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Independent System Operator

LCR Optimizer Enhancements - Update

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Agenda

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- LCR Optimization
- Problem Statement/Scope
- Scope detail
  - Objective function
  - Net CONE (cost) curves
- 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

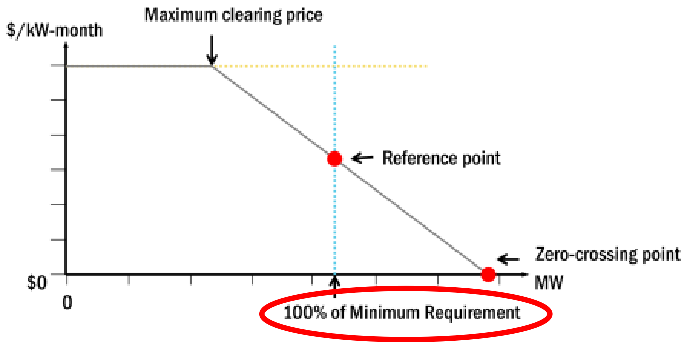
LCR Optimization

- 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.



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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

- 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.

$$\text{Minimize:}$$

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

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

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

$$\text{Subject to:}$$

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

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

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

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

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

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LCR Optimization

- 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

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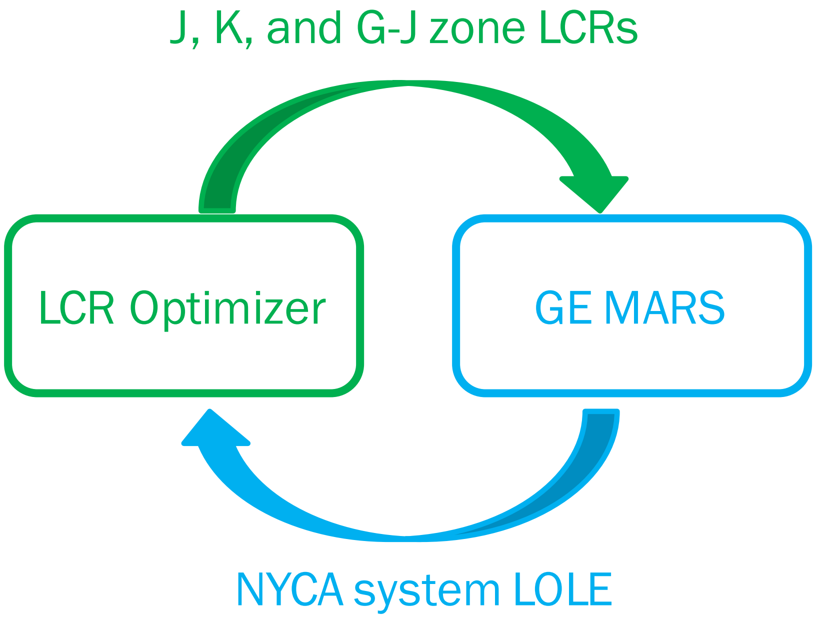
LCR Optimization

- 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)



Problem Statement/ Scope

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 cost instead of marginal production costs
  - Potential misalignment with the capacity demand curves
  - Potential misalignment with the IRM process

Scope

- Deliverable: Q3 2023 – Market Design Complete

- Investigate the need for and develop and 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 this summer (separately from this project).

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Scope Detail

Objective Function

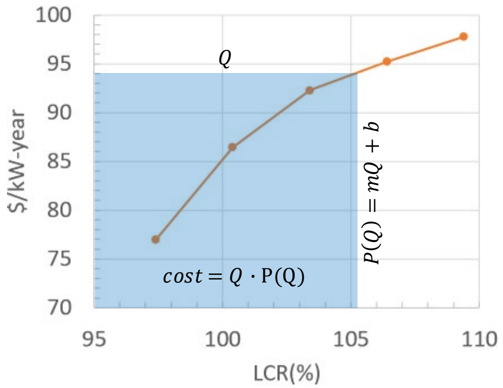
Production vs. Procurement cost

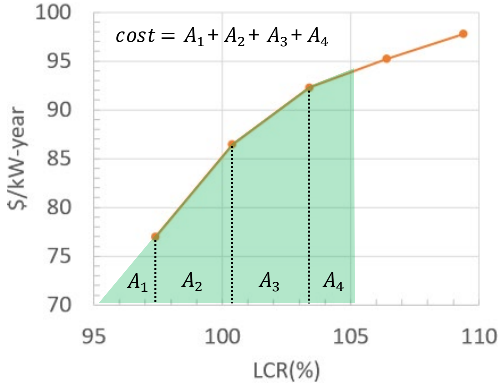
What should the LCR optimization minimize?

- Total "procurement" cost – Every MW of capacity is priced like the last MW.
- Total "production" cost – A rollup of incremental cost (area under the curve).
    - *The terms "procurement" and "production" refer to style of accounting for costs in the objective function, where capacity provided by the LCR is analogous to a product that has an associated cost to produce.*

The LCR Optimizer minimizes total procurement cost today, but minimizing total production cost is more appropriate for characterization of costs in an optimization and lends to finding the global minimum consistently. It may also avoid the need for any "smoothing" treatment of the net CONE curves.

An example with zone K is shown here.





Marginal Cost Curves

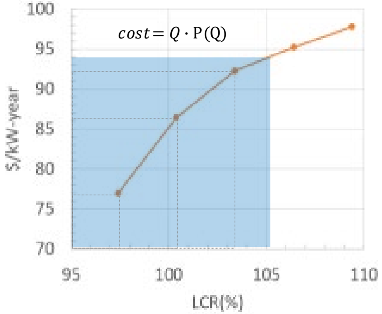
What's the difference?

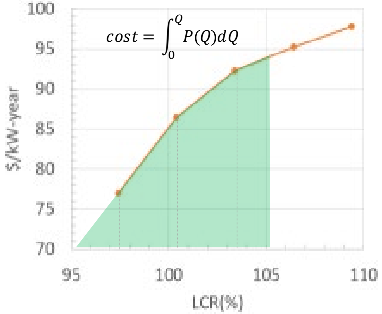
- In both methods, the optimization seeks the minimum total cost solution to setting LCRs.
- To examine the incremental effect of one LCR on total cost, we can look at the marginal cost curves (how much total cost changes with an increment of an LCR).

- Procurement method → Discontinuous (non-differentiable) across breakpoints.

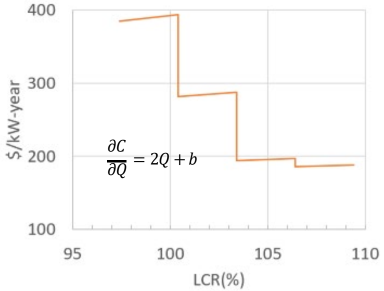
- Production method → solves back to the net CONE curve itself.

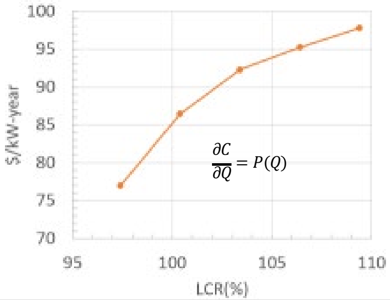
Net CONE curves and the method used in the objective to total-up costs (shaded area)





The resulting marginal cost curves





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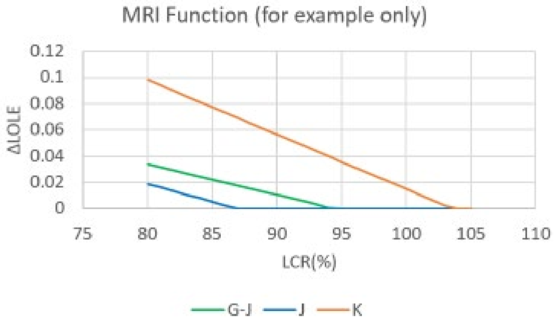
Production vs. Procurement cost

- Now, consider that we wish to find the minimum total cost solution that yields the target LOLE.
- The relationship between the change in LCRs and change in LOLE is not directly defined as it requires a separate Resource Adequacy model to determine… but assume we can estimate this for purposes of explanation.
- The Marginal Reliability Impact (MRI) describes the marginal effect of an amount of capacity on Resource Adequacy metrics, or ΔLOLE/ΔICAP.
  - These values are interpreted from MMU's 2021 SOM Report, but the general assumption that increasing LCR results in decreasing ΔLOLE results in the same conclusion for this example.

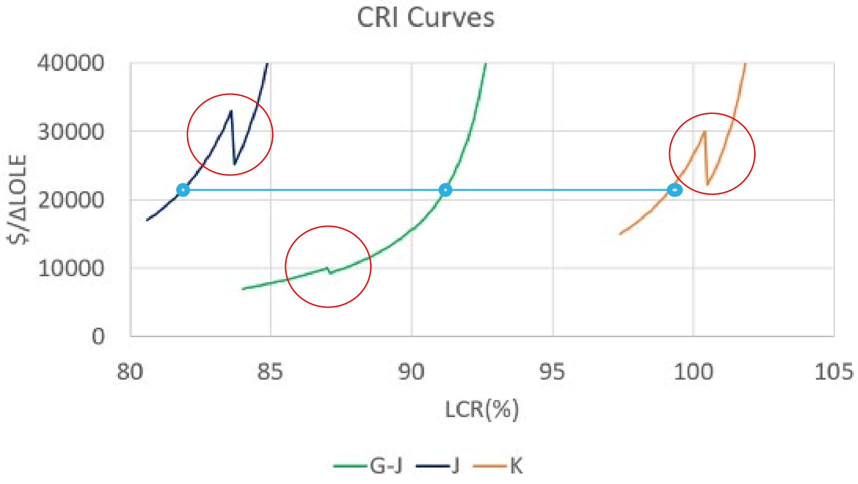


Production vs. Procurement cost

- A Cost of Reliability Improvement (CRI) in $/ΔLOLE can be theorized by looking at the marginal $/ΔICAP curves, divided by the estimated MRI (ΔLOLE/ΔICAP).

- The optimal condition is the lowest, balanced $/ΔLOLE that meets the target LOLE constraint.
  - Excluding the effect of TSL floor lower bounds.

→ Potential for instability and solving to a local minimum (versus the true global minimum). The proposed re-formulation will remove these discontinuities.



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Production vs. Procurement cost

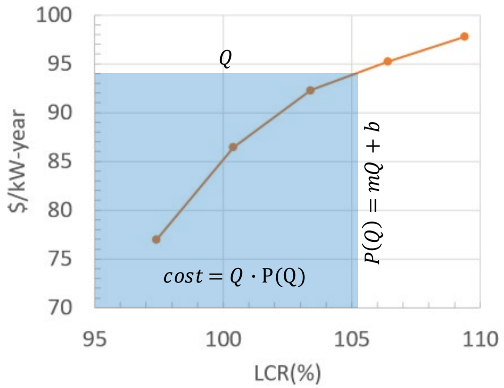
Changing the rollup of cost in the objective…

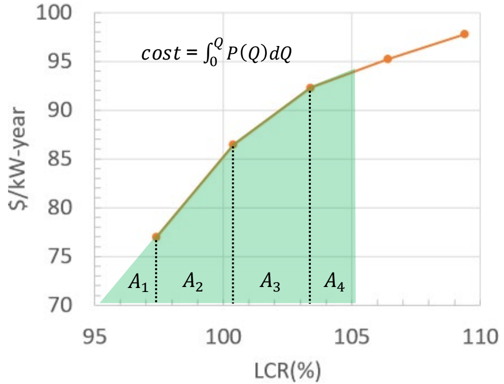
$$\text{Minimize:}$$

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

$$\text{Minimize:}$$

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





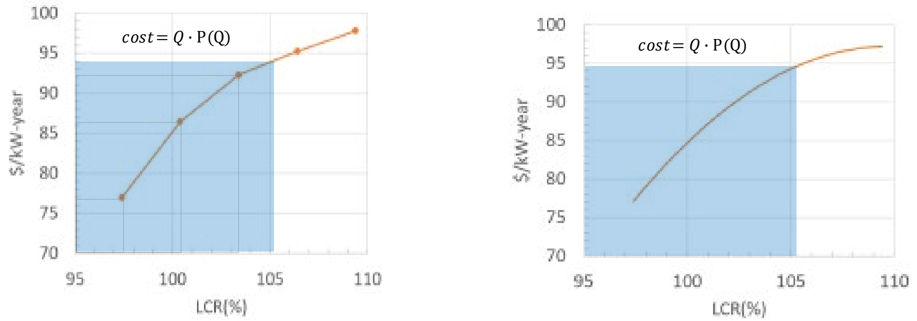
Scope Detail

Net CONE (cost) curves

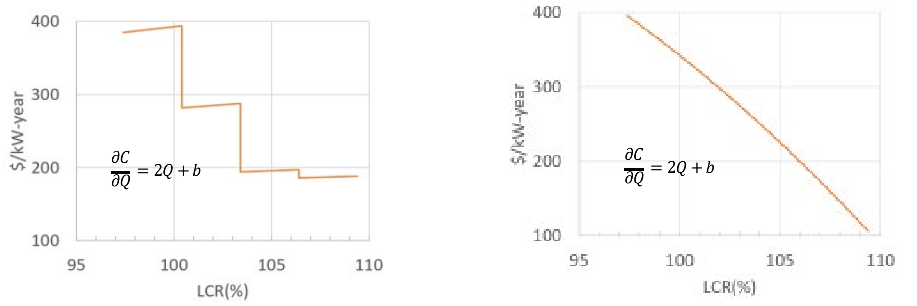
Net CONE curve "smoothing" alternative

- Recall that the marginal cost curves have discontinuities that create an issue with convergence to the global minimum.
- These are a function of the method by which cost is 'rolled-up' in the objective, and the abrupt change in slopes that are non-differentiable.
- An alternative to changing the entire objective is "smoothing" the net CONE curves (with a 2nd order polynomial fit or similar).

Existing net CONE curve (left), and a 2nd order polynomial fit (right)



The resulting marginal cost curves…



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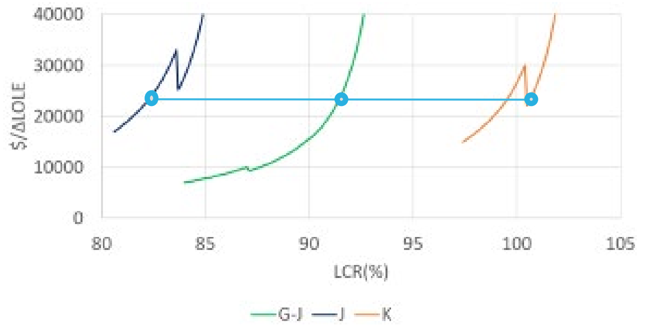
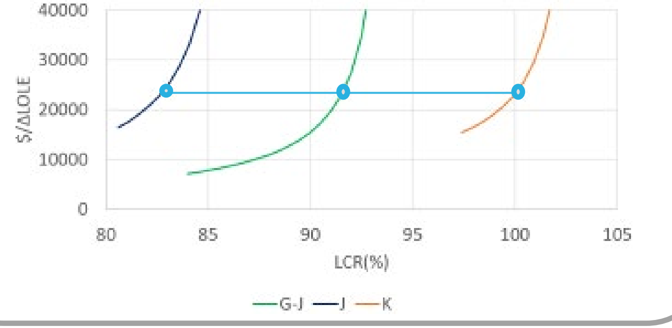
Net CONE curve "smoothing"

- The result of this treatment is Cost of Reliability Improvement curves without the local minima as seen before, which lends to consistently finding the global optimum.
- This is an alternative to the objective re-formulation concept that addresses some of the same concerns.

Example CRI curves with existing methods



2nd order polynomial smoothing applied



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GE Engagement Update

- NYISO has contracted GE Energy Consulting group to prototype and test the proposed objective function update and cost curve ‘smoothing’ alternative, work on both is in progress.
- When conclusive, results of the testing will be shared with Stakeholders.

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Next Steps

Next Steps

- Q2/3 2023 – ICAPWG/MIWG
  - Updates on external engagement with GE and tariff reviews

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- 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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