Installation, Performance and Safety Specifications of Battery Energy Storage Systems (BESS}

BESS must, among other things, must : (a) have a guaranteed (useful) capacity between (1) hours (MWh/MW)to (4) hours (MWh/MW) based on the maximum output of the RES systemand the technology used as defined in the scheme (b) have a round-trip efficiency of at least **80%** at the start of their operation, (c) when in standby mode, the total energy consumption for any purpose should not exceed **15%** of the guaranteed capacity on a daily basis, (d) achieve a power availability of at least **92%,** (e) meet all technical requirements for connection to the power system, according to the relevant decisions, in accordance with the relevant Regulations, as applicable at any given time, (f) can participate in frequency support reserve processes, manual and automatic frequency restoration reserves of the power system, (g) be compatible with standards EN IEC 62933-5-2, NFPA 855, EN IEC 61936-1 or equivalent international or national standards and regulations.

A. Installation specifications

Disclaimer: The following specifications are indicative and may be subject to change in the final scheme. Specifications provide a basic guideline for implementation to meet specific project needs. These information ensures that all applicants understand the baseline requirements and can plan accordingly, though some specifications and situational guidelines may be adjusted by operators (DSO/TSO) based on the specific project characteristics (i.e. technology used, size of the project etc).

The conditions following do not apply to all systems. The TSO/DSO will provide different conditions for each system. In the final scheme, these specifications will be omitted, as each project must consult the TSO/DSO before applying for the scheme to obtain terms based on its specific characteristics.

1. The PoC (point of connection) of BESS to the Cyprus electrical Transmission System will be located at the Voltage level (i.e. for HV systems based on capacity) , at the HV bay of an HV/MV substation, feeding the corresponding HV/MV power transformer.

2. BESS installation yard will be independent from the connecting HV/MV substation, connecting them to Transmission System, although they can be installed on adjacent areas. In case of adjacent areas, the substation fence will separate them. BESS yard and substation will have also independent entries. BESS yard could be fenced together with a renewable energy resource installation.

3. The HV/MV transformer and the primary MV switchgear connecting BESS to Transmission System will be always located in the HV/MV substation, whereas the secondary MV switchgear and the MV/LV transformers will be always located in the BESS installation area.

4. The AC and DC auxiliary power needed for BESS installation will be independent from the auxiliary power of the connecting HV/MV substation. No common low voltage busbars, transformers or chargers are allowed.

5. Electrical disconnecting switches shall be available at both sides of transformers and PCS (power conversion system) units, providing safety during maintenance.

6. The earthing grid of the HV/MV substation will be also independent from BESS earthing, unless the two installations are adjacent. In this case connections between the two earthing systems are allowed, following approval from the Transmission Operator.

7. Hazardous live parts of BESS shall be protected to avoid risk of electric shock and arc flash, including during erection and commissioning. BESS insulation, electric shock protection and earthing shall follow the provisions of IEC 62933-5-2 and IEC 61936-1. Also, the provisions of IEC 60364 series shall be followed, especially of IEC 60364 -4 -41. Alternatively, equivalent UL/IEEE standards can be followed. Resistance measurement of earthing shall be performed after installation, with the earthing system isolated from installations outside of BESS yard (e.g. isolated from HV/MV substation).

8. A multi-level electrical protection system shall be installed, providing at least over-current protection, as well as earth-fault detection in isolated (IT) systems or earth-fault protection in earthed (TN) systems. As far as possible, protection coordination shall be provided and documented. For the design, erection and commissioning of the electrical system of BESS, the provisions of IEC 62485-2 shall be followed. Also, the provisions of IEC 60364 series shall be followed, especially of IEC 60364-4-43, IEC 60364-5-53 and IEC 60364-5-57. Alternatively, equivalent UL/IEEE standards can be followed.

9. ESMS (energy storage management system) of BESS will be independent from the control and protection system of the HV/MV substation.

10. Clearance and fire-resistant barriers of transformers to other equipment shall follow IEC 61936-1 or equivalent UL/IEEE standards.

11. Requirements regarding emission and immunity EMC levels shall follow IEC 61000-6-2, IEC 61000 -6-4 or equivalent UL/IEEE standards.

12. All equipment of BESS (converters, transformers, battery modules) shall be type and routine tested, following the relevant IEC equipment standards and IEC 62933-5-2. Alternatively, they can follow equivalent UL/IEEE standards.

13. During commissioning, the specified by manufacturer initial charging and initial discharge/charge cycle shall be performed, in order to achieve guaranteed energy capacity, prolong battery lifetime and set correctly the SoC (state of charge) measurement.

B. Performance specifications

I. General

1. BESS will be able to provide/absorb maximum export/import active power at PoC, at outdoor temperature range between -10°C and 45°C. At high temperatures, solar radiation at noon of 1000 W/ m2 shall be considered. At low temperatures, snow and ice conditions shall be considered.

2. All performance requirements i.e. below mentioned guaranteed energy capacity, maximum export/import active power, efficiency requirements, standby energy consumption requirements and monitored operational period requirements will be referred to PoC.

3. The mentioned below reference conditions are meant only for declaration of performance values, not as actual operating conditions. The necessary corrections will be implemented to the measured performance values, in case of variations from reference conditions. Also, the mentioned below standby mode is meant as reference for declaration of standby energy consumption, not as obligation to operate that way. Definition of terms regarding BESS can be found in IEC 62933 -1, additionally to below mentioned ones.

4. Maximum export active power of BESS is the maximum continuous active power at PoC, that BESS will be contracted to provide during discharge to the Transmission or Distribution System, at

nominal voltage. Maximum import active power of BESS is the maximum continuous active power at PoC, that BESS will be contracted to absorb during charge from the Transmission System, at nominal voltage.

5. The guaranteed energy capacity of BESS is the total energy that BESS will be contracted to be able to provide at PoC during discharge, using maximum export active power from SoC 100% to SoC 0% (DoD100%). The nominal discharge time will vary from 1-3 hours min based on different technologies as indicated in the scheme.

6. During standby operating mode, with no charging or discharging of batteries, BESS shall be able to receive (and deliver) maximum import (and export) power at PoC without any intentional delay (meaning with sub-second delay) upon request. All frequency and voltage control functions will be active during this mode.

II. Round-Trip Efficiency

1. The round-trip efficiency (RTE) of BESS at PoC shall be higher or equal to **80%.**

2. RTE will be given at BoL (beginning of life), meaning right after commissioning and energization of BESS. Charge and discharge will be performed with maximum import and export active power, respectively and unity power factor.

3. RTE will include all essential loads of BESS installation, including battery cooling system and all necessary HVAC systems for any part of the installation, emergency lighting of BESS area, BMS (battery management system) and ESMS operation.

4. RTE will include all transformer and converter losses. Maximum import/export power and unity power factor will be retained at PoC at nominal voltage, as a reference condition, during the whole charge/discharge cycle.

5. RTE will be calculated with DoD (depth of discharge) 100%, meaning for one cycle with SoC from 0% to 100% and then back to 0%.

6. Outdoor temperature will be taken at 25°C and solar radiation at 600 W/ m2 as a reference condition.

Ill. Standby Energy Consumption. Self-Discharge

1. The standby energy consumption of BESS at PoC shall be lower or equal to 0.15*C/day (C is guaranteed energy capacity).

2. Standby energy consumption will include all essential auxiliary loads during standby state, as in (I) above, as a reference condition. Thermal conditioning of batteries will follow manufacturer's specifications. Batteries and PCS will be kept in a readiness/ active state, ready to supply maximum export power within one second. This means that the thermal conditioning system will keep the batteries at recommended temperature and the PCS will have the electronic valves energized (not blocked).

3. Standby energy consumption will be given at 100% SoC and it will also include the energy needed to recharge the batteries to this level, due to self-discharge.

4. Outdoor temperature will be taken at 35°C and solar radiation at 800 W/ m2 as a reference condition.

IV. Availability

1. The yearly equivalent availability factor (EAF) of BESS installation at PoC shall be above or equal to **92%** (charged/standby) during the first 10 years of operation. EAF will be calculated as a 2-year mean value, for each one of the five 2-year successive periods of the 10-year operation, based on actual data.

2. The calculation of EAF shall be based on IEEE 762 definitions and types, adapted for BESS as necessary. As mentioned in the above standard, besides the forced outages or derating, any derating due to environmental conditions, as well as any derating or outage due to planned maintenance, will affect the availability value.

V. Monitored Operational Period

1. BESS capacity will be augmented, so that the minimum required guaranteed energy capacity will be retained during the first 10 years of operation. Energy capacity and RTE will be measured at the end of each one of the five 2-yearsuccessive periods of the first 10-year operation period. BESS capacity shall not fall below minimum required guaranteed energy capacity at Bol at any of the above measurements.

2. There shall be enough free space on the BESS installation yard for the capacity augmentation, following calculations and guidelines from the manufacturer. **There shall be free space for installation during the 10-year period for at least 20% additional capacity,** calculated on the guaranteed energy capacity of BESS. Additionally to available free space, it is permitted to install initially the necessary additional capacity, above the minimum needed (1-3 MWh/MW), provided that no other capacity augmentation will be need ed during the 10-year period, following calculations of the manufacturer.

3. RTE shall also not fall below 75% at the end of the 10-year period. RTE limit values at the end of each 2- year period shall be distributed linearly between the Bol values stated in par. B.11 and the 10-year values stated in the present paragraph. RTE shall not fall below the corresponding limit value, at the end of any of the five 2-year periods.

C. Safety specifications

The below mentioned safety requirements are applied to outdoor, modular installation of BESS, using Li-ion batteries in walk-in or non-walk-in containers (outdoor metallic enclosures). Different types of batteries and installations shall have equivalent requirements. Other safety requirements, not mentioned here, as well as additional definitions, will follow the provisions of NFPA 855, IEC 62933-5-2, IEC 62485-5, IEC 62619, IEC 63056, IEC 62281, IEC 62477-1, IEC 61936-1, IEC 60364-5-57 or equivalent UL/IEEE standards.

I. General

1. Each battery module or rack, which is transported from factory to installation site as a unit, shall contain an impact sensor in its package. The battery modules transport packages pass the safety

tests foreseen in UN 38.3, as well as IEC 62281, IEC 63056 or equivalent UL/IEEE standards. Battery modules stressed by heavy impact shall not be installed on site, without prior thorough testing.

2. Design and bracing of all equipment and structures (battery racks, fire-protection, etc.) shall be earthquake-proof according to IEC 60068-3-3, with horizontal ground acceleration (zero period acceleration - ZPA) of 3.55 m/ s2 and vertical of 1.78 m/ s2• Power circuits and control system circuits, including monitoring, shall remain functional after a seismic event.

3. If there is a flooding risk in BESS installation, the containers shall be installed on an elevated steel or concrete base, above the flooding level.

4. The containers shall be weatherproof, protected against corrosion according to the environment corrosivity and the distance to seashore. Their painting shall be at least for environment corrosivity C3 (medium) and it shall have durability H (high), following ISO 12944-1, -2, -5.

5. Operation and maintenance, emergency response and fire response manuals shall be available in the local central control room, following the requirements of IEC 62933-5-2. The personal protection equipment (PPE) required for normal and emergency tasks shall be also available on site.

6. A sign shall be located near the access door of all battery containers, including electrical hazard icon and stating the type of battery technology, the used fire suppression agent and that occupancy only for inspection and maintenance is allowed. Also signs on every approach direction, readable from 30m away of BESS installation yard, shall state the presence of "Li-ion battery storage system" in Cyprus.

II. Safety Distances

1. Distance between BESS containers shall be 1m at least, but at the side having access doors the distance shall be 3m at least. BESS containers shall have walls with 1-h fire resistance. Alternatively, BESS containers without fire-resistant walls shall be located at least 6m to other containers. At any case, distance between the building or container housing the BESS central control room and other BESS containers shall be 6m at least. Battery containers (metallic enclosures) installed in contact to each other, having in total up to 100m2 footprint, can be regarded as one container.

2. Around the complete BESS installation but inside of the fence of BESS, an access road shall exist with at least 5m width, for access of fire-fighting vehicles. At least one side of each container of the installation shall lay on a 5m width road. The 5m roads of BESS installation shall be used as escape routes also and they shall have emergency lighting. The roads shall have fire hydrants for fire-fighting use.

3. BESS yard of installation, inside of the fence, shall be free of any combustible vegetation.

4. Battery containers in a BESS installation shall have at least **30m distance** from any other occupied buildings or storing spaces of combustible materials, excluding the ones associated with the BESS installation itself and the connecting HV/MV substation.

5. The containers housing batteries, PCS or transformers shall not be occupied during normal operation, only for maintenance reasons. Local central control systems of BESS shall be housed on a different container, located at least 3m from other containers. The exit of the operation container shall be to a 5m width road, not facing any other container.

6. A safety data sheet (SDS) for all included hazardous materials shall be posted within sight of the disconnecting switch in every battery container and in the local central control room of BESS.

III. Constructional Safety Measures

1. All air ingress openings of all containers shall have dust filters installed.

2. Battery containers shall be constructed so that no debris, shrapnel or pressure waves are ejected in case of a battery module explosion. Deflagration pressure reliefs (vents) shall be incorporated, not being directed towards walkways and roads.

3. Each Li-ion battery module shall incorporate a pressure relief, preventing explosion. The battery module type shall pass the mechanical, electrical and thermal "reasonably foreseeable misuse" tests, as well the other safety tests foreseen in IEC 62619 and IEC 63056 or equivalent UL/IEEE standards.

4. The battery racks type shall pass the safety tests foreseen in IEC 63056 or equivalent UL/IEEE standards, including reverse connection of a module on it during erection (if modules are erected on site).

5. Each battery container shall have a central power disconnecting switch, installed near the access door. Each battery rack shall also have a power disconnecting switch, installed on the rack. The switches shall be electrically and manually operated. Auxiliary power shall not be disconnected through these switches.

6. BMS will continuously monitor the temperature, voltage and current of each module. It will control charging/ discharging to prevent the above values reaching outside of safe limits. However, in case of overheating, BMS will send an alarm to the central control point of BESS and it will isolate the battery rack, containing the affected module, through tripping of the rack switch. In case of higher overheating and thermal runaway, BMS will isolate the entire battery container, housing the affected module, through tripping ofthe container switch. The above-mentioned protective functions of BMS shall be housed within each battery container. Failure of communication between BMS subsystems shall not lead to hazardous situation. The BMS type shall pass the relevant tests for the above-mentioned functions foreseen in IEC 62619, IEC 63056 or equivalent UL/IEEE standards.

7. In case of maloperation of above mentioned BMS monitoring and protection functions, the affected container shall be isolated through tripping of its power switch. Same will happen in case of fire alarm energization in the container.

IV. Fire Protection

1. All containers, including all transformers, shall have automatic fire alarm and fire suppression system. Automatic energization of fire suppression system by fire alarm shall be applied.

2. In battery containers, fire alarm system shall include off-gas detectors and signals from BMS. Off-gas detectors shall be sensitive to some or all of the gases released from Li-ion modules under thermal runaway (H2, CO, CO2, hydrocarbons). Activation of both overheating alarm from BMS and of an off-gas detector shall be necessary for energization of fire suppression system. Energization of fire suppression system shall follow an evacuation time, in case of walk-in containers. Also emergency

ventilation can be energized by fire alarm, but not if a flooding fire suppression system is installed and energized.

3. An external fire alarm beacon will be installed on each battery container. Audible alarm shall be also available in BESS installation. Both will be automatically energized by fire alarm system.

4. Fire suppression system shall be of water sprinkler type, suitable for electrical fires. The fire-fighting water density shall be at least 12.2 mm/min, meaning at least 12.2 lt/min per each m^2 of container area.

5. Alternatively, an aerosol or gas flooding agent fire suppression system can be installed in the battery containers. Before energization of the system, all access doors and openings shall automatically close and the ventilation stopped, allowing egress of air only through pressure reliefs (vents). After fire extinguishing, access doors and openings will remain locked, until flooding agent and smoke is removed through manual energization of ventilation. The manual ventilation energization point shall be located remotely from the battery containers and marked accordingly.

6. The battery cell and module type, as well as the battery rack and container type, as they will be installed, shall undergo a fire and explosion test (large-scale fire test) according to UL 9540A (cell, module, unit and installation levels). Reviewing of the test report shall verify that the design and the fire protection measures applied, up to the battery container level, are adequate to address a fire caused by battery thermal runaway.

7. Regardless of the fire suppression type, a permanent, reliable water supply shall be installed. If this is not possible or if the permanent supply cannot sustain the water flow needed, a water tank made from fireproof material shall be installed, having capacity of at least **20 m^3 of water.**

8. Regardless of the fire suppression type, if the battery modules are deluged with water by the fire-fighting personnel, they shall not short-circuit. Their power connections, as installed in the containers, shall be designed appropriately.

9. Before BESS installation, the owner shall submit to the local Fire Agency office the appropriate fire response manual from BESS manufacturer. Also the following information shall be submitted: location of BESS on map with coordinates, battery technology (Li-ion), guaranteed energy capacity of BESS, number of battery containers and the energy capacity of each, number of battery modules in each container and the energy capacity of each module, SDS of all hazardous material, description of the fire-alarm and the fire-suppression system, including the type of fire-suppression media used, permanent water supply connection or alternatively, the reasons why permanent water supply connection is not possible and the volume of local water tank, layout drawing of BESS installation, depicting the location of battery containers and their access doors, fire resistance rating of container walls, the roads for fire-fighting vehicles access, the locations of fire-fighting hydrants and of the water tank.

Check List

TECHNICAL SPECIFICATIONS OF MAIN EQUIPMENT

The tenderers must fill all the tables below. Where reference to technical documents is required, datasheets, manuals and/or certificates must be submitted with the Tender

1.1. Power Transformers (if applicable)

Will be defined by TSO/DSO accordingly.

1.2. BESS

No.	Requirement	Compliance (Yes/No)	Reference to technical datasheets, manuals or certificates
1.	Battery Technology: Lithium Ion LFP		
2.	Integration: DC or AC coupled		
3.	BESS shall be provided in prefabricated containers specially designed for battery storage solutions, fully assembled and tested in factory-controlled conditions.		
4.	The container construction shall allow for access to all internal equipment and devices for unobstructive inspection, maintenance and repair. The container exterior shall be galvanized and varnished with polyurethane enamel for protection against local weather conditions. The walls and roof should contain a rigid fire-proof polyurethane foam filling, to achieve water resistance and high efficiency thermal insulation.		
5.	BESS system shall be of modular type.		
6.	The cooling system along with the BMS must always keep the BESS within its optimal and nominal operating conditions, considering		

	the external ambient conditions, for maximizing performance and life		
7.	HVAC system must be intergraded for active cooling of the BESS. Homogeneous temperature distribution across all cells and modules is required to ensure long life of the system. HVAC system should be redundant.		
8.	BESS requires a complete and integrated protection system that includes: a. A gas detection system is employed to shut down faulty cells, activate a ventilation system and sound local and remote alarms b. An appropriate and capable automatic fire suppression system is installed and connected to the fire detection system c. Roof mounted blast panels and pressure relief vent to be installed.		
9.	AC and DC protections. AC and DC isolation.		
10.	Capacity**: ≥ XXX MWh per MW installed per technology according to the scheme./category**		
11.	C-rate ≤ based on a minimum XXX hours of discharge (0.5C)		
12.	**BESS shall be capable for at least one (1) cycle/day, during the guaranteed cyclic lifetime (7300 complete charge/discharge cycles).**		
13.	**Chronological lifetime: Minimum 10-years with no replacement of any major component technologies (based on 1 complete daily cycle)**		
14.	Cyclic lifetime: Able to match the minimum chronological lifetime (based on 1 complete daily cycle)		
15.	**Acceptable Performance Degradation – Energy Storage Capacity: <20 % over required chronological/cycle lifetime**		

16.	External ambient temperature: -10oC to +50oC		
17.	External ambient relative humidity: 0% to 100%		
18.	Installation: Outdoor		
19.	**DC to AC Round trip cycle efficiency ≥ 80%**		
20.	BESS Manufacturer Ability: • must hold a quality Assurance certificate ISO 9001:2015 or equivalent, regarding the manufacture and sales of utility scale storage equipment		
21.	IEC 62133, Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety		
22.	IEC 61427-1:2013: Secondary cells and batteries for renewable energy storage - General requirements and methods of test - Part 1: Photovoltaic off-grid application		
23.	CE marking		
24.	NFPA 855, IEC 62933, IEC 62477-1:2012		

1.3. BMS

No.	Requirement	Compliance (Yes/No)	Reference to technical datasheets, manuals or certificates
1.	Real-time monitoring battery operation: voltage, current, State of Charge (SoC), temperature and running status		
2.	SoC estimation		
3.	Battery health information regarding the remaining capacity as a percentage related to the nominal capacity as well as other battery health relevant information		
4.	Monitor battery safety: over-charge, over-discharge; over-heating, real-time monitoring of battery status		

5.	Self-test and self-diagnosis, fault isolation and hierarchical isolation.		
6.	Managing battery for a longer life, maintaining the battery SoC within specified limits. If the BMS detects any abnormal conditions, it shuts the battery down.		
7.	Prevent damage to the battery cells from over-charging and over-discharging		
8.	Able to fully integrate with the EMS in order to implement appropriate management strategies based on user condition. For example, the BESS shall be able to receive commands from the EMS related to the required mode of operation (e.g. required charged/discharged power/energy etc.). Nevertheless, in case the EMS requires abnormal battery operation then the BMS shall keep the BESS within the manufacturer's recommended limits and maintain maximum battery health.		
9.	Able to fully integrate with the existing RES park monitoring software		
10.	Monitor leakage current to ensure electrical system safe and reliable operation		
11.	Communication protocol based on IEC 61850 and/or Modbus TCP/IP, depending on the EMS solution		

1.4. EMS

No.	Requirement	Compliance (Yes/No)	Reference to technical datasheets, manuals or certificates
1.	The monitoring and control shall be accomplished through an internet portal by using a standard web browser and/or via an executable software. This shall allow access to the data from anywhere given the availability of internet access.		

2.	At least one (1) day ahead forecasting of both the on-site Renewable Energy/Power Generation and Energy Consumption and Power Demand in a 30-min resolution		
3.	Capability of the following daily operation modes by controlling the BESS operation**(Applies mainly for net-billing):** • Self-consumption maximization (i.e., minimizing the grid-import energy) • Tariff optimization (i.e., scheduling battery optimization based on the daily electricity tariffs and maximizing the daily economic benefit) • Peak load shaving • Load levelling		
4.	Adjust the real-time power flow, due to forecasting errors and any equipment/communication loss		
5.	The following minimum information shall be offered, in both raw data and user-friendly graphs: • Active, reactive and apparent power as well as energy imported and exported from and to the grid • BESS charged/discharged energy and power • BESS SoC • Active, reactive and apparent powers as well as energy of the RES park, imported and exported from and to the grid • Active, reactive and apparent powers as well as energy of each future equipment connected to the EMS • Weather information from the closest weather station (RES park's weather station may also be used)		
6.	Export capability of the above data to Excel		
7.	Ability to store historical data, log files and status, in at least 1-min resolution, during its whole operation period		

8.	Ability to expand and integrate with future equipment (e.g., switchgear, electrical loads etc.) under widely used communication standards and protocols such as IEC 61850, and Modbus TCP/IP		
9.	Acquisition, pre-processing and display of measured values		
10.	Operational metering		
11.	Sequence of event recording (SOE)		