Making Dollars and Sense of **CAISO's Price Spikes**

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Shareables

- Increases in solar penetration and tightening of thermal capacity in CAISO are leading to price spikes that fast-ramping generators can capture
- Price spikes are becoming less the exception and more the norm and a necessary element of a functioning CAISO market
- CAISO's proposed market reforms, if adopted, will primarily shift volatility-associated revenues from real-time (RT) to day-ahead (DA) and capacity payment streams

Executive Summary

The real-time markets in CAISO are seeing unprecedented price spikes. The combination of growing solar penetration and the tightening thermal capacity is creating frequent short periods in real-time markets to pay out fast-ramping generators. This is good news for both gas-fired peakers and storage, which can meet system fast-ramping needs, to capture favorable returns for the foreseeable future. While CAISO is proposing market reforms, the underlying issues that drive price spikes will likely still exist, and the value these units could realize through price volatility will shift to other markets they can participate in.

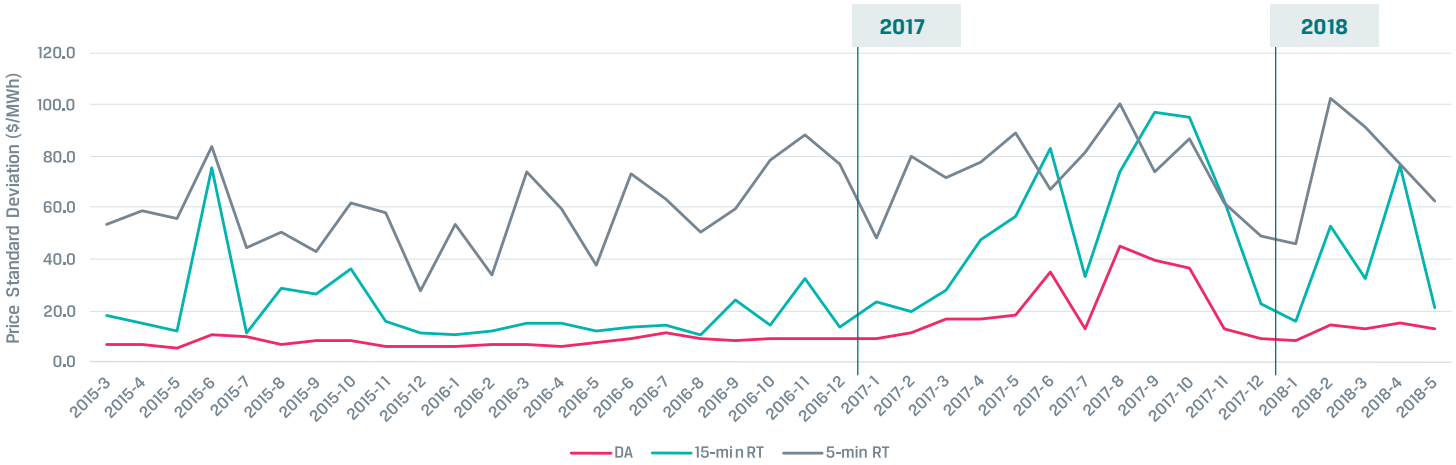
In 2017 CAISO experienced higher price volatility driven by greater price spikes than any other year in recent history, especially in real-time markets. Take NP-15 (a zone within CAISO) as an example: The 15-minute market reported a total of 62 hours where hourly average prices were above $200/MWh, compared with just four hours in 2016. While the lowest market prices remained at the same level as in 2016, highest prices in 15-minute intervals reached $1986/MWh.

CAISO Market Processes

- **Day-ahead market processes:** The day-ahead market co-optimizes the energy and ancillary services markets, determines the transmission capacity needed, and procures residual unit commitment capacity to meet forecasted day-ahead load on an hourly basis. The day-ahead market process starts seven days before the trade date and closes the day before the trade date.
- **Real-time market processes:** The real-time market runs as a spot market to balance instantaneous system supply and demand fluctuations on a sub-hourly basis. The real-time market has two components: a 5-minute market and a 15-minute market.

Part of this was associated with exceptional events that occurred in the summer of 2017, such as extremely hot weather in September and a significant under-forecast of annual peak demand. However, these price spikes did not just happen in summer peak months—April and December, for instance, also saw considerable spikes. Further, these price spikes have continued into the winter and spring of 2018. Exhibit 1 below shows the increased NP-15 price variability by month for the past three years.

EXHIBIT 1: VARIABILITY OF NP-15 PRICES 2015–2018



Source: CAISO

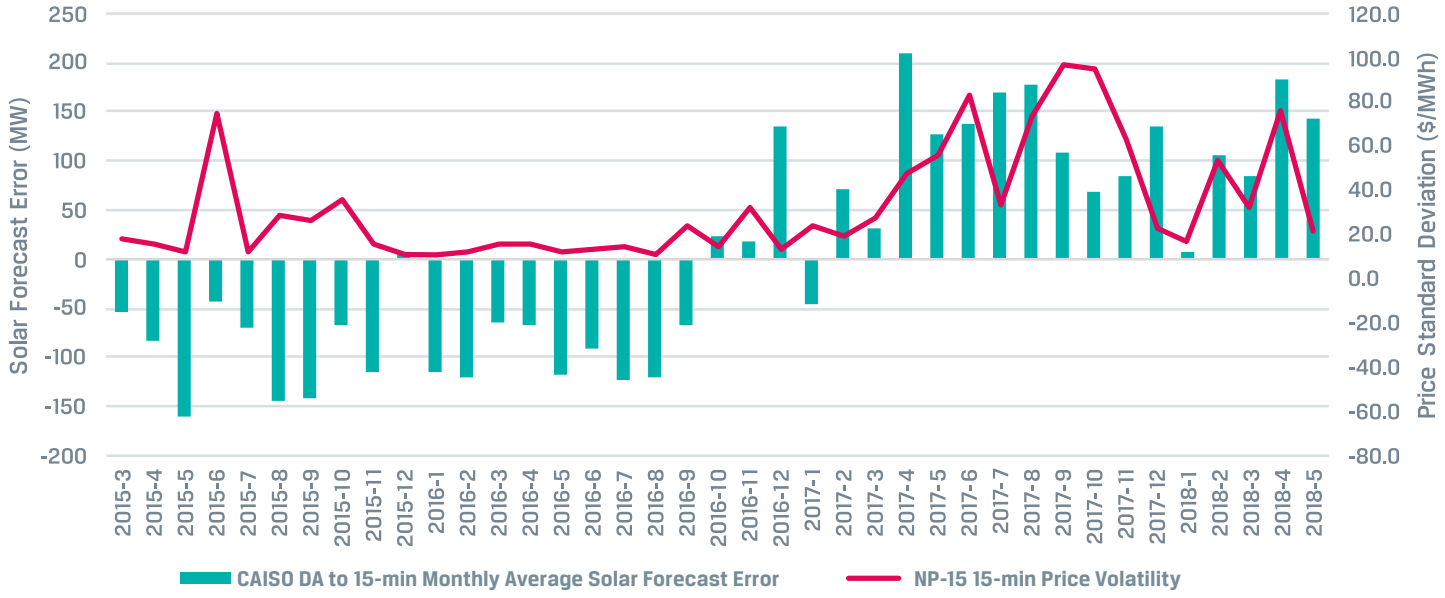
Price spikes are driven by market fundamental changes

These price spikes are increasingly driven by market fundamental changes in CAISO rather than exceptional events or sporadic factors. The system's increasing reliance on solar, both in front of and behind the meter, increases system ramping needs in real time. The continued tightening of thermal capacity in the market puts upward pressure on system ramping costs. These two factors together have driven the increasing frequency and magnitude of price spikes in all markets, real-time in particular.

Growing solar capacity and increasing forecast errors

The settlement of different markets in CAISO—day-ahead, 15-minute, and 5-minute—relies heavily on the forecast of demand and renewable energy generation made in their respective operational time lines. Forecast error between the DA and the RT markets creates unexpected ramping needs in real time, thus driving price volatility in RT markets. Exhibit 2 below shows how 15-minute price volatility has generally moved with the solar forecast error (DA to 15-minute market) in the past three years. As shown, under-forecasting of solar generation seen in 2015–2016 has given way to over-forecasting in 2017 and has likely been a contributor to increased price volatility.

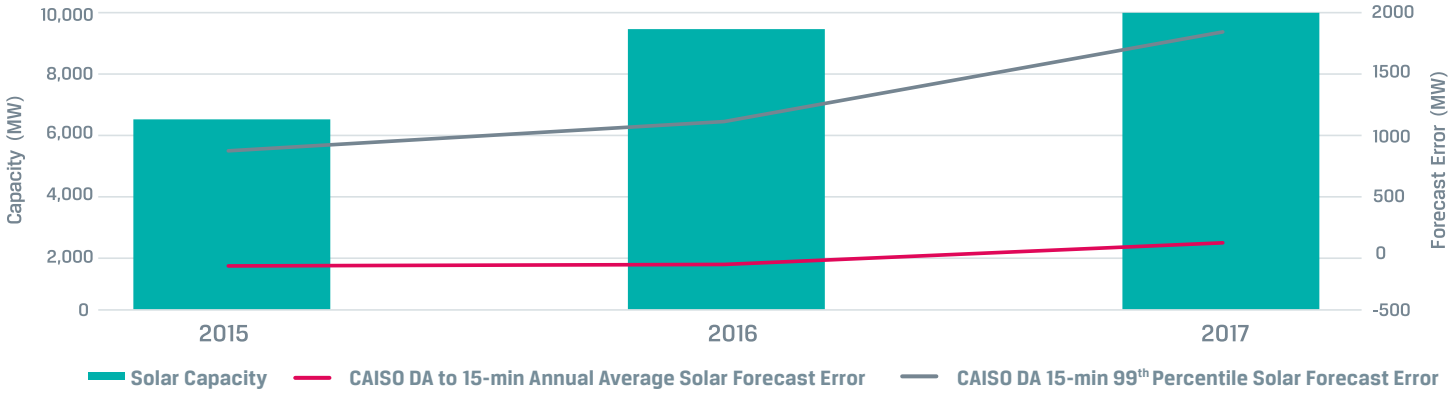
EXHIBIT 2: CAISO SOLAR FORECAST ERROR



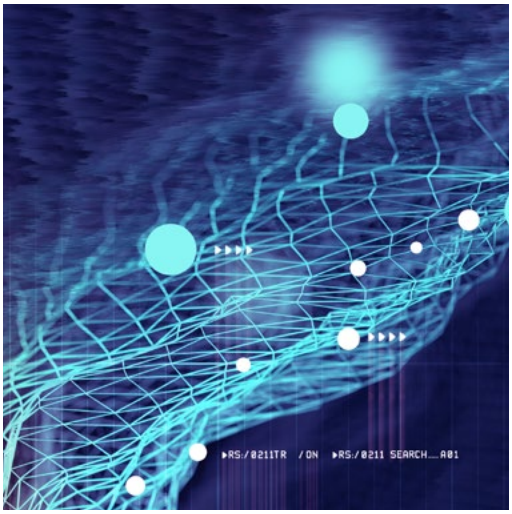
Source: CAISO

Extreme price events generally result in large price spikes. In this respect, solar forecast error has increased dramatically. The 99th percentile of the hourly DA forecast error rose from 888 MW in 2015 to 1,846 MW in 2017. Exhibit 3 presents a comparison of the distribution of solar forecast error from DA to 15-minute market in 2015 and 2017. While the average error has grown slowly, the 99th percentile forecast errors have grown sharply and exceeded the rate of growth in total solar capacity. This belies somewhat the argument that greater total solar penetration reduces errors due to averaging over a larger set of variables.

EXHIBIT 3: CAISO SOLAR CAPACITY AND FORECAST ERROR 2015–2017



Source: CAISO, Ventyx



Going forward, CAISO is expected to add another 12 to 13 GW of solar capacity to fulfill its Renewable Portfolio Standard requirement by 2030 and will continue to aggressively add behind-the-meter (BTM) solar capacity per the requirement from the California Energy Commission (CEC). The deployment of BTM solar brings special pressure on system reliability and price volatility in addition to the potential uplift of forecast error it might bring, it also increases the possibility of the system going through exceptional conditions because BTM capacity is net out of CEC load forecast (CAISO experienced far above-predicted annual peak, near a 1-in-10 level, in 2017), and it is not considered in the calculation of the effective load-carrying capacity (ELCC) that the state currently uses to calculate solar contribution to reserve margins.

Tightening thermal capacity

The CAISO system currently relies on gas capacity to address fast-ramping needs. The supply of gas capacity has tightened in CAISO recently due to poor economics and retirements driven by the Once-Through-Cooling (OTC) regulation. Gas capacity will further shrink in the coming years as another 5.3 GW of OTC-affected capacity are scheduled to retire between 2019 and 2025 while only 2.4 GW of gas capacity are to be added as replacements.

Meanwhile, fundamental demand growth is expected to be met by a combination of demand-side management and BTM solar, and reserve margins are to be maintained by further additions of utility-scale solar and energy-storage capacity. The overall tightening of thermal capacity puts upward pressure on system ramping costs, which, combined with increasing ramping needs, are expected to continue driving price spikes.

Price spikes reflect a correction of the market, not a failure

Though imposing challenges on RT system reliability, these price spikes shouldn't be considered as pure market failure. The increasing price spikes provide value uplift for fast-ramping capacity, which are fast becoming important revenue sources for dispatchable thermal capacity in a market that otherwise minimizes their value while needing their services. A typical gas-fired CT unit in NP-15 likely saw an increase in energy margins from 2016 to 2017 between $10–$30/kW-yr.

The tension between an increasing need of ramping capacity and longstanding under-compensation of existing thermal units has resulted in CAISO's increasing use of CPM and RMR contracts recently, which is uneconomic and a sign of market imperfection. However, going forward, as solar capacity continues to pick up, and as gas retirements tighten the supply situation of dispatchable resources, price spikes in RT markets will be one avenue to improve value for flexible units and keep needed capacity online.

Potential mitigants of volatility

Conventional wisdom suggests that regional coordination and battery storage provide avenues to mitigate volatility. Indeed, a more integrated Western Electric

Coordinating Council (WECC) system will allow dispatch of resources in a larger footprint and help reduce system ramping costs. However, California's neighbors are already effectively integrated in RT through the energy imbalance market (EIM), yet RT volatility in CAISO continues to increase. In the long run, many of CAISO's neighbors are also considering large renewable standards, sharply reducing the value of regional reserve sharing to CAISO.

Second, the addition of battery storage is seen as the eventual solution to integrating large solar fleets. California is rapidly increasing mandates; ICF predicts that around 5–7 GW of battery storage will be added to the CAISO system by 2030. However, as intermittent renewable penetration increases over time, the needs for battery or flexible capacity increase non-linearly. We expect that the addition of 5–7 GW of storage won't change market dynamics fundamentally. The relatively slow pace of storage additions compared to thermal retirements means that flexible gas units will see value uplift in the short- to medium-term at least.

Finally, it is true that one contributing element to price spikes is the ongoing operating restriction at the Aliso Canyon gas storage facility, which has reduced gas availability during critical times. However, one net result of Aliso Canyon's restrictions is to reduce the effective amount of total gas-fired generation capacity in the market (the other being gas price spikes), which is like a harbinger of the next few years when CAISO will see significant further reductions in actual gas capacity.

Proposed reforms will shift price spike revenues away from the RT market

Having said that price spikes provide economic value to the market, the sharp system ramping needs in real time that drive these spikes impose challenges on system reliability. As such, several ongoing stakeholder processes in CAISO seek to reduce these ramping needs in real time or shift them from the RT to the DA market.

The Day-Ahead Market Enhancement (DAME) process proposes to add 15-minute scheduling granularity in the DA market, as well as a DA flexible ramping product that intends to predict the forecast error and have flexible capacity ready. The system situation in terms of demand and renewable generation forecast is more volatile on a 15-minute basis than on an hourly basis in nature. As such, if the proposal is adopted, the system ramping needs, and associated revenues driven by 15-minute forecasting granularity and error, will largely be shifted to the DA market. The DA-flexible ramping product, together with associated rules that will potentially be established under flexible resource adequacy framework, will move part of the volatility-associated revenues to flexible capacity payments.

Therefore, the proposed market reforms, if adopted, will mainly serve to shift revenue streams and will not eliminate the increased value afforded to flexible units. This value uplift comes as a result of the fundamental challenges of managing increasing solar penetration whith reducing thermal capacity on the CAISO grid.

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