

Navigating PJM's Changing Capacity Market

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Introduction: preparing for 100% capacity performance

PJM and its market participants will enter unfamiliar waters in the spring of 2017. The Base Residual Auction for Delivery Year 2020/2021 will be the first time that PJM's capacity market will procure only capacity performance (CP) resources. The CP paradigm represents a fundamental shift in PJM's market rules that introduces new risks and new opportunities. With this shift comes increased complexity of analysis and decision making. Given the new rules and the inherent uncertainties in several key CP parameters, most PJM market participants do not possess the tools and strategies necessary to manage risk and maximize opportunity.

Since the transition to CP began two years ago, CRA consultants have provided diverse PJM market participants with insights and strategies to explore this new and uncertain landscape. Based on our analysis and experience, we make two observations about capacity offers under the CP regime. First, a reasoned approach to offering CP capacity should be based on an assessment of the opportunity cost of assuming a capacity obligation in RPM. This is a more complicated analysis than what was required under the prior rules, since simple "price taking" behavior is no longer an optimal offer strategy for most resources. Second, we observe that most market participants are failing to incorporate such considerations in their resource offers. This leads to risk exposure for individual resource owners and inefficient outcomes in the aggregate.

In this white paper, we provide a brief overview of CP, lay out CRA's approach to designing optimal capacity offers based on opportunity cost, and discuss methods to estimate capacity market outcomes under CP. In the last two sections, we describe our proprietary tools designed to assist clients with navigating the uncharted CP waters.

Overview of capacity performance

PJM developed CP largely in response to the imminent retirement of thousands of megawatts of baseload capacity and the near-shortage of capacity and energy during the polar vortex of 2014. The revised market rules, similar to ISO-NE's Pay-for-Performance program, were designed to align resource incentives with market goals; namely, to both provide capacity payments to sustain resource adequacy while also incentivizing investments and behavior to ensure that capacity resources are available to provide energy during times of system strain. There are many publicly available documents outlining the concept of performance incentives and how they are being applied in PJM through the CP construct. We will, therefore, only highlight a few key features critical to understanding CP:

- **Penalties** – During delivery years, committed CP resources are subject to penalties for non-performance or under-performance during emergency events, called Performance Assessment Hours (PAH). The parameters defined by PJM make it highly unlikely any resource will lose all of its capacity revenues. Penalty rates are designed to drive annual penalties to fully negate annual capacity revenue should a CP resource be completely non-performing for a large number of PAH in a year. For example, even at

the relatively low clearing price of \$100/MW-day, it would take more than 10 PAH without performance for a resource to owe more in penalties than it collects in revenues. This is a greater number of PAH than are expected for most years, particularly as system performance improves due to CP. There have not been any hours that would have qualified as PAH in the past two years. PJM analysis suggests that 42 PAH would have taken place across eight different days between 2011 and 2014, with nearly half of the hours occurring during the polar vortex from January 6–8, 2014.

There is a cap on annual penalties. Stop-loss provisions prevent penalties in excess of 1.5 times the cost of new entry in PJM, which could be the equivalent of as much as 3-4 times capacity revenues.

- **Bonus payments** – Committed CP resources may earn “bonus” revenue for performance that exceeds the fleet average. The bonus payment rate is driven by the size of the bonus pool, which is made up of revenue from penalties. Resources that do not take on CP obligations (“uncommitted resources”) may also receive payments from the bonus pool if they perform during events.
- **Status of CP transition** – To date, there have been two transitional auctions as PJM moves toward full implementation of CP rules. Starting with the Base Residual Auction (BRA) for Delivery Year 2018/19, resources could choose to offer as either a CP resource or as a “base capacity” resource, a classification with fewer performance obligations and penalties. The first auction with 100% of resources clearing as CP product will be held this spring, for Delivery Year 2020/21.

Designing optimal CP offer strategies

Prior to CP, low penalty rates meant capacity obligations came with very little downside risk. Accordingly, a rational offer strategy would have been based primarily on net going-forward costs, or the amount needed in excess of energy and other revenues to justify continued operations. Many existing resources, particularly those that had no intention of retiring in the near future, might have had an incentive to offer into the BRA as price takers. It is well documented that market participants frequently offered resources at \$0/MW-day to ensure clearing in the auctions.

Under CP, substantial penalties apply, and resources that do not clear avoid penalty risk while maintaining the ability to earn bonus payments. Even cleared CP capacity resources may receive bonus payments when they operate at higher than their expected output. These risks and incentives must now be taken into account in any resource’s competitive offer.

In light of the above, we believe that a properly formulated capacity offer under CP should be based on the opportunity cost of the resource. The cost of the opportunity to accept a CP obligation has two components: 1) risk of non-performance penalties, and 2) accepting lower bonus payments during PAH than it would receive as an uncommitted resource. This approach has been supported by the PJM Independent Market Monitor.

The calculation of an offer is specific to each generation owner, and varies depending on the generation owner's expectations with regard to unit performance, risk tolerance, the number of expected PAHs, and expected bonus payment levels. Our analysis suggests that the result of such a calculation is significantly dependent on assumptions regarding the frequency, depth, and duration of PAHs. However, the fact that there is considerable uncertainty about how PAH events will unfold, and particularly how frequently they will take place, introduces complexity to performing this calculation. PJM's CP rules also suggest to us that individual capacity resources may have a different competitive offer than a resource that is part of a larger portfolio, which may permit offers that facilitate hedging of unit-level, non-performance risk.

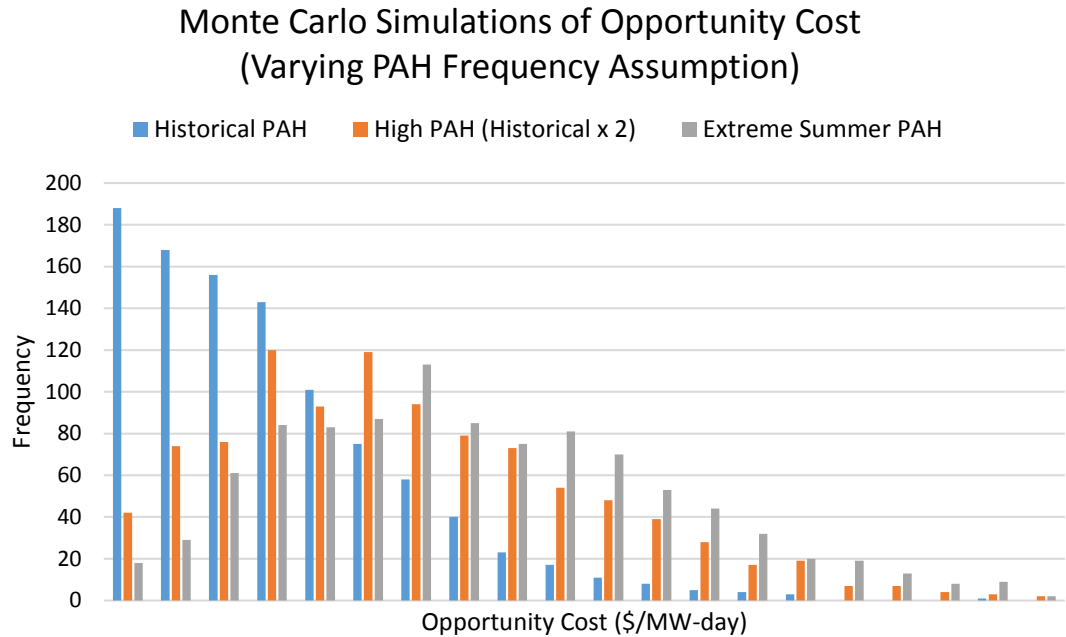
CRA's CP offer strategy model

CRA has developed a tool to calculate opportunity cost-based offers in a manner that accounts for unit-specific characteristics and the uncertainty regarding future PAH outcomes. The CP offer strategy tool provides insight into the potential benefits and costs of offering capacity to RPM under the CP rules. Our model takes on the new calculus for RPM participation, based on the risks and benefits of taking on a capacity obligation. It results in an indication of the RPM clearing price at which the resource owner would be economically indifferent to clearing in the RPM or becoming uncommitted.

As described above, the challenges associated with assessing the CP opportunity costs are numerous. In light of the uncertainty, CRA developed a Monte Carlo-style analysis of the opportunity cost of RPM participation. Monte Carlo simulations allow for an accounting of risk, where there is uncertainty in decision making, by laying out a range of possible outcomes. Inputs are based on CRA's analysis of historical market data and information about the specific resources in question. The output allows the resource owner to inform its decision on how to offer into the BRA with an understanding of the opportunity cost of the most likely outcomes, and the range of less likely outcomes. Understanding the likely range of outcomes can be beneficial for risk management.

Figure 1 depicts representative outcomes of the model for three different estimates of the number of PAH in a delivery year. The range and distribution can vary significantly based on many input variables.

Figure 1



Source: CRA analysis

For market participants with multiple resources, portfolio strategies can be developed using the results of the model for specific generating units. CRA has experience evaluating portfolio approaches that consider performance netting and integrate portfolio theory.

Estimating RPM outcomes

An economically optimal offer strategy does not consider the likely RPM clearing price. However, there is a great deal of interest in expected outcomes of both near-term and long-term RPM auctions. Capacity price estimates are significant drivers of portfolio plans, resource investment decisions, and a variety of other forecasting needs throughout the industry. This is especially true for generators operating in the current landscape of low energy revenues. CRA has developed a near-term capacity price forecasting model and altered our medium-term forecasting model to account for CP rules and expected offer behavior.

CRA's near-term CP forecasting model

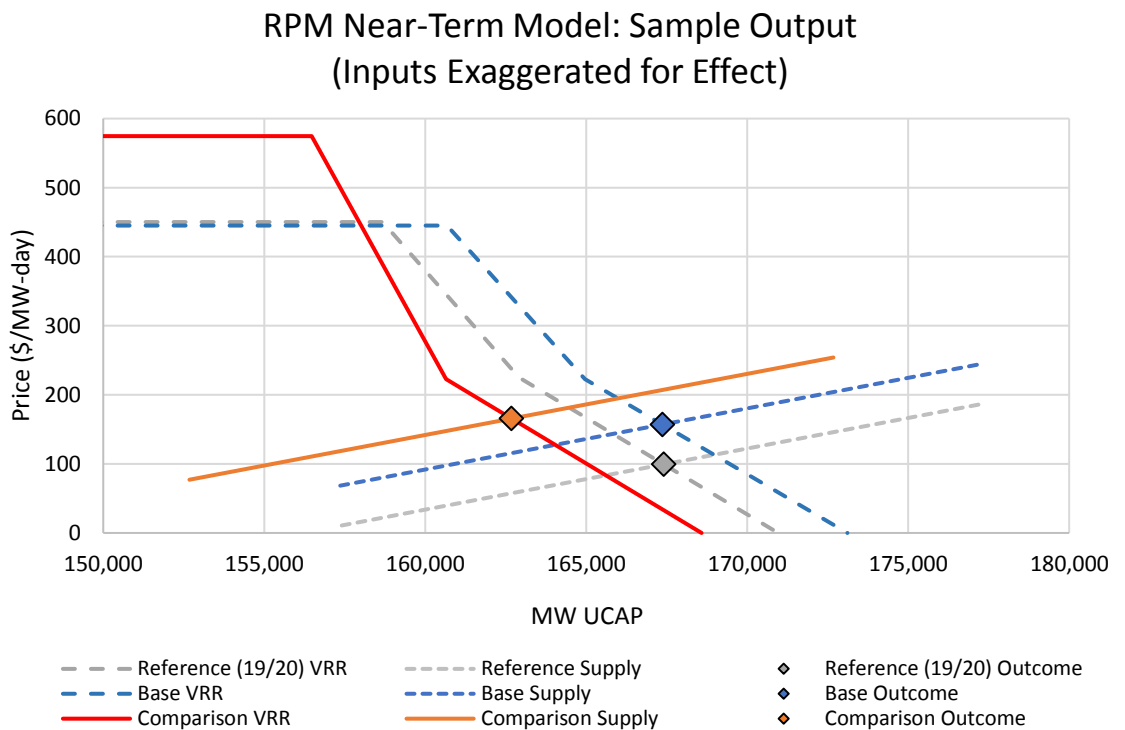
The CRA near-term CP forecasting model provides insight into capacity price and quantity outcomes in near-future BRAs. While each BRA outcome is based on the intersection of the PJM locational demand curves with supply (resource offer) curves, only the demand curve can be known with precision prior to each auction. The bottom-up supply curves approach, based on net going-forward costs for each resource in each PJM, has been

rendered ineffective by the CP paradigm. CP significantly relaxes offer rules and allows resource owners to develop offers based on their individual performance and parameter expectations. This new approach even allows for offers not based on economic fundamentals, as long as they remain within specified offer price boundaries. The lack of any PJM data about individual offers further complicates the situation.

The optimal forecasting method should begin with gleaning as much as possible from past outcomes. In particular, there is value in understanding the dynamics of the supply and demand curves around the clearing price and quantity. The near-term outcome can then be estimated by shifting assumptions about the supply curve depending on year-to-year changes in market rules, performance expectations, and any new entry or exit of capacity. Drawing on this understanding, CRA consultants built a tool focused on the characteristics of the supply curve at and around the point where it meets the demand curve. The resulting model draws insight from the results of recent BRAs and associated publications by PJM and PJM's market monitor.

Figure 2 shows a sample output from the model, which includes prior year results, a baseline estimate of the coming year, and a comparison case that allows the user to test outcome sensitivities. The data shown is not designed to represent actual CRA estimates for the upcoming BRA.

Figure 2



Source: CRA analysis

CRA's mid-term and long-term CP forecasting model

CRA forecasts capacity prices over the long term with a separate, proprietary capacity market model that is based on the characteristics of the PJM generating fleet, and that reflects the specific rules and design elements of the RPM. This fundamentals-based tool specifically represents the administratively-set demand curve in the RPM, along with a supply curve based on each market participant's projected "missing money." The missing money calculation is based on the levelized cost to build (for new units) or the fixed going-forward costs (for existing units) less projected energy and ancillary services revenues. The revenue projections are fully integrated with CRA's energy market analysis, performed with an hourly chronologic dispatch engine that assesses the performance of all plants in the market, allowing for an internally consistent long-term view of energy and capacity prices. Plant-level cost data is customized according to unit type, location, plant age, and other characteristics, while risks associated with potential capacity performance penalties and bonus payments can be incorporated in the supply curve development. The result is a forecast of RPM capacity prices designed to provide general insight about longer-term trends in capacity market outcomes.

Conclusion

After several years of transition, the upcoming Base Residual Auction will be the first full step into the world of capacity performance in PJM. While uncertainty surrounds capacity market outcomes and what will come when PAH events actually begin to take place, market participants can bolster their position by developing an understanding of the rules and implementing appropriate strategies. Above all, this means revising offer strategies to an opportunity cost approach, one that appropriately reflects the new risks and potential benefits associated with CP. CRA's experts are happy to share our thoughts with those interested in this highly important market.

About CRA

CRA's Energy Practice has a long history of working with clients on a variety of engagements related to PJM's capacity market, and capacity markets more generally. Our experience with capacity markets dates to their inception, as does our experience with the PJM CP construct. Our experts were engaged on behalf of participants in the CP design and implementation proceedings in PJM, as well as the Pay-for-Performance proceedings in ISO-NE. This included submitting expert testimony in FERC proceedings on behalf of our clients. We have specific experience in developing successful offer strategies for the RPM under CP. We have worked with both single plant and large portfolio owners on similar engagements to the one indicated in this white paper.

Related to CRA's experience and the modeling capabilities described above, we maintain detailed models and databases representing the RPM market and we provide market price forecasts to several market participants, including generation owners, developers, traders, and load-serving entities, on a regular basis.

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