Attachment II

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

New York Independent System Operator, Inc.) Docket No. ER18-1743-000

AFFIDAVIT OF
WESLEY HALL

I. Purpose of this Affidavit

1. The purpose of this affidavit is to support the New York Independent System Operator, Inc. ("NYISO") *Responses to July 10, 2018 Deficiency Letter* submitted in this proceeding ("NYISO Response") and in support of the proposed revisions to Section 5.11 of the NYISO Market Administration and Control Area Services Tariff ("Services Tariff") to modify the methodology by which the Locational Minimum Installed Capacity Requirement ("LCR") for each Locality will be established.[1] This "Alternative LCR Methodology" was originally filed with the Commission on June 5, 2018.[2]

2. Specifically, the NYISO Response provides: (a) an overview of the considerations that caused the NYISO to evaluate and develop the Alternative LCR Methodology and (b) the stakeholder process and analyses undertaken to develop the Alternative LCR Methodology.

II. Qualifications

3. I am presently employed within General Electric International, Inc. as a Principal Consultant in the Power Systems Strategy group for GE Energy Consulting ("GE Energy Consulting" or "GE"). In this capacity, I participated directly in (a) the review of the concerns arising with

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[1] Capitalized terms that are not specifically defined in this Affidavit shall have the meaning set forth in the NYISO Response or, if not defined therein, the meaning set forth in the Services Tariff.

[2] *New York Independent System Operator, Inc.*, Proposed Tariff Revisions To Determine Locational Minimum Installed Capacity Requirements, Docket No. ER18-1743-000 (June 5, 2018) ("NYISO June 5th Filing")

the current methodology for determining LCRs (*i.e.*, this methodology is commonly referred to as the "Tan 45 Method" or "Unified Method" and is described in Appendix A of New York State Reliability Council, L.L.C ("NYSRC") Policy 5-13);[3] and (b) the development of a comprehensive approach to determining LCRs for any set of Localities that considers the costs of investment in each Locality, which became the NYISO's proposed Alternative LCR Methodology.

4. In addition to my role as a Principal Consultant, I am also the Product Leader for GE's Multi-Area Reliability Simulation software program ("GE MARS"). In this capacity I have supported the use of GE MARS for resource adequacy studies worldwide. My expertise includes software development; economic and reliability planning studies regarding the impact of state and federal environmental regulations; capacity market design and analysis; natural gas and electric system coordination; and production cost and resource adequacy modeling.

5. In my current capacity at GE Energy Consulting, I am responsible for supporting the GE MARS work annually conducted by the NYISO and the Installed Capacity Subcommittee ("ICS") of the New York State Reliability Council ("NYSRC") for the annual development of the New York Control Area ("NYCA") Installed Reserve Margin ("IRM"). I also supervise the team that developed the programs used to perform the economic optimization consistent with the NYISO's proposed Alternative LCR Methodology design principles.

6. My recent projects have focused on resource adequacy modeling using GE MARS that impact several capacity market design enhancements being studied by the NYISO. I have led studies to determine the market impacts of capacity sales out of Localities to External Control

[3] NYSRC Policy 5-13 is available on the NYSRC website, www.nysrc.org, under Documents/Policies.

Areas, as well as continuing to assist the NYISO in analyzing the proposed Alternative LCR Methodology. Recently, I led GE Energy Consulting's involvement in the "New York State Resource Planning Analysis" working with the New York State Transmission Owners, NYISO, the New York State Energy Research and Development Authority, New York State Department of Public Service, and Utility Intervention Unit of the New York Department of State's Division of Consumer Protection. This work assessed the impacts of various resource mixes on bulk electric system reliability, prices, and emissions assuming business as usual conditions as well as achievement of New York State's Clean Energy Standard.[4] I have significant experience in analyzing the New York State Power System and working with NYISO stakeholders.

7. Prior to joining GE Energy Consulting, I was a planning engineer at the NYISO between 2010 and 2013. In this role, I was focused on determining the system-wide benefits of relieving transmission congestion, as well as economic and reliability analysis of state and federal environmental regulations.

8. I hold a Bachelor's Degree in Environmental Engineering from Clarkson University.

III. Role in Support of the Proposed Alternative LCR Methodology

9. The primary task for GE Energy Consulting, when it was engaged by the NYISO in this effort beginning in January 2016, was to develop an economic optimization software program that would establish a least cost solution for determining LCRs considering the cost of new entry information developed by the NYISO in establishing the ICAP Demand Curves. GE Energy Consulting assisted in the preparation and review of NYISO materials that were

[4] *See* NYPSC Case 15-E-0302, *Proceeding on Motion of the Commission to Implement a Large-Scale Renewable Program and a Clean Energy Standard*, Order Adopting a Clean Energy Standard (issued and effective August 1, 2016.).

produced for discussion at various NYISO stakeholder committees and working groups beginning in late 2016 through February 2018 related to the development of the Alternative LCR Methodology. I was present at several of these meetings and several meetings of the NYSRC's ICS, where the NYISO discussed this work.

10. At the outset of the project, the NYISO required that the optimization operate under two specific constraints. Fundamentally, the optimization software must produce capacity requirements that meet the 0.1 day per year loss of load expectation ("LOLE"). Second, the economic optimization must be able to optimize using a fixed IRM as established by the NYSRC and the corresponding GE MARS database or "IRM Database." The NYISO further directed that the tool should be robust enough to actually optimize both the IRM and LCRs together as well as operate with any possible configuration of Localities to address the potential for future changes to the system.

11. I acted as the primary developer of the software to meet the NYISO's specifications. Completion of optimization software tool for initial testing occurred in the fall of 2016.

12. The optimization uses the Constrained Optimization by Linear Approximation ("COBYLA") algorithm available through Python's scientific computing package for the linear programing optimization. As designed, the optimization program works with GE MARS to solve for the set of LCRs that result in the least cost solution while achieving the 0.1 day/year LOLE requirement. The linear programming optimization model solves the cost minimization function, which is specified on pages 3 through 5 of Exhibit 1 provided with this Affidavit and discussed in more detail in the NYISO's Response, while maintaining the 0.1 day per year LOLE. The optimization achieves this objective by working with GE MARS iteratively to generate LCR combinations that reduce the cost of capacity at the level of excess

conditions utilized in establishing the ICAP Demand Curves (“Level of Excess”) while not violating any fixed constraints (*i.e.*, LOLE). The optimization program stops iterating with GE MARS when the change in the LCRs between two subsequent iterations is less than the user defined stopping criteria.

13. The LCRs that are specified by the Alternative LCR Methodology are provided without any rounding. I have confirmed that under these conditions, the 0.1 days per year LOLE was maintained when optimizing the LCRs using the proposed economic optimization algorithm in the proposed Alternative LCR Methodology. For example, the 2018/2019 LCRs determined using the Alternative LCR Methodology are 79.7% for the New York City (“NYC”) Locality, 107.5496% for the Long Island (“LI”) Locality, and 90.82415% for the G-J Locality. These values are exactly the same as output from the optimization software without rounding. Rounding these LCR values would result in small differences to the final LOLE.

14. After the optimization program was developed, I ran numerous additional sensitivity analyses at the direction of the NYISO to test the tool against the market design principles that were established by the NYISO at the outset of the stakeholder process. The established market design principles for the Alternative LCR Methodology require that it be cost effective and robust while also enhancing the transparency, predictability and stability of the annual LCR determinations. A cost effective design produces the necessary prices signals to attract and retain the resources necessary to maintain a reliable system while it also minimizes costs. A robust design creates a process that works consistently over a wide range of changing system conditions, including the potential for changes to the configurations of Localities. To build additional transparency into the process, the design should avoid unnecessary complexities

and be able to be conducted in a manner consistent with the current approach used to determine the IRM. Enhancing the predictability and stability of the LCR determinations requires the design to respond appropriately to changes in assumptions in a manner that is understandable in both the direction of shifting requirements as well as the changes to megawatt values of the shifting requirements in response to the corresponding system changes. The sensitivities presented in the NYISO stakeholder process demonstrate that the Alternative LCR Methodology minimizes costs at the prescribed Level of Excess while meeting the LOLE criteria. The robustness of the methodology is demonstrated by its ability to produces LCRs for any configuration of Localities. Another example of the robustness of the design is that the optimization software can optimize LCRs with a fixed IRM, as set by the NYSRC, or be run to optimize both the IRM and the LCRs together should the NYSRC approve such a change to their IRM setting process in the future. The optimization software's capability to produce a least cost solution while also being able to implement additional discrete constraints on the LCR results provides further evidence of its flexibility and robustness. This was demonstrated by the design's ability to readily integrate transmission security limits into the process. Transparency was a guiding principal throughout the market design effort, as evidenced by the number of sensitivities run and presented to stakeholders. The Alternative LCR Methodology readily lends itself to the current processes of evaluating a base case set of assumptions as well as producing a large number of results for sensitivities and will be valuable throughout the process conducted by NYSRC's ICS to establish the annual IRM. The numerous sensitivities run throughout the course of the market design effort also demonstrate that the design enhances the predictability and stability of LCR determinations. It minimizes the variability associated with the generator entry and exit assumptions that have been observed with the current Tan 45 Method, while demonstrating an appropriate sensitivity to drivers such as changes in transmission topology, load, and net cost of new entry ("CONE") values.

15. In support of the Alternative LCR Methodology, the sensitivity analyses were run using both the 2017/18 IRM database to test and refine methodology, as well as the 2018/19 IRM database to finalize the design. These simulations validated that the proposed Alternative LCR Methodology would produce an optimal distribution of capacity across Localities. These simulations considered the potential impacts of numerous factors, including but not limited to: changes in the system resource mix, changes in the net cost of new entry values, changes in transmission system topology and limitations, and changes in the IRM.

16. As part of the effort to develop an Alternative LCR Methodology, I worked with the NYISO to understand the concerns observed with the current Tan 45 Method. Section 3.4.1 of the NYSRC's Policy 5 provides the following summary of the Tan 45 Method.[5] "The procedure utilized for establishing NYCA IRM requirements is termed the *Unified Method* because it provides a coordinated approach that can also be used by the NYSO for its analysis of the Locational Capacity Requirements (LCRs). The Unified Method reflects a graphical relationship between the NYCA IRM and the LCRs as depicted in Figure 3-2 [below]. Under this method capacity is removed from zones west of the Central-East interface that have excess capacity when compared to their forecast peaks until a study point IRM is reached. At this point, capacity is shifted from Zones J and K into the same zones as above until the 0.1 LOLE criterion is violated. Doing this at various IRM points yields a curve such as depicted in Figure 3-2, whereby all points on the curve meet the NYSRC 0.1 days/year

[5] NYSRC Policy 5-13 is available on the NYSRC website, www.nysrc.org, under Documents/Policies.

LOLE criterion. Furthermore, all LCR "point pairs" for NYC and LI curves along the IRM axis represent a 0.1 LOLE solution for NYCA."

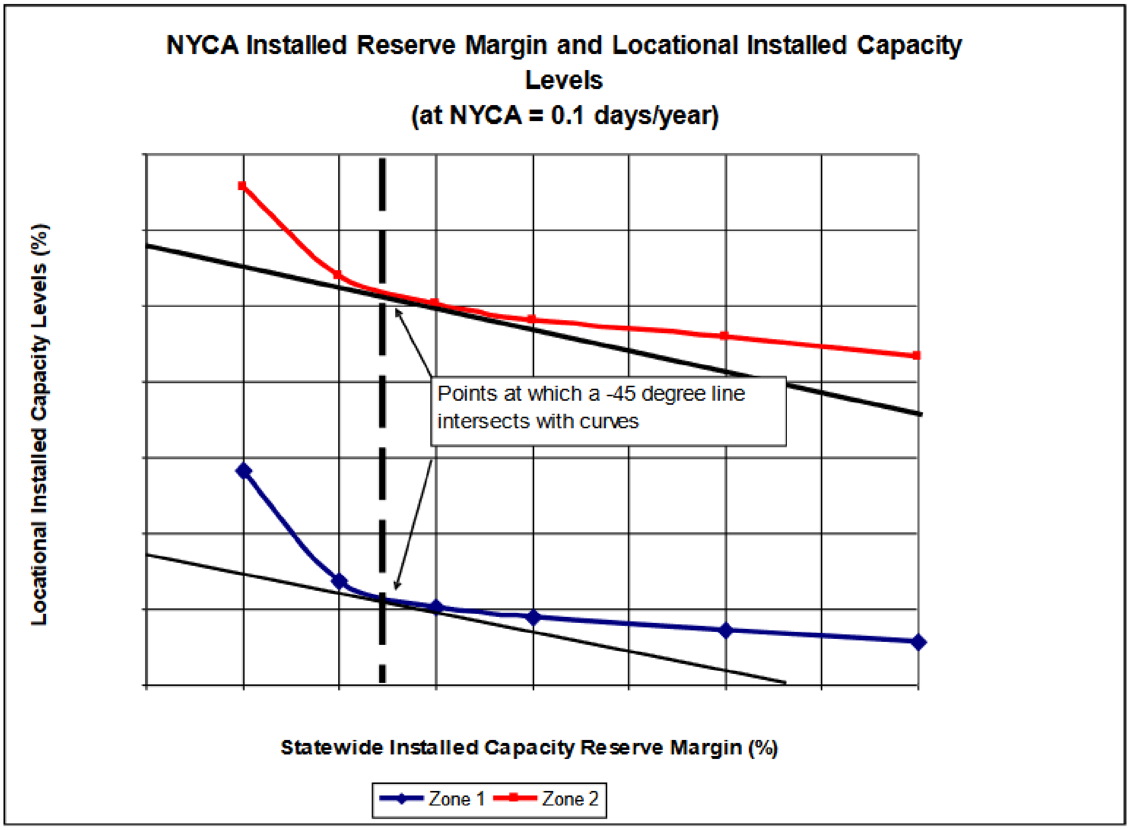

Figure 3-2: Unified Curve and IRM Anchor Point

17. I worked with the NYISO to develop a set of simple numerical examples to present to stakeholders to explain how generator exit and entry decisions using the Tan 45 Method resulted in highly variable results that were not correlated with the generator exit or entry. These examples illustrate how, mathematically, the shifting methodology prescribed in the Tan 45 Method was a significant factor in the historical variability of LCRs. As described in NYSRC's Policy 5 and discussed further in the NYISO Response, the Tan 45 Method was developed and originally applied to just the NYC and LI Localities. During the

implementation of the G-J Locality, the NYISO created an additional step to shift megawatts out of the G-J region in order to calculate a G-J LCR. This additional shift is a step that occurs after the Tan 45 Method, as described in Policy 5, is conducted to establish the LCRs for the NYC and LI Localities.[6] As such, the hierarchical shifting protocols prescribed by the Tan 45 Method for the NYC and LI Localities (and ultimately the post hoc shift for the G-J Locality that was put in place when this new Locality was implemented in 2014) are observed to drive LCR volatility in response to generator entry and exit. This undue variability in response to generation exit and entry is discussed throughout the NYISO Response. It is readily observed in the NYSRC IRM Reports and the NYISO LCR studies conducted in 2012, 2013, 2014 and 2015 in relation to the modeling of the Danskammer facility.

18. These numerical examples, initially presented by the NYISO and GE at the February 15, 2017 Installed Capacity ("ICAP") Working Group meeting, demonstrate how the variable LCR results that are highly correlated with generator exit and entry are driven by the Tan 45 Method's protocol for determining the fixed ratio to simultaneously shift generation out of NYC and Long Island. This shift ratio is dependent on the ratio of the excess capacity in each Load Zone, which can change significantly in the annual LCR determinations as new generators are added to a Locality or existing generators exit. The additional *post hoc* shifting protocol for the G-J Locality in the current Tan 45 Method exacerbates this undue variability when adding or subtracting capacity from any of the three Localities.

[6] The full description of the steps taken when determining the LCRs in NYISO's Locational Capacity Requirement Calculation Process, which is posted on the NYISO website. http://www.nyiso.com/public/webdocs/markets_operations/market_data/icap/Reference_Documents/LCR_Calculation_Process/LCR%20Calculation%20Process%2012_13_13.pdf

19. As discussed in the NYISO Response, GE conducted numerous sensitivities using the Alternative LCR Methodology and the current Tan 45 Method to evaluate how both approaches respond to the addition or subtraction of supply capacity from each Locality. These sensitivities demonstrate that the Alternative LCR Methodology produces more stable results than the current Tan 45 Method with regard to the addition or loss of generation.

20. The NYISO also directed GE to conduct sensitivity analyses to evaluate and compare how both the Alternative LCR Methodology and the Tan 45 Method respond to increases in the transfer capability at both the UPNY-SENY and Dunwoodie South transmission interfaces. The results show that when holding the IRM constant, the LCRs determined using the Alternative LCR Methodology respond to the increase in the transfer capability with a corresponding reduction in the LCR value. The analysis also demonstrates that, while the current Tan 45 Method shows a directionally correct reduction in the requirements, it is a much smaller change than the amount of import capability created by the increase to the interface limit.

21. On August 1, 2018, I made a presentation at the NYSRC ICS meeting held at the NYISO. A copy of the presentation is attached to this affidavit as Exhibit 1. I was asked by the NYISO to make this presentation in response to comments made at the May 29, 2018 ICS meeting where representatives from the Long Island Power Authority ("LIPA") asserted that their own analysis using the GE MARS model, the LCRs calculated by GE using the Alternative LCR Methodology, and the 2018/19 IRM Database, could not achieve an LOLE that met the 0.1 day per year criteria. My presentation provides that both the LOLE and the Transmission Security Limits are hard constraints that must be met for the optimal least cost solution. I provided the exact LCR values that were determined to be optimal and I confirmed to the ICS

that the LCRs determination associated with the 2018 IRM base case sensitivity analysis met the 0.1 day/year LOLE and provided the exact outputs from the tool. Finally, I provided several reasons why an attempt to validate the LOLE of 0.1 by LIPA or any other stakeholder may differ from the results achieved by GE, including any rounding of the LCR values.

22. This concludes my affidavit.

ATTESTATION

I am the witness identified in the foregoing affidavit. I have read the affidavit and am familiar with its contents. The facts set forth therein are true to the best of my knowledge, information and belief.

Wesley Hall
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Subscribed and sworn to before me

this 7th day of August, 2018.

Cheryl L Collamer
____

Notary Public

CHERYL L. COLLAMER
Notary Public, State of New York
Residing in Saratoga County
Commission Expires 4/30/19

My commission expires: 4/30/19

Exhibit 1

Alternative LCR Methodology

Wes Hall
Principal Consultant
Power Systems Strategy
GE Energy Consulting

01 August 2018

Objective

The Alternative Methodology for setting LCRs proposes an optimization of LCRs utilizing the Constrained Optimization by Linear Approximation method.[1] This method uses iterative linear approximations of the constraint and objective functions to find a least cost solution.

GE MARS is used to approximate the LOLE constraint function.

NYISO asked GE to provide the ICS with further explanation regarding how the 0.100 days/year LOLE constraint is respected in this optimization.

1 Powell M.J.D. (1994) A Direct Search Optimization Method That Models the Objective and Constraint Functions by Linear Interpolation. In: Gomez S., Hennart JP. (eds) *Advances in Optimization and Numerical Analysis. Mathematics and Its Applications, vol 275.* Springer, Dordrecht

Objective Function

Minimize:

$$Cost\ of\ Capacity\ Procurement$$

$$= \sum_x [Q_x + LOE_x] \cdot P_x(Q_x + LOE_x)$$

$$+ \sum_y \left[Q_y + LOE_y - \sum_z LOE_z\right] \cdot P_y\left(Q_y + LOE_y + \sum_z Q_z\right) +$$

$$+ \left[Q_{Pool} + LOE_{Pool} - \left(\sum_x (Q_x + LOE_x) + \sum_y (Q_y + LOE_y)\right)\right] \cdot P_{Pool}(Q_{Pool} + LOE_{Pool})$$

Objective Function

Where:

P = Price Elasticity Function (*i.e.*, Net CONE)

Q = Quantity of Capacity (*i.e.*, Peak Load * LCR)

LOE = Quantity Associated with the Level of Excess

x = Single Load Zones that are Localities (*i.e.*, Zone J, Zone K)

y = Locality which wholly contains another Locality (*i.e.*, GHIJ)

z = Single Locality located within another Locality (*i.e.*, Zone J)

Pool = New York Control Area

Constraints

Subject to:

$$\log_{10}(Reference\ LOLE) - \log_{10}(Current\ LOLE) \geq 0$$

And, if specified:

$$Transmission\ Security\ Limit\ or\ other\ Lower\ Bound \leq LCR$$

$$LCR \leq Upper\ Bound$$

These are hard constraints and must be maintained for the solution to be optimal

Capacity Adjustment

NYCA

1. Calculate the amount of ICAP that needs to be removed from NYCA to meet the IRM
2. Remove ICAP from zones of excess west of Total East (A, C, D) proportional to their UCAP excess until the IRM is met
3. Convert to UCAP using each area's 5 year EFORd

Zone J

1. Calculate the amount of ICAP that needs to be removed from Zone J to meet the Zone J LCR and remove from Zone J
2. Add to zones of excess west of Total East (A, C, D) proportional to their UCAP excess to maintain IRM
3. Convert to UCAP using each area's 5 year EFORd

Zone K

1. Calculate the amount of ICAP that needs to be removed from Zone K to meet the Zone K LCR and remove from Zone K
2. Add to zones of excess west of Total East (A, C, D) proportional to their UCAP excess to maintain IRM
3. Convert to UCAP using each area's 5 year EFORd

GHIJ

1. Calculate the amount of ICAP that needs to be removed from GHIJ to meet the GHIJ LCR
2. Adjust for the ICAP which has already been removed from Zone J
3. Remove from Zone GHI Proportional to UCAP
4. Add to zones of excess west of Total East (A, C, D) proportional to their UCAP excess to maintain IRM
5. Convert to UCAP using each area's 5 year EFORd

Potential reasons for differing results

For the Alternative LCR Analysis GE used:

- The 2018 IRM Base Case
- MARS Version 3.21.10 on a Linux Operating System
- The NYCA Loss of Load Expectation aggregated without loss of load events in the dummy areas
- The LCRs exactly as output from the tool without rounding:
  - Zone J: 79.7%
  - Zone K: 107.5496%
  - GHIJ: 90.82415%