LCR Optimizer Enhancements – Update

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Agenda

- Background
- LCR Optimization
- Problem Statement/Scope
- Recommended Solutions
- Proposed Tariff Change
- Next Steps

Background

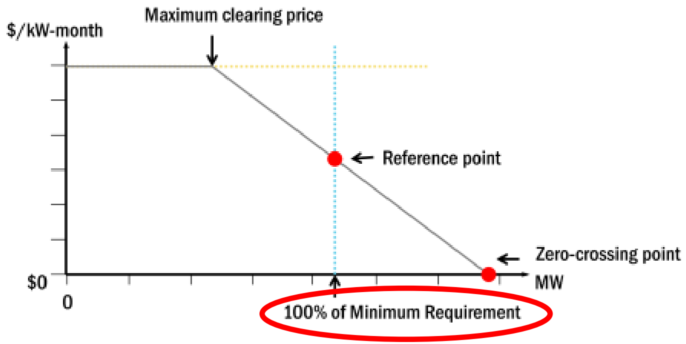
Background

- 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 New York State Reliability Council (NYSRC) approved final installed reserve margin (IRM).
- 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.

LCR Optimization

LCR Optimization

- For each Capability Year, 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 Locality Installed Capacity Demand Curves.



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LCR Optimization

- The process for determining LCRs begins after the IRM study is completed and the NYSRC has approved the IRM value for the upcoming Capability Year.

- With the IRM 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 NYSRC-approved IRM and the transmission security limit (TSL) 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-year needed to support the fixed costs of the hypothetical reference resource (i.e., the peaking plant) for each ICAP Demand Curve determined as part of the quadrennial Installed Capacity Demand Curve reset (DCR), less estimated Energy and Ancillary Service revenues earned by such resource through participation in the NYISO-administered markets.

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LCR Optimization(existing)

- The optimizer solves for the LCR values (shown as Q_j, Q_k, and $Q_{G\text{-}J}$ 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, $LOE_{G\text{-}J}$, and LOE_{NYCA} here) are the reference unit size as determined by the DCR.
- Q quantities are installed capacity in the 'at criteria' system, representing values that, at a minimum, maintain 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.

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:

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

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

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

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

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

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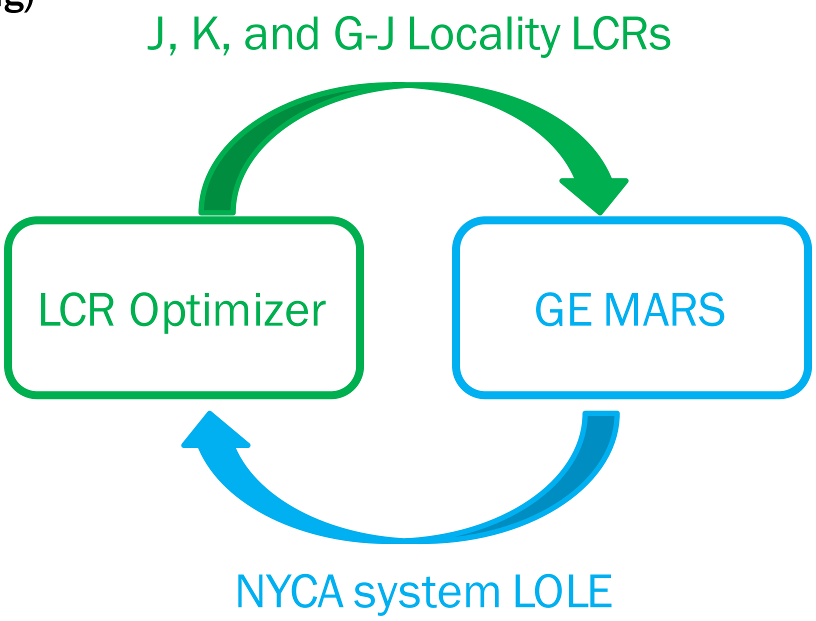
LCR Optimization(existing)

- LCR optimization is done in iteration with GE Multi-Area Reliability Simulation (MARS) runs to produce the minimum procurement cost solution for LCR values, while meeting all constraints.
- The GE 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)



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Problem Statement/ Scope

Issues Identified by MMU

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

MMU's considerations in the 2021 SOM 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 (i.e., NYCA-wide)
  - Resulting LCRs are strongly influenced by changes in the net CONE (i.e., cost) curves.
  - Updates to the cost curves can cause LCRs to change when underlying reliability values remain relatively unchanged, making the year-over-year LCRs sensitive to (and subject to variability 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

Scope

- Deliverable: 2023 – Market Design Complete

- Investigate the need for enhancements to the LCR Optimizer (and, if warranted, develop the necessary modifications) 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

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.

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Recommended Solutions

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Recommendation #1

Implement the investment cost (or ‘area under the curve’) objective function change in the LCR optimizer

This represents local installed capacity as an ‘investment’ (or supply) cost to be minimized versus the single-buyer ‘procurement’ cost. This also mathematically yields a better conditioned optimization problem and promotes more consistent results from the solver.

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Procurement to Investment Cost

What should the LCR optimization minimize?

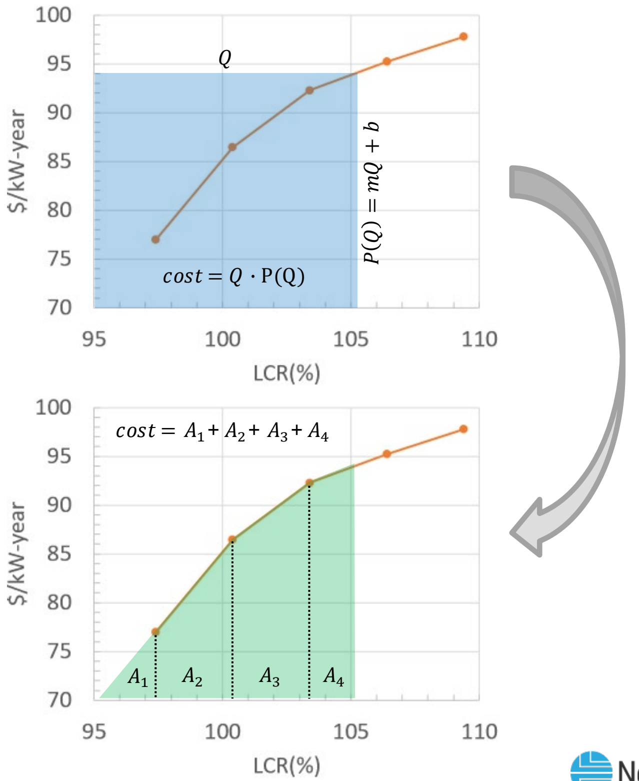
- Total Procurement Cost (Current Methodology) – Every MW of capacity is priced like the last MW. The cost from a single buyer perspective is minimized, with potential substitution of the competitive "product" (LCR) with another to minimize those costs to the buyer.

- Total Investment Cost (Proposed Enhancement) – 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 <u>the equilibrium marginal investment cost that meets the reliability metric</u>, and
- Improve solver ability to find the global minimum consistently.

An example with zone K is shown here.

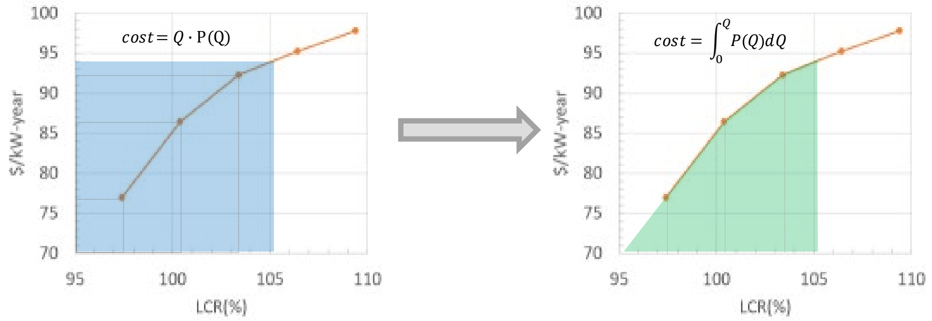


Procurement to Investment Cost

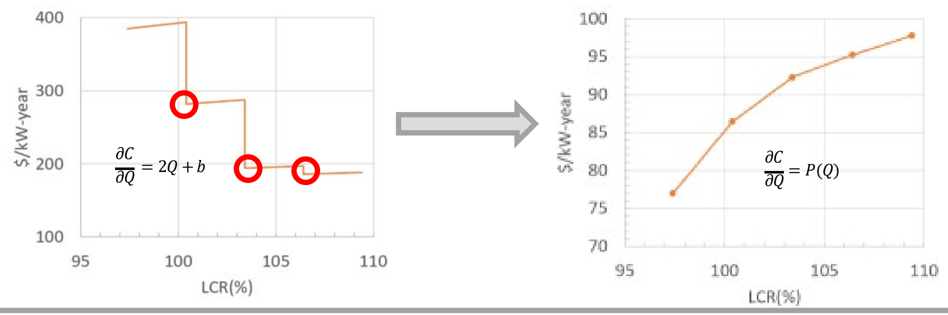
Why this is easier for the solver…

- **Looking at the marginal cost, could a solver get "stuck" seeking the solution?**
- **Procurement method (Current) → Creates discontinuities (non-differentiable) across breakpoints and the shape creates 'pockets' and multiple solutions for the same cost. <u>Local minima exist*</u>**
- **Investment method (Proposed) → 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, the effect is even more pronounced when adjusted to represent the effective cost for reliability improvement

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Procurement to Investment Cost

The proposed change to the objective function is as follows

$$\textit{Minimize:}$$

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

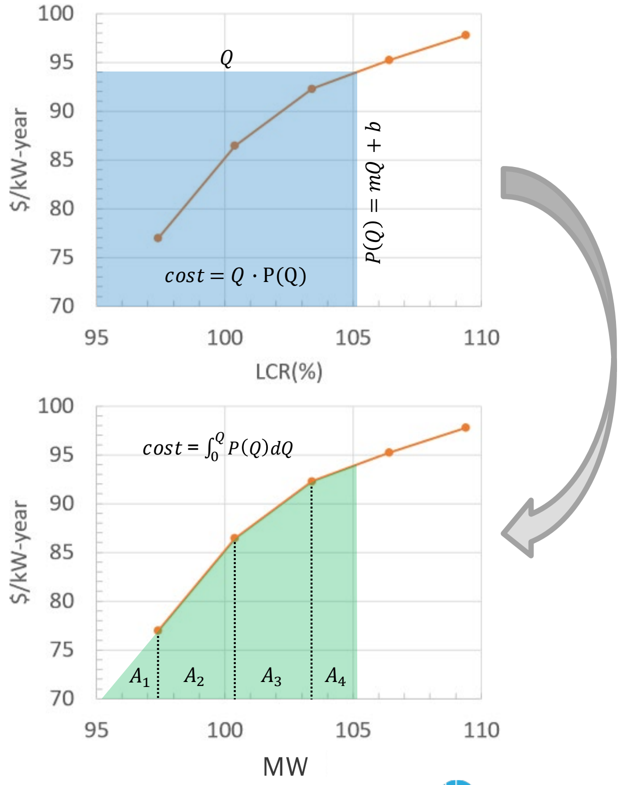
$$+[Q_{(G-J)} + LOE_{(G-J)} - Q_J - LOE_J] \times P_{(G-J)}(Q_{(G-J)} + LOE_{(G-J)})$$

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

$$OBJ = \int_0^{Q_K+LOE_K} NetCONE_K(Q_K)\, dQ_K + \int_0^{Q_J+LOE_J} NetCONE_J(Q_J)\, dQ_J$$

$$+ \int_{LOE_J}^{Q_{GHI}+LOE_{GHIJ}} NetCONE_{GHI}(Q_{GHI})\, dQ_{GHI}$$

$$+ \int_{LOE_{GHIJ}+LOE_K}^{Q_{ROS}+LOE_{NYCA}} NetCONE_{ROS}(Q_{ROS})\, dQ_{ROS}$$



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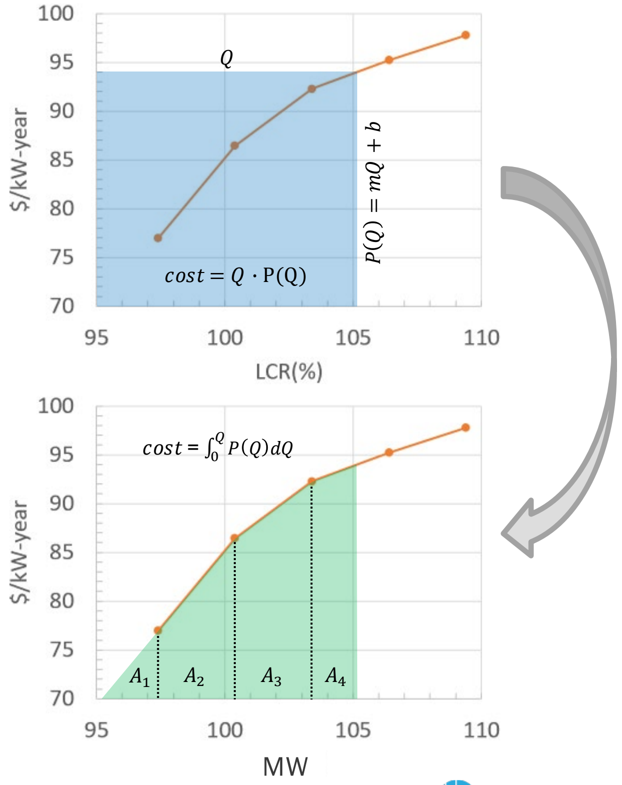
Procurement to Investment Cost

Note however that the decision variables of the problem are now Q_J, Q_K, Q_{GHI}, and Q_{ROS}.

Previously, the decision variables were aligned with the LCRs as Q_J, Q_K, and Q_{GHIJ} …with Q_{NYCA} set to the NYSRC-established IRM and treated as a static parameter.

$$OBJ = \int_{0}^{Q_K + LOE_K} NetCONE_K(Q_K)\, dQ_K + \int_{0}^{Q_J + LOE_J} NetCONE_J(Q_J)\, dQ_J + \int_{LOE_J}^{Q_{GHI} + LOE_{GHIJ}} NetCONE_{GHI}(Q_{GHI})\, dQ_{GHI} + \int_{LOE_{GHIJ} + LOE_K}^{Q_{ROS} + LOE_{NYCA}} NetCONE_{ROS}(Q_{ROS})\, dQ_{ROS}$$



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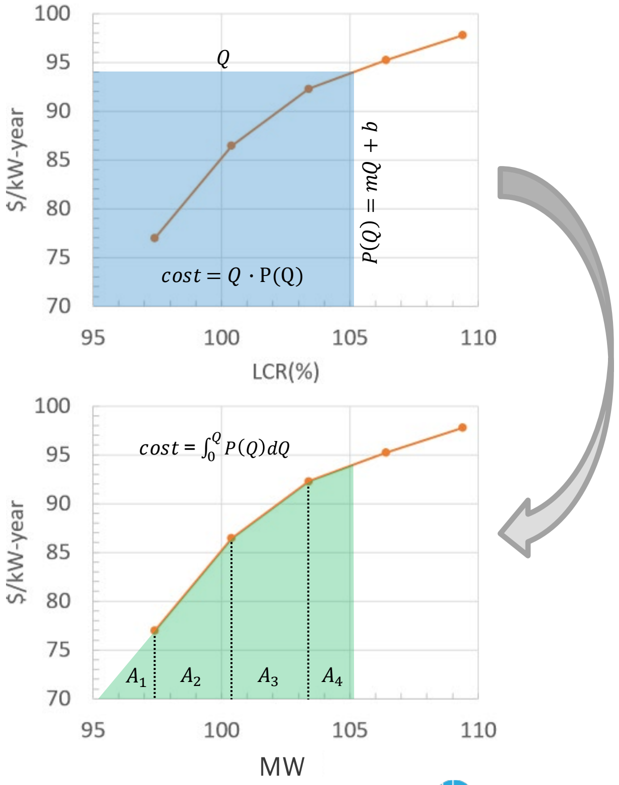
Procurement to Investment Cost

The output LCR values will reflect the following relationship to the decision variables.

- $LCR_J = Q_J$
- $LCR_K = Q_K$
- $LCR_{GHIJ} = Q_{GHI} + Q_J$

And in addition to the existing LOLE constraint, these constraints will be required...

- $Q_J \geq TSL_J$
- $Q_K \geq TSL_K$
- $Q_{GHI} + Q_J \geq TSL_{GHIJ}$
- $IRM_{NYCA} = Q_{ROS} + Q_{GHI} + Q_J + Q_K$



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Recommendation #2

Determine the net CONE curves without the LOE adder

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

The timing between the LCR Optimizer software revision deployment and 2025-2029 DCR is such that the LCR study for the 2025-2026 Capability Year may be the first to incorporate these changes. An interim solution should not be needed.

Note: Information relating to the net CONE curves for use in the LCR process is developed as part of each quadrennial DCR

Revised Net CONE Curves

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.

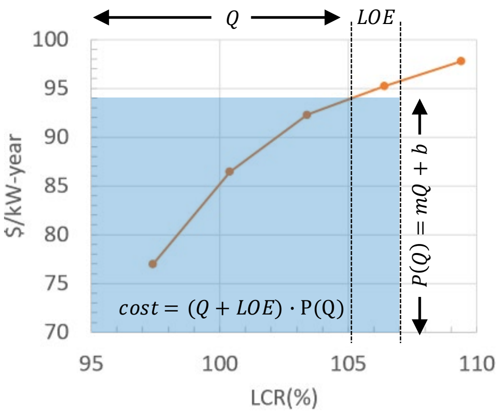
In the zone K term, cost is a function of Q (%LCR). The LOE adder is implicit to the curve.

$$\textit{Minimize:}$$

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

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

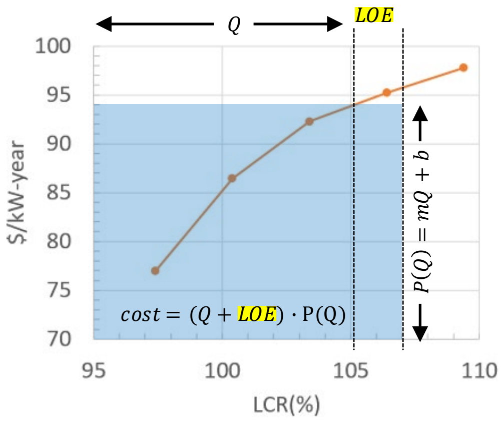
$$+[Q_{NYCA} + LOE_{NYCA} - Q_{(G-J)} - LOE_{(G-J)} - Q_K - LOE_K] \times P_{NYCA}(Q_{NYCA} + LOE_{NYCA})$$

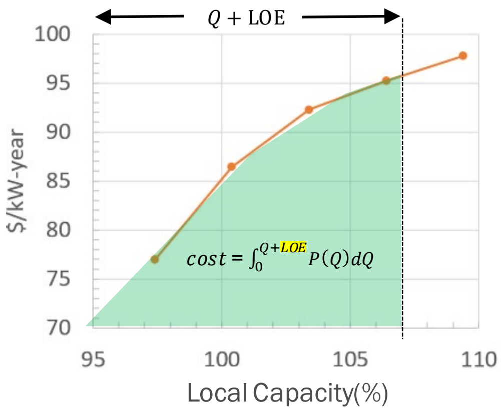


Revised Net CONE Curves (cont.)

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 <u>include</u> the LOE adder in the <u>quantity</u> term and <u>exclude</u> it in the <u>cost lookup</u>, the new method can only include it into the integration bounds.





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Recommendation #3

Development of 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 to be conducted. This additional modeling would first be performed in connection with the ongoing 2025-2029 DCR

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

Caveat

- This new LCR formulation has not been tested.
- The NYISO strives to validate the new formulation meets the goals of this project, however this will need to be confirmed with prototyping and testing.
  - NYISO will return to stakeholders with an update on these testing efforts at future ICAPWG meetings.

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Proposed Tariff Change

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Proposed Tariff Change

MST 5.11.4(a) - LSE Locational Minimum Installed Capacity Requirements

- Propose a clarifying edit to account for the proposed change to the objective function (i.e., minimizing of total investment cost instead of procurement cost).

…The ISO shall compute the Locational Minimum Installed Capacity Requirements in accordance with ISO Procedures:

(a) to minimize the total investment cost of capacity at the prescribed level of excess…

Next Steps

Next Steps

4Q 2023

- Prototyping and testing ongoing
- ICAPWG/MIWG – Provide updates regarding test results
- Consumer Impact Analysis results (Qualitative)
- OC (for informational purposes)
- BIC – Seek stakeholder approval of proposed enhancements

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Our Mission & Vision

Mission

Ensure power system reliability and competitive markets for New York in a clean energy future

Vision

Working together with stakeholders to build the cleanest, most reliable electric system in the nation

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Appendix (Net CONE curve development for testing)

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Process to Establish net CONE Curves (2021-2025 DCR)

In the 2021-2025 DCR:

- GE MAPS was used to simulate LBMPs for each hour of each year of the reset period (2021-2025) under the prescribed level of excess conditions, plus multiple points above and below such conditions (-6%,-3%,0,+3%,+6%).

- The LBMPs produced by the GE MAPS runs were used to develop level of excess adjustment factors (LOE-AFs) by taking the ratio of the average of LBMPs in the base case to the LOE cases for each capacity zone.

- The LOE-AFs are used to adjust 3-year historical LBMP input to the energy and ancillary services (E&AS) revenue model.

- The E&AS revenue model is then run for each installed capacity condition relative to LOE (-6%,-3%,0%,+3%,+6%) to determine estimated E&AS revenues for developing the net CONE curves for the various system conditions assessed.

- Gross CONE – E&AS revenues = net CONE

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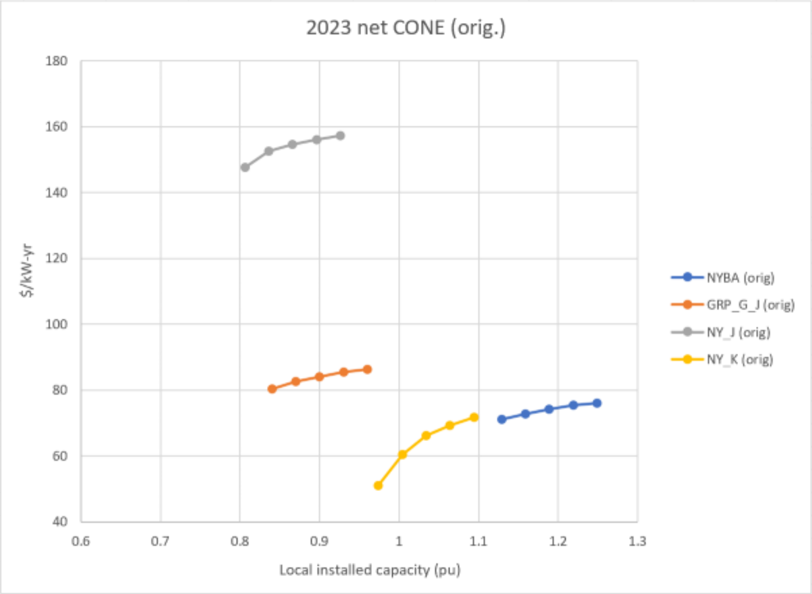
Net CONE Cost Curves – 2023-24 Values

2023 LCR study LCR-CONE-00 (original)			
Area	LOE adder	LCR(PU)	$/kw-year
NYBA (orig)	326.7	1.129	71.12
		1.159	72.75
		1.189	74.13
		1.219	75.44
		1.249	75.99
GRP_G_J (orig)	347	0.84	80.41
		0.87	82.57
		0.9	84.14
		0.93	85.58
		0.96	86.27
NY_J (orig)	348.8	0.806	147.67
		0.836	152.55
		0.866	154.53
		0.896	156.09
		0.926	157.2
NY_K (orig)	348.8	0.974	50.95
		1.004	60.42
		1.034	66.26
		1.064	69.21
		1.094	71.76



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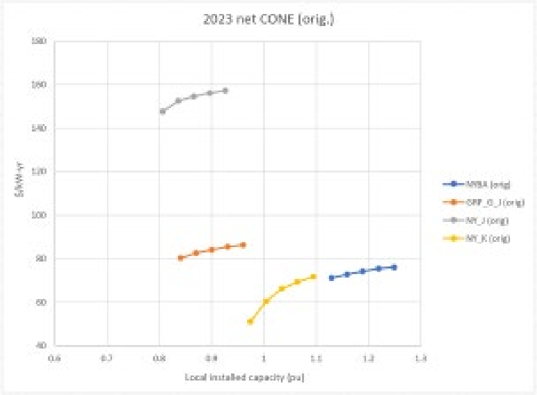
Net CONE Cost Curves for Test - Addressing the LOE Adder

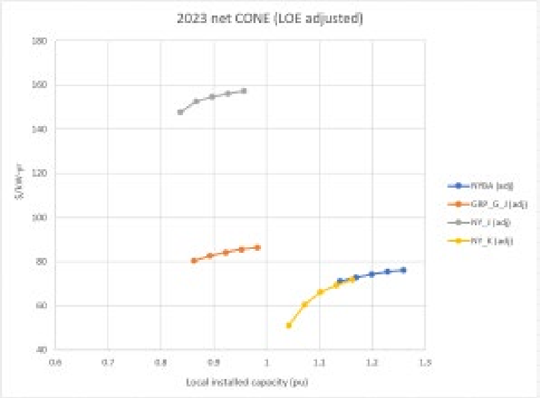
Reincorporate LOE adder…

Points shift to the right as LOE adder value is reintroduced

%new → ((%old*peak)+LOE)/peak
$/kw-yr → unchanged

2023 LCR study LCR-CONE-00 [LOE adjusted]						
Area	LOE adder	LCR(PU)	$/kw-year			peak
NYBA (adj)	326.7	1.13913149	71.12		NYBA	32246
		1.16913149	72.75		GRP_G_J	15406.8
		1.19913149	74.13		NY_J	11285
		1.22913149	75.44		NY_K	5133.3
		1.25913149	75.99			
GRP_G_J (adj)	347	0.86252252	80.41			
		0.89252252	82.57			
		0.92252252	84.14			
		0.95252252	85.58			
		0.98252252	86.27			
NY_J (adj)	348.8	0.83690829	147.67			
		0.86690829	152.55			
		0.89690829	154.53			
		0.92690829	156.09			
		0.95690829	157.2			
NY_K (adj)	348.8	1.04194849	50.95			
		1.07194849	60.42			
		1.10194849	66.26			
		1.13194849	69.21			
		1.16194849	71.76			





all curves move by LOE MW but scaling to peak is different, especially b/t K and NYBA

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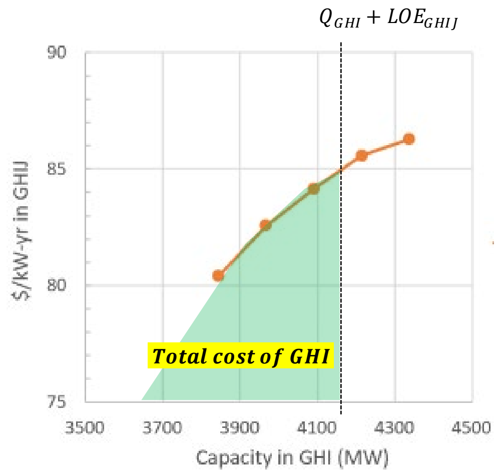
Net CONE Cost Curves for Test - Addressing Nested Zones

The proposed enhancement to address the challenge of accommodating nested zones with an investment cost method is to relate quantity in the nested zone directly to the cost of its parent zone.

This requires the net CONE curves of GHIJ (or NYCA) to be re-formatted to express the $/kW-year cost in GHIJ (or NYCA) as a function of the quantity of capacity in GHI (or ROS).

The quantity of capacity in GHI (or ROS) would also be represented in terms of MW within the nested zone.



Net CONE Cost Curves for Test- Addressing Nested Zones

Create NetCONEghi and NetCONEros…

1) Take LOE adder adjusted (re-introduced) values

2) Convert all installed capacity values to MW within the nested area

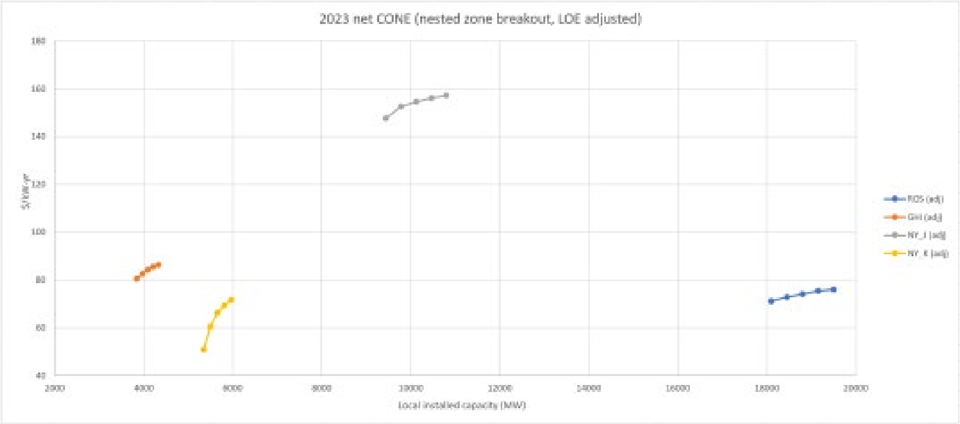
3) For each net CONE test point (i.e., -6%, -3%, center point, +3%, +6%):
   Nested zone MWs ('x' value) = Parent zone MWs less other child zone MWs
   Nested zone $/kw-yr ('y' value) = Parent zone $/kw-yr

$$NetCONE_{GHI}(x,y)[i] = (NetCONE_{GHIJ}(x)[i] - NetCONE_{J}(x)[i], NetCONE_{GHIJ}(y))$$

$$NetCONE_{ROS}(x,y)[i] = (NetCONE_{NYCA}(x)[i] - NetCONE_{GHIJ}(x)[i] - NetCONE_{K}(x)[i], NetCONE_{NYCA}(y))$$

	NYBA MW	GHIJ MW	J MW	K MW	GHI MW	ROS MW
-6%	36732.434	13288.712	9444.51	5348.634	3844.202	18095.09
-3%	37699.814	13750.916	9783.06	5502.633	3967.856	18446.26
center point	38667.194	14213.12	10121.61	5656.632	4091.51	18797.44
3%	39634.574	14675.324	10460.16	5810.631	4215.164	19148.62
6%	40601.954	15137.528	10798.71	5964.63	4338.818	19499.8

Area	LOE adder	LCR(PU)	$/kw-year
ROS (adj)	326.7	18095.0878	71.12
		18446.2648	72.75
		18797.4418	74.13
		19148.6188	75.44
		19499.7958	75.99
GHI (adj)	347	3844.202	80.41
		3967.856	82.57
		4091.51	84.14
		4215.164	85.58
		4338.818	86.27
NY_J (adj)	348.8	9444.51	147.67
		9783.06	152.55
		10121.61	154.53
		10460.16	156.09
		10798.71	157.2
NY_K (adj)	348.8	5348.6342	50.95
		5502.6332	60.42
		5656.6322	66.26
		5810.6312	69.21
		5964.6302	71.76



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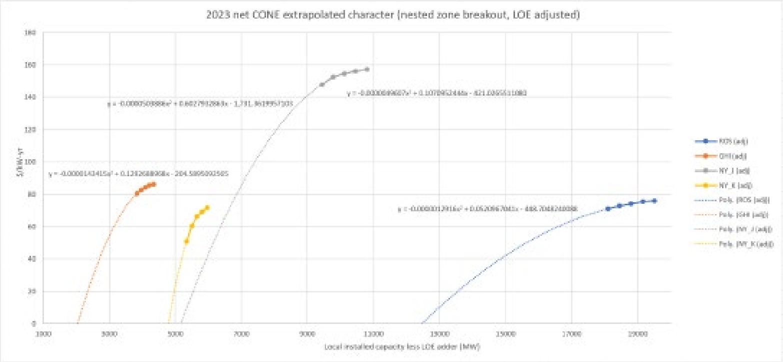
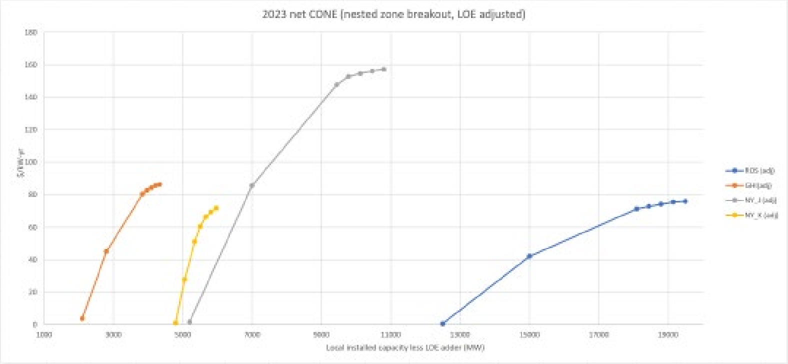
Net CONE Cost Curves for Test – Fully Define Assumed Shape

4) Add additional points to approximate character

5) Final curves for testing complete.

2023 LCR study LCR-CONE-00 (LOE adjusted, nested zone break-out, 2 new character defining points)			
Area	LOE adder	LCR(PU)	$/kw-year
ROS (adj)	326.7	12500	0.6025
		15000	42.03
		18095.0878	71.12
		18446.2648	72.75
		18797.4418	74.13
		19148.6188	75.44
		19499.7958	75.99
GHI(adj)	347	2100	3.60778
		2800	44.89672
		3844.202	80.41
		3967.856	82.57
		4091.51	84.14
		4215.164	85.58
		4338.818	86.27
NY_J (adj)	348.8	5200	1.700672
		7000	85.5257
		9444.51	147.67
		9783.06	152.55
		10121.61	154.53
		10460.16	156.09
		10798.71	157.2
NY_K (adj)	348.8	4800	1.02944
		5050	27.6440275
		5348.6342	50.95
		5502.6332	60.42
		5656.6322	66.26
		5810.6312	69.21
		5964.6302	71.76





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