LCR Optimizer Enhancements – Update
(Revision 1)

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Agenda

- Background
- LCR Optimization
- Problem Statement/Scope
- Recommended Solutions
- Update
- 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 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.

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LCR Optimization

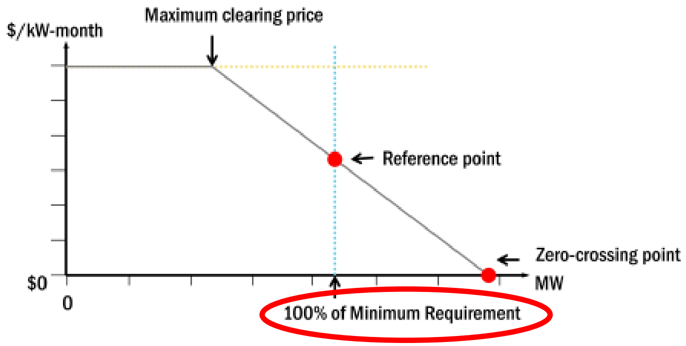
LCR Optimization

- 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.



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.

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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 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.

Minimize:

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

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

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

Subject to:

$$\text{NYCA system LOLE} \leq \text{target LOLE}$$

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

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

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

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

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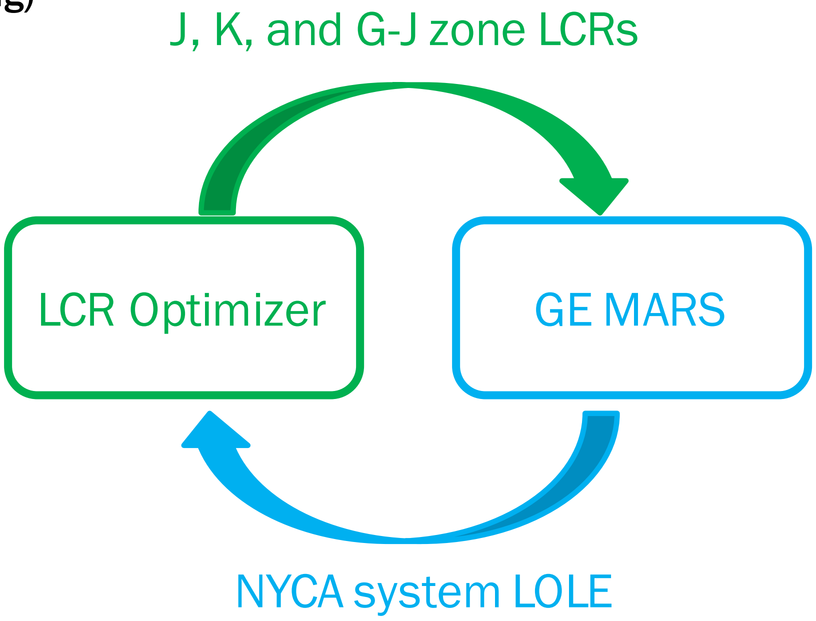
LCR Optimization(existing)

- LCR optimization is done in iteration with GE 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)



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Problem Statement/ Scope

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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

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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

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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

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**

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.

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Procurement vs. Investment Cost

What should the LCR optimization minimize?

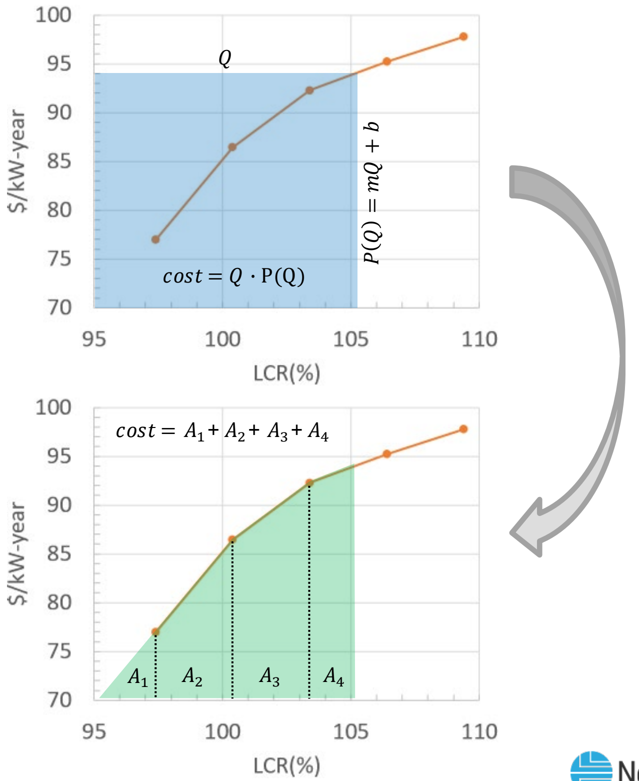
- Total Procurement Cost – Every MW of capacity is priced like the last MW. The cost from a single buyer perspective is minimized, with potential substitution of the competitive "product" (LCR) with another to minimize those costs to the buyer.

- 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.



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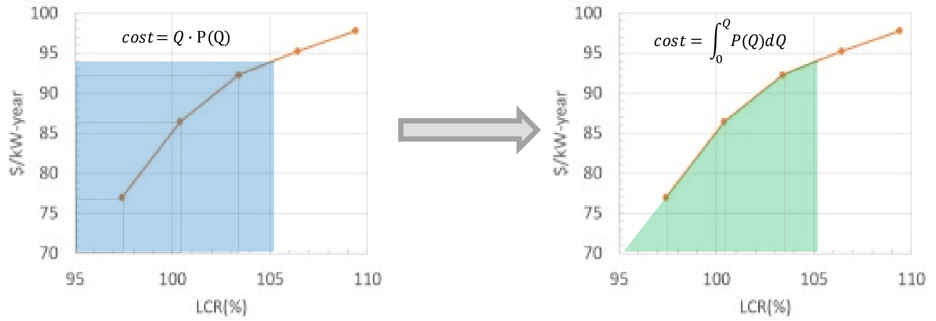
Procurement vs. Investment cost

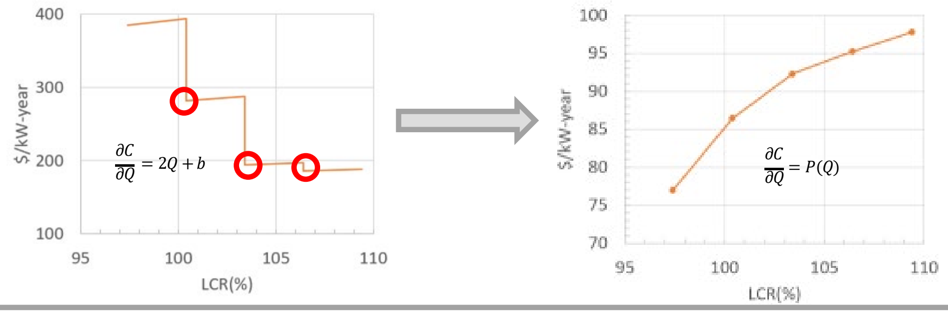
Why this is easier for the solver…

- 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

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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.

Relation between the DCR net CONE curve and LCR Optimizer

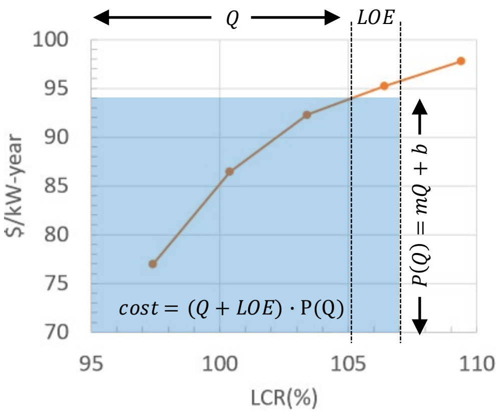
Currently, net CONE curves are defined as a function of %LCR to cost with the LOE MW adder included implicitly.

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.

Minimize:

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



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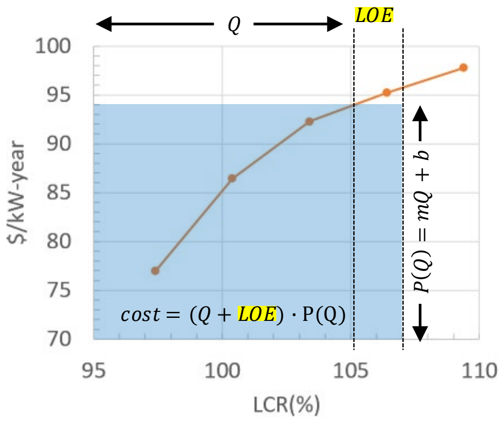
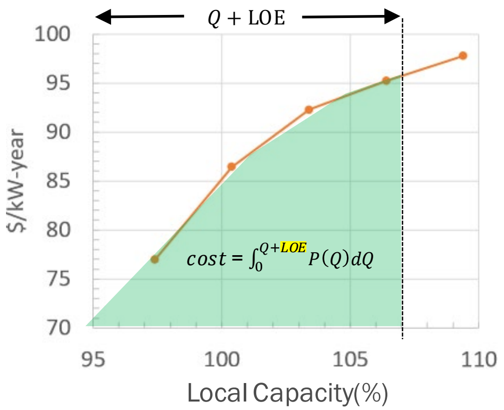
Relation between the DCR net CONE curve and LCR Optimizer

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.





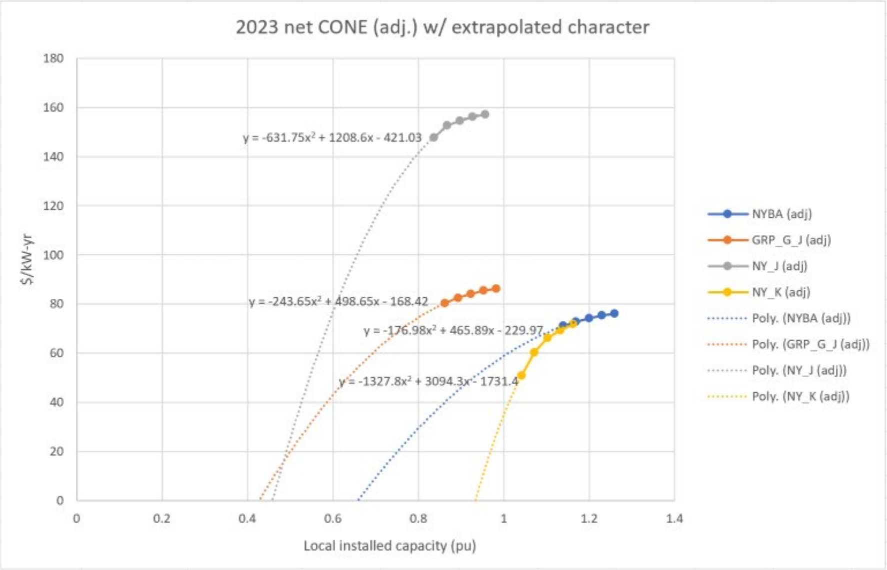
Proposal

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.



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Update

Update

Comments from MMU and Stakeholders have prompted us to revise the proposed objective function change to better represent nested zones.

- LCRs are determined for zone J, K, and GHIJ locality. The NYCA ICR is constant, set by the IRM.
- 2 nested capacity zones are represented, GHI and ROS (the combination of A,B,C,D,E,F).
- While the net CONE curves are determined for J, K, GHIJ, and NYCA, the objective rolls up cost in the non-overlapping areas where capacity is located (J, K, GHI, and ROS).
- The J and K terms are straight-forward in development of the total investment cost objective, but the GHI and ROS terms (nested within GHIJ and NYCA, respectively) require a different approach.

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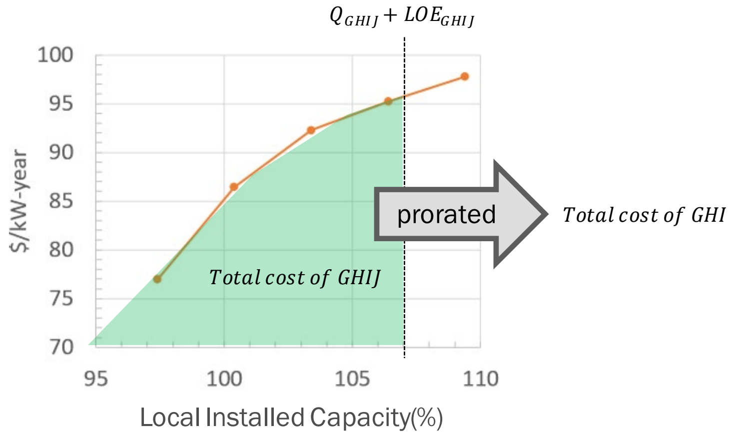
Addressing Nested Zones

<u>In the previous proposal</u> for the objective function change, the nested zones were accommodated by pro-ration of the "outer" zone's total investment cost.

For example, in the GHI term the total investment cost of the GHIJ outer zone is first determined, then this $ quantity is prorated by the ratio of GHI to GHIJ MW quantity.



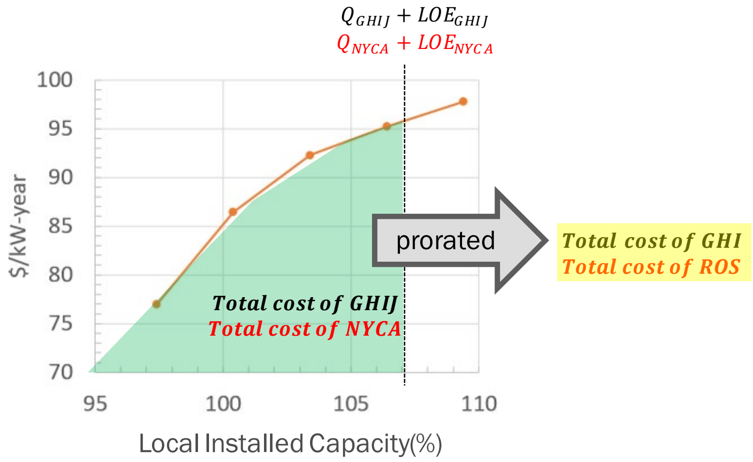
$$\left[\frac{Q_{(G-J)} + LOE_{(G-J)} - Q_J - LOE_J}{Q_{(G-J)} + LOE_{(G-J)}}\right] \times \int_{0}^{Q_{(G-J)}+LOE_{(G-J)}} P_{(G-J)}\left(Q_{(G-J)}\right) dQ_{(G-J)}$$

Addressing Nested Zones

Feedback from MMU and stakeholders is that this is an incorrect approach to handling the NYISO's nested zones, because the marginal costs for GHI do not resolve to the net CONE curve for GHIJ (and ROS as to NYCA).

As well there is the potential for the unwanted effect of child zones other than the nested zone of interest to influence the marginal cost.

For example, the marginal cost for a change in Qj is reflected in the Qj term but may also be complicated by marginal cost of the $Qghij$ term.

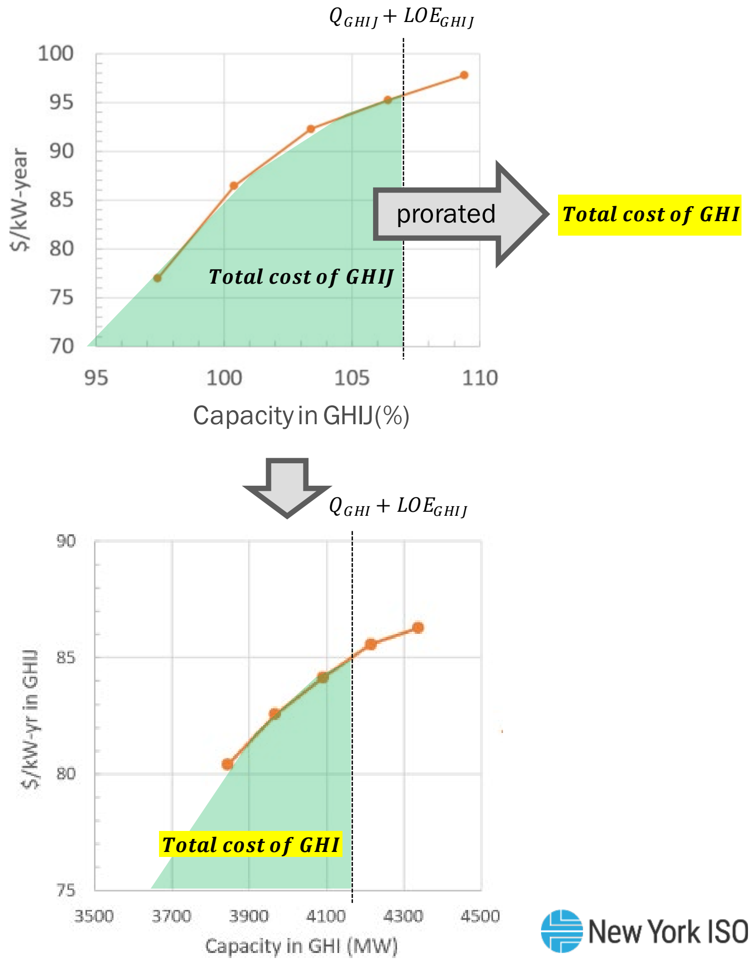


Addressing Nested Zones

Our solution 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).

As well, the quantity of capacity in GHI (or ROS) will be in terms of MWs of capacity within the nested zone.



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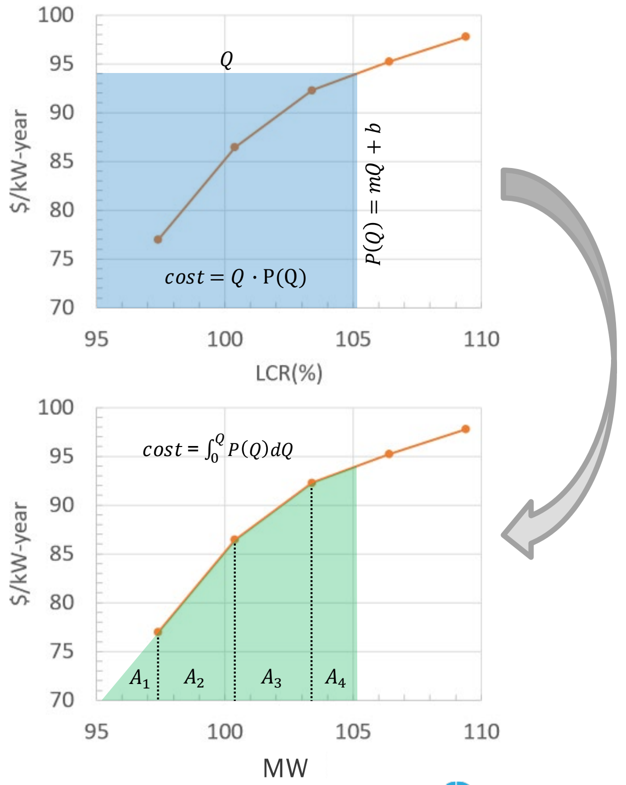
Addressing Nested Zones

The final objective function change would then be 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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Addressing Nested Zones

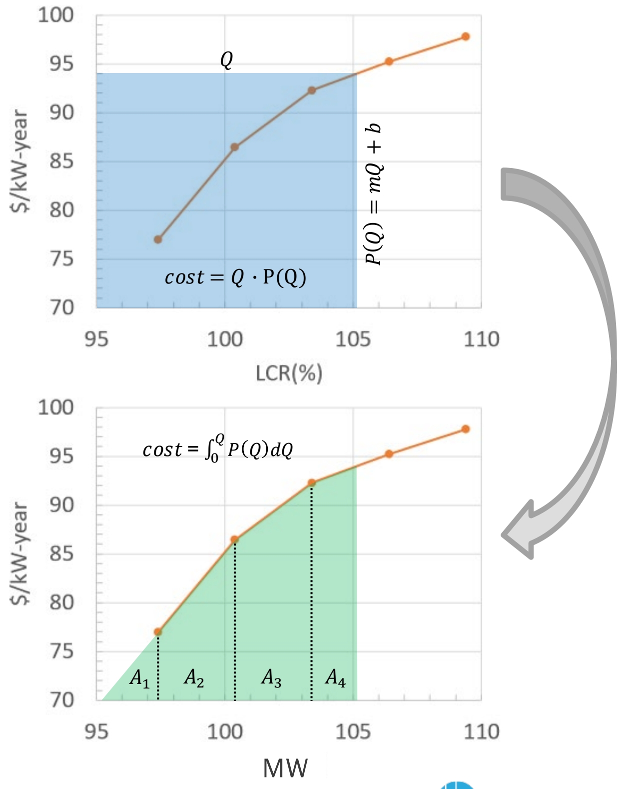
Note however that the decision variables of the problem are now Q_J, Q_K, Q_{GHI}, and Q_{ROS}.

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

$$OBJ = \int_{0}^{Q_K + LOE_K} NetCONE_K(Q_K)\, dQ_K + \int_{0}^{Q_J + LOE_J} NetCONE_J(Q_J)\, dQ_J$$

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

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



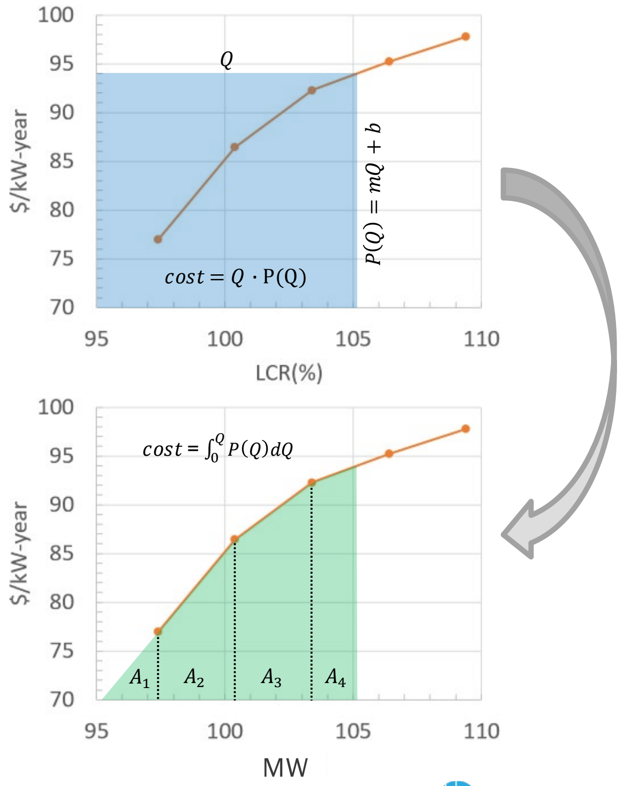
Addressing Nested Zones

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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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.

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Next Steps

Next Steps

4Q 2023

- Begin prototyping and testing

- MIWG – Share test results
- Consumer Impact Analysis Results
- OC (for Information)
- BIC – Market Design Complete

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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

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