Sixth Review of the PJM's RPM VRR Curve Parameters

MEETING #1: KICKOFF AND REQUEST FOR STAKEHOLDER INPUT

PRESENTED BY
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PRESENTED TO
PJM Market Implementation Committee

SEPTEMBER 27, 2024

Brattle

Agenda

Study Scope and Timeline

Introduction to Objectives, Current Curve, New Issues

Approach to Reference Technology, CONE, and Net E&AS Offset

Approach to VRR Curve Shape

Next Steps

Scope and Timeline of the Quadrennial Review

Tariff Requirements for the Quadrennial Review

Quadrennial review will evaluate the ability of the VRR curve to meet reliability needs, including:

- VRR Curve Shape
- Gross CONE
- E&AS Offset Methodology

Updated VRR Curve parameters will apply for planning years 2029/30 through 2032/33
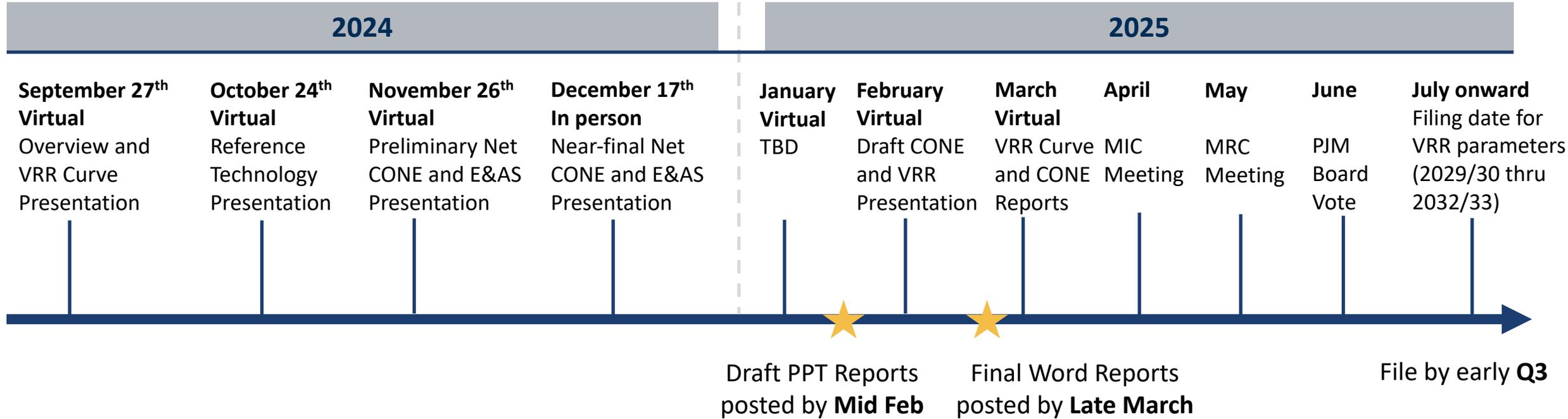
"Beginning with the Delivery Year that commences June 1, 2018, and continuing no later than for every fourth Delivery Year thereafter, the Office of the Interconnection shall perform a review of the shape of the Variable Resource Requirement Curve.

Such analysis shall be based on simulation of market conditions to quantify the ability of the market to invest in new Capacity Resources and to meet the applicable reliability requirements on a probabilistic basis. *Based on the results of such review, PJM shall prepare a recommendation to either modify or retain the existing Variable Resource Requirement Curve shape."*

-PJM Tariff, Attachment DD.5.10, Section (a)(iii)

Timeline for Quadrennial Review

Quadrennial review will take stakeholder input at several points.

2024	2025

September 27th
Virtual
Overview and VRR Curve Presentation

October 24th
Virtual
Reference Technology Presentation

November 26th
Virtual
Preliminary Net CONE and E&AS Presentation

December 17th
In person
Near-final Net CONE and E&AS Presentation

January
Virtual
TBD

February
Virtual
Draft CONE and VRR Presentation

March
Virtual
VRR Curve and CONE Reports

April
MIC Meeting

May
MRC Meeting

June
PJM Board Vote

July onward
Filing date for VRR parameters (2029/30 thru 2032/33)

Draft PPT Reports posted by **Mid Feb**

Final Word Reports posted by **Late March**

File by early **Q3**

Introduction

VRR Design Objectives

Current Curve Structure

Forward-Looking Market/Regulatory Context

VRR Curve Design Objectives
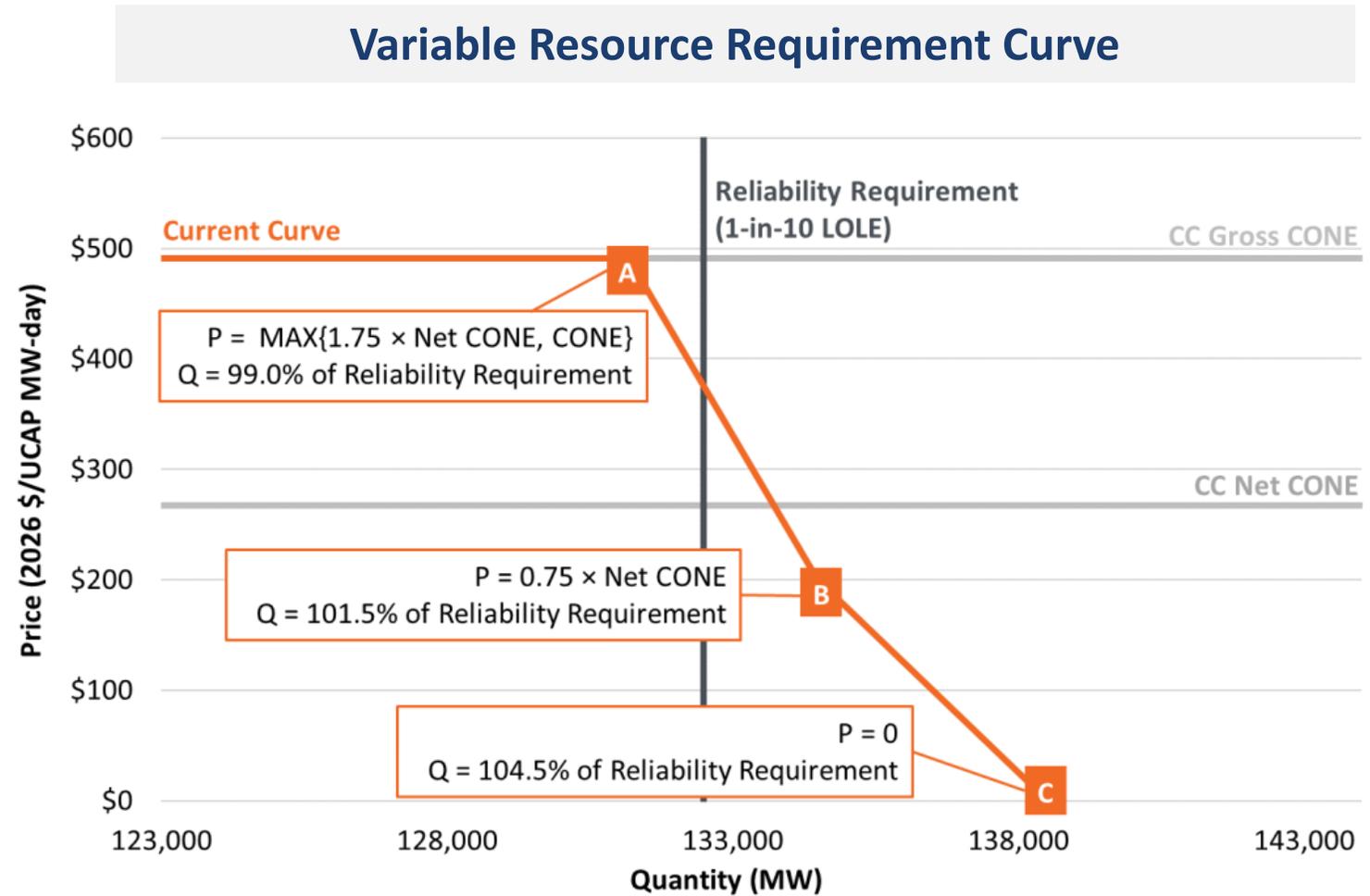
Demand Curve Objectives (Adapted from Prior VRR Curve Review)	
Reliability	• **Maintain 1-in-10 LOLE system-wide planning target on a long-term average basis**; maintain 1-in-25 conditional LOLE in each LDA. (Reliability as measured immediately prior to the delivery year) • **Assess curve performance with additional criteria** including, LOLE, LOLH, and EUE on avg and extremes • **Rarely drop below a "minimum acceptable" level** when PJM would intervene (at IRM minus 1%) • **Maintain reliability across a range of potential market conditions**, while mitigating the potential for over-procurement
Prices	• Prices **high enough to attract entry when needed** for reliability; prices low enough to enable efficient exit and retirements during surplus • **Reduce price volatility** due to small changes in supply and demand, but allow prices to move sufficiently to reflect changes in market conditions • **Mitigate susceptibility to exercise of market power** • **Few outcomes at the administrative cap**
Other	• Strike a balance among competing objectives • Aim for **simplicity, stability, and transparency**

Notes: VRR Curve design objectives adopted from the Fifth Review of PJM's Variable Resource Requirement Curve for Planning Years Beginning 2026/27 and Discussions with PJM. LOLE = Loss of Load Events; IRM = Installed Reserve Margin; CONE = Cost of New Entry

VRR Curve Current Design

The VRR curve sets the quantity of capacity that PJM will procure in each capacity auction as a function of price:

- **Quantities**: Tied to the reserve margin needed to meet LOLE standard

- **Prices**: tied to Net CONE, the estimated long-run marginal cost of capacity, so market can be expected to achieve target.

- **Shape/Width**: Balance tradeoffs among reliability, price volatility, and cost. Shape has been informed by but never explicitly tied to relative reliability value (e.g., across zones).

Variable Resource Requirement Curve

Current Curve

Reliability Requirement (1-in-10 LOLE)

CC Gross CONE

$$P = MAX\{1.75 \times Net\ CONE, CONE\}$$
$$Q = 99.0\%\ of\ Reliability\ Requirement$$

A

CC Net CONE

$$P = 0.75 \times Net\ CONE$$
$$Q = 101.5\%\ of\ Reliability\ Requirement$$

B

$$P = 0$$
$$Q = 104.5\%\ of\ Reliability\ Requirement$$

C

Price (2026 $/UCAP MW-day)

Quantity (MW)

Sources and Notes: VRR Curve design as adopted from the Fifth Review of PJM's Variable Resource Requirement Curve for Planning Years Beginning 2026/27.
CC = Combined Cycle Gas Turbine, CT: Combustion Gas Turbine

Considerations in the Market/Regulatory Outlook

A complicated investment environment

- EPA's new regulations under Clean Air Act Section 111 could make gas-fired CCs much less attractive to build if the rules survive legal challenge

- Continued consideration of state policies affecting resource options in certain LDAs

- Widespread resource development challenges due to interconnection timelines, tight supply chains, permitting delays, and still high interest rates

A transforming fleet and shifting reliability drivers

- Changing technologies being built (queue primarily solar, wind, BESS), with less conventional value profile

- The changing nature of reliability challenges is spurring changes in market design (e.g., recent accreditation changes, and the possibility that PJM will pursue a seasonal capacity market)

Prices in 2025/26 BRA at cap in SWMAAC & DOM, and approx. Net CONE elsewhere (see PJM analysis here)

Auction parameters for 2026/27: **Net CONE of 0**

Outlook for **high load growth** combined with expected retirements raises the stakes for RPM to maintain resource adequacy at a reasonable cost

Approach to Assessing Reference Technology, CONE and Net E&AS Offset

Review: Current Ref Tech, CONE and Net E&AS, from last Quad Review

2022 Cone Study: Basis for Selecting Reference Resource			
Technology	**Feasible to Build for Delivery Year**	**Economic Source of Capacity**	**Accuracy of Net CONE Estimates**
Gas CC	Yes	Yes (significant recent entry; lowest 2026/27 Net CONE)	Highest
Gas CT	Yes (may be infeasible in NJ)	Unclear (few recently built; Net CONE 20% higher than CC)	High (higher forward E&AS uncertainty due to lack of forward pricing matching CT dispatch)
Battery Storage	Yes	Unclear (no cleared capacity to date; highest 2026/27 Net CONE among candidates)	Low (uncertain future AS revenues; falling costs)

Other Key Elements
- Two 1x1 CC: 7HQ.02 w/DF, SCR, Dry cool, Firm gas

- 20-year life
- Level-nominal levelization
- 8.85% ATWACC

- Forward EAS Offset

Parameters for 2026/27 Auction
- $543/MW-day ICAP CC
- $0 Net CONE in many zones

Workplan for Reference Technology Screening and Selection

1. Agree on Full Set of Candidates
Which to consider?

2. Apply Evaluation Criteria in High-Level Screening
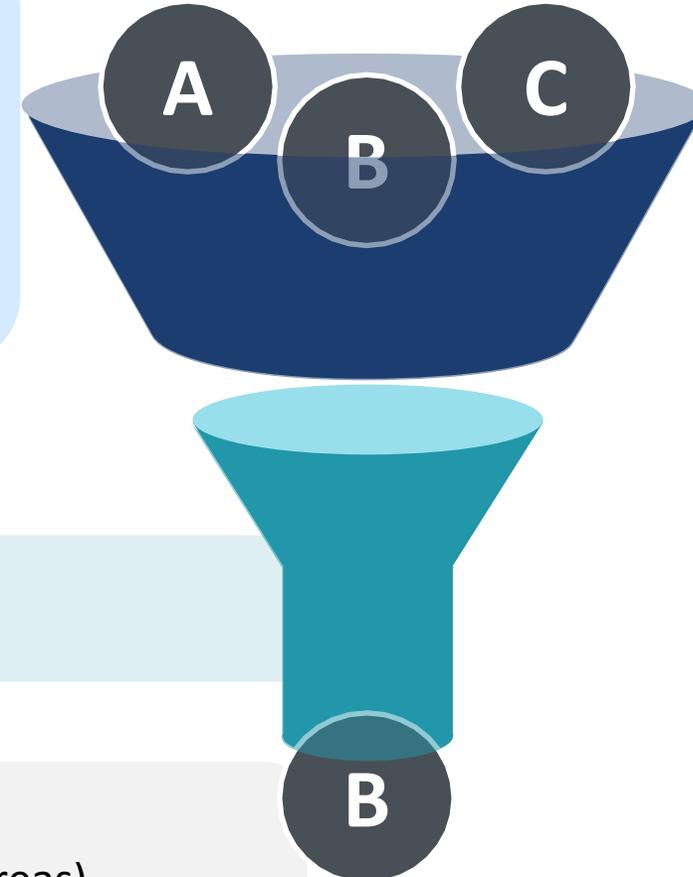*Criteria from PJM RFP:*
1. Economic viability
2. Feasibility to build at scale by Delivery Year (DY)
3. Ability to accurately assess CONE and EAS
4. Compliance w/all regulations and can operate as needed
5. Stable reliability contribution over the DY

Any initial input on these?

3. Conduct detailed analysis on short-listed technologies and reapply evaluation criteria

4. Recommend Reference Technology
(or technologies if appropriate for different areas)

Workplan for Cost Buildup

1. For each technology, **define locations and specifications** based on prior study + new data on revealed preference

2. S&L to **develop full plant design and quantify current overnight cost**, annual FOM (and VOM and operating parameters)

3. S&L and Brattle to **escalate costs to construction dates**

4. Develop method for annual updates

Any new issues to consider affecting costs of candidate techs?

Workplan for ATWACC

∞ Prior ATWACC, as of August 31, 2022, is 8.85%

∞ Analysis as of May 22, 2024: 10.0%

∞ Next: update analysis with latest market data incl. effects of Fed cuts; search for new fairness opinions

∞ Question to private companies: Can you provide fairness opinions for M&A transactions of merchant generation?

Summary of ATWACC Analyses (May 22, 2024)

10.0% recommended ATWACC at 21% federal tax rate

Workplan for CONE Calculations

Framework: CONE represents the first-year revenues a resource would need to earn to enter, given its costs, its projected future net revenue trajectory, and its cost of capital

- Determine levelization "shape" (e.g., level-nominal) and economic lifetime

- Apply ATWACC

- Calculate first-year revenue requirement for NPV=0 in CONE spreadsheet model (accounts for taxes w/depreciation, etc.)

Review from last Quad Review: level-nominal, 20-year economic life

This study

- Reconsider economic life and revenue trajectory for each technology, given regulatory and market outlook

- Question to stakeholders: input on these matters for each technology

Workplan for Net E&AS Offset

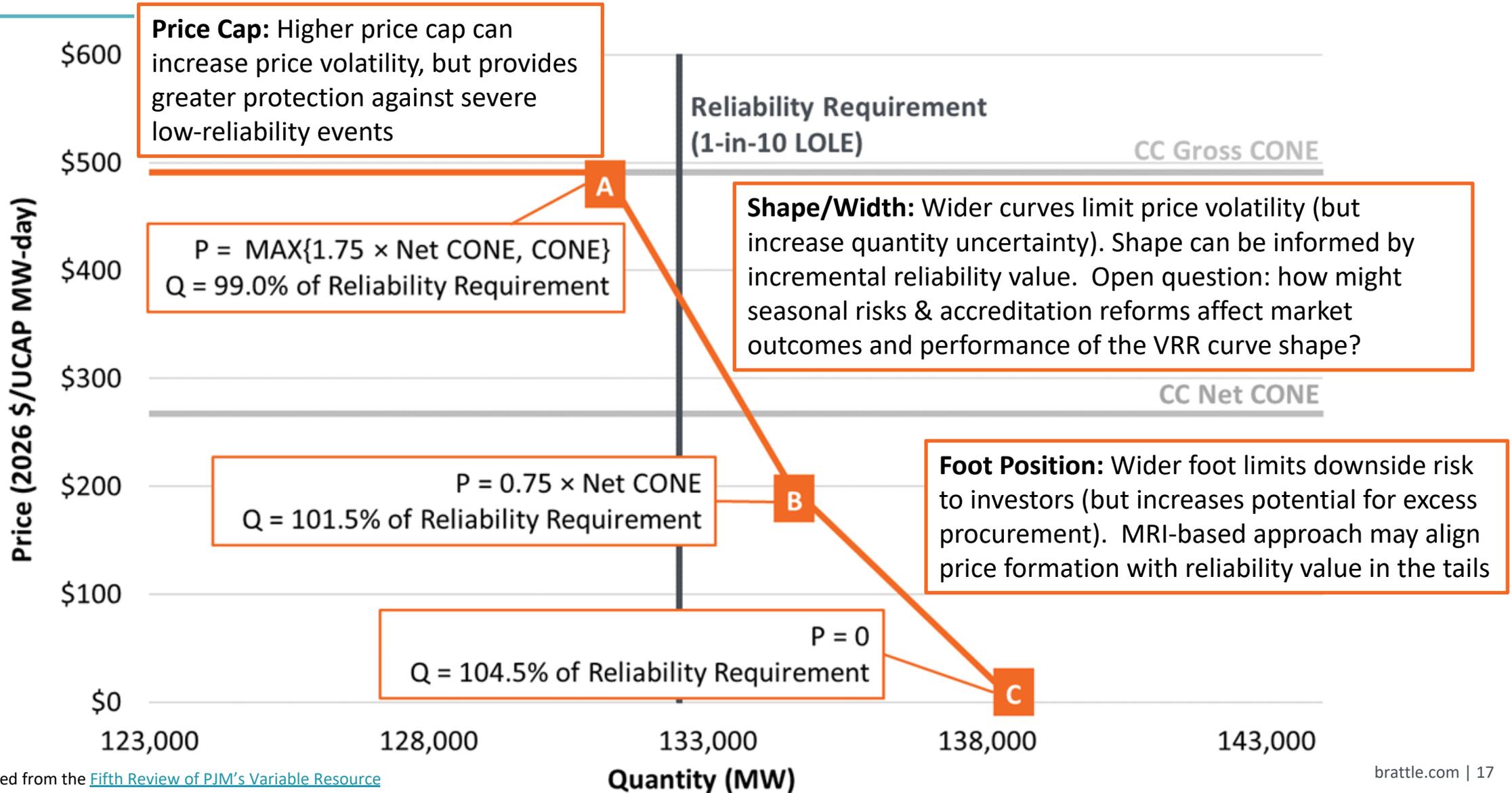Reassess elements of the Forward EAS structure developed last time, including:

- The liquidity of gas and electric hubs

- The applicability of long-term FTR data

- The approach for ancillary services, which may account for a larger fraction of revenues for BESS

Discuss whether to reassess more fundamentally, considering:

- "0 Net CONE" for 2026/27

- Consider "Equilibrium EAS" concept introduced in prior review?

- Other new ideas?

Approach to Assessing VRR Curve Shapes

Conceptual Basis for VRR Curve Parameters

Price Cap: Higher price cap can increase price volatility, but provides greater protection against severe low-reliability events

$$P = MAX\{1.75 \times \text{Net CONE, CONE}\}$$
$$Q = 99.0\% \text{ of Reliability Requirement}$$

Shape/Width: Wider curves limit price volatility (but increase quantity uncertainty). Shape can be informed by incremental reliability value. Open question: how might seasonal risks & accreditation reforms affect market outcomes and performance of the VRR curve shape?

$$P = 0.75 \times \text{Net CONE}$$
$$Q = 101.5\% \text{ of Reliability Requirement}$$

Foot Position: Wider foot limits downside risk to investors (but increases potential for excess procurement). MRI-based approach may align price formation with reliability value in the tails

$$P = 0$$
$$Q = 104.5\% \text{ of Reliability Requirement}$$

Reliability Requirement (1-in-10 LOLE)

CC Gross CONE

CC Net CONE

Price (2026 $/UCAP MW-day)

Quantity (MW)

Potential Considerations in System-Wide VRR Curve Review

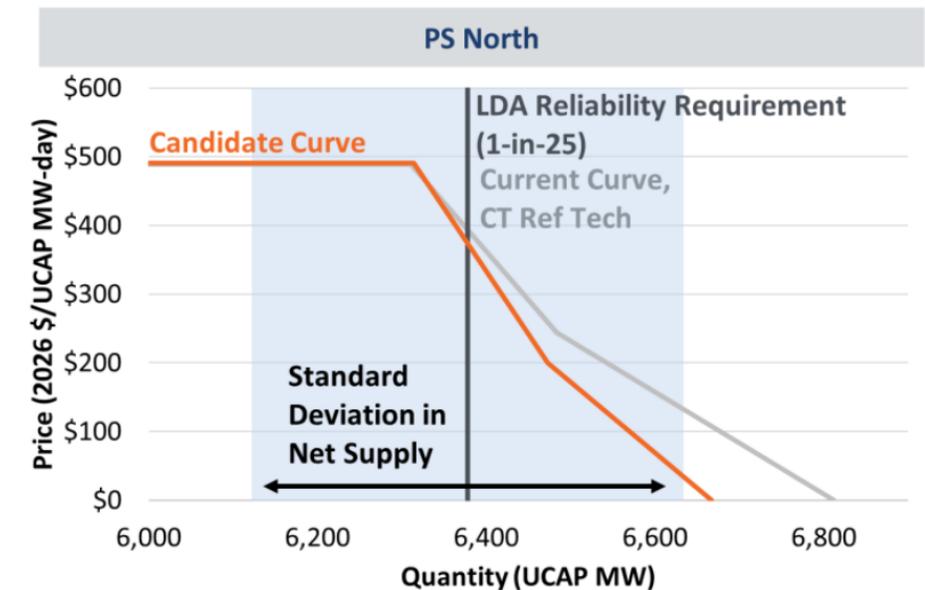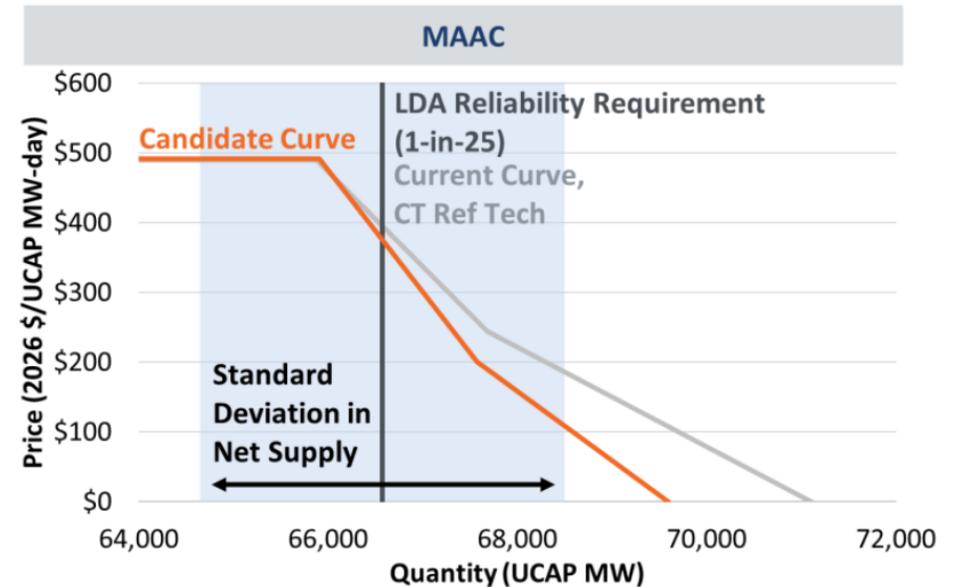**Input Requested: What analysis/information is needed to inform VRR curve updates?**

- How to consider **updates to reliability modelling** and associated MRI-based curves in VRR curve shape?

- How might **accreditation reforms** tend to increase/decrease anticipated market volatility?

- How do **season-specific reliability drivers** interact with the VRR curve (i.e., the reliability requirement)?

- To what extent do **2025/26 auction outcomes** inform the VRR curve shape (vs. reflective of a temporary combination of market fundamentals & reform transition)?

Demand Curves Assessed in 2022 Quad Review
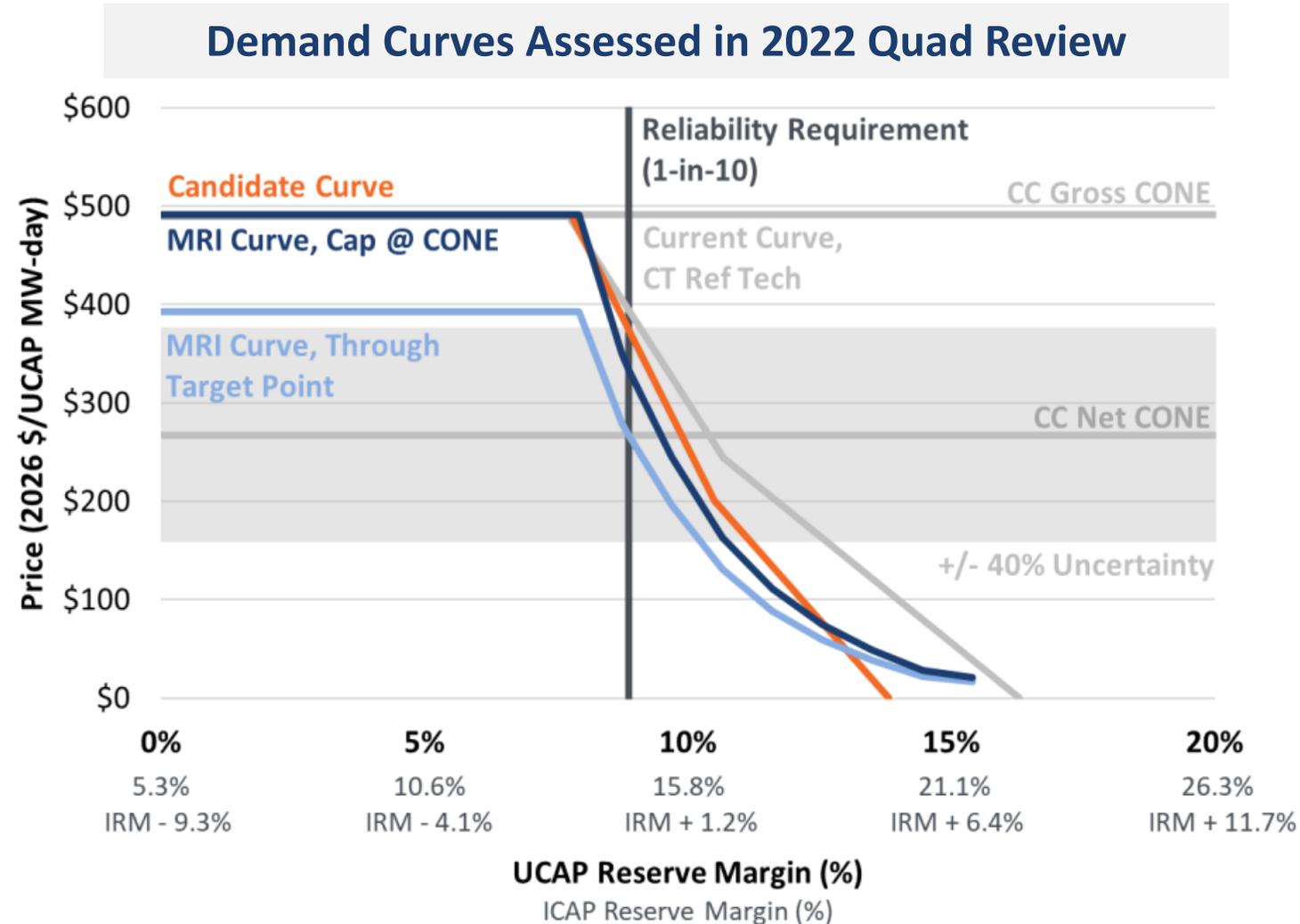
LDA-specific Considerations

Input Requested: What information/analysis is needed to inform locational VRR curves?

- How should location-specific curves manage locational **supply/demand variability** and susceptibility to price spikes?

- How can location-specific curves most meaningfully reflect **relative reliability value** of capacity across the footprint?

- Do LDA-specific curves materially interact with reforms to **reliability modelling and resource accreditation**?


Source: Fifth Review of PJM's Variable Resource Requirement Curve for Planning Years Beginning 2026/27.

Modeling Approach: Probabilistic Assessment around Equilibrium Market Conditions

Concept: Assess potential long-term outcomes under current/alternative VRR curve shapes, to understand tradeoffs relative to design objectives (e.g. tradeoffs between reliability and cost)

Modeling Approach

- Monte Carlo model of 3-year forward capacity market clearing price and quantity outcomes

- Simulate year-to-year variability in supply curve shapes, supply quantity, and demand quantity (not time-sequential)

- All model inputs derived from historical market data (must be adapted to align with accreditation reforms)

- Assess long-run equilibrium conditions with prices equal to Net CONE (accounting for the possibility that "true" Net CONE could differ from the administrative estimate)

- Produce an expected distribution of price, quantity, and reliability outcomes; compared to design objectives

Supply and Demand Variability
(Illustrative)
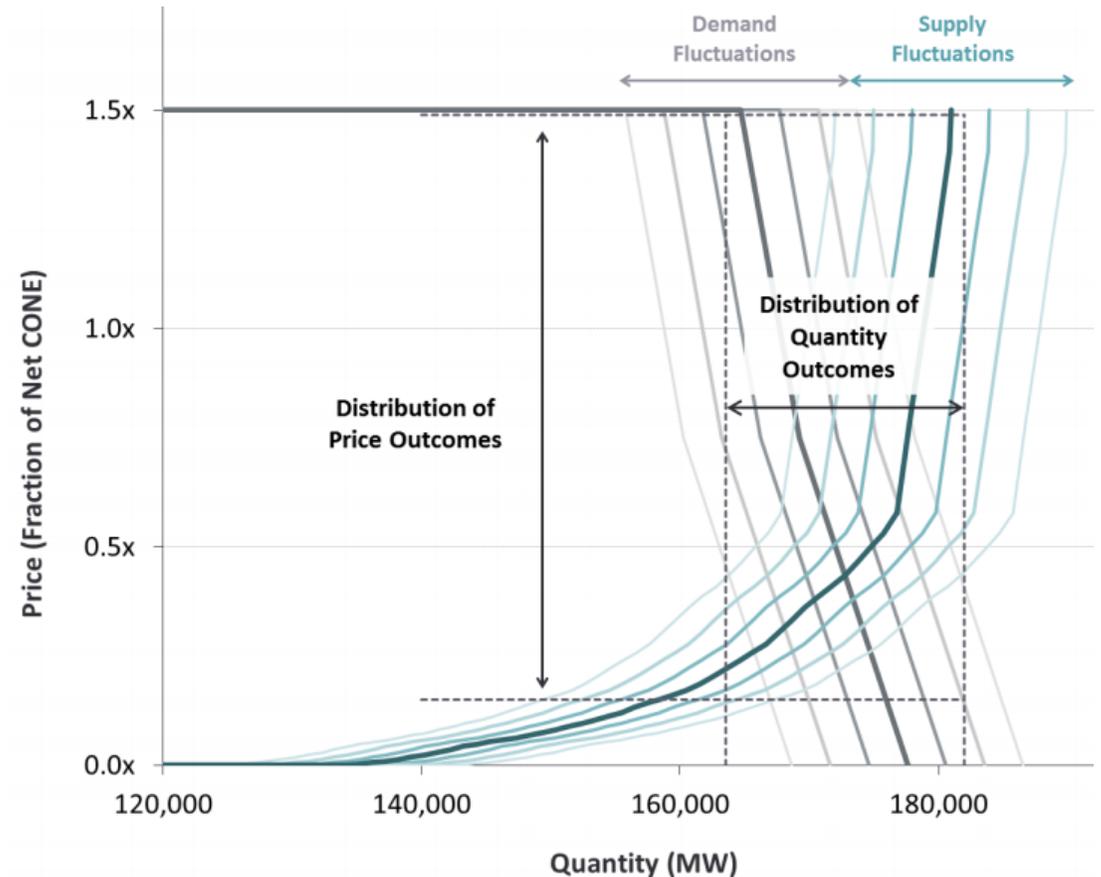
Note: For a more comprehensive description of modeling approach, see the Fourth VRR Curve Review.

Other Potential Components of the VRR Curve Review

In addition to the topics discussed above, we seek stakeholder input on:

- How is the current VRR curve likely to perform over the coming years, in light of substantial changes to market fundamentals, fleet transition & reliability drivers?

- How do recent and anticipated changes to other aspects of the PJM capacity market design need to be accounted for in the VRR curve?

- What alternative VRR curve shapes/formulas should be considered and why (both system & local)?

- What information gaps presently exist that should be addressed in the QER review?

Next Steps

Plan for Next Stakeholder Meeting (October 24, 2024)

Review of Candidate Reference Resource Technologies

- Including indicative Net CONE values, and tornado diagrams to identify drivers

E&AS Methodology Update

- Assessment of liquidity of gas and electric hubs
- Applicability of long-term FTR data
- The approach for AS, which may account for a larger fraction of revenues for BESS

VRR Curve Concepts

- Marginal Reliability Impact based design methodology
- Potential interactions with updated reliability modelling, accreditation & seasonal risks

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