



2750 Monroe Blvd.
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2014 PJM Variable Resource Requirement Parameter Review

At PJM's direction and having successfully earned the bid to perform the work, The Brattle Group conducted a review of Variable Resource Requirement curve parameters. The review was completed in compliance with the Section 5.10a of the PJM Tariff, which requires a quadrennial review of the three key parameters in the Variable Resource Requirement curve: the shape of the VRR curve, the Cost of New Entry, and the Energy and Ancillary Services offset methodology.

Brattle's preliminary findings were shared with PJM stakeholders in an April 29 special meeting of the MRC and Brattle's final reports and recommendations to PJM are posted on pjm.com

PJM has reviewed Brattle's analysis and recommendations and subsequently, has developed preliminary PJM staff recommendations. These recommendations will be the basis for discussion by stakeholders in the Capacity Senior Task Force in which PJM will seek to achieve consensus on modifications to the shape of the VRR Curve, CONE and E&AS. PJM's preliminary recommendations are posted on pjm.com.

The deadline for stakeholder consensus on recommendations is August 31, 2014, with a FERC filing deadline of October 1, 2014.



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May 15, 2014

PJM Membership/ Stakeholders:

Re: VRR Curve Key Parameter Review, PJM Preliminary Recommendations

Dear PJM Members:

In accordance with its Tariff, PJM has reviewed the shape and key parameters of its Variable Resource Requirement Curve that is used to clear the Reliability Pricing Model auctions. Section 5.10 a) (iii) and Section 5.10 a) (vi) (C)-(D) of Attachment DD of the PJM Open Access Transmission Tariff states that beginning with the delivery year that commences June 1, 2018, and continuing no later than for every fourth delivery year thereafter, PJM will perform a review of: (1) the shape of the VRR Curve, (2) the Cost of New Entry for CONE areas used in the VRR Curve and (3) the methodology for determining the Net Energy and Ancillary Services Revenue Offset or E&AS for the region PJM serves and for each zone. Based on the results of such review, PJM shall prepare a recommendation to either modify or retain the existing VRR Curve shape, CONE and E&AS Offset methodology.

The RPM Base Residual Auction for the 2018/2019 delivery year will be held in May 2015. As PJM previously advised members, PJM retained an independent consultant, The Brattle Group, to review the VRR Curve, CONE values and E&AS methodology. Brattle has prepared two detailed and comprehensive reports setting forth its analysis and recommendations for changes in these areas. These reports, entitled "Brattle 2014 CONE Study" and "Brattle 2014 VRR Curve Report" were posted to the PJM website on May 15, 2014.

Based on its own review of the work done by Brattle, PJM staff has developed preliminary recommendations with regard to the VRR Curve, CONE and the E&AS Offset methodology as outlined in Section 5.10 of Attachment DD of the Tariff. These recommendations initiate a Tariff-prescribed process of stakeholder and PJM Board review, the timing of which is proposed in FERC filing ER14-1660. Under amended timing specified in this filing, PJM's proposed modifications to the Tariff are to be provided to the stakeholders by May 15, 2014. Tariff changes resulting from that process for use in the May 2015 BRA must have final stakeholder input by Aug. 31, 2014, with a PJM Board review to conclude with changes submitted to the Federal Energy Regulatory Commission by Oct. 1, 2014, as proposed in ER14-1660. The changes resulting from the stakeholder process could include a completely different set of recommended changes, a modified version of PJM staff preliminary recommendations or the PJM staff preliminary recommendations as outlined below.

Variable Resource Requirement Curve Shape

Consistent with the Tariff, Brattle conducted detailed probabilistic simulation modeling of various VRR Curve shapes and parameterizations to determine which curve would best facilitate investment in new capacity, efficiently retain existing resources and satisfy applicable reliability requirements. Through its analyses, Brattle found that the existing VRR Curve shape would not satisfy defined performance objectives and fails to achieve resource adequacy objectives at both the system level and the local level on a long-term average basis. Brattle has concluded that changing the VRR Curve shape and parameters would enhance RPM performance and better meet defined reliability and economic objectives such as mitigation of price volatility, achievement of an average Loss-of-Load Expectation of one event in 10 years for the system, and a 1-in-25 conditional LOLE in each modeled Locational Deliverability Area – particularly in the face of changes in market conditions and underestimates of Net CONE relative to the current VRR Curve.

1. Brattle Recommendations:

Brattle recommends and provides support for the following changes to the VRR Curve to improve performance and better meet reliability and economic objectives:

- System Curve
 - *Right shift the price cap (point “a”)*
 - Shifting point “a” to a quantity at 1-in-5 LOLE (approximately Installed Reserve Margin-1 percent) would significantly improve reliability outcomes by providing stronger price signals when capacity resource supplies are reduced or become more expensive and would not increase long-term average prices.
 - *Stretch the VRR Curve into a convex shape*
 - This convex shaped curve is steeper at lower reserve margins and flatter at higher reserve margins. Under Brattle base modeling assumptions, the recommended convex curve will meet the 1-in-10 reliability standard on average.
- Local VRR Curve
 - *Adopt the system-level recommendations at LDA level, with additional recommendations to:*
 - *Increase the LDA price cap to 1.7x Net CONE*
 - Brattle found that a higher cap substantially improves simulated outcomes in LDAs because stronger price signals when supplies become scarce.
 - *Impose a minimum curve width equal to 25 percent of Capacity Emergency Transfer Limit*

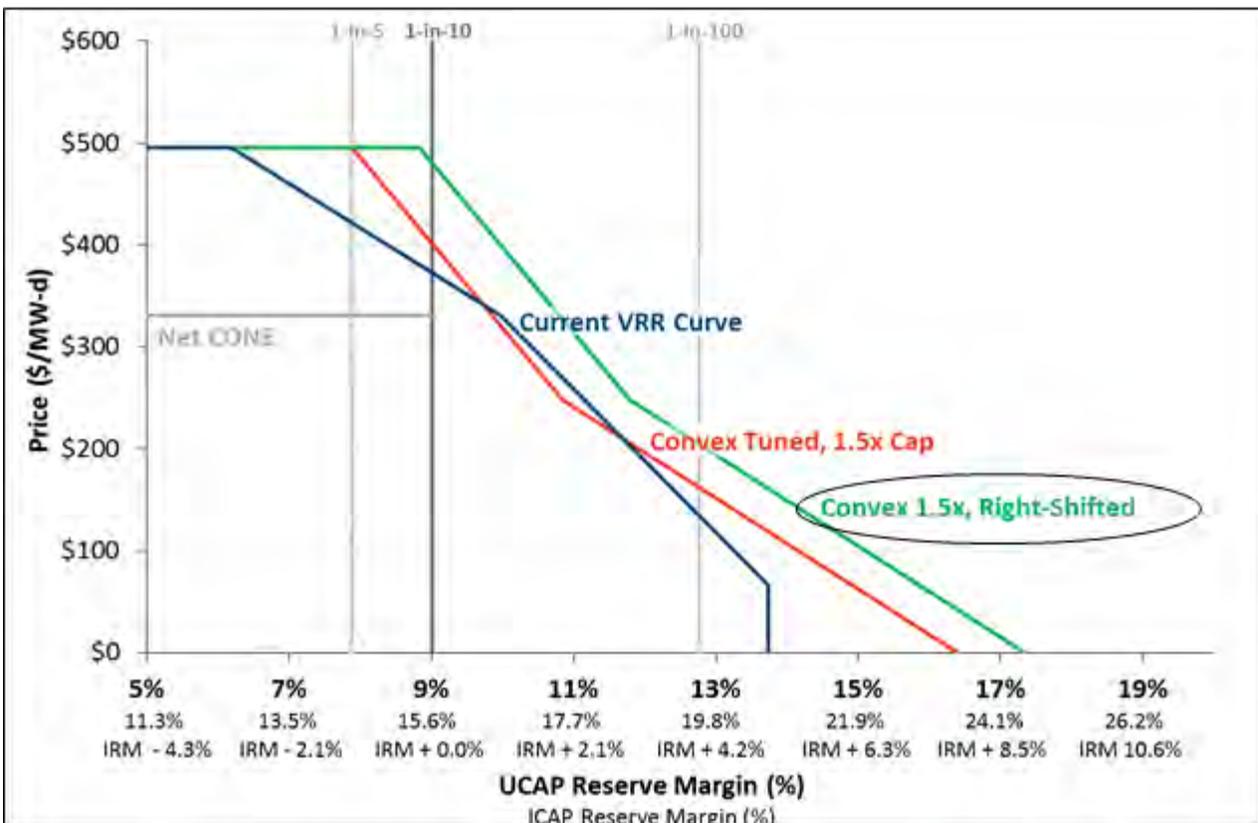
2. PJM Preliminary Recommendations:

PJM has reviewed the Brattle analysis and probabilistic simulations and recommends several changes to the current VRR Curve shape. PJM agrees that the convex curve shape proposed by Brattle will allow for a more robust, reliable capacity market by quickly incentivizing capacity as the system goes short and providing price stability as the system goes long. PJM believes the Brattle simulation results demonstrate that a convex curve will provide better long-term reliability at the least cost. PJM preliminary recommendations are to:

- ***Adopt the convex curve recommended by Brattle but right-shifted by 1 percent***

- This would mean new parameter values of:
 - Point a: Price cap maximum of (150 percent Net CONE, or 100 percent of Gross CONE) at UCAP level of (IRM - 0.2 percent)
 - Point b: Price of 75 percent Net CONE at UCAP level of (IRM + 2.9 percent)
 - Point c: Zero price at UCAP level of (IRM + 8.8 percent)
 - Through probabilistic simulation modeling, Brattle found that the current shape does not meet the 1-in-10 objective on average and shows procurement below the reliability requirement 35 percent of the time. The Brattle-recommended convex curve meets the 1-in-10 objective but still shows procurement below the reliability requirement 29 percent of the time.
 - PJM's recommended convex curve shows procurement below the reliability requirement only 16 percent of the time. It meets the 1-in-10 objective and it allows RPM to better handle year-to-year volatility in system conditions. While this curve does not meet the reliability target 100 percent of the time in simulations, PJM believes this curve strikes an appropriate balance between reliability objectives and minimizing overall cost to consumers.
- **Use the same curve for LDAs as is used for the System**
 - PJM recommends using the same curves for LDAs as are used for the system.

VRR Curve Shapes: Current Curve, Brattle Recommendation (Convex Tuned, 1.5x Cap) and PJM Preliminary Recommendation (Convex 1.5x, Right-Shifted 1%)



Cost of New Entry

Similar to prior studies used to develop Gross CONE values for RPM, Brattle conducted a detailed “bottom-up” analysis of the fixed costs to install and operate a new combustion turbine plant and a new combined cycle plant in each CONE Area in the region PJM serves. Brattle selected engineering services firm Sargent & Lundy to determine capital and O&M costs for Gross CONE for the specified technologies. Brattle developed estimates for the remaining categories of input costs such as gas and electric interconnection costs, property taxes, and other associated costs as well as reviewed the methodologies and calculation of Gross CONE apart from engineering cost estimates.

1. Brattle Recommendations:

- *Update Gross CONE estimates using Sargent & Lundy’s estimates*
 - Brattle concluded that PJM should update Gross CONE values with the values specified in their study. Using these study estimates, the new Gross CONE values for the Tariff mandated CT reference resource would be (based on level nominal):
 - **Eastern MAAC:** \$150,000/MW-Yr or \$411/ MW-Day (ICAP)
 - **Southwest MAAC:** \$148,400/MW-Yr or \$407/ MW-Day
 - **Rest of RTO:** \$138,000/MW-Yr or \$378/ MW-Day
 - **Western MAAC:** \$143,500/MW-Yr or \$393/ MW-Day
 - **Dominion:** \$141,200/MW-Yr or \$387/ MW-Day
 - Brattle updated the CC Gross CONE values to (based on level nominal):
 - **Eastern MAAC:** \$203,900/MW-Yr or \$559/ MW-Day (ICAP)
 - **Southwest MAAC:** \$197,200/MW-Yr or \$540/ MW-Day
 - **Rest of RTO:** \$188,100/MW-Yr or \$515/ MW-Day
 - **Western MAAC:** \$190,900/MW-Yr or \$523/ MW-Day
 - **Dominion:** \$182,400/MW-Yr or \$500/ MW-Day
- *Consider replacing the Handy-Whitman Index*
 - Brattle recommends switching from the Handy Whitman “Other” Index to the Bureau of Labor Statistics’ indices for wages, materials and turbine. It concluded that Bureau of Labor Statistics’ indices can provide a more accurate escalation factor for CONE estimates year over year.
- *Adopt level-real CONE values*
 - As with previous RPM reviews, Brattle believes that level-real CONE would be more representative of investors’ expected recovery of capital and fixed costs over the long term.
- *Consider adopting the average of CC and CT Net CONE values defining the VRR curve*
 - Brattle investigated the appropriateness of a CT as the PJM Tariff-mandated reference resource and looked to empirical as well as financial data in determining the recommended reference resource. Based on its findings, Brattle has recommended using an average of CT and CC Net CONEs as the reference technology Net CONE value.
 - Brattle concludes that using this methodology would recognize that CC plants are the predominant technology under development by merchant generators (which increases the accuracy of gross CONE estimates), while

avoiding a complete switch away from the currently defined CT reference technology.

- **Revise CONE areas to align more closely to modeled LDAs**
 - Brattle recommends (a) using the CONE Area 3: Rest of PJM estimate for the system-wide VRR curve (rather than the current fixed value adopted in settlement); (b) using the CONE Area 4: Western MAAC estimate for the MAAC VRR curve (rather than taking the minimum of sub-LDA numbers); and (c) combining CONE Area 5: Dominion into CONE Area 3: Rest of PJM, given that the Area 5 estimate has not been used to date
- **Consider introducing a test for a separate Gross CONE for small LDAs**
 - This recommendation is only needed if the small LDA is persistently import-constrained, shows little evidence of potential for new entry and shows evidence of structurally higher entry costs

2. PJM Preliminary Recommendations:

PJM supports several Brattle recommendations and provides justification for those it does not, focusing on the objective of most accurately capturing new entrant costs within PJM and in specific PJM LDAs

- **Adopt updated CONE Values as stated by the Study's findings**
 - PJM finds these estimates to be reasonable and well-supported by Brattle analysis and recommends the adoption of these values as PJM CONE values for the 2018/2019 delivery year.
 - Updated Gross CONE estimates are within -8 percent to +6 percent of CONE used in 17/18 parameters
 - Additionally, these estimates are consistent with changes in costs over the last three years from studies done for Energy Information Administration for its Annual Energy Outlook modeling.
- **Add dual-fuel capability to reference technology for CONE Area 3**
 - Dual fuel should be included in Gross CONE modeling for all areas except CONE Area 2 CC Gross CONE in which PJM adopts the Brattle recommendation of firm gas transportation. For CONE Area 3 the Gross CONE with dual fuel capability are for the CT \$147,500/MW-year or \$404/MW-day and for the CC \$193,700/MW-year or \$531/MW-day.
- **Continue to use frame-model CT as the reference resource technology in RPM**
 - PJM recommends maintaining the GE Frame 7FA model combustion turbine as the reference resource in the PJM Tariff (Attachment DD, Sec. 2.58). This CT should include selective catalytic reduction technology in all CONE areas and dual fuel capability in all CONE areas for the CT.
 - PJM believes that continuity in maintaining the same technology type provides market stability and avoids perceived opportunistic switching to units with more favorable economics in any given year. Additionally, PJM notes the consistency with the precedent in the New York Independent System Operator capacity market, which recently selected a CT as its reference technology, and the reduction in Net CONE estimation error due to CTs' lower net E&AS revenue offset compared with that of a CC.
 - Per Brattle's study, initial CT and CC Net CONE estimates are fairly close and it appears they may result in similar values in the long run. Therefore, the utilization of CT reference is preferred because it appears to be more

- accurate as it is less sensitive to energy revenue offset modeling parameters and assumptions.
 - And while no new frame-model CTs have been built in PJM in recent years, there have been more expensive (\$/MW-day basis) aero-derivative CTs built, which indicates that frame-model CTs are still an economically viable new entry technology
- **Switch to Bureau of Labor Statistics indices for yearly Gross CONE escalation**
 - PJM supports the use of the Bureau of Labor Statistics' quarterly census of employments and wages, producer price index commodity data for stage of processing and machinery and equipment, weighted appropriately, for the escalation of Gross CONE values.
 - When compared to estimated cost changes from Brattle and Energy Information Administration, the Bureau's data tracks these changes much more closely and accurately than the Handy-Whitman Index has done. Additionally, the bureau's data is publicly available.
- **Continue the use of level-nominal Gross CONE**
 - Using level-nominal Gross CONE results in the same net present value as the level-real Gross CONE over 20 years, but accelerates a developer's investment recovery in real-terms and reduces the risk to developers of waiting for investment recovery toward the end of the 20 year asset life, thereby reducing the real-option to wait for more information before making the investment decision.
- **Adopt a new method of aligning CONE areas with modeled LDAs (see below)**
 - PJM believes that the market can send more accurate price signals by better aligning CONE areas and LDAs.
- **Eliminate Dominion as a CONE Area**
 - PJM recommends incorporating the Dominion Zone into the determination of CONE Area 3 Gross CONE value because the Dominion zone has not historically been used as a CONE area and its value tends to be close to the value in CONE Area 3.

Energy & Ancillary Services Methodology

Brattle has found that the current PJM E&AS methodology is not always an accurate reflection of actual energy and ancillary services net revenues. In the case of CC technologies in particular, Brattle found that current methodologies overstate revenues, thus understating true Net CONE. For CT technologies, the current historical actual E&AS methodology is more accurate, as computed E&AS revenues more closely match E&AS revenues earned by CTs. Furthermore, E&AS revenues are less significant in investment recovery for CT resources. Brattle has proposed the following changes to the current methodology to ensure a more accurate Net CONE:

1. Brattle Recommendations:

- **Develop a forward-looking E&AS calculation methodology**
 - Brattle believes that an E&AS offset based on three years of historical prices (the current methodology) can be easily distorted by anomalous market conditions that are not representative of what market participants expect in the future RPM delivery year. Historical prices are also four to six years out of date relative to delivery period corresponding to a three-year forward Base

Residual Auction and, therefore may not be a good indicator of future market conditions.

- ***Align E&AS offset and Net CONE calculations more closely to modeled LDAs***
 - Under current construct, E&AS offset that is applied to a specific LDA may not be calculated based on prices in that LDA, but on prices in the parent LDA, a sub-LDA or an adjacent LDA.
- ***Consider imposing the parent LDA Net CONE value as a minimum for sub-LDA Net CONE values***
 - This recommendation would safeguard against errors and associated under-procurement in small LDAs that are always modeled and/or binding.
- ***Calibrate historical E&AS estimates to reflect plant actuals***
 - Given the large discrepancies in simulated historical E&AS and actual unit margins, especially for CCs, Brattle recommends that PJM compile a more detailed set of plant-specific cost and revenue data for representative units that can be used for such a calibration, and then adjust its historical simulation approach to develop E&AS numbers that are as reflective as possible of these actual plant data in each location.

2. PJM Preliminary Recommendations:

After reviewing the E&AS methodology recommendations above, PJM agrees that certain measures can be put in place to ensure a more accurate E&AS calculation. PJM believes that using the following recommendations, the system will more accurately capture the actual economics and expectations of future E&AS used in decision making regarding new entry into the PJM market:

- ***Align E&AS offset calculation more closely to modeled LDAs***
 - PJM finds that the average of E&AS offsets of all zones in an LDA is more representative of actual E&AS economics than using one zone E&AS offset as new capacity may be built anywhere in an LDA.
- ***Develop a forward-looking E&AS methodology***
 - Outliers and disruptions in normal trends, as could be seen with the most recent winter, should not be included in E&AS calculation. The impacts of such abnormalities can be mitigated by switching from a historical actual to a forward-looking methodology.
 - PJM will continue to investigate whether its existing methodology to look forward for the energy and environmentally limited opportunity cost adder to cost-based energy offers, as outlined in Manual 15, could be a suitable template for the forward-looking E&AS offset methodology.
- ***Calibrate historical three-year values considering actual history of similar units***
 - PJM believes that by calibrating the current E&AS model to actual CC and CT performance, the system will more accurately capture the actual economics used in market participant decision making.
 - PJM proposes to investigate reasons for differences between Net E&AS estimated for the reference resource (using peak-hour dispatch) and actual Net E&AS for similar generation resources. PJM will seek to revise methodology used to estimate Net E&AS for its reference resource based on this investigation.
- ***Impose a minimum Net CONE for sub-LDAs at the parent LDA value***

- Imposing this minimum will keep investment signals strong in constrained areas, where capacity is most needed, and mitigate the locational reliability consequences of understating LDA Net CONE.

In accordance with the Tariff, PJM looks forward to reviewing all of these preliminary recommendations with stakeholders and receiving their input and possible alternative recommendations in the hope of reaching a stakeholder consensus that can be filed with the Commission. Should you have any questions with regard to this matter, please contact me.

Sincerely,



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Executive Vice President- Markets

cc: Dr. Joseph Bowring, Monitoring Analytics, LLC