CRA Insights: Energy

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October 2019

Addressing capacity performance risk for variable energy resources

PJM's Capacity Performance program has created new risks and opportunities for generators in PJM, shifting the calculus and complicating capacity market offer strategies. Concerns are particularly acute for renewable generators that have limited ability to control output during performance events and face the spectre of considerable under-performance penalties. Thus, renewable generators need to determine whether to participate, at what price to offer their megawatts, and how much capacity to offer and exposure to take on. Thoughtful review of available data and strong analytics can address these uncertainties and allow for robust decision-making under uncertainty.

Background

PJM's capacity market provides a valuable revenue stream to owners of generating resources in the PJM footprint, including power plants with intermittent output. However, taking on a capacity obligation is not the low risk proposition it used to be. In June 2015, the Federal Energy Regulatory Commission (FERC) accepted PJM's proposal for adding capacity performance (CP) rules to its capacity construct.[1] The intent of CP was to create incentives, through penalties and bonus payments, for capacity resources to provide energy when it is most needed.

Under CP, PJM assesses performance during certain PJM-determined periods of system need, called performance assessment intervals (PAI). During each PAI, committed resources are expected to perform at least as well as the average of all capacity resources (quantified as the "balancing ratio"). Committed resources that fail to deliver as expected face penalties on the order of $3,000 / MWh. Accompanying the penalty scheme, CP creates the opportunity to earn bonuses during PAI by outperforming expectations. For resources with capacity obligations, performance above the balancing ratio leads to bonus payments. For resources that do not have a capacity obligation, all MWh produced during a PAI can earn bonus payments.[2]

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1 On a similar timeline, ISO-NE implemented an analogous program, called pay-for-performance (PFP). In this paper, we focus on PJM's CP program. Most of the findings and capabilities described, however, apply in both markets.

2 The bonus payment rate does not vary between resources with or without capacity obligations. The size of the bonus payment rate in PJM is calculated on an event-by-event basis and is equivalent to the total penalty payments during the event divided among the pool of over-performance MWh. In ISO-NE's PFP program, the bonus payment rate is set equal to the penalty rate, and a separate arrangement is in place to handle account imbalances.

Offer strategies under uncertainty

The CP penalty and payment structure informs an optimal offer in PJM capacity auctions. A resource considering participation must compare expected revenues available for an uncommitted resource (bonus payments for all MWh during PAI) to the expected net revenues for a committed resource (bonus payments only for over-performing MWh and penalties for under-performing MWh during PAI). In most cases, the capacity price must cover the resource's "opportunity cost" of accepting an obligation. This comparison determines the competitive offer price, as shown in the following formula:[3]

Competitive Offer Price =

(Expected bonus payments as non-committed resource) –

(Expected bonus payments as committed resource – Expected penalties as committed resource)

While the formula is relatively straightforward to articulate, determining expected payments and penalties, and the risks and likelihoods associated with each, is complex. The underlying problem is fundamentally probabilistic, with considerable uncertainty about when events will occur as well as numerous other factors that drive the expectations of market participants, including:

- **Event frequency:** How frequently will PAIs take place? How long will they last? Is event incidence correlated with season, time of day, day of week, etc.?
- **Pool performance:** How will the pool of capacity resources perform during each event? How will pool performance change based on event timing?
- **Resource performance:** Accounting for the above, how do I expect my generator to perform during events as compared to the pool?
- **Bonus rate:** How large will the bonus rate be during each event as a function of performance by both capacity and non-capacity resources?
- **Evolution of resource mix:** Will the evolving resource mix change event timing and pool performance? Will experience with CP rules improve pool performance?

These uncertainties are also complicated by the lack of experience with the program. CP has technically been an active program since 2016, but there have only been two events to date, and one was very minor.[4] Thus, readily available data on event frequency or participant response is limited to PJM's analysis of hypothetical historical events. While this is useful information, it is confounded by the likelihood that CP rules will influence outcomes during future periods of system strain, as well as changing resource mix and shifting market fundamentals, thus limiting the value of the historical dataset.

Uncertainty about the financial ramifications of CP is particularly acute for renewable resources. This stems primarily from the inability, in most cases, for these resources to control output during PAI. Renewable resource owners must also navigate the considerable leeway in the PJM rules regarding

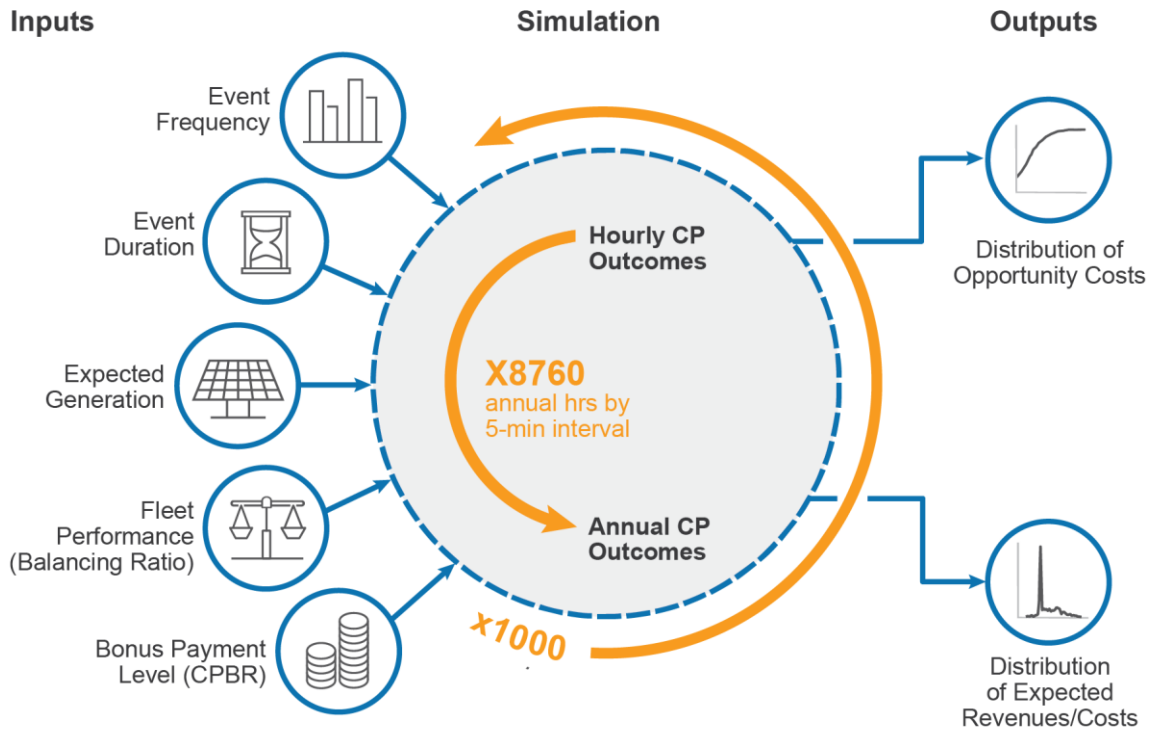
[3] This logic applies to capacity offers in both the Base Residual Auction and Incremental Auctions. Some resources with very high avoidable going forward costs may also need to consider such costs as well, but that is not generally the case, particularly for renewable resources.

[4] On May 29, 2018, there was a 30-minute event that affected only AEP-Edison. More recently, on October 2, 2019, there were two hours of PAIs in the AEP, BGE, DOM, and PEPCO zones during unseasonably hot weather.

the quantity of unforced capacity (MW of UCAP, the denomination transacted in the capacity market) that may be offered by intermittent resources.

A CRA analytic approach and model

To address the probabilistic uncertainty associated with CP participation, CRA developed a model that can help our clients determine offer strategies that incorporate uncertainty and account for complexities of the PJM capacity market. Our purpose-built model takes a Monte Carlo simulation approach, which supports decision-making under uncertainty by developing probabilistic expectations across a range of possible outcomes. This approach relies on a large number of repeated simulations, with each simulation representing a settlement interval to which a randomly selected set of circumstances applies, all based on distributions of historical events. For each interval, the financial result is calculated for the modeled CP resource. This analysis is performed across the study year and annual results are summarized. The study-year analysis is then repeated 1,000 times to develop a distribution of possible annual outcomes for a given capacity commitment period, which can then be presented as a range of opportunity costs or revenue expectations. This approach is illustrated below:



To calibrate the model inputs, we use all historical data available in PJM publications. We are then able to modify these inputs to account for expected future changes and to test the sensitivity of the model outcomes to different input parameters. The model can be structured to reflect solar production profiles, wind production profiles, or the production characteristics of a conventional generator.

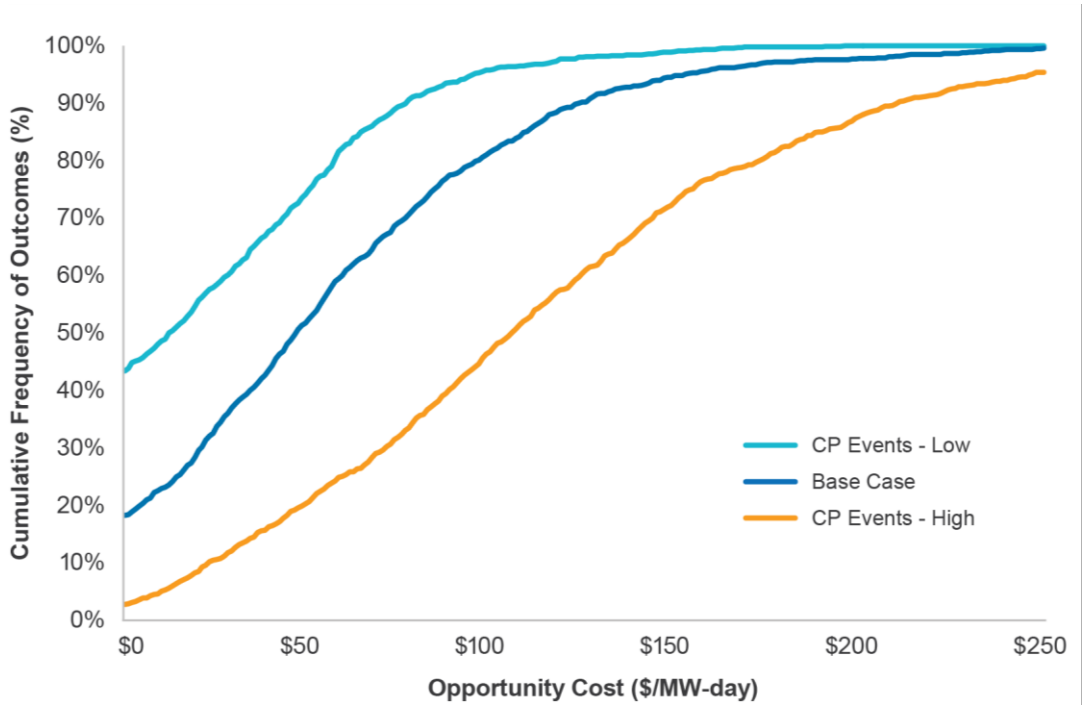
Select observations and discussion

We provide a set of observations and discussion based on our learnings from several engagements on this topic and a set of model runs for a representative, non-tracking solar facility located in New

Jersey.[5] Note that CRA's CP model is not designed to result in a single suggested competitive offer or a single revenue expectation for a capacity resource. Rather, the results of our simulations provide a probability distribution of potential outcomes, which can then be interpreted and acted upon by market participants based on risk tolerance. CRA offers our clients guidance on interpretations and strategies.

First, we observe the expected outcomes: the opportunity cost of taking on a capacity obligation is highly dependent on expectations for how frequently CP events will take place. Less frequent events lead to fewer opportunities for uncommitted resources to earn large bonus revenues or to avoid penalties. Fewer expected events therefore suggest lower opportunity costs of taking on capacity obligations. This analytic result is shown in Figure 1. The lightest blue line, represents fewer expected events and shows a higher frequency of low opportunity cost outcomes.

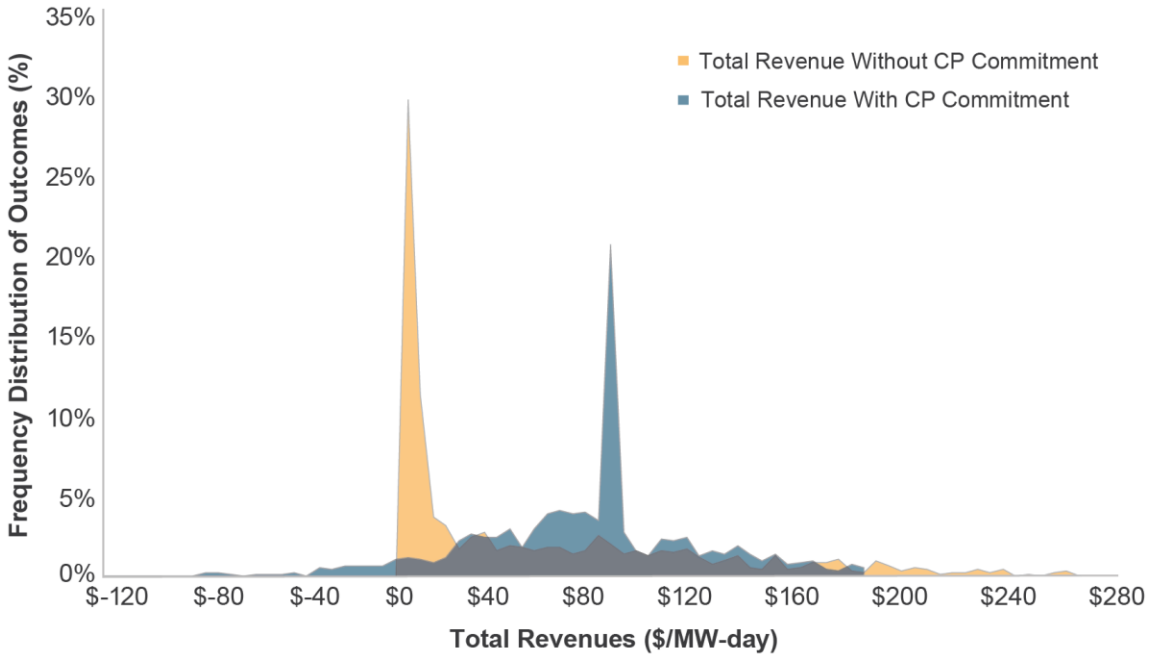
Figure 1: Opportunity cost curves under different expectations for frequency of CP events



Beyond developing an analytic foundation for an informed capacity market offer, resource owners will also want to understand and compare overall expected revenues from the capacity market under alternative market participation strategies. Taking on a capacity obligation provides the certainty of the primary capacity payment along with the uncertainty of CP payments and penalties that in many years may be relatively small. In contrast, participating as an energy-only resource means completely forgoing any revenue certainty from the capacity market, but also gaining the opportunity to earn significant, if infrequent, bonus revenues. Energy-only resources also avoid the possibility of net negative outcomes since they are not exposed to penalties. Figure 2 shows a distribution of expected total revenue outcomes for the representative solar resource with a CP commitment (blue) and without a CP commitment (orange).

[5] Due to the simpler production profile of solar resources as compared to wind generators, we focus here on this sample "typical" solar resource.

Figure 2: Revenue distribution for different market participation strategies



Further complicating participant decision-making is the latitude PJM provides solar resource owners in determining the amount of UCAP they can offer. Intermittent resources can offer capacity on an annual or seasonal basis. The rules also appear to allow a solar generator to justify an offer of as much as its full summer UCAP on an annual basis. While this can potentially lead to higher up-front capacity payments, the owner must consider its increased penalty exposure.

Figure 3 presents CP revenue distributions for an example resource that offers and clears either summer UCAP (high), average of summer and winter UCAP (middle), or winter UCAP (low).

Figure 3: Box and whiskers plot of revenue distribution (100 MW hypothetical plant)

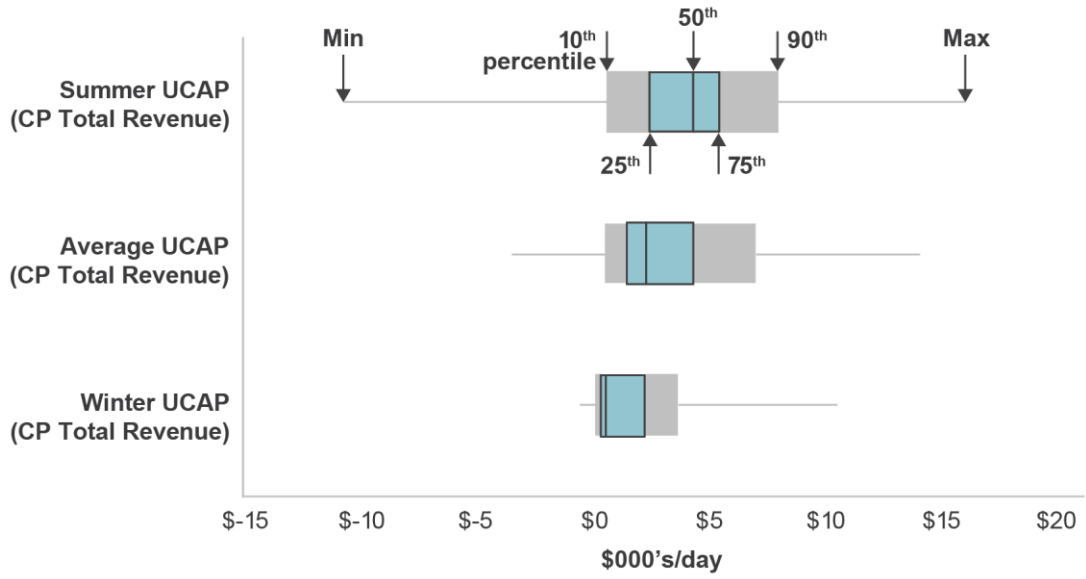


Figure 3 shows that offering a summer UCAP on a year-round basis shifts the central tendency of the revenue distribution to the right. This is mainly driven by the higher capacity revenue from selling a larger quantity of UCAP. Selling more UCAP also leads to a wider distribution of outcomes with more downside risk in extreme cases. Depending on the risk preferences of the market participant, this observation may support a more aggressive approach to establishing the quantity of UCAP to be sold for a solar resource, particularly if insurance is obtained to cover downside risk in extreme cases. While not presented in this white paper, the CRA model has been used to evaluate CP insurance options.

Conclusion

Resource owners evaluating participation options for the PJM capacity market face complex decisions and considerable uncertainty. A thorough understanding of the market rules, paired with a rigorous and flexible analytical capability, supports reasoned decision-making under uncertainty. CRA consultants developed a tool and approach that together incorporate a robust characterization of the risks and opportunities associated with PJM capacity market participation. While we presented a representative, simplified case for a solar resource, additional complexity and resource types can be included. For example, the model supports evaluation of CP insurance offerings available in the marketplace, as well as the trade-off between offering capacity as a seasonal or annual resource. With this model and CRA's extensive capacity market expertise, we are well positioned to support market participants in formulating their competitive capacity market offers and in making other related decisions.

About CRA's Energy Practice

Charles River Associates is a leading global consulting firm that offers strategic, economic, and financial expertise to major corporations and other businesses around the world. CRA's Energy Practice provides services to a wide range of industry clients, including utilities, ISOs, RTOs, large customers, and investors. The Energy Practice has offices in Boston, New York City, Washington, DC, Toronto, and London. Learn more at **www.crai.com/energy**.

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