

Review of Under Frequency Load Shed Programs in Consideration of Rapidly Changing Resource Mix and Integration of Large Loads

Under Frequency Load Shed Working Group

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I. Introduction

Automatic Underfrequency Load Shedding (UFLS) programs are designed to arrest declining frequency, assist recovery of frequency following underfrequency events and to provide a last resort of system preservation measures. In consideration of the compliance obligations applicable to the New York Control Area (NYCA) there is both a NERC continent wide standard (PRC-006-5) as well as NPCC regional requirements (PRC-006-NPCC-2).¹

Both the continent-wide and NPCC UFLS standards require NERC registered Planning Coordinators to perform a significant bulk power system study at least every five years to evaluate whether the program design continues to meet the established frequency performance characteristics and volts/Hz criteria. At the September 2024 NYSRC Executive Committee (EC) meeting the EC discussed the rapid integration of Behind the Meter (“BtM”) distributed solar resources and the possible addition of several, new large loads. The NYSRC EC directed the NYSRC Reliability Rules Subcommittee (RRS) to consider the need for a more frequent analysis of the 5-Year Study currently required by NERC PRC-006-5 and NPCC PRC-006-5-NPCC-2. At the October RRS #292 Meeting the RRS agreed to form a new working group to (1) Consider whether a new NYSRC local rule should be developed to require NYISO Planning to perform the 5-Year Study more frequently than five years and, if so, (2) draft a new rule for RRS consideration.

In December 2024 the RRS commenced the formation of the UFLS Working Group. This working group consists of NY Transmission Owner Subject Matter Experts (“SME”) with expertise in the areas of designing and managing their specific utility UFLS programs and NYISO SMEs with expertise UFLS. The UFLS WG developed a work plan to:

¹ Unless otherwise specified, the remainder of the whitepaper, unless discussing differences between PRC-006 and PRC-006-NPCC, they are generally referred to as the UFLS standards.

1. Collect descriptions of individual NY Transmission Owner UFLS programs, how they are managed, and the frequency of their review process.
2. Review the process for UFLS reporting and compliance documented in the NYISO System Protection manual to ensure compliance with existing criteria²
3. Review the process followed by the NYISO for completing the UFLS design assessments
4. Write a white paper supporting a recommendation to the NYSRC RRS

II. Recent NYSRC Comments to NERC and FERC Regarding UFLS Reliability Concerns

In February 2024 the NYSRC provided comments to the Inverter-Based Resource Performance (IRPS) Subcommittee's regarding the SPIDER WG PRC-006-5 Standard Authorization Request ("SAR"). The NYSRC offered that the drafting team should review Requirement 4 of the continent-wide standard which requires a UFLS design assessment at least once every five years and consider if the five-year study should be performed more frequently. As the result of other priorities work on this SAR was delayed during 2024. See Appendix A for the specific NYSRC February 2024 NYSRC comments.

On November 1, 2024, the FERC held a Commission-led technical conference to discuss generic issues related to the co-location of large loads at generating facilities. Thereafter, a notice of Request for Comments was issued inviting post-conference comments. On December 9, 2024, the NYSRC provided comments suggesting;

1. It may not be possible for a utility to find a sufficient amount of additional load shedding capability to cover new, large loads and that this issue should be identified and mitigated in the interconnection process.
2. Automatic UFLS programs should be evaluated as part of the interconnection studies under NERC Standard FAC-001 and FAC-002.
3. The current NERC requirement for a five-year UFLS study should be modified to require annual UFLS studies

² The NYISO System Protection Manual can be found [here](#). Section 4 documents the UFLS reporting and compliance process.

On January 9, 2025, the NERC Member Representative Committee (“MRC”) requested input on risks to reliability that are emerging quickly and require and require an accelerated response. More specifically the NERC MRC asked, “What risks to reliability, resilience, and security to you see with the increasing integration of large loads?” and “What should the NERC do to address these emerging risks?” On January 25 the NYSRC provided a response to the NERC MRC solicitation.

1. The NYSRC repeated its December 9, 2024, comments to the FERC
2. Emphasized that the current PRC-006-5 requirement for five-year UFLS study requirement is not adequate to preserve reliability given the present pace of accelerating connection of large loads
3. Emphasized the need for new interconnection processes for large loads to ensure that when studied under TPL standards (including PRC-006 review) and deficiencies are identified, they are not permitted to interconnect until the deficiencies are addressed.

At the June 2025 NERC RSTC meeting, the RSTC discussed and directed the NERC IRPS to continue work on the PRC-006-5 SAR and adopt the NYSRC February 2024 comments to review the five-year study requirement to a more frequent basis.

III. Review of NY Transmission Owners UFLS Programs

At a high level it is the responsibility of the Transmission Owners to meet the required load shed attributes documented in Attachment C of the NPCC UFLS standard, and to identify which loads to shed to meet the criteria. Other Distribution Provider and Transmission Owner criteria are further prescribed throughout the UFLS standards.

The UFLS WG developed a set of survey questions to better understand how NY Transmission Owner’s are managing their UFLS programs. The survey questions included consideration of increasing penetration of BtM solar resources on distribution feeders³, potential connections of new, large loads, accounting of non-utility loads, critical loads, and ensuring that distribution feeders designated for manual load shedding are not part of Transmission Owner UFLS programs.

Management of UFLS Programs in Consideration of Increasing BtM Solar Connections on Electric Feeders

³ NERC Reliability Guideline, “Recommended Approaches for UFLS Program Design with Increasing Penetrations of DERs”, issued in December 2021 ([here](#)) provides information regarding practices for addressing BtM solar resources on UFLS programs.

Transmission Owners make modifications by adding additional distribution feeders to their UFLS programs to compensate for distribution feeders experiencing increasing BtM solar penetration. These Transmission Owner reviews and adjustments are performed once a year. In the event a Transmission Owner is deficient with their UFLS settings they are obligated (PRC-006-NPCC, R4) to immediately notify the Planning Coordinator and either develop a Corrective Action Plan (CAP) to quickly get into conformance or perform a study demonstrating that their non-conformance does not result in failure of the overall UFLS performance criteria. Transmission Owners did acknowledge they may need to add additional load shedding capability more frequently than once a year. While many Transmission Owners reported growing challenges in finding additional feeders, all Transmission Owners stated they are meeting existing criteria.

Critical Loads

The Transmission Owners reported that consideration is given to certain critical customer loads including yet not limited to hospitals, electric motor-driven gas compressors, and nuclear station service. Yet to the extent that load shed allocations are not perfectly pro-rata due to public safety consideration, adequate load shed compensation is currently added to UFLS programs to meet criteria.

Predicted Enhancements for Potential New Large Loads

The Transmission Owners' reported awareness of potential, future large loads.

Transmission Owners reported that decisions will need to be made whether to; (1) Include large loads on pro-rata basis, (2) Include large loads on a total basis if the large load customer has a single point of interconnections, (3) Excuse the large load entirely from participation in the UFLS Program which would require adding additional load on other load shed feeders. Con Edison offered that for network loads, a pro-rata approach is not an option. Con Edison prefers an approach that requires new large loads be required to participate in utility UFLS programs.

Many utilities currently have large industrial customers accounts with existing large loads distributed across several distribution feeders. Generally, to date, there have been very few single-circuit customer connections above 20 MW.

Regarding very large loads it is unclear how much of these very large loads will have customer processes and accounts spread across many or few interconnections and it is unclear how and what decisions Transmission Owners will make based on critical versus

non-critical customer processes. Some Transmission Owners noted that even for large loads they are connected gradually and the load growth occurs over significant time.

IV. NYISO Operations Engineering Review of NY Transmission Owner Annual Updates of UFLS Programs

Annually the NY Transmission Owners update their UFLS programs to ensure that their UFLS relay schemes are designed to disconnect a sufficient amount of electric load at each defined frequency threshold per criteria per PRC-006-NPCC-2, R9. While existing criteria does not explicitly require Transmission Owners to make changes for BtM solar, existing criteria does require that the load shed in the five stages is based on actual net load. In their annual review, NY Transmission Owners make modifications as necessary based on the changing characteristics of net load, especially as related to BtM solar. These reviews and modifications are based on the actual loads and load characteristics during the entity's integrated hourly peak net load during the previous year, as determined by measuring or calculating load through the switches that would disconnect load as triggered by the UFLS relays.

In the performance of their review through the annual survey or other relay setting review efforts, if a Transmission Owner

determines that there is an insufficient amount of load shed capability per existing, defined criteria, they would be obligated to meet the requirement R4 of the NPCC UFLS standard, which requires within 30 calendar days of determining that it does not meet the specified parameters, notification to the NYISO; and within the following 180 calendar days from this notification provide the NYISO either:

- A corrective action plan and schedule for implementation that is agreed upon by the NYISO for meeting conformance with the criteria, or
- A technical study demonstrating that deviation from the program parameters does not result in failure of UFLS performance criteria being met for any island.

The requirements for addressing deficiencies in UFLS programs is described more thoroughly in Section 5.

The NYISO compiles all individual transmission owners load shed capabilities and updates the load shed curves and the NYISO's Protection Memos and provides both to the NY Transmission Owners. The NYISO reviews the updated load shed curves and Protection Memos in operator training.

V. UFLS Design Assessments

The UFLS standards require that at least once every five years the Planning Coordinator conduct and document a UFLS design assessment to determine through dynamic simulation whether the UFLS program design meets the established performance characteristics. While the objective of the study is to demonstrate conformance with the UFLS standards, from a practical perspective the real intent is to ensure any newly developed islands remain stable during and immediately after a significant reduction in system frequency.

Amongst the NPCC member community, these UFLS assessments are coordinated through the Task Force on System Studies (TFSS) SS-38 working group. The most recent UFLS study coordinated through this working group was completed in December 2023. Due to the nature of the study the compliance conformance for the NYISO has historically be done in coordination with this working group and the NYISO continues to follow along with the frequency of the study as coordinated by this working group with the other NPCC Areas facing many of the same challenges and risks as observed in New York.

For the NYISO, the study models utilized in the assessment follows along with the assumptions for load, generation, and transmission assumed as available in the Reliability Planning Process.⁴ This includes generation additions and retirements, the in-service status of existing and proposed transmission, updates to load forecast, and the inclusion of large load projects in the interconnection queue that are also included in the load forecast (*i.e.*, Gold Book), and other load projects that meet the NYISO's Reliability Planning Process case development rules for reliability studies. BtM solar resources are not a significant factor in the evaluation of system peak as that occurs nearer to sundown during summer or after sunset in winter.

As required in the UFLS standards, this assessment evaluates one or more islands for its UFLS programs. The UFLS assessment considers the formation of the New York Control Area as an island but also considers historical events and the results of system studies showing the potential formation of islands (see PRC-006-5 R1 and R2).⁵ There are no islands in New York that are designed to form as a result of the operation of a relay scheme or Remedial Action Scheme (RAS) action. As appropriate for the island formation, the assessment to identify islands for the UFLS assessment includes interconnected portions of the bulk electric system in areas adjacent to New York. Further, the system studies

⁴ NYISO Reliability Planning Process studies include those such as the Reliability Needs Assessment (RNA) or Short-Term Assessments of Reliability (STARS). The study inclusion rules for these assessments are documented in the NYISO Reliability Planning Process Manual ([here](#)).

⁵ Examples of such studies include extreme contingency evaluations covered in NPCC and NYSRC Area Transmission Reviews and also NERC TPL-001 planning assessments.

performed for the identification of potential island formation includes consideration of both design and extreme contingencies with New York interfaces stressed close to their respective emergency limits. The out-of-step swings and coherent generation groups present with these simulations are reviewed to determine potential island boundaries.

Regardless of the island formed, the UFLS standards specify the frequency performance characteristics as well as voltage criteria (e.g. see PRC-006 R3 for specific criteria). Further, the islands formed are evaluated for a generation and load imbalance of up to 25 percent.⁶

In NYISO's planning judgement, provided that the Transmission Owners continue to meet the established load shed requirements UFLS, there is no indication that the findings from the 2023 UFLS assessment, which concluded that all evaluated islands meet all the requirements of the UFLS standards, is invalid.

Under the existing UFLS standards, UFLS design assessments may be required to be performed by Transmission Owners. The details of this compliance obligation are found specifically in the PRC-006-NPCC standard requirement R4. Under requirement R4, when Transmission Owners do not meet the UFLS program parameters for load shedding they are obligated to notify the NYISO within 30 calendar days of this determination and within 180 calendar days from this notification either: (1) develop a corrective action plan and schedule for implementation that is mutually agreed upon with the NYISO or, (2) provide the NYISO with a technical study (*i.e.*, same type of study as the UFLS design assessment) that demonstrates that the deviations from the program parameters will not result in failure of the UFLS performance criteria being met for any island.

When Transmission Owners do not meet the UFLS program attributes for load shedding, requirement R3 of the PRC-006-NPCC standard also allows for additional load shed compensation from other Transmission Owners within the same island via mutual agreement.

VI. Reliability Concerns of the Effectiveness of UFLS Programs as Large Loads Connect to the Electric System

1. Existence of Sufficient Potential Load Shed Capability yet Transmission Owner UFLS Programs May Not be Modified Soon Enough:

⁶ Imbalance = [(load-actual generation output)/load]

This risk assumes that the Transmission Owners are not modifying their UFLS programs unless triggered by the annual review initiated by the NYISO and required for compliance with the NPCC regional requirements which looks back to the last year's summer peak.⁷ As such, this risk assumes that a large load may be in-service for nearly two years prior to being captured by the survey and assumes good utility practices may not be followed.⁸ Further, there is no compliance requirement for the Transmission Owners to review and update their UFLS program prior to large loads being placed in-service.

Potential Solutions:

- i. Inclusion of a forward-looking component to the annual UFLS survey. While Requirement R9 of the NPCC UFLS standard requires that this annual survey be backwards looking to each of the Transmission Owners integrated hourly coincident peak, R6 of the continent-wide UFLS standard has no such limitation. As such, the NYISO may update its survey processes to also look forwards in time. As such, a new reliability rule to make this modification would not be required.

The change in survey practice would continue to meet the backwards looking requirement for the UFLS survey but would also require the Transmission Owners to look forward five-years and provide data for each future year for both a summer and winter peak. Should the Transmission Owners observe that they are not meeting the UFLS program parameters from the annual survey they would be obligated to meet the compliance obligations in PRC-006-NPCC R4 to either develop a corrective action plan to achieve conformance or complete a technical study that demonstrates that non-conformance does not result in failure of the UFLS performance.

To ensure the UFLS load shed requirements are maintained, the Transmission Owners should also modify their internal procedures to adjust/add UFLS load-shed programs prior to the connection of the new, large load.

⁷ PRC-006-NPCC-2 R9 requires that the Transmission Owner annually provide documentation to the NYISO (as Planning Coordinator) of the actual net load that would have been shed by the UFLS relays at each UFLS stage based on the actual net load coincident with the Transmission Owners integrated hourly peak net load during the previous year. The annual survey initiated by the NYISO is discussed in Section 4.4 of the NYISO System Protection Manual.

⁸ E.g.: The annual survey is submitted sometime in the early summer of each year. The 2025 UFLS survey, based only on R9 of the regional standard would review and collect the UFLS data based on each Transmission Owners 2024 coincident summer peak. If a large load comes into service sometime after the Transmission Owners coincident summer peak in 2025, the survey completed in 2026 would not capture the impact of this large load as this example assumes the large load comes into service after the peak has occurred. The load would then not be captured in the survey until 2027.

- ii. Require Transmission Owners to identify in their interconnection process with large loads to large load projects that they may either need to immediately or at some identified future date, as needed to maintain UFLS load shed requirements, participate in Transmission Owner UFLS programs. This would create the option for the Transmission Owner to include the large load in the UFLS programs. The working group members recommend the New York Transmission Owners conduct a survey to review how Transmission Owners in other Areas are maintaining their UFLS programs.

If a new NYSRC Reliability Rule was developed, it would be applicable to the Transmission Owners.

2. **Insufficient Remaining Load Shed Capability to Add After Interconnections of Large Loads.**

As the result of a large amount of BtM solar and load designated for manual load shedding, a Transmission Owner might not have enough other electric feeders to add to their UFLS programs. In this instance, the Transmission Owner may be out of compliance. However, existing criteria in the regional standard (*i.e.* R3) allows Transmission Owners to coordinate, via mutual agreement, with other Transmission Owners within the same island to find and incorporate enough other total load to shed. If there continues to be insufficient load shed capability the Transmission Owner would also be required to perform an assessment to demonstrate that a deviation from criteria does not result in a failure of the UFLS performance criteria (see R4 of the regional standard).

Potential Solutions:

- I. Require that new large loads are required to participate in the Transmission Owner's UFLS programs prior to interconnection. (see 1, iii above)
- II. While not a solution, it is possible additional UFLS capability becomes available as the parts of the system transition to winter peak.

3. Transmission Owner UFLS Programs are Properly Modified Quickly yet Load Characteristics and Topology have Changed Significantly Creating the Potential that the 5-Year Planning Coordinator Study Results are no Longer Valid.

The NYISO's approach to the development of the model utilized in the UFLS assessment follows along with study inclusion rules developed for the NYISO's Reliability Planning Process. The UFLS assessments, as coordinated through the NPCC Task Force on System Studies (TFSS) SS-38 working group, have historically only performed the UFLS assessment on the five-year compliance cycle.

With rapidly changing electric system characteristics such as the retirement of synchronous generation, inclusion of more inverter-based generating resources, inclusion of large loads, and changes to transmission topology it may be needed to perform UFLS assessments more frequently. Yet if Transmission Owners proactively add sufficient load shed feeders to continuously meet existing load shed stage requirements and actual changes over five years are relatively well aligned with the reliability planning assumptions this risk is marginal.

Potential solutions

- I. As the risks outlined above are not unique to New York, the Working Group recommends that the NYISO and the Transmission Owners request with NPCC member community working groups (e.g., TFCP, TFSS, SS-38, etc.) to assess the need to identify and develop screening practices and metrics to determine if a UFLS study needs to be completed more frequently than the typical five-year timeframe.

VII. Conclusions and Recommendations to the NYSRC RRS

The UFLS WG believes that the majority of the concerns related to the effectiveness of the UFLS programs as large loads connect to the electric system are mitigated if Transmission Owners quickly and continuously add sufficient, additional load shedding to their UFLS programs. This assumes that the Transmission Owners utilize forward-looking peak loads and that that sufficient additional UFLS capability exists. Creating the option for a Transmission Owner to be able to require a large load to participate should create sufficient UFLS capability. More frequent studies will not solve a physical shortage of UFLS capability but are important to identify if the overall UFLS program will not work.

Coordinated efforts across the NPCC member community (e.g., SS-38) could develop screening practices and metrics to determine if a UFLS study needs to be completed sooner than the five-year study timeframe.

The UFLS WG makes the following recommendations to the NYSRC RRS;

1. Transmission Owners should establish in the planning horizon as part of the local TO interconnection requirements and planning criteria, or collectively recommend to the NYSRC RRS the need for an NYSRC reliability rule that the large load project may be required to participate in Transmission Owner UFLS programs as needed in the future to meet and maintain compliance UFLS load shed requirements that gives Transmission Owners an option to require new large loads to participate in Transmission Owner UFLS programs.
2. The NYISO should revise their UFLS survey requirements provided in the System Protection Manual to require the Transmission Owners to provide UFLS information for their forecasted coincident system peaks (including the impact of large loads) for each year of the five-year planning horizon as well as for coincident summer and winter peaks. As discussed in Section 6, item 1 of this whitepaper this change in practice would not require revisions to existing criteria or the development of new criteria.
3. Transmission Owners, following an identification of a deficiency in the UFLS Program, should update their UFLS programs prior to the connection of a new, large load.
4. The NYISO and New York Transmission Owners should request the NPCC member community working groups (e.g., TFCP, TFSS, SS-38, etc.) to assess the need to identify and develop screening practices and metrics to determine if a UFLS study needs to be completed more frequently than the typical five-year timeframe.

Appendix A: NYSRC February 2024 Comments to SPIDER WG on PRC-006-5 Standard Authorization Request SAR

Comment	Proposed Change
The NYSRC believes that the SPIDER WG PRC-006-5 SAR should include a review by the drafting team of R4. R4 calls for a five year study interval. For rapidly decarbonizing systems, this interval is much too long. Automatic UFLS is critical to resilience and is well known as the "last line of defense". A review of the standard's UFLS program design basis should be performed more frequently than five years. A shorter interval of one to two years at the most, should be considered by the drafting team.	Include in the Project Scope section the following sentence: Review the current five year study interval in R4 and consider why the current five year study interval is too long for rapidly decarbonizing systems and consider a 1-2 year study interval given the importance of automatic UFLS to the resilience of the Bulk Electric System.
In support of the comment make the following change to the summary in the Detailed Description section.	In the summary portion at the end of the Detailed Description, after item 3) add new item 4) as follows: Consider shortening the design review analysis interval in R4 from the current five year interval to one to two years given the importance of automatic UFLS to the resilience of the Bulk Electric System and the rapidly change in nature of the Bulk Electric System.
The NYSRC endorses the effort of the SPIDER WG group to address the imbalance equation and the methods used as it has proposed. the NYSRC has no comments on that aspect of the draft except to say that limiting the next review of the UFLS standard to solely this problem alone will not help rapidly decarbonizing Bulk Electric System. The design review should be undertaken more frequently as discussed above	

