34kV AND BELOW BATTERY ENERGY STORAGE SYSTEMS (BESS) - ESU AND SITE CONTROLLER MAINTENANCE TEMPLATE

AM-CE-P034-R1076
Rev. 0

Revisions to this document shall be communicated in accordance with program document AM-EU-P034 to ensure alignment between Maintenance Templates and field work procedures.

34kV & below Battery Energy Storage Systems (BESS) - Energy Storage Unit (ESU) and Site Controller					
Component Classification Categories					
Criticality	I	X			All BESS DER Locations (DERL) installations with liquid cooling systems
	II		X		All BESS DER Locations (DERL) exclusive of Criticality I
Duty Cycle	Heavy Load	N/A	N/A		
	Normal Load	N/A	N/A		
Service Condition	In Service	X	X		
	Spare	N/A	N/A		

Condition Monitoring Tasks	**Task Frequencies***	**Task Frequencies***	**Failure Codes**	**Comments**
Periodic Vendor Review	**1M**	**1M**	**2a, 2c-d, 4a-b**	Frequency will vary depending on time of year and usage profile. Monthly is minimum.
Verify electrical ground connections	**1Y**	**1Y**	**1a**	
Visual Inspection	**1Y**	**1Y**	**1a-b, 1d, 2c-d, 2g, 3a-f, 4a**	
Coolant level check - Inverter and Battery	**1Y**	**n/a**	**2f**	
Inspect Control Cabinet	**1Y**	**1Y**	**1d, 2b-c, 2e, 2g, 3a-d, 3f, 4a**	
Time Directed	**Task Frequencies***	**Task Frequencies***	**Failure Codes**	**Comments**
Replace HVAC Air Filter on each ESU	**n/a**	**1Y**	**2f**	Installations with HVAC systems only, otherwise task is not applicable.
Replace UPS Battery in Master Controller	**2Y**	**2Y**	**2e**	Lockheed Martin installations only
Pump replacement - Battery	**5Y**	**n/a**	**2f**	
Refrigerant refill - Battery	**5Y**	**n/a**	**2f**	
Replace site controller PCs	**5Y**	**5Y**	**2e**	Lockheed Martin installations only
Replace network router in Master Controller	**5Y**	**5Y**	**2e**	Lockheed Martin installations only
Replace smoke sensor in each ESU	**5Y**	**5Y**	**2f**	Lockheed Martin installations only
Coolant refill - Inverter and Battery	**10Y**	**n/a**	**2f**	
Fan replacement	**10Y**	**10Y**	**2f**	Tesla Powerpack installations only. Includes Battery and Inverter, as applicable.
Pump replacement - Inverter	**10Y**	**n/a**	**2f**	
Bypass valve replacement - Battery	**10Y**	**n/a**	**2f**	
Door gasket replacement - Battery	**10Y**	**10Y**	**3a**	Tesla Powerpack installations only
Failure Finding Tasks	**Task Frequencies***	**Task Frequencies***	**Failure Codes**	**Comments**
Functional Alarm Test	**1Y**	**1Y**	**2e, 4b**	Perform task if operation has not occurred within the prescribed frequency
Capacity Test	**1Y**	**1Y**	**1c, 2a, 2c, 4a**	
Condition Directed Tasks	**Task Frequencies***	**Task Frequencies***	**Failure Codes**	**Comments**
None	**n/a**	**n/a**	**n/a**	

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34kV AND BELOW BATTERY ENERGY STORAGE SYSTEMS (BESS) - ESU AND SITE CONTROLLER MAINTENANCE TEMPLATE

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34kV & below Battery Energy Storage Systems (BESS) - Padmounted Operating Devices							
Component Classification Categories							
Criticality	I	X					BESS DER Location (DERL) installations at DC (Distribution Center), SS, TDC, and TSS locations that serve O'Hare & Midway Airports
	II		X				BESS DERL installations at ComEd locations exclusive of Criticality I, DC (Distribution Center), and≤ 34kV ESS (Electric Service Station) locations
	III			X			BESS DERL installations at ComEd DC (Distribution Center) locations exclusive of Criticality I &
	IV				X		All other BESS DER Locations (DERL) installations
Duty Cycle	Heavy Load	N/A	N/A	N/A	N/A		
	Normal Load	N/A	N/A	N/A	N/A		
Service Condition	In Service	X	X	X	X		
	Spare	N/A	N/A	N/A	N/A		

Condition Monitoring Tasks	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Failure Codes**	**Comments**
Visual Inspection	**5W**	**10W**	**3M**	**1Y**	**5a-d, 6a-d, 7a, 9a-e**	
Check Pressure	**5W**	**10W**	**3M**	**1Y**	**7b**	Only applies to gas-insulated load centers, otherwise task is not applicable.
Thermography	**1Y**	**1Y**	**1Y**	**1Y**	**8a**	
Time Directed	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Failure Codes**	**Comments**
None	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	
Failure Finding Tasks	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Failure Codes**	**Comments**
None	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	
Condition Directed Tasks	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Failure Codes**	**Comments**
None	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	

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34kV & below Battery Energy Storage Systems (BESS) - Transformer							
Component Classification Categories							
Criticality	I	X					BESS DER Location (DERL) installations at DC (Distribution Center), SS, TDC, and TSS locations that serve O'Hare & Midway Airports
	II		X				BESS DERL installations at ComEd locations exclusive of Criticality I, DC (Distribution Center), and≤ 34kV ESS (Electric Service Station) locations
	III			X			BESS DERL installations at ComEd DC (Distribution Center) locations exclusive of Criticality I &
	IV				X		All other BESS DER Locations (DERL) installations
Duty Cycle	Heavy Load	N/A	N/A	N/A	N/A		
	Normal Load	N/A	N/A	N/A	N/A		
Service Condition	In Service	X	X	X	X		
	Spare	N/A	N/A	N/A	N/A		

Condition Monitoring Tasks	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Failure Codes**	**Comments**
Visual Inspection	**5W**	**10W**	**3M**	**1Y**	**10a-e, 11a, 12b**	
Thermography	**1Y**	**1Y**	**1Y**	**1Y**	**12a**	
Time Directed	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Failure Codes**	**Comments**
None	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	
Failure Finding Tasks	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Failure Codes**	**Comments**
None	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	
Condition Directed Tasks	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Failure Codes**	**Comments**
None	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	

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34kV & below Battery Energy Storage Systems (BESS) - Low-Voltage Switchboard							
Component Classification Categories							
Criticality	I	X					BESS DER Location (DERL) installations at DC (Distribution Center), SS, TDC, and TSS locations that serve O'Hare & Midway Airports
	II		X				BESS DERL installations at ComEd locations exclusive of Criticality I, DC (Distribution Center), and≤ 34kV ESS (Electric Service Station) locations
	III			X			BESS DERL installations at ComEd DC (Distribution Center) locations exclusive of Criticality I &
	IV				X		All other BESS DER Locations (DERL) installations
Duty Cycle	Heavy Load	N/A	N/A	N/A	N/A		
	Normal Load	N/A	N/A	N/A	N/A		
Service Condition	In Service	X	X	X	X		
	Spare	N/A	N/A	N/A	N/A		

Condition Monitoring Tasks	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Failure Codes**	**Comments**
Visual Inspection	**5W**	**10W**	**3M**	**1Y**	**13a, 14a, 15a-b, 17a, 18a-e**	
Thermography	**1Y**	**1Y**	**1Y**	**1Y**	**13b, 14b, 16a**	Control Cabinet only and not required for 480V bus cabinet
Time Directed	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Failure Codes**	**Comments**
None	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	
Failure Finding Tasks	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Failure Codes**	**Comments**
None	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	
Condition Directed Tasks	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Failure Codes**	**Comments**
None	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	

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34kV & below Battery Energy Storage Systems (BESS) - Metering and Relaying							
Component Classification Categories							
Criticality	I	X					BESS DER Location (DERL) installations at DC (Distribution Center), SS, TDC, and TSS locations that serve O'Hare & Midway Airports
	II		X				BESS DERL installations at ComEd locations exclusive of Criticality I, DC (Distribution Center), and≤ 34kV ESS (Electric Service Station) locations
	III			X			BESS DERL installations at ComEd DC (Distribution Center) locations exclusive of Criticality I &
	IV				X		All other BESS DER Locations (DERL) installations
Duty Cycle	Heavy Load	N/A	N/A	N/A	N/A		
	Normal Load	N/A	N/A	N/A	N/A		
Service Condition	In Service	X	X	X	X		
	Spare	N/A	N/A	N/A	N/A		

Condition Monitoring Tasks	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Failure Codes**	**Comments**
Visual Inspection	**5W**	**10W**	**3M**	**1Y**	**19b, 20b, 21b, 22b, 23b**	
Inspect Control Cabinet	**5W**	**10W**	**3M**	**1Y**	**19b, 20b, 21b, 22b, 23b**	
Time Directed	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Failure Codes**	**Comments**
Verify Protective Relay and Power Quality Relay settings are as specified	**6Y**	**6Y**	**6Y**	**6Y**	**19a, 20a, 21a, 22a, 23a**	Includes verifying trip unit settings (i.e. Digitrip or equivalent) and ar off-site Power Quality Relays that provide metering to the site controller.
Verify operation of the relay inputs and outputs essential to proper functioning of the Protection System	**6Y**	**6Y**	**6Y**	**6Y**	**19b, 20b, 21b, 22b**	Task not applicable for trip units (i.e. Digitrip or equivalent).
Verify acceptable measurement of power system input values	**6Y**	**6Y**	**6Y**	**6Y**	**19c, 20b-c, 21b-c, 22b-c, 23c**	Task not applicable for trip units (i.e. Digitrip or equivalent).
Verify that each trip coil is able to operate the circuit breaker, interrupting device, or mitigating device	**6Y**	**6Y**	**6Y**	**6Y**	**20c, 21c, 22c, 23c**	Task not applicable for trip units (i.e. Digitrip or equivalent).
Verify all paths of the trip and close circuits inclusive of all auxiliary relays through the trip & close coil(s) of the circuit breaker or other interrupting devices	**6Y**	**6Y**	**6Y**	**6Y**	**19c, 20c, 21c, 22c, 23c**	Task not applicable for trip units (i.e. Digitrip or equivalent).
Failure Finding Tasks	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Failure Codes**	**Comments**
Verify operation and reset of relay internal alarms and power supply fail alarms from the point of origin to the dispatcher or SCADA system logging database and local annunciation where applicable	**6Y**	**6Y**	**6Y**	**6Y**	**19c, 20c, 21c, 22c, 23c**	Applies to non-trip unit (i.e. Digitrip or equivalent) Protective and Power Quality Relays including off-site Power Quality Relays that provide metering to the site controller.
Condition Directed Tasks	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Task Frequencies***	**Failure Codes**	**Comments**
None	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	

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34kV AND BELOW BATTERY ENERGY STORAGE SYSTEMS (BESS) - ESU AND SITE CONTROLLER
MAINTENANCE TEMPLATE

FAILURE MODE	FAILURE CAUSES	MAINTENANCE TASKS
	ESU and Site Controller	
1. Fails to Provide Adequate Conduction Path	1a. External Loose / Corroded Connections	Visual Inspection
1. Fails to Provide Adequate Conduction Path	1a. External Loose / Corroded Connections	Verify electrical ground connections
1. Fails to Provide Adequate Conduction Path	1b. Insulation Failure	Visual Inspection
1. Fails to Provide Adequate Conduction Path	1c. Internal Post Connections	Capacity Test
1. Fails to Provide Adequate Conduction Path	1d. Vegetation / Animal Intrusion	Inspect Control Cabinet
1. Fails to Provide Adequate Conduction Path	1d. Vegetation / Animal Intrusion	Visual Inspection
2. Fails to Provide Adequate Voltage/Capacity	2a. Internal Component Contamination	Capacity Test
2. Fails to Provide Adequate Voltage/Capacity	2a. Internal Component Contamination	Periodic Vendor Review
2. Fails to Provide Adequate Voltage/Capacity	2b. Internal Component Contamination	Inspect Control Cabinet
2. Fails to Provide Adequate Voltage/Capacity	2c. Loose / Corroded Connections	Visual Inspection
2. Fails to Provide Adequate Voltage/Capacity	2c. Loose / Corroded Connections	Capacity Test
2. Fails to Provide Adequate Voltage/Capacity	2c. Loose / Corroded Connections	Periodic Vendor Review
2. Fails to Provide Adequate Voltage/Capacity	2c. Loose / Corroded Connections	Inspect Control Cabinet
2. Fails to Provide Adequate Voltage/Capacity	2d. Under / Over Charge	Visual Inspection
2. Fails to Provide Adequate Voltage/Capacity	2d. Under / Over Charge	Periodic Vendor Review
2. Fails to Provide Adequate Voltage/Capacity	2e. BESS Controller Hardware / Software Malfunction	Replace UPS Battery in Master Controller
2. Fails to Provide Adequate Voltage/Capacity	2e. BESS Controller Hardware / Software Malfunction	Replace site controller PCs
2. Fails to Provide Adequate Voltage/Capacity	2e. BESS Controller Hardware / Software Malfunction	Replace network router in Master Controller
2. Fails to Provide Adequate Voltage/Capacity	2e. BESS Controller Hardware / Software Malfunction	Functional Alarm Test
2. Fails to Provide Adequate Voltage/Capacity	2e. BESS Controller Hardware / Software Malfunction	Inspect Control Cabinet
2. Fails to Provide Adequate Voltage/Capacity	2f. Insufficient Cooling	Coolant level check - Inverter and Battery
2. Fails to Provide Adequate Voltage/Capacity	2f. Insufficient Cooling	Replace HVAC Air Filter on each ESU
2. Fails to Provide Adequate Voltage/Capacity	2f. Insufficient Cooling	Pump replacement - Battery
2. Fails to Provide Adequate Voltage/Capacity	2f. Insufficient Cooling	Refrigerant refill - Battery
2. Fails to Provide Adequate Voltage/Capacity	2f. Insufficient Cooling	Coolant refill - Inverter and Battery
2. Fails to Provide Adequate Voltage/Capacity	2f. Insufficient Cooling	Fan replacement
2. Fails to Provide Adequate Voltage/Capacity	2f. Insufficient Cooling	Pump replacement - Inverter
2. Fails to Provide Adequate Voltage/Capacity	2f. Insufficient Cooling	Bypass valve replacement - Battery
2. Fails to Provide Adequate Voltage/Capacity	2f. Insufficient Cooling	Replace smoke sensor in each ESU
2. Fails to Provide Adequate Voltage/Capacity	2g. Vegetation / Animal Intrusion	Inspect Control Cabinet
2. Fails to Provide Adequate Voltage/Capacity	2g. Vegetation / Animal Intrusion	Visual Inspection
3. Fails to Maintain Boundary / Structural Integrity	3a. Gasket Failure	Visual Inspection
3. Fails to Maintain Boundary / Structural Integrity	3a. Gasket Failure	Door gasket replacement - Battery
3. Fails to Maintain Boundary / Structural Integrity	3a. Gasket Failure	Inspect Control Cabinet
3. Fails to Maintain Boundary / Structural Integrity	3b. Weld Failure	Visual Inspection
3. Fails to Maintain Boundary / Structural Integrity	3b. Weld Failure	Inspect Control Cabinet
3. Fails to Maintain Boundary / Structural Integrity	3c. Tank Corrosion	Visual Inspection
3. Fails to Maintain Boundary / Structural Integrity	3c. Tank Corrosion	Inspect Control Cabinet
3. Fails to Maintain Boundary / Structural Integrity	3d. Loose Connections	Visual Inspection
3. Fails to Maintain Boundary / Structural Integrity	3d. Loose Connections	Inspect Control Cabinet

34kV AND BELOW BATTERY ENERGY STORAGE SYSTEMS (BESS) - ESU AND SITE CONTROLLER
MAINTENANCE TEMPLATE

FAILURE MODE	FAILURE CAUSES	MAINTENANCE TASKS
3. Fails to Maintain Boundary / Structural Integrity	3e. Concrete Pad Spalling	Visual Inspection
3. Fails to Maintain Boundary / Structural Integrity	3f. Lock Missing or Not Engaged	Visual Inspection
3. Fails to Maintain Boundary / Structural Integrity	3f. Lock Missing or Not Engaged	Inspect Control Cabinet
4. Fails to Provide Proper DC Output	4a. Loose / Corroded Connections	Visual Inspection
4. Fails to Provide Proper DC Output	4a. Loose / Corroded Connections	Capacity Test
4. Fails to Provide Proper DC Output	4a. Loose / Corroded Connections	Periodic Vendor Review
4. Fails to Provide Proper DC Output	4a. Loose / Corroded Connections	Inspect Control Cabinet
4. Fails to Provide Proper DC Output	4b. Internal Component Failure / Drift	Functional Alarm Test
4. Fails to Provide Proper DC Output	4b. Internal Component Failure / Drift	Periodic Vendor Review
Padmount Operating Devices		
5. Fails to Close	5a. Corroded Hinge Pivot Point	Visual Inspection
5. Fails to Close	5b. Coupling / Linkage Failure	Visual Inspection
5. Fails to Close	5c. Structure / Foundation Alignment	Visual Inspection
5. Fails to Close	5d. Vegetation / Animal Intrusion	Visual Inspection
6. Fails to Open	6a. Corroded Hinge Pivot Point	Visual Inspection
6. Fails to Open	6b. Coupling / Linkage Failure	Visual Inspection
6. Fails to Open	6c. Structure / Foundation Alignment	Visual Inspection
6. Fails to Open	6d. Vegetation / Animal Intrusion	Visual Inspection
7. Fails to Insulate	7a. External Contamination	Visual Inspection
7. Fails to Insulate	7b. Low Pressure	Check Pressure
8. Fails to Provide Conductive Path	8a. High Resistance Connection	Thermography
9. Fails to Maintain Boundary / Structural Integrity	9a. Gasket Failure	Visual Inspection
9. Fails to Maintain Boundary / Structural Integrity	9b. Module Weld Failure	Visual Inspection
9. Fails to Maintain Boundary / Structural Integrity	9c. Corrosion	Visual Inspection
9. Fails to Maintain Boundary / Structural Integrity	9d. Concrete Pad Spalling	Visual Inspection
9. Fails to Maintain Boundary / Structural Integrity	9e. Lock Missing or Not Engaged	Visual Inspection
Padmount Transformers		
10. Fails to Maintain Boundary / Structural Integrity	10a. Gasket Failure	Visual Inspection
10. Fails to Maintain Boundary / Structural Integrity	10b. Weld Failure	Visual Inspection
10. Fails to Maintain Boundary / Structural Integrity	10c. Tank Corrosion	Visual Inspection
10. Fails to Maintain Boundary / Structural Integrity	10d. Concrete Pad Spalling	Visual Inspection
10. Fails to Maintain Boundary / Structural Integrity	10e. Lock Missing or Not Engaged	Visual Inspection
11. Fails to Provide Proper AC Voltage / Transformation	11a. Loose Connections	Visual Inspection
12. Fails to Provide Adequate Insulation Level	12a. Loss of Oil	Thermography
12. Fails to Provide Adequate Insulation Level	12b. Vegetation / Animal Intrusion	Visual Inspection

34kV AND BELOW BATTERY ENERGY STORAGE SYSTEMS (BESS) - ESU AND SITE CONTROLLER
MAINTENANCE TEMPLATE

FAILURE MODE	FAILURE CAUSES	MAINTENANCE TASKS
	Low-Voltage Switchboard	
13. Fails to Close	13a. Control Circuit Failure	Visual Inspection
13. Fails to Close	13b. Control wiring / loose connection	Thermography
14. Fails to Open	14a. Control Circuit Failure	Visual Inspection
14. Fails to Open	14b. Control wiring / loose connection	Thermography
15. Fails to Interrupt	15a. Mechanical / Linkage Failure	Visual Inspection
15. Fails to Interrupt	15b. Stored Energy Failure (Spring)	Visual Inspection
16. Fails to Provide Adequate Conductive Path	16a. High Resistance Connection	Thermography
17. Fails to Provide Adequate Insulation Level	17a. Contamination	Visual Inspection
18. Fails to Maintain Boundary / Structural Integrity	18a. Gasket Failure	Visual Inspection
18. Fails to Maintain Boundary / Structural Integrity	18b. Cabinet Weld Failure	Visual Inspection
18. Fails to Maintain Boundary / Structural Integrity	18c. Cabinet Corrosion	Visual Inspection
18. Fails to Maintain Boundary / Structural Integrity	18d. Concrete Pad Spalling	Visual Inspection
18. Fails to Maintain Boundary / Structural Integrity	18e. Lock Missing or Not Engaged	Visual Inspection
	Metering and Relaying	
19. Fails to Accurately Monitor	19a. Improper Settings or Configuration	Verify Protective Relay and Power Quality Relay settings are as specified
19. Fails to Accurately Monitor	19b. Relay Hardware Failure	Verify operation of the relay inputs and outputs essential to proper functioning of the Protection System
19. Fails to Accurately Monitor	19b. Relay Hardware Failure	Visual Inspection
19. Fails to Accurately Monitor	19b. Relay Hardware Failure	Inspect Control Cabinet
19. Fails to Accurately Monitor	19c. Control Circuitry Failure	Verify all paths of the trip and close circuits inclusive of all auxiliary relays through the trip & close coil(s) of the circuit breaker or other interrupting devices
19. Fails to Accurately Monitor	19c. Control Circuitry Failure	Verify acceptable measurement of power system input values
19. Fails to Accurately Monitor	19c. Control Circuitry Failure	Verify operation and reset of relay internal alarms and power supply fail alarms from the point of origin to the dispatcher or SCADA system logging database and local annunciation where applicable
20. Fails to Trip Properly with Fault	20a. Improper Settings or Configuration	Verify Protective Relay and Power Quality Relay settings are as specified
20. Fails to Trip Properly with Fault	20b. Relay Hardware Failure	Verify operation of the relay inputs and outputs essential to proper functioning of the Protection System
20. Fails to Trip Properly with Fault	20b. Relay Hardware Failure	Verify acceptable measurement of power system input values
20. Fails to Trip Properly with Fault	20b. Relay Hardware Failure	Visual Inspection
20. Fails to Trip Properly with Fault	20b. Relay Hardware Failure	Inspect Control Cabinet
20. Fails to Trip Properly with Fault	20c. Control Circuitry Failure	Verify that each trip coil is able to operate the circuit breaker, interrupting device, or mitigating device

34kV AND BELOW BATTERY ENERGY STORAGE SYSTEMS (BESS) - ESU AND SITE CONTROLLER
MAINTENANCE TEMPLATE

FAILURE MODE	FAILURE CAUSES	MAINTENANCE TASKS
20. Fails to Trip Properly with Fault	20c. Control Circuitry Failure	Verify all paths of the trip and close circuits inclusive of all auxiliary relays through the trip & close coil(s) of the circuit breaker or other interrupting devices
20. Fails to Trip Properly with Fault	20c. Control Circuitry Failure	Verify acceptable measurement of power system input values
20. Fails to Trip Properly with Fault	20c. Control Circuitry Failure	Verify operation and reset of relay internal alarms and power supply fail alarms from the point of origin to the dispatcher or SCADA system logging database and local annunciation where applicable
21. Slow trip with fault	21a. Improper Settings or Configuration	Verify Protective Relay and Power Quality Relay settings are as specified
21. Slow trip with fault	21b. Relay Hardware Failure	Verify operation of the relay inputs and outputs essential to proper functioning of the Protection System
21. Slow trip with fault	21b. Relay Hardware Failure	Verify acceptable measurement of power system input values
21. Slow trip with fault	21b. Relay Hardware Failure	Visual Inspection
21. Slow trip with fault	21b. Relay Hardware Failure	Inspect Control Cabinet
21. Slow trip with fault	21c. Control Circuitry Failure	Verify that each trip coil is able to operate the circuit breaker, interrupting device, or mitigating device
21. Slow trip with fault	21c. Control Circuitry Failure	Verify all paths of the trip and close circuits inclusive of all auxiliary relays through the trip & close coil(s) of the circuit breaker or other interrupting devices
21. Slow trip with fault	21c. Control Circuitry Failure	Verify acceptable measurement of power system input values
21. Slow trip with fault	21c. Control Circuitry Failure	Verify operation and reset of relay internal alarms and power supply fail alarms from the point of origin to the dispatcher or SCADA system logging database and local annunciation where applicable
22. Unnecessary trip with fault	22a. Improper Settings or Configuration	Verify Protective Relay and Power Quality Relay settings are as specified
22. Unnecessary trip with fault	22b. Relay Hardware Failure	Verify operation of the relay inputs and outputs essential to proper functioning of the Protection System
22. Unnecessary trip with fault	22b. Relay Hardware Failure	Verify acceptable measurement of power system input values
22. Unnecessary trip with fault	22b. Relay Hardware Failure	Visual Inspection
22. Unnecessary trip with fault	22b. Relay Hardware Failure	Inspect Control Cabinet
22. Unnecessary trip with fault	22c. Control Circuitry Failure	Verify that each trip coil is able to operate the circuit breaker, interrupting device, or mitigating device
22. Unnecessary trip with fault	22c. Control Circuitry Failure	Verify all paths of the trip and close circuits inclusive of all auxiliary relays through the trip & close coil(s) of the circuit breaker or other interrupting devices
22. Unnecessary trip with fault	22c. Control Circuitry Failure	Verify acceptable measurement of power system input values
22. Unnecessary trip with fault	22c. Control Circuitry Failure	Verify operation and reset of relay internal alarms and power supply fail alarms from the point of origin to the dispatcher or SCADA system logging database and local annunciation where applicable
23. Unnecessary trip with no fault	23a. Improper Settings or Configuration	Verify Protective Relay and Power Quality Relay settings are as specified
23. Unnecessary trip with no fault	23b. Relay Hardware Failure	Visual Inspection
23. Unnecessary trip with no fault	23b. Relay Hardware Failure	Inspect Control Cabinet

34kV AND BELOW BATTERY ENERGY STORAGE SYSTEMS (BESS) - ESU AND SITE CONTROLLER MAINTENANCE TEMPLATE

FAILURE MODE	FAILURE CAUSES	MAINTENANCE TASKS
23. Unnecessary trip with no fault	23c. Control Circuitry Failure	Verify that each trip coil is able to operate the circuit breaker, interrupting device, or mitigating device
23. Unnecessary trip with no fault	23c. Control Circuitry Failure	Verify all paths of the trip and close circuits inclusive of all auxiliary relays through the trip & close coil(s) of the circuit breaker or other interrupting devices
23. Unnecessary trip with no fault	23c. Control Circuitry Failure	Verify acceptable measurement of power system input values
23. Unnecessary trip with no fault	23c. Control Circuitry Failure	Verify operation and reset of relay internal alarms and power supply fail alarms from the point of origin to the dispatcher or SCADA system logging database and local annunciation where applicable

34kV AND BELOW BATTERY ENERGY STORAGE SYSTEMS (BESS) - ESU AND SITE CONTROLLER MAINTENANCE TEMPLATE

TASK	DEFINITION
ESU and Site Controller	
Bypass valve replacement - Battery	Replace Battery bypass / pressure relief valve, as recommended by the equipment manufacturer. Only applicable for installations with liquid cooling systems.
Capacity Test	Functional test to gauge ability of Energy Storage Units to perform as required. Test measures ESU performance during the following procedure: -Charge all ESUs to 100% capacity -Discharge all ESUs to 0% capacity -Allow ESU to recharge to a steady-state level
Coolant level check - Inverter and Battery	Visually verify coolant levels are within acceptable range.
Coolant refill - Inverter and Battery	Refill coolant with 50/50 ethylene glycol/water coolant mix for both the battery and inverter cooling systems.
Door gasket replacement - Battery	Replace door gasket for battery, as recommended by the equipment manufacturer.
Fan replacement	Replace fan as specified by equipment manufacturer, if applicable. Includes both ESU and inverter fans, as applicable.
Functional Alarm Test	Verify alarm for BESS is sent to substation control house and System Operations (if applicable). Test should be performed by bringing up an alarm at the equipment and verifying it is received in the substation control house and System Operations (if applicable). Includes verifying operation of smoke detectors.
Inspect Control Cabinet	Check interior of control cabinet for accumulation of dust and dirt; clean as necessary. Check door gasket for effective seal, repair or replace as required. Check for broken or loose wiring terminals and blown fuses. Visually inspect circuit boards for burnt or damaged components. Verify control box heaters are operational (if applicable).
Periodic Vendor Review	Remote verification of BESS operation to ensure equipment is functioning as designed. Review shall include: -Assess state of health based on usage and predicted degradation -Assess temperature trends within ESUs to verify HVAC is within performance specification -Assess warning/fault log; create corrective action plan for unexpected entries
Pump replacement - Battery	Replace battery pump as specified by equipment manufacturer. Only applicable for installations with liquid cooling systems.
Pump replacement - Inverter	Replace inverter pump as specified by equipment manufacturer. Only applicable for installations with liquid cooling systems.
Refrigerant refill - Battery	Refill refrigerant / coolant for Battery as specified by equipment manufacturer. Only applicable for installations with liquid cooling systems.
Replace HVAC Air Filter on each ESU	Replace internal HVAC Air filter, if applicable.
Replace network router in Master Controller	Remove, replace & configure new router, as necessary.
Replace site controller PCs	Remove, replace & configure primary and backup computers, as necessary.
Replace smoke sensor in each ESU	Replace smoke sensors, as necessary.
Replace UPS Battery in Master Controller	Remove and replace UPS, as necessary.
Verify electrical ground connections	Inspect ground connections for corrosion or damage; test ground connection as required by O&M manual; clean and torque connections as required to pass test.

34kV AND BELOW BATTERY ENERGY STORAGE SYSTEMS (BESS) - ESU AND SITE CONTROLLER
MAINTENANCE TEMPLATE

TASK	DEFINITION
Visual Inspection	This inspection approximates real-time condition monitoring that can detect developing problems and degradation, and provides condition data used to initiate corrective actions. These items should be checked and addressed through corrective action as required: -Ensure no breaches in external enclosure -Inspect for pest infestation or vegetation growth; apply sealant as required to prohibit entry -Inspect general installation for evidence of rodent infestation -Inspect wiring for degradation or damage -Inspect enclosure integrity for evidence of rust damage or degraded gaskets -Inspect ventilation systems, external fans and radiators for debris and general cleanliness -Inspect electrical connections, cables, and sensors for evidence of overheating, corrosion or damage -Inspect integrity of seals for evidence of water intrusion -Inspect hinges, locks and sliders and lubricate as required
Padmounted Operating Devices	
Check Pressure	Visual check the SF6 pressure gauge for proper gas pressure.
Thermography	Perform infrared inspection of electrical equipment and power path components to identify any hot spots that may exist either in the contacts, connections or within control cabinet.
Visual Inspection	This inspection approximates real-time condition monitoring that can detect developing problems and degradation, and provides condition data used to initiate corrective actions. These items should be checked and addressed through corrective action as required: -Inspect general installation for evidence of rodent infestation -Inspect wiring for degradation or damage -Inspect enclosure integrity for evidence of rust damage or degraded gaskets -Inspect ventilation systems, external fans and radiators for debris and general cleanliness -Inspect electrical connections, cables, and sensors for evidence of overheating, corrosion or damage -Inspect integrity of seals for evidence of water intrusion -Inspect hinges, locks and sliders and lubricate as required
Transformer	
Thermography	Perform infrared inspection of electrical equipment and power path components to identify any hot spots that may exist in connections or identify overheating due to loss of oil.
Visual Inspection	This inspection approximates real-time condition monitoring that can detect developing problems and degradation, and provides condition data used to initiate corrective actions. These items should be checked and addressed through corrective action as required: -Inspect general installation for evidence of rodent infestation -Inspect wiring for degradation or damage -Inspect enclosure integrity for evidence of rust damage or degraded gaskets -Inspect ventilation systems, external fans and radiators for debris and general cleanliness -Inspect electrical connections, cables, and sensors for evidence of overheating, corrosion or damage -Inspect integrity of seals for evidence of water intrusion -Inspect hinges, locks and sliders and lubricate as required
Low-Voltage Switchboard	

34kV AND BELOW BATTERY ENERGY STORAGE SYSTEMS (BESS) - ESU AND SITE CONTROLLER
MAINTENANCE TEMPLATE

TASK	DEFINITION
Visual Inspection	This inspection approximates real-time condition monitoring that can detect developing problems and degradation, and provides condition data used to initiate corrective actions. These items should be checked and addressed through corrective action as required: -Inspect general installation for evidence of rodent infestation -Inspect wiring for degradation or damage -Inspect enclosure integrity for evidence of rust damage or degraded gaskets -Inspect ventilation systems, external fans and radiators for debris and general cleanliness -Inspect electrical connections, cables, and sensors for evidence of overheating, corrosion or damage -Inspect integrity of seals for evidence of water intrusion -Inspect hinges, locks and sliders and lubricate as required
Metering & Relaying	
Inspect Control Cabinet	Check interior of control cabinet for accumulation of dust and dirt; clean as necessary. Check door gasket for effective seal, repair or replace as required. Check for broken or loose wiring terminals and blown fuses. Visually inspect circuit boards for burnt or damaged components. Verify control box heaters are operational (if applicable).
Verify acceptable measurement of power system input values	Verifies integrity of relay's AC input circuitry. Each utilized power system input is checked by either applying test signals or using actual power system signals to verify protective relay receives the power system inputs per design.
Verify all paths of the trip and close circuits inclusive of all auxiliary relays through the trip & close coil(s) of the circuit breaker or other interrupting devices	Verifies all paths of the trip and close circuits inclusive of all auxiliary relays through the trip & close coil(s) of the circuit breakers or other interrupting devices including control circuitry associated with Sudden Pressure Relaying. If an external trip or a trip coil fails to operate power system interrupting device(s), it could impact fault isolation, relay coordination, or Breaker Failure operations. If a close operation fails to operate it could prevent automatic load restoration or station reconfiguration.
Verify operation and reset of relay internal alarms and power supply fail alarms from the point of origin to the dispatcher or SCADA system logging database and local annunciation where applicable	Verifies integrity of relay alarm contact(s) and circuitry by simulating alarm conditions and verifying alarm was received in SCADA. An undetected relay fail alarm or relay major and/or minor alarm could cause a relay misoperation as well as impact relay coordination, reclosing, or Breaker Failure operations.
Verify operation of the relay inputs and outputs essential to proper functioning of the Protection System	Verifies integrity of relay's DC input and output circuitry. Each utilized control input and output is checked to verify it operates per design. Multiple contacts in series are checked to verify that operation of one contact does not initiate an input.
Verify Protective Relay and Power Quality Relay settings are as specified	Verifies relay settings are as specified at the conclusion of maintenance activities, whether those settings may have "drifted" since the prior maintenance or whether changes were made as part of the testing process.
Verify that each trip coil is able to operate the circuit breaker, interrupting device, or mitigating device	Verify that each trip coil is able to operate the circuit breaker, interrupting device, or mitigating device. If an external trip or a trip coil fails to operate power system interrupting device(s), it could impact fault isolation, relay coordination, or Breaker Failure operations.

34kV AND BELOW BATTERY ENERGY STORAGE SYSTEMS (BESS) - ESU AND SITE CONTROLLER
MAINTENANCE TEMPLATE

TASK	DEFINITION
Visual Inspection	This inspection approximates real-time condition monitoring that can detect developing problems and degradation, and provides condition data used to initiate corrective actions. These items should be checked and addressed through corrective action as required: -Inspect general installation for evidence of rodent infestation -Inspect wiring for degradation or damage -Inspect enclosure integrity for evidence of rust damage or degraded gaskets -Inspect ventilation systems, external fans and radiators for debris and general cleanliness -Inspect electrical connections, cables, and sensors for evidence of overheating, corrosion or damage -Inspect integrity of seals for evidence of water intrusion -Inspect hinges, locks and sliders and lubricate as required

34kV AND BELOW BATTERY ENERGY STORAGE SYSTEMS (BESS) - ESU AND SITE CONTROLLER MAINTENANCE TEMPLATE

34kV and below Battery Energy Storage Systems (BESS) Maintenance Template Summary

The Preventive Maintenance program is documented via maintenance templates. Templates have been developed that address transmission, substation, and distribution equipment that is owned and maintained by Exelon Utilities. Each template documents the program tasks, frequencies, failure modes, and maintenance basis for the associated equipment. Tasks and associated frequencies are designed to address known failure modes of the equipment covered by the template. In general, the tasks included in the maintenance templates are the result of good industry practices, industry experience, and manufacturer recommendations.

References:

IEEE Std 1679.1 (2017) - IEEE Guide for the Characterization and Evaluation of Lithium-Based Batteries in Stationary Applications
IEEE C57.152-2013 - IEEE Guide for Diagnostic Field Testing of Fluid-filled Power Transformers, Regulators and Reactors
PRC-005-6 Protection System Maintenance Standard (Tasks and Intervals adapted as needed for this document to apply to distribution systems and equipment)
AM-CE-P034-R3019 - Padmounted Operating Devices Maintenance Template
AM-CE-P034-R3016 - Padmounted Transformers Maintenance Template
Preventative Maintenance Service Agreements & Schedules including but not limited to:
-Lockheed Martin Distribution Applications of Battery Energy Storage Systems Microgrid DOE - SHINES and Feeder Projects [dated 3/12/2018]
-Tesla's Distribution Applications for Battery Energy Storage Systems RFP 001647

Boundary Definitions

34kV AND BELOW BATTERY ENERGY STORAGE SYSTEMS (BESS) - ESU AND SITE CONTROLLER MAINTENANCE TEMPLATE

The boundary for the purpose of this document is defined to include the five component areas for Battery Energy Storage Systems (BESS) that operate at 34kV and below: Self-contained energy storage units (ESUs) and site controller, low-voltage switchboard, step-up transformer, primary voltage switchgear and metering / relaying. Note that the ESU includes both the batteries and inverter. All components with the exception of metering and relaying are within enclosures and are included within this document's scope. Metering / relaying equipment mounted within a ComEd control building are included within the scope of this document, however the control building is not. The template is constructed to be as inclusive as possible terms of equipment deployed. Therefore, component maintenance is considered to be Not Applicable for any installation that does not include one or more of the five components listed above.

Excluded from this treatment are:
- Associated distribution protection system equipment and interrupting devices for the BESS source feeds (i.e. 12kV normal and emergency feeds, 34kV sectionalizers, etc.); associated secondary equipment that interfaces with the BESS such as SCADA controls, feeder protective relaying and controls external to the BESS
-Non-BESS power equipment such as transformers, circuit breakers, transmission lines etc; any and all equipment considered to be part of the Bulk Electric System as defined in the NERC Glossary of Terms or any and all equipment otherwise applicable to PRC-005 or subsequent reliability standards.

Failure Experiences
Failures are subject to investigation. Findings / recommended corrective actions are incorporated into the template as required.

Vendor Recommendations
Vendor documentation was reviewed in the development of this template.

Disposition of Vendor Recommendations
n/a

34kV AND BELOW BATTERY ENERGY STORAGE SYSTEMS (BESS) - ESU AND SITE CONTROLLER MAINTENANCE TEMPLATE

Basis for Template Tasks

Bypass valve replacement - Battery: Recommended per vendor (Tesla) for liquid-cooled installations and included in maintenance contract.

Capacity Test: Task intended to monitor the capacity degradation expected to occur over time. Per IEEE 1679.1-2017, lithium-based batteries require monitoring but very limited maintenance.

Check Pressure: For gas switches, verify proper gas pressure. Recommended by manufacturer in S&C Vista® Underground Distribution Switchgear UnderCover™, Vault-Mounted, and Pad-Mounted Styles manual.

Coolant level check - Inverter and Battery: Task monitors level of coolant in the liquid cooling system to maximize life of the power electronics through effective thermal management. Recommended per vendor (Tesla) for liquid-cooled installations.

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Coolant refill - Inverter and Battery: Recommended per vendor (Tesla) for liquid-cooled installations and included in maintenance contract.

Door gasket replacement - Battery: Recommended per vendor (Tesla) for liquid-cooled installations and included in maintenance contract.

Fan replacement: Task ensures liquid cooling system maximizes life of the power electronics through effective thermal management. Task is recommended per vendor (Tesla) and included in maintenance contract.

Functional Alarm Test: Good industry practice to verify proper operation of the auxiliary systems. Although not applicable for BESS equipment, task is included in NERC Standard PRC-005.

Inspect Control Cabinet: Task intended to ensure cabinet is free of debris and the door seal is an effective barrier against moisture intrusion. Also provides for a check for damaged components that need repair. Task considered to be good utility practice to monitor condition of control cabinets.

Periodic Vendor Review: Recommended per vendor (Lockheed Martin) to ensure proper operation of BESS.

Pump replacement - Battery: Recommended per vendor (Tesla) for liquid-cooled installations and included in maintenance contract.

Pump replacement - Inverter: Recommended per vendor (Tesla) for liquid-cooled installations and included in maintenance contract.

Refrigerant refill - Battery: Recommended per vendor (Tesla) for liquid-cooled installations and included in maintenance contract.

Replace HVAC Air Filter on each ESU: Recommend per vendor (Lockheed Martin) to ensure proper operation of BESS cooling system.

Replace network router in Master Controller: Recommend per vendor (Lockheed Martin) to ensure proper operation of BESS master controller.

Replace site controller PCs: Recommend per vendor (Lockheed Martin) to ensure proper operation of BESS master controller.

Replace smoke sensor in each ESU: Recommend per vendor (Lockheed Martin) to ensure proper operation of BESS fire protection system.

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Replace UPS Battery in Master Controller: Recommend per vendor (Lockheed Martin) to ensure proper operation of BESS master controller.

Thermography: IEEE C57.152 identifies thermography as a primary tool for detection of connection issues, bushing issues and issues with the cooling systems.

Verify electrical ground connections: Recommend per multiple vendors to ensure proper safety (checking electrical ground connections) and proper operation (torque checks) of BESS.

Verify acceptable measurement of power system input values: Confirms proper interpretation of power system values by the protective relay. Although not applicable for BESS equipment, task is included in NERC Standard PRC-005.

Verify all paths of the trip and close circuits inclusive of all auxiliary relays through the trip & close coil(s) of the circuit breaker or other interrupting devices: Confirms ability of protective relay contacts, interfacing control circuitry and interrupting device trip circuitry to operate interrupting device as required. Although not applicable for BESS equipment, task is included in NERC Standard PRC-005.

Verify operation and reset of relay internal alarms and power supply fail alarms from the point of origin to the dispatcher or SCADA system logging database and local annunciation where applicable: Confirms ability of relay failure alarm contact and interfacing circuitry to convey notification of trouble and need for additional field investigation. Although not applicable for BESS equipment, task is included in NERC Standard PRC-005.

Verify operation of the relay inputs and outputs essential to proper functioning of the Protection System: Confirms information is received by the relay so that automation can be executed by the relay based on external conditions. Although not applicable for BESS equipment, task is included in NERC Standard PRC-005.

Verify Protective Relay and Power Quality Relay settings are as specified: Confirms relay is set as designed by protection & control engineering. Although not applicable for BESS equipment, task is included in NERC Standard PRC-005.

Verify that each trip coil is able to operate the circuit breaker, interrupting device, or mitigating device: Confirms ability of trip coil to open device, as designed. Although not applicable for BESS equipment, task is included in NERC Standard PRC-005.

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Visual Inspection: This inspection approximates real-time condition monitoring that can detect developing problems and degradation, and provides condition data used to initiate corrective actions. Task considered to be good utility practice to monitor condition of metering and relaying equipment.

34kV AND BELOW BATTERY ENERGY STORAGE SYSTEMS (BESS) - ESU AND SITE CONTROLLER MAINTENANCE TEMPLATE

	Revision 0	**Date 1/31/2020**
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Reason Written	Maintenance template creation.	