UFLS PRC-006-5 D.B.3.1 Corrective Action Plan

Underfrequency Load Shedding Work Group

February 25, 2025

Contents

Affected Planning Coordinators

- Alberta Electric System Operator
- Arizona Public Service Company
- Avista Corporation
- Balancing Authority of Northern California
- Bonneville Power Administration
- British Columbia Hydro
- California Independent System Operator
- Centro Nacional de Control de Energia
- El Paso Electric Company
- Idaho Power Company
- Imperial Irrigation District
- Los Angeles Department of Water and Power
- Nevada Power Company
- NorthWestern Energy
- PacifiCorp Eastern Balancing Area
- PacifiCorp Western Balancing Authority
- Portland General Electric Company
- Public Service Company of Colorado
- Public Service Company of New Mexico
- PUD No. 1 of Chelan County
- PUD No. 1 of Douglas County
- PUD. No. 2 of Grant County
- Puget Sound Energy
- Salt River Project
- Seattle City Light
- Southwest Power Pool
- Tacoma Power
- Tucson Electric Power Company
- Turlock Irrigation District
- Western Area Power Administration – Desert Southwest Region
- Western Area Power Administration – Rocky Mountain Region
- Western Area Power Administration, Sierra Nevada Region

Background

PRC-006 is a NERC Reliability Standard designed "To establish design and documentation requirements for automatic underfrequency load shedding (UFLS) programs to arrest declining frequency, assist recovery of frequency following underfrequency events and provide last resort system preservation measures." This also includes limited requirements for simulation and system performance. In this standard, WECC has an approved regional variance for several requirements, due to differences in the WECC footprint and the history of the WECC coordinated UFLS programs.

To ensure appropriate studies are conducted, WECC convenes an Under Frequency Load Shedding Work Group (UFLSWG). This group is open to WECC members and interested participants. The UFLSWG biennially performs or coordinates and reviews the WECC Off-Nominal Frequency Load Shedding Plan (Plan) to help WECC Members meet their compliance obligation to evaluate the Plan's consistency in accordance with NERC Reliability Standard PRC-006. Recent UFLS program assessments were performed in 2019, 2021, and 2023 (in progress). The UFLSWG does not have any direct compliance obligations, but coordinates data and study work on behalf of its members, who represent various Planning Coordinators (PCs), UFLS related entities, and other interested parties. Compliance obligations ultimately are the responsibility of the NERC registered entities.

Identification of Performance Deficiencies

In the recent work for the 2023 UFLSWG assessment, system performance issues were identified outside the limits D.B.3.1 for frequency response, and D.B.3.3 subparts for V/Hz response. The low frequency level exceedance occurred in the Northern Island simulations, where frequency dropped below 58.0 Hz, and the V/Hz response issues occurred in all simulations for various generators and buses across various UFLS islands and UFLS plans. The UFLSWG identified these deficiencies in the draft assessment report in late 2024.

In accordance with the PRC-006, the D.B.3 requirement and measured system performance is the responsibility of the PC in whose system these buses and generators reside. The requirement, measure, and VSL are shown below for reference.

Upon subsequent review, it was also identified that similar issues existed in previous UFLS assessments performed or coordinated by the UFLSWG. With regards to frequency response specifically, Figure 1 shows the required performance characteristics of PRC-006-5 Attachment 1. Figures 2 – 4 show instances of this non-compliance from each of the three previous assessments. Essentially, system frequency must remain above 58 Hz for the duration of the simulation. The three plots below show frequency falling below 58 Hz.

Requirements in D.B.3, from NERC PRC-006-5

D.B.3. Each Planning Coordinator shall adopt a UFLS program, coordinated across the Western Interconnection, including notification of and a schedule for implementation by UFLS entities within its area, that meets the following performance characteristics in simulations of underfrequency conditions resulting from an imbalance scenario, where an imbalance = [(load — actual generation output) / (load)], of up to 25 percent within the identified island(s). *[VRF: High][Time Horizon: Long-term Planning]*

D.B.3.1. Frequency shall remain above the Underfrequency Performance Characteristic curve in PRC-006-5 - Attachment 1, either for 60 seconds or until a steady-state condition between 59.3 Hz and 60.7 Hz is reached, and

D.B.3.2. Frequency shall remain below the Overfrequency Performance Characteristic curve in PRC-006-5 - Attachment 1, either for 60 seconds or until a steady-state condition between 59.3 Hz and 60.7 Hz is reached, and

D.B.3.3. Volts per Hz (V/Hz) shall not exceed 1.18 per unit for longer than two seconds cumulatively per simulated event, and shall not exceed 1.10 per unit for longer than 45 seconds cumulatively per simulated event at each generator bus and generator step-up transformer high-side bus associated with each of the following:

D.B.3.3.1. Individual generating units greater than 20 MVA (gross nameplate rating) directly connected to the BES

D.B.3.3.2. Generating plants/facilities greater than 75 MVA (gross aggregate nameplate rating) directly connected to the BES

D.B.3.3.3. Facilities consisting of one or more units connected to the BES at a common bus with total generation above 75 MVA gross nameplate rating.

Measure for D.B.3. , from NERC PRC-006-5

M.D.B.3. Each Planning Coordinator will have evidence such as reports, memorandums, e-mails, program plans, or other documentation of its adoption of a UFLS program, coordinated across the Western Interconnection, including the notification of the UFLS entities of implementation schedule meeting the criteria in Requirement D.B.3 Parts D.B.3.1 through D.B.3.3.

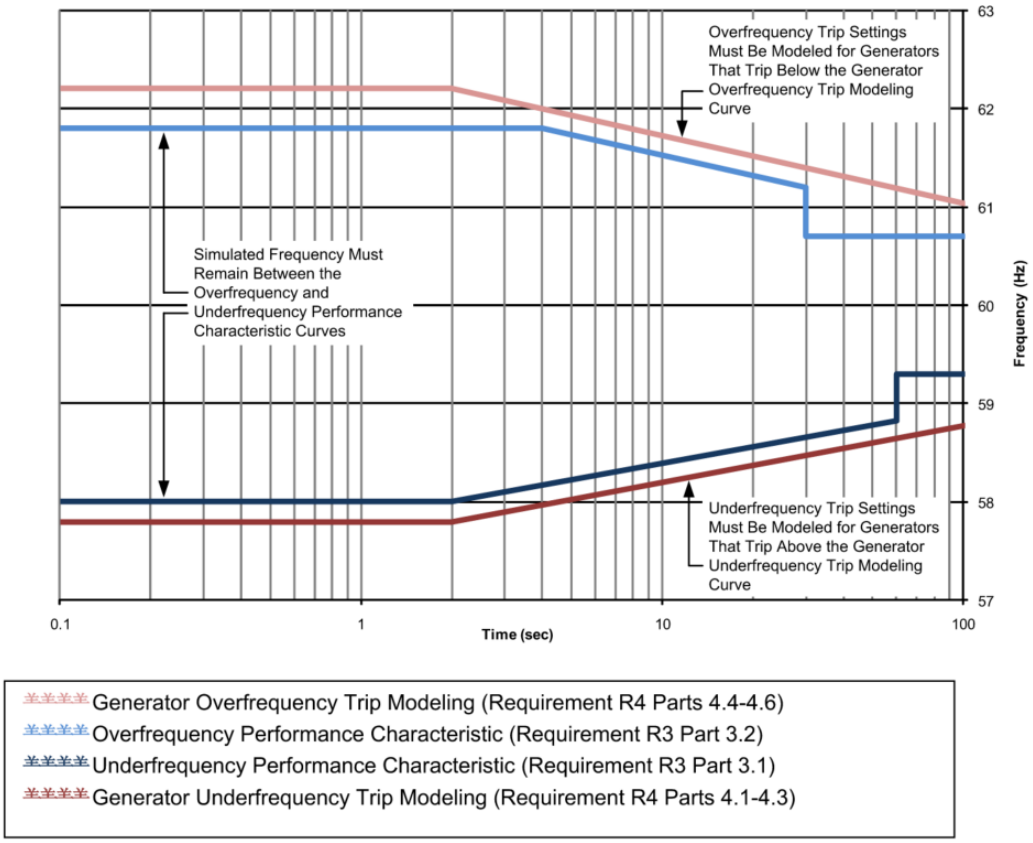

Figure 1 – PRC-006- 5 Attachment 1: Underfrequency Load Shedding Program Design Performance and Modeling Curves

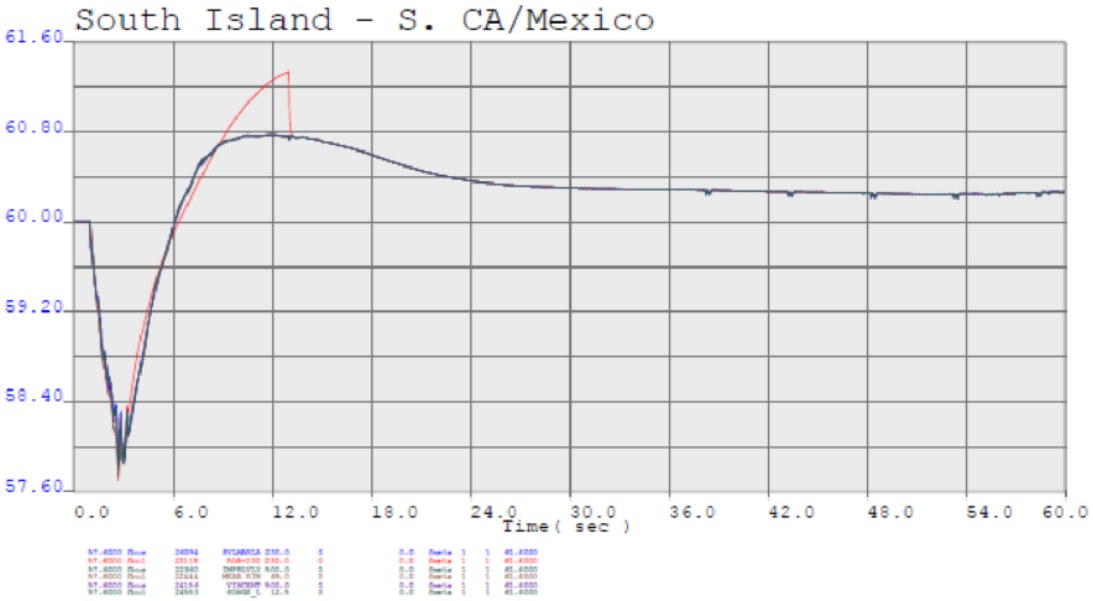

Figure 2 – 2019 UFLS Assessment, South Island 25% Imbalance Simulation

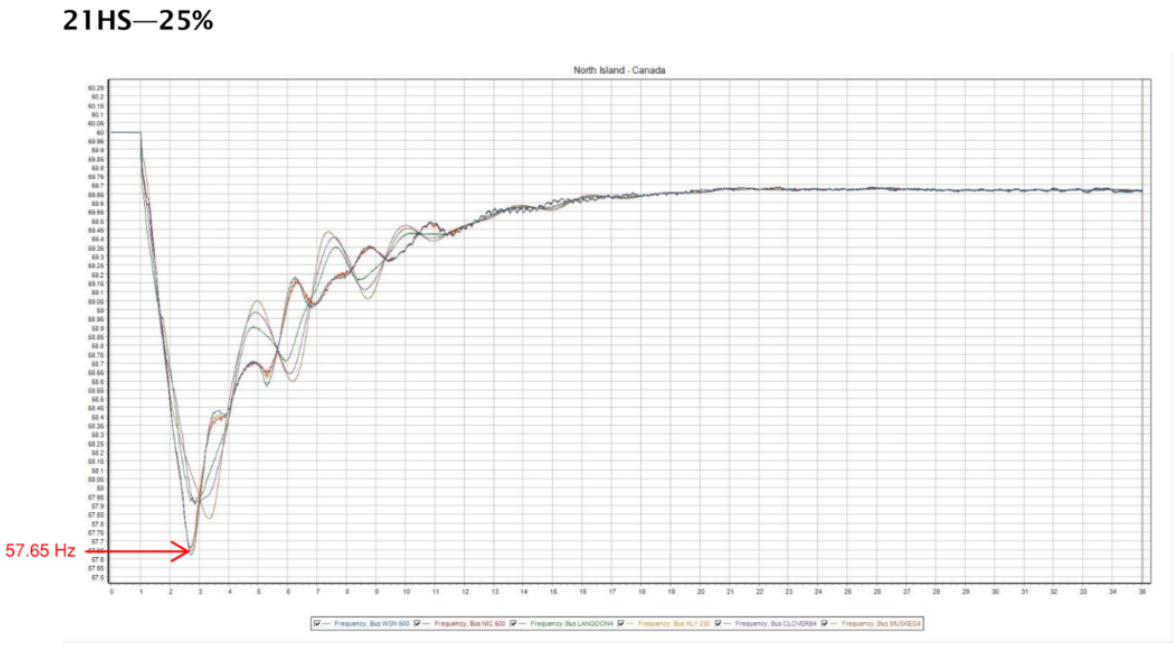

Figure 3 – 2021 UFLS Assessment, North Island (Canada) 25% Imbalance Simulation

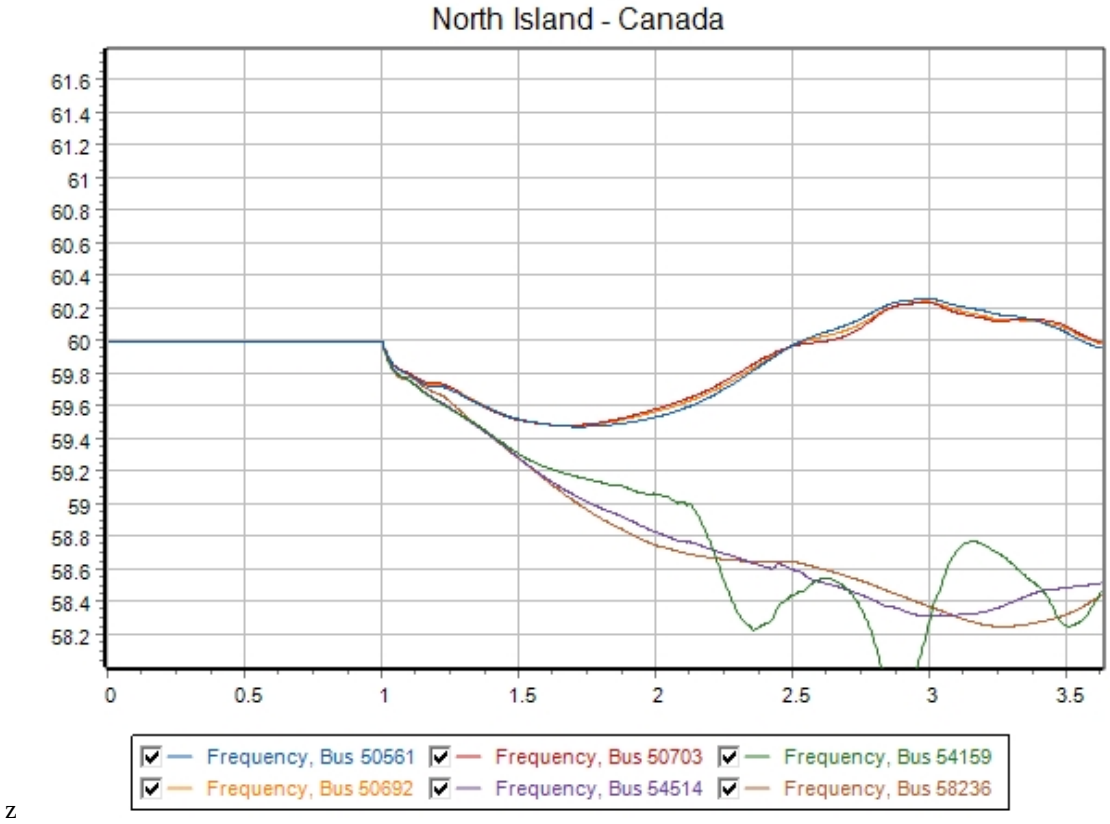

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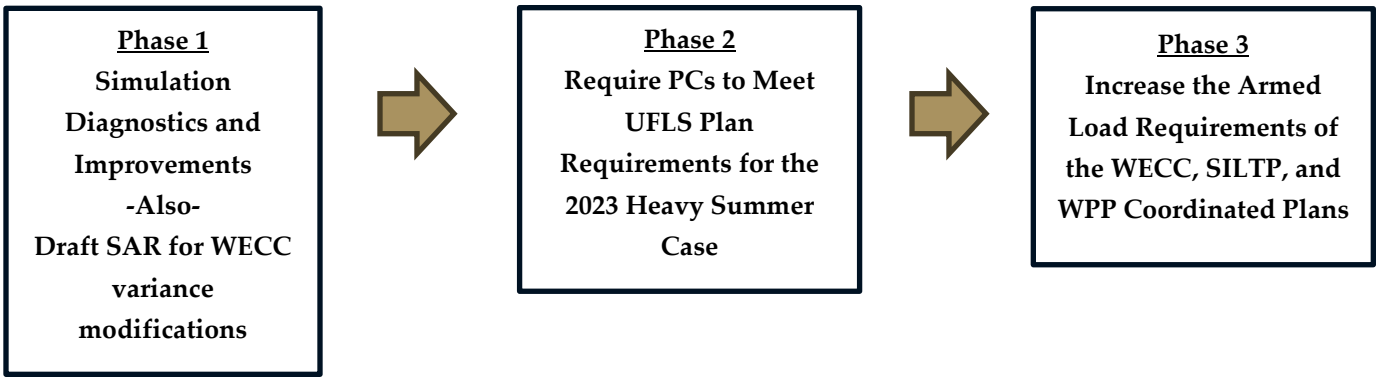
Figure 4 – 2023 UFLS Assessment, North Island (Canada) 25% Imbalance Simulation

The intent for PRC-006-5 is that PCs develop and implement a UFLS program that meets performance requirements in simulations with generation imbalance of up to 25 percent. As noted previously, there were both frequency and V/Hz issues in the 2023 UFLSWG coordinated assessment.

Corrective Action Plan

The proposed Corrective Action Plan is separated into three phases, with the first phase being the least severe method of correcting the D.B.3 issues. Should Phase 1 be successful, Phase 2 and 3 would not be necessary and so forth.



Phase 1 – Simulation Diagnostics and Improvements

The frequency issue of D.B.3.1 occurs in the Northern Island under the worst case 25% imbalance contingency. This is an intensive contingency that puts stress not only on WECC's transmission system but the simulating software itself. There are numerous methods that can be utilized to improve the simulation results and potentially bring the frequency within the bounds of Attachment 1. These methods are summarized below:

1. Existing Model Review
2. Enhance Model Detail
3. Load Shed Check
4. Generator Ride-Through Check
5. Other Simulation Techniques

Detailed Description of methods:

1. Existing Model review – In further review of the UFLS cases, a number of helpful model updates were identified by UFLSWG members and UFLS study participants such as:
    a. Update of the UFLS load model tripping file to the latest submittal files
    b. Correction of erroneous substation load levels
    c. Corrections to UFLS relay tripping times
    d. Poor generator terminal voltage (<0.95) in base cases requires further review.
    e. Questionable autotransformer tap and reactive device status in base cases requires further review.
    f. Generators with missing or old models should be updated in the UFLS cases.
    g. Ensure tripping flags on generator relays (trip or alarm) are set to the appropriate status.
    h. V/Hz issues should be identified in the simulation and each PC should evaluate the affected units with issues in their control area and validate the behavior of the model. If model updates are required, these should be communicated to the necessary people including the parties performing the assessment. It is also possible that certain generator models were missing in the assessment cases.
    i. Review of applicable generator spinning reserves in the UFLS cases or generators operating in the simulation below Pmin (impacts simulated inertia in the case).
    j. Review netted generation in dynamic data file
    k. Review commented out plant controllers in dynamic data

2. Enhance Model Detail – in the UFLS simulations, pre- and post-contingency low voltages and poor system performance occurred in portions of the models used for simulation. The UFLSWG and UFLS study participants should review the following device-specific models for potential use in the UFLS assessment. Typical device model names are included in parenthesis ():
    a. Capacitor and Reactor switching models (MSC1/MSR1)
    b. Transmission line switching models for high and low voltage (tlin1, tlin1O)
    c. Out-of-step models (OOSLEN)
    d. Generator overspeed (GP3, LHSRT, global simulation settings)
    e. Remedial Action Schemes (RAS) that could operate during a UFLS-type event
    f. Other schemes that would be expected operate in the time frame of the simulations.
    g. Use of software features to highlight and report potential data errors or model deficiencies.

3. Load Shed Check - Perform a model validation check for the amounts of load shed and the timing of the load shed by the LSDT1, LSDT9 and TLIN relays within the UFLS cases. The armed load validation check done in the 2023 assessment for the 2023 Heavy Summer case

revealed only 25.6% of the North Island load was armed to trip on under frequency in the 2023 Heavy Summer case. This is significantly less than the plan requirements for WPP and WECC, which require 28% and 31.1% respectively. From case to case it is common that loads and transmission lines can change identifiers which can cause their association to a load shedding relay to be lost. Each PC within the group should confirm that their UFLS program is modeled accurately in the case being used. Additionally, total relay and breaker timing should be reviewed to assess conformance with the UFLS program requirement to trip in no more than 14 cycles (0.233 seconds). In the 2023 UFLS Assessment process, a number of loads in the 'instantaneous' blocks were noted as taking longer than the allowed time.

4. Generator Ride-Through Check - Perform a check on all generators in the case to confirm that their Low/High Frequency Ride through Generation Protection is modeled in accordance with PRC-024-3. PRC-024-3 provides a no-trip frequency zone, see Figure 5 below.

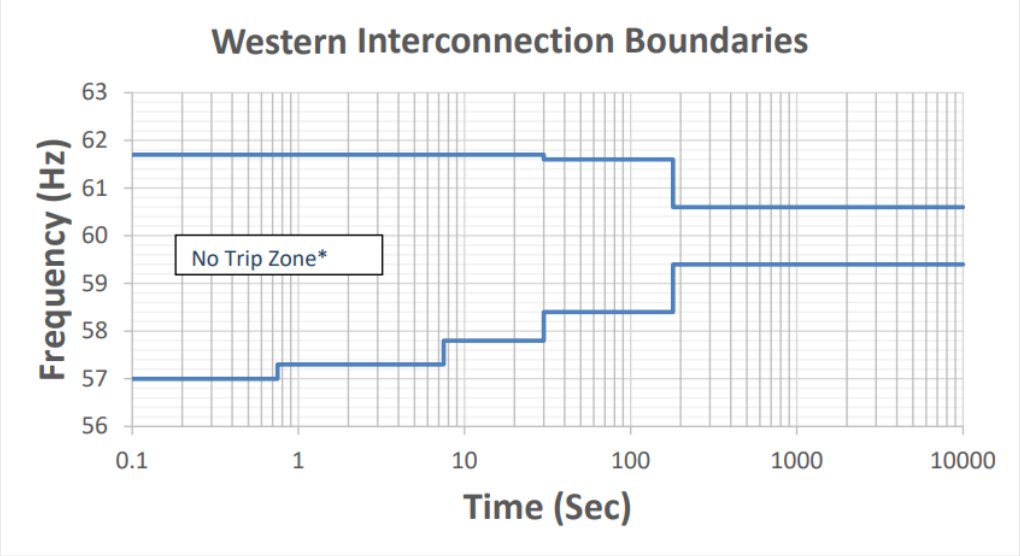


Figure1.3

**** The area outside the "No Trip Zone" is not a "Must Trip Zone."***

Figure 5 – PRC-024-3 No Trip Zone for generation

5. Other Simulation techniques - Implement a tripping delay for a portion of the generation in the 25% imbalance contingency of the Northern Island. As previously mentioned, creating an instantaneous generation imbalance of 25% is extremely intensive on both the transmission system and simulation software. Allowing a delay for generation within select areas of the Northern Island could provide significant improvement of the simulation results. A similar delay was utilized in the PG&E Area in the South Island with success. When implementing a delay, it is vital to keep the time difference as minimal as possible. It also vital that the lowest frequency trip points are still being hit to fully test the Northern Islands two UFLS Plans, the

WECC and WPP Plan. The lowest frequency trip points are 58.3 Hz and 58.6 Hz for the WECC and WPP Plan respectively.

Phase 1 – Draft SAR

NERC SAR - On review of the UFLS findings, it was noted that the WECC regional variance does not have an analogous requirement to the NERC PRC-006 R15, which describes steps to take if a simulation does not meet the performance requirements. Furthermore the VRF for WECC regional variance requirement D.B.3. did not seem to align well with what was being required of PCs in the requirement portion of the WECC variance language. There are differences in the WECC D.B.3. assessment process than what is described in the NERC R3 assessment process, but it does not appear the VRF for WECC D.B.3. was adequately modified to address these differences. The UFLSWG plans to draft a Standard Authorization Request (SAR) to submit to NERC to address both items.

Phase 2 – Require PCs to Meet UFLS Plan Requirements for the 2023 Heavy Summer Case

The armed load validation check performed in the 2023 assessment revealed that only 25.6% of the load within the Northern Island is armed for UFLS in the 2023 Heavy Summer Case used. 25.6% of load armed is not compliant with either the WECC or WPP Coordinated UFLS Plans. Table 1 below provides the results from this validation check.

Table 1: Armed Load Shed Data Validation for the 2023 Heavy Summer Case 25% WECC Island

	Modeled Armed Load Validation 2023 Heavy Summer Case				
Load Shedding Block	North Island (WPP & WECC plans)			South Island (SILTP plan)	
	Plan Design WPP	Plan Design WECC	Modeled	Plan Design SILTP	Modeled
1	5.6% (59.3 Hz)	5.3% (59.1 Hz)	7.02% (≥ 59.1 Hz)	5.3% (59.1 Hz)	5.88% (59.1 Hz)
2	5.6% (59.2 Hz)	5.9% (58.9 Hz)	4.29% (≥ 58.9, < 59.1 Hz)	5.9% (58.9 Hz)	5.89% (58.9 Hz)
3	5.6% (59.0 Hz)	6.5% (58.7 Hz)	4.78% (≥ 58.7, <58.9 Hz)	6.5% (58.7 Hz)	6.53% (58.7 Hz)
4	5.6% (58.8 Hz)	6.7% (58.5 Hz)	4.65% (≥ 58.5, < 58.7 Hz)	6.7% (58.5 Hz)	6.64% (58.5 Hz)
5	5.6% (58.6 Hz)	6.7% (58.3 Hz)	3.32% (≥58.3, < 58.5 Hz)	6.7% (58.3 Hz)	6.2% (58.3 Hz)
< 58.3 Hz	N/A	N/A	1.54%	N/A	17.13%
TOTAL	28.0%	31.1%	25.60	31.1%	48.27%
UF	6.0%	6.0%	4.48%	6.0%	6.15%

PRC-006-5 requires PCs to review their UFLS programs annually and confirm that their program meets their UFLS Plan requirements. This check is done under their system's peak load conditions, and for entities in the Northern Island, their system peak generally occurs during winter. A concern is that while these entities are compliant during the winter, they may not have adequate load armed for a summer scenario. The 2023 assessment was performed on a heavy summer case.

The intent of PRC-006-5 is that the transmission system be resilient enough to recover from a generation imbalance of 25% under any loading condition. Phase 2 of this Corrective Action Plan would require that Northern Island PCs perform an armed load check of their system for the 2023 Heavy Summer Case used in the Assessment. If the PCs are not meeting the requirements of their selected coordinated plan, they would need to add additional ULFS relays to their system to meet the requirements. These additional relays would be selected by the PCs and added to the case in order to improve the simulation results. If the simulation is successful with these additional relays, it will justify the time and cost required to physically install them on the transmission system.

Phase 2 of this Corrective Action Plan would also require an update to PRC-006-WECC-CRT-3.1—Underfrequency Load Shedding to require an armed load check be performed for both winter and summer peaks in Attachment A.

Phase 3 – Increase the Armed Load Requirements of the WECC, SILTP, and WPP Coordinated Plans

If Phase 1 and Phase 2 of this Corrective Action Plan are unsuccessful, that would be evidence that the WECC, SILTP, and WPP Coordinated Plans are insufficient in meeting the requirements of PRC-006-5. The WECC and WPP Coordinated Plan requirements are shown in Tables 2 and 3 below. For the SILTP requirements, refer to the Southern Island Load Tripping report provided year-to-year to WECC.

Table 2: WECC Coordinated Plan Armed Load Requirements

Block	Frequency	Plan Requirement
1	59.1	5.3%
2	58.9	5.9%
3	58.7	6.5%
4	58.5	6.7%
5	58.3	6.7%
	TOTAL	**31.1%**

Table 3: WPP Coordinated Plan Armed Load Requirements

Block	Frequency	Plan Requirement
1	59.3	5.6%
2	59.2	5.6%
3	59.0	5.6%
4	58.8	5.6%
5	58.6	5.6%
	TOTAL	**28.0%**

Should Phase 3 of this Corrective Action Plan be necessary, the load block percentages required in these plans would be increased until the simulation was successful. Understanding that the process of determining additional load to be armed, updating individual entity UFLS plans, and physically installing relays in the field is a significant undertaking; Phase 3 is the final resort of this Corrective Action Plan.

Timeline

Specific Action	Responsible Party	Timetable Start	Timetable End	Constraints	Notes
Phase 1 – Simulation diagnostics and improvements; draft of SAR	All	1/1/25	12/1/2025		
Phase 2a – PCs identify UFLS plan changes for peak summer conditions	PCs	1/1/2025	6/1/2025		
Complete Assessment with results from Phase 1	All	1/1/25	12/1/2025		
Phase 2b - Assess if additional armed load is sufficient	Consultant	6/1/2025	7/1/2025		
Phase 2c – PCs develop CAPs for UFLS entities in their PC areas	PCs	7/1/2025	8/1/2025		
Phase 2d – UFLS entities implement additional load tripping	UFLS entities	8/1/2025	4/1/2026		
Phase 3a – Recommend increasing the Armed Load Requirements of the WECC, SILTP, and WPP Coordinated Plans	All	6/1/2025	12/1/2025		
Phase 3b –PCs develop CAPs for UFLS entities in their PC areas	PCs	12/1/2025	2/1/2026		
Phase 3c –UFLS entities implement additional load tripping	UFLS entities	2/1/2025	9/27/2026	The date of 9/27/2026 is two years after the deficiency was identified.	This would be 7.5 years since the last valid report was issued.
Complete Assessment with PRC-006-5 compliant results	All	1/1/2025	12/1/2026		