module mounting structure, below the modules. In such case, the canopy is not required, and the column and foundation shall be designed accordingly.

5.03 String inverter shall have suitable communication port (TCP-IP/PLC) for SCADA integration. All necessary hardware, software and accessories used for communication with SCADA (including smart logger Data logger) at both the ends shall be provided by the bidder. String Inverters system shall support dual master communication.

5.04 String inverter shall have string monitoring (MPPT level) capability and reporting to SCADA system. Any special software if required for this purpose shall be provided for local and remote monitoring and report generation.

5.05 Anti-PID device along with all hardware and communication cable/device shall be provided in case negative grounding of PV string provision is not available in string inverter. Data logger used in Anti-PID device shall be integrated with SCADA system

5.06 DC fuse requirement for PV string at string inverter end shall be as per string manufacturer/system requirement and same shall be finalized during detail engineering stage.

5.07 Provision for AC and DC electrical isolation device (such as MCB/MCCB/Isolator) inside string shall be as per string inverter manufacturer practice.

5.08 Local Display unit for viewing important parameters, configuration and troubleshooting purpose shall be provided as per string inverter manufacture practice.

5.09 LT Junction box, switchboard, and switchgear requirement for string inverter system as per chapter B-1 (LT Switchgear).

6.00 TYPE TESTING

Applicable both for Central and String Inverter

During detailed engineering, the contractor shall submit all the type test reports including temperature rise test and surge withstand test carried out within last ten years from the date of techno-commercial bid opening for Owner's approval. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of techno-commercial bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client/owners representative and submit the reports for approval.

A-6 POWER CONDITIONING SYSTEM (PCS)

1.00 The Power Conversion System (PCS) shall be bi-directional Inverter and shall act as an interface between the DC battery system & the AC grid. PCS shall be design to charger & discharge the BESS battery in coordination with energy management system and battery management system. The PCS shall consist of solid state electronic switch along with all associated control & protection, filtering, measuring instruments and data logging devices. The PCS shall be bi-directional inverter with four quadrant operation. The PCS output shall always follow the grid voltage & frequency by sensing the grid voltage and phase and the PCS shall always remain synchronized with the grid. The PCS shall use only self-commutated device which shall be adequately rated.

2.00 CODES AND STANDARDS

The PCS shall conform to the all applicable IEC standard. Where an applicable IEC standard is not available, IS/ any applicable international standard shall be referred to as best practice.

IEC-61683	Efficiency Measurements
IEC 61000	Emission/ Immunity requirement
IEEE 519	Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
IEC 60068 / IEC 62093	Environmental Testing
IEC 62116/ IEEE 1547	Protection against Islanding of Grid
IEC 62109 / IEC 62103	Safety of power converters for use in power systems
IEC 60529	Ingress protection test
IEEE 1547	Standard for interconnecting distributed resources with electrical power systems.
Grid Connectivity	Relevant CEA Regulations (including LVRT/HVRT compliance) and Grid Code as amended andrevised from time to time.

3.00 GENERAL REQUIREMENTS

3.01 The PCS, in conjunction with the control system, shall be capable of completely automatic, unattended operation, including self-protection, synchronizing and paralleling with the utility, and disconnect.

3.02 The minimum euro efficiency of the PCS as per IEC 61683 shall be 97%. The bidder shall specify the conversion efficiency at following load conditions i.e. 25%, 50%, 75% and 100% during detail engineering, which shall be confirmed by type test reports.

3.03 The PCS shall remain connected to the grid as per Central Electricity Authority Technical (standards for connectivity to the grid) regulation 2007 with all latest amendments and its components shall be designed accordingly.

3.04 The PCS shall be capable of operating in the frequency range of 47.5 Hz to 52 Hz and shall be able to deliver rated output in the frequency range of 49.5 Hz to 50.5 Hz.

3.05 Internal Surge Protection Device (SPD) shall be provided in the PCS on DC and AC side. It shall consist of Metal Oxide Varister (MOV) type arrestors. The discharge capability of the SPD shall be at least 12.5kA at 8/20 micro second wave as per IEC 61643-12.

3.06 The PCS shall be capable of supplying reactive power as per grid requirement (manual intervention through SCADA) during normal operation hours. However, reactive power support, beyond 0.95 power factor, might be at the behest of active power.

3.07 The PCS shall have protection against any sustained fault in the feeder line and against lightning discharge in the feeder line.

3.08 The PCS must be self-managing and stable in operation.

3.09 The PCS shall include appropriate self-protective and self-diagnostic feature to protect itself and the battery system from damage in the event of PCS component failure or from parameters beyond the PCS'S safe operating range due to external causes. The self-protective features shall not allow signals from the PCS front panel to cause the PCS to be operated in a manner which may be unsafe or damaging. Faults due to malfunctioning within the PCS, including commutation failure, shall be cleared by the PCS protective devices.

3.10 PCS shall have active power control, reactive power and power factor control feature. Plant operator shall be able to provide (manual intervention) Active power, reactive power and power factor control/limit set point through SCADA HMI and local control display unit (or Laptop computer). PCS shall be provided with remote start and stop facility from SCADA HMI. All required hardware and software required for this purpose shall be provided by Bidder.

3.11 PCS shall have thermal overloading protection to prevent failure of switching devices (i.e. IGBT) and other components of Inverter. PCS controller shall automatically regulate/limit the power output in order to reduce the PCS cabinet and switching devices temperature. Bidder to submit the PCS power vs ambient temperature curve during details engineering stage. PCS shall be able to provide inverter inside cabinet and IGBT's (switching device) temperature (in soft analog value) to SCADA system for remote monitoring, storing and report generation purpose.

3.12 The PCS shall be capable of starting and operating as black start i.e., without the presence of the utility voltage. Exercise of the black start capability shall be manual and interlocked and shall under no circumstance result in an accidental energizing of the owner's utility bus. PCS black start shall be possible from EMS without any setting modification at PCS panel locally.

3.13 PCS must have provision to be isolated from grid through Air Circuit Breakers/MCCB's. The ACBs/MCCBs as required can be provided as a part of PCS/its Modules or separately based on standard design and configuration of PCS manufacturer.

3.14 PCS shall have suitable rated DC isolator/contactor for isolation of DC Battery system from inverter. One set spare terminals with fuse/link (as applicable) and holder shall be provided for the future use.

3.15 The PCS should be designed for parallel operation through galvanic isolation. Solid state electronic devices shall be protected to ensure smooth functioning as well as ensure long life of the inverter. Parallel operated PCS system are also accepted subjected to recommendation of PCS manufacturer. In such case, PCS design shall also ensure that no abnormal interaction shall take place among the PCS unit during any grid operating condition which may result in outages.

3.16 In case of modular design of PCS is offered, the Contractor shall ensure that no abnormal interaction shall take place among the various PCS modules during any grid operating condition which may result in outages. The PCS controller offered by the Contactor shall be such as to ensure stability, reliability and a good dynamic performance. The Bidder shall indicate the control scheme adopted for modular PCS and its merits and the test which will check its performance.

3.17 Bidder may offer liquid cooling system subject to NTPC approval. In case Liquid cooled inverters are offered, Bidder to ensure that coolant is used in closed cycle. Complete inverter along with cooling system shall be of proven design.

3.18 Local Display unit for viewing important parameters, configuration and troubleshooting purpose shall be provided. Display shall include all important parameter such as DC input voltage, DC input current, AC output voltage, AC output current, AC output power, frequency etc. Inverter shall also be provided with required software along with accessories (2 sets) for interface with Laptop PC for viewing, configuration, troubleshooting purpose. Training (at site) shall be provided to operate them.

3.19 PCS shall have suitable communication card (Modbus/Ethernet) for networking and EMS/SCADA integration. Communication port shall be preferably TCP/IP protocol or better. PCS shall include all important measured & internal calculated analog values and alarm & trip signals for remote monitoring, storing and report generation purpose in SCADA system. Details list of above such parameters shall be provided along with their Modbus address during detail engineering stage.

3.20 Automatic ‘ Sleep’ mode shall be provided so that unnecessary losses are minimized.

3.21 Inverter shall have emergency stop push button for tripping of inverter with complete DC & AC electric isolation.

3.22 PCS shall have the following feature as minimum,

a) AC & DC overcurrent protection.
b) Synchronization loss protection.
c) Over temperature protection.

d) DC & AC under and over voltage protection.
e) Under & over frequency protection.
f) Cooling system failure protection
g) Ground fault monitoring & detection
h) LVRT protection
i) Anti-islanding protection
j) Grid monitoring
k) Black start feature

3.23 EARTHING OF INVERTERS:-

The PCS shall be earthed as per manufacturer recommendation. During detail engineering the Bidder needs to submit the details earthing arrangement of PCS and system earth pit requirement during detail engineering stage. The detail specification for panel earthing for safety has been mentioned elsewhere in this specification

3.24 PCS shall meet the following technical parameter.

1.	Nominal output voltage frequency	50Hz
2.	Continuous operating frequency range	47.5 Hz to 52 Hz
3.	Continuous operating AC voltage range	± 10% rated AC voltage
4.	Operating power factor range	± 0.9 lead or lag
5.	Maximum input DC voltage	1500V or as per application requirement.
6.	Current THD value	< 4% at nominal load
7.	Operating ambient temperature	0 to 45 ° C
8.	Humidity	95 % non-condensing
9.	Maximum Noise level	75 dBA
10.	DC Injection	<0.5 % at rated current
11.	Flicker	As per IEC61000

3.25 INDOOR INVERTER

a. The PCS enclosure protection class shall be IP 20 or better protection.

b. COOLING AND VENTILATION:-

To prevent the maximum permissible temperature in the inverter room from being exceeded because of internal heat emission of inverters and other auxiliaries in the inverter room, the inverter room shall be adequately ventilated. The Ventilation plant capacity and air quality of inverter room shall be as per inverter and other auxiliary system manufacturers recommendations, filter banks at the ari inlet of the inverter room shall be provided to prevent dust ingress. Bidder shall furnish peak power consumption of cooling system (cooling fans, pumps etc.) of the PCS along with the data sheet

Ventilation shall be designed in such a way that the temperature rise of the inverter the maximum designed temperature of Inverters and other auxiliary equipments placed inside the

inverter room. Accordingly the air velocity through the filter shall be suitably chosen to remove the heat from the inverter room. All exhaust and fresh air fans shall be provided with thermostat control

3.26 OUTDOOR INVERTER

a) Outdoor PCS with metallic enclosure are acceptable. The enclosure must be suitable to withstand the harsh environmental conditions for complete life of plant.

b) The PCS enclosure protection class shall be IP 54 or better protection.

c) Bidder to submit temperature endurance test report of complete assembly during detail engineering stage.

d) Complete assembly should be placed inside a shed with at least 50cm projection in front side. Alternatively Bidder can also provide integrated protection to the inverter enclosure through suitable other arrangement (s) subjected to NTPC approval.

3.27 TYPE TESTING

During detailed engineering, the contractor shall submit all the type test reports including temperature rise test and surge withstand test carried out within last ten years from the date of techno-commercial bid opening for Owner's approval. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of techno-commercial bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client/owners representative and submit the reports for approval.

A-7 BATTERY AND BATTERY MANAGEMENT SYSTEM

1.0 GENERAL

The primary application of BESS for the current Project shall be mitigation of intermittent fluctuations of solar power generation (due to cloud, rain, tripping of solar inverter or any other reason) by smoothening of power output from the Solar PV plant and to provide the emergency power back up during non-sunny hours of the day. In addition to the above two-application requirement, BESS shall also have feature of manual operation, VAR support, anti-islanding operation and Black start operation. The BESS shall remain connected to the grid as per Central Electricity Authority Technical (standards for connectivity to the grid) regulation with all latest amendments and its components shall be designed accordingly.

Battery Energy Storage System (BESS) shall have following modes of operation:

A. <u>SOLAR GENERATION SMOOTHENING MODE</u>:

BESS is required to mitigate the intermittent fluctuations of solar power generation by smoothening the Solar PV plant output power to grid. The BESS shall absorb the short term power variations in Solar PV plant output power by fast charging or discharging the battery and generate a smoother generation curve that can be absorbed in the grid in an easier way. The BESS shall also to have suitable control methodology to avoid unwanted charging and discharging of BESS Battery during clear sunny days without intermittency.

BESS shall ensure that the combined Solar PV and BESS output to grid (injected grid power) follows the grid reference target power and shall be within the band as per the relevant CEA guidelines.

The BESS shall meet the demand upto its rated MW capacity at PCS only in case sudden dip or rise in PV plant output power more than rated capacity of BESS.

B. <u>MANUAL MODE:-</u>

i. In manual mode the BESS operator shall be able to provide reference grid power set point to EMS controller through BESS SCADA HMI.

ii. BESS operator shall be able to ramping up or down the BESS power (upto maximum BESS MW rating) by providing BESS power set point to EMS controller through BESS SCADA HMI. Once this mode is initiated, the BESS shall remain at the designated output (or input) power level until terminated by BESS SCADA with manual intervention or battery charging or discharge limit is reached.

<u>Note for clause A & B above:-</u>

At a time only one mode shall be active i.e. solar generation smoothening or manual mode as described in clause 1.0 A & B above and the BESS operator shall be able to select any one of

the above mode based on operational requirement. The operational & functional requirement as mentioned under the selected mode shall be applicable.

C. VAR SUPPORT MODE:-

The BESS shall be required to provide VAR support to grid during grid connected and in islanded mode operation for voltage regulation purpose. BESS operator shall be able to provide reactive power/power factor set point to EMS controller/PCS through BESS SCADA HMI (manual intervention).

D. ANTI-ISLANDING MODE:-

The BESS shall have anti-islanding protection as per IEC 62116 or equivalent international standard. During Anti Islanding mode of operation the BESS should be able to provide active and reactive power as per the requirement of the island.

E. BLACK START/ISLAND MODE:-

BESS shall have black start operation feature and shall be able to form a micro-grid with solar PV plant & local loads connected on 33kV switchgear. BESS shall set and automatically control the micro-grid voltage & frequency within acceptable limit and shall charge or discharge the battery based on micro-grid requirement. As per requirement, BESS shall also control the active and reactive power (or power factor) of Solar PV plant by providing required set point to solar PV Inverters and also control (close/trip) LT breakers for load control purposes. BESS shall have all the required hardware, control and protection feature for safe operation of micro-grid. BESS shall also charge its battery for later use in case excess energy is available in the micro-grid after meeting the load power (including auxiliary power of solar plant and BESS plant) requirement. If the PV plant generated power is not sufficient to meet the load power requirement, then BESS shall discharge its battery to support the load power requirement.

2.0 BESS INTEGRATION WITH SOLAR PV PLANT:

For BESS EMS controller use, the Bidder shall take current transformers and voltage transformers input signals directly from HT switchgear solar feeders, grid feeders, MSW feeder, DG set feeders, local load feeders, BESS feeders and one no of spares panel feeder. Current transformers and voltage transformers used in HT switchgear panel for this application requirement shall be of 0.2S and 0.2 class respectively. Bidder shall use suitable and compatible devices (suitable for application requirement) as applicable for measurement of voltage, current, active power, reactive power, etc.

EMS shall have facility for direct control of 4MW Solar Plant Inverters for active and reactive power control and closing and tripping of Solar, DG set, MSW generation feeders, 4 nos of 33 kV outgoing feeder (including one no of spare feeder) for load and generation control and prioritizing purpose.

Bidder scope include measurement of load for individual 33kV feeders connected on 33kV bus and same shall be directly from panel mounted MFM meter (over Modbus protocol) or numerical relay (with IEC61850 port). Supply of MFM or numerical relay, control & communication cable, Ethernet switch and associated cabling work (including termination etc.) and integration with

Solar/BESS SCADA shall be in the Bidder scope. Detail shall be finalized during details engineering stage.

3.0 CODES AND STANDARDS

The BESS shall conform to the all applicable IEC and UL standard. Where an applicable IEC/UL standard is not available, IS/ any applicable international standard shall be referred to as best practice. The BESS shall meet all the CEA/CEIG and local statutory requirements for interconnection with grid at the required Voltage level.

As a minimum requirement, the following standards as applicable shall be complied with:

IEC-61427	Secondary cells and batteries for renewable energy storage for on-grid applications. Non-chemistry specific (applicable to all secondary battery types)
UL1973	Energy storage for stationary applications such as for PV. Non-chemistry specific (applicable to all secondary battery types)
IEC 62485-2	Safety requirements for secondary batteries and battery installations - to meet requirements on safety aspects associated with the erection, use, inspection, maintenance and disposal: Non- chemistry Specific (applicable to all secondary battery types)
IEC 61508	Functional Safety of Electrical/ Electronic/ Programmable Electronic Safety-related Systems: Applicable for all Battery Energy Storage Systems
UL 1642	Standard of Lithium Batteries (Safety of Lithium Ion Batteries)
IEC 62619	Safety requirements applications for larged scale industrial applications
IEC 62281	Safety of primary and secondary lithium cells and batteries during transport: Applicable for storage systems using Lithium Ion chemistries
UL9540	Safety of energy storage systems and equipment.
IEEE 1547	Standard for Interconnecting Distributed Resources with Electric Power Systems
Grid Connectivity	Relevant CEA Regulations (including LVRT/HVRT compliance) and Grid Code as amended and revised from time to time.
Battery management and Handling rules, 2001 Ministry of Environment, Forests and Climate Change.	
E-waste (management) rules-2016 Ministry of Environment, Forest and Climate Change.	

4.0 BATTERY ENERGY STORAGE SYSTEM :

The Scope of Work covered shall be but not limited to the following:

- Design, fabricate, and assemble a fully functional, containerized BESS that meets the requirements of operation, control and protection specified herein
- Develop site installation/construction drawings, specifications, and calculations
- Submission of document, drawings, reports, data of design and expected performance of the BESS
- Perform factory acceptance testing of the BESS, FAT procedure needs to be preapproved by NTPC
- Supply any special equipment and tools required for maintenance of the BESS.
- Supply an initial complement of spare parts including spare racks for future installation
- Provide warranty for the entire BESS and its constituent equipment
- Interconnection of the BESS with the grid is at 33 kV bus in the HT switchgear meant for future purpose shown in the tender drawing. The Contractor shall be responsible for all equipment, installation and commissioning activities for the interconnection of BESS with the HT system.
- Submission and approval of the detailed start-up procedure and site acceptance test (SAT), carrying out start up and SAT activities
- Submission of complete set of as-built drawings
- Provide a training class for the Employer's technicians and maintenance personnel.

4.1 Site-Specific Implementation Requirements

Item Description	Requirement
Battery Technology	Only Li ion battery technology (other than LCO)
Battery Voltage	As per bidder in line with the PCS suitability
BESS Interconnection	interconnected with 33 kV Bus on the spare HT switchgear
Rated No of Cycles (Minimum)	4000 cycles at rated energy capacity at 80% Depth of Discharge (DoD) at 25°C and up to C/3 Rate of Discharge
Real Power Rating (MW)	1 MW
Energy Rating (Wh rating)	1 MWh - dispatch able at the beginning of life and not less than 80% of this capacity at any point of time up to End of Battery Life. The bidder shall replace/augment the batteries to maintain the Energy rating up to the End of Life
System ac-dc-ac efficiency	> 80%
Use case requirements	1.0 Solar Power Generation Smoothening 2.0 Solar power Integration into DG Microgrid 3.0 Peak Management 4.0 Voltage Support 5.0 Black Start operation 6.0 Island Operation
Solar Power Integration in DG Microgrid	In this Use case, the microgrid shall be run so as to minimize DG loading with first preference to Solar PV power for meeting the load and charging of BESS.

Peak Management	In the Peak Management usage, power generated during the early and midday periods shall be stored in the BESS and released later in the day, during peak demand. In this case, the BESS shall be discharged in the Peak Limiting profile in the late afternoon to the extent to the total energy dispatched does not exceed the watt hour rating, the BESS may be further discharged in Constant Power Mode after Solar PV Plant is no more generating.
Charge-Discharge Cycles	One discharge cycle per day is envisaged for all use cases, combined.
VAR compensation /voltage support	Yes, to supply reactive power support so as to maintain the power factor between 0.95 leading and lagging.
Black Start Capability	Yes
Ventilation System inside the Container	Should be such as to maintain minimum and maximum Temperature as recommended by the manufacturer for optimum performance of the Batteries on continuous basis.
Grid Charging	Yes
Guaranteed service life	As per Bidder offered BESS system (minimum 10 years and maximum 25 years)
Response time	Response time of BESS system shall not be more than 1 (one) second.
Positive and Negative Ramp Rate	BESS shall have suitable positive and negative ramp rate to support smooth injection of Solar PV plant output power into grid.
BESS design operating ambient temperature	0º - 50º C
Point of Common Coupling (PCC)	BESS Feeder at Solar Plant 33kV as shown in tender SLD drawing.

NOTE:-

i) Ambient temperature as mentioned above shall be applicable in case of conflict between ambient temperature mentioned above and those specified elsewhere in the specification.

ii) Response time: Response time is the time interval between need for response is detected (change in solar plant generation/event) and the time when power as measured at the grid connecting point has attained the required target power level. This shall include all intermediate response time of system components.

iii) Battery End of life: End of battery life is that point in time when the BESS can no longer meet the power and/or energy discharge requirements of this Specification due to age or non-repairable malfunction of the battery subsystem, and/or non-replaceable components. When the system is no longer able to provide these requirements, the system has reached its end of life. Battery End of life shall not be less than 25 years from the date of Commissioning. It shall be the responsibility of the Contractor to make