AVEC TESTING REQUIREMENTS FOR GRID FORMING BATTERY ENERGY STORAGE SYSTEMS FOR DIESEL OFF MICROGRID OPERATION

*The test loads are represented as % Real Power (P) / % Reactive Power (Q), with 100% equal to the specified BESS kVA capacity. Specified capacity shall exceed microgrid peak kW load at 0.95 L power factor. Rated BESS capacity may exceed the specified output requirements.

Positive (+) denotes export of real power and/or inductive kVAR on the BESS.

Negative (-) denotes import of real power and/or capacitive kVAR on the BESS.

**The diesel genset used for testing must have a kVA rating no less than 50% of the BESS kVA capacity and no more than 200% of the BESS kVA capacity.

***If the diesel available for testing only operates in droop, then the bias signals for the BESS shall be frozen as the default setpoints. The steady state balance of the drooped BESS + drooped Diesel resources will be tested instead as an acceptable alternative.

I = Off Site, Safety and Configuration				
II = Off Site, Load Bank (Option A = Biasing or Option B = No Bias)				**4 Test Points Required**
	IIA.1	Parallel, Load Bank, No Bias, Balanced	Real/Reactive/Both/Discharging = 3 points, 1 quadrant + 2 axis	
	IIA.2	Parallel, Load Bank, No Bias, Unbalanced	Both/Discharging = 1 point, 1 quadrant	
	IIB.1	Parallel, Load Bank, Biased, Balanced	Real/Reactive/Both/Discharging = 3 points, 1 quadrant + 2 axis	
	IIB.2	Parallel, Load Bank, Biased, Unbalanced	Both/Discharging = 1 point, 1 quadrant	
III = On Site, Safety and Configuration				
IV = On Site, Load Bank				**12 Test Points Required**
	IV.1	BESS Only, Load Bank, Biased, Balanced	Real/Reactive/Both/Discharging = 3 points, 1 quadrant + 2 axis	
	IV.2	BESS Only, Load Bank, Biased, Unbalanced	Both/Discharging = 1 point, 1 quadrant	
	IV.3	Parallel, Load Bank, Biased, Balanced	Real/Reactive/Both/Charging vs Discharging = 6 points, 4 quadrant + 2 axis	
	IV.4	Parallel, Load Bank, Biased, Unbalanced	Both/Charging vs Discharging = 2 points, 2 quadrant	
V = On Site, Microgrid				**6 Test Points Required**
	V.1	Parallel, Microgrid - Partial, Biased	Both/Charging vs Discharging = 2 quadrant	
	V.2	Parallel, Microgrid, Biased	Both/Charging vs Discharging = 2 quadrant	
	V.3	BESS Only, Microgrid, Biased	Both/Charging vs Discharging = 2 quadrant (Charging is renewable dependent)	

DRAFT   NOT APPROVED

Test Index	IPP Requirements	Test Description	BESS Mode	Real / Reactive Load Bank*	BESS Load	Diesel Load**	Neo 6000	Record
I.1	Recommended	Visual Inspection for completeness, including grounding.	-	-	-	-	-	Photo(s)
I.2	Recommended	Demonstrate readiness of fire suppression system (excluding suppressant release).	-	-	-	-	-	Video
I.3	Recommended	Demonstrate readiness of all PCS/inverter electrical protections.	-	-	-	-	-	Provide PDF of protection setpoints.
I.4	Recommended	Demonstrate readiness of all BMS/battery electrical protections.	-	-	-	-	-	
I.5	Recommended	Demonstrate readiness of all mechanical protections.	-	-	-	-	-	Provide PDF of protection setpoints.
I.6	Recommended	Demonstrate heating system thermostat control and output.	-	-	-	-	-	
I.7	Recommended	Demonstrate cooling system thermostat control and output.	-	-	-	-	-	
I.8	Recommended	Demonstrate HVAC faults and alarming.	-	-	-	-	-	
I.9	Recommended	Demonstrate how BMS protects batteries from overcharging and overdischarging.	-	-	-	-	-	
I.10	Recommended	Demonstrate how the BMS protects the batteries if the module overcools. Test by temporarily modifying the temperature limits.	-	-	-	-	-	
I.11	Recommended	Demonstrate how the BMS protects the batteries if the module overheats. Test by temporarily modifying the temperature limits.	-	-	-	-	-	
I.12	Recommended	Confirm HMI/display screens are complete, user-friendly, communicating, and accurate.	-	-	-	-	-	Photo(s)
I.13	Recommended	Confirm BMS SOC setpoints for low, minimum, high and maximum.	-	-	-	-	-	Record setpoints and provide to utility.
I.14	Recommended	Confirm all MODBUS reads and writes from the Battery Management System(s) to the IPP controller.	-	-	-	-	-	
I.15	Recommended	Confirm all MODBUS reads and writes from the Power Conversion System/inverter(s) to the IPP controller.	-	-	-	-	-	
I.16	Recommended	Demonstrate a fault message from the BMS and a fault reset.	-	-	-	-	-	
I.17	Recommended	Demonstrate a fault message from the inverter and a fault reset.	-	-	-	-	-	
I.18	Recommended	Demonstrate PCS responds to voltage and frequency setpoint changes.	GFL	-	-	-	-	
I.19	Recommended	Confirm phase rotation, current and power metering accuracy, and polarities.	GFL	-	-	-	-	
I.20	Recommended	Switch inverter mode from grid following mode to grid forming mode while parallel with diesel. Confirm no PQ disruptions and null export of real and reactive power during the transition.	Both	0% P / 0% Q	-	Connected	-	Define PQ Requirements
I.21	Recommended	Switch inverter mode from grid forming mode to grid following mode while parallel with diesel. Confirm no PQ disruptions and null export of real and reactive power during the transition.	Both	0% P / 0% Q	-	Connected	-	Define PQ Requirements
I.22	Recommended	Demonstrate equalization/balance charge process. If equalizing takes the BESS out of service, demonstrate how the BESS indicates whether the process is completed or not for return to service. SOC setpoints may be temporarily modified to expedite this test.	Either	-	-	-	-	Written Narrative
Test Index	**IPP Requirements**	**Test Description**	**BESS Mode**	**Real / Reactive Load Bank***	**BESS Load**	**Diesel Load****	**Neo 6000**	**Record**
IIA.1	Recommended	If BESS Emergency Stop is provided, demonstrate trip will stop operation under load without equipment damage.	GFM	Any	Any	-	-	
IIA.2	Recommended if BESS supplier is not site integrator	RLC Load Bank + BESS Only. Load Steps from 0% P / 0% Q to test transient response in GFM.	GFM	+50% P / 0% Q	+50% P / 0% Q	-	Yes	Record of f/V outputs and final setpoint.
IIA.3	Recommended if BESS supplier is not site integrator	RLC Load Bank + BESS Only. Load Steps from 0% P / 0% Q to test transient response in GFM.	GFM	0% P / +50% Q	0% P / +50% Q	-	Yes	Record of f/V outputs and final setpoint.
IIA.4	Recommended if BESS supplier is not site integrator	RLC Load Bank + BESS Only. Load Steps from 0% P / 0% Q to test transient response in GFM.	GFM	0% P / -50% Q	0% P / -50% Q	-	Yes	Record of f/V outputs and final setpoint.
IIA.5	Recommended if BESS supplier is not site integrator	RLC Load Bank + BESS Only. Load Steps from 0% P / 0% Q to test transient response in GFM.	GFM	+50% P / +50% Q	+50% P / +50% Q	-	Yes	Record of f/V outputs and final setpoint.
IIA.6	Recommended	If multiple inverters are paralleled together, then during +50% P / +50% Q test, evaluate real power balance by recording sum of absolute values of all instantaneous kW inverter outputs, then record and compare to net kW output.	GFM	+50% P / +50% Q	+50% P / +50% Q	-	-	Record of absolute sum and net values.
IIA.7	Recommended	If multiple inverters are paralleled together, then during +50% P / +50% Q test, evaluate reactive power balance by recording sum of absolute values of all instanataneous kVAR inverter outputs, then record and compare to net kVAR output.	GFM	+50% P / +50% Q	+50% P / +50% Q	-	-	Record of absolute sum and net values.
IIA.8	Recommended if BESS supplier is not site integrator	RLC Load Bank + BESS Only. Load Steps from 0% P / 0% Q to test transient response in GFM.	GFM	+50% P / -50% Q	+50% P / -50% Q	-	Yes	Record of f/V outputs and final setpoint.

ID	Requirement	Description	Mode	Col1	Col2	Col3	Rec	Notes
IIA.9	Recommended if BESS supplier is not site integrator	RLC Load Bank + BESS Only. Load Steps from 0% P / 0% Q to test transient response in GFM.	GFM	+100% P / 0% Q	+100% P / 0% Q	-	Yes	Record of f/V outputs and final setpoint.
IIA.10	Recommended	Review BESS module heat rise at +100% P / 0% Q (full load) for 30 minutes.	GFM	+100% P / 0% Q	+100% P / 0% Q	-	-	Record outdoor ambient temp, module temp, max inverter temperature, min cell temp, and max cell temp.
IIA.11	Recommended if BESS supplier is not site integrator	BESS Only + RLC Load Bank. Repeat +50% P / +50% Q test with only one phase of load bank connected in order to evaluate phase imbalance perfomance/negative reactance in GFM. Repeat with one two phases of load bank connected.	GFM	+50% P / +50% Q	+50% P / +50% Q	-	Yes	Record voltages and currents for each phase. Note any freqency/voltage disturbances plus settling times.
IIA.12	Required	Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses onto the diesel in parallel to the BESS at a load share balance of: **Diesel at [+50% P / 0% Q] and BESS at [+50% P / 0% Q]**	GFM	+100% P / 0% Q	+50% P / 0% Q	+50% P / 0% Q	Yes	Record and freqency and voltage deviation plus settling times.
IIA.13	Required	Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses onto the diesel in parallel to the BESS at a load share balance of: **Diesel at [0% P / +50% Q] and BESS at [0% P / +50% Q]**	GFM	0% P / +100% Q	+0% P / +50% Q	+0% P / +50% Q	Yes	Record and freqency and voltage deviation plus settling times.
IIA.14	Required	Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses onto the diesel in parallel to the BESS at a load share balance of: **Diesel at [+50% P / +50% Q] and BESS at [+50% P / +50% Q]**	GFM	+100% P / +100% Q	+50% P / +50% Q	+50% P / +50% Q	Yes	Record and freqency and voltage deviation plus settling times. Determine inertia value in seconds by extrapolating Hz/s slope.
IIA.15	Recommended if BESS supplier is not site integrator	Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses onto the diesel in parallel to the BESS at a load share balance of: **Diesel at [0% P / -50% Q] and BESS at [0% P / -50% Q]**	GFM	0% P / -100% Q	0% P / -50% Q	0% P / -50% Q	Yes	Record and freqency and voltage deviation plus settling times.
IIA.16	Recommended if BESS supplier is not site integrator	Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses onto the diesel in parallel to the BESS at a load share balance of: **Diesel at [+50% P / -50% Q] and BESS at [+50% P / -50% Q]**	GFM	+100% P / -100% Q	+50% P / -50% Q	+50% P / -50% Q	Yes	Record and freqency and voltage deviation plus settling times.
IIA.17	Recommended if BESS supplier is not site integrator	Use RLC load bank + Diesel + BESS in GFM. Record BESS f/V setpoints when using the loaded diesel to charge the BESS a load share balance of: **Diesel at [+50% P / -50% Q] and BESS at [-50% P / -50% Q]**	GFM	0% P / -100% Q	+50% P / -50% Q	-50% P / -50% Q	Yes	Record and freqency and voltage deviation plus settling times.
IIA.18	Recommended if BESS supplier is not site integrator	Use RLC load bank + Diesel + BESS in GFM. Record BESS f/V setpoints when using the loaded diesel to charge the BESS a load share balance of: **Diesel at [+50% P / +50% Q] and BESS at [-50% P / +50% Q]**	GFM	0% P / +100% Q	+50% P / +50% Q	-50% P / +50% Q	Yes	Record and freqency and voltage deviation plus settling times.
IIA.19	Required	Demonstrate normal transition under load from Diesel + BESS to BESS Only.	GFM	+50% P / +50% Q	-	+50% P / +50% Q	Yes	Note any freqency/voltage disturbances, plus settling times.
IIA.20	Required	Demonstrate normal transition under load from BESS Only to Diesel + BESS.	GFM	+50% P / +50% Q	+25% P / +25% Q	+25% P / +25% Q	Yes	Record time to synchronize, note any freqency/voltage disturbances upon closure, plus settling times.
IIA.21	Required	Single phase imbalance test. Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses onto the diesel in parallel to the BESS with only 1 phase of 3 phases loaded. Line-to-neutral load connection preferred over line-to-line load connection.	GFM	+100% P / +100% Q	+50% P / +50% Q	+50% P / +50% Q	Yes	Record voltages and currents for each phase. Note any freqency/voltage disturbances plus settling times.
IIA.22	Recommended	Double phase imbalance test. Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses onto the diesel in parallel to the BESS with only 2 phase of 3 phases loaded. Line-to-neutral load connection preferred over line-to-line load connection.	GFM	+100% P / +100% Q	+50% P / +50% Q	+50% P / +50% Q	Yes	Record voltages and currents for each phase. Note any freqency/voltage disturbances plus settling times.

Test Index	IPP Requirements	Test Description	BESS Mode	Real / Reactive Load Bank*	BESS Load	Diesel Load**	Neo 6000	Record
IIB.1	Recommended	If BESS Emergency Stop is provided, demonstrate trip will stop operation under load without equipment damage.	GFM	Any	Any	-	-	
IIB.2	Recommended if BESS supplier is not site integrator	RLC Load Bank + BESS Only. Load Steps from 0% P / 0% Q to test transient response in GFM.	GFM	+50% P / 0% Q	+50% P / 0% Q	-	No	Record of f/V outputs.
IIB.3	Recommended if BESS supplier is not site integrator	RLC Load Bank + BESS Only. Load Steps from 0% P / 0% Q to test transient response in GFM.	GFM	0% P / +50% Q	0% P / +50% Q	-	No	Record of f/V outputs.
IIB.4	Recommended if BESS supplier is not site integrator	RLC Load Bank + BESS Only. Load Steps from 0% P / 0% Q to test transient response in GFM.	GFM	0% P / -50% Q	0% P / -50% Q	-	No	Record of f/V outputs.
IIB.5	Recommended if BESS supplier is not site integrator	RLC Load Bank + BESS Only. Load Steps from 0% P / 0% Q to test transient response in GFM.	GFM	+50% P / +50% Q	+50% P / +50% Q	-	No	Record of f/V outputs.
IIB.6	Recommended	If multiple inverters are paralleled together, then during +50% P / +50% Q test, evaluate real power balance by recording sum of absolute values of all instantaneous kW inverter outputs, then record and compare to net kW output.	GFM	+50% P / +50% Q	+50% P / +50% Q	-	-	Record of absolute sum and net values.
IIB.7	Recommended	If multiple inverters are paralleled together, then during +50% P / +50% Q test, evaluate reactive power balance by recording sum of absolute values of all instanataneous kVAR inverter outputs, then record and compare to net kVAR output.	GFM	+50% P / +50% Q	+50% P / +50% Q	-	-	Record of absolute sum and net values.
IIB.8	Recommended if BESS supplier is not site integrator	RLC Load Bank + BESS Only. Load Steps from 0% P / 0% Q to test transient response in GFM.	GFM	+50% P / -50% Q	+50% P / -50% Q	-	No	Record of f/V outputs.
IIB.9	Recommended if BESS supplier is not site integrator	RLC Load Bank + BESS Only. Load Steps from 0% P / 0% Q to test transient response in GFM.	GFM	+100% P / 0% Q	+100% P / 0% Q	-	No	Record of f/V outputs.
IIB.10	Recommended	Review BESS module heat rise at +100% P / 0% Q (full load) for 30 minutes.	GFM	+100% P / 0% Q	+100% P / 0% Q	-	-	Record outdoor ambient temp, module temp, max inverter temperature, min cell temp, and max cell temp.
IIB.11	Recommended if BESS supplier is not site integrator	BESS Only + RLC Load Bank. Repeat +50% P / +50% Q test with only one phase of load bank connected in order to evaluate phase imbalance perfomance/negative reactance in GFM. Repeat with one two phases of load bank connected.	GFM	+50% P / +50% Q	+50% P / +50% Q	-	No	Record voltages and currents for each phase. Note any freqency/voltage disturbances plus settling times.
IIB.12	Required	Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses onto the diesel in parallel to the BESS at a load share balance of: **Diesel at [+50% P / 0% Q] and BESS at [+50% P / 0% Q]**	GFM	+100% P / 0% Q	+50% P / 0% Q	+50% P / 0% Q	No	Record and freqency and voltage deviation plus settling times.
IIB.13	Required	Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses onto the diesel in parallel to the BESS at a load share balance of: **Diesel at [0% P / +50% Q] and BESS at [0% P / +50% Q]**	GFM	0% P / +100% Q	+0% P / +50% Q	+0% P / +50% Q	No	Record and freqency and voltage deviation plus settling times.
IIB.14	Required	Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses onto the diesel in parallel to the BESS at a load share balance of: **Diesel at [+50% P / +50% Q] and BESS at [+50% P / +50% Q]**	GFM	+100% P / +100% Q	+50% P / +50% Q	+50% P / +50% Q	No	Record and freqency and voltage deviation plus settling times. Determine inertia value in seconds by extrapolating Hz/s slope.
IIB.15	Recommended if BESS supplier is not site integrator	Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses onto the diesel in parallel to the BESS at a load share balance of: **Diesel at [0% P / -50% Q] and BESS at [0% P / -50% Q]**	GFM	0% P / -100% Q	0% P / -50% Q	0% P / -50% Q	No	Record and freqency and voltage deviation plus settling times.
IIB.16	Recommended if BESS supplier is not site integrator	Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses onto the diesel in parallel to the BESS at a load share balance of: **Diesel at [+50% P / -50% Q] and BESS at [+50% P / -50% Q]**	GFM	+100% P / -100% Q	+50% P / -50% Q	+50% P / -50% Q	No	Record and freqency and voltage deviation plus settling times.

IIB.17	Recommended if BESS supplier is not site integrator	Use RLC load bank + Diesel + BESS in GFM. Record BESS f/V setpoints when using the loaded diesel to charge the BESS a load share balance of: **Diesel at [+50% P / -50% Q] and BESS at [-50% P / -50% Q]**	GFM	0% P / -100% Q	+50% P / -50% Q	-50% P / -50% Q	No	Record and freqency and voltage deviation plus settling times.
IIB.18	Recommended if BESS supplier is not site integrator	Use RLC load bank + Diesel + BESS in GFM. Record BESS f/V setpoints when using the loaded diesel to charge the BESS a load share balance of: **Diesel at [+50% P / +50% Q] and BESS at [-50% P / +50% Q]**	GFM	0% P / +100% Q	+50% P / +50% Q	-50% P / +50% Q	No	Record and freqency and voltage deviation plus settling times.
IIB.19	Required	Demonstrate normal transition under load from Diesel + BESS to BESS Only.	GFM	+50% P / +50% Q	-	+50% P / +50% Q	No	Note any frequency/voltage disturbances, plus settling times.
IIB.20	Required	Demonstrate normal transition under load from BESS Only to Diesel + BESS.	GFM	+50% P / +50% Q	+25% P / +25% Q	+25% P / +25% Q	No	Record time to synchronize, note any freqency/voltage disturbances upon closure, plus settling times.
IIB.21	Required	Single phase imbalance test. Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses onto the diesel in parallel to the BESS with only 1 phase of 3 phases loaded. Line-to-neutral load connection preferred over line-to-line load connection.	GFM	+100% P / +100% Q	+50% P / +50% Q	+50% P / +50% Q	No	Record voltages and currents for each phase. Note any freqency/voltage disturbances plus settling times.
IIB.22	Recommended	Double phase imbalance test. Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses onto the diesel in parallel to the BESS with only 2 phase of 3 phases loaded. Line-to-neutral load connection preferred over line-to-line load connection.	GFM	+100% P / +100% Q	+50% P / +50% Q	+50% P / +50% Q	No	Record voltages and currents for each phase. Note any freqency/voltage disturbances plus settling times.

Test Index	IPP Requirements	Test Description	BESS Mode	Real / Reactive Load Bank*	BESS Load	Diesel Load**	Record
III.1	Required	Visual Inspection for completeness, including grounding.	-	-	-	-	Photo(s)
III.2	Required	Demonstrate readiness of fire suppression system (excluding suppressant release).	-	-	-	-	Video
III.3	Required	Demonstrate readiness of all PCS/inverter electrical protections.	-	-	-	-	Provide PDF of protection setpoints.
III.4	Required	Demonstrate readiness of all BMS/battery electrical protections.	-	-	-	-	Provide PDF of protection setpoints.
III.5	Required	Demonstrate readiness of all mechanical protections.	-	-	-	-	Provide PDF of protection setpoints.
III.6	Recommended	Perform visual inspection for coolant leaks, coolant level, and proper pressure.	-	-	-	-	Record initial module temperature.
III.7	Recommended	If venting is implemented, demonstrate ventilation system control and filtration cleaning.	-	-	-	-	Video
III.8	Recommended	Confirm no conflicts exist between heating and cooling system settings.	-	-	-	-	Record thermostat setpoints.
III.9	Recommended	Demonstrate heating system thermostat control and output.	-	-	-	-	
III.10	Recommended	Demonstrate cooling system thermostat control and output.	-	-	-	-	
III.11	Recommended	Demonstrate HVAC faults and alarming.	-	-	-	-	
III.12	Recommended	Demonstrate how BMS protects batteries from overcharging and overdischarging.	-	-	-	-	
III.13	Recommended	Demonstrate how the BMS protects the batteries if the module overcools. Test by temporarily modifying the temperature limits.	-	-	-	-	
III.14	Required	Demonstrate how the BMS protects the batteries if the module overheats. Test by temporarily modifying the temperature limits.	-	-	-	-	
III.15	Required	Confirm HMI/display screens are complete, user-friendly, communicating, and accurate.	-	-	-	-	Photo(s)
III.16	Required	Confirm BMS SOC setpoints for low, minimum, high and maximum.	-	-	-	-	Record setpoints and provide to utility.
III.17	Required	Confirm all MODBUS reads and writes from the Battery Management System(s) to the IPP controller.	-	-	-	-	Provide PDF of register map.
III.18	Required	Confirm all MODBUS reads and writes from the Power Conversion System/inverter(s) to the IPP controller.	-	-	-	-	Provide PDF of register map.
III.19	Required	Confirm all MODBUS reads and writes from the PV system to the IPP controller.	-	-	-	-	Provide PDF of register map.
III.20	Required	Demonstrate a fault message from the BMS and a fault reset.	-	-	-	-	
III.21	Required	Demonstrate a fault message from the inverter and a fault reset.	-	-	-	-	
III.22	Required	Demonstrate a fault message from the renewables system and a fault reset.	-	-	-	-	
III.23	Required	Confirm all MODBUS reads from utility controller to IPP controller.	-	-	-	-	Photo(s). Provide PDF of register map.
III.24	Required	Confirm all MODBUS writes from utility controller to IPP controller.	-	-	-	-	Photo(s). Provide PDF of register map.
III.25	Required	Demonstrate communications UPS functionality (if implemented) by removing its power input.	-	-	-	-	
III.26	Required	Determine the duration of communications latency between utility controller and IPP controller.	-	-	-	-	
III.27	Required	Confirm readiness of data logging.	-	-	-	-	
III.28	Required	Confirm default setpoints are 60Hz and 496V.	-	-	-	-	
III.29	Required	Confirm readiness of utility revenue metering of auxiliary and/or bulk power connections.	-	-	-	-	
III.30	Required	Provide utility with BESS isolation transformer nameplate data (if applicable).	-	-	-	-	Photo(s)
III.31	Required	Demonstrate how black start is disabled (unless explicit emergency utility permission is granted on case by case basis).	-	-	-	-	Witnessed by utility.
III.32	Required	Demonstrate how the potential for unsynchronized closures between diesel and BESS will be prevented.	-	-	-	-	Witnessed by utility.
III.33	Required	If restrictions inflict a kW charge limit and/or a kW discharge limit, demonstrate these limits are functioning and are communicated effectively to the utility controller.	GFL	-	-	-	
III.34	Recommended	Demonstrate inverter pre-charge and review status of IGBT's and DC link.	GFL	-	-	-	
III.35	Required	Demonstrate accuracy of AC metered voltages. Record the amount of voltage drop (or rise) between the diesel bus and the BESS module at 0% Real, 0% Reactive load level, and at +50% Real, +50% Reactive load level.	GFL	-	-	-	Record of both voltages at both loads.
III.36	Required	Demonstrate PCS responds to voltage and frequency setpoint changes.	GFL	-	-	-	
III.37	Required	Confirm phase rotation, current and power metering accuracy, and polarities.	GFL	-	-	-	

Test Index	IPP Requirements	Test Description	BESS Mode	Real / Reactive Load Bank*	BESS Load	Diesel Load**	Record
III.38	Required	Switch inverter mode from grid following mode to grid forming mode while parallel with diesel. Confirm no PQ disruptions and null export of real and reactive power during the transition.	Both	0% P / 0% Q	-	Yes	Define PQ Requirements
III.39	Required	Switch inverter mode from grid forming mode to grid following mode while parallel with diesel. Confirm no PQ disruptions and null export of real and reactive power during the transition.	Both	0% P / 0% Q	-	Yes	Define PQ Requirements
III.40	Required	Demonstrate equalization/balance charge process. If equalizing takes the BESS out of service, demonstrate how the BESS indicates whether the process is completed or not for return to service. SOC setpoints may be temporarily modified to expedite this test.	Either	-	-	-	Provide Written Narrative.
Test Index	IPP Requirements	Test Description	BESS Mode	Real / Reactive Load Bank*	BESS Load	Diesel Load**	Record
IV.1	Required	If BESS Emergency Stop is provided, demonstrate trip will stop operation under load without equipment damage.	GFM	Any		-	
IV.2	Recommended	Demonstrate BESS Black start process, only if required by the owner.	GFM	-		-	
IV.3	Required	RLC Load Bank + BESS Only. Load Steps from 0% P / 0% Q to test transient response in GFM.	GFM	+50% P / +50% Q	+50% P / +50% Q	-	Record of f/V outputs and setpoints.
IV.4	Required	RLC Load Bank + BESS Only. Load Steps from 0% P / 0% Q to test transient response in GFM.	GFM	+50% P / -50% Q	+50% P / -50% Q	-	Record of f/V outputs and setpoints.
IV.5	Required	RLC Load Bank + BESS Only. Load Steps from 0% P / 0% Q to test transient response in GFM.	GFM	+100% P / 0% Q	+100% P / 0% Q	-	Record of f/V outputs and setpoints.
IV.6	Recommended	Confirm no installation-related hotspots at +100% P / 0% Q (full load) using thermal sensing or camera.	GFM	+100% P / 0% Q	+100% P / 0% Q	-	
IV.7	Required	Demonstrate BESS Overload capability and response	GFM	+100% P / (Increasing) Q	+100% P / (Increasing) Q	-	Record Maximum load and duration and any frequency droop response.
IV.8	Required	BESS Only Phase Imbalance Test. Repeat +50% P / +50% Q test with only one phase of load bank connected in order to evaluate phase imbalance perfomance/negative reactance in GFM. Repeat with one two phases of load bank connected.					Record voltages and currents for each phase. Note any freqency/voltage disturbances plus settling times.
IV.9	Required	During Diesel + BESS load share, disconnect communications cable, and demonstrate BESS ramp down during loss of communications. Confirm comm lockout flag is set in system controller.	GFM	Any	Any	Any	
IV.10	Required	Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses from 0% P / 0% Q onto the diesel in parallel to the BESS at a load share balance of: **Diesel at [+50% P / 0% Q] and BESS at [+50% P / 0% Q]**	GFM	+100% P / 0% Q	+50% P / 0% Q	+50% P / 0% Q	
IV.11	Required	Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses from 0% P / 0% Q onto the diesel in parallel to the BESS at a load share balance of: **Diesel at [0% P / +50% Q] and BESS at [0% P / +50% Q]**	GFM	0% P / +100% Q	+0% P / +50% Q	+0% P / +50% Q	
IV.12	Required	Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses from 0% P / 0% Q onto the diesel in parallel to the BESS at a load share balance of: **Diesel at [+50% P / +50% Q] and BESS at [+50% P / +50% Q]**	GFM	+100% P / +100% Q	+50% P / +50% Q	+50% P / +50% Q	
IV.13	Required	Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses from 0% P / 0% Q onto the diesel in parallel to the BESS at a load share balance of: **Diesel at [0% P / -50% Q] and BESS at [0% P / -50% Q]**	GFM	0% P / -100% Q	0% P / -50% Q	0% P / -50% Q	
IV.14	Required	Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses from 0% P / 0% Q onto the diesel in parallel to the BESS at a load share balance of: **Diesel at [+50% P / -50% Q] and BESS at [+50% P / -50% Q]**	GFM	+100% P / -100% Q	+50% P / -50% Q	+50% P / -50% Q	
IV.15	Required	Use RLC load bank + Diesel + BESS in GFM. Record BESS f/V setpoints when using the loaded diesel to charge the BESS a load share balance of: **Diesel at [+50% P / -50% Q] and BESS at [-50% P / -50% Q]**	GFM	0% P / -100% Q	-50% P / -50% Q	+50% P / -50% Q	

Test Index	Site	Test Description	BESS Mode	Load*	BESS Load	Diesel Load**	Record
IV.16	Required	Use RLC load bank + Diesel + BESS in GFM. Record BESS f/V setpoints when using the loaded diesel to charge the BESS a load share balance of: Diesel at [+50% P / +50% Q] and BESS at [-50% P / +50% Q]	GFM	0% P / +100% Q	-50% P / +50% Q	+50% P / +50% Q	
IV.17	Required	Demonstrate no load diesel charging of BESS at Diesel at [+100% P / 0% Q] and BESS [-100% P / 0% Q].	GFM	-	-100% P / 0% Q	+100% P / 0% Q	
IV.18	Required	Single phase imbalance test, discharging. Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses onto the diesel in parallel to the BESS with only 1 phase of 3 phases loaded. Line-to-neutral load connection preferred over line-to-line load connection.	GFM	+100% P / +100% Q	+50% P / +50% Q	+50% P / +50% Q	Record voltages and currents for each phase. Note any freqency/voltage disturbances plus settling times.
IV.19	Required	Single phase imbalance test, charging. Use RLC load bank + Diesel + BESS in GFM. With control loops biasing the frequency and voltage, demonstrate stability of the transient response and balance of the steady state by stepping load impulses onto the diesel in parallel to the BESS with only 1 phase of 3 phases loaded. Line-to-neutral load connection preferred over line-to-line load connection.	GFM	0% P / +100% Q	-50% P / +50% Q	+50% P / +50% Q	Record voltages and currents for each phase. Note any freqency/voltage disturbances plus settling times.
IV.20	Required of utility	Utility may temporarily lower setpoints for the exercise timer and for diesel minimum runtime for diesel transition testing. Utility to test Flags that prevent diesels off: 1. Minimum Runtime in Progress. 2. Switch Diesel from AUTO into manual RUN. Confirm flag for "AT LEAST 1 GEN IN RUN." 3. Diesel warming needed. 4. Exercise needed.	GFM	-	-	-	
IV.21	Required	Demonstrate normal transition under load from Diesel + BESS to BESS Only.	GFM	+50% P / +50% Q	-	+50% P / +50% Q	
IV.22	Required	Demonstrate normal transition under load from BESS Only to Diesel + BESS.	GFM	+50% P / +50% Q	+25% P / +25% Q	+25% P / +25% Q	Record time to synchronize, note any freqency/voltage disturbances upon closure, settling times.
IV.23	Recommended	Complete a full Duty Cycle Test for the purposes of witnessing full SOC range, establishing an annual state of health baseline, confirming total storage capacity, and calculating round trip efficiency. A. Demonstrate the BESS reaching the normal low SOC setpoint (not the minimum). Confirm that the system control stops it from discharging when the setpoint is reached. B. Record the meter's starting kWh for both auxiliary power and bulk power. Record BESS DC voltage at low SOC. Record the start time. C. Complete a full duty cycle at full load. Charge then demonstrate the BESS reaches the normal high SOC setpoint (not the maximum). Confirm that the system control stops it from charging when the setpoint is reached. D. Record the charged kWh for both auxiliary power and bulk power. Record BESS DC voltage at high SOC. Record the time to charge. E. Discharge again to low SOC. Record the final kWh for both auxiliary power and bulk power. Record the time to discharge. Use kWh records to determine round trip efficiency. Keep kWh and DC voltage records for long term state of health evaluation.	GFM	+100% P / 0% Q	-	-	Record the following: Starting kWh for auxiliary power. Starting kWh for bulk power. BESS DC voltage at low SOC. Charge start and stop time. Charged kWh for auxiliary power. Charged kWh for bulk power. BESS DC voltage at high SOC. Final discharged kWh for auxiliary power. Final discharged kWh for bulk power. Discharge start and stop time. Round trip efficiency.
IV.24	Required	Use RLC load bank + Diesel + BESS in GFM. Hit the Diesel E-Stop.	GFM	+50% P / +50% Q	+25% P / +25% Q	+25% P / +25% Q	Record minimum frequency and voltage and recovery time to nominal.
IV.25	Required	Reset Diesel from shutdown. Then trigger a shutdown fault on the BESS and confirm that the diesel will respond to restore the outage.	GFM	+50% P / +50% Q	+25% P / +25% Q	+25% P / +25% Q	Record time to restore.
IV.26	Required	Demonstrate Diesel adheres to Minimum loading setpoint.	GFM	+50% P / 0% Q	(As needed)	Diesel Minimum kW	
IV.27	Required	Switch between diesels one at a time under load. For each diesel, remove load and step it back on as an impulse to demonstrate that each machine's transient response does not create instability.	GFM	+50% P / +50% Q	+25% P / +25% Q	+25% P / +25% Q	

			Mode	Load	BESS	Record	Notes
V.1	Required	Diesel + BESS in GFM. Connect to community microgrid with only 1-2 feeders at first. Demonstrate charging and discharging of BESS in parallel with the diesel using imbalanced community load.	GFM	Partial Microgrid Load	Charging and Discharging	Yes	Record BESS f/V setpoints and diesel bias levels. Record % Total Harmonic Distortion measurement, and review waveforms for abnormalities.
V.2	Required	Demonstrate diesel charging of BESS with microgrid load as constrained by winter charging limit.	GFM	Microgrid Load	-	Yes	Record BESS f/V setpoints and diesel bias levels. Record % Total Harmonic Distortion measurement, and review waveforms for abnormalities.
V.3	Required	Demonstrate BESS discharging with microgrid load during parallel operation.	GFM	Microgrid Load	-	Yes	Record BESS f/V setpoints and diesel bias levels. Record % Total Harmonic Distortion measurement, and review waveforms for abnormalities.
V.4	Required	Transition from Diesel + BESS to BESS Only.	GFM	Microgrid Load	-	Yes	
V.5	Required	Demonstrate Diesel Off operation. If renewables are available, demonstrate both charging and discharging while diesel off.	GFM	Microgrid Load	-	Yes	
V.6	Required	Transition from BESS Only to Diesel + BESS.	GFM	Microgrid Load	-	Yes	
V.7	Required	Use Village + Diesel + BESS. Hit the Diesel E-Stop.	GFM	Microgrid Load	-	Yes	Record minimum frequency and voltage and recovery time to nominal.
V.8	Required	Confirm remote accessibility by IPP. Confirm remote accessibility by utility for both monitoring and for control. Review cybersecurity measures.	-	-	-	-	
V.9	Required	Confirm remote notifications to IPP. Confirm remote notifications to utility.	-	-	-	-	
V.10	Required	Perform the following testing with the Secondary Heat System: A. Confirm ambient temperature, SHS temperatures, and SHS electrical meter are reading correctly in the system controller. Confirm diesel plant minimum temperature setpoints. B. Demonstrate AVEC plant ventilation control. C. Demonstrate any SHS protections, faults and reset process. D. Confirm SHS operation is limited to diesel off operation. E. Go diesel off/BESS only. Demonstrate ventilation control if implemented. Demonstrate that the SHS will energize once the setpoint is reached. Confirm setpoint hysteresis to limit SHS cycling. F. Temporarily disable the SHS. Demonstrate a cycle of diesel warming. Temporarily modify the minimum temperature setpoint as needed. Confirm flag for "Diesel Warming" and that a diesel returns online. Confirm hystersis conditions are met (timer and/or temperature) for diesel warming cycle to conclude. Reenable SHS. G. If minimum loading is controlled in accordance with ambient temperature, demonstrate a change in mimimum load.	GFM	-	-	-	Record ambient temperature, SHS temperatures, and SHS setpoints. Record SHS protections. Record diesel warming conditions (timer and/or temperature).