ATTACHMENT B

For electrical infrastructure security purposes certain Critical Energy/Electric Infrastructure Information contained in the study has been redacted.

UI
An Avangrid company

Distribution Generation Interconnection Impact Study

West Haven Energy Center BESS
335 Elm Street, West Haven, CT 06516

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Index

1. Executive Summary

This re-study of the interconnection impacts of the proposed Battery Energy Storage System (BESS), located at 335 Elm Street, West Haven, CT 06516, is a following step recommended in the previous study. The re-study covers some key aspects identified previously based on most recent models, system conditions, and a more detailed representation of the elements. None of the BESS operation or design elements were changed from the original study issued on October 10, 2023 for this restudy. If any, operation or design elements (such as charge and discharge schedule) of the BESS were to change the original results from the study and this re-study would not longer be valid.

This re-study report presents updated recommendations that supersede the previous ones. For the Project information and other analysis not mentioned in this document, the previous recommendations remain the most current.

The simulations results have shown that the proposed DG interconnection of 15,000 kW of BESS must make the mitigations identified in this report prior to operation, based on the United Illuminating (UI) criteria. After these mitigations are made, the Project will result in no adverse impacts on the Electric Distribution Company (EDC) distribution system, nor to customers supplied from the same distribution feeder to which the Project would interconnect.

The proposal cannot be implemented as requested without the following system upgrades:

- Enable Reverse Power operation in the LTC controllers with settings identical to the Forward Power settings and ensure transformer secondary side (13.8 kV) is regulated regardless of power flow direction.
- LTC controller programming and any required equipment to subtract BESS power flows out of the Load Drop Compensation (LDC) scheme calculations.
- Should subtracting BESS flows from the LDC scheme be infeasible, utilize the following LTC settings:
    - Band Center = 122 V
    - Bandwidth = 2 V
    - LDC Resistance = 3 V
    - LDC Reactance = 0 V
- BESS operational schedule (charge/discharge) implementation to eliminate the possibility of output volatility.

A summary of results is shown in Table 1.

Table 1: Results Summary

Analysis	Criteria	Results	Upgrades	Notes
Voltage Change	97.5% - 105%	Fail	Project BESS Ensure operational schedule recommended in previous report (charging during light load and discharging during peak load) is implemented Substation Transformer LTC's 1. Subtract BESS flows from LDC calculations 2. If 1. is not achievable, utilize the following settings: • Band Center = 122 V • Bandwidth = 2 V • LDC Resistance = 3 V • LDC Reactance = 0 V	High voltages up to 105.07% experienced under peak load, no generation, max BESS charging scenario
Voltage Fluctuations (Transient)	ΔV< ½ LTC Bandwidth	Fail		Pre-tap ΔV up to 1.14% experienced when BESS transitions from full discharge to full charge
Interconnection Transformer	Meets UI standards for utility grade	Pass	None	
Harmonics	< 5% THD, Individual Harmonic Requirements	Pass	None	Not evaluated in re-study
System Imbalance	Voltage Imbalance <3% Current Imbalance <15% Difference between phases <50 Amps	Pass	None	Not evaluated in re-study
Potential Ferroresonance	Wye connected primary	Pass	None	Not evaluated in re-study
Risk of Islanding	LROV	Fail	A safe approach to avoid islanding is to implement a logic system based on the status and current of transformer breakers. These signals should be taken to the BESS control by wires. This system would ensure that if the transformers are out of service, BESS would automatically trip	Not evaluated in re-study
	Sandia Screen	Fail		Sandia Screen at the Substation and Feeder levels fail Not evaluated in re-study
Thermal Loading	No facilities loaded >90%	Pass	None	
Reverse Flow	No reverse power flow	Fail	Enable Reverse Power operation in LTC controllers with settings identical to Forward Power settings and ensure transformer secondary side (13.8 kV) is regulated regardless of power flow direction. For M-2001D UI recommends REGULATE FORWARD.	Reverse power flow at the feeder breaker and substation are present. LTC controllers are sufficient to accommodate reverse power flow and only settings changes are required

2. INTRODUCTION AND EVALUATION DESCRIPTION

The following items have been identified as necessary to be re-studied and were included as part of this re-study:

a. **Voltage Change Analysis** - evaluation of the steady-state distribution voltage level on the network to ensure that voltage levels stay within acceptable limits.

b. **Voltage Fluctuation Analysis** – evaluation of the rapid change in voltage caused by changes in output at the generating station. This study was performed to ensure that transient voltages during generation output transitions do not cause excessive voltage swings.

c. **Substation Thermal and Reverse Power Analysis** – evaluation of reverse power flow through the substation transformer and into the transmission grid due to the DG installation, as well as any thermal issues present at the substation.

3. STUDY MODELS AND ASSUMPTIONS

Characteristics of the proposed DG interconnection and UI system are summarized below. The full one-line diagram of this interconnection is available in Appendix A and model layouts are available in Appendix B.

A system model has been developed in the CYME version 9.2r5 power system simulation software. A diagram showing the circuit configuration is available in Appendix B. This model represents the BESS, the GSU transformers, and the interconnecting distribution feeder with protection equipment.

Below is a list of assumptions made as part of the modeling and analysis:

- The system model considered both peak and light load conditions on the supply feeder, using 2022-2024 load information for maximum and minimum load data respectively, for the total demand of the substation. This study used the worst-case scenarios of the last 3 years to determine possible mitigation techniques for observed adverse impacts. The load was allocated in the CYME model according to the connected kVA of the loads in the model. Because the study was for BESS, the peak load was chosen across all 24 hour periods. The light load condition, however, was selected during daytime hours due to the amount of PV interconnected (approximately 11,918 kW) at the Elmwest substation. The exiting feeder conditions are in the following table.

Table 2: Existing Elmwest Substation Loading Conditions

Load Model	Time	MW	MVAR	PF
Peak	[redacted]	[redacted]	[redacted]	[redacted]
Light	[redacted]	[redacted]	[redacted]	[redacted]

- All other customers' existing generators and all generation on the feeders prior to the proposed Project were assumed to be in service. This includes the following generation:
    - [redacted] of photovoltaic (PV)
    - [redacted] of BESS
    - [redacted] of fuel cells

- Loads were modeled as constant power type.

- The substation contains parallel LTC transformers, which utilize the following settings:
    - CT Ratio: 3,200/0.2 A = 16,000
    - PT Ratio: 7,960/120 V = 66.3
    - Block Raise: 125.7 V
    - Runback Deadband: 2 V
    - Block Lower 114.9 V
    - Runup Deadband: N/A (Runup disabled)
    - Band Center: 120 V
    - Bandwidth: 2 V
    - LDC Resistance: 10 V
    - LDC Reactance: 0 V

- The Load Flow analysis was conducted to determine the Project impact on steady-state circuit voltage. To ensure adequate voltage to customers (114 V to 126 V), the circuit voltage must remain within the range of 117 V to 126 V (120 V base) during normal operation. In general, the circuit voltage at the substation must remain in the range of 120 to 126 V to maintain an adequate voltage on circuits under all anticipated load conditions, regardless of generation operation.

- The CYME model contains [redacted] capacitors, with [redacted] capacitors possessing switching capabilities and operating within the Elmwest Power Factor Control (PFC) scheme. These capacitors monitor the substation bus and are controlled such that the substation VAR flows is as close to zero as possible via remote monitoring and switching priority order. For the Peak and Light load models specified in Table 2, PFC capacitor bank states were initially modeled per UI Distribution Capacitor Bank Reporting data. All feeder loads for both loading conditions were allocated accordingly with these states implemented; however, this resulted in various negative feeder load power factors, which would indicate inaccuracies in the capacitor bank states. Therefore, these states were manipulated such that feeder load power factors were reasonable (≥ 85%) with consideration given to the switching priority order. The states used for load profile load allocations and corresponding evaluations can be seen in Table 3.

Table 3: Elmwest PFC Capacitor States Per Load Model

[redacted]

- All voltages shown in the report refers to the Medium Voltage level (13.8 kV) converted to a per unit basis.
- The analyses in Section 4 include the following four (4) scenarios and corresponding descriptions:
    - Pre-Project, No Generation: pre-Project scenario with all existing/earlier queued generation offline
    - Pre-Project, Max Generation: pre-Project scenario with all existing/earlier queued generation online at full output
    - Post-Project, No Generation, Max BESS Charging: post-Project scenario with all existing/earlier queued generation offline and the Project BESS fully charging at -15,000 kW
    - Post-Project, Max Generation, Max BESS Discharging: post-Project scenario with all existing/earlier queued generation online at full output and the Project BESS fully discharging at +15,000 kW

4. INTERCONNECTION EVALUATION

The system models developed were used to complete the required analyses and simulations to meet the screening criteria identified in Section 2 of this report. The subsequent sections provide the detailed performance of the DG interconnection against this criteria under multiple loading Scenarios.

4.1. Voltage Change Analysis

Voltage impact is a key screening criterion when interconnecting DG to the utility system. At a baseline, the impact of the DG under steady state conditions needs to meet standards to ensure that it can operate under normal conditions without causing issues to the system or other UI customers. UI criteria for this evaluation is as follows:

- 97.5% ≤ Medium Voltage ≤ 105%

To ensure worst case voltages were captured, both Top of Band (ToB) and Bottom of Band (BoB) scenarios, or the upper and lower bounds of regulation device's bandwidth, were simulated. The Elmwest transformer LTC's operate with a 120 V Band Center and 2 V Bandwidth; therefore, these values were modeled as follows:

- LTC ToB = 120 V + 2 V/2 = 121 V
- LTC BoB = 120 V - 2 V/2 = 119 V

Note that with these settings in place, an infinite tap solution was utilized such that convergence was achieved at the exact values specified. In order for this to be possible, CYME solves for non-integer tap positions with precision up to the 9th decimal point rather than integer positions as would be expected in real world operation. This methodology is for worst case planning purposes.

Furthermore, the Project BESS units were operated under maximum charging (-15,000 kW) and maximum discharging (+15,000 kW) scenarios.

The steady state voltage with and without the Project interconnected are shown in the following table.

Table 4: Steady State Voltages – Existing LTC Settings

Loading	Scenario	Voltages					
		ToB Violations	Highest	Ckt	BoB Violations	Lowest	Ckt
Peak	Pre-Project, No Generation	No violations	104.12%	625	No violations	99.04%	620
	Pre-Project, Max Generation	No violations	103.84%	646	No violations	98.99%	620
	Post-Project, No Generation, Max BESS Charging	HV at northern end of 625	105.07%	625	No violations	99.90%	620
	Post-Project, Max Generation, Max BESS Discharging	No violations	102.93%	646	No violations	98.04%	620
Light	Pre-Project, No Generation	No violations	102.42%	627	No violations	99.34%	627
	Pre-Project, Max Generation	No violations	102.28%	627	No violations	98.86%	627
	Post-Project, No Generation, Max BESS Charging	No violations	103.24%	627	No violations	100.08%	627
	Post-Project, Max Generation, Max BESS Discharging	No violations	101.49%	627	No violations	98.16%	627

As shown, high voltages up to 105.07% were experienced under the post-Project, no generation, maximum BESS charging scenario. Therefore, the following mitigation was required:

- Subtract BESS flows from LTC LDC calculations such that LTC's operate near-identically to pre-Project scenarios.

Updated steady state voltages were obtained with the proposed mitigation. These results can be seen in the following table.

Table 5: Steady State Voltages – BESS Flows Subtracted from LDC Calculations

Loading	Scenario	Voltages					
		ToB Violations	Highest	Ckt	BoB Violations	Lowest	Ckt
Peak	Pre-Project, No Generation	No violations	104.09%	625	No violations	98.98%	620
	Pre-Project, Max Generation	No violations	103.84%	646	No violations	98.99%	620
	Post-Project, No Generation, Max BESS Charging	No violations	104.09%	625	No violations	98.96%	620
	Post-Project, Max Generation, Max BESS Discharging	No violations	103.86%	646	No violations	99.01%	620
Light	Pre-Project, No Generation	No violations	102.41%	627	No violations	99.34%	627
	Pre-Project, Max Generation	No violations	102.28%	627	No violations	98.98%	627
	Post-Project, No Generation, Max BESS Charging	No violations	102.41%	627	No violations	99.34%	627
	Post-Project, Max Generation, Max BESS Discharging	No violations	102.28%	627	No violations	98.98%	627

It can be seen that pre- to post-Project voltages are nearly identical, regardless of Project BESS operation.

Should it not be feasible to subtract BESS flows from the LDC calculations, the following settings may be utilized alternatively:

- Band Center = 122 V
- Bandwidth = 2 V
- LDC Resistance = 3 V
- LDC Reactance = 0 V

Note that with these settings in place, the following ToB and BoB parameters were simulated:

- LTC ToB = 122 V + 2 V/2 = 123 V
- LTC BoB = 122 V - 2 V/2 = 121 V

The results with these settings implemented can be seen in the following table.

Table 6: Steady State Voltages – Alternative LTC Settings

Loading	Scenario	Voltages					
		ToB Violations	Highest	Ckt	BoB Violations	Lowest	Ckt
Peak	Pre-Project, No Generation	No violations	103.78%	625	No violations	98.49%	620
	Pre-Project, Max Generation	No violations	103.86%	646	No violations	99.04%	620
	Post-Project, No Generation, Max BESS Charging	No violations	104.50%	625	No violations	98.76%	620
	Post-Project, Max Generation, Max BESS Discharging	No violations	103.60%	646	No violations	98.72%	620
Light	Pre-Project, No Generation	No violations	103.42%	627	No violations	100.31%	627
	Pre-Project, Max Generation	No violations	103.70%	627	No violations	102.60%	623
	Post-Project, No Generation, Max BESS Charging	No violations	103.57%	627	No violations	100.54%	627
	Post-Project, Max Generation, Max BESS Discharging	No violations	103.47%	627	No violations	100.13%	627

UI shall make final determination on the LTC settings implemented to comply with voltage change criteria.

4.2. Voltage Fluctuation Analysis

One of the most significant limiting factors of interconnecting a new generating source is how much the voltage changes when the full capacity of the DG is suddenly disconnected from the system or in the case of the Project BESS, when the DG fully transitions from one output state to another (i.e. full discharge to full charge). These voltage changes may impact the safety, power quality, and reliability of supply to other customers which are served by the same feeder that the proposed DG will be interconnected to.

This evaluation was held to the following UI criteria:

- Pre- and post-tap voltage deltas < ½ regulation device bandwidth at the regulation device
- Pre- and post-tap voltage deltas < 3% at the Project point of interconnection (POI)

In the case of the Elmwest network, the only voltage regulation devices are the transformer LTC's. As discussed in Section 3, the LTC's are set with a Bandwidth of 2 V and therefore, the ½ regulation device bandwidth criteria dictates that the voltage deltas shall not exceed 1 V on 120 V base, or 0.833% on a per unit base.

Furthermore, RLC performed an additional evaluation where LTC taps were monitored for reference purposes. The criteria for this evaluation was as follows:

- Devices taps < 2 positions for any given Project operation event

For each criteria, the following scenarios were evaluated:

- Full discharge to full charge (100% to -100%, or 15,000 kW to -15,000 kW)
- Float to full discharge (0% to 100%, or 0 kW to 15,000 kW)
- Float to full charge (0% to -100%, or 0 kW to -15,000 kW)

Similar to Section 4.1, the following LTC control schemes were simulated for this evaluation:

- Existing LTC Settings
- BESS Flow Subtracted from LDC Calculations
- Alternative LTC Settings

Tables 7 through 12 provide summaries of the voltage fluctuation analyses for the Existing LTC Settings.

Table 7: Voltage Fluctuation Summary – Existing LTC Settings – 100% to -100%

Loading	Scenario	Project Output	Voltage Levels @ POI (%)			Voltage Levels @ LTC (%)		
			VA	VB	VC	VA	VB	VC
Peak	Pre-Tap	100%	101.36	101.00	101.16	101.34	100.98	101.14
		-100%	100.24	99.88	100.04	100.20	99.84	100.00
		ΔV	1.12	1.12	1.12	**1.14**	**1.14**	**1.14**
	Post-Tap	-100%	103.02	102.65	102.82	103.03	102.66	102.83
		ΔV	1.66	1.65	1.66	**1.69**	**1.68**	**1.69**
Light	Pre-Tap	100%	99.67	99.61	99.67	99.66	99.60	99.66
		-100%	99.32	99.25	99.31	99.32	99.26	99.31
		ΔV	0.35	0.36	0.36	0.34	0.34	0.35
	Post-Tap	-100%	100.59	100.53	100.58	100.59	100.53	100.58
		ΔV	0.92	0.92	0.91	**0.93**	**0.93**	**0.92**

Table 8: Device Tapping Summary – Existing LTC Settings – 100% to -100%

Loading	Device	Number of Tap Operations		
		A	B	C
Peak	A Bank LTC	4	4	4
	B Bank LTC	4	4	4
Light	A Bank LTC	2	2	2
	B Bank LTC	2	2	2

Table 9: Voltage Fluctuation Summary – Existing LTC Settings – 0% to 100%

Loading	Scenario	Project Output	Voltage Levels @ POI (%)			Voltage Levels @ LTC (%)		
			VA	VB	VC	VA	VB	VC
Peak	Pre-Tap	0%	101.73	101.37	101.53	101.73	101.37	101.53
		100%	102.04	101.69	101.85	102.05	101.69	101.85
		ΔV	0.31	0.32	0.32	0.32	0.32	0.32
	Post-Tap	100%	102.04	101.69	101.85	102.05	101.69	101.85
		ΔV	0.31	0.32	0.32	0.32	0.32	0.32
Light	Pre-Tap	0%	99.70	99.64	99.70	99.71	99.65	99.70
		100%	99.67	99.61	99.66	99.67	99.61	99.66
		ΔV	0.03	0.03	0.04	0.04	0.04	0.04
	Post-Tap	100%	99.67	99.61	99.66	99.67	99.61	99.66
		ΔV	0.03	0.03	0.04	0.04	0.04	0.04

Table 10: Device Tapping Summary – Existing LTC Settings – 0% to 100%

Loading	Device	Number of Tap Operations		
		A	B	C
Peak	A Bank LTC	0	0	0
	B Bank LTC	0	0	0
Light	A Bank LTC	0	0	0
	B Bank LTC	0	0	0

Table 11: Voltage Fluctuation Summary – Existing LTC Settings – 0% to -100%

Loading	Scenario	Project Output	Voltage Levels @ POI (%)			Voltage Levels @ LTC (%)		
			VA	VB	VC	VA	VB	VC
Peak	Pre-Tap	0%	101.73	101.37	101.53	101.73	101.37	101.53
		-100%	100.92	100.56	100.72	100.92	100.55	100.72
		ΔV	0.81	0.81	0.81	0.81	0.82	0.81
	Post-Tap	-100%	103.02	102.66	102.82	103.03	102.66	102.82
		ΔV	1.29	1.29	1.29	1.30	1.29	1.29
Light	Pre-Tap	0%	99.70	99.64	99.70	99.71	99.65	99.70
		-100%	99.31	99.25	99.31	99.32	99.26	99.31
		ΔV	0.39	0.39	0.39	0.39	0.39	0.39
	Post-Tap	-100%	100.59	100.53	100.58	100.59	100.53	100.58
		ΔV	0.89	0.89	0.88	0.88	0.88	0.88

Table 12: Device Tapping Summary – Existing LTC Settings – 0% to -100%

Loading	Device	Number of Tap Operations		
		A	B	C
Peak	A Bank LTC	3	3	3
	B Bank LTC	3	3	3
Light	A Bank LTC	2	2	2
	B Bank LTC	2	2	2

As shown, the Existing LTC Settings fail both the UI ½ regulation device bandwidth criteria under both pre- and post-tap scenarios, and optional RLC tapping criteria. Note that these settings were deemed infeasible in the presence of the Project BESS per Section 4.1 and are shown for reference purposes only.

Tables 13 through 18 provide summaries of the voltage fluctuation analyses for the BESS Flow Subtracted from LDC Calculations.

Table 13: Voltage Fluctuation Summary – BESS Flow Subtracted from LDC Calculations – 100% to -100%

Loading	Scenario	Project Output	Voltage Levels @ POI (%)			Voltage Levels @ LTC (%)		
			VA	VB	VC	VA	VB	VC
Peak	Pre-Tap	100%	102.04	101.68	101.84	102.04	101.68	101.84
		-100%	100.90	100.54	100.70	100.90	100.54	100.70
		ΔV	1.14	1.14	1.14	**1.14**	**1.14**	**1.14**
	Post-Tap	-100%	101.61	101.24	101.40	101.61	101.24	101.40
		ΔV	0.43	0.44	0.44	0.43	0.44	0.44
Light	Pre-Tap	100%	99.67	99.61	99.66	99.67	99.61	99.66
		-100%	99.31	99.25	99.31	99.31	99.25	99.31
		ΔV	0.36	0.36	0.35	0.36	0.36	0.35
	Post-Tap	-100%	99.95	99.89	99.94	99.95	99.89	99.94
		ΔV	0.28	0.28	0.28	0.28	0.28	0.28

Table 14: Device Tapping Summary – BESS Flow Subtracted from LDC Calculations – 100% to -100%

Loading	Device	Number of Tap Operations		
		A	B	C
Peak	A Bank LTC	1	1	1
	B Bank LTC	1	1	1
Light	A Bank LTC	1	1	1
	B Bank LTC	1	1	1

Table 15: Voltage Fluctuation Summary – BESS Flow Subtracted from LDC Calculations – 0% to 100%

Loading	Scenario	Project Output	Voltage Levels @ POI (%)			Voltage Levels @ LTC (%)		
			VA	VB	VC	VA	VB	VC
Peak	Pre-Tap	0%	102.44	102.08	102.24	102.44	102.08	102.24
		100%	102.74	102.38	102.54	102.74	102.38	102.54
		ΔV	0.30	0.30	0.30	0.30	0.30	0.30
	Post-Tap	100%	102.74	102.38	102.54	102.74	102.38	102.54
		ΔV	0.30	0.30	0.30	0.30	0.30	0.30
Light	Pre-Tap	0%	99.70	99.64	99.70	99.70	99.64	99.70
		100%	99.67	99.61	99.66	99.67	99.61	99.66
		ΔV	0.03	0.03	0.04	0.03	0.03	0.04
	Post-Tap	100%	99.67	99.61	99.66	99.67	99.61	99.66
		ΔV	0.03	0.03	0.04	0.03	0.03	0.04

Table 16: Device Tapping Summary – BESS Flow Subtracted from LDC Calculations – 0% to 100%

Loading	Device	Number of Tap Operations		
		A	B	C
Peak	A Bank LTC	0	0	0
	B Bank LTC	0	0	0
Light	A Bank LTC	0	0	0
	B Bank LTC	0	0	0

Table 17: Voltage Fluctuation Summary – BESS Flow Subtracted from LDC Calculations – 0% to -100%

Loading	Scenario	Project Output	Voltage Levels @ POI (%)			Voltage Levels @ LTC (%)		
			VA	VB	VC	VA	VB	VC
Peak	Pre-Tap	0%	102.44	102.08	102.24	102.43	102.07	102.23
		-100%	101.61	101.24	101.40	101.61	101.24	101.40
		ΔV	0.83	0.84	0.84	0.82	0.83	0.83
	Post-Tap	-100%	101.61	101.24	101.40	101.61	101.24	101.40
		ΔV	0.83	0.84	0.84	0.82	0.83	0.83
Light	Pre-Tap	0%	99.70	99.64	99.70	99.70	99.64	99.70
		-100%	99.31	99.25	99.31	99.31	99.25	99.31
		ΔV	0.39	0.39	0.39	0.39	0.39	0.39
	Post-Tap	-100%	99.95	99.89	99.94	99.95	99.89	99.94
		ΔV	0.25	0.25	0.24	0.25	0.25	0.24

Table 18: Device Tapping Summary – BESS Flow Subtracted from LDC Calculations – 0% to -100%

Loading	Device	Number of Tap Operations		
		A	B	C
Peak	A Bank LTC	0	0	0
	B Bank LTC	0	0	0
Light	A Bank LTC	1	1	1
	B Bank LTC	1	1	1

It can be seen that the BESS Flow Subtracted from LDC Calculations fail the UI ½ regulation device bandwidth criteria under pre-tap scenarios during 100% to -100% transitions. Therefore, the Project BESS must operate with an operational schedule (charge/discharge) to eliminate the possibility of output volatility and shall not be permitted to participate in any frequency markets, should these settings be utilized.

Tables 19 through 24 provide summaries of the voltage fluctuation analyses for the Alternative LTC Settings.

Table 19: Voltage Fluctuation Summary – Alternative LTC Settings – 100% to -100%

Loading	Scenario	Project Output	Voltage Levels @ POI (%)			Voltage Levels @ LTC (%)		
			VA	VB	VC	VA	VB	VC
Peak	Pre-Tap	100%	102.07	101.71	101.87	102.03	101.67	101.84
		-100%	100.89	100.52	100.68	100.96	100.59	100.76
		ΔV	1.18	1.19	1.19	1.07	1.08	1.08
	Post-Tap	-100%	102.32	101.96	102.12	102.32	101.95	102.12
		ΔV	0.25	0.25	0.25	0.29	0.28	0.28
Light	Pre-Tap	100%	100.95	100.89	100.94	100.94	100.88	100.94
		-100%	100.61	100.55	100.60	100.57	100.51	100.57
		ΔV	0.34	0.34	0.34	0.37	0.37	0.37
	Post-Tap	-100%	101.22	101.16	101.22	101.23	101.16	101.22
		ΔV	0.27	0.27	0.28	0.29	0.28	0.28

Table 20: Device Tapping Summary – Alternative LTC Settings – 100% to -100%

Loading	Device	Number of Tap Operations		
		A	B	C
Peak	A Bank LTC	2	2	2
	B Bank LTC	2	2	2
Light	A Bank LTC	1	1	1
	B Bank LTC	1	1	1

Table 21: Voltage Fluctuation Summary – Alternative LTC Settings – 0% to 100%

Loading	Scenario	Project Output	Voltage Levels @ POI (%)			Voltage Levels @ LTC (%)		
			VA	VB	VC	VA	VB	VC
Peak	Pre-Tap	0%	101.73	101.37	101.53	101.73	101.37	101.53
		100%	102.04	101.69	101.85	102.05	101.69	101.85
		ΔV	0.31	0.32	0.32	0.32	0.32	0.32
	Post-Tap	100%	102.04	101.69	101.85	102.05	101.69	101.85
		ΔV	0.31	0.32	0.32	0.32	0.32	0.32
Light	Pre-Tap	0%	100.98	100.91	100.97	100.98	100.92	100.98
		100%	100.94	100.88	100.94	100.94	100.88	100.94
		ΔV	0.04	0.03	0.03	0.04	0.04	0.04
	Post-Tap	100%	100.94	100.88	100.94	100.94	100.88	100.94
		ΔV	0.04	0.03	0.03	0.04	0.04	0.04

Table 22: Device Tapping Summary – Alternative LTC Settings – 0% to 100%

Loading	Device	Number of Tap Operations		
		A	B	C
Peak	A Bank LTC	0	0	0
	B Bank LTC	0	0	0
Light	A Bank LTC	0	0	0
	B Bank LTC	0	0	0

Table 23: Voltage Fluctuation Summary – Alternative LTC Settings – 0% to -100%

Loading	Scenario	Project Output	Voltage Levels @ POI (%)			Voltage Levels @ LTC (%)		
			VA	VB	VC	VA	VB	VC
Peak	Pre-Tap	0%	101.73	101.37	101.53	101.73	101.37	101.53
		-100%	100.92	100.56	100.72	100.92	100.55	100.72
		ΔV	0.81	0.81	0.81	0.81	0.82	0.81
	Post-Tap	-100%	102.32	101.96	102.12	102.32	101.96	102.12
		ΔV	0.59	0.59	0.59	0.59	0.59	0.59
Light	Pre-Tap	0%	100.98	100.91	100.97	100.98	100.92	100.98
		-100%	100.59	100.53	100.58	100.59	100.53	100.58
		ΔV	0.39	0.38	0.39	0.39	0.39	0.40
	Post-Tap	-100%	101.22	101.16	101.22	101.23	101.16	101.22
		ΔV	0.24	0.25	0.25	0.25	0.24	0.24

Table 24: Device Tapping Summary – Alternative LTC Settings – 0% to -100%

Loading	Device	Number of Tap Operations		
		A	B	C
Peak	A Bank LTC	2	2	2
	B Bank LTC	2	2	2
Light	A Bank LTC	1	1	1
	B Bank LTC	1	1	1

It can be seen that the Alternative LTC Settings fail the UI ½ regulation device bandwidth during 100% to -100% transitions, and optional RLC tapping criteria under 100% to -100% and 0% to -100% scenarios. Therefore, the Project BESS must operate with an operational schedule (charge/discharge) to eliminate the possibility of output volatility and shall not be permitted to participate in any frequency markets, should these settings be utilized. Note that the optional RLC tapping criteria may be neglected and is solely provided for reference purposes.

UI shall make final determination on the LTC settings utilized to comply with voltage fluctuation criteria.

4.3. Substation Thermal and Reverse Power Analysis

Excessive thermal loading of distribution equipment can lead to damage or failure of facilities. The interconnection of new DG facilities can create conditions where the direction of flow is changed and even increased from normal conditions. The change in loading across distribution facilities needs to be evaluated to ensure that the Project does not create an overload condition. UI criteria for this evaluation is as follows:

- Thermal loading ≤ 90% of facility rating
- No reverse power flow

The following scenarios were evaluated for this analysis:

- Normal configuration (N-0): substation transformer Normal rating [redacted]
- Loss of A Bank (N-1): substation transformer Normal and LTE ratings [redacted]
- Loss of B Bank (N-1): substation transformer Normal and LTE ratings [redacted]

Tables 25 through 29 summarize loading of the Elmwest substation transformers across the scenarios specified above. Note that since the Project BESS interconnects directly at the substation, additional equipment on the individual distribution circuits was not monitored. Also note that any negative values are indicative of reverse power flow.

Table 25: Substation Transformer Loading – Normal Configuration (N-0) – Normal Ratings

Transformer Specifications		Transformer Loading				
Parameter	Value	Scenario	Project Status	Metric	A Bank	B Bank
Normal Rating (MVA)	70	Peak Load, Max BESS Charging	Offline	Max Amps	146.20	147.00
				% of Rating	41.60%	41.83%
Primary Nominal Voltage (kV)	115		Online	Max Amps	185.80	186.20
				% of Rating	52.87%	52.98%
Secondary Nominal Voltage (kV)	13.8	Light Load, Max BESS Discharging	Offline	Max Amps	17.60	18.00
				% of Rating	5.01%	5.12%
Primary Current Rating (A)	351.43		Online	Max Amps	-20.40	-21.20
				% of Rating	-5.80%	-6.03%

Table 26: Substation Transformer Loading – Loss of A Bank (N-1) – Normal Ratings

Transformer Specifications		Transformer Loading				
Parameter	Value	Scenario	Project Status	Metric	A Bank	B Bank
Normal Rating (MVA)	70	Peak Load, Max BESS Charging	Offline	Max Amps		302.80
				% of Rating		86.16%
Primary Nominal Voltage (kV)	115		Online	Max Amps		396.10
				% of Rating		112.71%
Secondary Nominal Voltage (kV)	13.8	Light Load, Max BESS Discharging	Offline	Max Amps		35.80
				% of Rating		10.19%
Primary Current Rating (A)	351.43		Online	Max Amps		-41.60
				% of Rating		-11.84%

Table 27: Substation Transformer Loading – Loss of A Bank (N-1) – LTE Ratings

Transformer Specifications		Transformer Loading				
Parameter	Value	Scenario	Project Status	Metric	A Bank	B Bank
Normal Rating (MVA)	92	Peak Load, Max BESS Charging	Offline	Max Amps		302.80
				% of Rating		65.56%
Primary Nominal Voltage (kV)	115		Online	Max Amps		396.10
				% of Rating		85.76%
Secondary Nominal Voltage (kV)	13.8	Light Load, Max BESS Discharging	Offline	Max Amps		35.80
				% of Rating		7.75%
Primary Current Rating (A)	461.88		Online	Max Amps		-41.60
				% of Rating		-9.01%

Table 28: Substation Transformer Loading – Loss of B Bank (N-1) – Normal Ratings

Transformer Specifications		Transformer Loading				
Parameter	Value	Scenario	Project Status	Metric	A Bank	B Bank
Normal Rating (MVA)	70	Peak Load, Max BESS Charging	Offline	Max Amps	304.00	
				% of Rating	86.50%	
Primary Nominal Voltage (kV)	115		Online	Max Amps	403.70	
				% of Rating	114.87%	
Secondary Nominal Voltage (kV)	13.8	Light Load, Max BESS Discharging	Offline	Max Amps	35.80	
				% of Rating	10.19%	
Primary Current Rating (A)	351.43		Online	Max Amps	-41.60	
				% of Rating	-11.84%	

Table 29: Substation Transformer Loading – Loss of B Bank (N-1) – LTE Ratings

Transformer Specifications		Transformer Loading				
Parameter	Value	Scenario	Project Status	Metric	A Bank	B Bank
Normal Rating (MVA)	92	Peak Load, Max BESS Charging	Offline	Max Amps	146.20	
				% of Rating	41.60%	
Primary Nominal Voltage (kV)	115		Online	Max Amps	185.80	
				% of Rating	52.87%	
Secondary Nominal Voltage (kV)	13.8	Light Load, Max BESS Discharging	Offline	Max Amps	17.60	
				% of Rating	5.01%	
Primary Current Rating (A)	461.88		Online	Max Amps	-20.40	
				% of Rating	-5.80%	

Based on the established criteria, the Project may potentially cause the following violations:

- Transformer Normal rating: loss of A or B bank during peak load, maximum BESS charging scenarios
- Reverse power flow: normal configuration, loss of A bank, or loss of B bank during light load, maximum BESS discharging scenarios

The transformer Normal rating violations are permissible during N-1 conditions since there are no transformer LTE rating violations, however, it is recommended that respective LTE time durations are considered when the Project BESS is online under these conditions.

The LTC controllers are currently set to block reverse power flow. Therefore, UI shall enable Reverse Power operation in the LTC controllers with settings identical to the Forward Power settings and ensure transformer secondary side (13.8 kV) is regulated regardless of power flow direction.

The EDC always reserves the right to limit BESS operation at any time for conditions that may cause negative impact to the system or its customers.

5. CONCLUSION

The 15,000 kW BESS system was evaluated against the interconnection criteria described and summarized in this report using the source from Elmwest substation. Both peak load and light load models were evaluated.

Based on these results, the BESS system may be interconnected once the following upgrades have been met:

- The LTC controllers are currently set to block reverse power flow. Therefore, UI shall enable Reverse Power operation in the LTC controllers with settings identical to the Forward Power settings and ensure transformer secondary side (13.8 kV) is regulated regardless of power flow direction. For M-2001D UI recommends REGULATE FORWARD
- The LTC controllers shall be programmed and any required equipment shall be included to subtract BESS power flows out of the Load Drop Compensation (LDC) scheme calculations.
- If subtraction of the BESS power flows from the LDC calculations is not achievable, the following LTC settings can be implemented to meet criteria:
    - Band Center = 122 V
    - Bandwidth = 2 V
    - LDC Resistance = 3 V
    - LDC Reactance = 0 V
- BESS operational schedules (charge/discharge) shall be implemented to eliminate the possibility of output volatility and frequency market participation shall not be permitted.
- All conductors, switches, reclosers, etc. used to serve the Project shall be properly sized to accommodate its full 15,000 kW (~628 A at 13.8 kV) output.
- The EDC always reserves the right to limit BESS operation at any time for conditions that may cause negative impact to the system or its customers.
- The operation schedule recommended in the previous study: charging during light load and discharging during peak load is still valid.

Additional studies not undertaken as part of this re-study, such as short circuit and protection criteria, may require system improvements or modifications for interconnection.

Appendix A - CUSTOMER ONE-LINE DIAGRAM

Appendix B - MODEL DIAGRAMS

Appendix C – INVERTER SPEC SHEET