REQUEST FOR PROPOSALS

FOR

NORTH KOHALA

ENERGY STORAGE

ISLAND OF HAWAI‘I

MARCH 24, 2023

Docket No. 2022-0012

Appendix O – Functional Requirements

Hawai‘i Electric Light

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1. Project Overview

The North Kohala Reliability Project will be designed to allow a segment of the North Kohala 34.5kV system including the Maliu Ridge, Halaula, and Hawi distribution substations to be operated safely and reliably as a microgrid isolated from the bulk Hawaii Electric Light (Company) power system utilizing a Battery Energy Storage System ("BESS"). The Hawi Renewable Development (HRD) wind farm located on the same radial segment of the Hawaii Electric Light power system will not be expected to operate in the microgrid island due to its size in comparison to the size of the microgrid, the controller complexity required to enable such operation, and the legacy of equipment used at the site. Further, an additional smaller microgrid allowing operation of just the Hawi Substation islanded independent of the 34kV system, utilizing the same BESS resource and interconnection equipment, is expected.

1.1 BESS Location, Interconnection, and Demarcation

The Company plans to acquire approximately 1.2 acres of land adjacent to the existing Hawi Distribution Substation ("Land") for sighting and interconnecting the BESS. The Land will be provided for the BESS developer to install the BESS. The Land includes the 34kV line tap where the Hawi Distribution Substation is connected and where additional microgrid interconnection equipment would be expected to be installed. The BESS provider will be expected to provide all equipment on the BESS side of the BESS 34kV breaker including the BESS 34kV breaker. The Company will be responsible for all equipment on the line side of the BESS 34kV breaker including but not limited to: the microgrid controller, the Hawi Isolation Breaker, and the Hawi Substation 34kV breaker; as well as other enabling equipment beyond the Hawi Interconnection including but not limited to the Maliu Ridge Isolation Switch, fault indicators, 34kV relay protection, and any additional PTs and CTs needed at the existing sites. A Conceptual SLD of the microgrid area depicting the above-described equipment is provided in Figure 1 below.

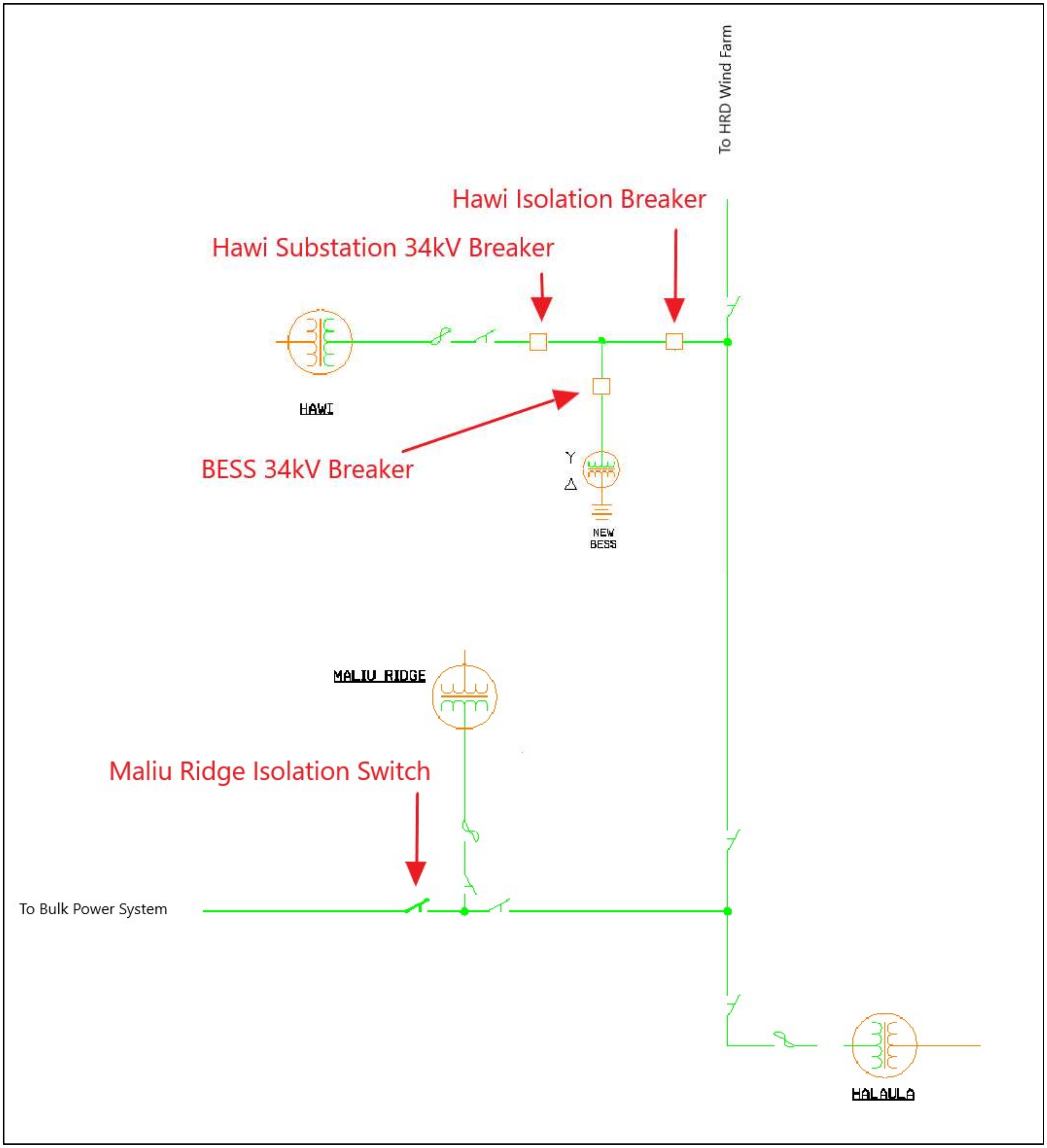

Figure 1. Conceptual SLD depicting the North Kohala Microgrid area and locations of equipment or interest.

1.2 Communications Requirements and Existing Infrastructure Capability

The Company will be responsible for all required inter microgrid communications links and communications links external to the microgrid utilizing the existing Company network infrastructure in the area. Details of how the BESS will communicate to the microgrid controller and the existing SCADA system will be established in more detailed design phases, but in general the BESS communications capability should be prepared to support a variety of possible hardware and protocol interfaces for ease of integration (i.e. fiber, copper, serial, IP, etc.). The interface between the

BESS communication system and the Company communication system will be achieved in a dedicated demarcation cabinet or acceptable equivalent.

An automation architecture diagram to depict the expected automation of the microgrid controller and devices it controls will be developed as part of the more detailed design. The automation architecture diagram will include decision blocks where manual controls are expected.

2. Microgrid Configurations and Transitions

The North Kohala microgrid is being designed to operate in two distinct islanded configurations.

2.1 Configuration 1: "North Kohala 34kV Microgrid"

This is the preferred configuration of the microgrid when system conditions allow (i.e. fault external to the 34 kV microgrid area). In this configuration the point of isolation from the larger power system will be at the Maliu Ridge Isolation Switch located near Maliu Ridge Distribution Substation and on the Waimea side of the Maliu Ridge substation 34kV tap such that the 34kV system between the Maliu Ridge, Halaula and Hawi substations is used to serve those stations in the microgrid.

Transitions to islanded operation in this configuration should include:

2.1.1 Configuration 1: Planned Transition

Upon a control signal from the system operator to initiate the transition to islanded operation, the microgrid will balance the power flow at the point of isolation in preparation for the isolation switch opening to achieve islanded operation. The actual operation of the isolation switch should be designed to be triggered automatically by the microgrid controller when conditions are met or manually by the system operator should manual operation be preferred or required.

2.1.2 Configuration 1: Unplanned Transition

Upon a sustained fault being detected and isolated by the Waimea and Hawi Renewable Development (HRD) 34kV breakers; the microgrid controller and system operator should be informed of the fault location. If the fault location is determined to be in the segment of line between Waimea and the Maliu Ridge Isolation Switch the Maliu Ridge Isolation Switch is to be opened by the microgrid controller to isolate the microgrid area from the fault and allow for restoration. Automation of the unplanned transition is the preferred design, but system operators can also be trained to perform steps if manual operations are required. The details of automation versus manual operations can be established in more detailed design stages and may be influenced by existing communications infrastructure and work practices.

2.2 Configuration 2: "Hawi Microgrid"

The Hawi Microgrid is an alternative configuration of the microgrid islanded area expected to be utilized only if system conditions do not allow for operation of the North Kohala 34kV Microgrid (i.e. fault internal to the 34 kV Microgrid). In the Hawi Microgrid configuration the point of isolation from the larger power system is expected to be at the Hawi Tap Breaker located on the 34kV tap to the Hawi substation such that the 34kV system between the Maliu Ridge, Halaula and Hawi will remain de-energized while Hawi is able to be energized through a very small segment of 34kV bus/line between the BESS and the Hawi distribution substation main power transformer.

Transitions to island in this configuration should include:

2.2.1 Configuration 2: Planned Transition

A planned transition to this configuration is not expected as the Hawi Microgrid is not expected to be leveraged for planned outages at this time. Should a need to operate in this configuration for planned outages be identified in future work the planned transition to this configuration should be similar to that described for the North Kohala 34kV Microgrid configuration but using the Hawi Tap Breaker for isolation rather than the Maliu Ridge Isolation Switch, and would need to be commanded through a separate SCADA point than the North Kohala 34kV Microgrid to distinguish the expected islanding configuration for the microgrid controller to transition to.

2.2.2 Configuration 2: Unplanned Transition

Upon a fault being detected and isolated by the Waimea and Hawi Renewable Development (HRD) 34kV breakers (the line will attempt a single reclose of the Waimea breaker in an attempt to restore the line after temporary faults); the microgrid controller and system operator should be informed of the fault location. Existing relaying technology provides estimated fault location based on impedance-based measurements, but fault indicators around the Maliu Ridge Isolation Switch may be a necessary improvement for accurate fault location in this application. If the fault location is determined to be in the segment of line between the Maliu Ridge Isolation Switch and the Hawi Isolation Breaker, the Hawi Isolation Breaker is to be opened to isolate the Hawi Microgrid area from the fault and allow for restoration of the Hawi loads. Automation of the unplanned transition is the preferred design, but system operators can also be trained to perform steps if manual operations are required. The details of automation versus manual operations can be established in more detailed design stages and can be influenced by existing communications infrastructure and work practices.

2.3 Black Start

It is required that the BESS be capable of black start, that is self-starting in the absence of a grid connection, but only in the designed microgrid island mode and is not required as a "cranking path" to facilitate the starting of other grid-connected generators. The black start energization of the North Kohala 34kV Microgrid or Hawi Microgrid should be achieved in a controlled method that ensures the BESS remains in operation for all transformer energizations and load additions and minimizes observable power quality issues for customers connected in the microgrid as transformers and loads are energized.

2.3.1 Configuration 1: Unplanned Transition: Black Start Method 1: "Energize All"

The preferred method to start the North Kohala 34kV Microgrid after an Unplanned Outage of the 34kV line ("Black Start Method") is by energizing all the islanded transformers and loads in a single breaker closure of the BESS such that all utility customers expected to be energized by the BESS are restored power simultaneously and are not exposed to subsequent transformer and load additions which are likely to cause a noticeable voltage flicker. The BESS capability to support this mode of energization will need to be validated through detailed resource dynamics and transformer and load energization modeling.

2.3.2 Configuration 1: Unplanned Transition: Black Start Method 2: "Energize Main Power Transformers Then Loads"

This method for black start of the North Kohala 34kV Microgrid would allow energizing all the islanded transformers with the utility customer loads disconnected and loads can be added in single feeder segments after the substation main power transformers are energized. The energization of the transformers could be achieved in a single breaker closure of the BESS such that all islanded transformers are restored to rated line voltage simultaneously or can be done in a method of controlled voltage increase to minimize inrush if the BESS supports such an energization method and if such a method would be preferred by the BESS. The BESS capability to support this mode of energization will need to be validated through detailed resource dynamics and transformer energization modeling. Further the subsequent energizations of the feeders' cold load and the power quality effect that has on already connected customers would need to be studied to ensure power quality is acceptable for load additions and can be supported by the BESS.

2.3.3 Configuration 2: Unplanned Transition: Black Start Method 1: "Energize All"

The preferred method to black start the Hawi Microgrid is by energizing the Hawi distribution main power transformer and loads in a single breaker closure of the BESS such that all islanded customers are restored simultaneously and are not exposed to subsequent load additions which could cause a noticeable voltage flicker. The BESS capability to support this mode of energization will need to be validated through detailed resource dynamics and transformer and load energization modeling.

2.3.4 Configuration 2: Unplanned Transition: Black Start Method 2: "Energize Main Power Transformers Then Loads"

This method for black start of the Hawi Microgrid would allow energizing the Hawi distribution substation main power transformer with the customer loads disconnected and loads can be added in single feeder segments after the substation main power transformer is energized. The energization of the transformer could be achieved in a single breaker closure of the BESS such that transformer is restored to rated line voltage in a single breaker operation or can be done in a method of controlled voltage increase to minimize inrush if the resource supports such an energization method and if such a method would be preferred by the BESS. The BESS capability to support this mode of energization will need to be validated through detailed resource dynamics and transformer energization modeling. Further the subsequent energizations of the feeders' cold load and the power quality effect that has on already connected customers would need to be studied to ensure power quality is acceptable for load additions and can be supported by the BESS.

2.4 Transition Back to Grid Connected:

The 34kV grid connection is expected to be restored through manual switching up to the point of isolation (Maliu Ridge Isolation Switch or Hawi Tap Breaker). Once the grid connection is restored up to the point of isolation the re-connection of the microgrid to the grid is expected to be initiated through a command from SCADA. Once the control signal to reconnect the microgrid to the grid is received the microgrid controller will verify the grid connection is energized (acceptable voltage and frequency), the BESS will synchronize the microgrid voltage and frequency to grid voltage and frequency and when acceptably synchronized will command the microgrid isolation switch or breaker to close.

2.5 Planned work on 34kV segments within the North Kohala 34kV Microgrid

At this time the majority of planned work is expected to occur between the Waimea Substation and the Maliu Ridge Isolation Switch such that the North Kohala 34kV Microgrid will be able to support all the loads that would be isolated. If in future years a need for planned work is expected on 34kV segments within the North Kohala 34kV Microgrid area those configurations would be investigated when the need is identified.

The preferred option to facilitate 34kV work within the North Kohala 34kV Microgrid will be established as the need is identified and in coordination with work schedules and practices. Additional studies to ensure safe and reliable operation in the alternate configurations will be conducted as the need is identified to support the operations and work.

2.6 Distribution Circuit Ties

To reduce complexity and the number of studies that would need to be conducted, the North Kohala 34kV Microgrid and Hawi Microgrid configurations will not consider for operation with distribution circuits within the microgrid tied and/or loads transferred. If there are circuit exceptions (circuits within the microgrid are tied or offloaded) the microgrid will not be able to operate until the configuration can be studied to ensure adequate safety and power quality in the specific configuration. Circuits within the microgrid should be restored to a non-exception status ahead of operating them in the microgrid.

3. Normal Operation and BESS Operation when Grid Connected

3.1 Normal Operation

In normal operation the 34.5kV sub-transmission line from Waimea to Maliu Ridge substation ("3300 line") supplies power to the North Kohala area via the Maliu Ridge, Halaula, and Hawi distribution substations, and allows export from the HRD wind farm.

3.2 BESS Operation when Grid Connected

When the BESS is grid connected it is expected to retain its full energy capacity in preparation for any unplanned or planned outages of the 34kV line. The restoration of energy to the BESS (charging of the BESS) is expected to be achieved through a setpoint control from SCADA and is only expected to occur when under SCADA control. The potential for the BESS to regulate voltage when grid connected will need to be studied in detail to ensure no adverse controller interactions are created between the resource and the existing HRD wind farm which also has provision for voltage regulation at its 34kV point of interconnection. If voltage regulation from the BESS is found to be favorable; the BESS will be expected to regulate voltage at its 34kV terminals through provision of reactive power to a voltage setpoint control from SCADA to the extent it can when not generating (zero active power flow or consuming energy).

3.3 No Additional Contracted Services from the BESS

The BESS is expected to be used exclusively by and dedicated to the North Kohala Microgrid. It is not expected to provide any capacity or energy dependent ancillary services to the grid when grid connected as this will conflict with its primary purpose of supporting islanded microgrid operation for extended outages of the 34kV line. Further the 69-34kV transformation capacity at the Waimea Substation is completely allocated to the capacity of the HRD wind farm and so any service when grid connected would need to be coordinated with the output of the wind farm to ensure no overloads occur. This additional complexity is not expected to be worth the small potential incremental benefit of utilizing this BESS for grid capacity or energy in addition to those services conflicting with the primary purpose as a North Kohala Reliability Resource.

The BESS will be considered for a contingency frequency response service that could be triggered in response to a frequency deviation outside of a deadband to immediately stop consuming energy if consuming energy at the time of an underfrequency event or immediately start consuming energy if there is capacity to consume energy during an overfrequency event. The response of this service would be aligned with the FFR-1 grid service procured for the Island of Hawaii and described in greater detail in the *Request for Proposals for Delivery of Grid Services from Customer-Sited Distributed Energy Resources for the Islands of O'ahu, Maui & Hawai`i*[1]. No specific allocation of capacity to this service is expected and no additional cost for this service should be contemplated as it will be enacted only when the conditions for it to operate are met and it would only be supplemental to the primary use case as the North Kohala Reliability Resource. This frequency response service should be able to be enabled and disabled through SCADA control and should only be allowed to be enabled when grid connected.

4. Grid Following and Grid Forming Capability (for Inverter Based Resources)

4.1 Grid Following (GFL)

Grid Following is defined as follows: An inverter-based resource that relies on fast synchronization with the external grid in order to tightly control the inverter's active and reactive current outputs. If these inverters are unable to remain synchronized effectively during grid events or under challenging network conditions, they are unable to maintain controlled, stable output. Advanced version of these devices (Advanced Inverters) can provide grid supporting functions such as: voltage and frequency ride-through, volt-VAR, frequency-Watt, volt-watt, etc.; when they are able to remain synchronized.

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[1] https://www.hawaiianelectric.com/documents/clean_energy_hawaii/selling_power_to_the_utility/competitive_bidding/20190822_final_stage_2_rfp_book_7.pdf (reference pdf pages 235-237)

4.2 Grid Forming (GFM)

Grid Forming is defined as follows: GFM controls set an internal voltage waveform reference such that an inverter with the GFM control shall be able to synchronize with the grid and regulate active and reactive power generation appropriately, regardless of the grid's strength, or operate independently of other generation. An inverter with GFM control shall immediately respond to grid disturbances to support stability of the grid and maintain its own control stability during the system disturbances.

4.3 Microgrid Resource Mode of Operation

The BESS will be required to be capable of operating in a Grid Forming mode when grid connected and when islanded to ensure a seamless transition from grid connected to islanded and back. The BESS when islanded will need to operate in a Grid Forming isochronous frequency control mode to control voltage and frequency in the microgrid in the absence of any other synchronous or frequency and voltage controlling resource. The BESS can remain in Grid Forming mode while grid connected but would be expected to operate on a DROOP primary frequency response and not as an isochronous source, or could be switched to a Grid Following mode of operation and provide the grid support functions it is capable of in the Grid Following mode. The mode of operation when grid connected and not transitioning to islanded will need to be studied to identify the preferred mode of operation when grid connected.

5. Power System Protection

5.1 When Grid Connected

When the microgrid is grid connected the existing power system protection schemes are expected to operate as designed.

5.2 When Islanded

Both the 34kV and Hawi Microgrid configurations will need to be studied in detail to ensure power system protection is safe and reliable for all desired configurations; and should be designed to be selective and secure to the extent achievable in all desired configurations. A model representing the detailed BESS behavior during fault conditions will need to be used to study the detailed operations of protection devices. The BESS model for this protection study should include expected limits of the BESS (ride-through, current, imbalance, etc.) so those can be avoided by power system protection systems operating ahead of those limits to still retain selectivity in the microgrid to the extent the BESS can support.

5.2.1 Hawi 34kV Bus

The BESS is expected to be interconnected to the system at a new 34kV bus created between a new BESS 34kV breaker, a new Hawi Isolation Breaker, and a new Hawi Substation 34kV breaker ("New Hawi 34kV Bus"). This segment of 34kV bus is expected to be protected utilizing an overcurrent bus protection scheme.

5.2.2 BESS Protection

The BESS will be expected to be designed with appropriate protection of the equipment on the BESS side of the BESS 34kV breaker. When grid connected the BESS protection scheme can rely on short circuit current being provided from the system. When islanded the BESS protection will need to be coordinated to the extent possible with the protection schemes described above for islanded operation. Islanded operation protection coordination will be investigated and informed in the detailed protection study. BESS protection when grid connected will also be validated as part of the detailed protection study.

5.3 Applying Alternate Settings Between Grid Connected and Islanded Operation

If any power system protection settings are expected to need to be changed between grid connected and islanded operation the protective relays will be pre-programmed with the appropriate settings for each configuration and the microgrid controller would inform the relays of which settings are to be active based on the expected microgrid configuration. The change in settings are expected to be applied ahead of operating as a microgrid to ensure safety at all times, even if it sacrifices selectivity during the transition between grid connected and islanded operation.

6. Distributed Energy Resource (DER)

6.1 Existing DER

All existing DER systems interconnected to the circuits in the microgrid area will be expected to be capable of operating when the microgrid is in an islanded configuration. Existing DER is expected to contribute to the energy capacity of the microgrid in the same form it contributes when grid connected under the existing agreement for interconnection. The BESS energy and power capacity requirements were derived with inclusion of existing DER contributions of energy into the islanded microgrid.

6.1.1 Need for BESS to consume energy when in Islanded mode

At existing levels of DER deployment in the microgrid area DER export is never more than the gross load in the area and therefore it is not envisioned that the BESS would ever need to consume energy when in islanded mode. Further, all future DER programs with capacity remaining for interconnection have a requirement for advanced inverter functions such as frequency-watt to aid in stabilizing frequency when high, as well as an ability to be externally controlled by the utility for excess energy conditions; so if future deployment of DER in the area poses an excess energy condition when in islanded mode a means to leverage the external utility control of DER can be pursued. Also given the planned nature of this microgrid for most of its operations, should a potential excess energy condition be predicted the planned work could be manipulated to try to reconnect the microgrid ahead of the excess energy condition being reached.

6.2 DER as a Microgrid Capacity Grid Service

Given stakeholder interest to allow for DER participation in a potential “Microgrid Capacity Grid Service”, the BESS sizing can contemplate an option for this potential service to be provided by DERs and the capacity acquired through this service would supplement the sizing of the BESS. A DER provided capacity service is not expected to eliminate the need for a BESS given the need for a “Grid Forming” source within the microgrid to allow for “Grid Following” DER to operate. The DER provided service would be expected to be competitively procured in conjunction with a competitive sizing of the BESS. If a DER grid service is being proposed the details of monitoring and control required of the DER to the microgrid controller for reliable cost-effective operation of the BESS in coordination with the Microgrid Capacity Grid Service DER will need to be established. The proposed design and cost to build such an interface between DER and the microgrid controller would be expected to be provided in a proposal offering a DER service solution for proper comparison of costs.