New York ISO
Independent System Operator

LCR Optimizer Enhancements - Update

John Meyer

Senior Market Solutions Architect

Installed Capacity Working Group / Market Issues Working Group

September 18th, 2023

Agenda

- Background
- LCR Optimization
- Problem Statement/Scope
- Recommended Solutions
- Test Results
- Next Steps

New York ISO

Background

New York ISO

Background

- Since 2019, the NYISO has utilized an economic optimization software ("LCR Optimizer") to establish the Locational Minimum Installed Capacity Requirements (LCRs) for NYC, LI and G-J Locality. The LCR Optimizer is designed to produce least cost LCRs while maintaining the NYSRC's final IRM and the corresponding Resource Adequacy criterion for Loss of Load Expectation (or LOLE).
- Since implementing the LCR Optimizer, multiple concerns have been raised regarding the year over year stability of the LCRs and the transparency of the optimization function.
- Re-examining this process and the methodology could lead to improvements in the stability and transparency of the LCRs.

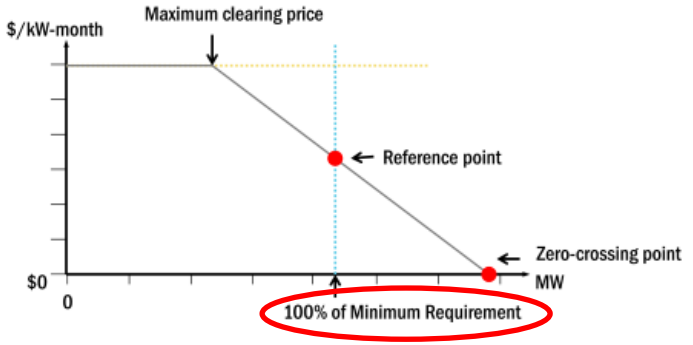
New York ISO

LCR Optimization

New York ISO

LCR Optimization

- For each Capacity Market capability year, Locational Minimum Installed Capacity Requirements (LCRs) are set for the NYC, LI, and G-J locality capacity zones.
- The LCR values are representative of the amount of installed capacity that must be sourced from supply that is electrically within the capacity zone and is expressed as a fractional amount or percentage of that zone's non-coincident peak load.
- LCRs (and the IRM) tie capacity market signals back to resource adequacy requirements and the 1 day in 10 years Loss of Load Expectation (LOLE) reliability metric.
- The finalized LCRs are used in the capacity market as the 100% of Minimum Requirement value on the Locational Installed Capacity Demand Curves.



New York ISO

LCR Optimization

- The process for determining LCRs begins after the Installed Reserve Margin (IRM) study is completed and the New York State Reliability Council (NYSRC) has approved the IRM value for the upcoming capability year.

- With the IRM and its corresponding LOLE value held constant, LCRs for capacity zone J, K and the G-J locality are optimized for the minimum cost to procure capacity, subject to the target LOLE and the Transmission Security Limits (TSLs) floors.

- The 'cost' that is minimized is based on the net Cost of New Entry (CONE) curves for NYCA and each locality, which express the $/kw-yr needed to support the fixed costs of the Demand Curve Reset (DCR) reference unit, less estimated Energy and Ancillary Service revenues.

New York ISO

LCR Optimization (existing)

- The optimizer solves for the LCR values (shown as Q_j, Q_k, and Q_{G-J} here).
- Q_{NYCA} is effectively a static parameter, set to the NYSRC approved IRM determined beforehand.
- Level of excess (shown as LOE_J, LOE_K, LOE_{G-J}, and LOE_{NYCA} here) are the reference unit size as determined by the DCR process.
- Q quantities are representative of installed capacity in the 'at criteria' system, i.a.w. values that produce the target LOLE (e.g. 0.100 days/year).
- Q + LOE quantities (as used in this objective) are representative of the installed capacity in the 'level of excess' system.

$$\textit{Minimize:}$$

$$\textit{Cost of Capacity Procurement} = [Q_J + LOE_J] \times P_J(Q_J + LOE_J) + [Q_K + LOE_K] \times P_K(Q_K + LOE_K)$$

$$+[Q_{(G-J)} + LOE_{(G-J)} - Q_J - LOE_J] \times P_{(G-J)}(Q_{(G-J)} + LOE_{(G-J)})$$

$$+[Q_{NYCA} + LOE_{NYCA} - Q_{(G-J)} - LOE_{(G-J)} - Q_K - LOE_K] \times P_{NYCA}(Q_{NYCA} + LOE_{NYCA})$$

$$\textit{Subject to:}$$

$$NYCA\ system\ LOLE \leq target\ LOLE$$

$$Q_{NYCA} = NYCA\ system\ peak\ load\ forecast \times (1 + NYSRC\ approved\ IRM)$$

$$Q_J \geq Q_{TSL(J)}$$

$$Q_K \geq Q_{TSL(K)}$$

$$Q_{(G-J)} \geq Q_{TSL(G-J)}$$

New York ISO

LCR Optimization(existing)

- The costs in the objective (P_J, P_K, P_{G-J}, and P_{NYCA}) use the net CONE curves which are piecewise linear functions of LCR and $/kw-yr, consisting of multiple points that are linearly interpolated.
- For a specific capacity zone, the procurement cost is:
  - Level-of-excess quantity receiving payment, times the price at the last MW of the level-of-excess quantity.
- TSL floors are determined in a separate process with inputs from load forecasts, bulk power transmission capability, and locality derating factors.
- TSL floors are input as constraints in the optimization.

$$Minimize:$$

$$Cost\ of\ Capacity\ Procurement = [Q_J + LOE_J] \times P_J(Q_J + LOE_J) + [Q_K + LOE_K] \times P_K(Q_K + LOE_K)$$

$$+[Q_{(G-J)} + LOE_{(G-J)} - Q_J - LOE_J] \times P_{(G-J)}(Q_{(G-J)} + LOE_{(G-J)})$$

$$+[Q_{NYCA} + LOE_{NYCA} - Q_{(G-J)} - LOE_{(G-J)} - Q_K - LOE_K] \times P_{NYCA}(Q_{NYCA} + LOE_{NYCA})$$

$$Subject\ to:$$

$$NYCA\ system\ LOLE \leq target\ LOLE$$

$$Q_{NYCA} = NYCA\ system\ peak\ load\ forecast \times (1 + NYSRC\ approved\ IRM)$$

$$Q_J \geq Q_{TSL(J)}$$

$$Q_K \geq Q_{TSL(K)}$$

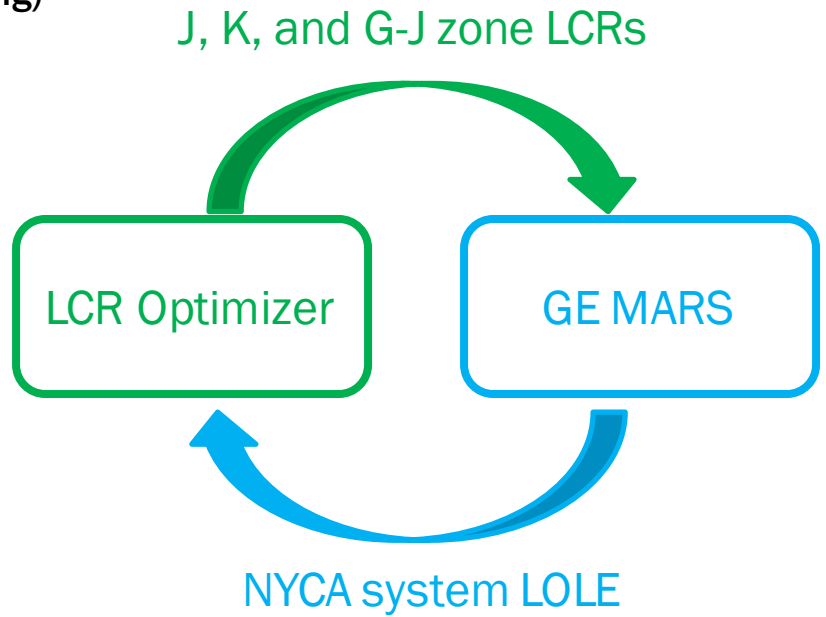
$$Q_{(G-J)} \geq Q_{TSL(G-J)}$$

The TSL Floor Calculation method was updated and presented on October 4th, 2022:
https://www.nyiso.com/documents/20142/33562316/22_10_04_ICAPWG_Transmission_Security_Limit_Calculation.pdf

New York ISO

LCR Optimization(existing)

- LCR optimization is done in iteration with GE MARS runs to produce the minimum procurement cost solution for LCR values, while meeting all constraints.
- The GE Multi-Area Reliability Simulation (MARS) software calculates the NYCA system LOLE, which is provided to the Optimizer to compare against the targeted LOLE constraint when developing LCR results.
- This iteration is continued until convergence of a solution (~20-30 times)



New York ISO

Problem Statement/ Scope

New York ISO

Issues Identified by MMU

- In the 2021 State of the Market Report (SOM) from MMU, a number of considerations are listed in the section titled “Problems with the LCR-Setting Process”.

MMU’s considerations in the 2021 SOM Report can be categorized as potential issues with the…

- Cost curve (net CONE) – Is it in the right format to use as costs in the optimizer?
  - The piecewise linear form, in conjunction with the current objective formulation, may result in convergence on local minimums, i.e. the results produce minimum costs for specific zones, instead of minimum total costs for the system
  - Resulting LCRs are strongly influenced by changes in the cost curve.
  - Updates to the cost curve can cause LCRs to change when underlying reliability values are the same, making the year-over-year LCRs volatile with annual net CONE updates.
- Objective function – Are we calculating cost correctly and minimizing the right quantity?
  - Minimizing total procurement (substitution) cost instead of marginal production costs
  - Potential misalignment with the capacity demand curves
  - Potential misalignment with the IRM process

New York ISO

Scope

- **Deliverable: 2023 – Market Design Complete**

- **Investigate the need for and develop the necessary modifications and enhancements to the LCR Optimizer to improve the stability and transparency of the LCRs, with the following two focuses:**
  - Reviewing the format of cost curves used in the LCR Optimizer
  - Reviewing the appropriateness of the objective function in the LCR Optimizer

New York ISO

Scope (cont.)

Transmission Security Limit (TSL) floors

- Procedures for determining and applying TSL floor values in the LCR Optimization are NOT in scope for this project.
- The proposed changes to the LCR optimizer in this project assume that TSL floors continue to lower bound the LCR values and may constrain the solution for one or more capacity zones.
- The next steps for addressing transmission security in the Capacity Market and alignment with NYISO Planning Department studies will be discussed separately from this project.

New York ISO

Recommended Solutions

New York ISO

Recommendation

These are our recommendations for the modifications to the LCR optimization software and process.

1) **Implement the investment cost (or 'area under the curve') objective function change in the LCR optimizer**

Go forward with the previously proposed objective function change (ICAPWG 4/27). This represents local installed capacity as an 'investment' (or supply) cost to be minimized versus the single-buyer 'procurement' cost. As well, this mathematically yields a better conditioned optimization problem and promotes consistent results from the solver.

New York ISO

Procurement vs. Investment Cost

What should the LCR optimization minimize?

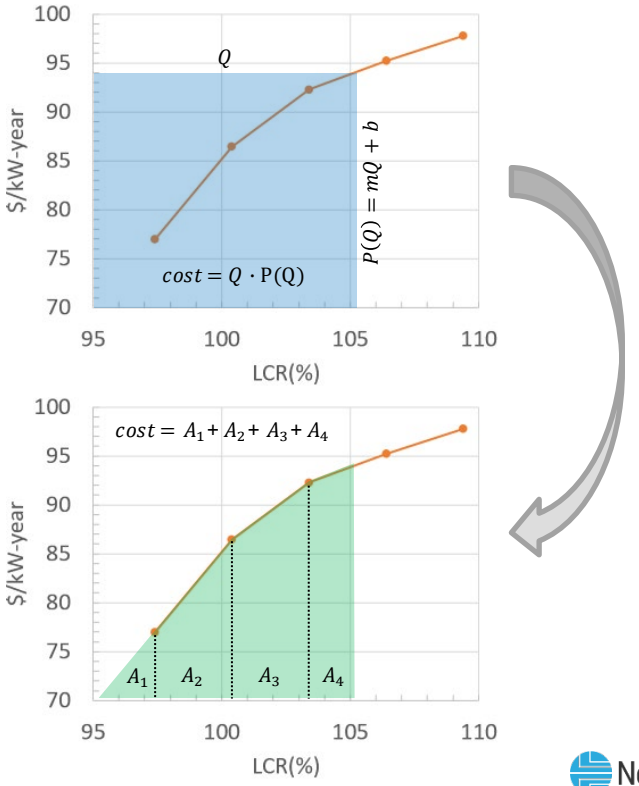
- Total Procurement Cost – Every MW of capacity is priced like the last MW. The cost from a single buyer perspective is minimized, with potential substitution of the competitive "product" (LCR) with another to minimize those costs to the buyer.

- Total Investment Cost – A rollup of incremental investment cost (area under the curve). A competitive market form, where the total cost of supply itself is minimized.

The LCR Optimizer minimizes total procurement cost today, but minimizing total investment cost is more appropriate to:

- Solve for LCRs considering the equilibrium marginal investment cost that meets the reliability metric, and
- Improve solver ability to find the global minimum consistently.

An example with zone K is shown here.



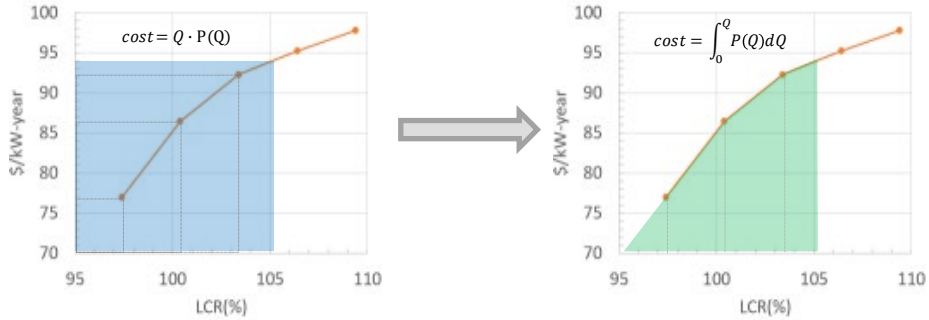
New York ISO

Procurement vs. Investment cost

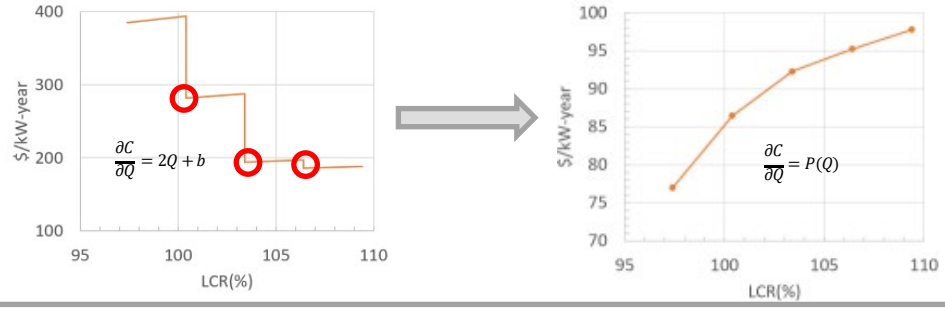
Why this is easier for the solver…

- Looking at the marginal cost, could a solver get "stuck" seeking the solution?
- Procurement method → Creates discontinuities (non-differentiable) across breakpoints and the shape creates 'pockets' and multiple solutions for the same cost. Local minima exist*
- Investment method → solves back to the net CONE curve itself. Better conditioned problem.

Net CONE curves and the method used in the objective to total-up costs (shaded area)



The resulting marginal cost curves



*As described in the 2021 SoM report, the effect is even more pronounced when adjusted to represent the effective cost for reliability improvement

New York ISO

Procurement vs. Investment Cost

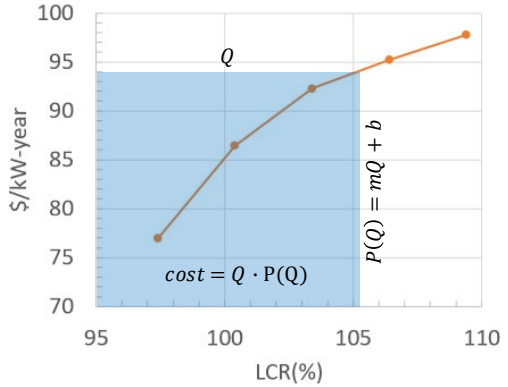
Changing the rollup of cost in the objective…

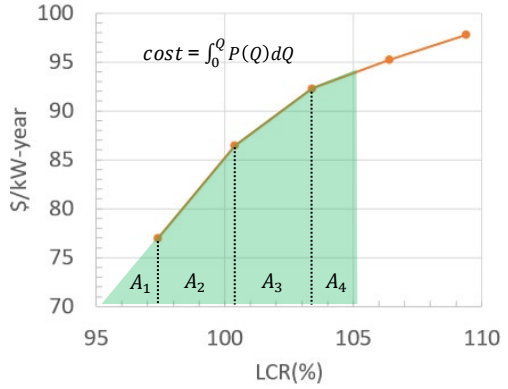
$$\textit{Minimize:}$$

$$\begin{aligned}\textit{Cost of Capacity Procurement} &= [Q_J + LOE_J] \times P_J(Q_J + LOE_J) + [Q_K + LOE_K] \times P_K(Q_K + LOE_K) \\ &+ [Q_{(G-J)} + LOE_{(G-J)} - Q_J - LOE_J] \times P_{(G-J)}(Q_{(G-J)} + LOE_{(G-J)}) \\ &+ [Q_{NYCA} + LOE_{NYCA} - Q_{(G-J)} - LOE_{(G-J)} - Q_K - LOE_K] \times P_{NYCA}(Q_{NYCA} + LOE_{NYCA})\end{aligned}$$

$$\textit{Minimize:}$$

$$\begin{aligned}&\textit{Cost of Capacity Production} \\ &= \int_0^{Q_J+LOE_J} P_J(Q_J)\, dQ_J + \int_0^{Q_K+LOE_K} P_K(Q_K)\, dQ_K \\ &+ \left[\frac{Q_{(G-J)} + LOE_{(G-J)} - Q_J - LOE_J}{Q_{(G-J)} + LOE_{(G-J)}}\right] \times \int_0^{Q_{(G-J)}+LOE_{(G-J)}} P_{(G-J)}(Q_{(G-J)})\, dQ_{(G-J)} \\ &+ \left[\frac{Q_{(NYCA)} + LOE_{(NYCA)} - Q_{(G-J)} - LOE_{(G-J)} - Q_K - LOE_K}{Q_{(NYCA)} + LOE_{(NYCA)}}\right] \times \int_0^{Q_{NYCA}+LOE_{NYCA}} P_{NYCA}(Q_{NYCA})\, dQ_{NYCA}\end{aligned}$$





New York ISO

Recommendation

2) Determine the net CONE curve without the LOE adder in the current DCR project

Omitting the LOE adder from the net CONE curves developed in the DCR makes the revised LCR Optimizer formulation simpler.

The timing between the LCR Optimizer software revision deployment and DCR project is such that the LCR study for the 2025-26 capability year may be the first to incorporate these changes. An interim solution should not be needed.

New York ISO

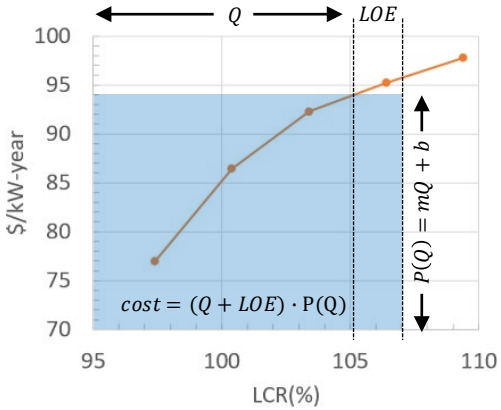
Relation between the DCR net CONE curve and LCR Optimizer

Currently, net CONE curves are defined as a function of %LCR to cost with the LOE MW adder included implicitly.

So, some of the LOE MW adder terms in the objective function are implied, but not coded, as these are “baked in” to the development of the net CONE points.

In the zone K term, cost is a function of Q (%LCR). The LOE adder is implicit to the curve.

$$\textit{Minimize: Cost of Capacity Procurement} = [Q_J + LOE_J] \times P_J(Q_J + LOE_J) + [Q_K + LOE_K] \times P_K(Q_K + LOE_K)$$
$$+[Q_{(G-J)} + LOE_{(G-J)} - Q_J - LOE_J] \times P_{(G-J)}(Q_{(G-J)} + LOE_{(G-J)})$$
$$+[Q_{NYCA} + LOE_{NYCA} - Q_{(G-J)} - LOE_{(G-J)} - Q_K - LOE_K] \times P_{NYCA}(Q_{NYCA} + LOE_{NYCA})$$



New York ISO

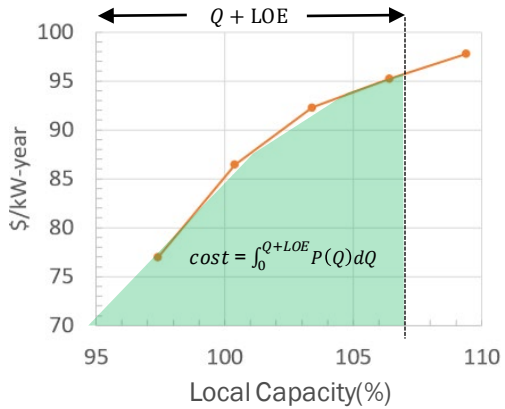
Relation between the DCR net CONE curve and LCR Optimizer

If the net CONE curve LCR points were to exclude the LOE adder in the curve development, the relation to the revised LCR Optimizer objective function is simpler to implement.

Why… because while the current optimizer can include the LOE adder in the quantity term and exclude it in the cost lookup, the new method can only include it into the integration bounds.

$$\textit{Minimize:}$$

$$\textit{Cost of Capacity Production} = \int_0^{Q_J+LOE_J} P_J(Q_J)\,dQ_J + \int_0^{Q_K+LOE_K} P_K(Q_K)\,dQ_K + \left[\frac{Q_{(G-J)}+LOE_{(G-J)}-Q_J-LOE_J}{Q_{(G-J)}+LOE_{(G-J)}}\right] \times \int_0^{Q_{(G-J)}+LOE_{(G-J)}} P_{(G-J)}(Q_{(G-J)})\,dQ_{(G-J)} + \left[\frac{Q_{(NYCA)}+LOE_{(NYCA)}-Q_{(G-J)}-LOE_{(G-J)}-Q_K-LOE_K}{Q_{(NYCA)}+LOE_{(NYCA)}}\right] \times \int_0^{Q_{NYCA}+LOE_{NYCA}} P_{NYCA}(Q_{NYCA})\,dQ_{NYCA}$$



New York ISO

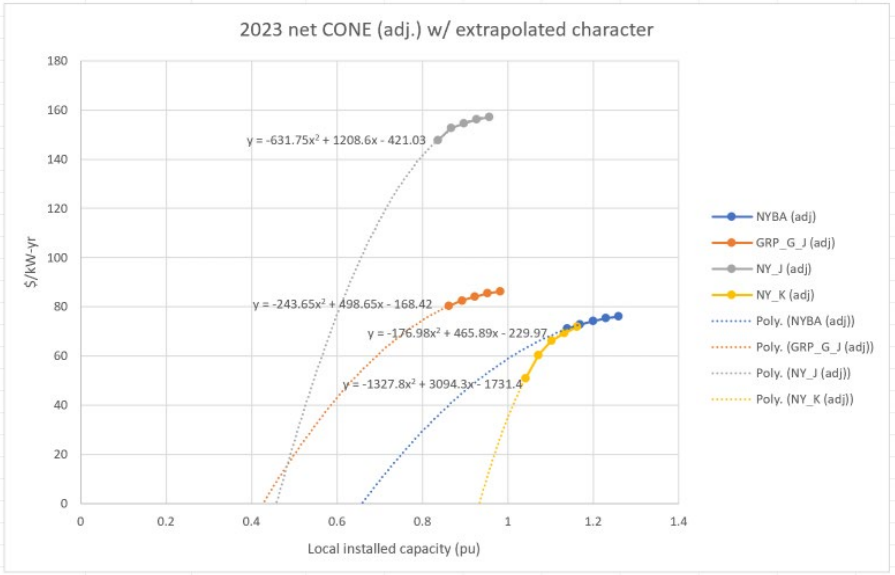
Proposal

3) Additional net CONE test points in the current DCR project

Knowing the character of the net CONE curves beyond the range of plausible LCR values becomes important with the proposed objective function modification as it is a view of total investment.

To best capture this, we plan for additional E&AS revenue modeling test points in the DCR project.

* The full shape of the net CONE may look like this.



Test Results

New York ISO

Test Results

~40 re-runs of LCR studies with various software configurations and multiple years.

Cases included relevant combinations of:

- **Objective function style**
  - Total Procurement Cost (Current)
  - Total Investment Cost
- **Treatment of undefined left-hand net CONE region**
  - Linear extrapolation from 1st 2 points
  - Constant $/kw-yr value of 1st point as a "block"
  - Define the region
- **Net CONE format**
  - Current (5 points piecewise linear)
  - Smoothed current (quadratic)
  - With/without upper bound as constraint or constant value beyond a threshold
  - Linear (linear fit of existing net CONE and approximated full curve)
  - Full curve (down to $0/kw-yr) with additional points (approximated for test)
  - With/without TSL Floors
  - With/without LOE adder
- **Capability year**
  - 2021
  - 2022
  - 2023

Recommended Solution

New York ISO

Test Results (trial – 2nd order "smoothing")

- Trial of 2nd order (quadratic) fit of the net CONE curve, with the existing objective function.
- Without an upper bound on a quadratic curve, the solver can move across the vertex making the LCRs unsolvable.
- This case did not converge.

		G to J LCR(%)	J LCR(%)	K LCR(%)
2023 net CONE smoothing	w/ TSL floor	96.9	86.1	155.4
	w/o TSL floor	Not run	-	-

		G to J LCR(%)	J LCR(%)	K LCR(%)
2023 Reference	w/ TSL floor	85.4	81.7	105.2
	w/o TSL floor	85.0	76.7	111.8

RED → TSL Floors binding

New York ISO

Test Results (trial – 2nd order "smoothing" with upper limits)

- Trial of 2nd order (quadratic) fit of the net CONE curve, with the existing objective function, and upper limiting the LCR variables with a solver upper bound to prevent going over the vertex.
- The upper bound case created acceptable results, and though it should be better conditioned in terms of local minima, it still uses the existing objective function (the total procurement cost method).

2023 smoothing w/ upper bound on LCR		G to J LCR(%)	J LCR(%)	K LCR(%)
	w/ TSL floor	85.4	81.7	105.2
	w/o TSL floor	85.9	77.3	109.7

2023 Reference		G to J LCR(%)	J LCR(%)	K LCR(%)
	w/ TSL floor	85.4	81.7	105.2
	w/o TSL floor	85.0	76.7	111.8

RED → TSL Floors binding

New York ISO

Test Results (trial – new objective w/ left-hand side treatments)

- For applying the new objective function, a method to integrate the left-hand side of the defined net CONE curve was necessary. These methods were to either apply a constant $/kw-yr value equal to the 1st net CONE point as a "block", or linearly extrapolate the LHS from the first 2 points of the curve.

2023 LHS by constant value "block" at 1st point value		G to J LCR(%)	J LCR(%)	K LCR(%)
	w/ TSL floor	85.4	81.7	108.1
	w/o TSL floor	82.8	76.2	118.7

2023 LHS by linear extrap of first 2 points		G to J LCR(%)	J LCR(%)	K LCR(%)
	w/ TSL floor	85.4	81.7	105.2
	w/o TSL floor	83.1	76.3	116.1

2023 Reference		G to J LCR(%)	J LCR(%)	K LCR(%)
	w/ TSL floor	85.4	81.7	105.2
	w/o TSL floor	85.0	76.7	111.8

RED → TSL Floors binding

- Given the criticality to capture the full shape of the net CONE with the new objective method, it was later decided to ensure that it is defined (by additional or re-positioned points).

New York ISO

Test Results (recommended method)

- This recommended method uses the new objective function (total investment cost) with fully defined net CONE curves.
- To create this case, the existing net CONE curves were assumed to have a consistent 2nd order character across the range of possible LCRs, and additional net CONE points were created.

		G to J LCR(%)	J LCR(%)	K LCR(%)
2023 (with TSL floors)	Current	85.4	81.7	105.2
	Proposed	85.4	81.7	105.2

		G to J LCR(%)	J LCR(%)	K LCR(%)
2023 (without TSL floors)	Current	85.0	76.7	111.8
	Proposed	83.1	76.7	114.1

RED → TSL Floors binding

New York ISO

Next Steps

New York ISO

Next Steps

4Q 2023

- Consumer Impact Analysis Results
- OC (for Information)
- BIC – Market Design Complete

New York ISO

Our mission, in collaboration with our stakeholders, is to serve the public interest and provide benefit to consumers by:

- Maintaining and enhancing regional reliability
- Operating open, fair and competitive wholesale electricity markets
- Planning the power system for the future
- Providing factual information to policymakers, stakeholders and investors in the power system

New York ISO