

Quadrennial Review: PJM with (VC Barrow) PA PUC Joint Proposals

Market Implementation Committee
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BACKGROUND:

No later than every fourth delivery year, the Office of the Interconnection shall perform a review of:

1. Shape of the Variable Resource Requirement (VRR) Curve

- Reliability Pricing Model (RPM)
- Set of price and megawatt quantities that shape the curve

2. Cost of New Entry (CONE) for each Locational Deliverability Area (LDA)

- Selection of the Reference Resource for each LDA to set CONE
- Reference Resource may vary by LDA

3. Methodology for determining the Net Energy and Ancillary Services Revenue Offset (EAS Offset)

- Calculated for each zone in the PJM region
- EAS Offset is subtracted from the Gross CONE value to calculate Net CONE

Updated VRR Curve parameters will be effective with the 2028/2029 Delivery Year.

The proposed package represents PJM management's proposal for a solution to the Quadrennial Review

1. The PJM Board of Managers has not yet endorsed this proposal and seeks stakeholder feedback,
2. The proposal is focused on the defined scope of the Quadrennial Review, and
3. PJM has endeavored to strike the best balance of reliability and cost implications.

Additional potential market design changes raised during this review will need a separate stakeholder process to address.

PJM and the (VC Barrow) PA PUC have two joint proposals that replace PJM's initial proposal

Joint Proposal 1: PJM & PA PUC – CC

1. Adopt PA PUC VRR Curve as to be a function of Gross CONE and Net EAS
2. Adopts Net EAS change of using the 67th percentile for each applicable area
3. Use the Brattle calculated Gross CONE values for CC

Joint Proposal 2: PJM & PA PUC – CT

- 1) Adopt PA PUC VRR Curve as to be a function of Gross CONE and Net EAS
- 2) Adopts Net EAS change of using the 67th percentile for each applicable area
- 3) Use the Brattle calculated Gross CONE values for CT

The (VC Barrow) PA PUC VRR curve provided a reasonable alternative to account for the uncertainty separately around Gross CONE and Net EAS values that was adopted in these joint proposals.

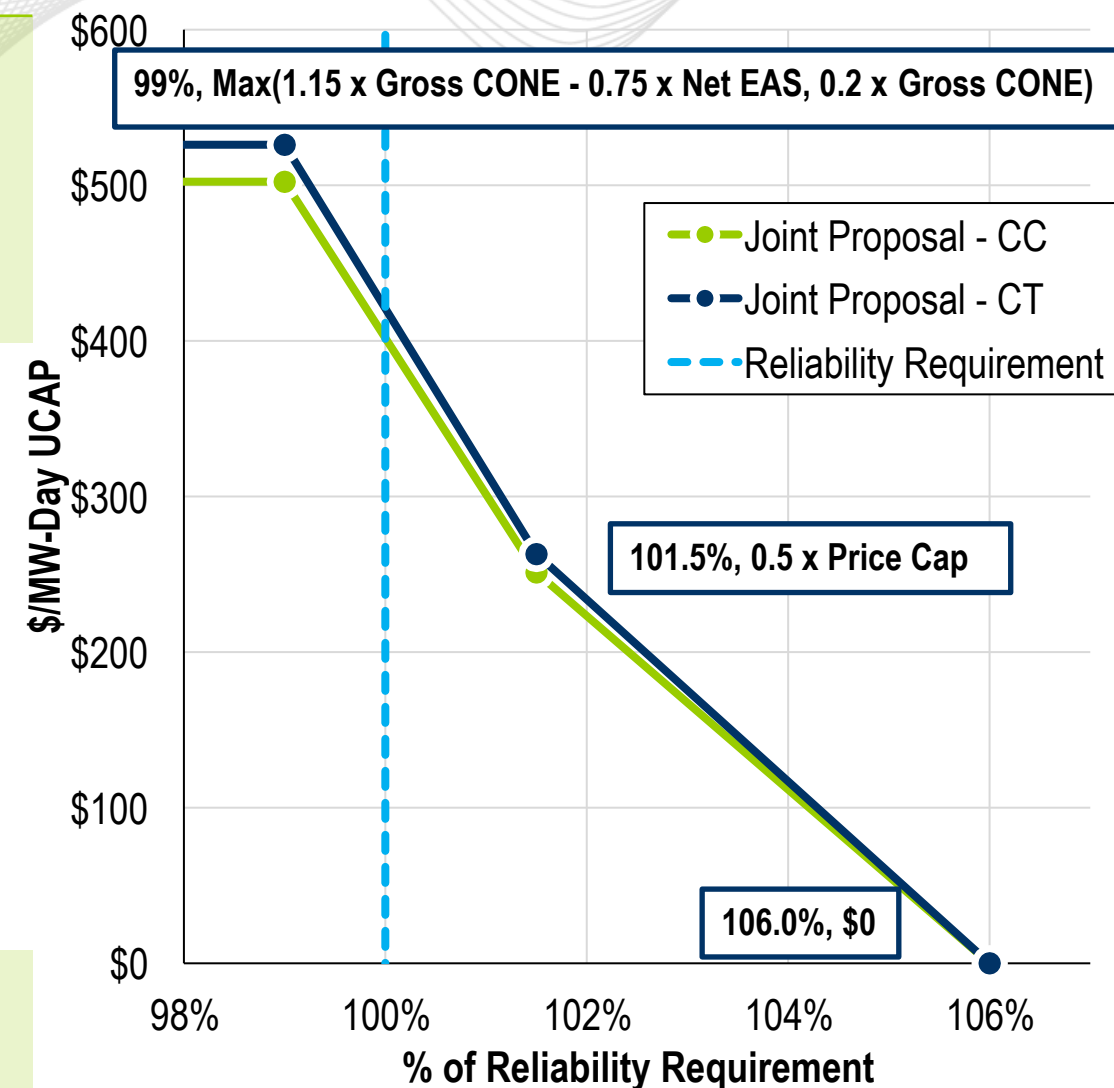
Reference Resource: Joint Proposal 1 recommends the Brattle calculated Combined Cycle for every CONE Area, and Joint Proposal 2 recommends the Brattle calculated Combustion Turbine for every CONE Area.

VRR Curve: PA PUC VRR Curve and lower safeguard

- Point A is updated to $\text{Max}(1.15 \times \text{Gross CONE} - 0.75 \times \text{Net EAS}, 0.2 \times \text{Gross CONE})$, to stabilize curve and decrease volatility
- Tie point B to 50% of Price Cap (Stability of VRR Curve)
- Extend point C to 106%

Same VRR shape for LDAs

EAS: Status Quo with updated Reference Resource parameters



Joint Proposal 1: PJM is recommending the **Combined Cycle (CC)** as the Reference Resource for all areas

Joint Proposal 2: PJM is recommending the **Combustion Turbine (CT)** as the Reference Resource in all areas

CONE Area	Joint Proposal 1 – Combined Cycle		
	Gross CONE (\$/MW-Day ICAP)	Gross CONE (\$/MW-Day UCAP)	Estimated Net CONE (\$/MW-Day UCAP)
EMAAC: CONE Area 1	\$752	\$928	\$498
SWMAAC: CONE Area 2	\$752	\$939	\$191
Rest of RTO: CONE Area 3	\$757	\$934	\$119
WMAAC: CONE Area 4	\$754	\$931	\$237
COMED: CONE Area 5	\$860	\$1,061	\$555
RTO	\$777	\$959	\$173

Joint Proposal 2 – Combustion Turbine		
Gross CONE (\$/MW-Day ICAP)	Gross CONE (\$/MW-Day UCAP)	Estimated Net CONE (\$/MW-Day UCAP)
\$596	\$754	\$554
\$608	\$769	\$336
\$590	\$747	\$247
\$592	\$749	\$343
\$679	\$860	\$589
\$613	\$776	\$289

Combined Cycle considerations:

- Most economically viable technology
- Feasibility to build at needed scale
- Observed new entrants in RRI and queue (TC2) support CC as a reasonable Reference Resource

The proposal mitigates prior concerns with adopting a Combined Cycle:

- The December 205 filing switching the Reference Resource back to a CT was due to the volatility and uncertainty of Net CONE for a CC and the EPA 111(d) potentially limiting run hours. Both primary drivers for reverting to a CT have been addressed within this proposal or through external forces:
 - **VRR Curve Stability:** PJM is proposing enhancements to help stabilize the VRR Curve shape
 - **Regulatory Risk:** The concern around the EPA 111(d) rule has been abated based on recent court filings and future expectations. The appellate case is being held in abeyance at the DC Circuit (No. 24-1120) while the EPA issues a final rule expected by the end of this year.

Updated CC Unit Parameters result in a lower Net CONE than the Net CONE for BESS in ComEd

CP Penalty Rate: Outside the scope for the Quadrennial Review, but is an outstanding issue that will need to be considered



Considerations for Selecting Combustion Turbine Technology

Combustion Turbine considerations:

- Provide stability to Net CONE values with less reliance on calculated Net EAS
- More certainty in calculation of Net CONE relative to other technologies
- PJM has relied on CTs historically

Updated CT Unit Parameters result in a lower Net CONE than the Net CONE for BESS in ComEd

Ref. Technology/Net CONE: Reference Resource

	EMAAC 33 rd Percentile CONE Area 1 (\$/MW-Day UCAP)	SWMAAC 33 rd Percentile CONE Area 2 (\$/MW-Day UCAP)	Rest of RTO 33 rd Percentile CONE Area 3 (\$/MW-Day UCAP)	WMAAC 33 rd Percentile CONE Area 4 (\$/MW-Day UCAP)	COMED CONE Area 5 (\$/MW-Day UCAP)	RTO 33 rd Percentile (\$/MW-Day UCAP)
Net CONE						
CT	\$554	\$336	\$247	\$343	\$589	\$289
CC	\$498	\$191	\$119	\$237	\$555	\$173
BESS	\$622	\$461	\$586	\$610	\$674	\$593

Net CONEs are calculated using Update Gross CONE values, and Net EAS values calculated in August

PJM is recommending the status quo Net E&AS Offset Methodology with enhancements: Forward-Looking Optimized Dispatch Approach for Energy and Ancillary Service Revenue

Updated unit-specific parameters to reflect updated Reference Resource technologies [as detailed in the Net E&AS presentation](#)

Updated BESS methodology to be the average of two runs: perfect foresight and day-ahead only value

Currently, all proposals are using the Forward Net E&AS methodology.

Point A: $\text{Max}(1.15 \times \text{Gross CONE} - 0.75 \times \text{Net EAS}, 0.2 \times \text{Gross CONE})$

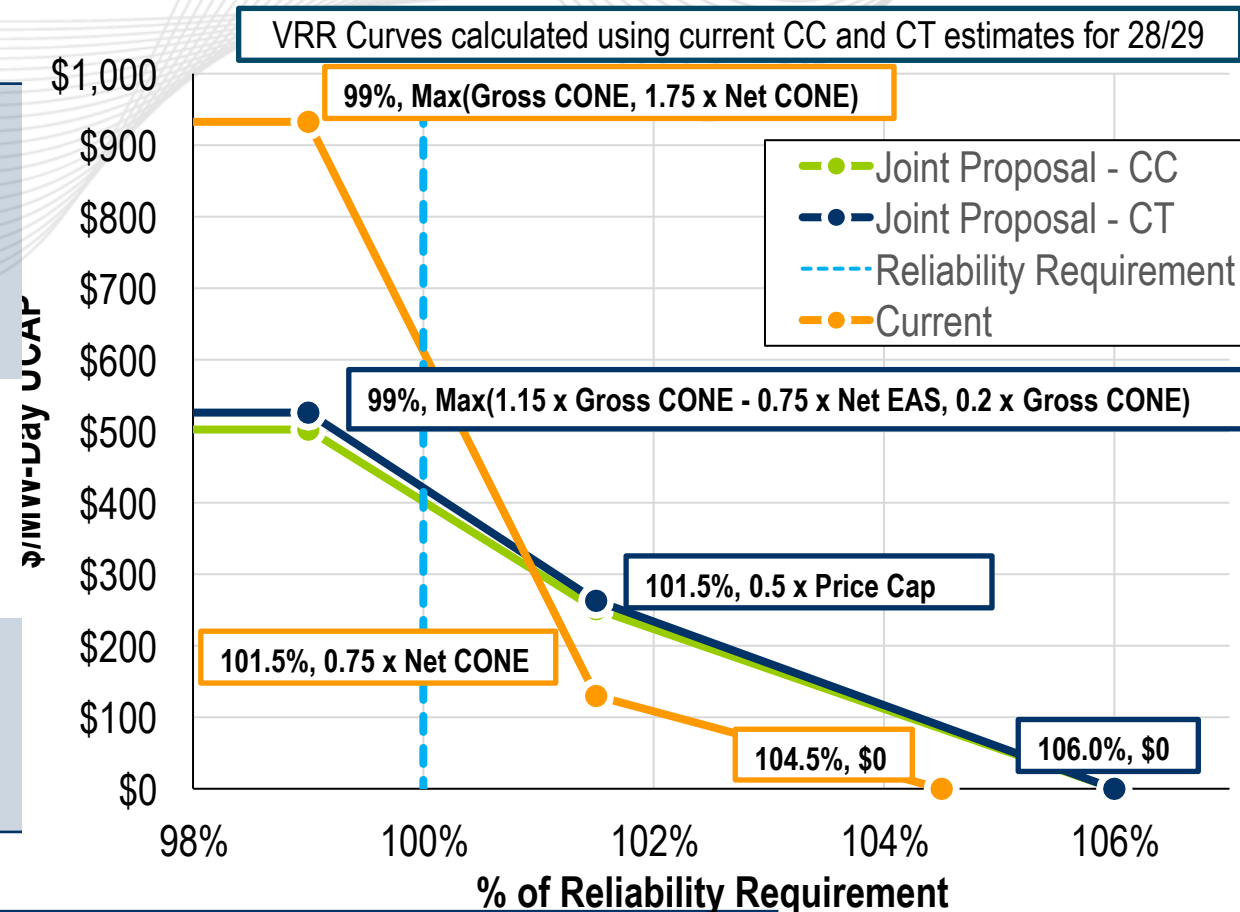
Adopt the VC Barrow PA PUC VRR Curve

Point B: $0.5 \times \text{Price Cap}$

Approximately $0.75 \times \text{Net CONE} / 1.75 \times \text{Net CONE}$

Point C: 106.0% of the Reliability Requirement

Push the foot of the VRR Curve out



	Current		PJM/PAPUC VRR Curve	
	MW	Price	MW	Price
Point 1	99.0%	$\text{Max}(1.75 \times \text{Net CONE}, \text{Gross CONE})$	99.0%	$\text{Max}(1.15 \times \text{Gross CONE} - 0.75 \times \text{Net EAS}, 0.2 \times \text{Gross CONE})$
Point 2	101.5%	$0.75 \times \text{Net CONE}$	101.5%	$0.5 \times \text{Price Cap}$
Point 3	104.5%	\$0	106.0%	\$0

PJM and VC Barrow PAPUC: Price Cap Comparison

Accounting for 75% of Net E&AS decreases the price cap volatility and lowers the price cap in high Net CONE areas (EMAAC and COMED)

The PA PUC curve is less likely to have a calculated price cap of \$0, even without a safeguard

The Joint Proposal has a 0.2 x Gross CONE safeguard

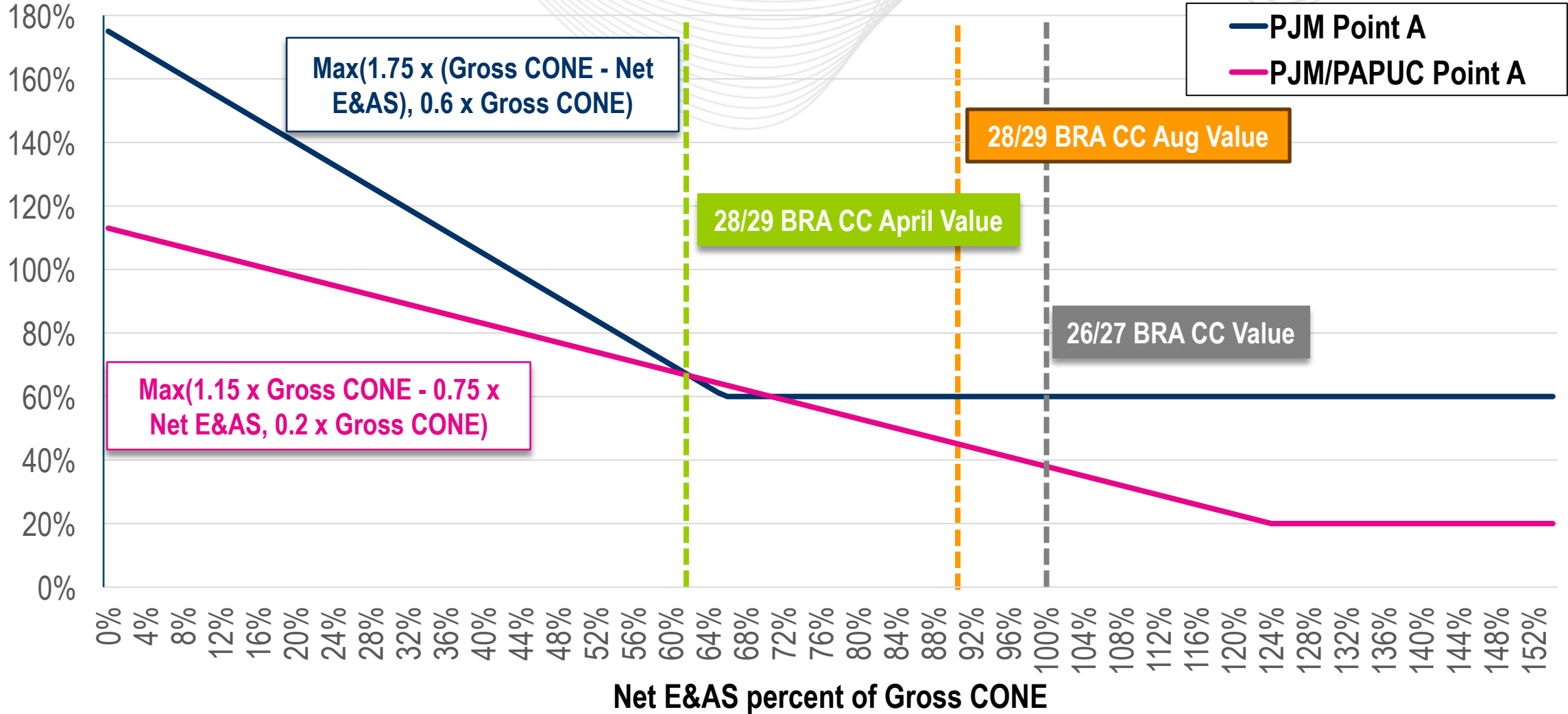
CONE Area	PJM and PA PUC Price Cap - CC (\$/MW-Day UCAP)	PJM and PA PUC Price Cap - CT (\$/MW-Day UCAP)
EMAAC: CONE Area 1	\$744	\$718
SWMAAC: CONE Area 2	\$520	\$560
Rest of RTO: CONE Area 3	\$463	\$483
WMAAC: CONE Area 4	\$550	\$557
COMED: CONE Area 5	\$841	\$785
RTO	\$502	\$526

Net EAS is using the 67th percentile of Net EAS for the applicable area

Price Caps are similar with a CC or CT as the Reference Resource.

Estimated Price Cap as a function of Net E&AS Relative to Gross CONE

Percent of Gross CONE



Performance of Recommended VRR Curve

Brattle simulated the PJM Proposed VRR curve, and the reliability metrics indicate similar reliability performance between the proposed curve and existing curve

2022 QR Curve

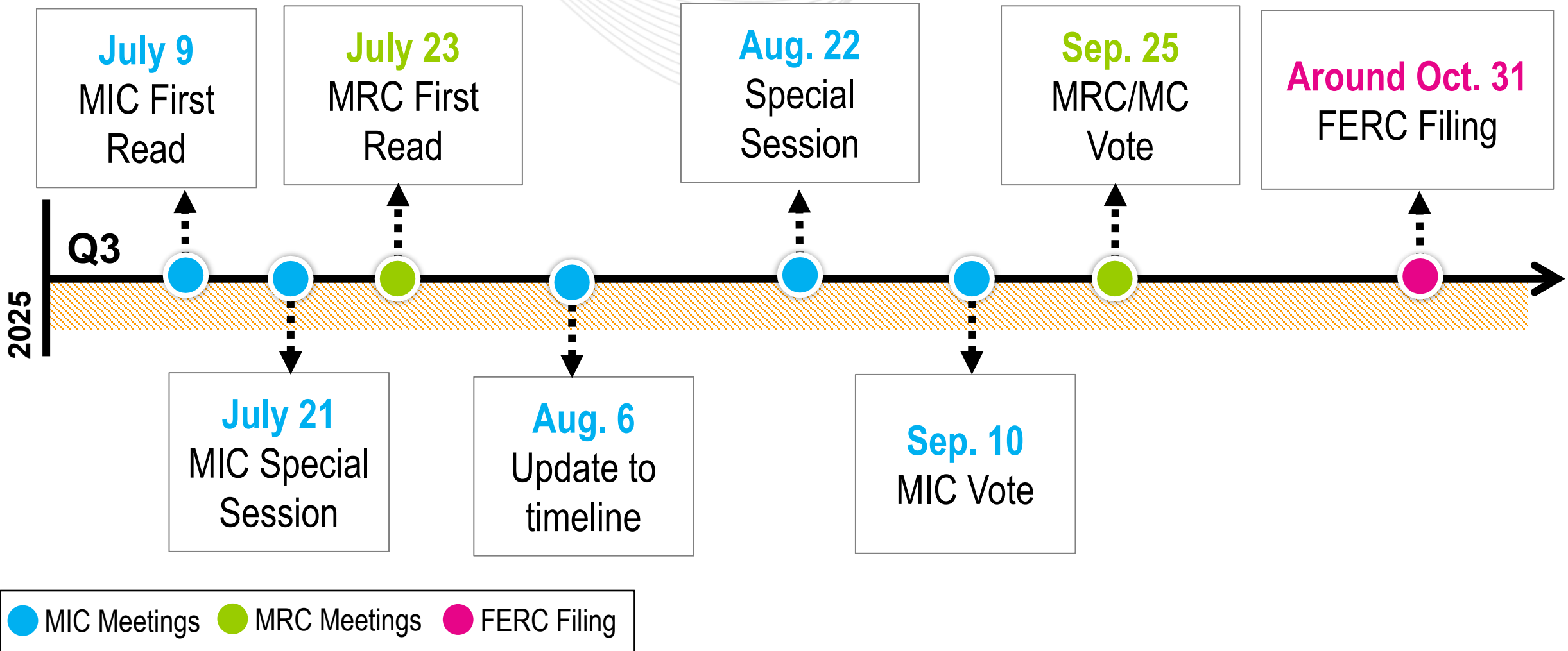
	Price			Reliability				Cost	
	Average	Standard	Frequency	Average	Average	Average	Frequency	Average	
	(\$/MW-d)	Deviation	at Cap	LOLE	Excess	Excess	Below	Procurement	
		(\$/MW-d)	(%)	(events/yr)	(MW)	(IRM + X %)	Target	Cost	
							(%)	(\$ mln/yr)	
Candidate Curve									
True Net CONE = 0.6 x CC	\$160	\$57	0.0%	0.043	2,861	2.5%	0.0%	0.0%	\$7,939
True Net CONE = CC	\$267	\$85	2.7%	0.073	1,221	1.1%	10.9%	3.3%	\$13,104
True Net CONE = CT	\$326	\$94	9.8%	0.098	388	0.4%	31.0%	11.5%	\$15,889
True Net CONE = 1.4 x CC	\$374	\$94	21.2%	0.128	-393	-0.3%	50.0%	24.8%	\$18,092

PJM/PAPUC Proposed VRR Curve

	Price			Reliability						Cost
	Average	Standard	Frequency	Average	Average Excess	Average Excess	Normalized	Frequency	Frequency	Average
	Clearing	Deviation	at Cap	LOLE	(Deficit) Above	(Deficit) Above	Portfolio	Below	Below 99% of	Procurement
	Price	(\$/MW-d)	(%)	(events/yr)	Reliability	Target Reserve	EUE (% of	Reliability	Reliability	Cost
					Requirement	Margin	Target)	Requirement	Requirement	(\$ mln/yr)
					(MW)	(UCAP RR + X %)	(%)	(%)	(%)	
Net CONE Overestimated	\$228	\$94	0.1%	0.034	4,093	2.90%	34.9%	1.0%	0.1%	\$11,504
Net CONE Correctly Estimated	\$380	\$150	6.7%	0.070	1,844	1.33%	74.8%	16.4%	6.7%	\$18,843
Net CONE Underestimated	\$532	\$151	30.8%	0.146	(514)	-0.32%	175.1%	49.9%	30.8%	\$25,869

Any lower price caps result in quick degradation of reliability with any misestimation of Net CONE (See [Table 5 of VRR Report](#))

Topic	Description
LDA VRR Curve Shape	Same VRR Curve shape as the RTO
RTO Gross CONE	Average of all CONE Areas
Net CONE for RTO and Global LDAs (MAAC, EMAAC, SWMAAC)	33 rd Percentile of Net CONE for zones within the applicable area
Net EAS for RTO and Global LDAs (MAAC, EMAAC, SWMAAC)	67 th Percentile of Net EAS for zones within the applicable area
Gross CONE Escalation	<p>BLS Indices as described in Table 28 of the CONE Report</p> <p>ComEd escalated by Asset Life Factor in Table 29 of the CONE Report</p>



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Quadrennial Review:

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