Sixth Review of PJM's RPM VRR Curve Parameters

PRELIMINARY DRAFT RECOMMENDATIONS

PREPARED BY

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PJM Market Implementation Committee

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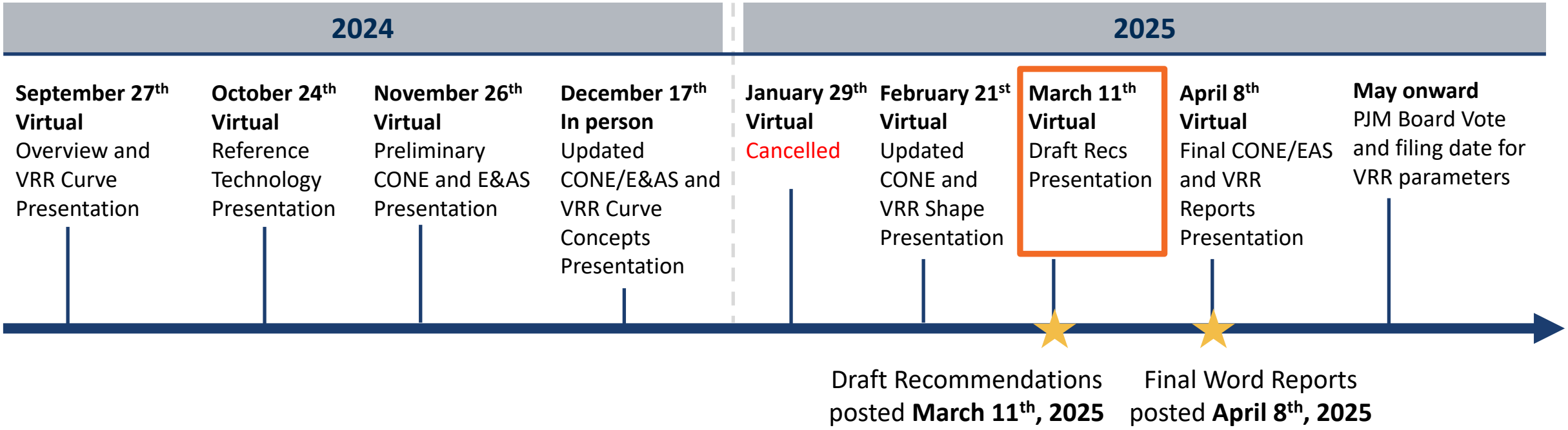
Brattle

Where we are in the Net CONE and VRR Review



Draft Quadrennial Review Recommendations

System-Wide Variable Resource Requirement (VRR) Curve

- **Adopt Marginal Reliability Impact (MRI) VRR curve,** with prices reflective of incremental reliability value
- **Stabilize Pricing Parameters** by adopting "Reference Price" to replace Net CONE parameter (see Feb 21 MIC presentation for indicative range, final recommendation pending Net CONE updates). Annual updates relative to consumer price index (CPI) between quadrennial reviews
- **Price Cap:** In the range of 1.5-1.75 × Reference Price (approximately $450-625/MW-day). Quantity at the cap no lower than 99% × Reliability Requirement (lower price cap corresponds to higher quantity at the cap to maintain 1-in-10)

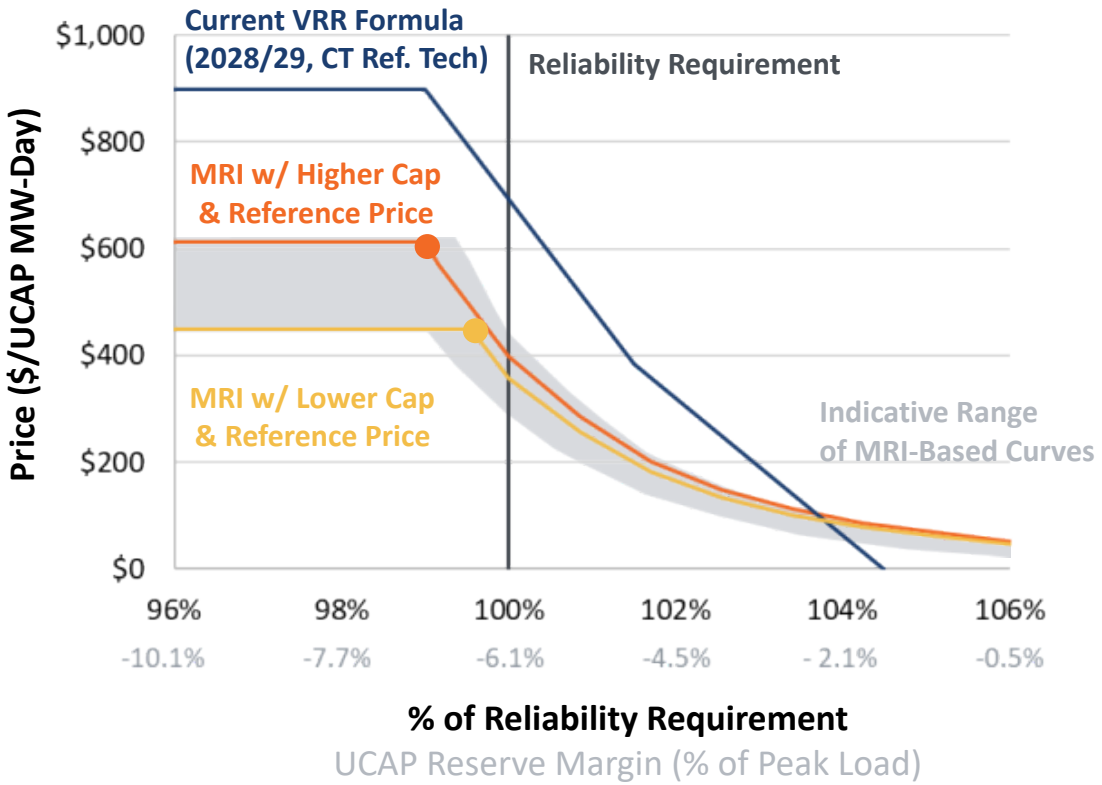
Locational VRR Curves

- **Locational Deliverability Area (LDA)** VRR curves drawn through location-specific MRI curves. Local reference price may be higher in some locations (pending final outcomes from Net CONE study)

Interactions with Reliability Pricing Model (RPM) Performance

- **Enhance Reliability Backstop** to: (1) trigger review in the event of a shortfall (i.e. price cap) event on an LDA-specific basis (not just RTO-wide); and (2) enable backstop procurements more quickly in a more competitive fashion
- **Restore 3-Year Forward Period** of the Base Residual Auctions (BRAs)
- **Transition to Sub-Annual Capacity Construct** with at least two seasons

Draft Recommendation: MRI-Based VRR Curve

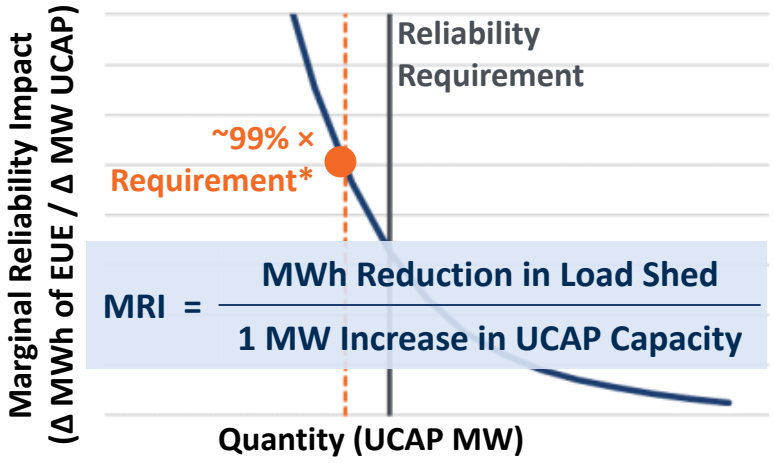


Sources and Notes: Recommended Curve constructed using Reference Price of $300/MW; Current VRR Formula from PJM, Open Access Transmission Tariff. Attachment DD, Section 5.10.a.iii, using Brattle estimates of CT Net CONE ($513/MW-day) and CT CONE ($834/MW-day); 1.75 × Net CONE is the binding parameter in setting the price cap.

System-Wide Curve: Transition to MRI-based Demand Curve

Draft Recommendation: Adopt demand curve derived from MRI, with VRR prices reflective of incremental reliability value

MRI Curve



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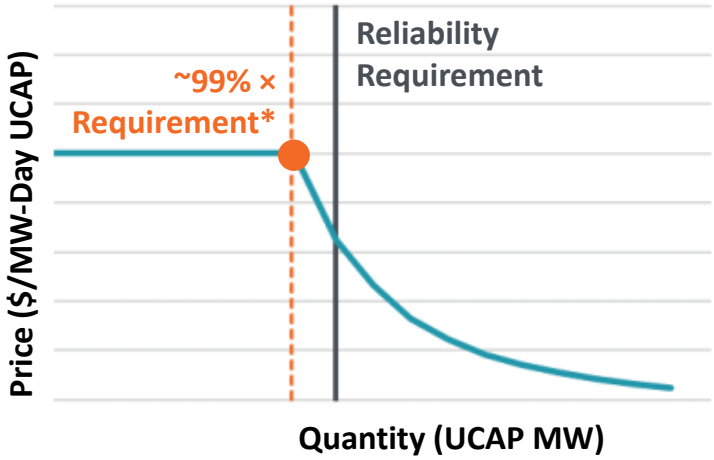
Scaling Factor
($/MWh)

=

MRI-Based VRR Curve



Step 1: Develop MRI Value

- Y-axis in units of reliability (Δ EUE/Δ MW)
- Derived from PJM reliability modeling
- Can be separately calculated for system, LDA, and sub-annual periods

Step 2: Multiply by "Scaling Factor"

- Translates from units of reliability into units of price
- Scaling factor sized to run through the price cap

Step 3: Calculate MRI-Based VRR Curve

- Y-axis in units of price ($/MW-day)
- Reflects willingness to pay vs. quantity
- Subject to price cap at ~99% × Reliability Requirement*

*Final recommendation for quantity at the cap pending final Net CONE estimates and stakeholder input (lower multiple of Reference price would correspond to higher volume at the cap).

Stabilize Net CONE and Reference Price

Draft Recommendation: Stabilize VRR curve pricing parameters

- "Reference Price" replaces Net CONE parameter
- Initial value established for 2028/29. See Feb 21 MIC presentation* for indicative range, subject to revision pending final Net CONE study results
- Simplified annual updates based on CPI between quadrennial reviews

- Stabilizing pricing parameters of VRR curve can offer more certainty to investors and customers and is more consistent with a value of reliability (that would not fluctuate with changes in costs or energy market prices)
- Multiple technologies and data points may be considered in selecting reference price within each quadrennial review
- Transition away from single reference technology will help avoid swings in pricing parameters associated with industry transition
- Eliminates need for CONE-based minimum on price cap
- Ideally, few market design changes or shifts in fundamentals would be large enough to require updates to Reference Price between quadrennial reviews (counter examples may be large E&AS market reforms that may substantially increase resource revenues, or state moratoria on certain supply resources)

* The Brattle Group, Sixth Review of PJM's RPM VRR Curve Parameters, Updated Gross CONE and VRR Curve Analysis, February 21, 2025.

Stabilize Price Cap

Draft Recommendation: Price cap at 1.5-1.75 × Reference Price

- Approximately $450-625/MW-day UCAP (pending final Reference Price recommendation)
- Quantity at or somewhat above 99% × Reliability Requirement, where Reliability Backstop is triggered (specific value to be aligned with Reference Price and "tuning" to 1-in-10)
- Remove CONE-based minimum (not needed to mitigate possibility of low/zero Net CONE if Reference Price is stabilized over review period)

Consideration	Range	Suggests Price Cap:
Historical RPM Price Cap	$500-$550	• Historical price cap range has been sufficient to maintain supply-side interest in new developments (except in most recent auction; other issues at play)
Proposed Temporary Cap	$325	• Negotiated proposal to temporarily reduce price cap & mitigate customer exposure to price-cap events under near-term tight supply conditions. Paired with price floor at $175 to maintain supply interest
Neighboring Markets' Caps	$500-$626	• Price high enough to align with price caps in neighboring capacity markets and compete for imports when multiple regions are tight
Simulation Modeling	162%-191% × Net CONE	• 162%-191% cap in that range supports 0.1 LOLE if minimum is at 99% Requirement. • Lower cap at 1.5x Net CONE would be right-shifted at minimum quantity
Reference Technology (Numbers refer to Feb 21 MIC QER Update)	$400-$850	• **CC Reference Tech:** Price cap of approximately $400-$850/MW-day may be relevant considering uncertainty range around CC Net CONE • Higher price cap of approximately $850 or $1,275 if CT or BESS is reference technology (~1.7 × preliminary Net CONE estimates)

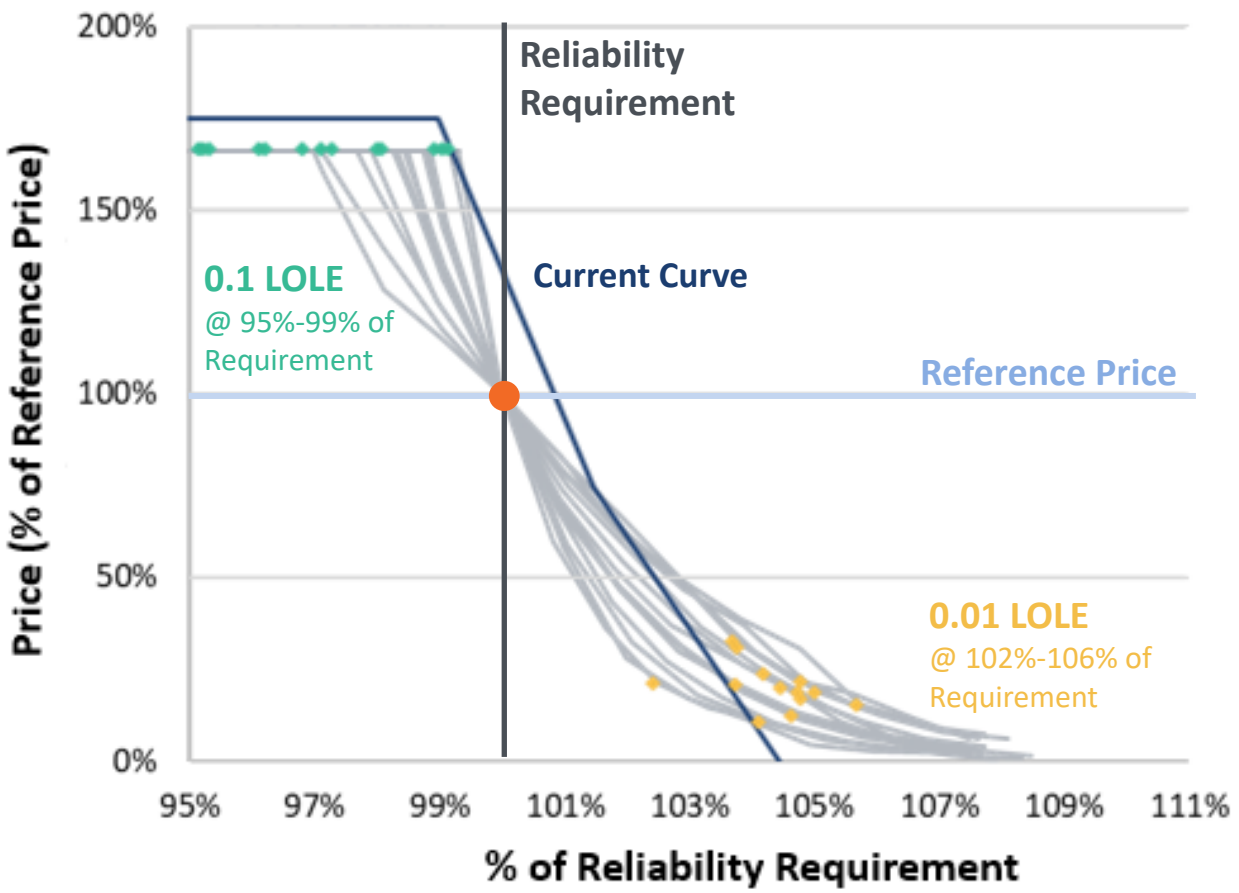
Note: Historical price caps are adjusted up to account for transition to ELCC, not adjusted for inflation. Neighboring market caps reflect 2026$, and UCAP of each market.

LDA VRR Curves: Transition to MRI-Based Demand Curves

Draft Recommendation: LDA-specific MRI curves

- LDA curves defined by target point at Reliability Requirement and Reference Price, produces a different scaling factor in each LDA
- Price cap at 1.5-1.75 × LDA Reference Price
- LDA Reference Price may be higher in LDAs with evidence of persistent higher long-run cost of supply
- Quantity at cap ranges 95%-99% of LDA Reliability Requirement (flatter curve reflects graduated reliability value)
- Longer-term: Consider moving to uniform $/MWh scaling factor across all LDAs and seasons (will help to manage tradeoffs in reliability vs. cost by location and season, but requires updated clearing logic similar to ISO-NE)

Draft Recommendation: MRI-Based Curve in LDAs



Notes: Each gray line represents the MRI curve for a different LDA.

Enhance Reliability Backstop Provisions

Role of Price Cap vs. Reliability Backstops

- A well-functioning capacity market ideally produces few events at the price cap and rarely or never relies on a reliability backstop
- However, it is difficult to set a price cap for a single-year commitment high enough to procure sufficient capacity in *all* conceivable conditions
- To mitigate risks posed by acute and transient tight supply conditions, a backstop may be needed, but the current RPM backstop can be improved to be more systematic, competitive and limit impacts on the broader market

Current RPM Backstop Mechanism:

- **<99% Reliability Requirement (1 Year):** Triggers investigation to review reasons for shortfall to recommend changes to address shortfall (e.g. address barriers to entry, increase VRR curve prices)
- **<99% Reliability Requirement (3 Consecutive Years):** Triggers post-BRA backstop auction (up to 15-year commitments, seller offers collected for 6-month bid window, sellers compete on price)
- Backstop mechanisms apply only on an RTO-wide basis (not to LDAs)

Current Backstop Provisions: PJM Tariff Attachment DD.16.

Potential Enhancements to Reliability Backstop Mechanism

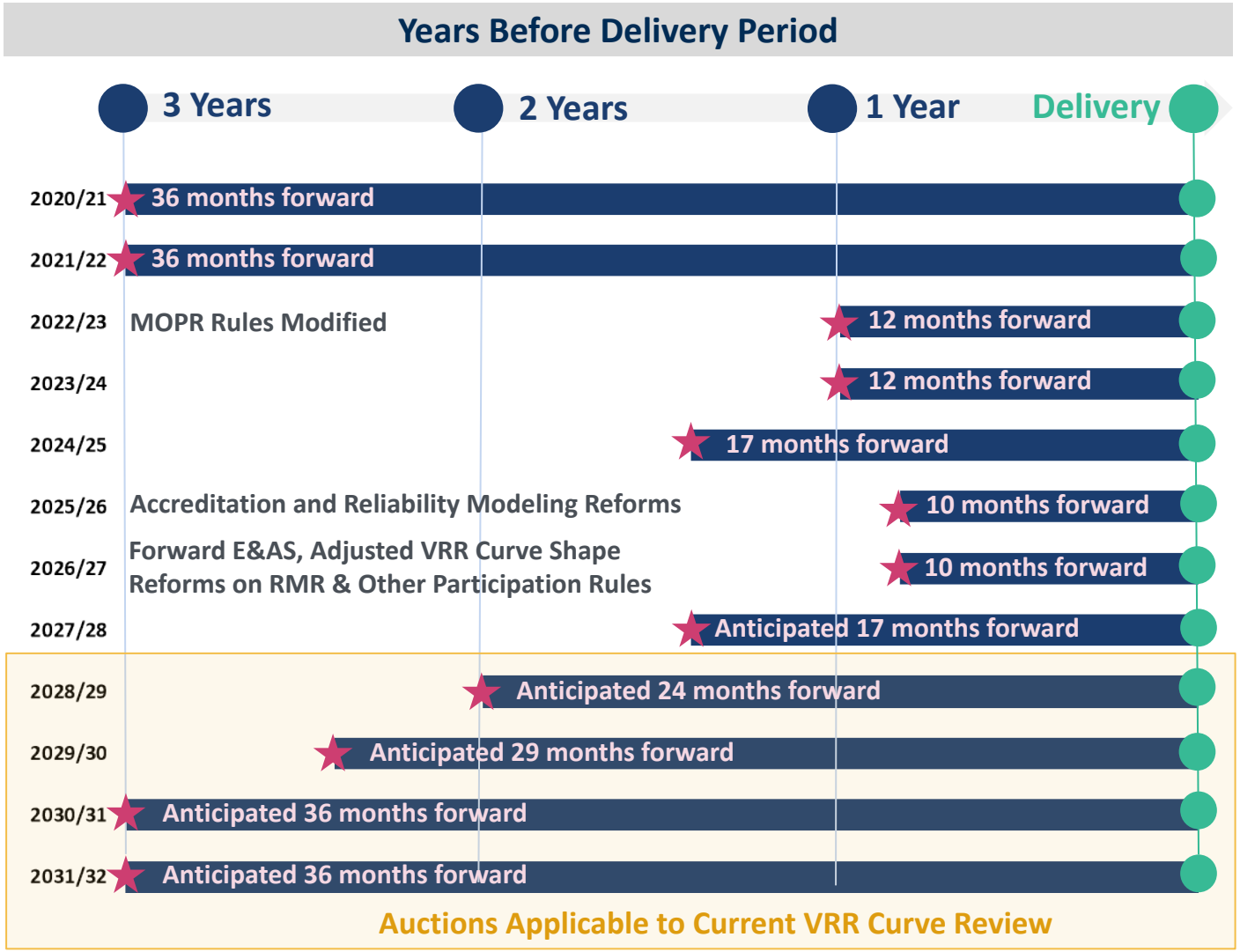
- **Timing of Backstop Procurement:** Update timing of backstop auction to be automatically triggered if BRA auction clears short, to avoid delay in attracting supply
- **Procurement Trigger and Volume:** Backstop procurement triggered to restore cleared volume up to minimum acceptable levels: 99% RTO wide, and volume at cap for LDAs (95-99% of Requirement)
- **Term:** If one year at price cap is insufficient to attract supply, procure incremental supply at the price cap, but under a multi-year commitment (ranging from 2- to 15-year terms)
- **Format of competitive procurement**:
  - At or below the price cap: sellers compete on price (lowest-price offers clear for 1-year commitments), as usual
  - Backstop at the price cap: sellers compete on term up to 15 years (shortest term wins)*
- **Sellers eligible for multi-year commitments**: New resources, plus existing resources with demonstrated cost consistent with the price cap & offered term
- **Other sellers**: Earn 1-year commitment @ price cap (same as today)
- **Applicability to LDAs:** Apply investigation & backstop triggers for both RTO-wide and LDA-specific shortfall events (e.g. LDA-specific investigation may identify localized barriers to entry or supply cost issues)

*Details of procurement format would need to be refined to incentivize sellers to offer at the lowest price and/or term they are willing to accept and address the possibility that the price cap and term together remain insufficient to attract offers.

Restore Full 3-Year Forward Delivery Period

Draft Recommendation: Maintain current schedule to restore 3-year forward period, aligned with overall RPM design

- May require some reforms to be implemented in a staged fashion (delay implementation rather than delaying auctions)
- Compared to recent compressed forward periods, full 3-year-forward auctions can allow more time for market participants to manage design changes and bring supply online



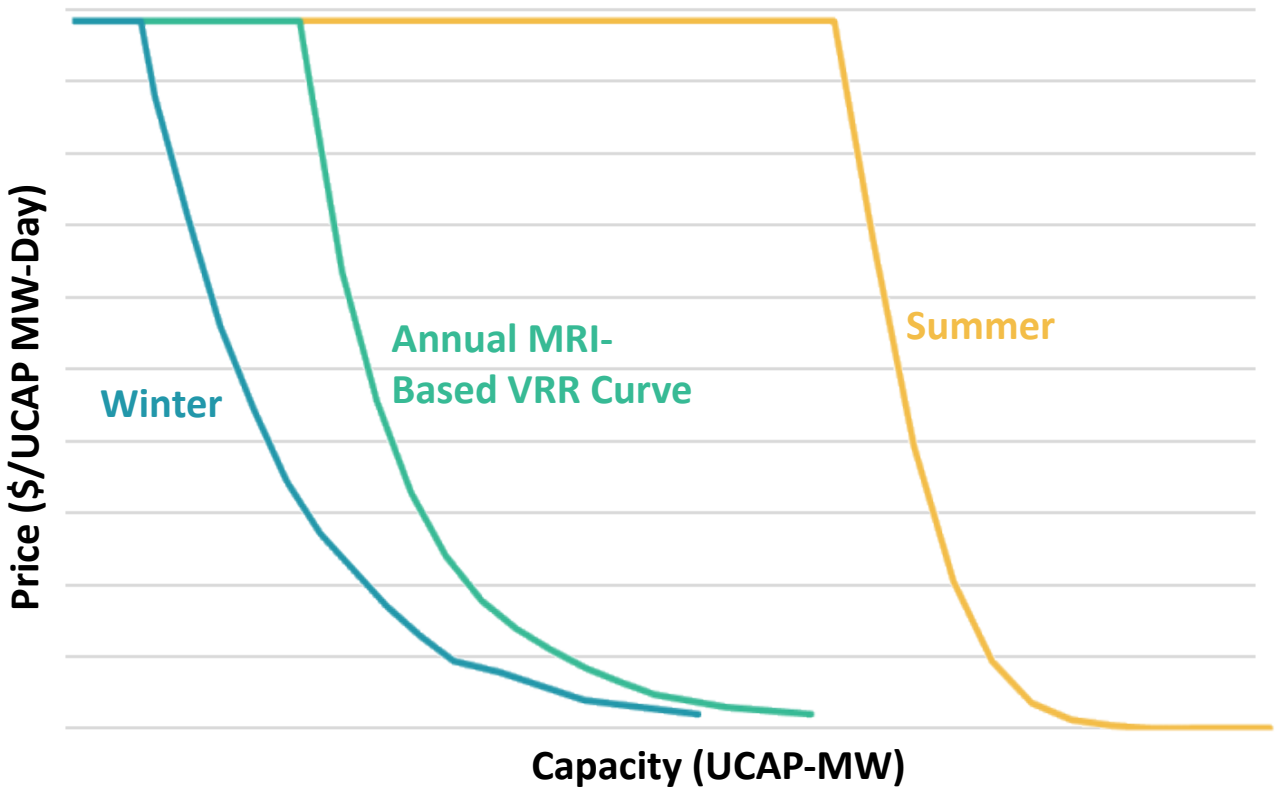
Sources and Notes: Timeline of future auctions from PJM, Auction Schedule, 2024.

Transition to sub-annual capacity market

Draft Recommendation: Transition to sub-annual capacity market with MRI-based VRR curves

- Will substantially improve capability to manage of reliability needs across seasons with different reliability drivers, resource capabilities, and relative supply-demand balance
- Sub-annual MRI-based curves can naturally balance economic value by season (same $/MWh scaling factor by sub-annual period, similar to MISO's 4-season MRI curves)

Illustrative Seasonal Capacity Demand Curves

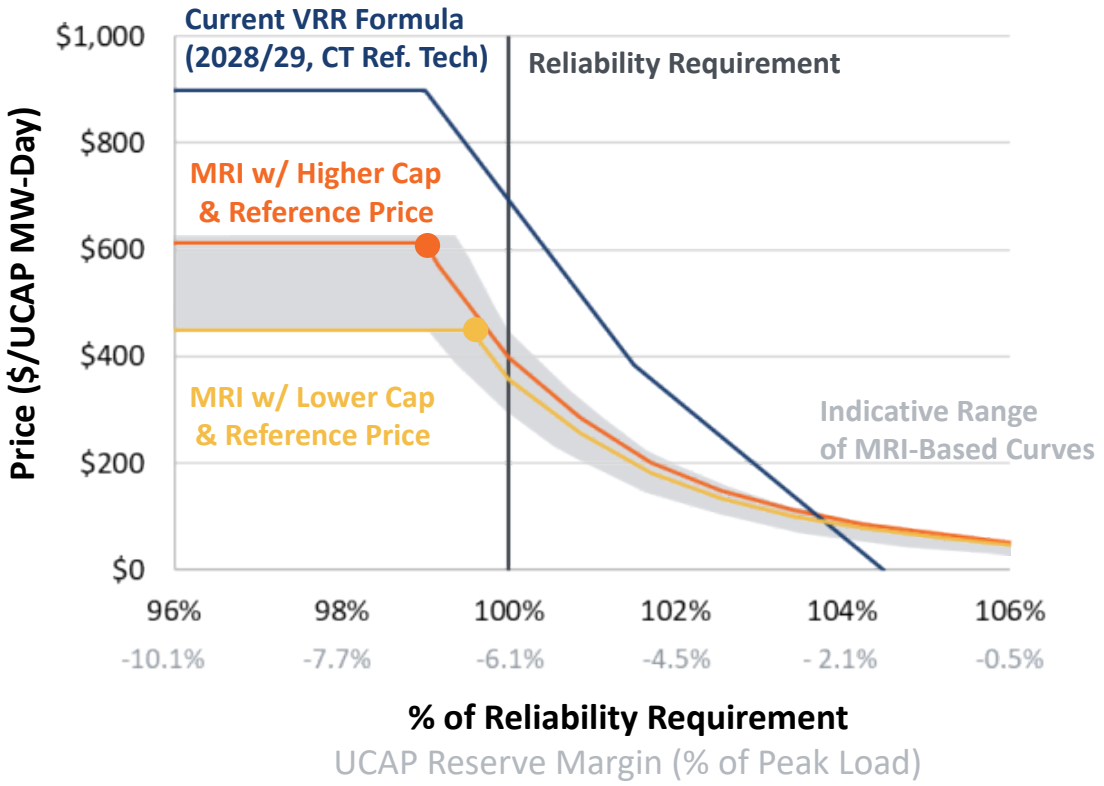


Sources and Notes: Curves are illustrative set based on projections of winter and summer peak demand. Seasonal curves use the same scaling factor as the annual curve.

Discussion & Next Steps

- Seeking stakeholder input on draft recommendations
- Final recommendations to be included in full quadrennial review report by April 8th, 2025

Draft Recommendation: MRI-Based VRR Curve



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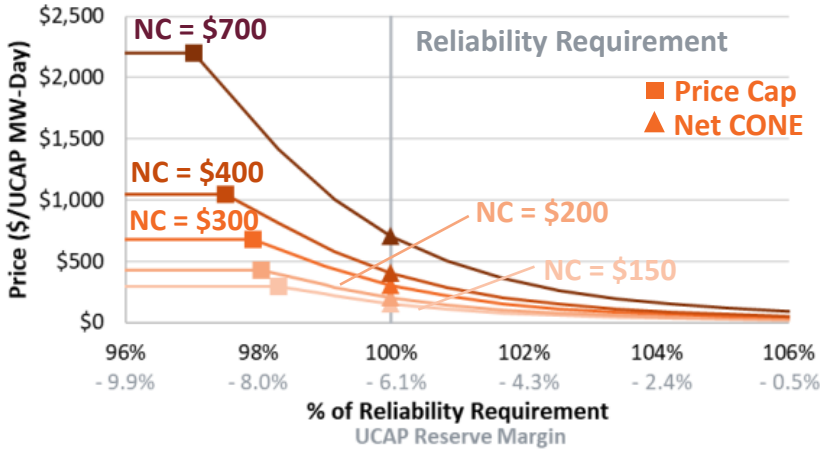
Appendix: Tuned MRI Curve Detail*

* The Brattle Group, Sixth Review of PJM's RPM VRR Curve Parameters, Updated Gross CONE and VRR Curve Analysis, February 21, 2025.

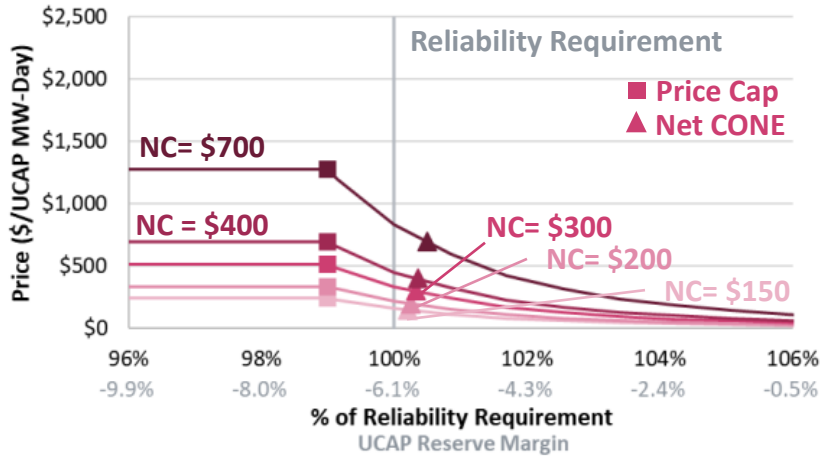
APPENDIX

Summary of Implications for Price Cap Given Net CONE Uncertainties

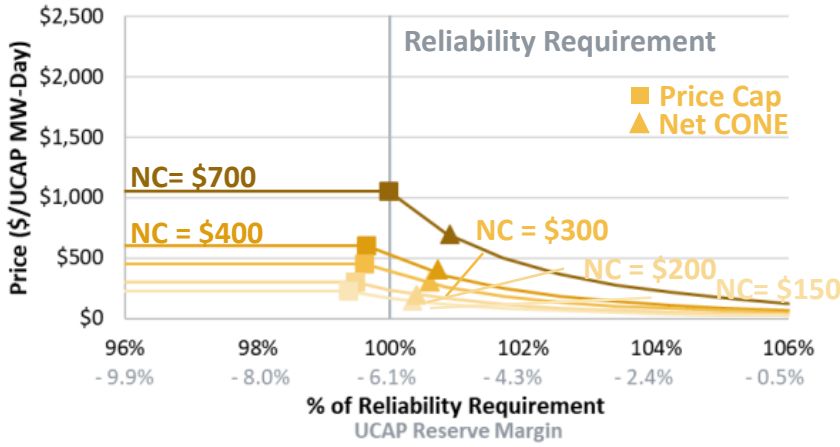
Curve #1: Anchored @ Target Point



Curve #2: Cap @ 99% of Requirement



Curve #3: Cap @ 150% of Net CONE



	Anchored to Target Point					Anchored to Cap at 99% of Reliability Requirement					Anchored to Cap at 1.5 X Net CONE				
	Price Cap			Quantities		Price Cap			Quantities		Price Cap			Quantities	
	Price ($/MW-D)	Multiple of Net CONE (%)	Adder to Net CONE ($/MW-D)	Quantity at Price Cap (% of RR)	Quantity at Net CONE (% of RR)	Price ($/MW-D)	Multiple of Net CONE (%)	Adder to Net CONE ($/MW-D)	Quantity at Price Cap (% of RR)	Quantity at Net CONE (% of RR)	Price ($/MW-D)	Multiple of Net CONE (%)	Adder to Net CONE ($/MW-D)	Quantity at Price Cap (% of RR)	Quantity at Net CONE (% of RR)
Net CONE = $150	$290	193%	$140	98.3%	100.0%	$245	163%	$95	99.0%	100.2%	$225	150%	$75	99.4%	100.3%
Net CONE = $200	$430	215%	$230	98.0%	100.0%	$335	168%	$135	99.0%	100.2%	$300	150%	$100	99.5%	100.4%
Net CONE = $300	$675	225%	$375	97.9%	100.0%	$515	172%	$215	99.0%	100.3%	$450	150%	$150	99.6%	100.6%
Net CONE = $400	$1,050	263%	$650	97.5%	100.0%	$695	174%	$295	99.0%	100.3%	$600	150%	$200	99.7%	100.6%
Net CONE = $700	$2,200	314%	$1,500	97.0%	100.0%	$1,280	183%	$580	99.0%	100.5%	$1,050	150%	$350	100.0%	100.8%

Curve #1: Cap is a substantially higher multiple of Net CONE compared to today. Poorer reliability before reaching cap

Curve #2: Cap @ 99% of requirement and lower value than current CONE-based minimum. Curve runs through Net CONE @ about 0.5% above Requirement

Curve #3: Lowering cap to 50% of Net CONE requires right-shifting the curve another 0.5% to maintain reliability

APPENDIX

Tuned MRI Curves: Performance with Varying Net CONE

Curve 1: Curves tuned to Net CONE and Reliability Requirement

Curve 2: Curves tuned to Price Cap and 99% of Reliability Requirement

Curve 3: Curves tuned to Price Cap and 1.5 × Net CONE

	Clearing Price			Price Cap @ 1-in-10			Reliability							Cost
	Average Clearing Price	Standard Deviation	Frequency at Cap	Price	Multiple of Net CONE	Adder to Net CONE	Average LOLE	Average Excess (Deficit) Above Reliability Requirement	Average Excess (Deficit) Above Target Reserve Margin	Average EUE	Normalized Portfolio EUE (% of Target)	Frequency Below Reliability Requirement	Frequency Below 99% of Reliability Requirement	Average Procurement Cost
	($/MW-d)	*($/MW-d)*	*(%)*	*($/MW-d)*	*(%)*	*($/MW-d)*	*($/MW-d)*	*(MW)*	*(UCAP RR + X %)*	*(MWh)*	*(%)*	*(%)*	*(%)*	*($ mln/yr)*
Net CONE = $150	$150	$62	2.8%	$290	193%	$140	0.100	329	0.25%	1,564	102.9%	47.7%	9.4%	$7,348
Net CONE = $200	$200	$88	3.6%	$430	215%	$230	0.100	323	0.25%	1,589	104.6%	44.1%	12.6%	$9,810
Net CONE = $300	$300	$150	3.9%	$675	225%	$375	0.100	379	0.29%	1,599	105.2%	37.1%	15.0%	$14,728
Net CONE = $400	$400	$231	4.4%	$1,050	263%	$650	0.100	474	0.36%	1,619	106.5%	36.2%	14.7%	$19,646
Net CONE = $700	$700	$515	4.9%	$2,200	314%	$1,500	0.100	706	0.53%	1,664	109.5%	31.9%	18.1%	$34,403

	Clearing Price			Price Cap @ 1-in-10			Reliability							Cost
	Average Clearing Price	Standard Deviation	Frequency at Cap	Price	Multiple of Net CONE	Adder to Net CONE	Average LOLE	Average Excess (Deficit) Above Reliability Requirement	Average Excess (Deficit) Above Target Reserve Margin	Average EUE	Normalized Portfolio EUE (% of Target)	Frequency Below Reliability Requirement	Frequency Below 99% of Reliability Requirement	Average Procurement Cost
	($/MW-d)	*($/MW-d)*	*(%)*	*($/MW-d)*	*(%)*	*($/MW-d)*	*($/MW-d)*	*(MW)*	*(UCAP RR + X %)*	*(MWh)*	*(%)*	*(%)*	*(%)*	*($ mln/yr)*
Net CONE = $150	$150	$58	7.9%	$245	163%	$95	0.100	405	0.30%	1,593	104.8%	44.2%	7.9%	$7,348
Net CONE = $200	$200	$77	11.9%	$335	168%	$135	0.100	414	0.32%	1,614	106.2%	35.6%	11.9%	$9,809
Net CONE = $300	$300	$126	13.0%	$515	172%	$215	0.100	494	0.38%	1,621	106.7%	33.6%	13.0%	$14,728
Net CONE = $400	$400	$177	14.3%	$695	174%	$295	0.100	550	0.42%	1,636	107.6%	33.5%	14.3%	$19,643
Net CONE = $700	$700	$364	17.6%	$1,280	183%	$580	0.100	783	0.59%	1,681	110.6%	32.5%	17.6%	$34,410

	Clearing Price			Price Cap @ 1-in-10			Reliability							Cost
	Average Clearing Price	Standard Deviation	Frequency at Cap	Price	Multiple of Net CONE	Adder to Net CONE	Average LOLE	Average Excess (Deficit) Above Reliability Requirement	Average Excess (Deficit) Above Target Reserve Margin	Average EUE	Normalized Portfolio EUE (% of Target)	Frequency Below Reliability Requirement	Frequency Below 99% of Reliability Requirement	Average Procurement Cost
	($/MW-d)	*($/MW-d)*	*(%)*	*($/MW-d)*	*(%)*	*($/MW-d)*	*($/MW-d)*	*(MW)*	*(UCAP RR + X %)*	*(MWh)*	*(%)*	*(%)*	*(%)*	*($ mln/yr)*
Net CONE = $150	$150	$55	12.7%	$225	150%	$75	0.100	460	0.35%	1,627	107.0%	41.3%	10.2%	$7,348
Net CONE = $200	$200	$70	17.3%	$300	150%	$100	0.100	469	0.36%	1,638	107.7%	31.1%	13.6%	$9,809
Net CONE = $300	$300	$111	20.9%	$450	150%	$150	0.100	586	0.44%	1,661	109.3%	28.2%	15.5%	$14,728
Net CONE = $400	$400	$154	23.3%	$600	150%	$200	0.100	619	0.47%	1,667	109.7%	29.9%	16.3%	$19,643
Net CONE = $700	$700	$296	31.4%	$1,050	150%	$350	0.100	889	0.67%	1,702	112.0%	31.5%	19.4%	$34,414

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