Quadrennial Review Proposal

Skyler Marzewski
Lead Market Design Specialist
Market Design

Markets & Reliability Committee
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The proposed package represents PJM management's initial 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.

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.
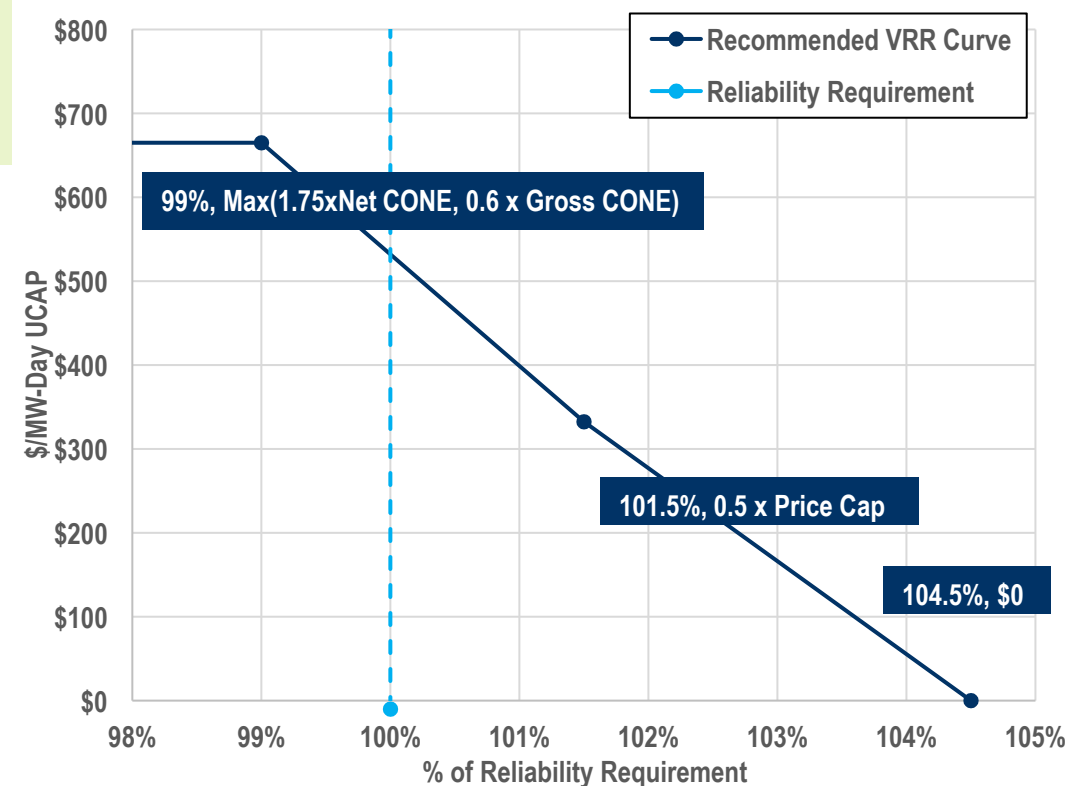
Reference Resource: Combined Cycle for every CONE Area, except 4-hour Battery Energy Storage System for ComEd

VRR Curve: Maintain 3-point VRR curve with price stability enhancements and improved safeguards

- Change floor for Point A from Gross CONE to 0.6 x Gross CONE (Generally rely on Net CONE for the Price Cap and add stability)

- Tie point B to 50% of Price Cap (Stability of VRR Curve)

Same VRR shape for LDAs

EAS: Status Quo with updated Reference Resource parameters, but open to refinements

PJM is recommending the **Combined Cycle (CC)** as the Reference Resource for all areas, except in **ComEd**, where the **4-hour Battery Energy Storage System (BESS)** is recommended.

In general, CC results in the lowest estimated Net CONE and is therefore the most economic new entrant.

CONE Area	Reference Resource	Gross CONE ($/MW-Day ICAP)	Gross CONE ($/MW-Day UCAP)	Estimated Net CONE ($/MW-Day UCAP)
EMAAC: CONE Area 1	CC	$816	$1,007	$673
SWMAAC: CONE Area 2	CC	$819	$1,011	$335
Rest of RTO: CONE Area 3	CC	$813	$1,004	$349
WMAAC: CONE Area 4	CC	$814	$1,005	$428
COMED: CONE Area 5	BESS	$726	$1,117	$720
RTO	CC	$813	$1,004	$380

Combined Cycle resources seem to best fit the definition of Reference Resource Technology:

- 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

Combined Cycles also carry risks and concerns that must be addressed:

- 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.

CEJA limits CC and CT asset life within the ComEd Zone which makes the BESS more economic

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

Ref. Technology/Gross CONE: Reference Resource

Net CONE

	EMAAC 33rd Percentile CONE Area 1 ($/MW-Day UCAP)	SWMAAC 33rd Percentile CONE Area 2 ($/MW-Day UCAP)	Rest of RTO 33rd Percentile CONE Area 3 ($/MW-Day UCAP)	WMAAC 33rd Percentile CONE Area 4 ($/MW-Day UCAP)	COMED 33rd Percentile CONE Area 5 ($/MW-Day UCAP)	RTO 33rd Percentile ($/MW-Day UCAP)
Net CONE						
CT	$756	$536	$503	$576	$862	$534
CC	$673	$335	$349	$428	$774	$380
BESS	$674	$505	$628	$652	$720	$629

- **There is an ongoing coordination with PJM, the IMM, and Brattle with S&L, with respect to the calculation of Gross CONE values:**
    - **Wet compression**
    - **Inlet pressure assumption**
    - **Capital spend/drawdown schedule**
    - **Project timelines**

- **Brattle with Sargent & Lundy are calculating updated CONE values for the CC and CT to reflect including wet compression technology and adjust the inlet pressure assumption**

- **These changes will result in lowering Gross CONE for the CT by approximately ~$50–$60/MW-day and Gross CONE for the CC by approximately $60–$70/MW-day.**

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

- While we recognize there are alternative ways to calculate the Net E&AS offset, the Forward-looking approach continues to make sense to us.

- PJM is open to refinements to the current Net E&AS methodology

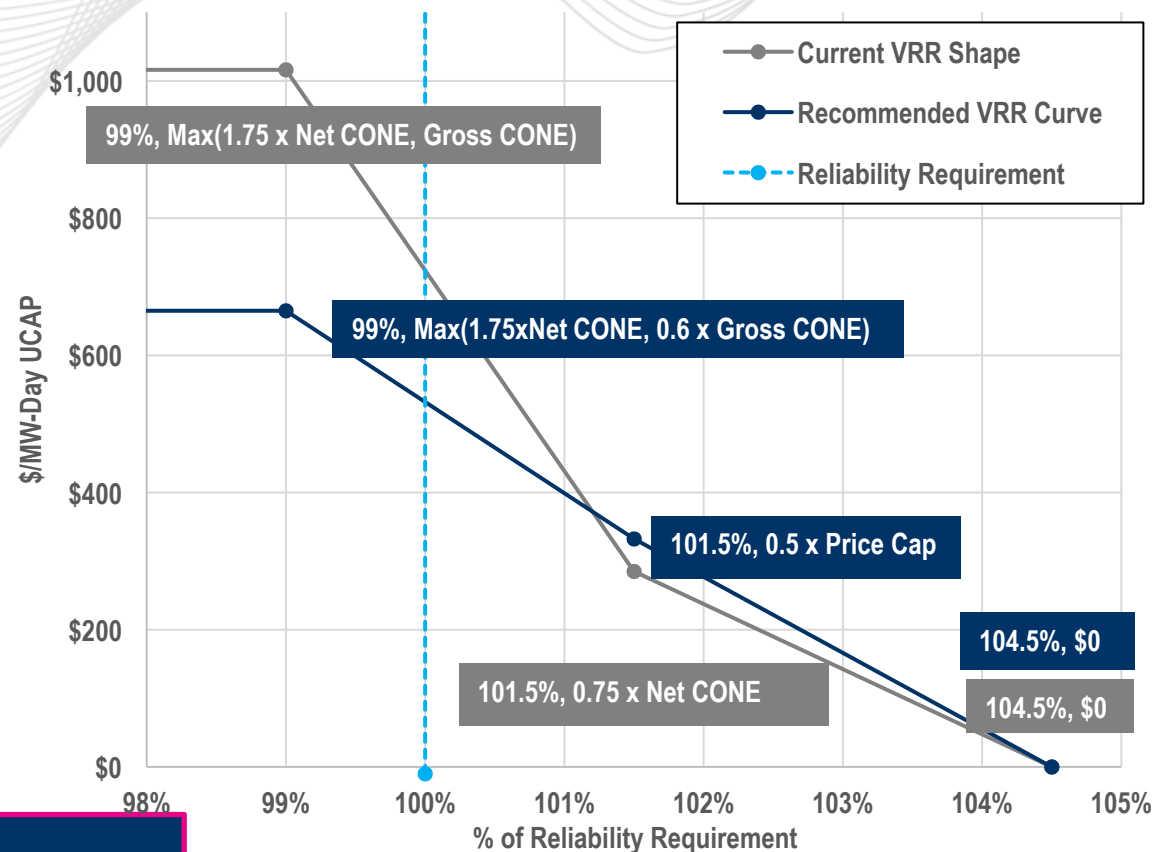**Currently, all proposals are using the Forward Net E&AS methodology.**

PJM Recommendation: *RTO VRR Curve*

In General: PJM is recommending to maintain general concept proposed in the 2022 Quadrennial Review while adjusting the following:

Point A:
Max (1.75 x Net CONE, 0.6 x Gross CONE)

Current estimation is 1.75 x Net CONE is approximately 0.6 x Gross CONE

Point B:
0.5 x Price Cap

Approximately 0.75 x Net CONE / 1.75 x Net CONE

Chart legend:
- Current VRR Shape
- Recommended VRR Curve
- Reliability Requirement

Chart labels:
- 99%, Max(1.75 x Net CONE, Gross CONE)
- 99%, Max(1.75xNet CONE, 0.6 x Gross CONE)
- 101.5%, 0.5 x Price Cap
- 101.5%, 0.75 x Net CONE
- 104.5%, $0
- 104.5%, $0

Y-axis: $/MW-Day UCAP
X-axis: % of Reliability Requirement

VRR Curves calculated using current CC estimates for 28/29

	Current		Recommended	
	MW	Price	MW	Price
Point 1	99.0%	Max(1.75 x Net CONE, Gross CONE)	99.0%	Max(1.75 x Net CONE, 0.6 x Gross CONE)
Point 2	101.5%	0.75 x Net CONE	101.5%	0.5 x Price Cap
Point 3	104.5%	$0	104.5%	$0

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 Deviation	Frequency at Cap	Average LOLE	Average Excess (Deficit)	Average Excess (Deficit)	Frequency Below Target	Frequency Below IRM - 1%	Average Procurement Cost
	($/MW-d)	($/MW-d)	(%)	(events/yr)	(MW)	(IRM + X %)	(%)	(%)	($ 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 Proposed VRR Curve

	Price			Reliability						Cost
	Average Clearing Price	Standard Deviation	Frequency at Cap	Average LOLE	Average Excess (Deficit) Above Reliability Requirement	Average Excess (Deficit) Above Target Reserve Margin	Normalized Portfolio EUE (% of Target)	Frequency Below Reliability Requirement	Frequency Below 99% of Reliability Requirement	Average Procurement Cost
	($/MW-d)	($/MW-d)	(%)	(events/yr)	(MW)	(UCAP RR + X %)	(%)	(%)	(%)	($ mln/yr)
Net CONE Overestimated	$228	$103	0.5%	0.044	3,003	2.13%	45.9%	1.9%	0.5%	$11,424
Net CONE Correctly Estimated	$380	$155	9.5%	0.084	1,158	0.84%	89.8%	21.4%	9.5%	$18,757
Net CONE Underestimated	$532	$143	37.7%	0.173	(1,153)	-0.77%	212.9%	58.7%	37.7%	$25,745

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, while using the applicable Reference Resource Technology
RTO Gross CONE	Average of CONE Area 1, 2, 3, and 4
Net CONE for RTO and Global LDAs (MAAC, EMAAC, SWMAAC)	33rd Percentile of Net CONE for zones within the applicable area
Gross CONE Escalation	BLS Indices as described in Table 28 of the CONE Report

CONE Area	Reference Resource	Estimated Price Cap ($/MW-Day UCAP)	Estimated Point B ($/MW-Day UCAP)
EMAAC: CONE Area 1	CC	$1,177	$589
SWMAAC: CONE Area 2	CC	$587	$294
Rest of RTO: CONE Area 3	CC	$610	$305
WMAAC: CONE Area 4	CC	$749	$375
COMED: CONE Area 5	BESS	$1,261	$631
RTO	CC	$665	$333

$/MW-Day UCAP

Legend:
- IMM VRR Curve
- LS Power VRR Curve
- PAPUC VRR Curve
- PJM VRR Curve
- Reliability Requirement

X-axis: **% of Reliability Requirement** (98%–108%)
Y-axis: $0, $200, $400, $600, $800, $1,000
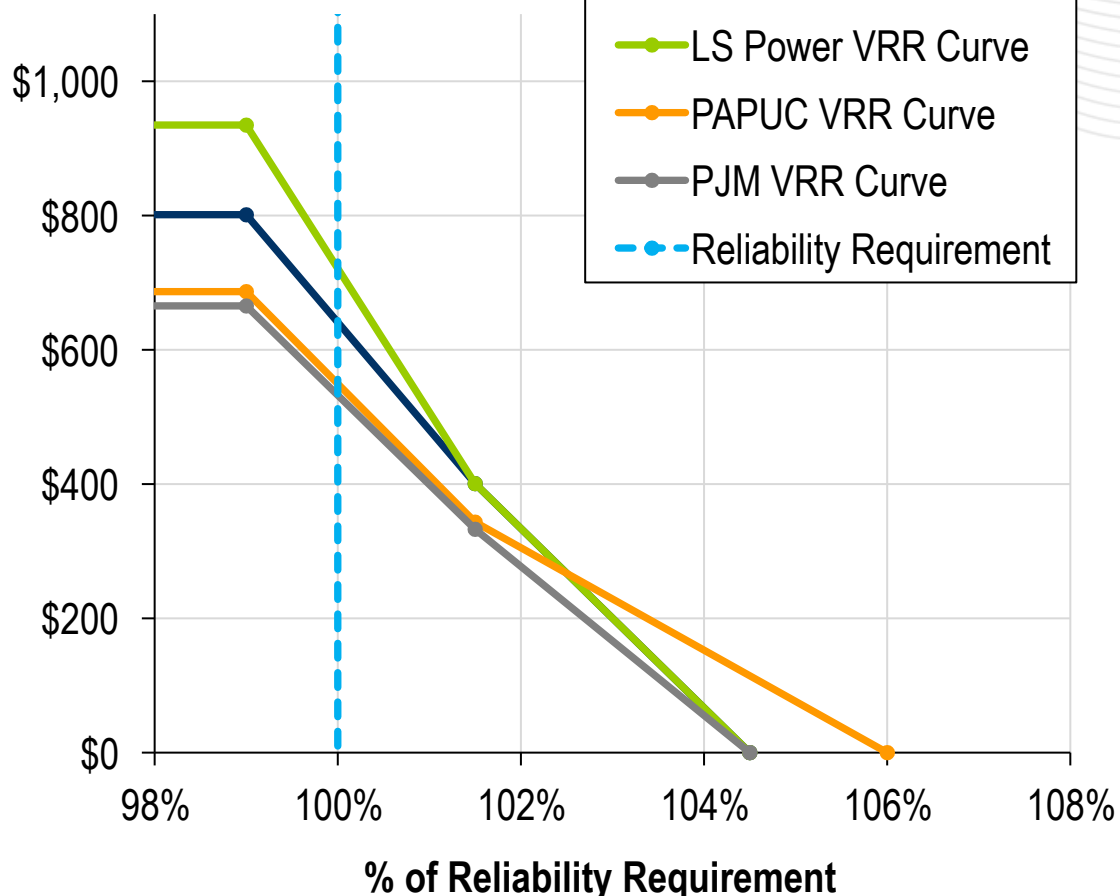
All proposed VRR curves maintain the 3-point VRR Curve design

IMM VRR Curve uses the 2018 QR VRR Curve with a CT, but eliminates the safeguard for Point A

- This means if Net CONE is calculated at $0, as observed with 26/27 BRA, there would be no demand curve for the capacity market

- Reliability outcomes require high degree of certainty around Net CONE, or else PJM would risk not maintaining the 1-in-10 LOLE standard

LS Power VRR Curve uses the 2022 QR VRR Curve, which results in the highest potential price cap

PA PUC VRR Curve applies separate conservative estimates on Gross CONE and Net E&AS which provides more stability to the VRR Curve

- Price Cap = 115% Gross CONE – 75% Net E&AS

- Reliability outcomes are slightly better than the PJM proposed demand curve, which makes this a viable candidate

- PA PUC Modeling Results

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

CONE Area	PJM Price Cap ($/MW-Day UCAP)	PA PUC Price Cap ($/MW-Day UCAP)	
EMAAC: CONE Area 1	$1,177	$908	**PJM is considering adopting the PA PUC VRR Curve as part of our proposal**
SWMAAC: CONE Area 2	$607	$657	
Rest of RTO: CONE Area 3	$611	$664	
WMAAC: CONE Area 4	$748	$722	
COMED: CONE Area 5	$1,263	$988	
RTO	$673	$693	

- Generally, Brattle's recommendations rely on changes outside the scope of the Quadrennial Review which encroach on broader RPM market design changes which should be discussed in a separate stakeholder process

- Current PJM estimated Net CONEs are closely aligned with Brattle calculated Reference Prices

    – PJM: Net CONEs update annually
    – Brattle: Reference Prices escalated annually by CPI

- PJM recognizes the merits of the MRI VRR curve, and believes a sub-annual RPM design would best realize these benefits

- PJM has not yet heard strong support for the MRI curve shape

CONE Area	Reference Resource	Estimated Net CONE ($/MW-Day UCAP)	Brattle Reference Price ($/MW-Day UCAP)
EMAAC: CONE Area 1	CC	$673	$600
SWMAAC: CONE Area 2	CC	$335	$350
Rest of RTO: CONE Area 3	CC	$349	$350
WMAAC: CONE Area 4	CC	$428	$425
COMED: CONE Area 5	BESS	$720	$725
RTO	CC	$380	$350

Brattle's proposal does not have a specific Reference Resource, but picks an expected long term pricing signal, "Reference Price":

- RTO: $350/MW-day UCAP
- WMAAC: $425/MW-day UCAP
- EMAAC: $600/MW-day UCAP
- SWMAAC: $350/MW-day UCAP
- ComEd: $725/MW-day UCAP

These values would be escalated by CPI for subsequent delivery years
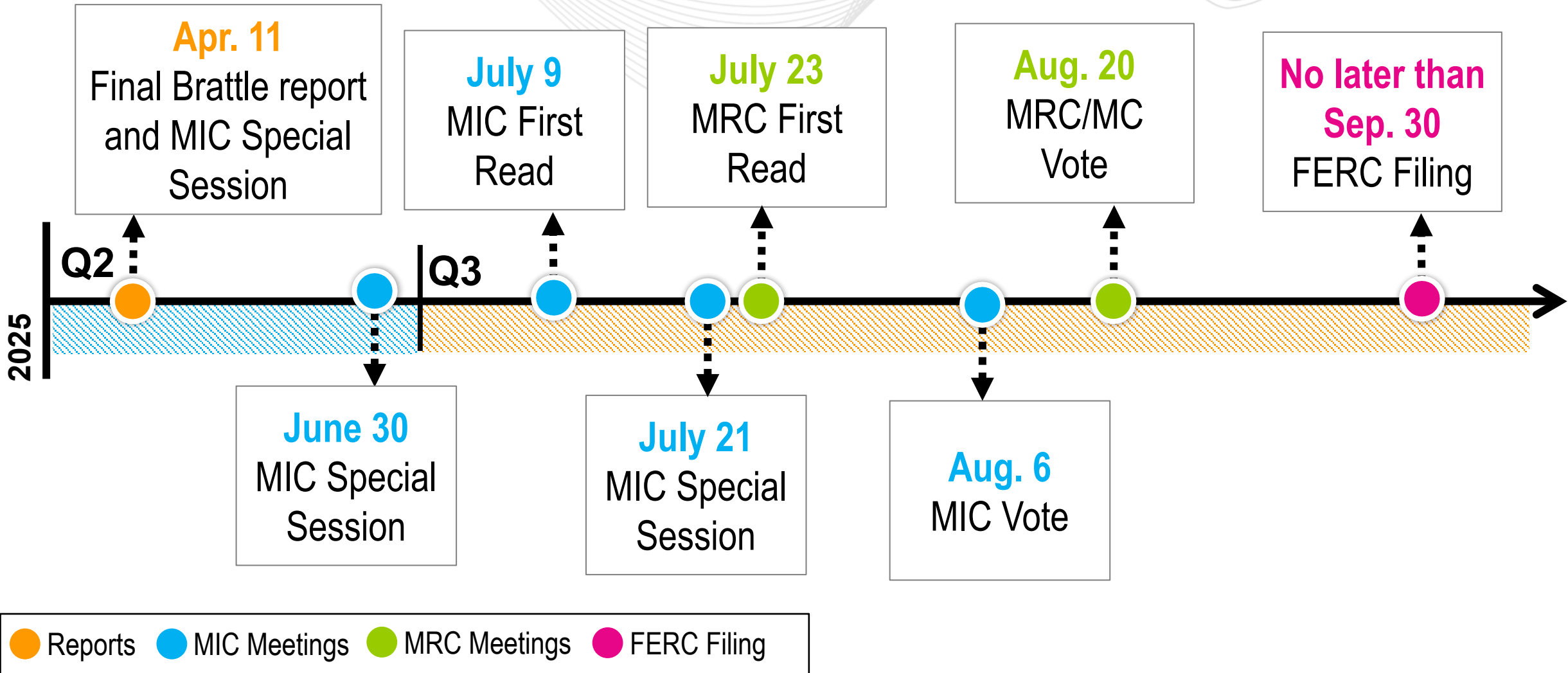
Brattle is recommending:
- MRI curves that exactly meet our reliability metric of 1-in-10 LOLE
- Using the Reference Price instead of Net CONE
- Have a price cap of 1.5 to 1.75 x Reference Price
- LDA MRI curves with varying minimum procurement targets

Interactions with RPM Performance:
- Restore 3-Year Forward Period of the Base Residual Auctions (BRAs)
- Transition to Sub-Annual Capacity Construct with at least two seasons
- Reliability Backstop to: (1) update investigation provisions to trigger in any shortfall (i.e. price cap) event on an LDA-specific basis (not just RTO-wide); and (2) review whether backstop procurement mechanisms are sufficient to address reliability risks

Brattle Recommendations and Final Reports

- [Sixth Review of PJM's RPM VRR Curve Parameters: Final Recommendations](#)

- [Brattle 2025 CONE Report for PJM](#)

- [Sixth Review of PJM's Variable Resource Requirement Curve](#)

Apr. 11
Final Brattle report and MIC Special Session

July 9
MIC First Read

July 23
MRC First Read

Aug. 20
MRC/MC Vote

No later than Sep. 30
FERC Filing

Q2

Q3

2025

June 30
MIC Special Session

July 21
MIC Special Session

Aug. 6
MIC Vote

Legend:
- Reports
- MIC Meetings
- MRC Meetings
- FERC Filing

Chair:
Lisa Drauschak,
Lisa.Drauschak@pjm.com

Secretary:
Dave Anders,
David.Anders@pjm.com

SME/Presenter:
Skyler Marzewski,
Skyler.Marzewski@pjm.com

Quadrennial Review Proposal

Member Hotline

(610) 666 – 8980

(866) 400 – 8980

custsvc@pjm.com