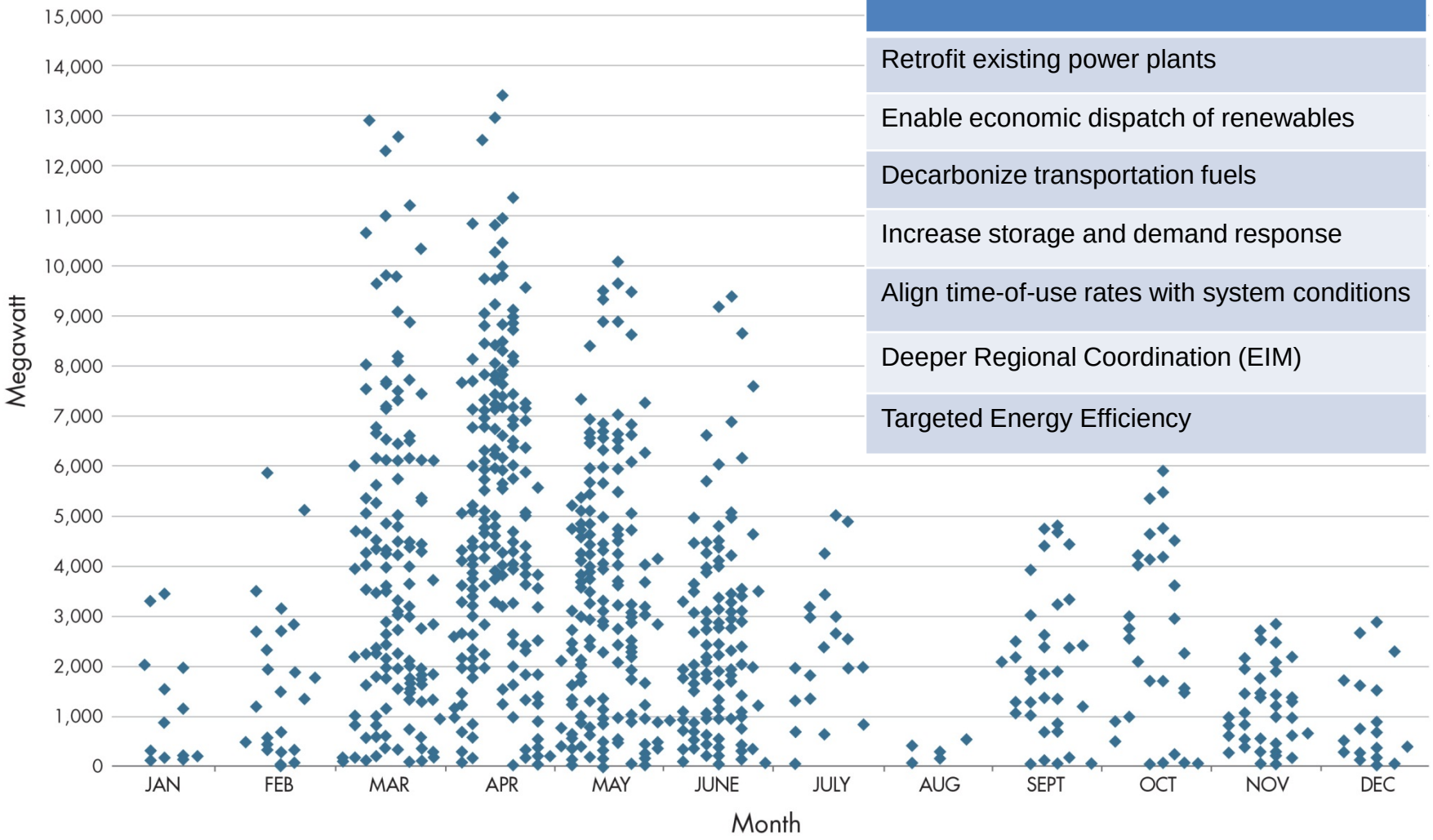
- Inertia
- Frequency Response
  - Fast Frequency Response
  - Primary Frequency Response

Traditional Ancillary Services

- Regulation
- Contingency Reserve
  - Operating Reserve – Spinning (Replaced Spinning Reserve in WECC)
  - Non Spinning Reserve

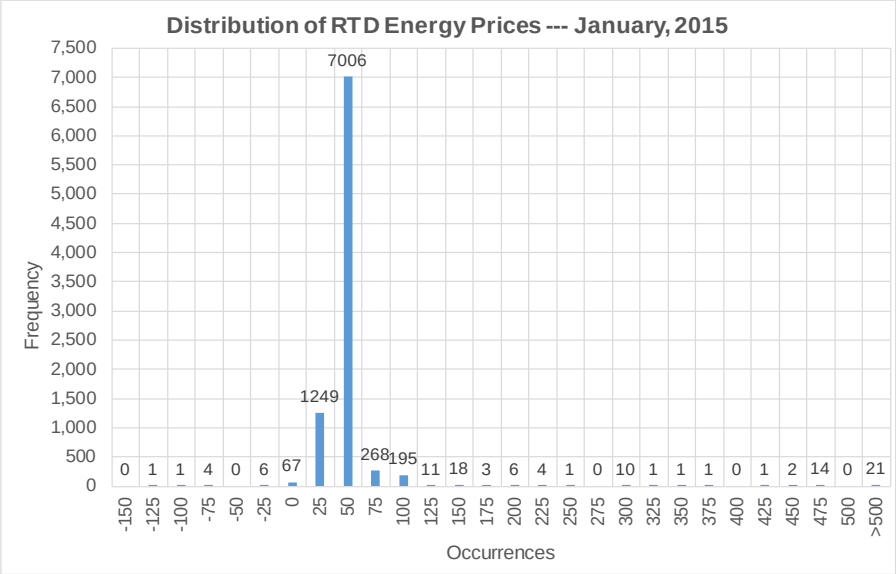
- Flexible Resources (dispatchable conventional resources including VERs, energy storage devices and dispatchable loads). Attributes include but not limited to:
  - Fast Ramping capability for defined periods
  - Change ramp direction quickly
  - Store energy or modify use
  - Multiple Stop/Start Capability
  - Low Pmin

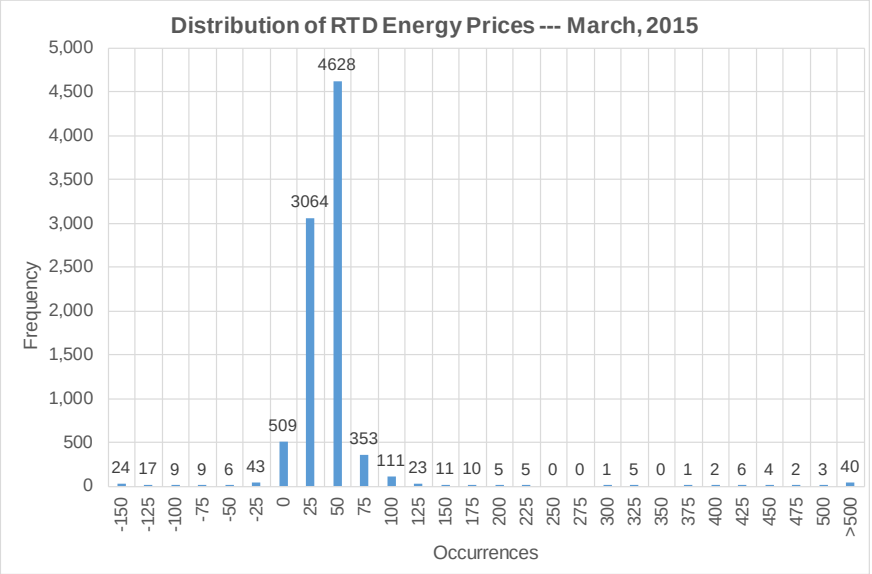
RPS Curtailment in 2024 – 40% RPS Scenario

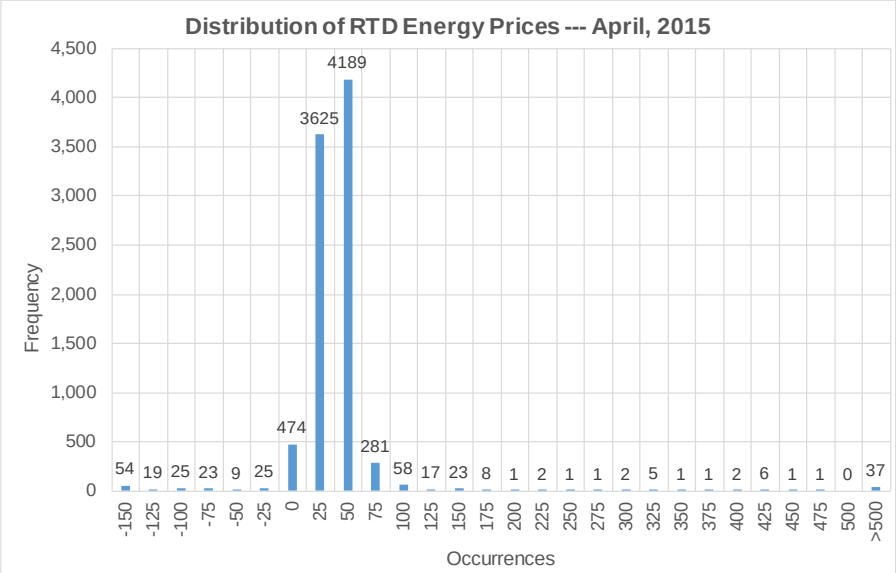


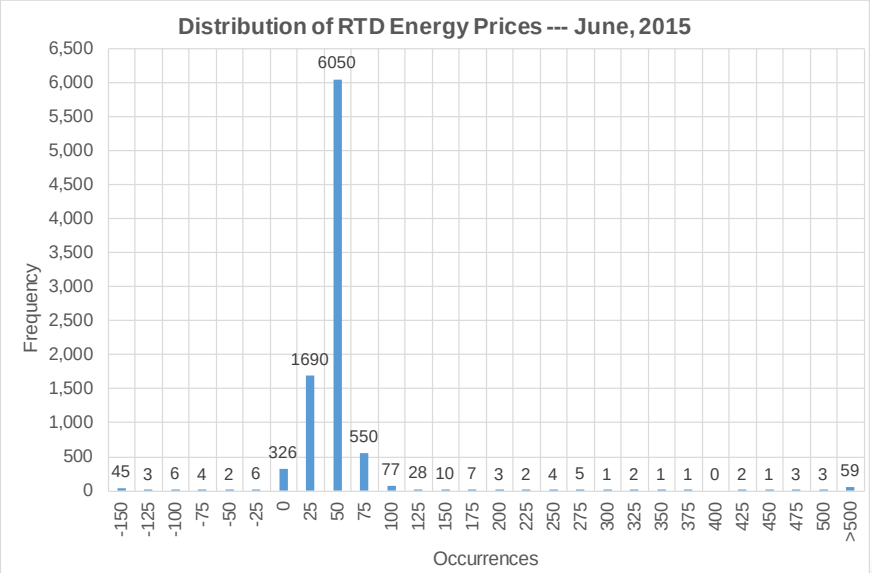
Solutions
Retrofit existing power plants
Enable economic dispatch of renewables
Decarbonize transportation fuels
Increase storage and demand response
Align time-of-use rates with system conditions
Deeper Regional Coordination (EIM)
Targeted Energy Efficiency

5-Minute energy price distribution for Jan, Mar, Apr & Jun

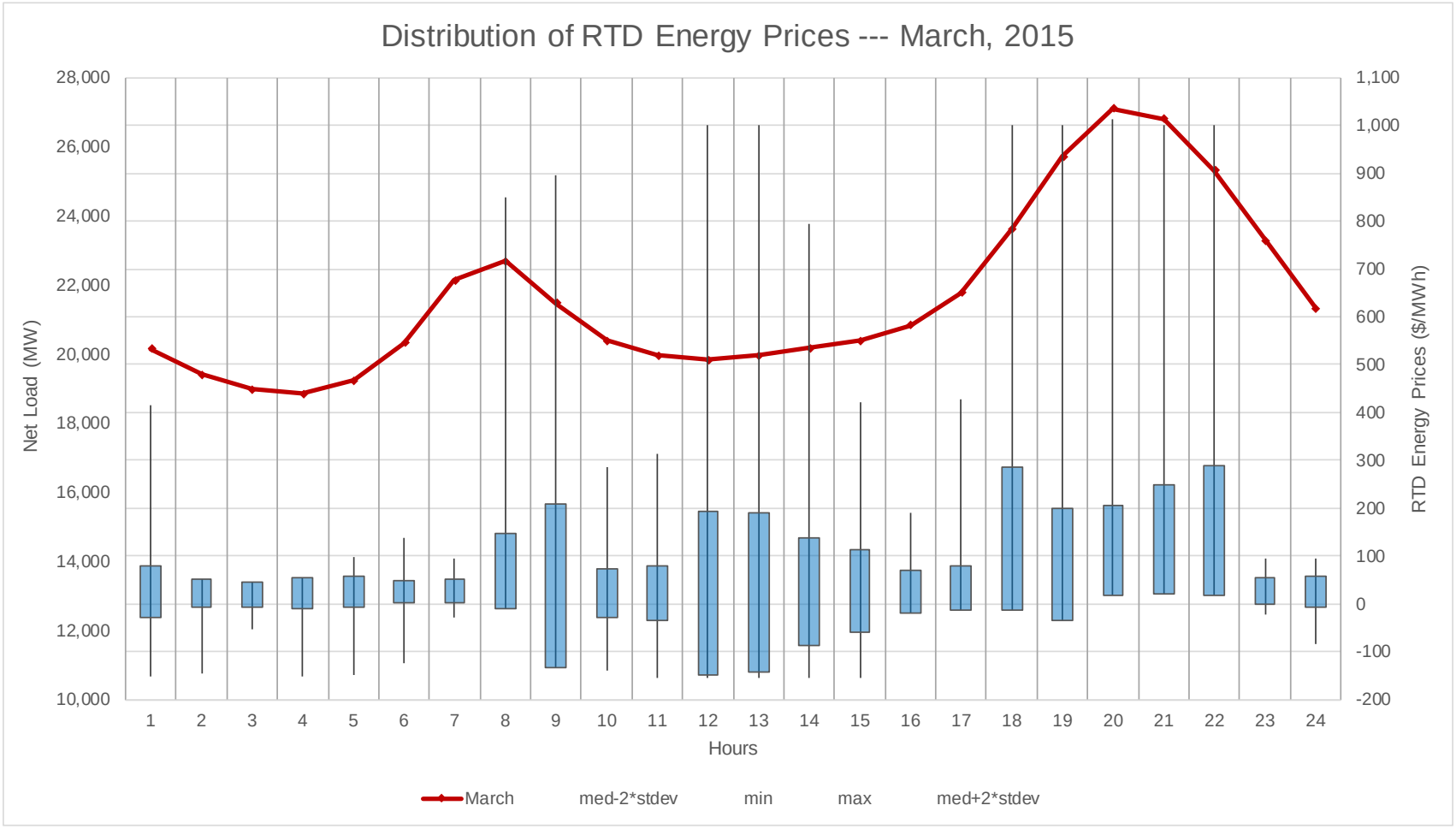




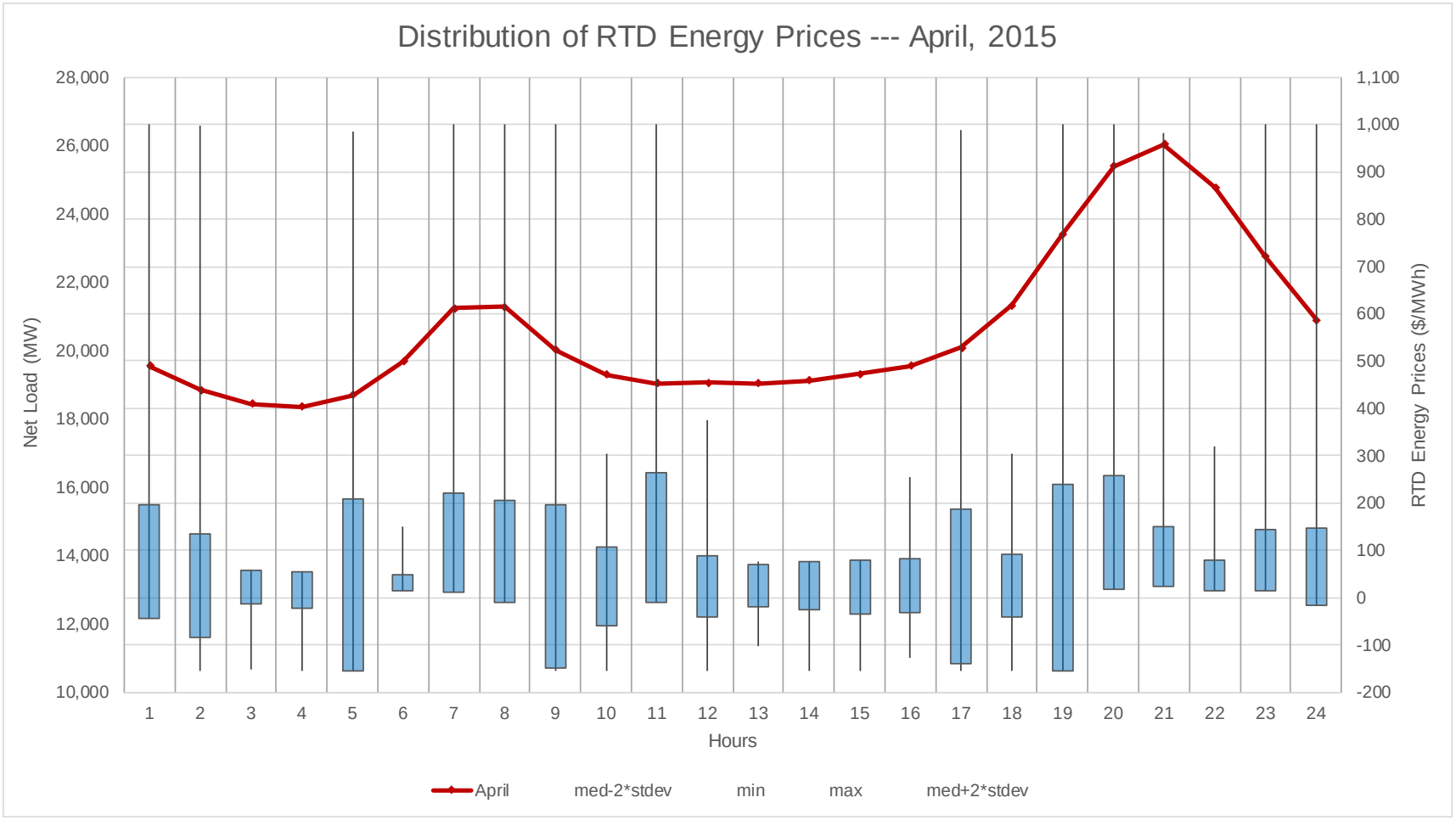




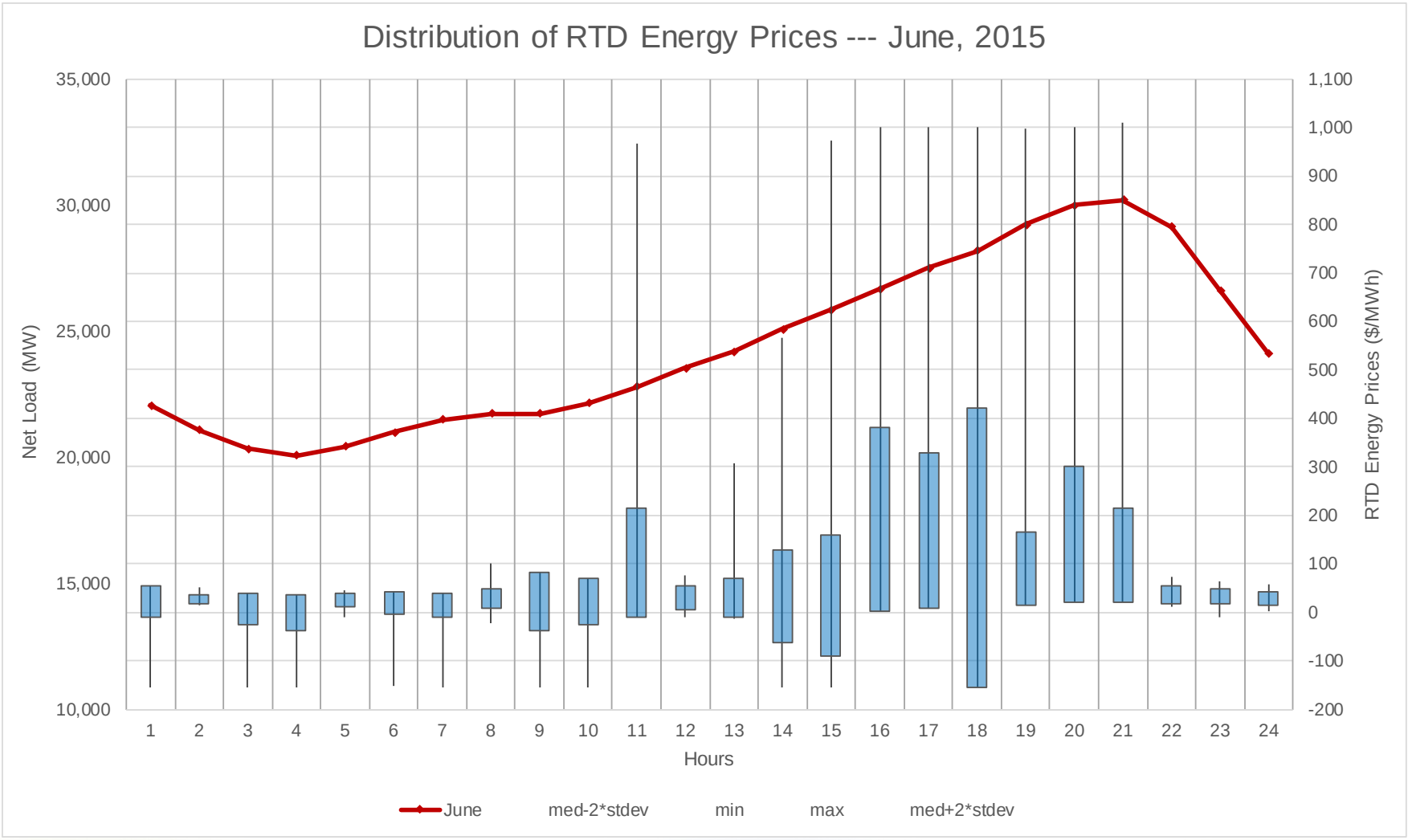
Distribution of RTD Energy Prices vs. Average Net Load --- March 2015



Distribution of RTD Energy Prices vs. Average Net Load --- April 2015

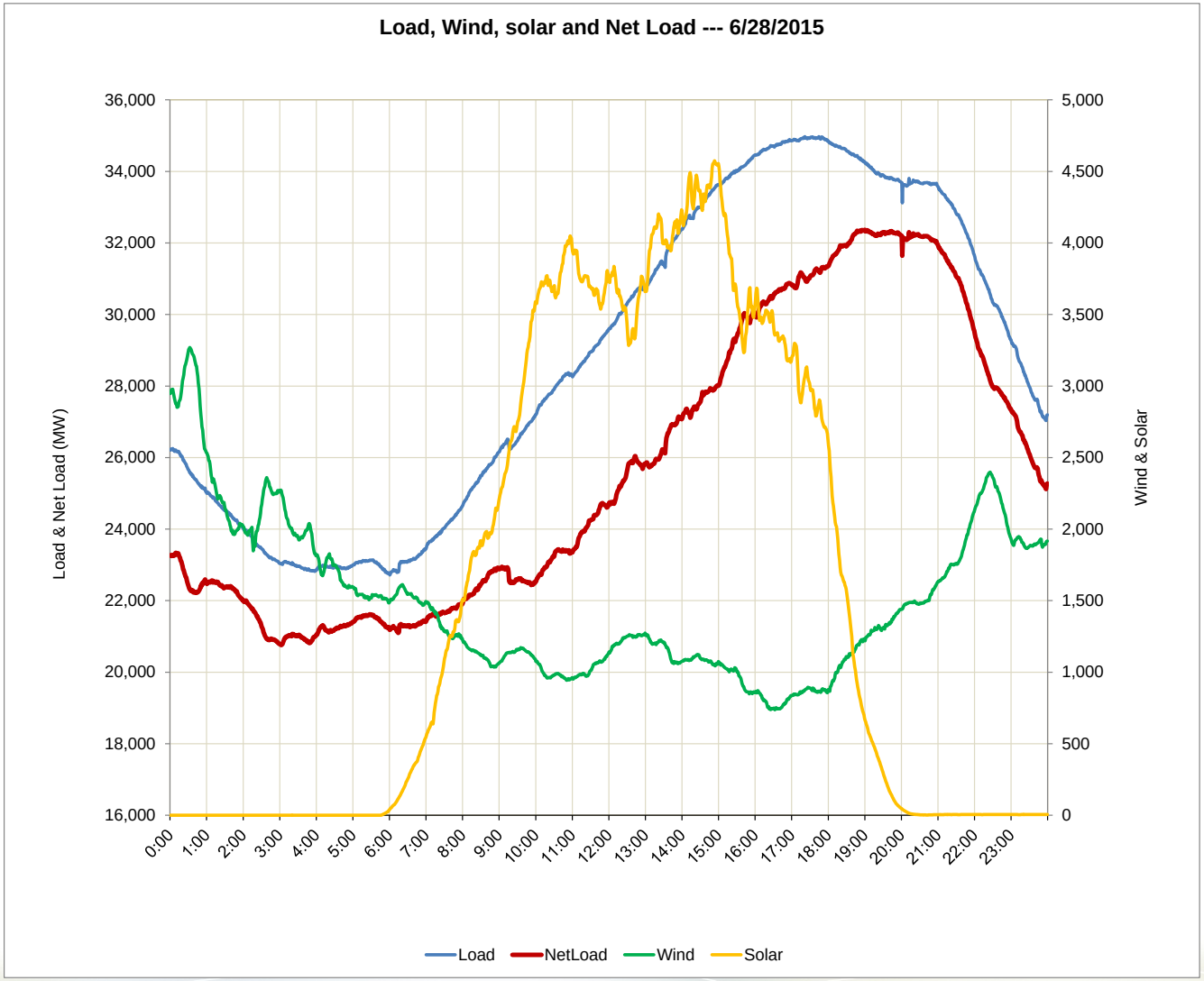


Distribution of RTD Energy Prices vs. Average Net Load --- June 2015

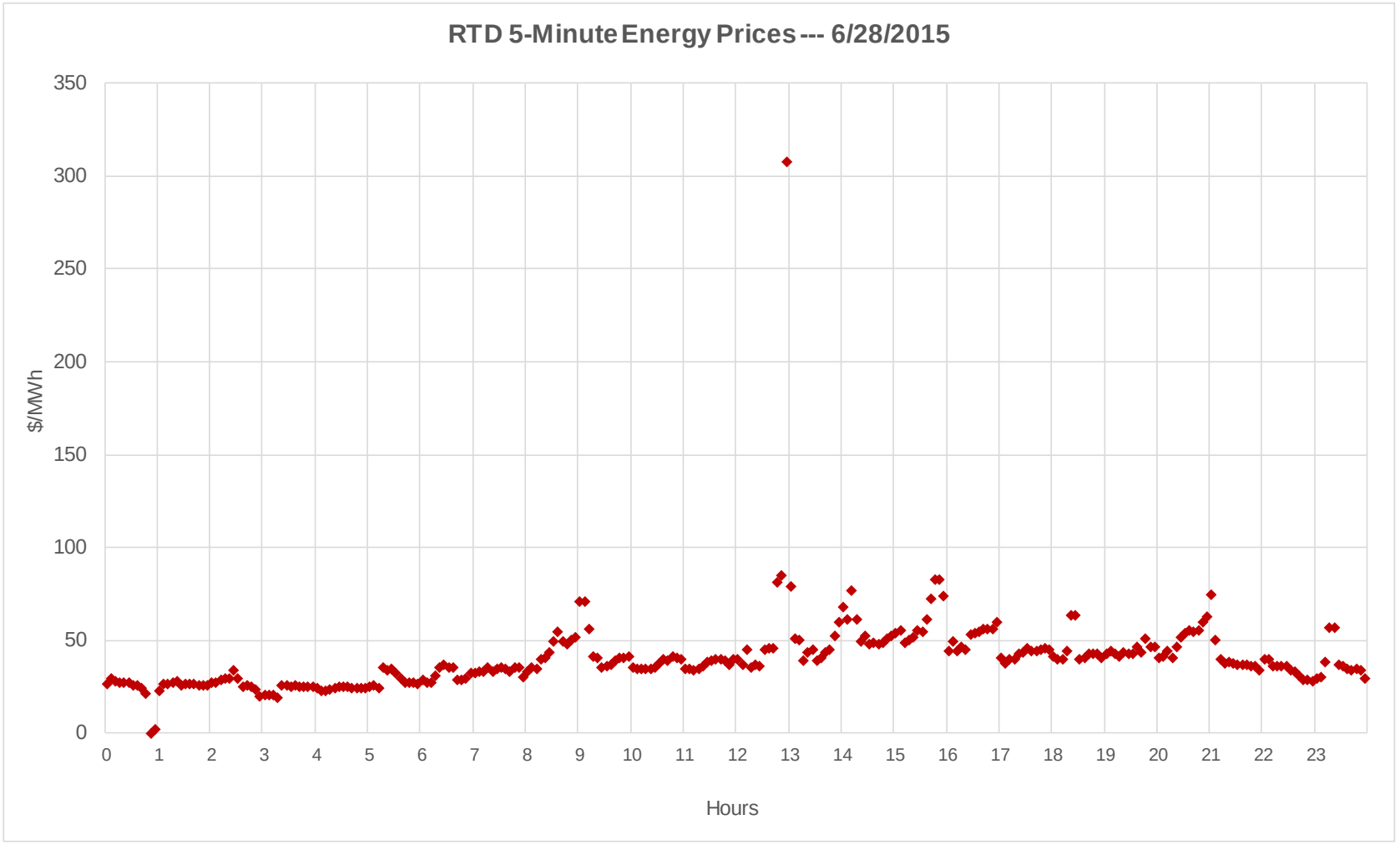


Load, wind and solar 1-minute variability for June 28, 2015

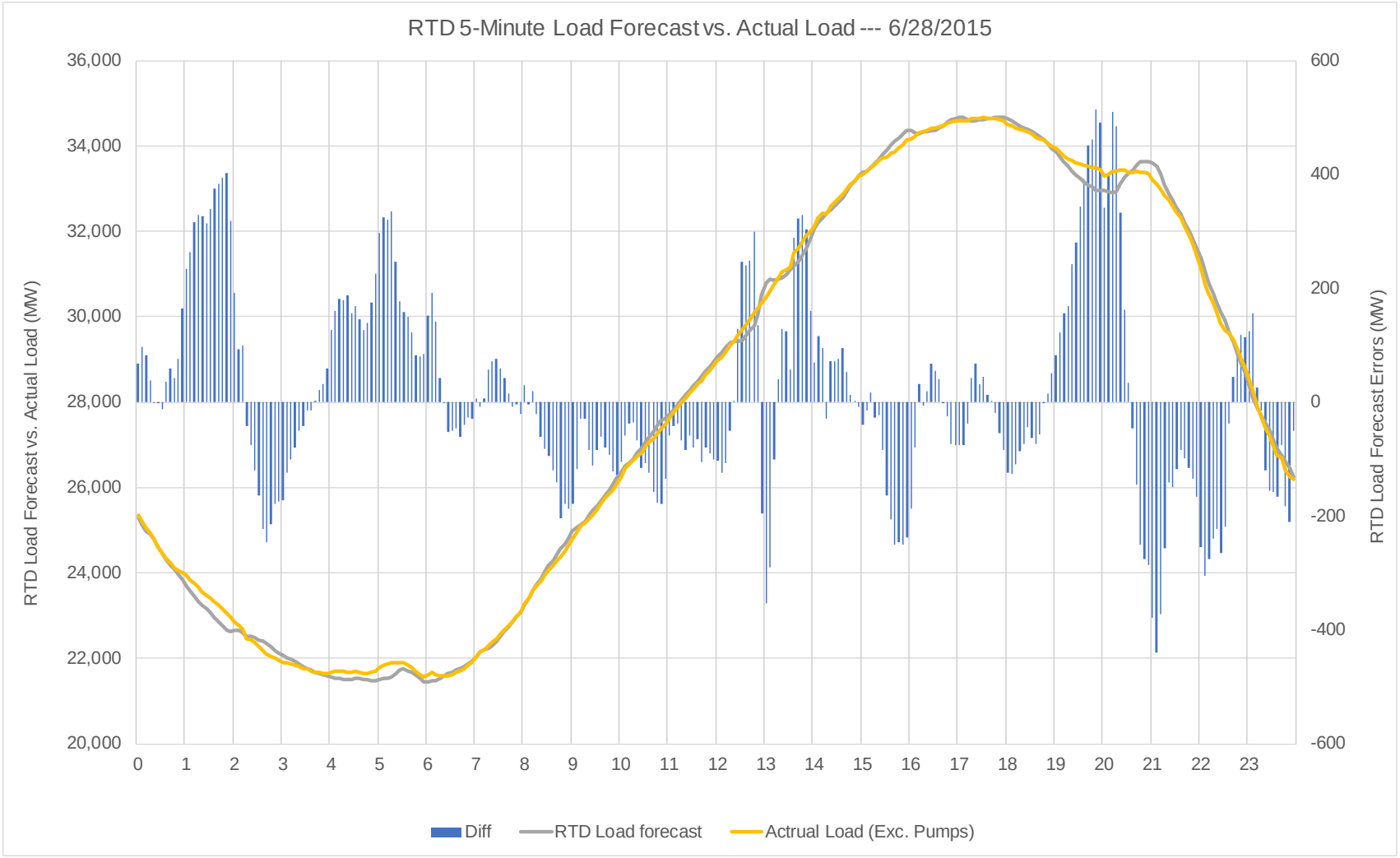
When the RTD run does not pick-up load, wind or solar variability at least 7.5 minutes before the dispatch interval, ramp deficiencies are not reflected in the 5-minute energy prices



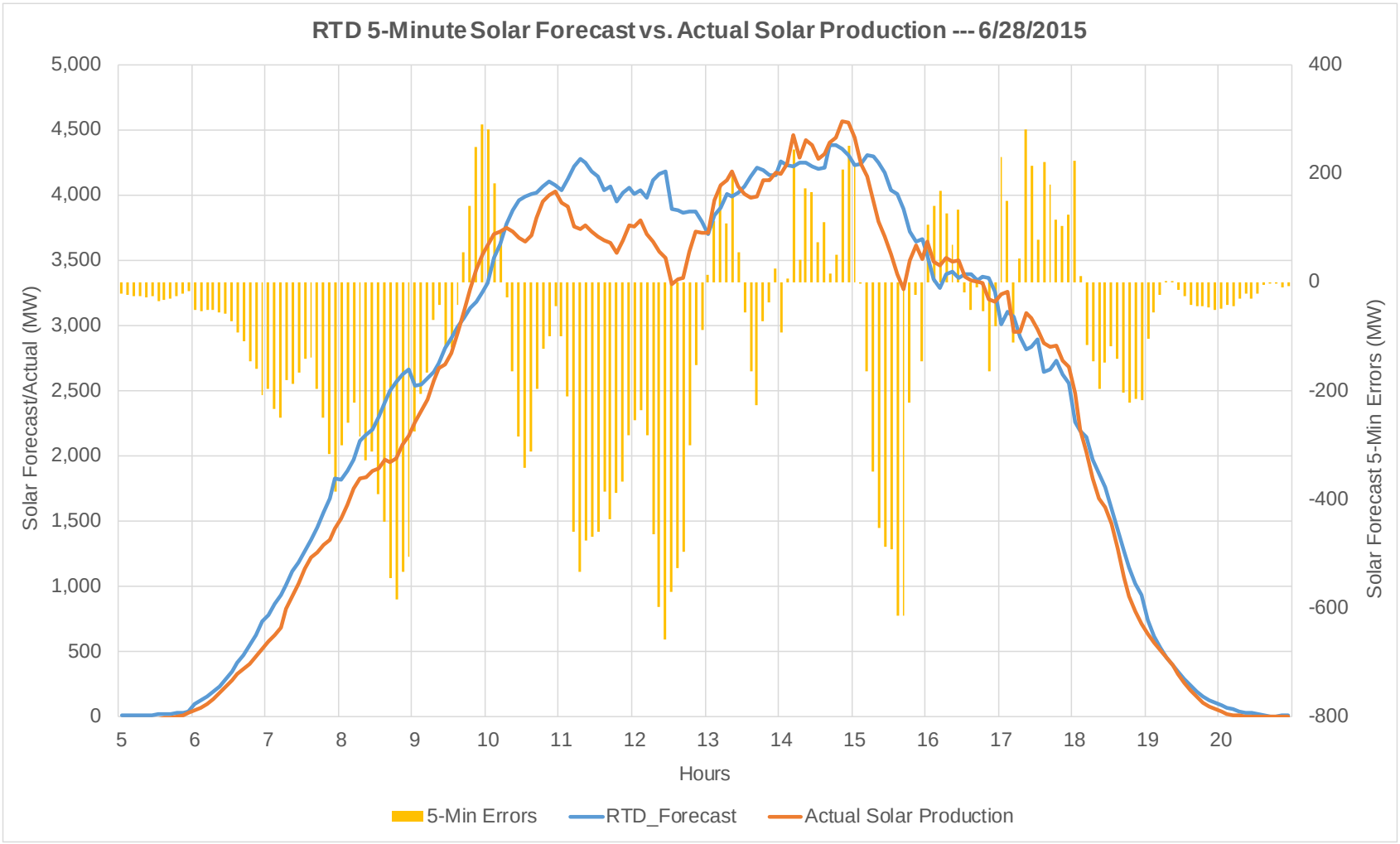
5-minute energy prices reflect 5-minute forecast ramping condition but may not reflect all actual intra-hour variability



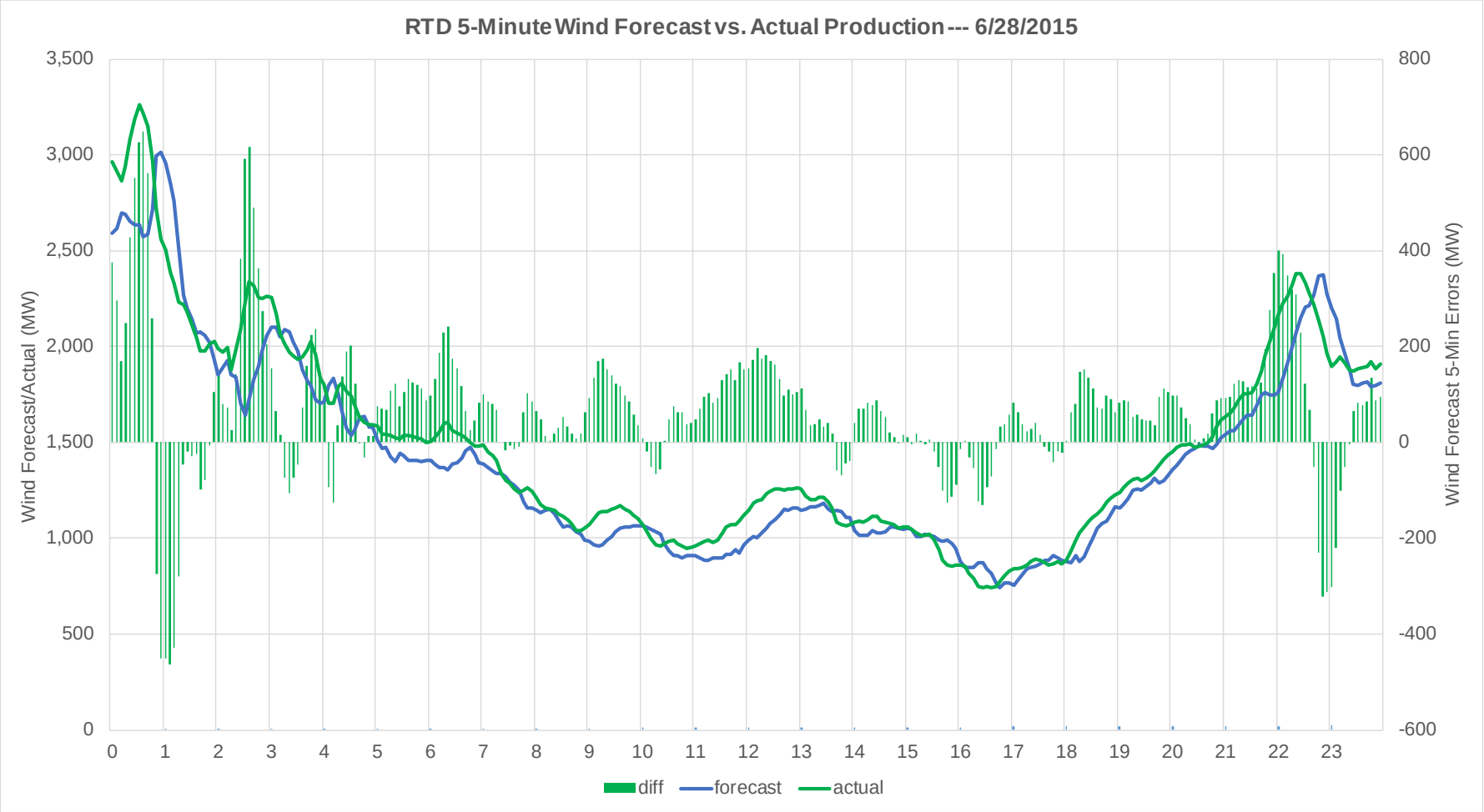
5-Minute RTD load forecast vs. actual load --- 6/28/2015



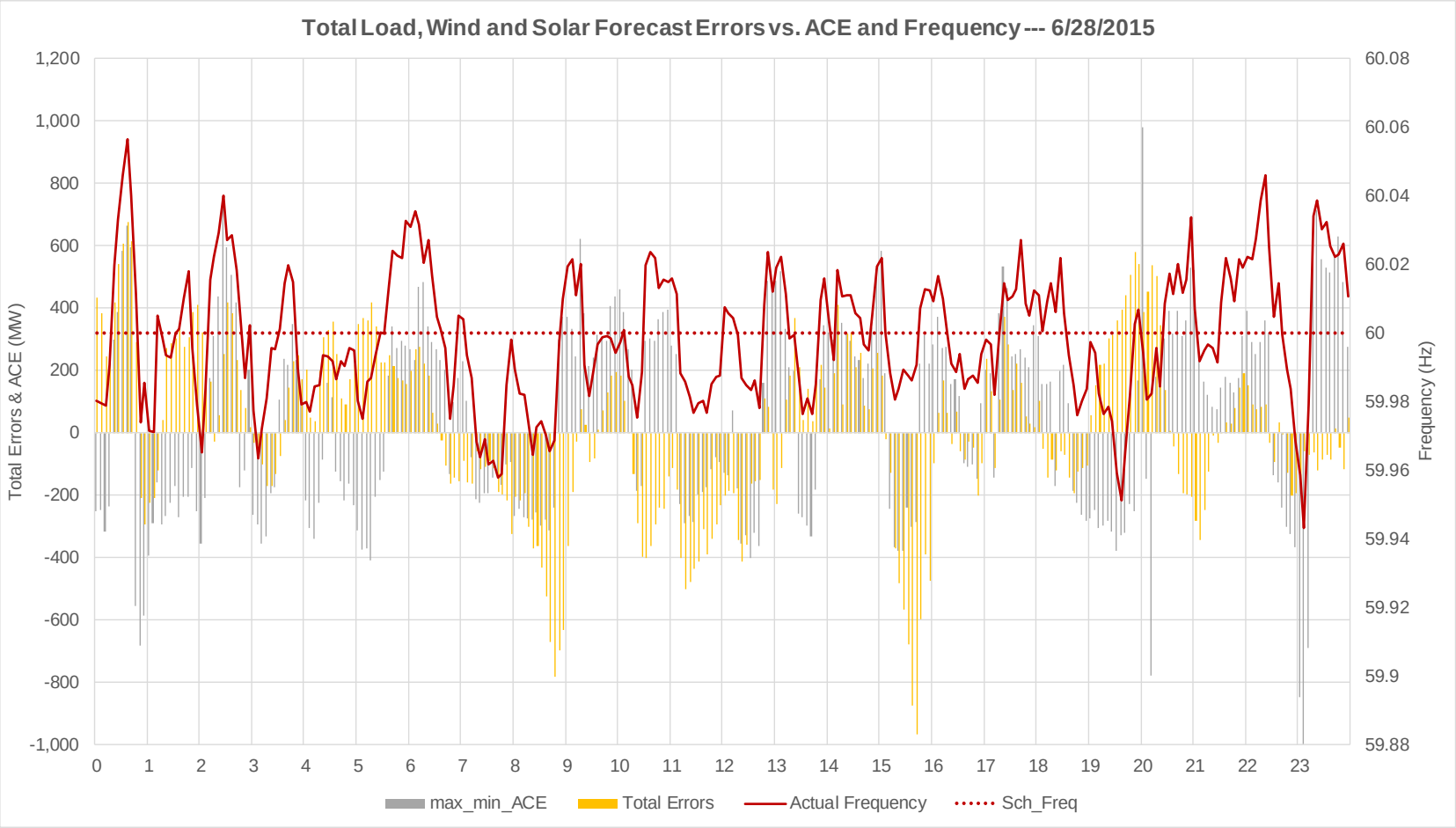
5-Minute RTD solar forecast vs. actual solar production --- 6/28/2015



5-Minute RTD wind forecast vs. actual wind production --- 6/28/2015



Generally when the total wind, solar and wind forecast errors are in the same direction as frequency deviations, affects on control performance are not reflected in 5-minute energy prices



Questions!