Draft Recommendations for a Capacity Demand Curve in ISO-NE

PREPARED FOR

ISO New England

PREPARED BY

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Contents

Motivation

- FERC and many stakeholders express concerns with a vertical demand curve, particularly after the price floor is removed in FCA8:
  - Likely volatile prices with a bimodal distribution
  - More exposure to exercise of market power (buy and sell side)
  - Prices not proportional to the incremental value of capacity
- ISO-NE's current administrative pricing rules address some of these concerns, but are less efficient and may be less effective than a sloped demand curve
- An additional but less-understood concern is that the vertical curve at NICR with a price cap is unlikely to achieve the 1-in-10 LOLE reliability objective on a long-term average basis

Demand Curve Objectives

Reliability

- Maintain 1-in-10 LOLE target on a long-term average basis (the current vertical curve at NICR curve would not meet this target)
- Rarely drop below a “minimum acceptable” reserve margin corresponding to a 1-in-5 LOLE level where ISO-NE might intervene in the market

Efficient Prices

- Long-run average price at Net CONE, consistent with a market capable of attracting sufficient merchant entry to attain reliability objectives at least cost
- Short-run prices consistent with current fundamentals, going above Net CONE during shortage and below Net CONE during surplus
- Rationalize prices according to the incremental value of capacity

Mitigate Price Volatility

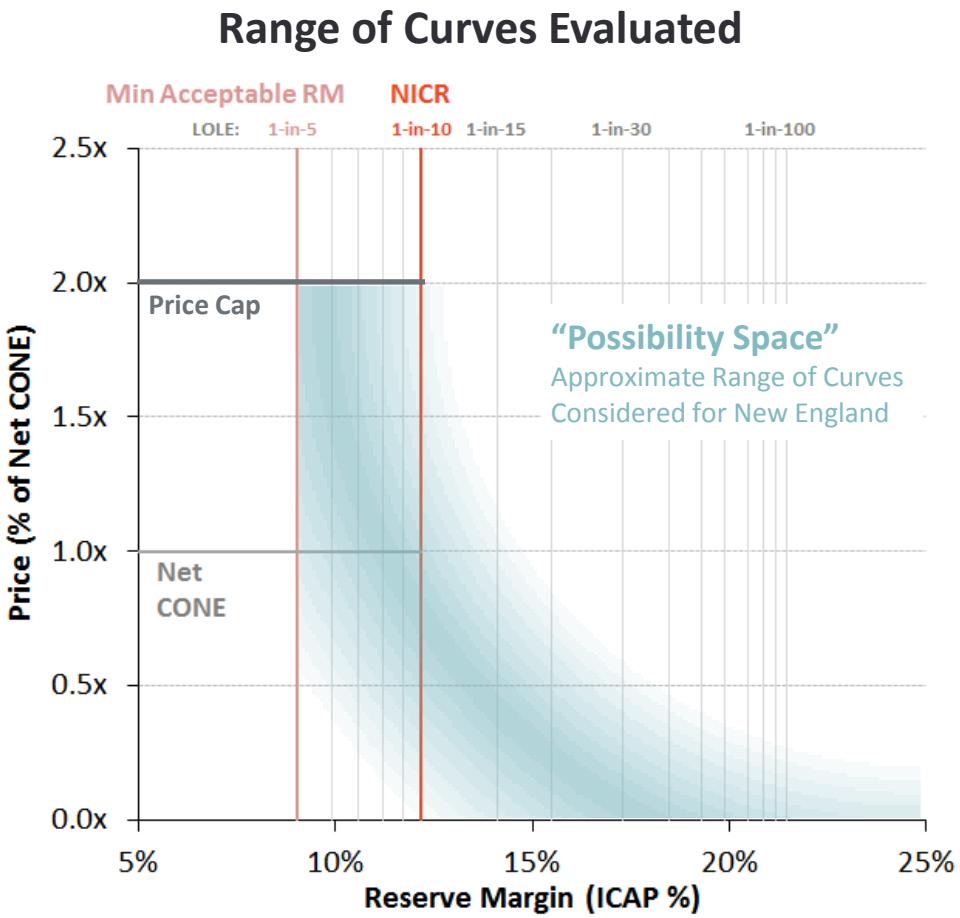
- Reduce price volatility impact from lumpiness and small movements and uncertainties in supply, demand, and transmission (no bimodal price distribution)
- Few outcomes at the administrative cap, with cap no greater than 2x Net CONE

Other

- Reduce susceptibility to market power
- Minimize contentiousness and uncertainty from administrative parameters

Approach

- Considering a wide variety of candidate demand curves, including the LICAP curve, other RTO curves, and many variations
- Developed Monte Carlo simulation model to test the curves' performance, tuning curves' parameters to meet reliability and other objectives
- Refining candidate curves into a range of well-functioning curves
- Evaluated interactions with other FCM design elements



Notes:

LOLE lines shown in gray between 1-in-5 and 1-in-10 increase by increments of 1 (i.e. 1-in-6, 1-in-7, etc.), while lines in gray between 1-in-15 and 1-in-100 increase by increments of 10 (starting at 1-in-20).

Contents

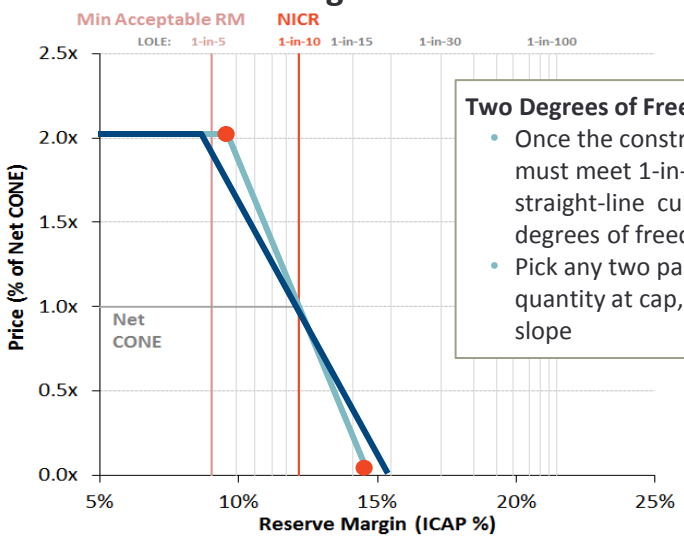
Evaluation of System Curves

Range of Demand Curves Evaluated

Began by casting a wide net of possible curves to evaluate, including:

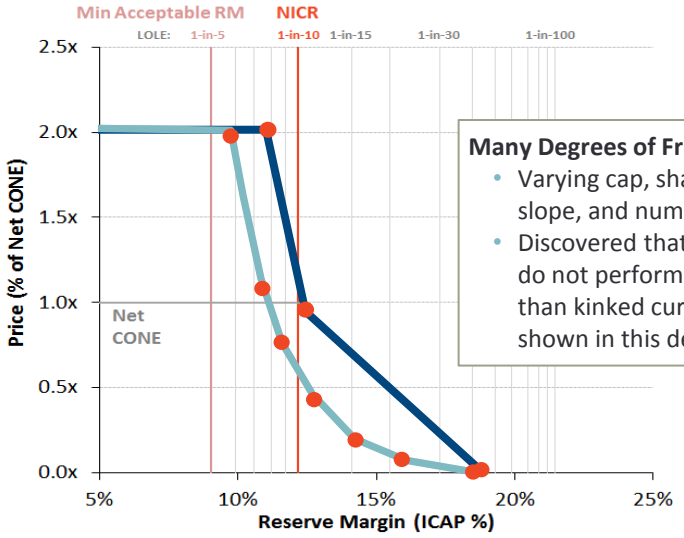
1. **Vertical**
   - Current vertical
   - Different price caps
   - Right-shifted to meet 1-in-10 reliability objective
2. **Off-the-Shelf Curves** (see next slide)
   - Stoft LICAP
   - PJM
   - NYISO
3. **Newly-Defined Curves** (see right)
   - Straight line, convex kink, or multi-point
   - Tested a range of slopes, shapes, price caps, and foot points
   - Parameters tuned to meet 1-in-10

Straight-Line Curves



Two Degrees of Freedom:
- Once the constraint that the curve must meet 1-in-10 is imposed, straight-line curves have two degrees of freedom left
- Pick any two parameters: price cap, quantity at cap, quantity at foot, or slope

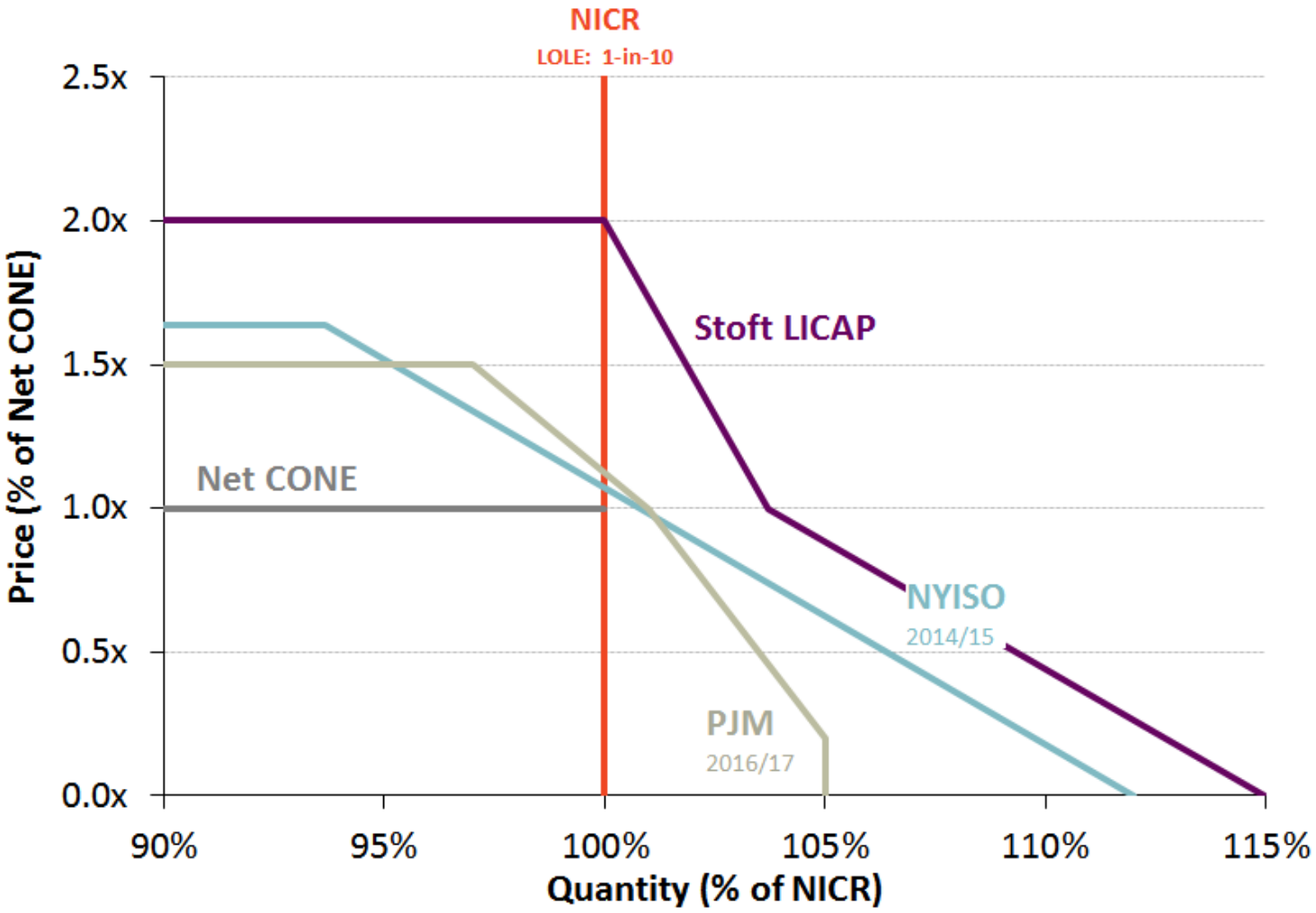
Kinked and Multi-Point Curves



Many Degrees of Freedom:
- Varying cap, shape, foot quantity, slope, and number of points
- Discovered that multi-point curves do not perform materially better than kinked curves (results not shown in this deck)

Evaluation of System Curves

Comparison of LICAP and Other RTOs' Curves



Notes:

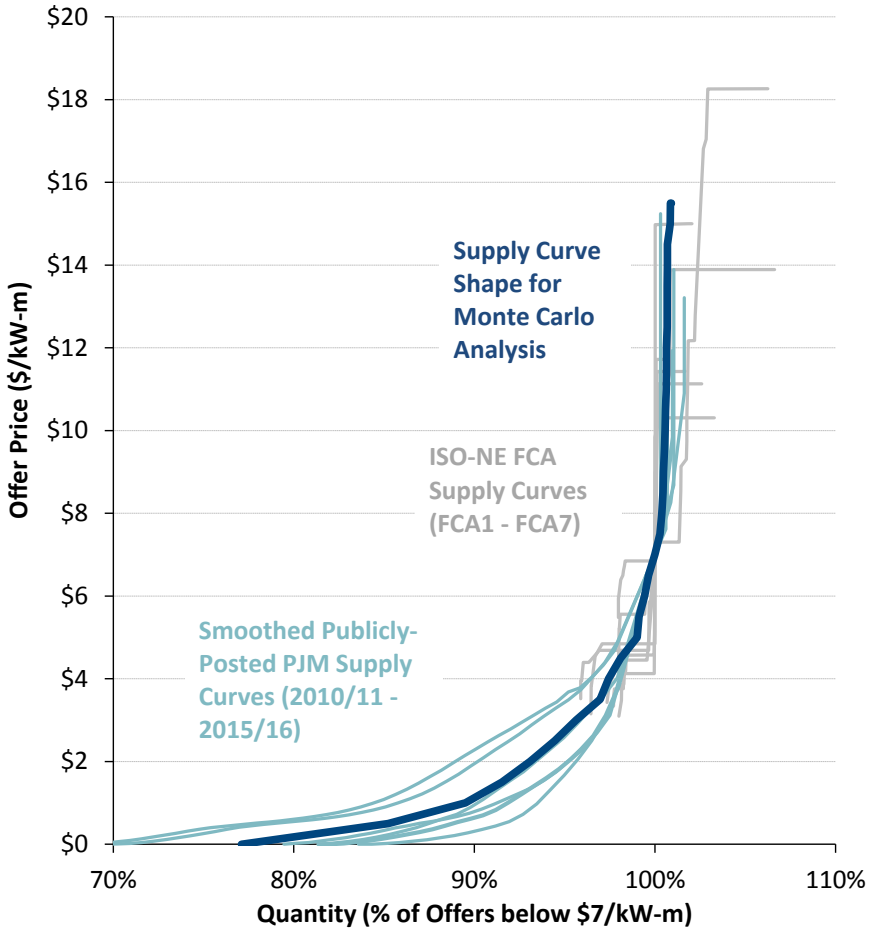
Other RTO curves are the system-wide curves drawn as a function of the 1-in-10 reliability requirement and Net CONE of their respective markets. PJM's curve is drawn before the subtraction of the 2.5% deduction for short-term resource procurements.

Evaluation of System Curves

Simulation Modeling Approach

- Simulated a distribution of outcomes using a Monte Carlo analysis of realistic "shocks" to supply and demand
- Assumed locational supply curves, demand curves, and transmission parameters consistent with FCA 7 (as adjusted for shocks)
- Adapted historical FCA and PJM offers to create a realistic supply curve shape
- Used a locational clearing model to calculate clearing prices and quantities
- Calibrated entry and exit so that the average price over all draws is equal to Net CONE
- Note: For the purposes of this analysis we assume that Net CONE = $8.3/kW-m (based on ORTP Gas CC results de-escalated to FCA7 terms). ***This assumption does not represent a position on the actual value of Net CONE***

Supply Curve Core Shape for Simulations



Sources and Notes:

Historical ISO-NE FCA supply curves provided by ISO-NE.

PJM supply curves from *The Second Performance Assessment of PJM's Reliability Pricing Model (2011, Pfeifenberger et al.)*

Historical offers inflated by Handy-Whitman Index.

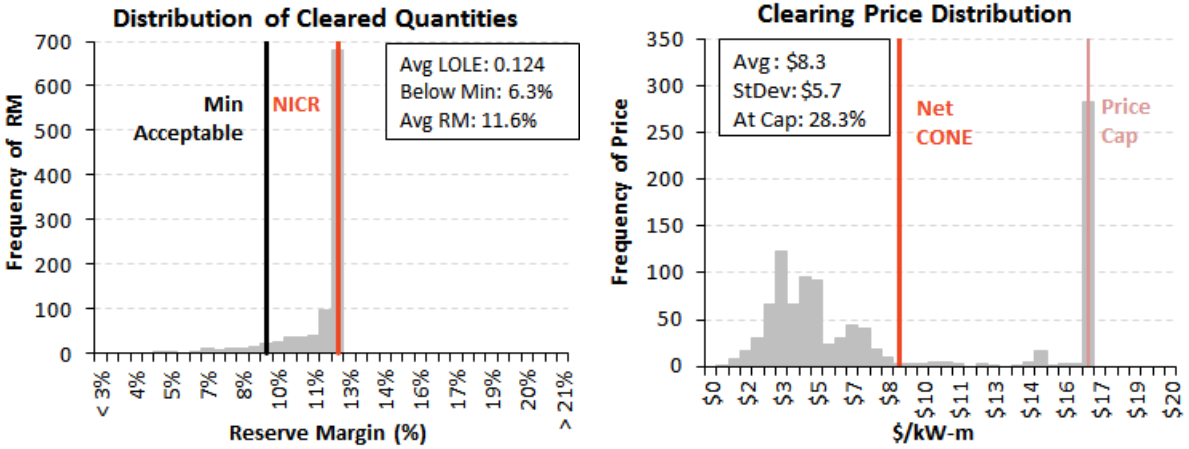
Evaluation of System Curves

Vertical Curve Does Not Meet 1-in-10 Reliability Target

- Reliability falls short of target
  - 0.124 LOLE (1-in-8), would need to right-shift the curve to achieve reliability objective
  - Below minimum acceptable 6.3% of the time
- High price volatility
  - $5.7/kW-m standard deviation
  - Bimodal price distribution
  - Price at the cap 28% of the time

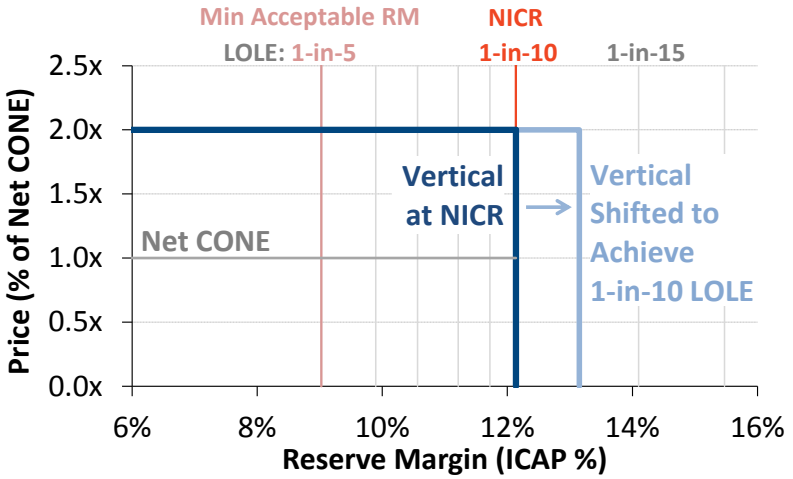
Simulated Outcomes with Vertical Demand Curve with Price Cap

Vertical at NICR, Cap at 2x Net CONE



Note: Distribution of cleared quantities and prices based on 1,000 simulation draws.

Right-Shifted Required to Achieve 1-in-10 LOLE



Evaluation of System Curves

Comparison of Vertical and Off-the-Shelf Curves

- A vertical curve with a price cap at 2x Net CONE could be shifted 0.9% to the right of NICR to achieve the 1-in-10 LOLE target, but prices would remain volatile
- "Richer" right-shifted curves (like Stoft LICAP) have good reliability by maintaining higher reserve margins, but consequently impose greater costs

Simulation Results

	Price			Reliability				Price * Quantity
	Average *($/kW-m)*	Standard Deviation *($/kW-m)*	Frequency at Cap *(% of draws)*	Average LOLE *(%)*	Average RM *(%)*	RM St. Dev. *(%)*	Frequency Below Min. Acceptable *(% of draws)*	Average *($mil/year)*
Vertical at NICR	$8.3	$5.7	28.3%	0.124	11.6%	1.2%	6.3%	$3,283
Vertical Shifted Right to Achieve 0.1 LOLE	$8.3	$5.7	28.8%	0.100	12.6%	1.2%	4.3%	$3,320
Stoft LICAP	$8.3	$3.0	3.0%	0.042	17.4%	2.6%	0.2%	$3,441
PJM Shape (applied to ISO-NE)	$8.3	$2.7	10.3%	0.117	12.5%	2.4%	11.4%	$3,299
NYISO Shape (applied to ISO-NE)	$8.3	$1.8	0.0%	0.112	13.0%	2.8%	11.2%	$3,308

Notes:

Average prices do not account for potential reductions in the cost of capital supported by more gradual demand curves; Net CONE is assumed constant.

The vertical curves have price caps at 2x Net CONE.

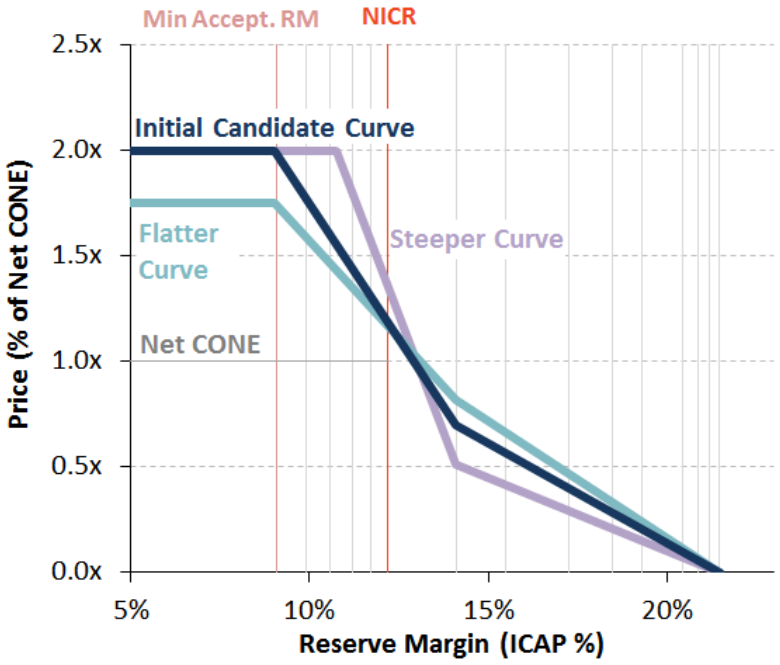
The reported Price * Quantity is the system price multiplied by the system total quantity, and does not reflect zonal price differentials.

Evaluation of System Curves

Tradeoffs Among Well-Performing Curves

- Tested a variety of demand curve shapes and slopes including straight, kinked, and multi-point curves, always tuning parameters to meet 1-in-10
- Refined into an "initial candidate" curve, shown here in comparison with two other well-performing variations to illustrate the tradeoffs between steeper and flatter curves:
  - Flatter: greater price stability, but more reserve margin uncertainty
  - Steeper: reduced likelihood of low-reliability outcomes, but higher price volatility
  - Very steep or very flat curves can both increase total system cost (steeper curve increases frequency of high-price events, flatter curve requires right-shifting the curve to maintain 1-in-10)
- Initial candidate curve strikes a balance among reliability, price volatility, and total cost objectives

Well-Performing Demand Curve Variations



Simulation Results

	Price			Reliability				Price * Quantity
	Average ($/kW-m)	Standard Deviation ($/kW-m)	Frequency at Cap (% of draws)	Average LOLE (%)	Average RM (%)	RM St. Dev. (%)	Frequency Below Min. Acceptable (% of draws)	Average ($mil/year)
Initial Candidate Curve	$8.3	$3.7	5.1%	0.100	13.1%	2.2%	6.1%	$3,309
Flatter Curve	$8.3	$3.0	6.2%	0.100	13.2%	2.4%	7.2%	$3,317
Steeper Curve	$8.3	$4.5	11.5%	0.100	12.9%	1.8%	5.3%	$3,316

Evaluation of System Curves

Draft System Curve Specifications

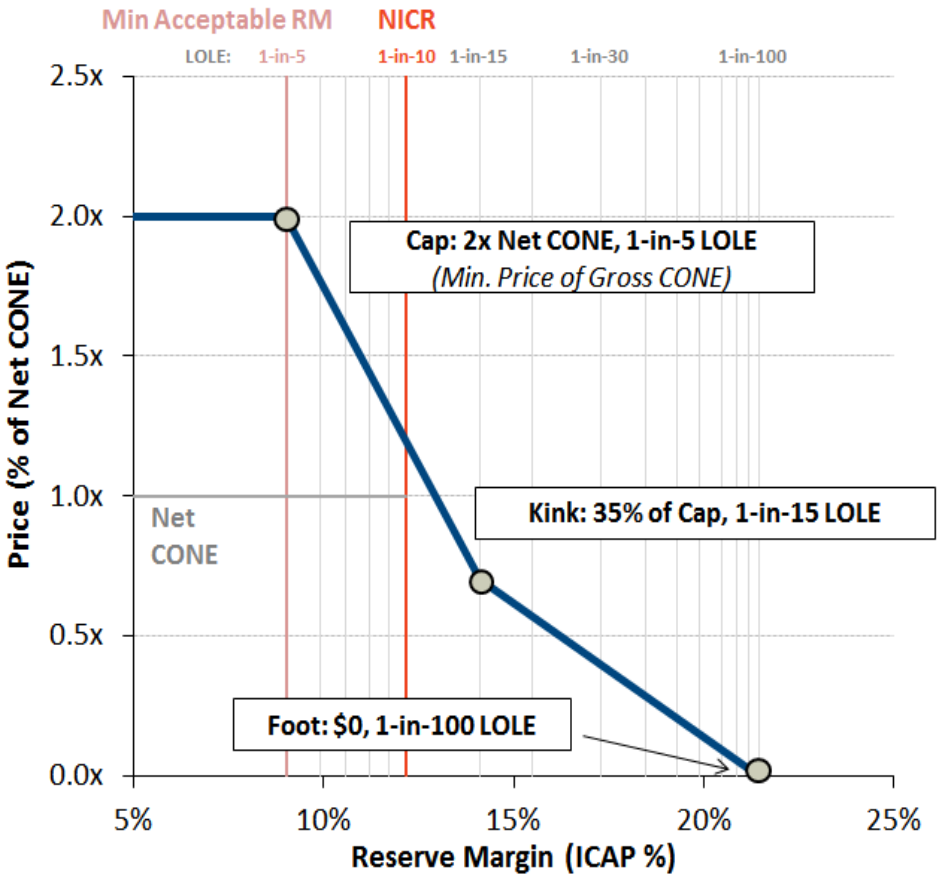
Features

- Price cap at 2x Net CONE, subject to a minimum of 1x Gross CONE to prevent the curve from collapsing
- Quantity point at price cap on the curve at the 1-in-5 LOLE minimum acceptable level of reliability
- Achieves 1-in-10 LOLE on average with average prices at Net CONE, based on simulation analysis
- Convex kinked shape theoretically sound, and loosely reflects value of capacity consistent with *Brattle*, Stoft, and Hobbs previous analyses

Parameter Updates

- Quantity points tied to LOLE levels from the annual ICR study
- Price points tied to Net CONE, with formulaic updates annually and full study updates every three years (same as ORTP)

Initial Candidate Demand Curve



Notes:

LOLE lines shown in gray between 1-in-5 and 1-in-10 increase by increments of 1 (i.e. 1-in-6, 1-in-7, etc.), while lines in gray between 1-in-15 and 1-in-100 increase by increments of 10 (starting at 1-in-20).

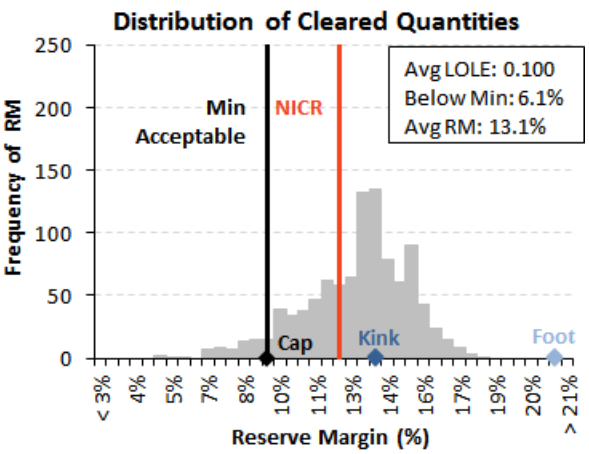
Evaluation of System Curves

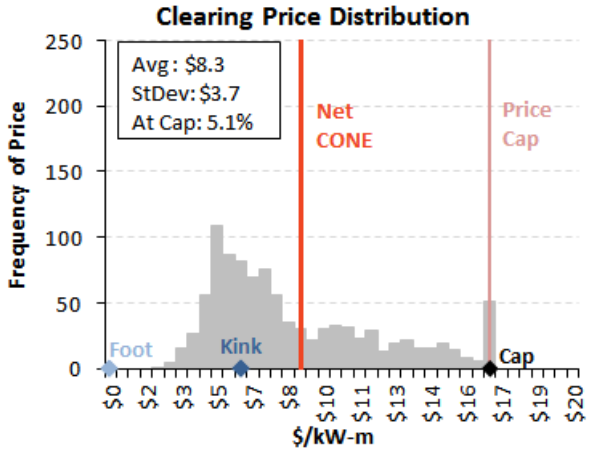
Initial Candidate vs. Vertical Curve Performance

Initial Candidate Demand Curve

- Reliability at target:
  - Achieves 0.1 LOLE (1-in-10)
  - Below minimum acceptable 6.1% of the time
- Moderate price volatility:
  - $3.7/kW-m standard deviation

Simulated Outcomes with Initial Candidate Demand Curve



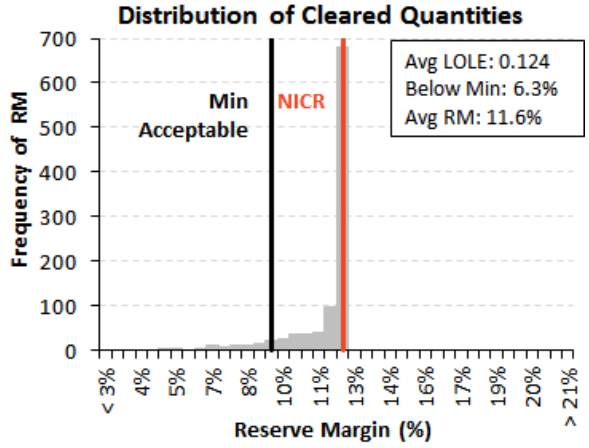


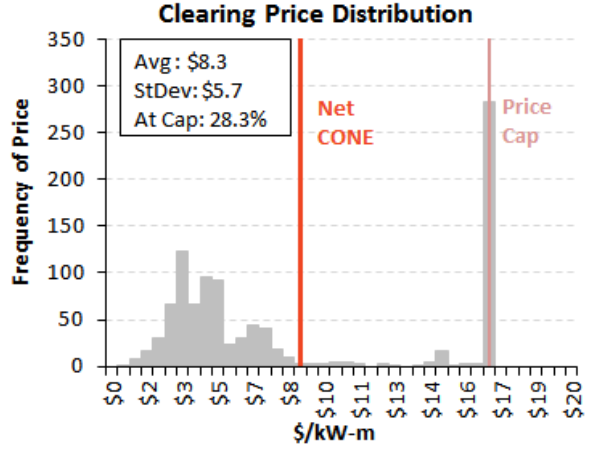
Vertical Demand at NICR

- Lower reliability:
  - 0.124 LOLE (1-in-8)
  - Below minimum acceptable 6.3% of the time
- Higher price volatility:
  - $5.7/kW-m standard deviation
  - Bimodal price distribution
  - Price at the cap 28% of the time

Simulated Outcomes with Vertical Demand

Vertical at NICR, Cap at 2x Net CONE

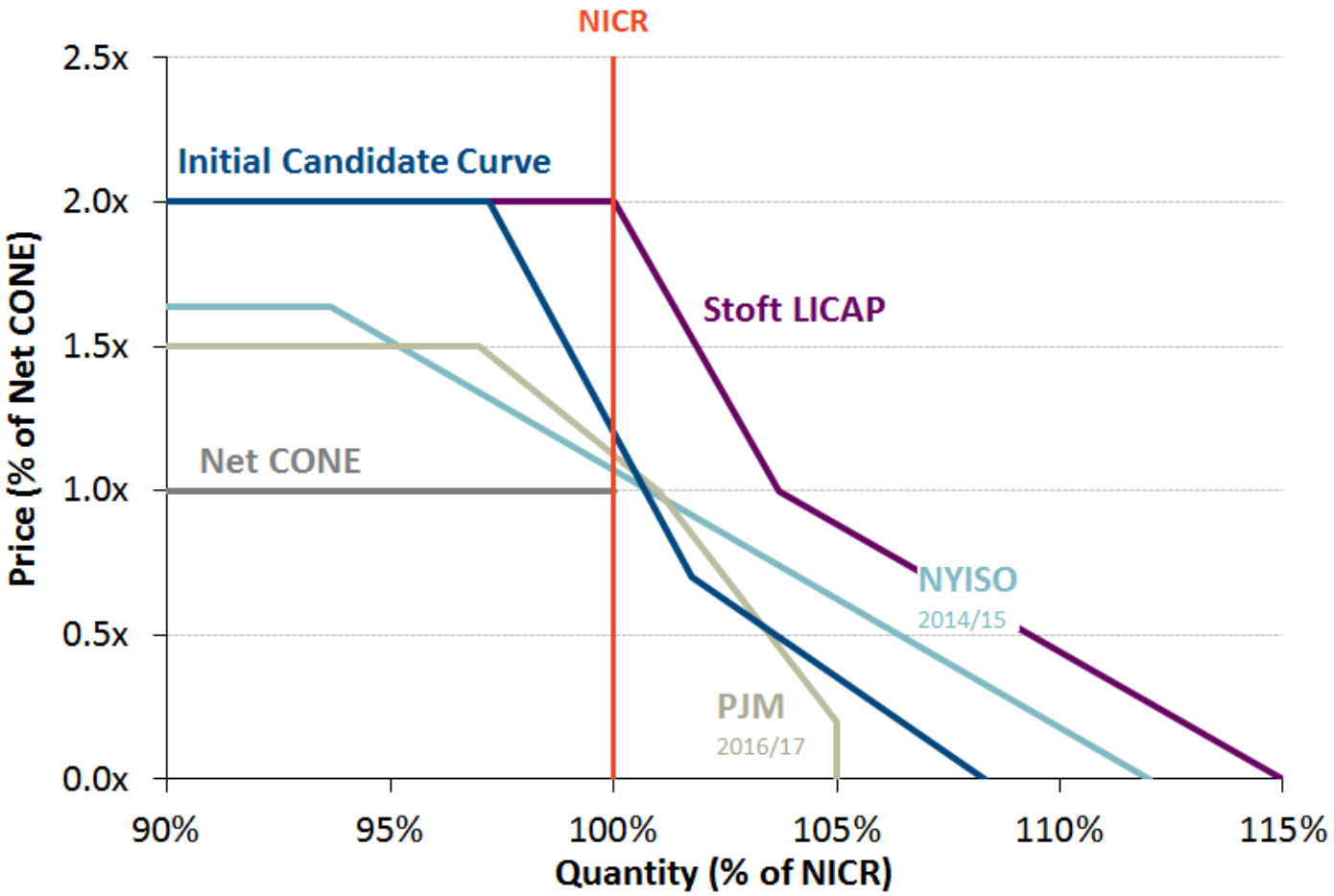




Note:
Distribution of cleared quantities and prices based on 1,000 simulation draws.

Evaluation of System Curves

Comparison to Other RTOs' Curves



Notes:

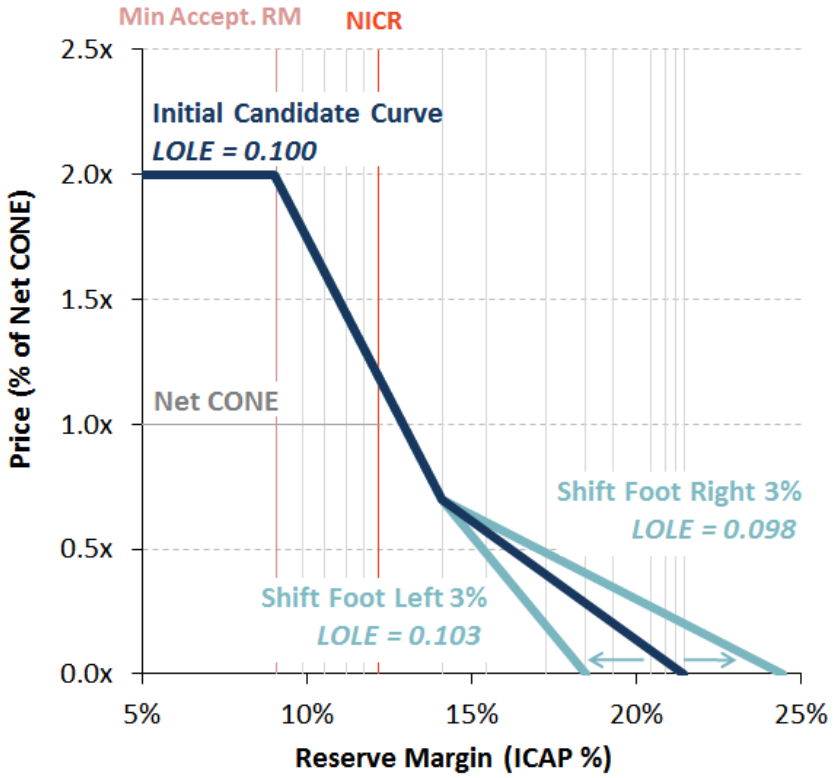
Other RTO curves are the system-wide curves drawn as a function of the 1-in-10 reliability requirement and Net CONE of their respective markets. PJM's curve is drawn before the subtraction of the 2.5% deduction for short-term resource procurements.

Impact of Changing One Dimension of Curve

- A change to just one dimension of the curve would affect reliability

Example: Impact of Shifting the Foot

Without Offsetting Changes to Maintain 1-in-10



- To maintain 1-in-10, changing one parameter requires adjusting others
- Changes that flatten (or steepen) the curve require offsetting changes that further flatten (or steepen) the curve

Parameter Change		
	Flatter	**Steeper**
Price Cap	Reduce	Increase
Quantity at Cap	Move Left	Move Right
Quantity at Foot	Move Right	Move Left
Kink Price/Quantity	Straighter	More Convex
Impacts (with offsetting changes to maintain 1-in-10)		
	Flatter	**Steeper**
Prices	Less Volatile	More Volatile & Bimodal
Reliability	More Volatile More Events < 1-in-5	Less Volatile

Notes: Changes to the kink point that increase (decrease) convexity will generally increase (decrease) volatility.

Evaluation of System Curves

Summary of Demand Curve Performance

- Initial candidate curve strikes a balance among reliability, price volatility, and cost objectives
- Flatter or steeper variants of the initial candidate curve can also perform well, with slight tradeoffs

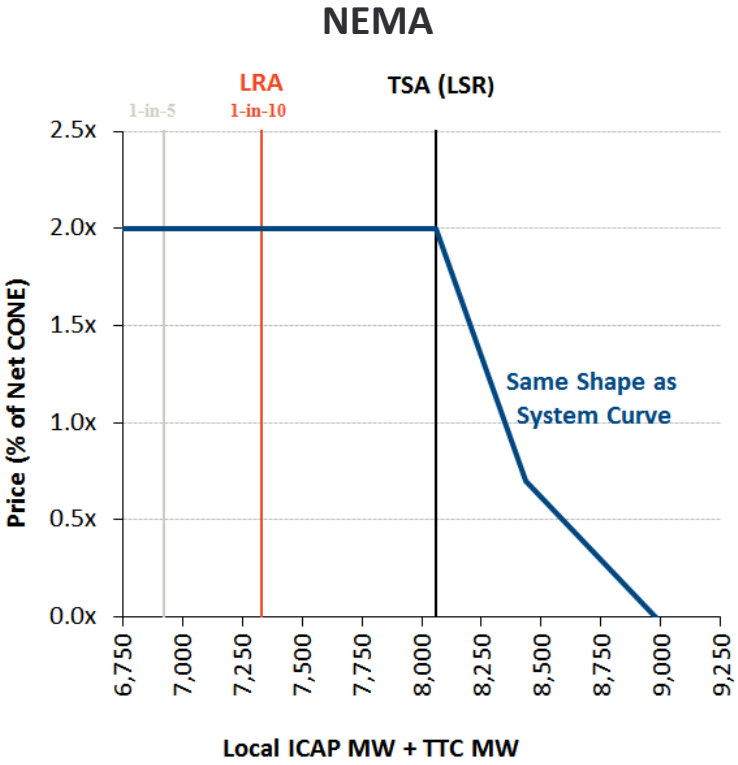
Comparison of Demand Curves' Performance

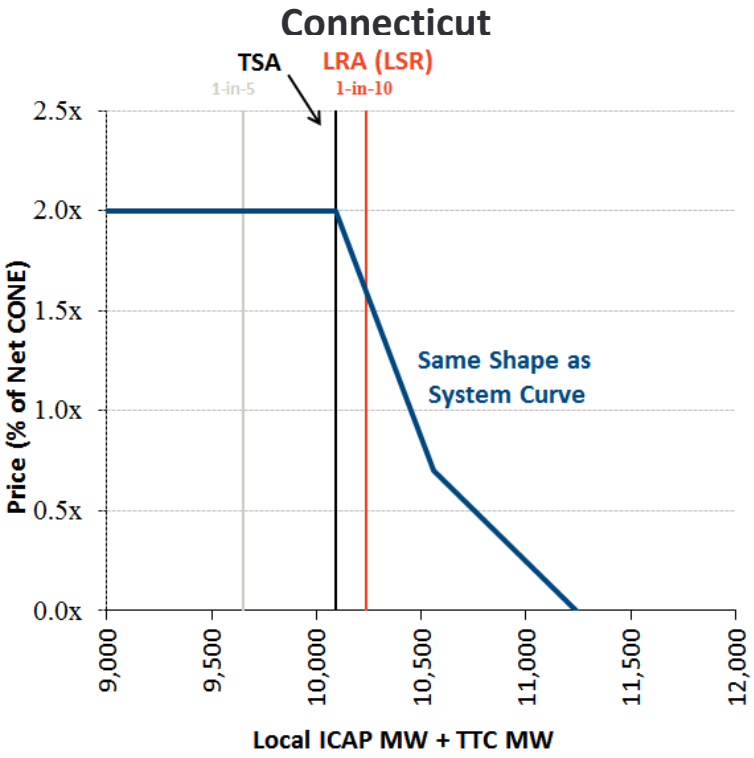
Curve	Reliability	Price Volatility	Capacity Cost
Initial Candidate	Good	Fair	Good
Flatter Kinked	Good (-)	Fair (+)	Good
Steeper Kinked	Good (+)	Fair (-)	Good
Vertical at NICR	Poor	Very Poor (steepest curve)	Good
Vertical at NICR+0.9% (Right-shift for 0.1 LOLE)	Good	Very Poor (steepest curve)	Good
Stoft LICAP	Excellent (1-in-24 LOLE)	Fair	Poor (highest reserve margin results in highest costs)

Contents

Capacity Zones

Initial Candidate NEMA and Connecticut Curves





- The shape of the system curve is applied to import constrained zones
- Quantities are the same percent above the minimum acceptable local quantity (max of 1-in-5 LOLE or TSA) as in the system curve
- Local Net CONE is equal to or greater than system Net CONE, with local Net CONE estimated as a separate local parameter only if its value is more than 15% greater than system (smaller differences in Net CONE are in the range of administrative error and do not introduce performance concerns)

Capacity Zones

Performance Compared to Alternative Local Curves

- Initial candidate local curve is right-shifted compared to vertical (necessary to limit outcomes below "minimum acceptable" at TSA), resulting in higher procurement
- Locations more susceptible to exercise of market power as well as price volatility, both mitigated by implementing a sloped local demand curve.
- Locations may have higher Net CONE (otherwise should not price-separate in long term):
  - Small differences with system Net CONE do not materially affect reliability, price, or cost outcomes
  - But if local Net CONE is >15% higher than system-wide, we recommend using the higher local Net CONE estimate (approximate threshold at which local low-reliability events become much more likely)

Simulated Performance if Net CONE in NEMA and CT is 15% Greater than System Net CONE

	Price			Cleared Quantity			Price * Quantity
	Average	Standard Deviation	Frequency at Cap	Average	Standard Deviation	Frequency Below TSA	Average
	($/kW-m)	*($/kW-m)*	*(% of draws)*	*(% Above LSR+TTC)*		*(% of draws)*	*($mil/year)*
NEMA/Boston							
Vertical Curve at LSR	$9.6	$4.6	20.3%	8.4%	9.3%	16.8%	$433
Initial Candidate Curve	$9.6	$4.3	14.9%	10.5%	9.3%	11.0%	$454
Curve Adjusted for 15% Higher Local Net CONE	$9.6	$4.7	8.1%	12.6%	9.5%	8.1%	$471
Connecticut							
Vertical Curve at LSR	$9.6	$4.5	20.3%	4.7%	5.8%	13.3%	$914
Initial Candidate Curve	$9.6	$4.2	13.9%	5.9%	5.7%	10.3%	$926
Curve Adjusted for 15% Higher Local Net CONE	$9.6	$4.5	6.8%	7.3%	5.8%	6.8%	$944

Notes: All simulations have initial candidate curve as the system curve, and have an average system price equal to system Net CONE. Price * Quantity results represent local prices and quantities only.

Export-Constrained Zone Context

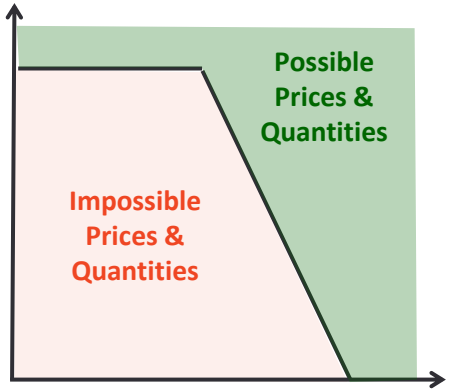
New Problem

- No other capacity market has used a demand curve in an export-constrained zone
- MISO and ISO-NE have defined fixed maximum capacity limits in export constrained zones (*i.e.*, vertical curve for export zones)

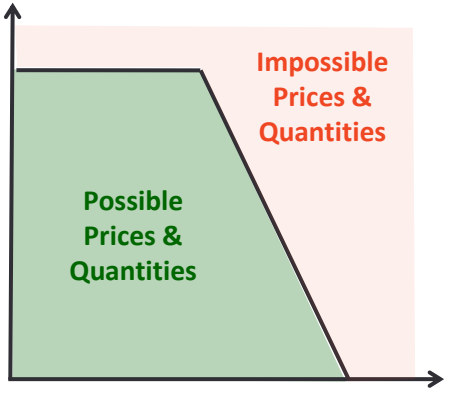
Different Type of Constraint

- Defines "maximum" demand curve constraint
- Unlike "minimum" demand curves applicable for total system and import-constrained zones

"Minimum" Demand Curve
(System and Import-Constrained Zones)



"Maximum" Demand Curve
(Export-Constrained Zones)



Capacity Zones

Initial Candidate Maine Curve

Initial Candidate Curve

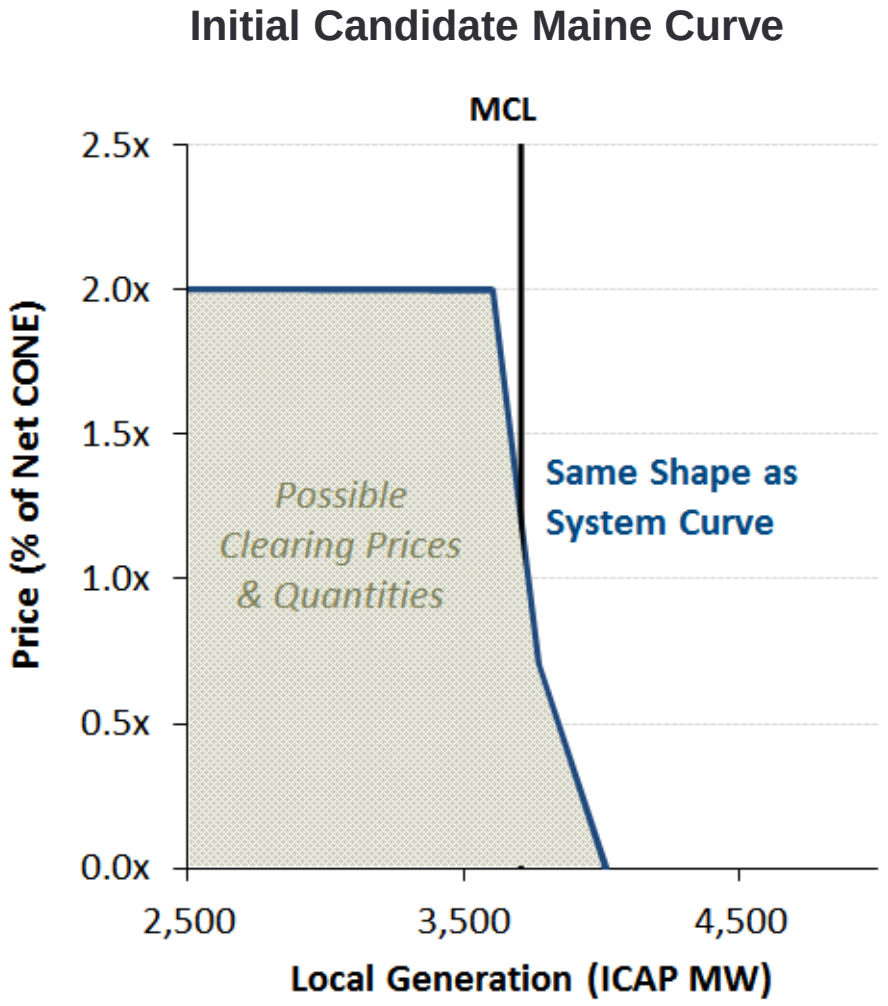
- The system curve adapted to Maine, with the quantity based on the same % of MCL as system is of NICR

Considerations

- Simple design
- Tested to assure low impact on system-wide reliability when procuring above MCL
- Prices loosely reflective of marginal reliability value (lower in export-constrained zones)

Possible Clearing Prices and Quantities

- There is a range of possible clearing outcomes below the curve, as explained on the prior slide



Contents

Interactions with PI

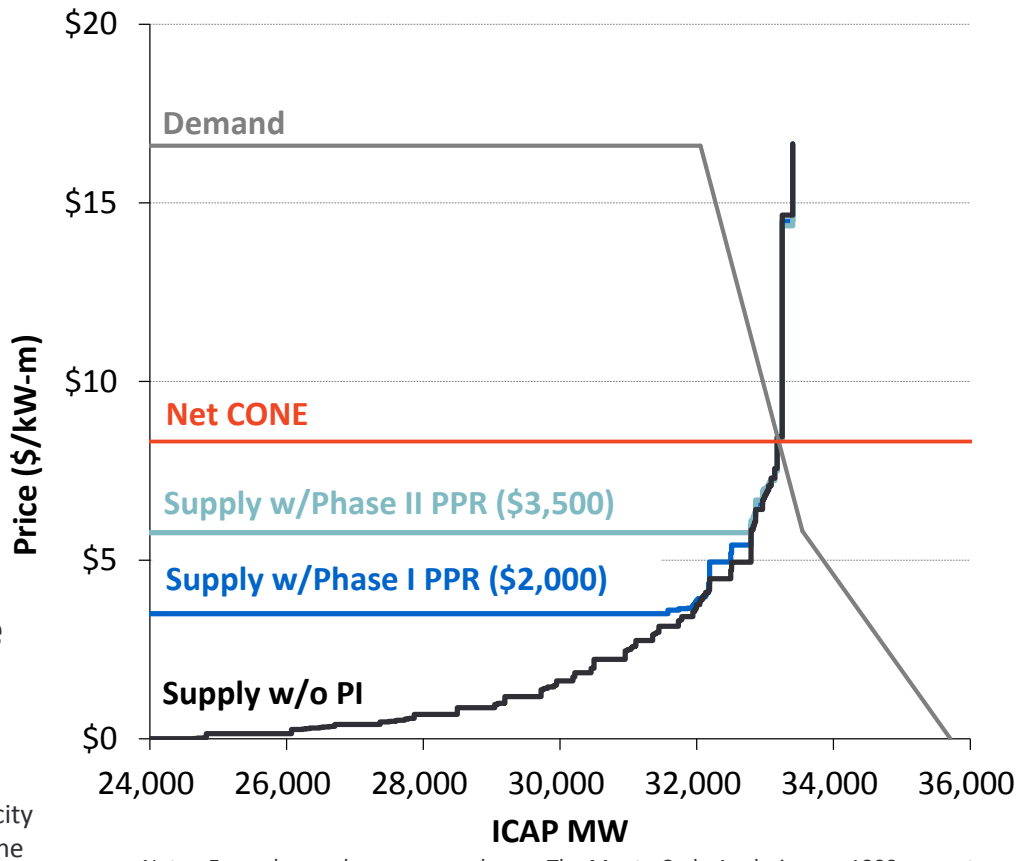
Performance During PPR Phase-In

- Implementing PI in combination with a demand curve would slightly reduce capacity price volatility and increase reliability relative to the no-PI case
- With H at NICR = 21 (based on ISO-NE estimates), the impact of PI on clearing results and reliability is minor:
  - LOLE = 0.100 w/o PI
  - LOLE = 0.099 w/ Phase I PPR
  - LOLE = 0.091 w/ Phase II PPR
- If H at NICR is less than 21 hours, the impacts would be smaller
- **These impacts are small enough that we do not recommend any adjustments to the demand curve**

- *Note*: The small improvement in reliability reflects operating capacity in excess of demand curve procurement in the few draws where the market clears at the common value at the bottom of the supply curve, and also the benefits of increased supply curve elasticity.

Simulated FCM Supply Curves with PI

(Phase I and Phase II PPR)



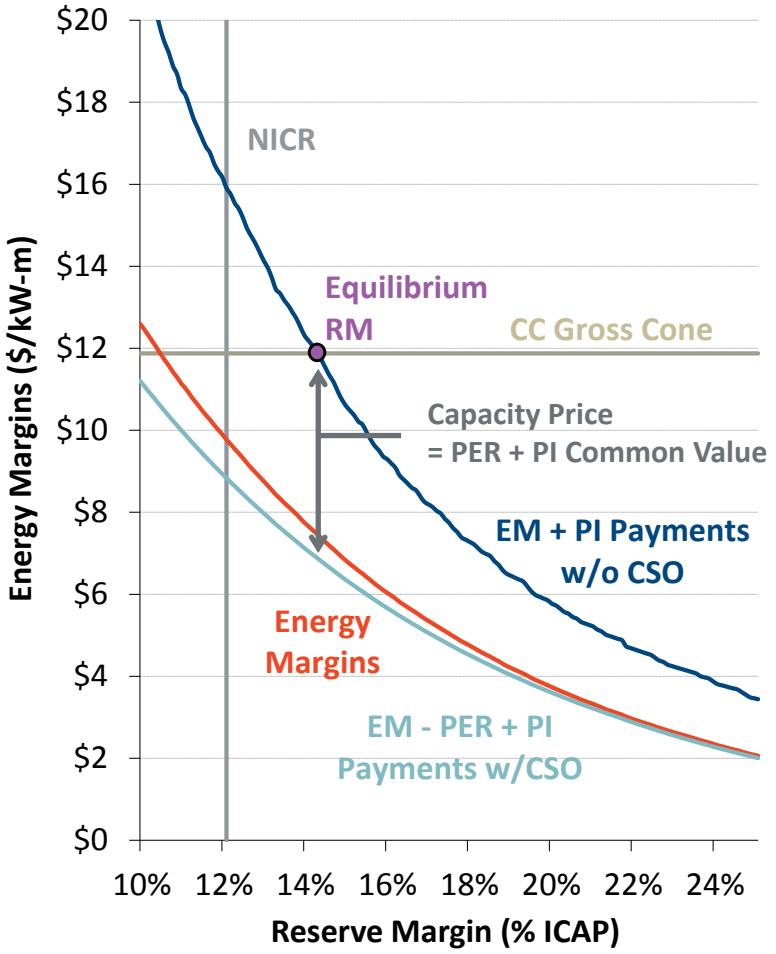
Notes: Example supply curves are shown. The Monte Carlo Analysis uses 1000 separate supply curves. These supply curves are based on H = 21 at NICR, from ISO-NE estimates. Net CONE shown does not account for PI payments.

Interactions with PI

Performance with High PI & High Energy Margins

- A completely different result could occur in an alternative scenario where both energy margins and PI payments are higher than anticipated
- In this case, energy margins + PI payments at NICR could be greater than the cost of new entry, meaning new plants would be built without a CSO
- Reserve margin and reliability outcomes would be determined by the relationship between shortage hours and the reserve margin (like an energy-only market), rather than the capacity market demand curve
- Such an outcome would render a demand curve ineffectual in most years, but would still protect against the possibility of low-reliability events
- **We therefore recommend the same demand curve with or without PI, in all phases of implementation**

Example Equilibrium
in a High PI & High Energy Margin Scenario



Notes: An example equilibrium is shown, where H = 14 at NICR and CC Energy Margins = $9.8/kW-m at NICR.

Contents

Interactions with Other FCM Elements

Other FCM Elements

- Reviewed interactions with many FCM elements, including ICAP vs. UCAP accounting, NYISO demand curve, LOLE modeling, reconfiguration auctions, and others
- Most FCM elements work equally well with a vertical or sloped demand curve (no changes necessary), but we recommend the following changes

Consider Eliminating Three Administrative Price Rules

- Consider eliminating Inadequate Supply, Insufficient Competition, and Carry Forward
- Rules were designed to mitigate against price volatility and exercise of market power
- Rules would have to be rewritten in presence of a demand curve, we recommend eliminating them instead, given that the demand curve works toward the same objectives more efficiently

Consider Eliminating or Modifying Descending Clock Auction

- Descending clock auction could result in incorrect price and clearing outcomes under some circumstances with a demand curve (i.e., final ME export quantity unknown in early rounds)
- Even without demand curve interaction, we do not view multi-round auctions as beneficial in capacity markets relative to single-round

Other Interactions

Administrative Pricing and Descending Clock Auctions

Element	How it Works	Reasons to Keep	Reasons to Eliminate
Inadequate Supply Rule	• New gen and DR are paid the price cap if there's a deficit in the total MW offered • Existing suppliers are paid 1.1 times the most recent FCA price for that zone	• Protect consumers from price spikes	• Problematic consequences of price discrimination: distorts investment and retirement incentives • Lost revenue to existing resources must be made up in other ways • Demand curve mitigates against price spikes more efficiently
Insufficient Competition Rule	• Triggered if insufficient existing supply to meet requirement at price cap, and the amount of new supply offered is small or is available from a pivotal supplier. • New supply paid clearing price, existing supply paid min of clearing price or 1.1 times last FCA price	• Mitigate against exercise of market power from existing and new resources • Protect consumers from price spikes	• Problematic consequences of price discrimination • Exercise of market power from existing resources effectively addressed by offer price review rules • Rule does not prevent new resources from benefiting from exercise of market power • Demand curve mitigates against exercise of market power more efficiently
Carry Forward Rule	• Triggered if excess supply from previous auction exceeds need for new resources. • Prices prevented from falling very low by setting at the minimum of: (a) CT-based offer review threshold, and (b) just below the offer price of the last withdrawn new resource	• Mitigate against downward market price volatility for existing resources	• Demand curve mitigates price volatility more efficiently
Descending Clock Auction Format	• Min and max prices in each round, successive rounds cover lower price bands	• May require additional software upgrades to change	• Existing format would have to be revised to avoid incorrect price and clearing outcomes (e.g. cannot know ME exporting quantity until total supply curve is visible) • Adopting a sealed bid auction format would reduce complexity

Summary of Findings and Recommendations

- Adopting a sloping demand curve would improve the performance of ISO-NE's capacity market by:
  - Increasing reliability sufficiently to meet the 1-in-10 objective and reducing the frequency of very low reliability events
  - Reducing price volatility
  - Reducing FCM's susceptibility to exercise of buy and sell side market power
- Initial Candidate curve seeks to balance reliability, economic, and other objectives (a range of other curves can also perform well, with somewhat different tradeoffs among price and reliability objectives)
- A demand curve works well with most other FCM elements including PI, but we do recommend eliminating other administrative pricing rules and moving to a single round auction