

**APPENDIX B**

**SOUTHERN CALIFORNIA PUBLIC POWER AUTHORITY**

**Energy Storage System paired with Renewable Energy Resources Specifications**

**PROJECTS WITHIN ladwp’S bALAnCING aUTHORITY**

**FOR**

**[Project Name]**

1. **Energy Storage System (ESS) Project Requirements:**
   1. ESS requirements shall apply to ESS paired with a renewable energy resource only. Stand-alone storage requirements will be addressed in a separate RFP.
   2. ESS requirements are meant to be technology agnostic, provided that the ESS project:
      1. meets all of the requirements and technological specifications provided in this Appendix A.
      2. As such, any requirements or technological specifications that cannot be met shall be explicitly stated in the proposal.
      3. Shall interconnect at transmission level only (greater than 100kV).
      4. ESS project to be interconnected to LADWP at LADWP point of interconnection with revenue grade metering.
   3. The renewable energy resources and ESS must be integrated into the LADWP as a network resource for serving load in LADWP’s balancing authority area.
   4. ESS shall consist of commercially available technology that is capable of absorbing energy, storing it for a period of time, and thereafter dispatching the energy.
   5. Seller shall be an experienced project developer with at least one member of the development team having (a) completed at least one project of similar technology and capacity to the Buyer, or (b) begun construction of at least one other project similar to the proposal being submitted.
   6. The ESS shall be installed, delivered, repaired and maintained by Seller; however, Buyer shall have full operational control over the ESS. Buyer will provide Seller payments for services provided. Buyer and Seller shall coordinate to pursue any available federal or state incentives for the project or its application, and payment will be structured to consider any incentives/tax credit that may be granted. Seller will provide Buyer with all operational requirements, limitations, and restrictions.
   7. The ESS shall be developed and installed in accordance with all applicable laws and best industry practices and standards for the applicable technology.
   8. All proposals shall explicitly provide operational capabilities and operating restrictions of proposed technology and include all control modes that ESS is capable of perform (see Table 1 for details)
   9. ESS shall have a minimum capacity at point of interconnection of one half the total capacities offered by the renewable energy resource with a minimum duration of four (4) hours. Buyer open to exploring durations longer than 4 hours if economically feasible.
   10. If the proposal includes a Battery Energy Storage System (BESS) product, the BESS proposal shall include, at minimum, information on each of the following elements:
       1. battery storage modules and racks;
       2. power conversion and transformation equipment;
       3. battery management systems;
       4. equipment for communication,
       5. thermal regulation,
       6. environmental conditioning and safety;
       7. control systems and related software;
       8. enclosures;
       9. and incidental and related equipment.
       10. BESS shall also comply with the target response times in the NERC Inverter-Based Resource Performance Guideline, as published during the anticipated design period, based on the BESS’ proposed COD.
   11. The Seller shall be obligated to maintain full ESS power and energy rating for the entire term of the agreement with Buyer.
       1. End of life ESS capacity shall match Seller’s proposed ESS capacity. If ESS capacity falls below the contracted value, the ESS will be considered not available. If the ESS capacity is overbuilt, Buyer would like the option to utilize the initial additional capability at cost with expected curve of degradation provided at commissioning and a real-time telemetered value for ESS capacity provided via SCADA.
       2. Any expected degradation of the ESS needs to be explicitly identified in Seller’s ESS proposal.
       3. Capacity shall be maintained via initial oversize, replacement and/or augmentation, at the Seller’s discretion. Seller shall be subject to liquidated damages if the Guaranteed MW and Guaranteed MWh of proposal is not maintained for the term of agreement.
       4. ESS PPA Term shall be equivalent to renewable energy resource.
   12. The ESS power shall be capable of continuous charge and discharge from Bottom of Charge (BOC) and continuous discharge from Top of Charge (TOC) for the full range of proposed MW rate and MWh.
   13. Buyer shall have ability to:
       1. Provide set points for charge and discharge of ESS as well as the ability to set specific MW charge/discharge values.
       2. Ability to specify a charge and discharge MW set point that the ESS will immediately produce, when requested.
       3. Communicate/connect with and control the ESS via LADWP SCADA, on DNP3 protocol.
   14. ESS metering shall comply with the applicable metering policies and requirements from the LADWP Bulk Electric System Meter Policy.
   15. The ESS shall be registered with the California Independent System Operator following the New Resource Implementation (NRI) Process. Such resource will become a Participating Resource in Buyer’s portfolio.
   16. The ESS system is subject to the following use limitations:
       1. Capability to provide a minimum of 400 equivalent throughput cycles per calendar year. Cycling during performance testing shall not be included in the minimum equivalent throughput cycles per year. Option for additional throughput cycles at extra cost requested.
       2. 5% annual grid charging energy allowed for ESS to have operational flexibility. (Grid charging energy- means all Charging Energy used to charge the ESS other than paired renewable energy resource proposed. Energy for grid charging will be provided by Buyer.)
       3. Be able to perform throughput cycles of one cycle per day minimum.
       4. No limitation shall be placed on ESS State of Charge levels.
       5. ESS shall have the ability to be dispatched up to the full proposed capacity, within 15 minutes. ESS dispatch requirement to be negotiated.
       6. Buyer requests option to have ESS provide between +0.8 power factor and -0.8 power factor with respect to facility capacity at the point of interconnection.
   17. The ESS shall have MESA-ESS communication standards capability as well as DNP3 communication protocol capability separately.
       1. The ESS shall establish a connection to external communications in the form of at least: one console for LADWP Energy Management System (EMS) and one console for local control.
       2. The ESS shall have Back Up Automatic Generation Control (AGC).
   18. Seller to provide real-time reporting of ESS status to Buyer via SCADA including, but not limited to:
       1. ESS throughput cycles available
       2. Specific grid charge percentage availability for the year
   19. Seller shall provide D-Curve for all 4 quadrants (MVAR output vs MW output) at all power factors to LADWP.
   20. ESS Round Trip Efficiency at rated capacity shall be explicitly provided in the proposal including auxiliary loads
   21. All ESS Warranty assumption, required standby time prior to operation, and any other system operational limitations shall be explicitly stated in the proposal.
   22. Seller will be responsible for environmental liability, and hazardous materials removal, as will be further defined and explained in the agreement between Buyer and Seller.
   23. Seller shall be responsible for disposal and end of life considerations; in the event that Buyer exercises purchase option, Seller must explicitly state in its proposal, cost to recycle or dispose all project equipment at end of life.
2. **Metering**
   1. Metering will be on the high side of the project transformer and adjusted for losses from the facility to the Point of Interconnection (POI).
      1. Energy Losses due to the resistive losses, pumps, power conversion system, MV transformers, battery management systems, & battery thermal regulation inefficiencies shall be borne by Seller.
      2. All Station Service, O&M and parasitic load (i.e., HVAC) to be absorbed by Seller with a separate meter. Seller to be responsible for all costs associated with station service and parasitic loads.
      3. Auxiliary load meters shall comply with the LADWP Bulk Electric System Meter Policy .
3. **Availability Guarantee**
   1. Throughout the Delivery Term, the ESS shall maintain monthly availability in an amount equal of ninety nine percent (99%) (the “Monthly Guaranteed Availability”). If the ESS fails to achieve the Monthly Guaranteed Availability, then Seller shall remedy such failure by paying to Buyer as liquidated damages, an amount proportional to ESS unavailability. If ESS Monthly Guaranteed Availability remains below ninety percent (90%), not including planned outage or curtailment at buyer’s discretion, after the agreed upon cure period, the ESS shall be considered in default. Liquidated damages shall include greater of maximum system cost or the CAISO fifteen-minute market (FMM) price along with EIM imbalance charges. See Exhibit C for Availability and Liquidated Damages Formula.
   2. Other Availability Requirements:
      1. Seller shall provide notification via email to LADWP communicating anticipated start and end dates of any outages. Outages subject to LADWP approval
      2. Renewable energy resources paired with ESS can be curtailed without a phone call notification. Buyer to have direct control of ESS.
      3. If SCADA for ESS is not available or visible to LADWP Energy Control Center, then the ESS will be considered unavailable.
      4. Seller shall coordinate the timing of ESS augmentation with Buyer and LADWP to ensure optimal timing and minimal interference and disruption to Buyer and LADWP.
4. **Performance Guarantee**
   1. The Seller shall guarantee the performance of the ESS for the term of the contract in accordance with the Performance Test Requirements to be mutually agreed upon by the Buyer and Seller. If the ESS does not pass the Performance Test, the entire ESS system will be considered not available until ESS does pass the Performance Test and Availability Guarantee Provision will be implemented.
   2. The following performance parameters are to be provided by Seller to Buyer for comparison against expected values provided in Exhibit 1 during performance testing, if applicable. Parameters may be modified for different technologies. All parameters measured at point of interconnection.
      1. Availability
      2. Round-Trip Efficiency (RTE)
      3. Full-rated Power
      4. Half-rated Power
      5. Charge Capacity (MW)
      6. Discharge Capacity (MW)
      7. Response Time
      8. Charge (s)Response Time
      9. Discharge (s)Storage Capacity (MWh)
      10. Charge Ramp Rate (MW/min)
      11. Discharge Ramp Rate (MW/min)
      12. Discharge Ramp Rate after synchronization (%/sec)
      13. Self-Discharge (MWh %/day)
      14. Noise (dBA)
      15. Startup Time (min)
      16. Shutdown Time (min)
      17. Minimum Charge Time (hr)
   3. Payment for ESS product will be performance-based. Payment shall be made in full if all performance parameters are met. A performance report shall be submitted by Seller to Buyer as a pre-requisite to the payment of a monthly invoice. Monthly invoice shall be paid after Buyer approves monthly performance report. Payment shall be reduced for underperformance. Performance parameter baselines and cure period to be negotiated with Buyer and Seller. Seller shall be in default if ESS performance does not meet mutually agreed baselines after cure period.
5. **Energy Storage System Control Modes (The ESS Products)**
   1. The general purpose of the ESS is to provide the ESS Products, which consist of different control modes listed and outlined in the Exhibit A Table 1 (“Control Modes”). Control Modes consist of settable functional parameters that trigger responses that the ESS can provide. The operation of any Control Mode or simultaneous Control Modes are subject to the ESS Operating Limitations, Control Mode setpoints and priorities as specified and scheduled by the Buyer, and the ESS conditions (e.g., state-of-charge, temperature, etc.) at the time of operation of such Control Mode(s). Buyer shall have the ability to provide Control Mode set points for charge and discharge of the ESS as well as the ability to set specific MW charge/discharge values and priorities, subject to those limitations and conditions. All functions should be operable from the Energy Management System (EMS) via DNP3.
   2. The following Control Modes are from the MESA-ESS Specification, and reference should be made to either the MESA-ESS Specification or IEC 61850-90-7, (or the applicable IEC 61850-90-7 replacement), or standard mutually agreed upon by the Buyer and Seller for further details with respect to each Control Mode. Tables 1 through 5 are BESS-centric and not all sections may be applicable to all ESS technologies. Seller to indicate not applicable portions in proposal.

**Table 1—Summary of Control Functions (The ESS Products)**

|  |  |
| --- | --- |
| **Control Mode Category** | **Control Mode** |
| Emergency Modes | 1. Voltage Ride-Through |
| 1. Frequency Ride-Through |
| 1. Dynamic Reactive Current |
| 1. Dynamic Volt-Watt |
| 1. Frequency-Watt (*Implement NERC Inverter- Based Performance Guideline)\** |
| Active Power Modes | 1. Charge-Discharge Storage |
| 1. Coordinated Charge-Discharge |
| 1. Active Power Limit |
| 1. Active Power Response (configurable as Peak Power Limiting, Load Following, or Generation Following modes) |
| 1. Automatic Generation Control |
| 1. Active Power Smoothing |
| 1. Volt-Watt |
| 1. Frequency-Watt Curve |
| 1. Pricing Signal |
| Reactive Power Modes | 1. Fixed Power Factor |
| 1. Volt-VAR Control |
| 1. Watt-VAR |
| 1. Power Factor Correction |

\* A frequency function/set point is needed to facilitate LADWP’s compliance to NERC Reliability Standard BAL-003-1.1, requirement R1 or its successor. That would be a temporary MW output or input triggered by a configured change in frequency.

**A.2**

The functionality set forth in Tables 2-5 below are covered in the various DNP 3.0 Control Modes in Table 1 above and will be implemented by such Control Modes. Setpoints to some Control Modes are included below to establish a common understanding of expected operations but Buyer shall have the right to direct changes to these setpoints at any time during the Agreement Term. In addition to the MESA Control Modes, the ESS shall implement the LADWP-specified “Frequency Rate of Change Response” in Table 2. The functionality set forth in Tables 2-5 is specific to Li-ion BESS products, however all other ESS products must document exceptions & deviations to any of the following terms that cannot be met due to technological limitations in the proposal/bid.

**Table 2 – AUTONOMOUS FUNCTIONS**

|  |  |  |
| --- | --- | --- |
| **AUTONOMOUS FUNCTIONS** | | |
| *Certain functions shall be available to be simultaneously armed and actively operated.* | | |
| **Frequency Rate of Change Response Control Mode**  Monitor grid frequency on the ESS side of the Point of Interconnection. Continuously compute rate of frequency change. | | |
| The ESS plant controller shall alternately have setpoints for positive or negative rate of change of frequency below or above which the ESS will respond with “Frequency Response Power” for a setpoint “Response Period”.  After the Response Period, ramp the ESS to the average power for “Rolling Average Period” before the frequency went above or below frequency rate of change thresholds. The rate at which ESS ramps back to the average power prior crossing the thresholds shall be a setpoint “Recovery Ramp Rate”. By responding with the active power from the ESS.  Set points required for Frequency Rate of Change Response: | | |
| Symbol | Value | Units |
| Δftrig | Magnitude of frequency change to trigger response | MHz |
| Δttrig | Maximum duration over which that change can accrue | sec |
| ΔPresp | Magnitude of MW response per decihertz | MW/dHz |
| tresp | Duration of MW response after triggered | sec |
| * Initiate frequency response if the magnitude of frequency change |Δf| is at least Δftrig within or at time interval Δttrig. * The response is a MW step change of amount Presp = ΔPresp × –Δf × k, where k is the unit conversion between dHz and the units used for Δf. * The response is recalculated throughout the frequency response period. Its magnitude increases if the magnitude of the frequency deviation increases as determined by comparing the current frequency and the starting frequency for calculation of Δftrig. The response magnitude is not permitted to decrease. * Frequency response ends at the expiration of response period tresp. * Ramp-out is at the same ramp rate as is used for active power control. No special ramp rate is needed for this mode.   Response time to the event shall comply with Table 2.1 in the NERC Inverter-Based Resource Performance Guideline for BESS products. | | |
| **Dynamic Reactive Current Support Mode Requirements** | | |
| Monitor voltage at Point of Interconnection | | |
| Default hold time (HoldTmms) for Dynamic Reactive Current Support Mode after voltage returns to inside the deadband is five (5) seconds.  Default to Frequency Response and Frequency Rate of Change Response are higher priority than Dynamic Reactive Current Support. | | |
| Ability to respond in a minimum of 1-3 Cycles from detecting and to provide reactive power in response to Point of Interconnection voltage falling below 0.8 pu. | | |
| **Reactive Power Control Modes Requirements** | | |
| Monitor voltage on ESS side at Point of Interconneciton. | | |
| While voltage remains between 1.1 and 0.8 pu respond to deviations in voltage outside a defined deadband with proportional reactive power. | | |
| Ramp rate (MVAR / Sec) for adjustment of reactive power. | | |
| Scheduled (day/night) fixed power factor setting for reactive power support. | | |
| **State of Charge Management (Coordinate Charge/Discharge Control Mode) Requirements** | | |
| Monitor ESS SOC and provide a mechanism to regulate SOC, principally to recover SOC after discharge events (both manual and automatic). | | |

**Table 3 – EXTERNAL OVERRIDE CONTROLS**

| **Provide functionality to trigger manual discharge, using the following parameters:** |
| --- |
| Continuous discharge power |
| Operator set point discharge time |
| Operator set point “On” ramp rate (MW / min or immediate) |
| Operator set point “Off” ramp rate (MW / min or immediate) |
| Reactive power set point (MVAR) |
| Reactive power set point timer (Hours) |
| Power factor set point |
| **In addition to the MESA-ESS specification of Charge/Discharge Storage Control Mode, provide the following functionality when the ESS is in Charge/Discharge Control Mode:** |
| 10 seconds maximum response time after receiving external command to execute manual discharge or apply reactive power |
| If present conditions do not permit requested discharge (e.g., SOC is too low), BESS shall report the maximally conforming parameters which are available over DNP 3.0. |
| During manual discharge or manual reactive control, ESS shall indicate which, if any, autonomous functions are disabled or degraded. |
| After manual discharge cycle is complete, ESS shall resume autonomous functions including automatic SOC management. |

**Table 4 – CONNECTION AND DISCONNECTION FROM LADWP GRID**

|  |
| --- |
| **CONNECTION AND DISCONNECTION FROM LADWP GRID** |
| While voltage and frequency remain within the specified voltage and frequency windows, the ESS shall remain connected to the LADWP grid unless instructed otherwise by disconnection signal or otherwise unavailable. System will stay connected and operational pursuant of Monthly Guaranteed Availability of the Agreement. |
| Provide function for commanded disconnection from LADWP grid both remotely and via local HMI. This is to be used for routine disconnection when sufficient warning is available to permit normal standard disconnect procedures by the ESS. |
| Provide functionality to accept an emergency disconnect input in the form of a dry contact. If instructed to open the ESS must immediately cease operation*.* |
| Startup and connection time from an “Off” or “Disconnected” state to “Connected and Idle” shall be no more than 300 seconds if the BESS/inverter thermal management loads are energized and the inverters are not set to “Sleep Mode”.  If the BESS is “Disconnected” but the main breaker is still closed, the BESS shall provide Buyer a timeout setpoint that causes the BESS to transition to a “Disconnected” state with the breaker closed but the inverters set to “Sleep Mode” after a Buyer setpoint number of minutes. The time to return from “Disconnected” and “Sleep Mode” to “Connected and Idle” shall be no more than 600 seconds if the BESS main breaker is closed and thermal management loads are energized. If a “Disconnected” or “Off” state opens the BESS main breaker, which removes battery and inverter thermal management power, then startup and connection time will be dependent on local temperature conditions and may exceed 600 seconds.  The BESS shall report estimated time to “Connected and Generating” at all times.  Inverters in “Sleep Mode” represents state where inverters are not switching and not synchronized to the grid. |
| 4 seconds maximum time for ESS Point of Interconnection disconnection after receiving emergency stop signal. |
| Behavior of ESS while the control systems are powered by a UPS, or an alternative auxiliary power supply, when the mains power line is shorted or opened shall be to disconnect until normal operations are restored. |
| Behavior of ESS when the mains power returns while the control systems are still powered by the UPS or an alternative power source shall be to reconnect as directed by Buyer. |
| The ESS shall have a microprocessor-based relay protection system (such as SEL 351) with CTs and PTs to detect overcurrents and to disconnect the AC breaker. |

**Table 5 – REMOTE MONITORING AND CONTROL**

| **REMOTE MONITORING AND CONTROL Requirements** |
| --- |
| 1 second sampling time for ESS-LADWP communication mechanism for data transfer during faults/triggered actions. |
| Connection to external communications systems via one console for LADWP EMS and one console for local control |
| Heartbeat timer to ensure communication path is online and processor is functioning |
| **Minimum available metrics via both data transfer and operator control updated by event driven data or buffers.** |
| Current operational status |
| Total real power (MW) |
| Total reactive power (MVAR) |
| Total complex power (MVA) |
| SOC (expressed as percent) and SOC = State of Energy / Contractual ESS Energy Amount (MWh)  Where:   1. The ESS must have full contractual ESS energy amount while complying with any warranty limitations, less Energy Losses. |
| State of Energy (Expressed as MWh of real power (alternating current)) and State of Energy = MWh ready to discharge (under real time conditions) |
| Current power capabilities in all quadrants |
| Voltage and frequency as measured at Point of Interconnection |
| Operation mode |
| Fault codes / description |
| Contractor to supply points list and sampling frequency |
| 2 seconds maximum response time for implementing changes to set points |

**Exhibit B: Safety Codes**

The ESS must comply with the most current iteration of the following safety codes at the time ofscheduled design period per proposed COD, in addition to local requirements:

* IEEE Standards 1547, 1547.1, 693, 519, P2686, P2800, P2800.1
* UL Standards 9540, 9540A, 1973, 1793, 1741, 1741SA
* NFPA Standards 855, 72, 70, 1
* IFC 2018/2021
* CFC 1206
* NEC 705, NEC 706
* ANSI C84.2006
* IEC 62933-5-2
* The ESS shall be programmed in accordance to NERC Standard PRC – 024-2 in consultation with LADWP.

## Exhibit C: Availability Calculations

Availability shall be calculated as follows:

\* 100%

Liquidated Damages = \* LD fee + EIM/FMM penalties

where

= P

PGMA = D \* (100% - GMA%)

PLD = P – PGMA

The following defined terms shall apply:

* The following requirements must be met for the ESS to be considered “Available”:
  + ESS is visible on SCADA system, can be controlled via SCADA, and perform as defined in ESS project requirements.
* EIM/FMM Penalties means CAISO pass-through cost.
* GMA means Guaranteed Monthly Availability.
* LD fee: $/MWh contract price + buyer’s add-in (To be negotiated).
* Term A - Hours exceeding planned Maintenance allowance
  + Planned Maintenance Allowance means number of hours in a month that the project is planned to have a regularly scheduled maintenance performed.
  + Any augmentation or major overhaul of the ESS shall be included in proposal of planned maintenance hours.
  + Pre-defined years in which augmentation and/or major overhaul will take place shall also be provided.
  + Any partial outage for maintenance during an hour shall count as a full hour for purposes of this definition.

* Term B - Hours of Unplanned Outage
  + Unplanned Outagemeans any outage that has not been planned and communicated to Buyer in advance.
  + Outages due to factors that are not in the control of Seller shall not be counted as “unplanned” hours in the calculation of the availability; including
    - Force Majeure,
    - Buyer Default,
    - Grid outages
  + Any partial outage during an hour shall count as a full hour for purposes of this definition.

Term C - Number of hours where the ESS fails to meet performance criteria (defined below).

* Performance criteria defined below are subject to change.

|  |  |
| --- | --- |
| **Performance Parameter** | **Performance Sub parameter** |
| Ramp Rate | Charge Ramp Rate |
| Discharge Ramp Rate |
| Response Time | Idle startup Time |
| Charge to Discharge Time |
| Spin to Charge/Discharge Time |

|  |  |
| --- | --- |
| Dispatched Power | Charge derate (includes physical limitations and control issues) |
| Discharge derate (includes physical limitations and control issues) |

* Term D = “Total Hours in the Month”, which means twenty-four (24) multiplied by the number of days in such month;

## Exhibit E: Specifications Template

## This template to be filled out by Seller for all applicable fields. Please indicate N/A for non-applicable items. Seller to indicate unavailable sections at time of proposal submittal.

| **Specification Parameter** | **Definition** | **Units** | **Expected Value** |
| --- | --- | --- | --- |
| Rated Continuous Discharge Power | The rate at which the ESS can continuously deliver energy for the energy storage component’s entire *specified* SOC range. | MW |  |
| Rated Apparent Power | The real or reactive power (leading and lagging) that the ESS can provide into the AC grid continuously without exceeding the maximum operating temperature of the ESS. | MVA |  |
| Rated Continuous Charge Power | The rate at which the ESS can capture energy for the energy storage component’s entire\* SOC range.  \*The percent state of charge when the charge rate may be reduced near top of charge at end of life (EOL) | MW % | **99%** |
| Rated Continuous AC Current | The AC current that the ESS can provide into the grid continuously and can be charged by the grid continuously without exceeding the maximum operating temperature of the ESS. | A |  |
| Output Voltage Range | The range of AC grid voltage under which the ESS will operate in accordance with the ESS specification. | p.u. |  |
| Total Response Time | Time between when the external signal (command) is received at the ESS boundary (site controller) and continuing until the ESS recharge/discharge power output (electrical or thermal) reaches 100 ± 2% of its rated power. | seconds |  |
| System Round-Trip Efficiency | Total Round-Trip Efficiency from beginning of life (BOL) to end of life (EOL), defined as the ratio of the delivered output energy of the ESS to the absorbed input energy required to restore it to the initial state of charge under specified conditions. | % |  |
| Ramp Rate | The maximum rate, expressed in megawatts per minute, that the ESS can change its input and output power. This may vary in multiple dimensions such as state of charge (SOC) and/or other parameters of the system that may be broken out into multiple line item values | MW/min |  |
|  | A description of the system enclosure including that supplied with the system, provided as a part of the site installation and/or comprised of building assemblies associated with the installation. |  |  |
|  | Length x Width (L x W) of equipment only (Includes ESS and all ancillary units as required) in intended layout | ft2 |  |
| Height | Equipment height plus safe clearance distances above the equipment | ft |  |
| Weight | Weight per individual sub-system (PCS, ESS, accessories, etc.), including maximum shipping weight of largest item that will be transported to the project site. Include total weight of each major component once assembled on site. | lb. |  |
| Maximum Equipment Structural Loading | Maximum weight per loaded area for any one piece of equipment | Lb/ft2 |  |
| Rated Discharge Energy | Specify the accessible energy that can be provided by the ESS at its AC terminals when discharged at its beginning of life (BOL) and end of life (EOL). | MWh |  |
| Rated Discharge Energy - Flow | Specify the accessible energy that can be provided by the ESS at its AC terminals when discharged at its beginning of life (BOL) and end of life (EOL). | MWh |  |
| Minimum  Charge Time | The minimum amount of time required for the ESS to be charged from minimum SOC to its rated maximum SOC. | Hr. |  |
| Typical Recharge Time | This should include any time for rest a period needed between a full or partial charge or discharge cycle. | Hr. |  |
| Expected Availability of System | Percentage of time that the system is in full operation performing application specific functions considering both planned and unplanned down-time. | % |  |
| Expected Term of the Warranty | For ESS | Yr. |  |

## System Ratings and Limits

| Specification Parameter | Description | Units | Expected Value |
| --- | --- | --- | --- |
| WMax | The maximum real power that the ESS can deliver to the grid, in Watts. | MW |  |
| VAMax | The maximum apparent power for ESS, in Volt-Amperes. | MVA |  |
| VARMax | The maximum reactive power the ESS can produce or absorb, in VARs. | MVARs |  |
| WChaMax | The maximum real power the ESS can absorb from the grid, in Watts (e.g. battery storage charging). Note that WChaMax may or may not differ from WMax. | MW |  |
| VAChaMax | The maximum apparent power the ESS can absorb from the grid, in Volt-Amperes (e.g. battery storage charging). Note that VAChaMax may or may not differ from VAMax. | MVA |  |
| Rated Discharge Energy | The accessible energy that can be provided by the ESS at its AC terminals when discharged at its beginning of life (BOL) and end of life (EOL). | MWh |  |
| ARtg | A nameplate value, the maximum AC current level of the ESS, in RMS Amps. | RMS Amps |  |
| Rated Continuous Discharge Power | The rate at which the ESS can continuously deliver energy for the entire specified SOC range of the storage device that comprises the ESS. | MW |  |
| Rated Apparent Power | The real or reactive power (leading and lagging) that the ESS can provide into the AC grid continuously without exceeding the maximum operating temperature of the ESS. | MVA |  |
| Overload Discharge Power | The magnitude of temporary real power (reactive power = 0) and the duration that the ESS can provide this power before overheating. | MW |  |
| Rated Continuous Charge Power | The rate at which the ESS can capture energy for the entire SOC range of the storage device that comprises the ESS. | MW |  |
| Rated Continuous Reactive Power (MW) | The magnitude of continuous reactive power (Real Power = 0) and the duration that the ESS can provide this power without overheating. | MVar |  |
| Overload Charge Power (MW) | The maximum grid overload capability of the ESS. | MW |  |
| Overload Reactive Power | The magnitude of temporary reactive power (Real Power = 0) and the duration that the ESS can provide this power before overheating. | MVar |  |
| Rated Continuous AC Current | The AC current that the ESS can provide into the grid continuously without overheating, including the AC current that the ESS can be charged by the grid continuously without overheating. | A |  |
| Overload AC Current | The temporary AC current that the ESS can provide into the grid and the duration that it can support this current before overheating. | A |  |
| Output Voltage Range | The range of AC grid voltage under which the ESS will operate in accordance with the ESS specification. | Vac |  |
| Voltage Unbalance Limit | Voltage unbalance requirements as per ANSI C84. 2006. |  |  |
| Output Frequency Range | The range of frequency under which the ESS will operate according to its specification. | Hz |  |
| AC Breaker | Description of how the ESS is protected from over-currents by an AC breaker. |  |  |
| Grounded or Isolated Output | Specify grounded or isolated output. |  |  |
| Phase Imbalance limits (on PCS, XFMR, etc.) | Load current imbalance that is acceptable on the output of the ESS without overheating or de-rating the rated power capability of the power systems. | % |  |
| Current THD into Resistive Load  (IEEE 519) | Total harmonic current of the ESS power output into a resistive load. | % |  |
| Power Conversion System Switching Frequency | Nominal switching frequency at which the ESS power switching devices operate. | Hz |  |
| Low Voltage (Fault) Ride Through Performance | Include a chart of the magnitude of ESS terminal voltage with respect to the time before the ESS disconnects or losses synchronization. | Chart |  |
| High Voltage Ride Through Performance | Include a chart of the magnitude of ESS terminal voltage with respect to the time before the ESS disconnects. | Chart |  |
| Withstand Voltage  (per Device) | Include a chart of the magnitude of ESS terminal voltage with respect to the time before the ESS is damaged. | Chart |  |
| Ramp Rate | The maximum rate, expressed in megawatts per minute, that the ESS can change its input and output power. This may vary in multiple dimensions such as state of charge (SOC) and/or other parameters of the system that may be broken out into multiple line item values. |  |  |

## System Efficiency

| Specification Parameter | Description | Units | Expected Value |
| --- | --- | --- | --- |
| System Round Trip Efficiency | Total Round-Trip Efficiency from beginning of life (BOL) to end of life (EOL), defined as the ratio of the delivered output energy of the energy storage system to the absorbed input energy required to restore it to the initial state of charge under specified conditions. |  |  |
| Provide the total round trip efficiency under the following conditions, at the beginning of life (BOL). |  |  |
| 100% DoD Cycles, @ 50% SOC, Full rated power. | % |  |
| 100% DoD Cycles, @ 50% SOC, Half rated power. | % |  |
| 100% DoD Cycles, @ 50% SOC, Quarter rated power. | % |  |
| 20% DoD Cycles, @ 50% SOC, Full rated power. | % |  |
| 20% DoD Cycles, @ 50% SOC, Half rated power. | % |  |
| 20% DoD Cycles, @ 50% SOC, Quarter rated power. | % |  |
| Provide the total round trip efficiency under the following conditions, at the end of life (EOL). |  |  |
| 100% DoD Cycles, @ 50% SOC, Full rated power. | % |  |
| 100% DoD Cycles, @ 50% SOC, Half rated power. | % |  |
| 100% DoD Cycles, @ 50% SOC, Quarter rated power. | % |  |
| 20% DoD Cycles, @ 50% SOC, Full rated power. | % |  |
| 20% DoD Cycles, @ 50% SOC, Half rated power. | % |  |
| 20% DoD Cycles, @ 50% SOC, Quarter rated power. | % |  |

## Recharge Characteristics

|  |  |  |  |
| --- | --- | --- | --- |
| Specification Parameter | Description | Units | Expected Value |
| Minimum Charge Time | The minimum amount of time required for the ESS to be charged from minimum SOC to its rated maximum SOC. | h |  |
| Recommended Charge Power | Recommended charge power while staying within the manufacturer's rated guidelines on SOC and internal temperatures. | MW |  |
| Typical Recharge Time | This should include any time for rest a period needed between a full or partial charge or discharge cycle. | h |  |

## Cycle Life

| Specification Parameter | Description | Units | Expected Value |
| --- | --- | --- | --- |
| Cycle Life | The numbers of cycles that the energy storage system can perform until end-of-life (EOL), independent of calendar life degradation, at specified depth of discharge after which electricity storage becomes inoperable or unusable for a given application. |  |  |
| Specify cycle life at full-rated power. | Qty. |  |
| Specify cycle life at half-rated power. | Qty. |  |
| Specify cycle life at quarter-rated power. | Qty. |  |
| End of Life Criteria | The condition of the ESS at the end of life in terms of capacity, impedance, efficiency, and other pertinent parameters. | Charts |  |
| Cycle Life Under Customer Application Load Profile | Chart of the degradation rate of capacity and impedance (if applicable) with respect to a measurable duty in the customer application (such as watt-hour through-put or cycles). Specify Charge/Discharge, DoD, and EOL conditions. | Charts |  |

## Environmental Operating Conditions

| Specification Parameter | Description | Units | Expected Value |
| --- | --- | --- | --- |
| System Minimal Operational Temperature | Minimal temperature at which the system can operate at its rated capacity  (also consider min/max temp limits when in standby or when idle). | °F |  |
| System Maximum Operational Temperature | Maximum temperature at which the system can operate at its rated capacity  (also consider min/max temp limits when in standby or when idle). | °F |  |
| System Maximum Operational Altitude | Maximum altitude at which the system can operate at its rated capacity  (also consider min/max temp limits when in standby or when idle). | ft |  |
| Mechanical Stress -Outdoor - Expected Period between Major Exterior Refinishing | Estimated time before exterior refinishing when operated in the intended customer application. | Yr. |  |
| Mechanical Stress - Outdoor - Snow Load Rating | Rated weight per area of snow before damage occurs to ESS components. | lb./ft2 |  |
| Mechanical Stress - Outdoor - Ice Load Rating | Rated thickness of ice on top of ESS components before damage occurs. | in |  |
| Mechanical Stress - Outdoor - Wind Speed Limit | Rated wind speed before damage to the ESS occurs. | mph |  |
| Mechanical Stress - Outdoor - Flood Tolerant (Height) | Rated flood tolerance height. | Mft |  |
| Mechanical Stress - Outdoor - Other | Other known outdoor mechanical stresses to consider for the project site. |  |  |
| System Operational Altitude Range | Rated maximum altitude at which the ESS can perform according to its full specifications. | ft |  |
| Range of Operational Humidity Range (%RH) | Range of humidity in which the ESS can operate according to its full specifications. | %RH |  |
| Storage Humidity Range | During construction phase and spare part storage requirements. | %RH |  |

## Emissions & Environmental Impact

|  |  |  |  |
| --- | --- | --- | --- |
| Specification Parameter | Description | Units | Expected Value |
| Sound Emissions – 6 ft High, 3 ft from Perimeter | Audible Noise dB at 3 ft distance (nearfield). | dB |  |
| Sound Emissions – 6 ft High, site boundary (approximately 40ft from ESS) | Audible Noise dB at site boundary (approx. 40 ft). | dB |  |
| Fluids Containment Necessary (Moat, Tank, or Pond) | Type, amount, and under which conditions. |  |  |
| PM – (Airborne) Particulate Matter | Type, amount of emitted airborne particulates and under which conditions with respect to the energy through-put. | MT/MWh |  |
| Gas Emissions (NOx or SOx or CO2) | Type, amount of emitted gas, and under which conditions with respect to the energy through-put. | MT/MWh |  |

## Auxiliary Power System & Components

|  |  |  |  |
| --- | --- | --- | --- |
| Specification Parameter | Description | Units | Expected Value |
| Auxiliary Power Components Required | The type of auxiliary power components required for the ESS if applicable.  May include the power required for cooling fans, oil pumps, and other ancillary equipment that is needed for the functioning of the ESS to charge or discharge ESS. 120/240 VAC and 480/277 VAC auxiliary power is provided at ESS unitized substation (transformer and breaker) as well as 125 VDC control power. |  |  |
| Total Auxiliary Power Required | Specify by each auxiliary power component.  Item A  Item B  Item C | kW (ea.) |  |
| Average Auxiliary Power Required - Continuous | Aux continuous power (used to estimate system tare losses and to size the continuous rating of a power transformer or other thermally tolerant devices). | kW |  |
| Total Auxiliary Power Required - Peak Power (Locked Rotor, etc.) | Aux peak power (locked rotor, etc.) used to size the ratings of in-line fuses and wiring and other thermally intolerant assets). | kW |  |
| Aux Nominal Voltage | Specify | Vac |  |
| Auxiliary VAC Wiring | Auxiliary number of phases (1, 2, or 3). | No of Phases |  |
| Aux Circuit Breaker Rating | Recommended breaker rating for auxiliary power circuits. | A |  |

## Thermal Management

|  |  |  |  |
| --- | --- | --- | --- |
| Specification Parameter | Description | Units | Expected Value |
| Type (HVAC, Chiller, Blower, etc.) | Thermal management systems that are used to heat or cool the ESS (if applicable). |  |  |
| Liquid Type Required (if Any) | Liquid used to transport heat from one part of the system to another (if applicable). |  |  |
| Expected 100% Capacity Availability of Thermal System | Amount of heat (watts) the thermal system can remove (or add) from (to) the ESS when the thermal system is operating at 100% capacity. | W |  |
| Redundancy | Redundancy built into the cooling system (if any). Percentage of ESS that will shut down if all or part of the cooling system were to fail or shut down for maintenance. Length of time the ESS can operate under partial capability conditions and specify conditions. | %, hr. |  |

## Maintenance

|  |  |  |  |
| --- | --- | --- | --- |
| Specification Parameter | Description | Units | Expected Value |
| Availability of System | Percentage of time that the system is in full operation performing application specific functions considering both planned and un-planned down-time. | % |  |
| Expected Unplanned Downtime of System for Repair | Mean Time Between Failures (MTBF) or actual field failure data welcome. | Hr. |  |
| Expected Planned Downtime for Maintenance | Expected time required for regular maintenance and types of maintenance. | hr./yr. |  |
| Expected Service Period between Regular Maintenance | Specify | days |  |
| Expected Time to Perform Regular Maintenance | Specify | Days |  |
| Expected Service Life before Major Replacement | Specify | years |  |
| Equipment Storage Requirements | Environmental requirements to be maintained around spare parts and system components prior to installation and/or during temporary storage, (temperature, humidity, leak containment, etc.) e.g. IEC 60721-3-1. |  |  |

## Start Up/Shut Down Characteristics

|  |  |  |
| --- | --- | --- |
| Specification Parameter | Description | Expected Value |
| Average Start Up Time | Typical start up time under the specified conditions. List for both cold start and from standby mode. |  |
| Maximum Start Up Time | Seconds |  |
| Typical Shut Down Time | Seconds |  |
| Maximum Shut Down Time | Seconds |  |
| Control Power UPS Back-Up Time | Expected minimum autonomy time on back-up power (provided by the UPS). |  |
| System Behavior when Main Power Is Interrupted | Behavior of system while the control systems are powered by a UPS, or an alternative auxiliary power supply, when the mains power line is shorted or opened. |  |
| System Behavior when Mains Power Returns | Behavior of system when the mains power returns while the control systems are still powered by the UPS or an alternative power source. |  |