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April 24, 2018

PJM Membership/Stakeholders:

Re: VRR Curve Key Parameter (Quadrennial) Review, PJM Preliminary Recommendations

Dear PJM Members:

In accordance with the PJM Open Access Transmission Tariff ("Tariff"), PJM has reviewed the shape and key parameters of its Variable Resource Requirement ("VRR") Curve that is used to clear the Reliability Pricing Model ("RPM") Auctions. Tariff, Attachment DD, section 5.10 (a)(iii) and section 5.10 (a)(vi)(C)-(D) 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 ("CONE") for CONE areas used in the VRR Curve and (3) the methodology for determining the Net Energy and Ancillary Services ("E&AS") Revenue Offset 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 Revenue Offset methodology.

PJM conducted the previous review, "The 2014 Review," prior to the May 2015 RPM Base Residual Auction ("BRA") for the 2018/2019 Delivery Year. As such, PJM is required to conduct the subsequent review prior to the May 2019 RPM BRA. To this end, PJM retained an independent consultant, The Brattle Group, to review the VRR Curve, CONE values and E&AS Revenue Offset methodology. Brattle prepared two reports detailing its analysis and recommendations for changes in these areas. These reports, entitled "Brattle 2018 CONE Study" and "Brattle 2018 VRR Curve Report" were posted to the PJM website on April 20, 2018.

Based on our review of the work done by Brattle, PJM staff has developed preliminary recommendations with regard to the VRR Curve, CONE and the E&AS Revenue Offset methodology. These recommendations initiate the stakeholder process and PJM Board review. Under the timing specified in the Tariff, PJM's proposed modifications to the Tariff are to be provided to the stakeholders by May 15, 2018. Tariff changes resulting from that process for use in the May 2019 BRA must have final stakeholder input by August 31, 2018, with a PJM Board review to conclude with changes submitted to the Federal Energy Regulatory Commission ("FERC") by October 1, 2018. 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.

Cost of New Entry

Similar to prior studies used to develop 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 updated the turbine technology used to determine CONE values for both combustion turbine ("CT") and combined cycle ("CC") plants, from GE Frame Model 7FA to GE Frame Model 7HA. Brattle selected 7HA turbines due to project development trends, improved efficiency, and lower costs. Brattle utilized services of the engineering firm Sargent & Lundy to determine capital and O&M costs for 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 CONE.

PJM Preliminary Recommendations:

- *Adopt a GE Frame Model 7HA combustion turbine as the Reference Resource*

The combustion turbine continues to provide the lowest CONE, shortest time to market, and derives the most significant portion of its revenue from the capacity market as compared to other resources. The fact that the CT receives the smallest amount of its revenue from the energy market means that its Net CONE value is the least likely to be significantly perturbed by potential changes in energy market prices. Thus, certainty is provided through the use of a peaking unit as reference resource because it minimizes the exposure to short-term energy revenue offset volatility. Also, PJM believes that maintaining the same technology type provides market stability and avoids perceived opportunistic switching to units with more favorable economics in any given year. This reasoning is even more critical in the face of significant changes in the CONE detailed in the Brattle reports.

Brattle noted that under equilibrium, the actual clearing levels in the RPM Auction ultimately will reflect the actual marginal resource, regardless of resource type, indicating that Net CONE requirements for needed capacity should converge.

It is also worth noting that the neighboring capacity markets of the New York Independent System Operator (“NYISO”) and the Independent System Operator of New England (“ISO-NE”) both found it advantageous to employ a CT as the reference resource, with NYISO proposing a GE 7FA in 2016 and ISO-NE proposing a GE 7HA model turbine in 2017. FERC accepted both the NYISO and ISO-NE’s use of combustion turbine technology for their respective reference resources. Additionally noteworthy, although not regulated by FERC, the Alberta Electric System Operator, which is developing a new capacity market, recommended the use of a CT as the reference resource. While the reasoning behind the decisions in each of these markets is unique, they do share some significant similarities in that each market is attempting to determine the reference resource that will provide an adequate price signal to ensure ongoing investment to maintain reliability.

PJM notes that the present CONE value includes the cost of installation of dual fuel oil facilities, except in Southwest MAAC where the cost of firm transportation service is included rather than the installation of dual fuel facilities because recent CC projects in the region obtained long-term firm transportation service contracts for natural gas. PJM continues to examine fuel security issues and may amend these preliminary recommendations to address appropriate costs related to maintaining reliable operations through events such as extended grid emergencies.

- *Adopt updated CONE Values*

PJM finds the Brattle CT estimates for all CONE areas, with the exception CONE Area 3, to be reasonable and well-supported by Brattle analysis. PJM believes emissions control costs (selective catalytic reduction and carbon monoxide catalyst) should be included in CONE modeling for all areas, including CONE Area 3. PJM thus recommends the adoption of these values as PJM CONE values for the 2022/2023 Delivery Year.

CONE Area	CONE \$/MW-Yr	CONE, \$/MW-Day ICAP
CONE Area 1 - Eastern MAAC	\$106,400	\$292
CONE Area 2 - Southwest MAAC	\$108,400	\$297
CONE Area 3 - Rest of RTO	\$103,000	\$282
CONE Area 4 - Western MAAC	\$103,800	\$284

- *Adjust weighting of composite of cost estimates used in annual update to CONE*

PJM recommends using Brattle's suggested weighting of the components in the CT composite index based on 20 percent labor, 55 percent materials (increased from 50 percent), and 25 percent turbine (decreased from 30 percent).

Variable Resource Requirement Curve Shape

Brattle conducted detailed probabilistic simulation modeling of VRR Curve shapes to determine which curve would best facilitate investment in new capacity, efficiently retain existing resources and satisfy applicable reliability requirements. Through its analyses, Brattle acknowledges that the existing VRR Curve shape would satisfy defined performance objectives and achieve resource adequacy objectives at both the system level and the local level on a long-term average basis. The Brattle analyses show that retaining the VRR Curve shape would maintain RPM performance and 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 significant changes in market conditions, continued resource retirements and reduction in Net CONE relative to the current value.

PJM Preliminary Recommendations:

- *Maintain the existing CT-based VRR curve, updated with CT Net CONE values*

The current curve shape will maintain a robust, reliable capacity market, under the significant decline in Net CONE. PJM believes the Brattle simulation results demonstrate that a CT-based curve will continue to provide long-term reliability at reasonable cost.

Modeling of the CT-based curve shows procurement does not drop below the reliability requirement. It meets the 1-in-10 objective on average and under simulated stress conditions. This allows the capacity market to better handle year-to-year volatility in system conditions. PJM believes this curve strikes an appropriate balance between reliability objectives and minimizing overall cost to consumers, achieving greater reliability at a reasonable cost.

Use of the CT-based curve minimizes the resulting volatility and impact of short-term energy and ancillary service revenues on longer-term focused capacity procurement.

- *Maintain the existing practice of using the same curves for LDAs as are used for the system*

PJM recommends continuing to use the same curves for LDAs as are used for the system, as we recommend no changes to system curve, and performance over the past 4 years has resulted in continued investment and met the resource adequacy requirements.

Energy & Ancillary Services Methodology

After reviewing Brattle's E&AS methodology recommendations, PJM agrees that certain measures can be put in place to ensure a more accurate E&AS calculation. PJM believes that with 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.

PJM Preliminary Recommendations:

- *Use median to determine Net E&AS offset*

PJM recommends determining the Net E&AS revenue for the RTO as the median of the Net E&AS revenues across all zones, and estimate Net E&AS revenues for each multi-zone LDA as the median of Net E&AS revenues across zones within the multi-zone LDA. Currently, the RTO Net E&AS revenue is determined by dispatching the Reference Resource CT against the hourly PJM RTO Locational Marginal Price (“LMP”) at a fuel price based on an average of the gas pricing points throughout the RTO; therefore, the current method uses electricity and gas prices that may not be consistent with each other and, against which no actual resource will be dispatched. In addition, the use of median versus average Net E&AS revenues will dampen the influence of a single zone having abnormally low or high Net E&AS revenue relative to the other zones.

- *Update natural gas pricing hubs for six zones*

In order to reflect the shifting natural gas flows in the PJM footprint caused by the proliferation in cost-effective natural gas production in the Marcellus and Utica shale gas regions, PJM recommends updating the natural gas pricing points as indicated below:

Zone	Current Hub	Recommended Hub
APS	Columbia-APP/TCO Pool	Dominion-South
DUQ	Columbia-APP/TCO Pool	Dominion-South
PENELEC	Dominion-North	Transco-Leidy Line
PEPCO	Transco-Z6 (non-NY)	Transco-Z5 Div
PPL	TETCO M3	Transco-Leidy Line
PSEG	Transco-Z6 (NY)	Blend Z6 (NY/non-NY)

- *Use sum of median monthly revenues from last three calendar years rather than average annual revenues from last three calendar years*

PJM recommends basing the Net E&AS revenue that is used to develop LDA and RTO VRR curves on the summation of the median monthly Net E&AS revenue determined for each month of the past three calendar years instead of the currently used, three-year annual average Net E&AS revenue. This approach provides a less volatile year over year determination of an annual Net E&AS value than that provided by a three year average by dampening distortion caused by a single anomalous month of unusual weather or fuel market conditions.

- *Include a 10 percent cost adder for CTs and CCs*

In order to incorporate the Tariff-defined ability of a generator to include a 10 percent adder to their computed cost offer to account potential uncertainties in measurement, PJM recommends applying a 10 percent cost offer adder to the variable operating costs of the CTs when determining Net E&AS revenues.

- *Maintain dispatch flexibility*

PJM recommends retaining its assumption of four hour block dispatch for CTs and sixteen hour blocks for CCs, and investigating CC assumption alternatives employed by the IMM.

- *Update reference resource characteristics and costs*

PJM recommends updating the heat rates and other unit characteristics to reflect the increased efficiency of GE H-class turbines.

Unit Characteristic	Current (GE 7FA - 2x)	Recommended (GE 7HA - 1x)
Capacity (MW)	(190 x 2) 380	320
Heat Rate (Btu/kWh)	10,096	9,134
Total Variable O&M (\$/MWh)*	6.47	7.00

*Includes major maintenance

PJM looks forward to reviewing these preliminary recommendations with stakeholders and receiving their input and possible alternative recommendations leading up to PJM Board review and filing with the Commission according to the Tariff-defined timeline.

Sincerely,



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Operations and Markets

cc: Dr. Joseph Bowring, Monitoring Analytics, LLC