periodic replacements/replenishments of unit batteries, if and when required, up to the End of Battery Life.

a. Battery Energy Storage System (BESS) shall primarily consists of major equipment such as battery, battery management system (BMS), EMS , PCS, output/isolation transformer (if required) and SCADA which is to be integrated with the solar plant SCADA system defined elsewhere in this document. Additional equipment shall include HVAC, wiring, connectors, protective devices, grounding, junction boxes and enclosures, instrumentation, enclosures, and all other items needed for a fully functional, grid-interactive BESS to meet the requirements of this specification.

b. The BESS shall be containerized, having minimum protection class IP54. When fully installed, all BESS components including battery racks all auxiliaries, such as HVAC and fire suppression systems, step-up transformers (if required), ac switchgear, and so on and tools shall be enclosed in (or on) the containers. The design and installation of Containers shall meet relevant regulatory requirements for occupational safety and health under national and state legislations

c. The battery cells may be supplied as separate, individual units or as group of cells combined into modules. The design, materials, and method of cell construction shall conform to the applicable code and/or standard.

d. The battery system may be ungrounded or grounded. Grounded configurations may be centre or one-pole-grounded and/or solid or high- resistance grounded. However, the battery system shall include a system to detect and alarm excessive ground leakage current levels. Ground fault detection shall be enabled for each container or, if more than one electrical series string is installed in the container, for each series string. The detection/trip level shall be field adjustable.

e. Battery container (for containerized solution) shall have minimum protection class IP54.

f. Suitable ventilation/controlled air conditioning and personnel safety measures in battery room/container must be provided by the bidder and should be maintained to minimize health hazards to any exposure to hazardous battery elements.

g. Automatic fire fighting system should be provided as per NFPA.

h. The BESS shall be designed for high starting reliability (more than 99%), minimum MTTR (Mean-time-to-repair) and high Availability.

i. 0.5% of Battery Module (of the rating as per the bidders offer for the battery) shall be provided as Spare

4.2 BATTERY MANAGEMENT SYSTEM (BMS):

i. The BMS shall be designed to provide automatic, unattended operation of the battery storage system.

ii. The BMS shall have the necessary monitoring and control system to protect the battery

cells/module/string from out of tolerance and unsafe operating conditions under any eventuality and mitigate fire risk.

iii. The BMS shall automatically control the charge and discharge of the individual cells/module, balancing between cells/module to optimize energy consumption and range, monitor cell/module heath and provide critical safeguards to protect the batteries from damage.

iv. BMS shall automatically determine the State of Charge (SOC) and State of Health (SOH) of the battery individual cell/module.

v. It should have History (Log Book Function) function for Monitoring and storing the battery's parameters, Alarm and fault generation function and these should communicate to the SCADA.

vi. IT should have provision for Isolating the battery in cases of any emergency.

BMS, EMS and PCS shall be operated in coordinated manner in order to achieve the above requirement.

Bidder to supply the BMS system as per battery OEM recommendation & requirement and shall be in line with the application requirements

5.0 FACTORY ACCEPTANCE TEST (FAT)

Battery and BMS along with SCADA (if separate SCADA for BESS) shall be subject for FAT approval for which FAT procedure shall be submitted by bidder for NTPC approval and after approval of FAT procedure, FAT will be witnessed by NTPC before dispatch of the material.

6.0 TYPE TESTING

During detailed engineering, the contractor shall submit all the type test reports 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 the tests under this contract at additional no cost to the owner at third party lab or in the presence of owner’s/clients representative and submit the reports for the approval.

B. AC SYSTEMS

B-1 LT SWITCHGEAR

1.0 GENERAL

LT Switchgear to be used as per the system requirement in Solar PV plant and BESS shall be in the scope of the bidder. The design, materials, and method of LT switchgear along with all the necessary components required for safe reliable and successful operation shall be as per the relevant IS/IEC standards with their latest amendments. Final scheme, components of switchgear assembly and number of feeders in LT switchgear shall be finalized during detailed engineering.

2.0 TECHNICAL PARAMETERS

A.	**POWER SUPPLY (AC SYSTEM)**	
(i)	Voltage	415V ± 10%, 3 Phase, 4 wire, Neutral Solidly Earthed
(ii)	Frequency	50 Hz +/- 5%
(iii)	Minimum system fault level	As per system fault current (for 1 sec)
(iv)	Short time rating for bus bars, ckt. breakers, current transformers and swgr. Assembly.	As per system fault current (for 1 sec)
(v)	Maximum ambient air temp Temperature	50 deg. C
B.	**DIGITAL MFM**	
(i)	Accuracy class	0.5
(ii)	MFM shall be provided at LT incomer feeder. MFM shall have suitable communication port for integration with SCADA system.	
C.	**CURRENT TRANSFORMERS**	
(i)	Type	Cast Resin Bar Primary
(ii)	Voltage class and frequency	650V, 50HZ
(iii)	CT Secondary Current	1 A
(iv)	Class of insulation	E or better
(v)	Accuracy class & burden	
	a) For Protection	5P20, 5VA
	b) For Metering	Class 0.5, 5VA (min)
(vi)	Instrument Security Factor for metering CT	5

D.	**VOLTAGE TRANSFORMERS**	
(i)	Type	Cast Resin
(ii)	Voltage Ratio	415 / 110V for line PT 415/√3 / 110/√3V for Bus PT
(iii)	Method of Construction	Vee Vee
(iv)	Accuracy Class	0.5
(v)	Rated Voltage factor	1.1 continuous, 1.5 for 30 sec.
(vi)	Class of insulation	E or better
(vii)	One minute power frequency withstand voltage	2.5 KV
E.	**HRC FUSES**	
(i)	Voltage Class	650 Volts
(ii)	Rupturing capacity	80kA (RMS) for AC circuits
F.	**CONTACTORS**	
(i)	Type	Air break electro magnetic
(ii)	Utilising Category	AC3 of IS/IEC 60947 for non reversible AC4 of IS/IEC 60947 for reversible drives
G.	**SWGR. CUBICLE CONSTRUCTIONAL REQUIREMENTS**	
(i)	Color finish	
	Exterior	RAL9002 (Main body) RAL 5012 (Extreme end covers) The paint thickness shall not be less than 50 microns
(ii)	Cable entry (Power / Control)	Bottom

The quantities/Nos. of the Feeders /MCCB shall be so as to meet the system requirements. 5% spare with minimum 01 No. to be provided on each board/switchgear having more than 5 MCCB. However, no spare Air circuit breaker panels are required.

3.0 Indoor distribution boards used for Auxiliary Power Supply system and String Inverter distribution board of rating upto & including 400A shall be of metal enclosed, indoor, floor-mounted, free-standing type. And shall be of bolted design. All switchboard frames and load bearing members shall be fabricated using suitable mild steel structural sections or pressed and shaped cold-rolled sheet steel of thickness 2.0 mm. Frames shall be enclosed in cold-rolled sheet steel of thickness 1.6 mm. Doors and covers shall also be of cold rolled sheet steel of thickness 1.6 mm. Stiffeners shall be provided wherever necessary. The gland plate thickness shall be 3.0 mm for hot / cold-rolled sheet steel and 4.0 mm for non-magnetic material.

4.0 All switchboards shall be of dust-proof and vermin-proof construction and shall be provided with a degree of protection of IP: 5X as per IS/IEC 60947. All cut outs shall be provided with EPDM / Neoprene gaskets.

5.0 All switchboards shall be supplied completely wired internally upto the terminals, ready to receive external cables.

6.0 Cable termination arrangement for power cables shall be suitable for heavy duty, 1.1 kV grade, stranded aluminium conductor, PVC/ XLPE insulated, armoured / unarmoured and PVC sheathed cables. All necessary cable terminating accessories such as supporting clamps and brackets, hardware etc., shall be provided by the contractor, to suit the final cable sizes.

7.0 All Switchgears, MCCs, Distribution Boards, Fuse boards, all feeders, local push-button stations etc. shall be provided with prominent, engraved identification plates.

8.0 ON/OFF status and protection trip status of incomers and bus coupler (if applicable as per SLD) be provided for SCADA system.

9.0 It shall be the responsibility of the bidder to fully coordinate the overload and short circuit breakers/fuses with the upstream and downstream circuit breakers / fuses, to provide satisfactory discrimination. Further the various equipment supplied shall meet the requirements of type II class of co-ordination as per IS: 8544.

10.0 Indoor distribution boards having rating more than 400A shall have distinct vertical sections (panels), each comprising of the separate compartments for busbar, switchgear/ feeder, cable and controls.

11.0 Temperature raise test of LT switchgear of rating more than 400A:- The temperature rise of the horizontal and vertical busbars and main bus links including all power draw out contacts when carrying 90% of the rated current along the full run shall in no case exceed 55 deg C with silver plated joints and 40 deg C with all other types of joints over an outside ambient temperature of 50 deg C. The temperature rise of the accessible parts/external enclosures expected to be touched in normal operation shall not exceed 20deg. C. The temperature rise of manual operating means shall not exceed 10deg. C for metallic & 15 deg. C for insulating material. Temperature rise for the busbars shall be carried out at 90% of the rated current.

12.0 **Circuit Breakers: (if applicable)** - shall be three pole, air break, horizontal draw out type, and shall have fault making and breaking capacities as per relavant standard or system requirement. The circuit breaker shall be provided with "SERVICE", "TEST" and "FULLY WITHDRAWN" positions indicators. Circuit breaker open/close shall be possible from SCADA and open/close status and all other important signal status shall be provided for SCADA monitoring.

13.0 **AC Junction boxes (for use with string inverters) -** Separate AC Junction box shall be used for string inverters AC output connection. Protection class for AC junction box shall be IP 54 or better protection. All components of junction box shall be suitable for rated output voltage (with + 10% variation) of string inverter, grid frequency of 50 Hz +/- 5%, ambient temperature 50 deg. C and system fault current for 1 sec.

B-2 INVERTER / PCS TRANSFORMER

1. Only Oil filled transformer is acceptable and should be offered by the bidder

2. Inverter/PCS Transformer shall have copper/Aluminum Shield winding between LV & HV windings. Each LV winding must be capable of handling **non-sinusoidal voltage with voltage gradient as per relevant applicable standards and Inverter manufacturer recommendation.** Also each shield winding shall be taken out to tank with two separate connection from shield to bushing with proper support with 2 nos. 3.6 kV shield bushings and same shall be brought down along with support insulator from tank & copper flat up to the bottom of the tank for independent grounding.

3. If Inverter/PCS transformer is provided indoor, it shall be necessarily of dry type.

4. Harmonic Factor as per Inverter/PCS manufacturer recommendation must be taken into account while designing the transformer. The extra no load loss due to voltage harmonics and load and stray load loss due to current harmonics (as applicable) and must be taken into consideration in transformer design. In addition, the dc bias component of 0.5% of rated Inverter/PCS output current is to be accounted for its effect on the transformer design.

5. The adverse effect on life of transformer due to cloud intermittency and solar generation loading cycle must be compensated through suitable design (as applicable).

6. The thermal design of Inverter/PCS Transformer needs to consider the temperature dependent performance of the Inverter/PCS. It is to in accordance with Inverter/PCS output and under worst condition it should not limit Inverter/PCS output.

7. The multi-winding transformer needs to be designed for long term operating conditions with asymmetrical load on LV side i.e., in case three winding design, the transformer needs to operate reliable with only one Inverter/PCS supplying power to only one LV winding.

8. For multi winding transformer, it is recommended to have close coupling and equal impedances on each of LV winding to HV winding and to have high enough impedance (8% min. based on one LV winding rating) between two LV windings in order to decouple these windings.

9. In case of inverter/PCS transformer, it shall be proven and of successfully type tested design including short circuit test as per IEC 60076-5.

10. Contacts from Inverter/PCS transformer fittings/protection devices shall be wired for tripping of Inverter/PCS transformer Circuit Breaker. Detailed scheme regarding same shall be finalized during detailed engineering.

11. Single Line Diagram (SLD) will be finalized during detailed engineering however cumulative kVA rating of inverter/PCS transformer shall not be less than total kVA capacity of respective Inverters//PCSs.

12. Technical Parameter :

Sr. No.	TRANSFORMER	INVERTER / PCS TRANSFORMER
i)	VA Rating & Quantity	As per system requirement
ii)	Voltage Ratio (KV)	As per system requirement
iii)	Duty, Service & Application	Continuous Solar Inverter application and converter duty (Outdoor)
iv)	Winding	As per system requirement
v)	Frequency	50 Hz
vi)	Nos. of Phase	THREE
vii)	Vector Group & Neutral earthing	As per system requirement
viii)	Cooling	ONAN
ix)	Tap Changer	As per system requirement, OCTC +/- 5% (min.)
x)	Impedance at75^{0}C	
	a) Principal Tap	As per system requirement and SLD* & as per Inverter manufacturer recommendation.
	b) Other Taps	
xi)	Permissible Temperature rise over an ambient of 50 deg C (irrespective of tap)	
	a) Top Oil	50 deg.C
	b) Winding	55 deg.C
xii)	SC withstand time (thermal)	2 sec.
xiii)	Fault Level & Bushing CT	As per system requirement
xiv)	Termination	As per system requirement
xv)	Bushing rating, Insulation class (Winding & bushing)	As per relevant IS/IEC (However Inverter Transformer LV side winding & bushing insulation class shall be of at least 3.6 kV) Creepage distance : 31 mm/kV
xvi)	Noise level	AS PER NEMA TR-1
xvii)	Loading Capability	Continuous operation at rated MVA on any tap with voltage variation of +/-10%, also transformer shall be capable of being loaded in accordance with IS: 6600/ IEC60076-7.
xviii)	Flux density	Not to exceed 1.9 Wb/sq.m. at any tap position with +/-10% voltage variation from voltage corresponding to the tap. Transformer shall also withstand following over fluxing conditions due to combined voltage and frequency fluctuations: a) 110% for continuous rating. b) 125% for at least one minute. c) 140% for at least five seconds. Bidder shall furnish over fluxing char. up to 150%
xix)	Air Clearance	As per CBIP

12.1 Codes and Standards

Transformers	IS:2026, IS:6600, IEC:60076 , IS : 3639
Bushings	IS:2099, IEC:60137,IS 3347 ,IS 12676
Insulating oil	IEC 60296 ,IEC 61099/IS16081

Bushing CTs	IS:2705, IEC 60185
Indian Electricity Act 2003, BEE Guideline & CEA notifications	

12.2 General Construction

Transformer shall be constructed in accordance to IS: 2026 and IS: 3639 or equivalent to any other international standard. Transformer shall be complete & functional in all respect and shall be in scope of supplier.

The other important construction particulars shall be as below.

a. The Transformer tank and cover shall be fabricated from high grade low carbon plate steel of tested quality. The tank and the cover shall be of welded construction and there should be provision for lifting by crane.

b. A double float type Buchholz relay conforming to IS: 3637 shall be provided.

c. Suitable Inspection hole(s) with welded flange(s) and bolted cover(s) shall be provided on the tank cover. The inspection hole(s) shall be of sufficient size to afford easy access to the lower ends of the bushings, terminals etc.

d. All bolted connections to the tank shall be fitted with suitable oil-tight gaskets which shall give satisfactory service under the operating conditions for complete life of the transformer if not opened for maintenance at site

e. The transformer shall be provided with conventional single compartment conservator. The top of the conservator shall be connected to the atmosphere through indicating type cobalt free silica gel breather (in transparent enclosure). Silica gel shall be isolated from atmosphere by an oil seal.

f. Transformer shall have adequate capacity Conservator tank to accommodate oil preservation system and volumetric expansion of total transformer oil.

g. Transformer shall have Oil Temperature Indicator and Winding temperature Indicator with accuracy class of +/-2 deg.

h. Radiators shall be detachable type, mounted on the tank with shut off valve at each point of connection to the tank, lifts, along with drain plug/valve at the bottom and air release plug at the top.

i. M. Box shall be of sheet steel, dust and vermin proof provided with proper lighting and thermostatically controlled space heaters. The degree of protection shall be IP 55. Marshalling Box of all transformers shall be preferably Tank Mounted. One dummy terminal block in between each trip wire terminal shall be provided. At least 20% spare terminals shall be provided on each panel. The gasket used shall be of neoprene rubber. Also Marshalling Box, shall be at least 450 mm above ground level. Wiring scheme (TB details) shall be engraved in a stainless steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door

j. No inhibitors shall be used in the transformer oil. The oil supplied with transformers shall be new and previously unused and must conform to following while tested at supplier's premises and shall have following parameters.

S.No.	Property	Permissible values
1.	Kinematic Viscosity, mm^2/s	≤ 12 at 40 ° C ≤ 1800.0 at (-)30 ° C

S.No.	Property	Permissible values
2.	Flash Point, ° C	≥ 140° C
3.	Pour point, ° C	≤ (-)40 ° C
4.	Appearance	Clear , free from sediment and suspended matter
5.	Density kg/dm^3 at 20 ° C	≤ 0.895
6.	Interfacial Tension N/m at 25° C	≥ 0.04
7.	Neutralisation value, mgKOH/g	≤ 0.01
8.	Corrosive sulphur	Non Corrosive
9.	Water content mg/kg	≤ 30 in bulk supply ≤ 40 in drum supply
10.	Anti-oxidants additives	Not detectable
11.	Oxidation Stability -Neutralization value, mgKOH/g -Sludge, % by mass	 ≤ 1.2 ≤ 0.8
12.	Breakdown voltage As delivered, kV After treatment, kV	 ≥ 30 ≥ 70
13.	Dissipation factor, at 90° C And 40 Hz to 60 Hz	≤ 0.005
14.	PCA content	≤1%
15.	Impulse withstand Level, kVp	≥ 145
16.	Gassing tendency at 50 Hz after 120 min, mm^3/min	≤ 5

k. Inverter Transformer LV bushing palms shall be silver/tin plated.

l. All CTs (except WTI) shall be mounted in the turret of bushings, mounting inside the tank is not permitted.

m. All CT terminals shall be provided as fixed type terminals on the M. Box to avoid any hazard due to loose connection leading to CT opening. In no circumstances Plug In type connectors shall be used for CT.

12.3 Painting

PARTS NAME	TYPE OF PAINT	NO.OF COATS	TOTAL DFT
Inside of tank and accessories (except M Box)	Oil & heat resistant fully glossy white	One coat	Atleast 30 micron
External surface of transformer and accessories including M Box (except radiators)	Chemical resistant epoxy zinc phosphate primer, MIO (Micaceous iron oxide) as intermediate paint followed by polyurethane finish paint (RAL 5012 Blue) or (RAL6018 yellow green for ester filled)	One coat each	Atleast 100 micron
External Radiator surface	Anticorrosive primary paint followed by high quality full glossy outer finish	Two coats each	Atleast 100 micron

PARTS NAME	TYPE OF PAINT	NO.OF COATS	TOTAL DFT
	paint (RAL 5012 Blue) or (RAL6018 yellow green for ester filled)		
Internal Radiator surface	Hot oil proof, low viscosity varnish and subsequent flushing with transformer oil	---	---
Internal surface of M Box	Chemical resistant epoxy zinc phosphate primer followed by chemical and heat resistant epoxy enamel white paint	Two coats each	Not less than 100 micron

12.4 Neutral Earthing Arrangement

Neutral earthing shall be done as per system requirement and SLD. In case of solidly earthed neutral of Transformers, it shall be brought through insulated support from tank to the ground level at a convenient point with 2 nos. copper flat, for connection to ground network (as applicable).Neutral of Transformer if not used should be taken out through bushing and covered by insulating cap.

12.5 Cable boxes & disconnecting chamber (Disconnecting chamber applicable 3.3 kV and above & for Inverter Transformer both side)

(a) HV Cable boxes shall be of phase segregated air insulated type & shall be of sufficient size to accommodate Employer's cable & termination. Phase segregation shall be achieved by insulating barriers (for 3.3 kV and above side).

(b) Cable boxes shall have bus bars / suitable terminal connectors of adequate size & bolt holes to receive cable lugs. The degree of protection of cable boxes shall be IP 55.

(c) A suitable removable gland plate of non-magnetic material drilled as per the Employer's instruction shall also be provided in the cable box.

(d) The support from base for the cable box (for 3.3 kV and above side) shall be of galvanized iron