Triennial Review, VRR Curve Shape Issue: Critique of Brattle's Simulation Model and Recommended Alternative Assumptions (Part II)

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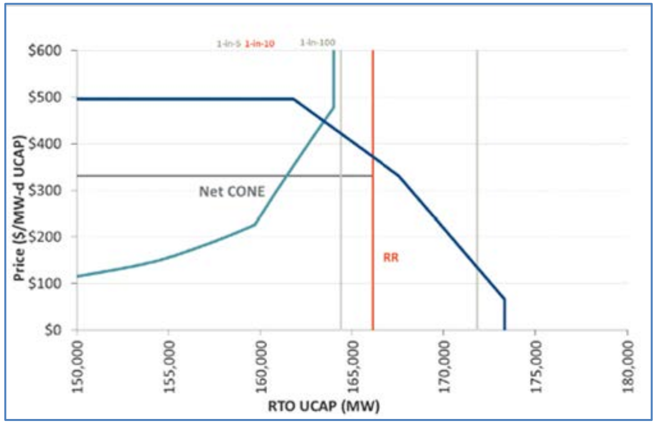
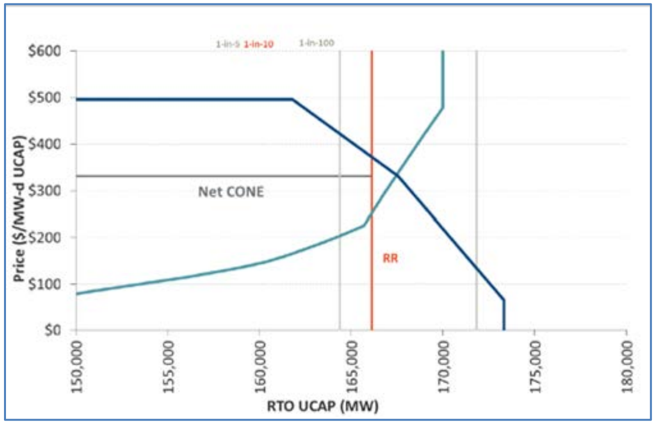
Scope of Presentation

1. Summary of structure of the Brattle Simulation Model
2. Comparison to Hobbs Model
3. Critique of Brattle Simulation Model
   - Critique of model structure and scope
   - Critique of specific assumptions and recommended alternatives
4. Comments on model-based conclusions regarding “Net CONE estimation errors”

1. The Brattle Group's Monte Carlo Simulation Model

- Simulation of three-year-forward base residual auctions
- 1000 Monte Carlo "draws"; each draw determines shifts ("shocks") to supply curve, demand curve, Net CONE values
- Outputs: cleared quantity and price





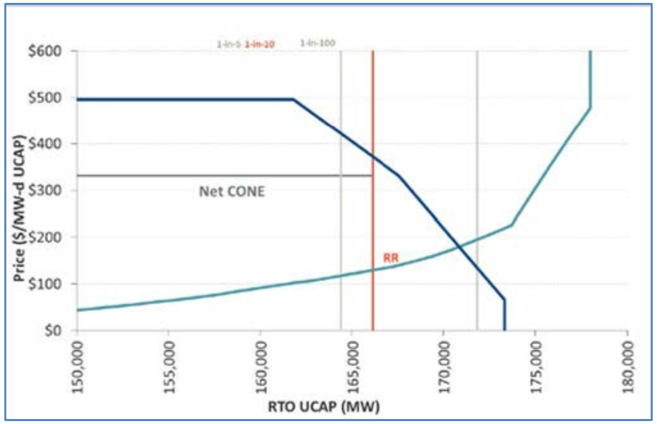
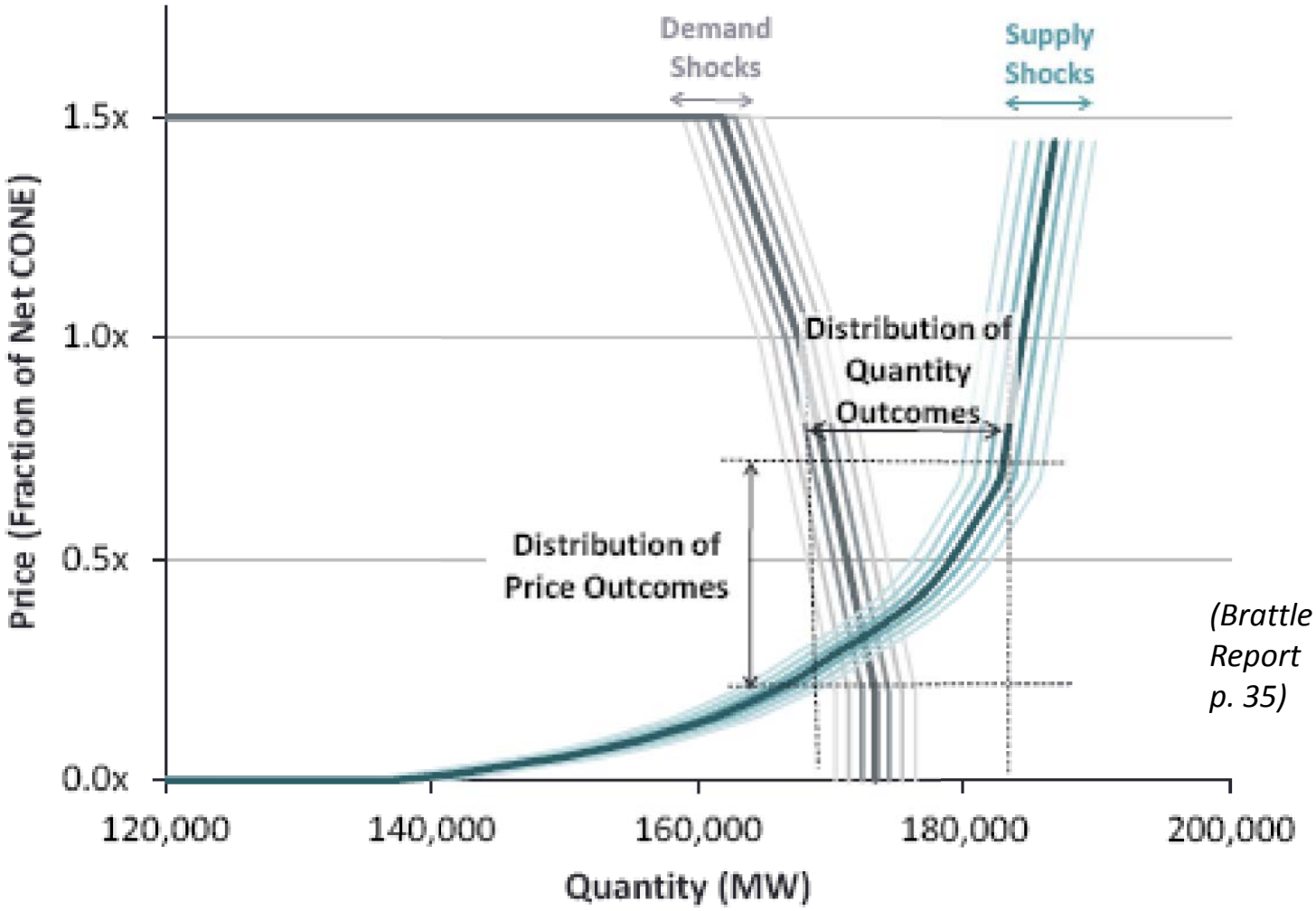
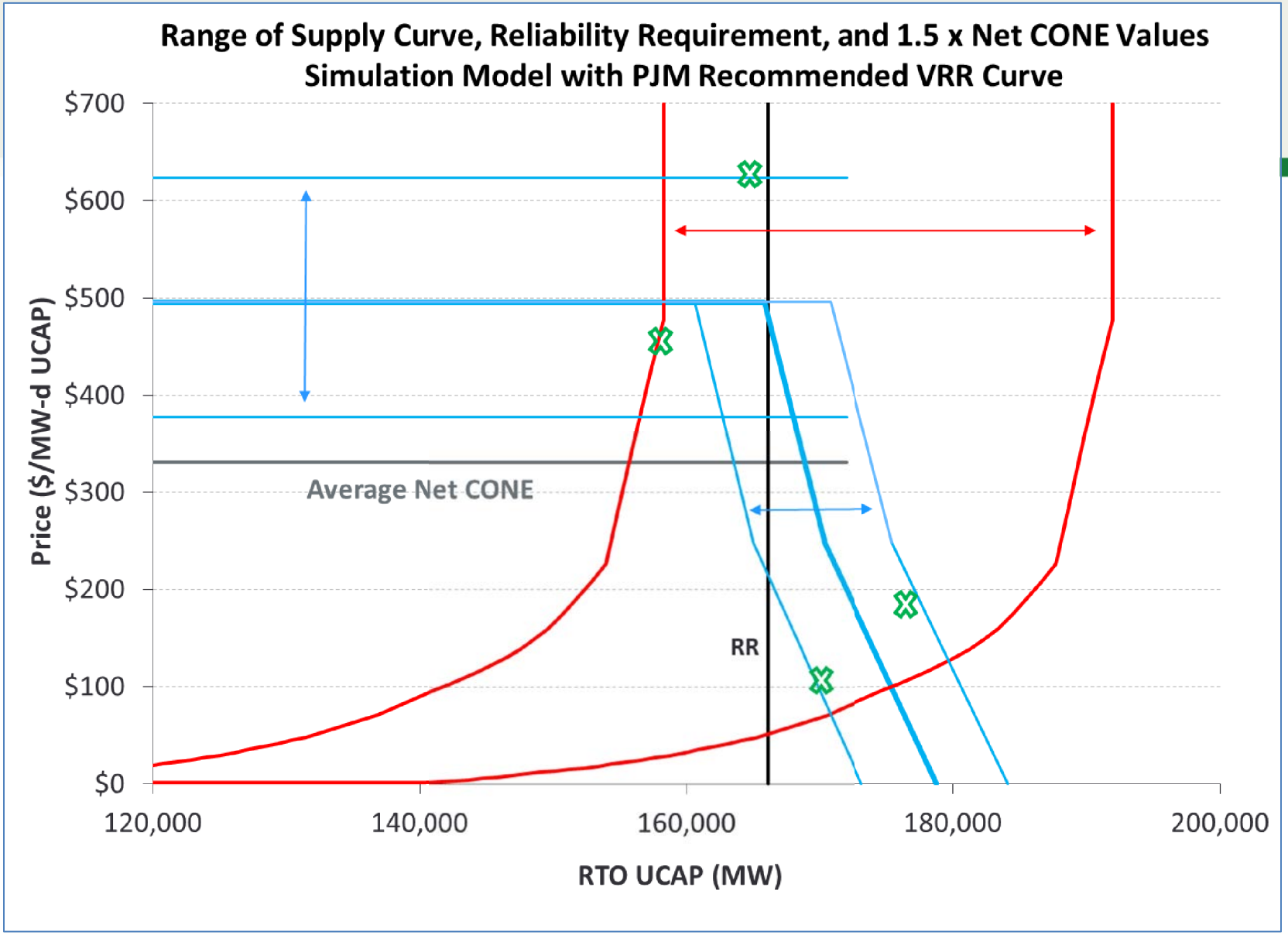


Figure 11
Stylized Depiction of Supply and Demand Shocks in the Monte Carlo Analysis



(Brattle Report p. 35)


Range of Supply Curve, Reliability Requirement, and 1.5 x Net CONE Values
Simulation Model with PJM Recommended VRR Curve
$700
$600
$500
$400
$300
$200
$100
$0
Price ($/MW-d UCAP)
Average Net CONE
RR
120,000
140,000
160,000
180,000
200,000
RTO UCAP (MW)

Brattle Simulation Model – What It Does and Doesn't Do

- Does do:
  - Models changes to supply curve quantity (horizontal shift), demand curve quantity (horizontal shift), demand curve price (vertical shift)
  - Calculates resulting cleared price and quantity
  - The supply curve is shifted (one-time) so that average price = Net CONE
- Does not do:
  - No dynamics – non-chronological (1,000 independent draws)
  - No market decision-making (supply curve w/shock represents offered supply); no entry decisions, no estimation of profitability of entry, etc.
  - No feedback from cleared quantities to E&AS revenues to Net CONE (Net CONE is fixed and independent of curve)

Brattle Simulation Model – Comparison to Hobbs Model

	Hobbs Model	Brattle Simulation Model
Prior applications in PJM	RPM settlement, two prior Triennial Reviews, other design issues (IAs, DR clearing)	None
Availability to stakeholders	Yes, spreadsheet posted to examine, run w/alt. assumptions	No; “proprietary”
Dynamics	Yes: dynamic, chronological	No (1,000 draws)
Entrant decision-making	Yes: Entry quantity dynamic, depends upon recent and anticipated energy and capacity earnings	No (fixed supply curve, single adjustment so price averages Net CONE)
Price volatility and risk aversion	Entrants are risk averse, require higher net margins to enter if capacity prices are more volatile	No modeling of entry decisions or risk aversion

Comparison to Hobbs Model (continued)

	Hobbs Model	Brattle Simulation Model
Supply curve shape	Dynamic new entry quantity at zero price, then vertical curve (can also model one price level)	Fixed shape, steeply sloped supply curve
E&AS revenues	Dynamic; a decreasing function of the actual DY reserve margins	Not modeled
Customer cost	Models total cost, capacity plus E&AS cost	Cost not modeled; price fixed at Net CONE, no E&AS
Uncertainties	Load growth is uncertain, cumulates year to year	Random, independent annual "shocks" to supply, demand, Net CONE
VRR curve Net CONE	Fixed value (model also has ability to use dynamic Net CONE)	Fixed at $330.53/MW-day

Comparison to Hobbs Model (continued)

	Hobbs Model	Brattle Simulation Model
Representation of post-BRA period	Dynamic – models load growth uncertainty, actual DY RM, E&AS revenues	None (simulates only base residual auction clearing)
Capacity purchases closer to DY	Can model additional capacity purchases closer to DY in IA	None (simulates only base residual auction clearing)

Conclusions from this comparison:

- The two models are not similar
- Nearly all differences are relative strengths of the Hobbs model
- The Brattle simulation model arguably does not fulfill the tariff requirement to simulate market conditions to quantify the ability of the market to invest in new Capacity Resources

Relationship Between DY Reserve Margin and E&AS Revenues: Assumption Used in Hobbs Model (2005)

The impact of lower reserve margins on E&AS prices and earnings is probably stronger today due to shortage pricing rules, higher DR penetration, etc.

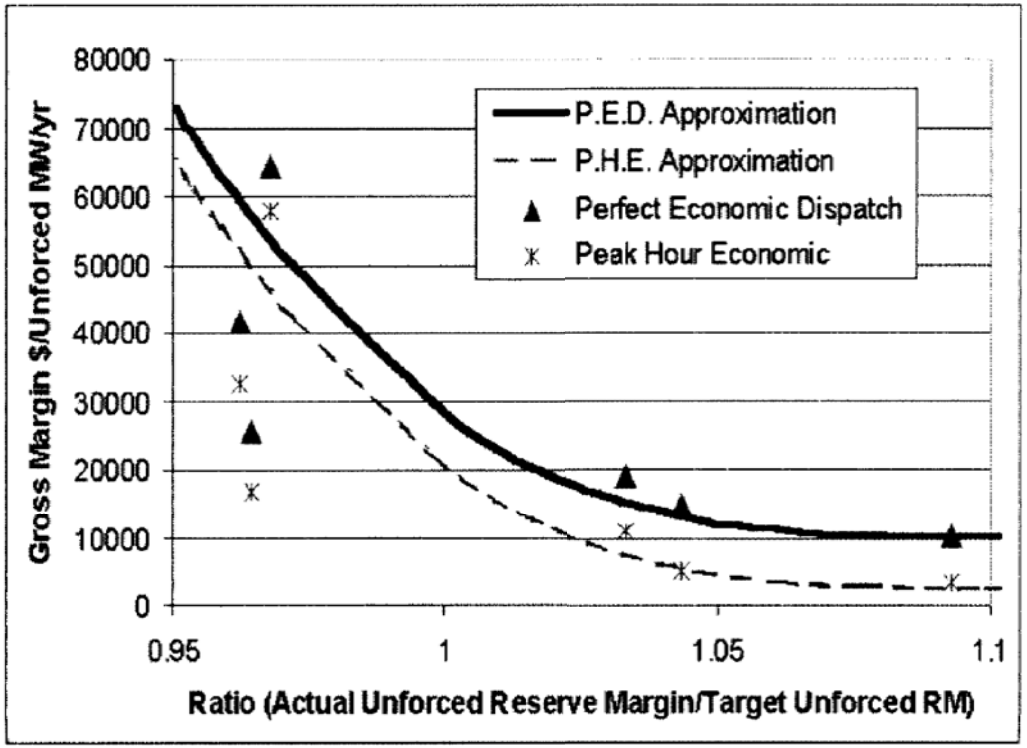


Figure 3. Relationship of E/AS Gross Margin to Unforced Reserve Margin Under Alternative Turbine Dispatch Assumptions, expressed as a Ratio With Respect to the Target Installed Reserve Margin for PJM

FYI: Tariff Requirement to Review VRR Curve Shape

PJM Tariff Att. DD section 5.10.a.iii (emphasis added):

"… the Office of the Interconnection shall perform a review of the shape of the Variable Resource Requirement Curve, as established by the requirements of the foregoing subsection. **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 Att. DD Section 2.55 PJM Region Reliability Requirement:

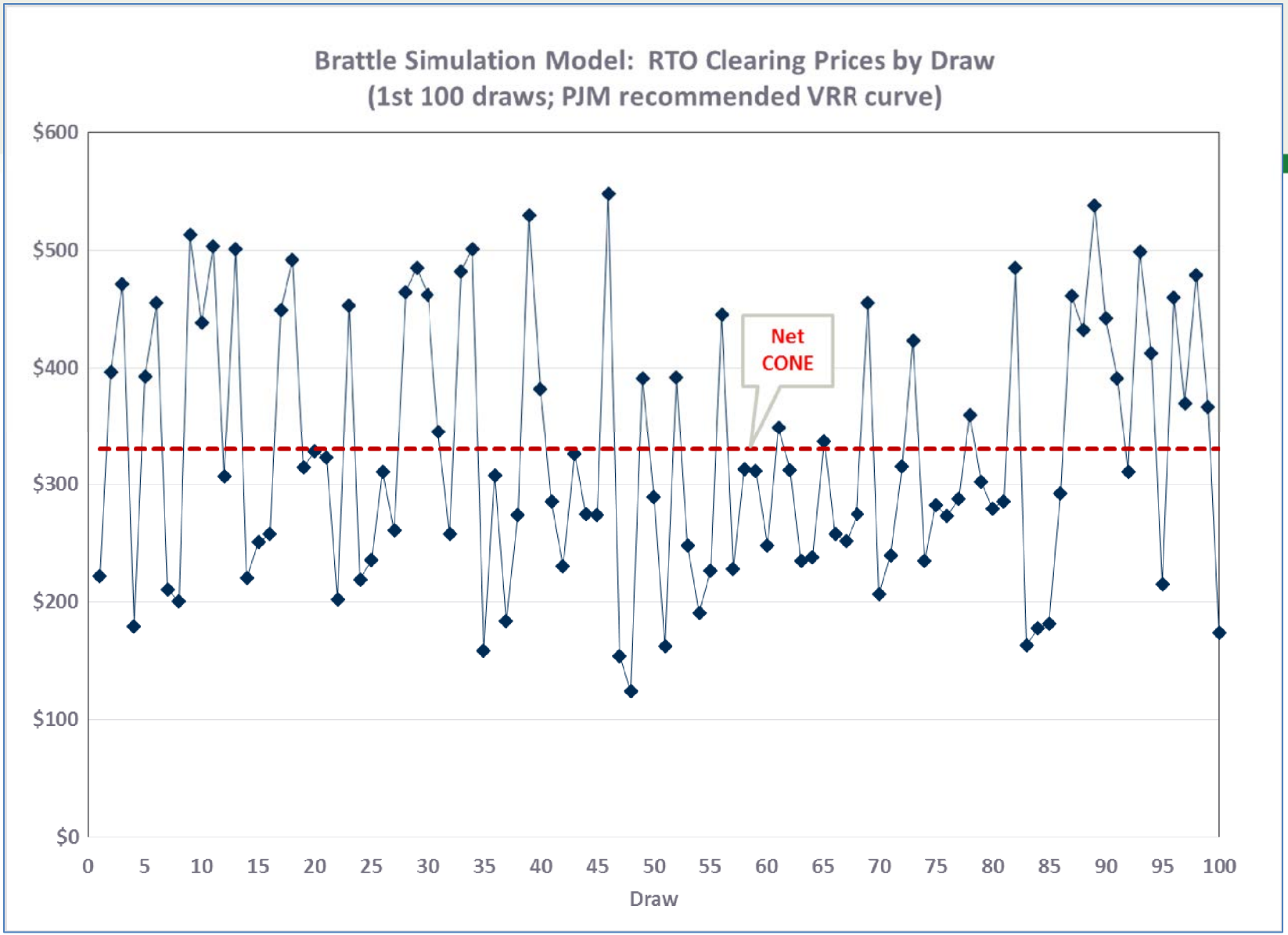
"PJM Region Reliability Requirement" shall mean, for purposes of the Base Residual Auction, the Forecast Pool Requirement multiplied by the Preliminary PJM Region Peak Load Forecast, less the sum of all Preliminary Unforced Capacity Obligations of FRR Entities in the PJM Region…"

2. Critique of Brattle Simulation Model – Overview

1. The Brattle simulation model focuses on a single aspect of capacity acquisition in PJM: changeable supply and demand

2. It greatly overstates the potential volatility of RPM price and reserve margin outcomes primarily due to the following features:

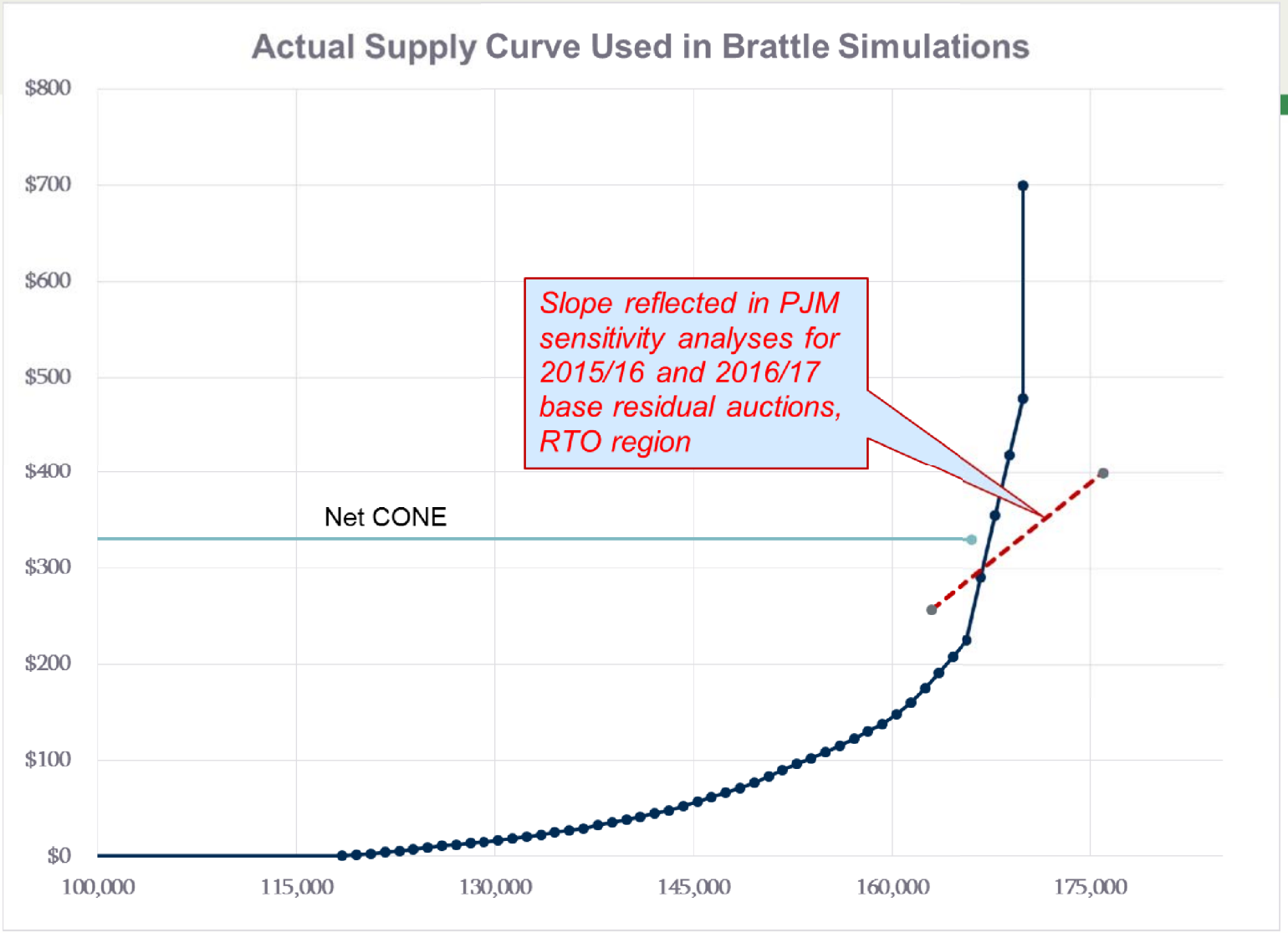
    1. No market anticipation of increases in demand or reductions in supply – this is not how markets work
    2. Magnitude of likely "shocks" over long term greatly overstated (magnitudes based on recent recession period, early years of RPM with many rules changes, etc.); and shocks treated as totally unpredictable, independent of each other (demand-supply, etc.), and independent year to year
    3. Assumed supply curve is unrealistically steep in relevant price range
    4. Missing linkage of cleared quantity outcomes to reserve margins, E&AS revenues, Net CONE values (Net CONE assumed fixed even if curve shifted)


Brattle Simulation Model: RTO Clearing Prices by Draw
(1st 100 draws; PJM recommended VRR curve)
$600
$500
$400
$300
$200
$100
$0
Net
CONE
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
Draw

The Assumed Supply Curve is Unrealistically Steep

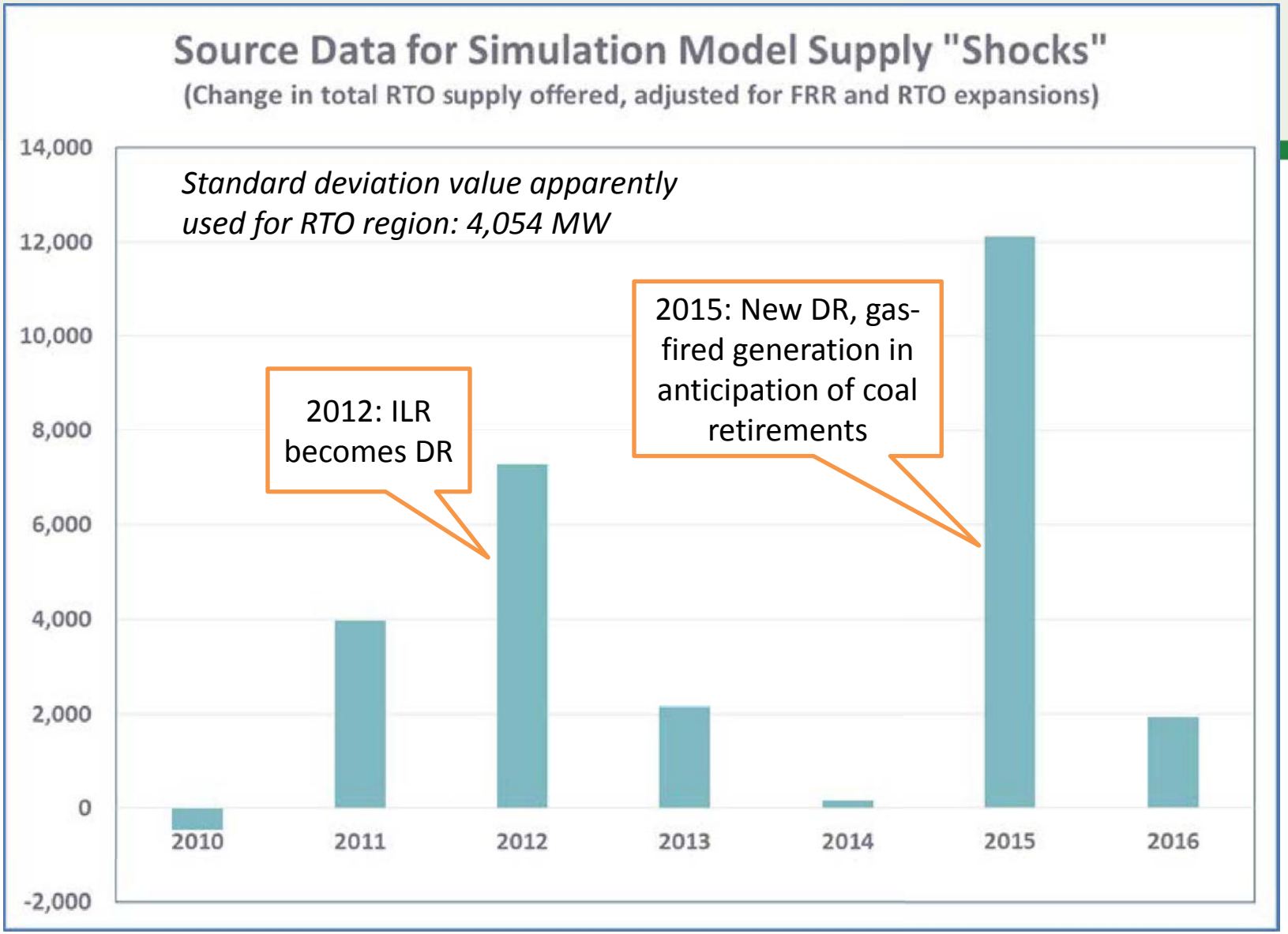
- A steep supply curve results in volatile cleared prices, quantities
- Brattle uses a supply curve based on 2009/10 to 2016/17 (p. 36)
  - Ignores trend toward more gradual supply curves, emphasized in the previous Triennial Review (pp. 21-24); PJM has also recognized this (ER13-535)
  - During this historical period, RTO prices averaged $94/MW-day
    - Few offers above $200/MW-day; such offers had no chance of clearing
    - Simulation model: prices assumed to average $330/MW-day; capacity can reasonably be offered at much higher prices under those conditions
- Recent auction results suggest market participants are offering capacity at higher prices when higher clearing prices are possible
  - PJM sensitivity analyses reveal slope of supply curve around clearing prices

Figure 12
Individual Supply Curve Shapes used in Monte Carlo Analysis


Actual Supply Curve Used in Brattle Simulations
$800
$700
$600
$500
$400
$300
$200
$100
$0
100,000
115,000
130,000
145,000
160,000
175,000
Net CONE
Slope reflected in PJM sensitivity analyses for 2015/16 and 2016/17 base residual auctions, RTO region

Supply “Shocks” Are Overstated

- Shock size based upon year to year changes in total supply offered, ‘09-’16
- Reflects changes that are not characteristic of what should be expected in “long term equilibrium”
  - Reflects changes in rules during first years of RPM operation
  - Reflects changes in supply during a deep recession
  - Reflects one-time transition due to new environmental regulations
  - Etc.
- The model unrealistically assumes these supply changes are “shocks” not foreseen in advance by the market (treated as Monte Carlo random)


Source Data for Simulation Model Supply "Shocks"
(Change in total RTO supply offered, adjusted for FRR and RTO expansions)
Standard deviation value apparently used for RTO region: 4,054 MW
2012: ILR becomes DR
2015: New DR, gas-fired generation in anticipation of coal retirements
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
-2,000
2010
2011
2012
2013
2014
2015
2016

Peak Demand "Shocks" Are Overstated

- Based upon year to year changes in load forecast, '07-'14
- As for Supply Shocks, reflects changes that are not characteristic of what should be expected in "long term equilibrium"
  - Reflects a period of deep recession and slow recovery, and extremely inaccurate underlying economic forecasts (Moody's booming recovery)
  - Reflects forecasts based on a now-replaced load forecast methodology
- Value used is 0.8% of peak load (compare to forecasted 1% annual load growth)
  - Assumes these load forecast changes are "shocks" not foreseen in advance by the market (treated as Monte Carlo random)
  - Also assumes increases equally likely as decreases (PJM's position – reductions are more likely due to conservative planning, optimistic economic forecasts)

Brattle Simulation Model: Recommended Assumptions

- Initial request (alternative base case):
  - Supply curve: Set slope in 160,000 – 175,000 MW range based on PJM sensitivity analyses for recent base residual auctions (~ $11/1,000 MW)
  - Supply shock: Use standard deviation excluding 2012, 2015 (approx. 40%)
  - Initially, no change to various other assumptions that overstate volatility and reliability risk (other shock values, independence, etc.)
- Other sensitivity cases:
  - Flat supply curve, as suggested in footnote 42, page 34 of Brattle Report
  - Others TBD

3. Re: Net CONE "Estimation Errors"

The Brattle Report states that administrative Net CONE estimation errors "can have a substantial impact on reliability outcomes", based on the simulation model, using a 20% under-estimate of Net CONE (p. 62)

1. The model evaluates RM3 (three year forward capacity and reserve margin) not DY reliability outcomes (LOLE) as discussed earlier.

2. The simulation model assumes a 20% under-estimate of Net CONE over the long term, which is implausible:

   - Every year there is auction evidence of entry and exit based on current Net CONE values; any error would be evident from the results and corrected
   - Owners of existing generation have a financial interest in higher Net CONE values and litigate even small details; substantial under-estimate is very unlikely

Re: Net CONE "Estimation Errors" (continued)

- In addition, Net CONE estimation errors are self-correcting:

  Administrative Net CONE estimate is low → less cleared RPM capacity → less available capacity in DY to extent not cured → higher E&AS prices → less missing money → actual Net CONE is lower → less error

The lack of feedback from VRR curve shape/position to E&AS and Net CONE is a significant flaw in the simulation model.

Summary and Suggested Next Steps

- Develop and apply approaches for analyzing cost, market power, other impacts of alternate VRR curves (Part I)
- Modify simulation model assumptions to address most significant flaws
- Provide simulation model for stakeholder use (protected cells as necessary)
- Provide detailed simulation model outputs and inputs by draw for current and recommended curves
- Additional sensitivity analysis for validation purposes