Navigating the new energy market dynamics

Utilities need to adopt new decision-making tools in order to compete in the "new normal" environment of renewable energy supply. By Gary Dorris and Carlos Blanco

The rapid deployment of renewable energy is fundamentally transforming energy supply and power markets, resulting in lower average prices but also more volatile prices. These new market dynamics are causing pain for inflexible generation resources, but also creating significant revenue-enhancing opportunities for flexible resources, particularly in the ancillary services and real-time markets.

Under this new paradigm, the shift to renewable generation has created new value chains and opportunities, while providing a threat to more entrenched players. From a risk- and decision-analysis perspective, traditional decision-support tools fall short of capturing the dichotomy between monthly price volatility and the new volatility in the hourly and five-minute markets. Power market participants that fail to adapt to these structurally changing market conditions will likely suffer the same fate as Kodak, Nokia and other companies that failed to respond to structural changes in their industries.

In this article, we will explore some of the key implications for decision analysis.

Structural change in power markets

Structural change in a market is a fundamental shift in the basic ways that a market operates. Power markets are at a turning point due to disruptive technologies on both the supply and demand sides. The shift in supply fundamentals of base energy from coal to renewable generation, and the shift in demand due to the rise of distributed generation and batteries, represents a structural change in the traditional models that electric utilities have operated in recent decades.

Fortunately, the speed of change in the utilities business model is slower than in other industries, such as cellphone technology or data storage, allowing for established companies to adapt to changing market fundamentals.

Some of the changes in power prices that have been brought by increased renewable penetration are consistent with developments in European power markets that have gone through a similar transformation: lower forward prices; substantial changes in the shape and dynamic of hourly price and implied heat rate profiles; and higher price volatility; particularly in hourly and sub-hourly markets.

As a result of these changes, the traditional approach of measuring and managing 'average' market exposures will result in suboptimal decisions and inaccurate risk projections. A key consideration moving forward is that uncertainty matters as much as the average and restructuring the portfolio to take advantage of hourly and sub-hourly price behaviour will be critical to capturing value in power markets.

Changing load patterns

One of the new market dynamics introduced by higher reliance on renewables is the changing load patterns. A clear example is the state of Hawaii, which has been working proactively to meet its goal of generating 100% clean energy by 2045. Policymakers have been aligning government regulations and policies with clean energy goals, facilitating the processes for developing renewable energy and deploying the renewable generation and grid infrastructure.

Figure 1 shows the system demand over the same week in June in the years 2006, 2009, 2012, 2014 and 2017. We can observe how system load levels and profiles have changed dramatically in 10 years. Loads for on-peak hours are down more than 20% and large increases in distributed generation photovoltaics have moved the peak load period to occur later in the day.

Additionally, system ramp patterns have changed, with increased frequency of changes in ramp direction. The erosion of demand is being embraced by the state of Hawaii: capital is being deployed, retail customers are installing rooftop solar, and large hotels have installed co-generation facilities, which fits the business model and strategic objective.

Power markets are at a turning point due to disruptive technologies on both the supply and demand sides

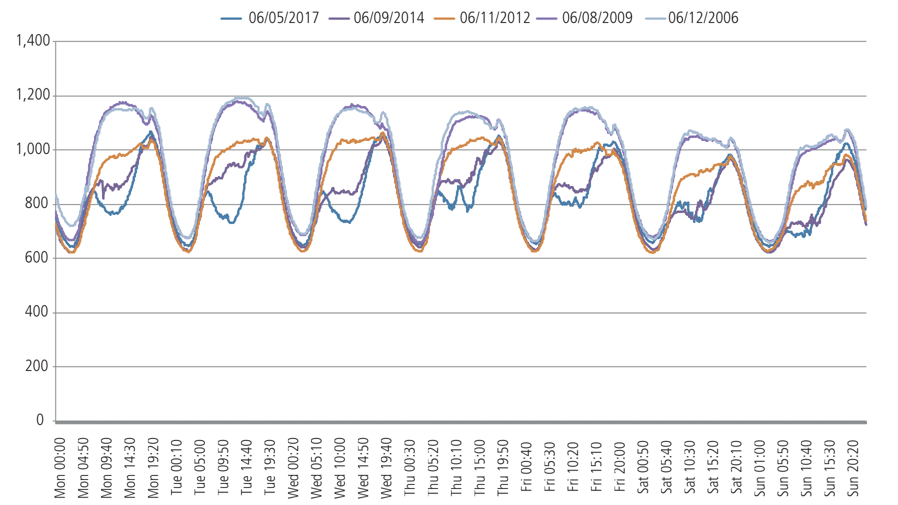
Solar generation and CAISO

On the US mainland, the impact of growing renewable penetration is particularly critical for CAISO (California Independent System Operator) and Ercot (Electric Reliability Council of Texas), driven primarily by solar and wind power, respectively. There are important lessons to be learned from the changes in market dynamics observed in recent years. In this article, we focus on CAISO.

Supply and demand fundamentals, CAISO

In CAISO, utility scale renewable generation is being added at a record pace. The California Energy Commission estimates 30% of 2017 retail electricity sales in California were served by renewable energy facilities, which is a significant increase from the 20% contribution level in 2014. The increasing supply of low variable cost wind and solar resources can be seen in changes in the supply stack, which represents the order in which units are dispatched to meet demand, stacked from the lowest cost to the least efficient. Renewables are displacing traditional base load resources and pushing the supply stack

1 Hawaiian Electric's changing load patterns, 2006–17



Source: Hawaiian Electric

outward, and this trend is projected to continue as renewables displace traditional baseload resources. However, while lower generation costs are already adding pressure on coal units and other traditional baseload resources to retire, the intermittency from renewables are at times creating higher prices and introducing new opportunities from additional market volatility.

The changes in the dynamics of hourly prices, as measured through hourly implied market heat rates (power price divided by natural gas price), follow the solar generation profiles advancing in California between 2014 and 2016, as shown in Figure 2.

Figure 2 shows the system-wide hourly solar generation in gigawatts (left Y-axis) as well as the hourly implied heat rates (right Y-axis) in California for 2014, 2015 and 2016. Average super-peak prices have dropped from $47/MWh to $36/MWh in the 2014–16 period and the implied heat rates during those hours have decreased from 10MMBtu/MWh to 8MMBtu/MWh. The decline in heat rates during those hours is due to the fact that there is significantly more solar generation.

While we see the decrease in prices and implied heat rates during the super-peak hours, the implied heat rates during shoulder hours increases due to high demand and low solar generation levels in the morning and early evening hours. Hours 18–21 had implied heat rates of about 14 in 2014 and, over the course of two years, the implied heat rates increased by 20% to a level close to 17MMBtu/MWh with similar conditions occurring in the early morning hours. These changes suggest a greater opportunity for highly flexible generation that can counterbalance the natural vicissitudes of renewable generation.

The inherent intermittency induced through increasing levels of renewable generation has become directly manifest in the volatility of market prices. The effect of renewable generation on market prices are demonstrated through the three different charts in Figure 3 of the CAISO node SP-15 (Southern California) in the 2014–16 period. The top chart shows with contribution of renewables increasing from 10% to 22% over the three-year period (top chart). Over the same period, the volatility in the day-ahead market prices correspondingly increased from 42% to 60% (middle chart) while the real-time (RT) price volatility increased from 50% to 100%.

As wind and solar generation displaces conventional sources of base energy, it is expected that volatility in locational marginal prices will continue increasing.

Another important dynamic is the increase in frequency and magnitude of real-time price spikes – both upwards and downwards, but principally upwards. Markets with high renewable penetration are characterised by extremely volatile real-time prices related to the inherent intermittency of renewables.

The nature of spot price dynamics are shown in Figure 4 through a series of frequency plots that show the number of times the five-minute RT prices exceeds $100/MWh using 2014 to 2016 data for SP15.

Understanding the relationship between the amount of renewable generation and the probability of price spikes can be used by owners of flexible resources to make optimal bidding decisions between energy and ancillary services markets.

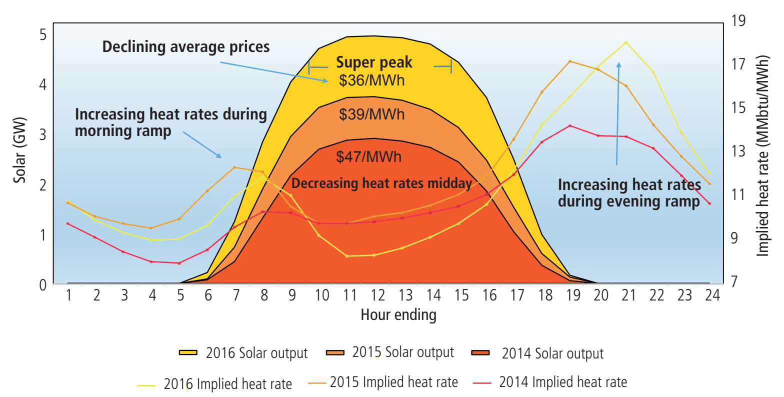
At the node level, price-volatility dynamics are not just a function of the hour of the day and month of the year, but also the node location. Figure 6 shows a volatility map of locational marginal prices, measured by their standard deviation. We can observe that volatility in CAISO is not homogeneous across nodes. As expected, the intermittency of renewables is one of the key drivers of volatility. Congestion appears greatest in the Central Valley, but volatility is also considerably larger as a result of the greater renewable penetration.

Decision-analysis tools in the 'new normal' environment

Structural change has arrived in power markets and it is here to stay. Management teams of market participants need to look forward and identify where opportunities and risks lie in this new environment.

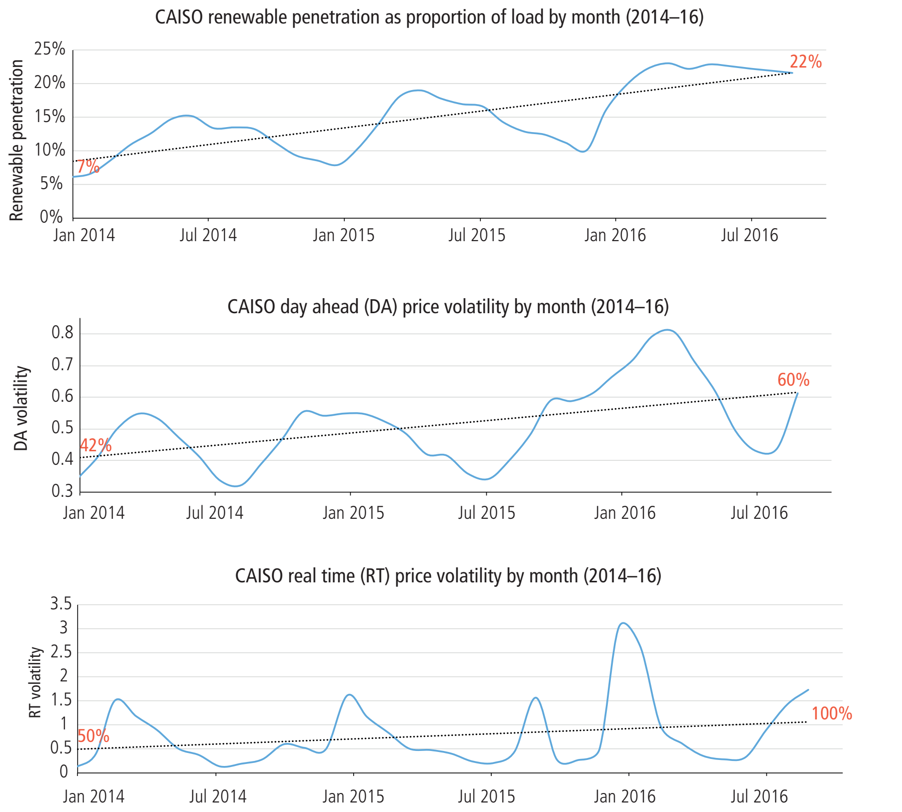
In the presence of wild price swings caused by the intermittency of renewables, decision-support tools need to incorporate weather-driven uncertainty and can no longer be based on weather normalised conditions or average prices and deterministic views.

2 Implied heat rate versus solar generation in California



Source: Ascend Analytics

3 SP-15 Market Analysis. Renewable penetration and price volatility (2014–16)



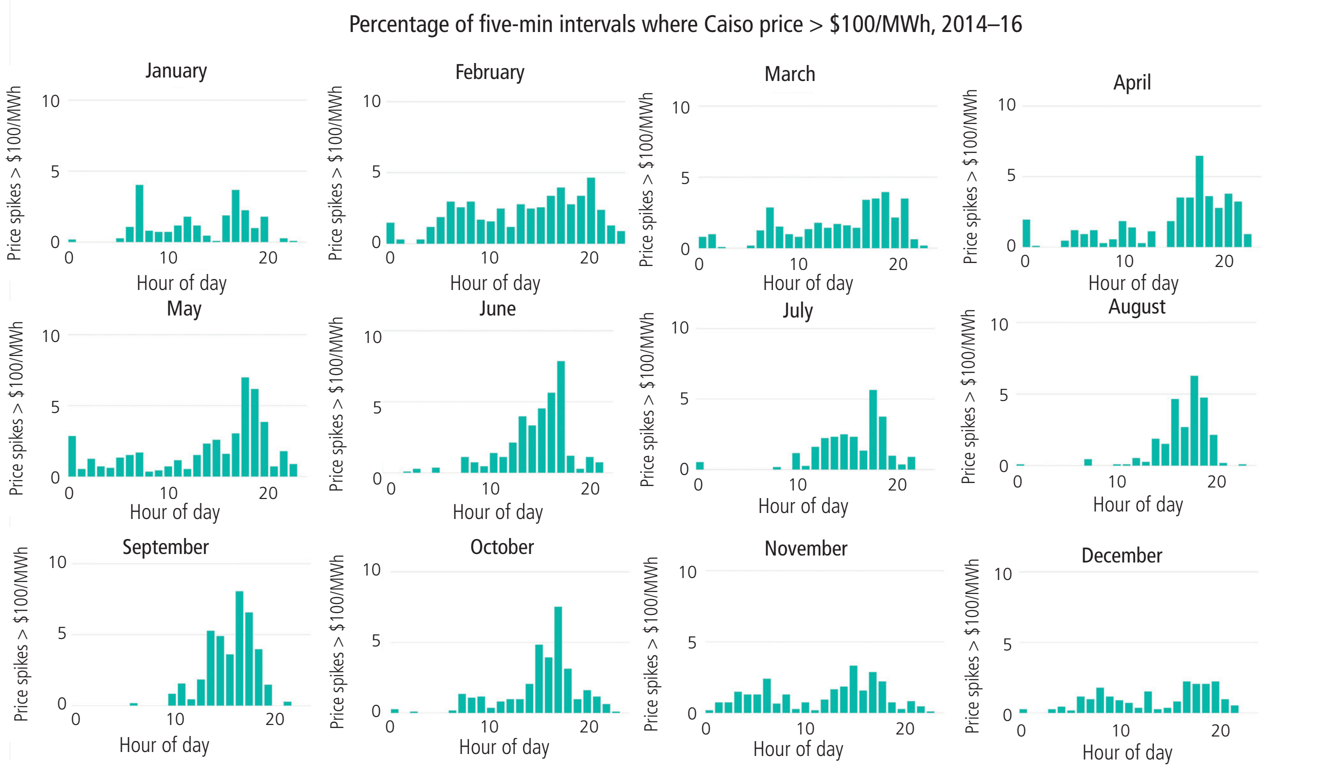
Source: Ascend Analytics

With a high concentration in renewables, weather has become the new fuel driving the price dynamics of power markets with unprecedented levels of volatility. Weather now has a pronounced influence on co-determining position and cashflow exposures. As a result, energy position exposures have become significantly divorced from financial position exposures. The question utilities face is not whether there are enough resources to meet the average load, but whether there are enough flexible resources in the portfolio that can isolate cashflows against the extreme market variability.

From a decision-analysis perspective, valuation and risk models that do not incorporate the relationship between weather and the supply and demand of power will likely lead to suboptimal decisions. As higher weather variability drives higher power price volatility, more accurate weather forecasting will have increasing value in the new market dynamics.

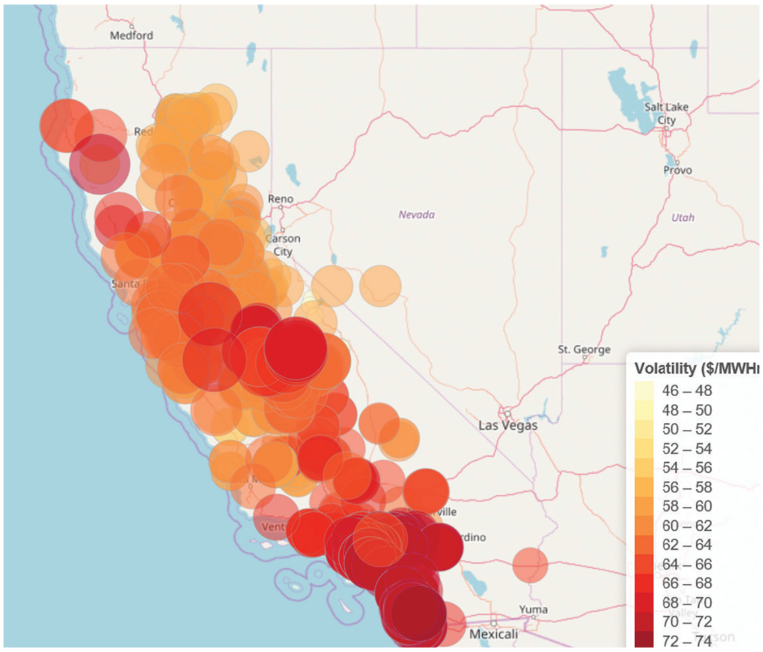
In addition, it is critical to ensure that models incorporate real-time price dynamics to provide greater insights into actual financial exposures. Under the new market dynamics, modelling day-ahead prices and loads is not sufficient because of the inherent natural exposure nearly all portfolios contain to large positive or negative price spikes and their

4 Frequency of real-time price spikes in SP-15, by month



Source: Ascend Analytics

5 Spatial heterogeneity of market price volatility



Source: Ascend Analytics

material financial implications. Any risk metrics based on average prices and average loads are likely to provide a false sense of security and misalignment of hedges to adequately mitigate uncertainty in future cashflows.

In this new environment, flexibility and timing is critical, even though energy is worth less on average. For example, when valuing renewable projects, it is essential to model hourly and sub-hourly price dynamics, because renewables are settled against the real-time price. Proactive management teams at leading utilities are already repositioning their portfolios to be more flexible, to capture volatility and short-duration price spikes. Highly flexible resources such as short-duration and high-capacity batteries or internal combustion engine generation units can provide isolation as well as take advantage of those price dynamics.

For example, let us assume a utility in California owns a flexible generation resource. The interaction of the flexible resource to market prices follows from figure 6, where the day-ahead energy, day-ahead generation offer price, and real-time (five-minute) settlement price are shown for a typical day in September.

For the hours when the day-ahead hourly energy price is above the generation offer price – shown in red – the utility would operate in the day-ahead market and effectively commit the generation to serve load. However, an additional source of revenue for the utility would come from price spikes in the real-time market in the time intervals where the real-time price exceeds marginal cost of generation. Another alternative is to collect rents in the ancillary services market when the likelihood of price spikes is low. Predictive analytics could help the utility determine the likelihood of a price spike in the real-time market based on existing grid conditions and expected renewable generation output for that time interval, and maximise net revenues between the real-time and the ancillary services market.

Markets with high renewable penetration are also seeing a large spread between day-ahead and real-time prices. The imbalance between buyers and sellers means sellers require a premium to sell in the day-ahead market given the increased uncertainty in the real time market. This again spells opportunity and risk for asset holders to retain customers by designing hedging programmes to take advantage of these new market dynamics.

Summary

As a result of unprecedented technological evolution, renewables are entering the market at an inexorable rate and causing a pronounced transformation of price formation, which is the foundation for structural change. Utilities can draw upon the many lessons from companies that have faced structural or regime changes in other industries, and develop an action plan to succeed in the new environment.

Management teams should keep the big picture in sight and incorporate the impact of structural change on price levels and volatility in the overall business strategy. In the new paradigm, uncertainty counts as much as averages to capture some of advantages of market structure and dynamics. Flexibility will also be a key source of value, while inflexibility will become a source of pain.

In order to navigate these new market dynamics, tools to support planning, portfolio and risk management decisions need to be improved to adequately capture the structural changes brought about by the increasing role of weather on power markets. ■

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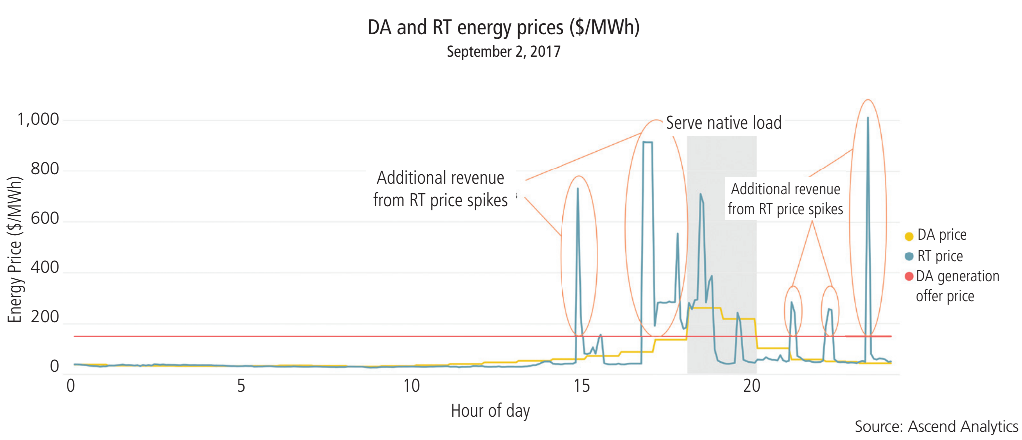
6 Day ahead and real-time energy prices for SP-15 and generation offer price



Source: Ascend Analytics