



**FEDERAL GOVERNMENT OF SOMALIA
MINISTRY OF ENERGY AND WATER RESOURCES**

**SOMALI ELECTRICITY SECTOR RECOVERY PROJECT
(Grant No. D931-SO; Project ID No. P173088)**

RFB No.: SO-MOEWR-565667-CW-RFB

Request for Bids

For

Design, Supply, Installation, Testing, and Commissioning of 6MWp
Solar PV Power Plant with 10 MWh of Battery Energy Storage
System for Wamo Energy Service Company (WESCO), Kismayo
City, Somalia.

VOLUME II. EMPLOYER'S REQUIREMENTS

Table of Contents

1.0 GENERAL SPECIFICATIONS	6
1.1 General.....	6
1.2 Document Priority.....	6
1.3 Completeness of Works	6
1.4 Space Requirement	7
1.5 Documentation and Drawings.....	7
1.6 Contractor's Quality Assurance Procedures	9
1.7 Guarantees and Particulars.....	9
1.8 Manufacturing and Shipment.....	9
1.9 Erection, Installation and Commissioning	11
1.10 On the Job Training	12
1.11 Tools	12
1.12 Spare Parts	12
2 GENERAL TECHNICAL SPECIFICATION	13
2.1 Standards.....	13
2.2 Units.....	13
2.3 Auxiliary Power Interruptions	13
2.4 Selectivity	13
2.5 Design and Materials	13
2.6 Equipment.....	16
2.7 Construction and Erection.....	17
2.7.1 Switchboards, Panels and Cabinets.....	17
2.7.2 Cable Laying and Routing	18
2.7.3 Earthing.....	18
3.0 PROJECT SPECIFIC DATA	19
3.1 Scope of Design and Supply of Plant and Installation Services	19
4.0 PARTICULAR TECHNICAL SPECIFICATIONS	22
4.1 SOLAR PV MODULES.....	22
4.1.1 IDENTIFICATION OF THE PV SOLAR PV.....	22
4.1.2 WARRANTIES FOR MODULES	23
4.2 PV MODULE MOUNTING STRUCTURES	24
4.3 String Combiner Box (SCB).....	27
4.4 Solar and DC Cables.....	28
4.8 SCOPE OF WORK - SUBSTATIONS	36

4.9	Battery Energy Storage System (BESS)	50
a)	Scope of Works.....	50
b)	Design and Fabrication	50
c)	DEFINITIONS.....	51
4.9.3	Technical Specification of Battery Energy Storage System	52
4.9.4	System Ratings (Overall System Real Power and Energy Ratings)	54
4.9.5	Peak Management (PM).....	54
4.9.6	Design, Fabrication, and Construction Requirements of BESS.....	54
4.9.9	Battery Subsystem Design Requirements	56
4.9.8	Power Conditioning System Design Requirements	57
4.9.9	BESS Transformer.....	58
4.9.10	AC System	58
4.9.11	Auxiliary Power.....	58
4.9.12	Control and Communication.....	58
5.0	SUPERVISORY CONTROLLED AND DATA ACQUISITION (SCADA)	66
5.1	Architecture.....	66
A.	Industrial IoT Controllers & Data Acquisition	67
B.	System Spare Capacity.....	67
C.	Functionalities.....	68
D.	Communication Cable Laying	68
E.	Software Licences	69
F.	Hardware at Main Control Room.....	69
5.2	Power Plant Controller.....	70
6.	ENERGY MANAGEMENT SYSTEM.....	70
7.1	EMS functionality for the BESS Control.....	70
6.2	EMS functionality for the Plant Control	71
6.3	Measurements.	71
6.4	Control & Power Supply Scheme	72
6.5	Software Documentation & Listings.....	72
7.0	LOW VOLTAGE SWITCHBOARDS	73
8.	CABLES	75
8.1	Conductors	75
9.0	LIGHTNING & EARTHING PROTECTION SYSTEM.....	82
9.1	Earthing of PV array field.....	83
9.2	PCU Earthing.....	84
9.3	Transformer Earthing.....	84

9.4 Inverter Room and Main Control Room Earthing	84
9.5 Switchyard Earthing.....	84
9.6 Earthing Design and Layout	84
9.7 Lightning & Over Voltage Protection.....	85
9.8 Lightning Protection System for Plant Pooling Substation.....	85
10 CIVIL AND STRUCTURAL WORKS.....	86
10.1 TYPES OF WORKS.....	86
10.2 Sequence of Construction	86
10.3 Drawings.....	86
10.4 Plan of Operations and Temporary Works.....	86
10.5 Employer's Approval of Finished Works.....	87
10.6 Basic Survey and Setting Out	87
10.7 Earthworks	87
10.8 Order of Work.....	88
10.9 Fill Material	88
10.10 . Compaction of fill	Error! Bookmark not defined.
10.11 Compaction of in situ Sub grades	Error! Bookmark not defined.
10.12 Spoil Material.....	Error! Bookmark not defined.
10.13 Expansive Material	8
10.14 Surplus Material.....	8
10.15 Excavation in "Rock".....	9
10.16 Drainage of Earthworks	9
10.17 Removal of Top Soil.....	9
10.18 Access and Internal Road.....	9
10.19 Grading Requirements	88
10.20 Plasticity Requirements.....	88
10.21 Bearing Strength Requirements	88
10.22 Quality Control	88
10.23 Tolerances	88
10.24 Materials for The Works	89
10.25 Drainage and Storm Water.....	89
10.26 Concrete Works	90
10.27 Concrete, Formwork and Reinforcement.....	91
10.28 Structural Steelworks	102
10.29 Metalwork and Containerized Control Room Solutions.....	103
11. Commissioning and Acceptance Tests. These shall be undertaken in accordance with the contract clauses GCC 24 &25.....	110
11.1 Mechanical Tests.	110
11.2 Functional Tests.....	110

11.3	PV Array	110
11.4	BESS	110
11.5	System Performance Tests	111
11.6	Trial operation tests.....	112
12.	APPENDICES.....	113
	APPENDIX 1: SLD FOR THE POWER PLANT (Attached Separately)	113
	APPENDIX 2: GUARANTEED TECHNICAL PARTICULARS.....	115
a)	GTP FOR PV MODULES.....	122

1.0 GENERAL SPECIFICATIONS

1.1 General

The scope of work, data sheets, special and general specifications constitute the complete technical specifications and must be read as a whole.

1.2 Document Priority

If in conflict, the ranking of documents in the technical specifications, in decreasing priority, is as follows:

- a) Scope of Works
- b) Particular technical specifications
- c) Project Specific Design Data
- d) General Technical specifications
- e) General Specifications
- f) Standards

In the event of any difference between the Drawings and the Specifications, the latter shall prevail. In the event of any difference between scaled dimensions and figures on the drawings, the figures shall prevail.

If the Bidder is of the opinion that there is conflict or disagreement between the particulars of the documents, standards etc., this must be clearly stated in the Bid, failing which, the materials and equipment offered shall be deemed to comply in every respect with the current Specification both in manufacture and in performance, and compliance thereof shall be insisted upon without additional cost to the Employer.

1.3 Completeness of Works

All apparatus, accessories or fittings which may not have been specifically mentioned, but which are usual or necessary in the respective equipment for the completeness of the finished work in an operable status, shall be deemed to be included in the Contract and shall be provided by the Contractor without any extra charge. All equipment shall be complete in all details, whether or not such details are mentioned in the Specifications. This includes fixation details and connection clamps and/or terminals.

All materials and skilled labour, whether of temporary or permanent nature, required by the Contractor for the design, manufacture, erection and testing at site of the equipment shall be supplied and paid for by the Contractor. All computer equipment shall be delivered with all software and licences necessary to achieve the specified functionality as well as the software necessary for programming, testing, service and maintenance through the lifetime of the equipment.

Any reference in the quantity and price schedules, the delivery period schedule or in the various clauses and schedules of the text of either the Specification or the Bid, to any equipment shall imply equipment that is complete with all accessories, apparatus and fittings. The Bidder shall be responsible for ensuring that the equipment supplied is fit for the purpose intended. Available information on the characteristics of the system, to which the works will be connected and associated, will be supplied on request to the Bidder who shall be responsible for obtaining and determining all applicable knowledge relevant to the works.

1.4 Space Requirement

The Bidder shall check the dimensions of rooms and outdoor plots where electrical equipment is proposed to be erected. The rooms and plots must accommodate the equipment as well as having workspace for operators and maintenance personnel.

The Bidder shall in his bid present arrangement drawings showing how he intends to adapt the equipment to the space available. If the space is not sufficient the Bidder shall indicate necessary enlargements. Failing to do so the Bidder shall bear the cost of later modifications of the facilities.

1.5 Documentation and Drawings

1.5.1 General

Contractor's obligations with regard to preparation and submission of drawings, calculations, samples, patterns, models, etc. are stated in the Conditions of Contract.

The Contractor shall prepare and submit to the Project Maor approval dimensioned general and detailed design drawings and other pertinent information of all the Plant and equipment specified in the Bid Documents. Unless otherwise agreed the information shall be exchanged on paper.

Approval of drawings shall not relieve the Contractor of his obligations to supply the Plant in accordance with the Specifications. The Contractor is responsible for any errors that may appear in the approved documents. He shall as soon as an error has been detected, deliver the corrected documents to the Project Manager for re-approval.

If the plant is to be connected to existing equipment the connection shall be documented in a coherent and overlapping way at least containing terminal identification in old equipment. Schematic diagrams shall contain complete loops.

All text on documents provided by the Contractor shall be in the English language in addition, if necessary, to that of the country of origin. All drawings shall be dimensioned in millimetres.

The Contractor shall, during the total project time, maintain a List of Documentation to be updated by him whenever needed. The List of Documentation shall include the date of original issue of each document submitted as well as the dates of every revision. The List of Documentation shall also include a time schedule for the submittal of the documentation.

Symbols used for electrical equipment shall be in accordance with IEC 60617. The Contractor shall establish a coherent system for physical and functional reference designation in accordance with IEC61346. A similar systematic scheme shall be defined for cable numeration. These schemes shall be used throughout on the drawings and documentation and the designation shall be labelled on the components and cables.

In addition to what is stated in Conditions of Contract, the following shall apply:

- The sizes of all documents and drawings shall conform to the ISO standard, i.e.:
- A1 594mm x 841mm A2 420mm x 594mm
- A3 297mm x 420mm A4 210mm x 297mm

Sizes larger than A1 shall be avoided. The schematic diagrams and, apparatus and cable lists shall be of size of A4 except for one original and possible transparency copies of schematic diagrams that shall be in A3. Scales to be used on the drawings shall be 1:10, 1:20, 1:40, 1:50 and multiples of this series.

- All drawings made special for this project including civil works drawings, mechanical drawings, layout drawings and circuit diagrams shall be compiled on a computer aided drawing system and as part of the as built documentation be handed over on a flash Disc with a format readable in AutoCAD version or another format to be agreed upon in addition to the paper copies.
- All drawings shall be bound in hard covers.

1.5.2 Bid Drawings

The Employer's drawings attached to the Bid Documents are of informative character. These drawings are intended to illustrate the basic requirements to be satisfied. It is the responsibility of the Contractor to prepare a detailed layout showing the manner in which the various items of equipment offered can be accommodated to best advantage within the available area.

The Contractor is at liberty to offer arrangements based on significantly different principles where it is considered that these offers economic or technical advantages. It is emphasized, however, that the main Bid should comply with the principles shown in the enclosed drawings, other arrangements being submitted solely as alternatives to the main offer.

The Bidder shall in his Bid enclose overall drawings showing dimensions, main working principles, internal components and fixing methods to a detail level allowing the Employer to evaluate the functionality and completeness of the plant and equipment.

The following specific drawings shall be enclosed with the Bid:

- Single Line Diagram for each part
- Layout proposals for each plant
- Proposal for arrangement of the apparatus and machinery
- Topological drawings of the Control System

1.5.3 Progress Plans

The Progress Plans shall at least contain the following milestones:

- Essential information delivered from Employer
- Documentation for approval from Contractor to Employer
- Release of factory documentation
- Factory Tests
- Shipment
- Site ready for erection
- Start erection
- Ready for pre-commissioning
- Ready for commissioning
- Test run
- Taking over
- Submittal of final documentation

1.5.4 Final Documentation

The Contractor shall supply final "as built" documentation taking into account all changes done under erection and commissioning. The Contractor shall also deliver manuals for operation and maintenance. These shall at least contain the following information:

- Detailed description of the equipment, the individual components, relevant clearances, tolerances, allowable temperatures, settings etc.
- Descriptions of main principles including flow diagrams, single line diagrams, circuit diagram, connection diagram, cable schedules, software documentation etc.
- Operational instruction. These shall illustrate the operational sequences in a clear and concise way.
- Test and adjustment procedures containing instruction for test and adjustment of the equipment under operation, after inspection and maintenance
- Test reports
- Spare part lists
- Maintenance instructions split into:

- Manuals for preventive maintenance indicating periodic inspections, cleaning, lubrication and other routine maintenance.
- Repair manuals describing fault location, dismantling, re-assembly etc.

The documentation shall provide detailed information to enable the operators and maintenance personnel to operate the plant in a safe and optimal way and to perform repairs usual to be done by such personnel. The Project Manager shall approve the manuals before final submission.

1.6 Contractor's Quality Assurance Procedures

The Contractor shall have established a quality assurance system based on ISO 9001 also covering sub-contractors. The Bidder shall include in the Bid a documentation of the system with a list of current procedures, an organisation chart of the quality organisation and the name of the quality manager. He shall also submit a list of quality revisions performed in the last twelve months with a list of closed and unclosed findings as well as planned revisions during the coming twelve months as well as a list of findings. The documentation shall give special emphasises on how subcontracts are included in the quality assurance system. The Employer shall be entitled to request quality revision at the Contractor or any subcontractor level with a two weeks' notice.

1.7 Guarantees and Particulars

The Works shall comply with the technical guaranteed data stated in the Bid. The Contractor shall be responsible for any discrepancies, errors, and omissions in the particulars and guarantees.

1.8 Manufacturing and Shipment

1.8.1 Places of Manufacture and Sub-Contractors

All equipment offered should be the product of recognized and experienced manufacturers and shall be of basic design and size similar to such that has been in successful continuous operation for at least three years preferably under similar climatic conditions. Proven plant reliability and high availability are of prime importance and the attention of the Bidder is drawn to these particular requirements.

The manufacturer's identity and places of manufacture, testing, and inspection before shipment for the various portions of the Contract Works shall be specified in the Technical Schedules and shall not be departed from without the agreement of the Project Manager.

As soon as practicable after entering into the Contract, the Contractor shall, having obtained the Project Manager's consent in accordance with the Conditions of Contract, enter into the Sub-contracts he considers necessary for the satisfactory completion of the Contract Works.

All Sub-contractors and Sub-suppliers of components and materials shall be subject to the approval of the Project Manager. Information shall be given on each Sub-order sufficient to identify the material or equipment to which the sub-order relates, stating that the material is subject to inspection by the Project Manager before despatch.

If the Employer at any stage in the design and production period finds out that the sub-contractor does not fulfil the requirements in the specifications and it is obvious that the required quality cannot be achieved by corrective measure, he can request the subcontract to be suspended and the works to be produced elsewhere without extra cost for the Employer.

1.8.2 Inspection and Testing

The Contractor shall submit for approval a programme of quality control and inspection procedures to assure that the product during manufacture and on completion comply with the specified requirements. The programme shall relate the quality control and inspection activities to the production cycle. The Contractor shall provide details of quality control and inspection procedures used. The Contractor shall retain responsibility for quality control and inspection activities made by his sub-contractors and shall indicate on the programme, which items are to be sub-contracted and how they are to be inspected and tested both at subcontractor's works and by Contractor's acceptance control. All materials used in the

Contract Works are subject to inspection by the Project Manager and it is the Contractor's responsibility to advise the Project Manager when equipment and materials are available for inspection, at least one month in advance. Factory tests on equipment shall be made according to the applicable IEC Standards, or as specifically specified or according to standards approved by the Project Manager. Routine tests shall be made on each unit of all equipment.

Type tests shall be made on one unit of each type of different equipment. Instead of carrying out the type tests the Contractor may submit certificates from accredited body of tests made on equipment of the same type; however, the Purchaser reserves the right of accepting these certificates or to reject them partially or totally.

On complex systems the Bidder shall propose factory acceptance tests (FAT) to be performed.

The Project Manager shall be at liberty to demand any additional testing at the manufacturer's works, at site or elsewhere in order to verify that the equipment complies with the conditions of the Specifications.

A test programme shall be submitted to the Project Manager for approval at least one month ahead of the commencement of testing. The program shall include tests to be performed at sub contractor's works.

Measuring apparatus shall be approved by the Project Manager and if required shall be calibrated at the expense of the Contractor at an approved laboratory.

1.8.3 Packing, Transportation and Storage

The Supplier shall provide such packing of the Goods as is required to prevent their damage or deterioration during transit and temporary storage up to their final destination as indicated in the Contract. The packing shall be sufficient to withstand, without limitation, rough handling and exposure to extreme temperatures, salt and precipitation. Packing case size and weights shall take into consideration, where appropriate, the remoteness of the Goods' final destination and the absence of heavy handling facilities at all points in transit. Indoor electrical equipment must be enclosed in welded polythene envelopes inside packing cases and the envelopes shall be evacuated or have a desiccant inside

The following information must be clearly stencilled or printed on each packing case, crate, cask, drum, bundle or loose piece, care being taken that the number and other particulars on each package agree with those entered in the packing list accompanying the Invoice:

- Employer's Identity
- Supplier's Identity
- Destination
- Contract No.
- Package No.
- Item Code
- Weight, dimensions
- Sub-Project (Plant Identity).

The marking shall be durable. The marking shall be upon the body of the package. Marking upon a batten fastened on the case, etc. shall not be used.

In the case of bags, bundles and loose pieces, the shapes of which do not permit the marks to be put on the actual package, each bag, bundle or loose piece shall have two metal labels each with two holes. Securely fastened by independent wires. Each label shall be die-stamped with the above particulars.

The Contractor shall, at its own risk and expense, ship and transport all the Plant and Equipment to the Site in an expeditious and orderly manner. The Contractor's tasks include any formalities for customs clearance in accordance with applicable GCC Clauses..

The Contractor shall notify the Employer of dispatch of each shipment by submitting the Notification of Shipment (NOS) form by facsimile or by e-mail. The required number of originals and copies of Shipping Documents will be informed to the Contractor at the kick-off meeting. It is advisable that at shipment, the Contractor forwards an advance copy of the shipping documents so as to enable the Employer carry out some lead preparatory works before the arrival of the equipment. This way the clearing time may be lessened.

Upon receipt of an item on Site, the Contractor and the Employer shall visually inspect the shipment. All deliveries within the Contract shall be checked and any discrepancies noted and recorded. Lost items shall be replaced. Damaged items shall be replaced, or repaired if permitted by the Employer, to conform to the Specifications. In all cases of irreparable damage, the Contractor shall immediately notify the relevant manufacturer for renewed manufacture and replacement of the damaged part(s). He shall also immediately notify the Employer of the actions he is going to undertake in order to repair or replace the damaged part(s) and of the consequences this damage will have on the completion date of the plant

1.9 Erection, Installation and Commissioning

1.9.1 Storage at Site

The Contractor shall be responsible for proper storage of equipment when delivered at the different sites until taking over. Care shall be taken to assure adequate storage to avoid damage to equipment due to rain or strong sunshine. The responsibility also covers security measures against theft and vandalism.

1.9.2 Erection.

The Contractor shall carry out erection, testing at site and commissioning of the Plants specified in the Specifications. All work, methods of work and workmanship, whether fully specified herein or not, shall be of the highest order in all respects, the generally accepted requirements and commonly recognised good practice for first-class work of the nature are to be adhered to.

The Contractor shall provide all staff, such as engineers, supervisory staff, skilled and unskilled labour necessary to carry out and complete the Contract Works on schedule as specified. Information regarding site staff shall be shown in the relevant Schedule.

The Contractor shall provide all equipment and tools necessary to carry out the Contract Works, including personnel transport.

1.9.3 Testing and commissioning

Testing at site shall be carried out by experienced testing engineers approved by the project manager. Functional tests shall be inherent in all test procedures. The Contractor shall record the test results in an approved test form in such a manner that the test reports can be used as the basis for future maintenance tests. Test methods and equipment shall be noted on the test sheets. The test protocols shall be submitted to the project manager in advance for approval.

A complete test report in 4 sets shall be handed over to the Project Manager not later than one month after the Plant being commissioned. The test engineers shall at site keep a complete record of correction made during testing and one set of corrected drawings shall be kept at site after commissioning and one set handed over to the Project Manager.

Commissioning shall be carried out by the Contractor in the presence of the Employer's engineers and the Project Manager. Once the pre-commissioning tests are complete, the testing engineer shall submit all the preliminary tests reports for review prior to the energising of the equipment. The tests shall be accompanied with a complete procedure for energising and loading of the equipment. The procedure shall include; a detailed commissioning schedule showing the sequence to follow step by step in all

connections, including control of phase sequence and other pertinent factors. Switching of energized components will be performed by the Employer.

1.10 On the Job Training

The Employer shall be allowed to take part in erection, pre-commissioning and commissioning thus taking part in a transfer of knowledge scheme. Before the erection starts, the Contractor shall arrange a two-day course in understanding of the Contractors documentation and reference system.

The contractor shall also demonstrate to the operators all the operations of the PV power plant & substation before the tests run of the station.

1.11 Tools

The Supplier shall supply in lockable boxes, for the Employer's use, any special tools that may be required for assembly, dismantling adjustments and maintenance of the equipment. The tools shall be unused and in new condition at the time of handover. Suitable special spanners shall be provided for bolts and nuts, which are not properly accessible by means of an ordinary spanner.

1.12 Spare Parts

Spare parts supplied under the contract shall be packed and preserved for long-term storage.

1.13 Environmental and Social (ES) requirements

Bidders must familiarize themselves with the project Environmental and Social Management Plan (ESMP) requirements and fully incorporate them in their proposal. The site ESMP is available through the following link: <http://sesrp.moewr.gov.so>.

2 GENERAL TECHNICAL SPECIFICATION

2.1 Standards

Ratings, characteristics, tests and test procedures, etc. for the electrical equipment encompassed by this Specification shall comply with the provisions and requirements of the standards of the International Electro-technical Commission (IEC) or equivalent, unless otherwise expressly stated in Particular Technical Specifications. Where the IEC standards do not fully cover all provisions and requirements for the design, construction, testing, etc. and for equipment and components that are not covered by IEC recommendations, recognised national or regional standards shall be applied. The standards of CEE (International Commission for the approval of electrical equipment) and the standards of CENELEC (Comité Européen de Normalisation Electrotechnique) may also be applied in such cases.

The latest revision or edition in effect at the time of Bid Invitation shall apply. Where references are given to numbers in the old numbering scheme from IEC it shall be taken as to be the equivalent number in the new five-digit number scheme. The Bidder shall specifically state the Precise Standard, complete with identification number, to which the various equipment and materials are manufactured. The Bid Documents do not contain a full list of standards to be used, as they only are referred to where useful for clarification of the text.

2.2 Units

The SI-system (meter, Newton, second) shall be used throughout the works covered by this Specification.

2.3 Auxiliary Power Interruptions

The Contractor shall ensure that the plants as a whole will function without interruptions if auxiliary AC power disappears. The plant shall be shut safely down by long interruptions in AC supply or by faults in the DC supply.

2.4 Selectivity

The contractor is responsible for selectivity in the auxiliary AC and DC power circuits and shall present calculations proving the selectivity between main and sub distributions under maximum and minimum short-circuit levels.

2.5 Design and Materials

2.5.1 General

Design and calculations shall be governed by the design criteria given in the Bid Documents, standards and normal design practice. Necessary safety factors shall be included. The contractor shall assure himself that the apparatus is suitable for intended use and the environment and stresses to which it will be exposed. Contractor shall also assure that the equipment is compatible with equipment it shall be connected to, or work together with.

The design shall be reliable and simple. The design shall incorporate every reasonable precaution and provision for the safety of the general public as well as for all those engaged in the operation and maintenance of the equipment itself or equipment connected to or installed in close proximity to it.

All apparatus shall be designed to ensure reliable and safe operation under the atmospheric conditions prevailing at the Site and under such sudden variations of load and voltage as may be met with under working conditions of the system. The plant shall withstand without permanent weakening or deformation from short circuit current within the rating of the apparatus (including those due to faulty synchronising) as well as normal atmospheric over voltages taking into account the use of lightning arresters. Special considerations shall be given to pressure rises by short circuits and fire risk. All material and equipment shall be designed and arranged so that over pressure will be relieved in a safe direction and so that fire risk is minimised and consequences of a fire reduced.

All conductors and current carrying parts must be dimensioned with ample cross sections so that temperatures are kept within limits in operation and under short circuits. Temperature rises on all equipment shall be kept within limits set in IEC standards provided nothing else is specified. For all current carrying parts the permissible short circuit duration shall be at least 1 second. All electrical connections shall be secured by bolts or set screws of ample size, fitted with locknuts or lock washers of approved types.

The equipment shall as far as possible be factory mounted with internal cables and internal equipment installed before shipment. Plug-in components can be shipped separately.

Equipment for use outdoors or in wet or damp rooms shall be constructed so that water runs off. It shall also have devices draining any inside condensation that may form. Axial bearings on such equipment must be equipped with durable sealing preventing water to ingress.

2.5.2 Electrical Equipment Materials

All materials supplied under this Contract shall be new and of the best quality and of the class most suitable for working under the conditions specified. They shall withstand the variations of temperature and atmospheric conditions arising under working conditions (including start and stop) without distortion deterioration or undue stresses in any parts and also without affecting the suitability of the various parts of the Works for which they were designed. The Plant shall be designed for a lifetime of minimum 30 years except for Battery Energy Storage System (BESS) which has to be of a minimum 20 years. Equipment with a shorter life cycle shall be identified and so arranged that they are easy to replace.

No welding, filling or plugging of defective parts will be permitted without the sanction in writing of the Project Manager.

Materials that are susceptible to mould growth under tropical conditions shall be treated to exclude moisture and prevent growth of mould after all machining has been carried out.

Copper and aluminium used as electrical conductors shall be of the electrolytic type and comply with the respective ASTM or DIN Standards.

Cast iron shall not be used for chambers of oil-filled apparatus or for any part of the equipment that is in tension or subject to impact stresses. Exception is made where it can be shown that service experience has been satisfactory with the grade of cast iron and the duty proposed.

2.5.3 Bolts, Studs, Nuts, Screws, Washers, etc

All bolts, studs, nuts, etc., shall have a standard metric threading and conform to the relevant standards as regards shape and tolerance. They shall be of Strength Class 8.8 and marked accordingly.

All bolts, studs, nuts, washers, screws, etc., used outdoor or in wet or moist environment shall be in stainless steel or hot-dip galvanised. If hot-dip galvanised bolts and nuts are used, special considerations shall be taken related to pre-stressing. Bolts, nuts, studs and screws that require frequent tightening and unbolting during inspection or maintenance procedures, shall be of stainless steel.

All bolts and nuts shall be hexagonal, either normally or of the round head socket type and secured in an approved manner against becoming loose during operation.

The Contractor shall supply the net quantities plus 5% of all permanent bolts, screws and other similar items and materials required for installation of the works at the site. Any such rivets, bolts, screws, etc., which are surplus after the installation of the equipment has been completed shall become spare parts and shall be wrapped, marked and handed over to the Employer.

Taper pins shall have threaded stems with nuts where dismantling of the pins is likely to be required.

Bolts shall not protrude more than 10 mm beyond the nut but not less than two full threads.

2.5.4 Surface Treatment and Painting, Electrical Equipment

Panel boards, cubicles, cabinets, etc. in dry rooms shall have interior surfaces painted with at least one priming and one finishing coat of anti-corrosion paint.

Exterior surfaces shall be adequately treated to be substantially corrosion resistant, with one priming coat, and two finishing coats.

Outdoor installations and indoor installations in wet and damp rooms shall at least have one priming coat and two layers of paint on zinc powder basis applied after perfect cleaning.

Structural supports outdoor and in wet or moist rooms and parts that cannot be readily painted, shall be hot-dip galvanised. All galvanising shall be in accordance with BS 729 or other internationally approved standards. Steel below ground shall in addition to galvanising be protected with Bitumen or a substance of similar quality.

The particulars of priming and finishing paintings shall be stated in the Bid, with specifications of paint, together with a listing of colours available, for each of the plant and equipment.

The Employer is not bound to accept the finishing colour proposed by the Bidder. Determination of colour shall be at the option of the Employer and shall be finalised at the time of approval of drawings.

2.5.5 Insulating Oil

All electrical equipment requiring insulating oil or other insulating liquids shall be furnished with the first filling including flushing, if required. An excess of 10% of the net amount of oil or liquid required for each component shall also be furnished by the Contractor as spare.

The Contractor shall endeavour to employ, as far as practicable, one type and make of insulating oil only for all the electrical equipment.

2.5.6 Sulphur hexafluoride gas (SF₆)

The SF₆ gas shall comply with the requirements of IEC 60376. In addition to the quantity of gas required to fill the equipment supplied, 20% shall be supplied as spare.

The high-pressure cylinders for shipment and storage of the SF₆ gas shall comply with the applicable national regulations. All the necessary pipes, couplings, flexible tubes and valves for coupling to the switchgear for filling or evacuating all the gases to be used, with all necessary instructions for the storage of this equipment, shall be provided.

2.5.7 Locking Devices and Padlocks

Facilities for applying safety or security padlocks to circuit breaker operating mechanisms, disconnectors and switch operating handles, control switches, control cubicles, outdoor cabinets etc. shall be provided for all equipment accessible by unauthorised personnel. The facilities shall be suitable for padlocks having a hasp diameter of 10 mm. Padlocks are not required.

2.5.8 Nameplates and signs

Marking shall be in corrosion resistant material with permanent lettering. All equipment shall be marked in accordance with standards and local practice. The Contractor must mark all components in a clear and unambiguous way so that it can be related to the documentation. All operating mechanisms as pushbuttons, switches and handles must be marked in a precise way and necessary warning signs must be supplied.

All outdoor nameplates and signs shall be made of non-corrosive weatherproof material as trafolyte aluminium or stainless steel.

Letters shall be white and engraved on black background. For aluminium and steel signs black letters on metallic background shall be used. For warning signs red background shall be used.

2.5.9 Tool Rack in the switchgear Room

A tool rack shall be installed in the switchgear room for all the, handles and tools required for operation of the switchgear including panel/marshalling boxes keys. The rack shall be easily accessible to operators and not cause obstruction to operations.

2.6 Equipment

2.6.1 Standardisation

The Contractor shall be responsible for the standardisation of all small mechanical and electrical equipment, materials and devices for the Works. Contractor shall arrange and perform the necessary co-ordination work with his subcontractors for the purpose of such standardisation. Such equipment, devices, fittings, etc. shall comprise, but not necessarily be restricted to, the following:

- Programmable controllers, control devices and control switches
- Electrical instruments and meters
- Terminals and terminal blocks
- Primary, secondary and auxiliary relaying devices
- Contactors, fuses, miniature breakers and the like.
- Lamps, bulbs, sockets, plugs, etc.
- Lubricants
- Oil

Where electrical sockets are installed for lamps, hand tools, measuring equipment etc., local standard sockets with earth connection shall be used for 16 A single phase sockets (lower rating shall not be used). Other sockets shall be according to IEC 60309 (CEE type). The Contractor shall endeavour to use components available in the local market and off the shelf.

2.6.2 Indicators and Instruments

All status and position indication lamps shall be of the light emitting diode type and be replaceable without use of soldering or special tools. In unmanned operation a switch shall be arranged for turning off the indication lights for the substation. A switch for lamp test shall be arranged. All indication contacts shall be galvanic isolated and potential free. Temperature indicators shall be of the PT 100 type protected to suit the environment where it is to be used. Pressure indicators shall be of corrosion proof material, IP 54, vibration class 1. The scale shall indicate bar or equivalent m water column. The diameter shall be 160 mm, and the measuring pipe shall be equipped with stop chock. If the indicator is exposed to vibration, it shall be filled with damping liquid (glycerine).

Limit switches for pressure, temperature and flow (even if combined with the indicators) shall be of class 1 without noticeable hysteresis. Where more than one limit is required, each limit shall be independently settable. Set points shall be easily readable.

Flow meters shall be graded in litres/s from zero to well above required value. Flow meters for water shall be electronic without moving mechanical parts.

Panel instrument shall be accuracy class 1.5 or better, dimensions 96x96 mm with non-reflective glass. Measuring converters shall be of accuracy class 0.5 with 4-20 mA output, DC auxiliary voltage and galvanic isolated potential free output.

2.6.3 Relays and Contactors

All resetting of relays and contactors must be possible without dismantling of any covers and without risk for electrical shock. All contactors and relays used in DC circuits must be approved for the relevant DC voltage and current.

Limit switches not mounted in enclosures shall be of the proximity type without need for separate power supply and equipped with light emitting diodes to indicate position.

2.6.4 Computer Based Controllers

Computer Based Controllers Inclusive Programmable Logical Controllers (PLC) can be used for individual control functions. Such equipment shall be designed for industrial environment and application in high voltage plants. The control equipment must be fed from the general station DC supply.

The control equipment must be equipped with internal “watchdog” function giving external potential free alarm by internal fault. The operational status shall be frozen by fault or un-normal function so it can be re-established after restart. The process must be shut down to a safe stage if fatale faults occur in the controller.

Analogue and digital in- and out puts must be galvanic isolated and potential free and must, together with the enclosure, screen against disturbance from electromagnetic field occurring by short-circuit, switching over voltages or lightning discharges. The control equipment shall be tested according IEC 60255 and fulfil relevant EMC requirements for Industrial Environment.

Digital in- and outputs shall be tested and approved for switching of DC voltages supplied by the main plant battery (AC values are irrelevant).

Programmes shall be stored in “flash ram” or similar storage medium and shall not be destroyed or changed by power failure (i.e. Separate backup battery shall not be used). The memory shall contain the last program version.

All programming of control sequences shall be documented in a self-explanatory way not requiring special program knowledge for understanding (function block programming or similar)

Communication between various controllers (and the main control system) can be over fibre optical cable provided agreement between the contractors. Such communication must use open protocols to be approved by the Project Manager. The Bidder shall in any case present a verification of transmission quality.

The Controllers shall be delivered with software and software licences needed for testing, setting ad reconfiguration. If hardware other than laptop is required for this such shall be included in the supply.

2.7 Construction and Erection

2.7.1 Switchboards, Panels and Cabinets

Switchboards, control, panel boards and cabinets shall be of robust construction, formed of a steel frame and covered with smooth steel plate (outdoor cabinets can be of aluminium). The steel plate shall be properly stiffened to prevent distortion. Panels shall normally be covered at their rear with hinged doors. The frames of the boards shall be designed to permit firm anchoring on the floor. The frames shall permit easy erection, and allowance shall be made for extension of the board by similar additional panels. Panes for power circuits shall be in accordance IEC 6034 (minimum partly type tested apparatus (PTTA)). All enclosures shall be ventilated so that the temperature inside the enclosure do not raise more than 5C° above ambient even with possible heaters connected.

IP 65 Outdoor-cabinets and cabinets for moist environments shall be provided with thermostat-controlled heaters to inhibit collection of moisture. The heater must be arranged not to overheat any cables or equipment. Openings for drainage of condense shall be provided at the lowest point in the cabinets.

All major or important compartments containing electrical equipment shall be provided with a single phase 16 A socket and internal lighting facilities switched off by a door switch.

Unless otherwise specified or agreed upon, all instruments, apparatus and devices on the panel fronts shall be provided for flush mounting. Flush mounted relays shall be provided with transparent cover. The cover shall be hinged to allow resetting and adjustment. All terminals and all equipment shall be accessible without dismantling other components. Equipment shall not be mounted in swing out doors. However, proper swing out frames may be used provided they can be opened will full load without twisting or distorting the panel. Windows shall be provided in front of rack mounted equipment.

2.7.2 Cable Laying and Routing

The final routing of HV and LV cables in indoor and outdoor installations shall be determined by the Contractor from the directives given in Particular Specifications, and the principles shown in the layouts on the drawings. All cable routing and arrangement shall be subject to the Project Manager's approval and must adapt to obstacles as tubes and ventilation channels. All penetrations of fire zone separations shall have the same fire classification as the separation itself.

Cables shall be laid on corrosion resistant (aluminium or hot dipped galvanised) cable trays and racks and by raising cables fixed to cable ladders. The trays shall be dimensioned and fixed so that it allows one man to climb on it in addition to the cable load. Each tray shall have at least 15 % spare capacity. The distance between each tray shall at least be 300 mm. For exposed outdoor installations cables shall be laid in covered cable trenches, plastic or steel ducts, depending on the available space.

Branch offs to individual equipment shall be fixed and supported all the way to the connection box. Cables and cable supports shall be properly fixed and secured against movement under short-circuit and strain caused by erection work. Particular attention shall be given to termination in confined areas where personnel may climb under erection and maintenance. Flexible tubes of "spiral type" shall not be used whereas tubes of "plica" type can.

Low power cables, i.e. cables for control, metering, etc. shall not be run in close parallel to high power cables or earth wires, but shall be run at the greatest possible separating distance.

The minimum distances are:

- High and medium voltage versus control and measuring cables 800 mm
- Low voltage power cables versus control and measuring cables 400 mm

Necessary EMC consideration shall be taken in accordance with EMC standards.

Additionally, cables for extra low power, i.e. mA and mV circuits and cables connected to low power solid state electronic circuits, shall be laid in separate sheet steel trays with covers. The DC trip and AC voltage supplies and wiring to main protective gear shall be segregated from those for back-up protection to the greatest extent possible.

Single-phase power cables shall be run in trefoil configuration, single-phase DC power cables shall be run in parallel. Special care shall be taken so that closed magnetic circuits do not form around single-phase cables.

All cross section must be checked against maximum load current, allowable burden on measuring transformers, short circuit values, voltage drop, protection requirements and selectivity.

The cables shall be marked with item designation in both ends as well as by entrances in enclosures. The cable marking shall be fire proof. Cables shall be laid in full runs and not spliced unless approved by Project Manager. Termination of multi-stranded conductor ends shall be with a suitable crimped thimble as specified above. All other cable lugs or similar shall be of crimped type adapted to the cable type and cross-section used. The tools used should be special approved for the lugs and cable type used. The cable supplier's instructions regarding handling and bending radius shall be followed

2.7.3 Earthing

An embedded earthing system shall be designed and supplied by the contractor. The embedded earthing system shall be arranged connected to exposed and accessible earthing bars. From here an exposed earthing system shall be arranged. The Contractor is responsible for installation and connecting of his equipment to this network so that all precautions are taken regarding safety and shielding against disturbances. Cables shall be earthed and shielded in accordance with earthing philosophy worked out by main switchgear contractor.

3.0 PROJECT SPECIFIC DATA

3.1 Scope of Design and Supply of Plant and Installation Services

3.1.1 Solar PV Power Plant General Scope

The project scope in this bid includes the design, supply, installation, configuration, testing and commissioning of a Solar Power Generating Plant with its associated Battery Energy Storage Services. The project defect liability period is **twelve (12) Months** starting from the date of Operational Acceptance Certificate. All required accessories and materials on turnkey basis for the completeness and functionality of the system shall be provided.

The project scope includes the design, supply, installation, configuration, testing, commissioning, operation and maintenance of the various Solar Power Generating Plants (SPGP) with Battery Energy Storage Systems (BESS). All required accessories and materials on a turnkey basis for the completeness and functionality of the system shall be provided.

ITEM NO.	ITEM DESCRIPTIONS	DETAILS
1	Project Location	Kismayo City, Jubaland State of Somalia.
2	Project Coordinates	0.3560° S, 42.5461° E
3	Altitude of the Area	440m
4	Project Accessibility	Accessible through the main highways
5	Available Area for Project Construction	TBD
6	Ambient Temperature	25°C
7	Humidity Level	34%-94%
8	Soil Type	Sandy Soil
9	Wind Speed	26km/h
10	Project DC Capacity	6.0 MWp
11	Project AC Capacity	4.8 MW
12	BESS Power Rating (MW)	2.5MW
13	BESS Power rating (MWhr)	10 MWhr
14	Module Mounting Structure Type	Fixed Tilt
15	The design life of the Plant	25 years
16	Interconnection Point to Grid	11kV
17	Acceptable PR ratio for the PV system	90%

Table 1 : Describes Project details and locations.

3.1.2 Solar PV Power Plant - Scope of Supply and Installations

The overall scope of the PV Power plant involves in the Engineering design, supply, installations, testing & commissioning of 6 MWp (ac) solar PV accompanied by BESS capacity of 10 MWhr.

The detailed scope for design, supply, installation, testing, commissioning, of the Solar PV plant shall comprise of the following:

- Solar PV modules which shall be of monocrystalline, necessary Mounting Module Structures (MMS), all necessary Aluminium support for both MMS and PV modules, reinforced concrete foundations (ground mount modules), bolts, nuts and all interconnection necessary for modules.
- Array Junction Boxes, combiner boxes, distribution boards containing all necessary protection devices including Breakers, cut outs, Fuses etc.
- Solar Cables of appropriate size and rating from PV Modules to SCB or to string inverters, along with straight/Y-connectors/branch connectors, ferrules, conduits, cable ties and other materials required for cable laying and termination at both the ends.
- DC Cables of appropriate size and rating from SCB to Inverter complete with cable termination kits, ferrules / tags, conduits, cable ties and other materials required for cable laying and termination at both the ends.
- AC Cables (LT & HT) of appropriate specified size and rating along with cable termination kits, ferrules / tags, conduits, cable ties and other materials required for cable laying and termination at both the ends.
- Inverter duty transformers of appropriate specified rating and in accordance with inverter manufacturer requirements, including fire protection system.
- Synchronization of the Existing 11kV HT Switchgear Panels including Vacuum or SF6 Circuit Breakers, Current Transformers, Voltage Transformers, Relays and other accessories at the inverter stations.
- 11kV HT Synchronizing or combiner panel of an extensible type, rated a minimum of 1600A with a minimum of an incoming transformer feeder bays of 6No. 630A VCB. The outgoing feeders shall be of a minimum of 2No. each rated at 630A VCB. The panel shall have a VCB breaker based on bus coupler of normally open type.
- Battery Energy Storage System (BESS)- Containerised Battery packs/modules/racks with Battery Management System (BMS), associated Fire Protection System, HVAC etc. (as required by the OEM design).
- BESS Power Conditioning System (PCS) of appropriate specified rating to deliver power at the Point of Common Coupling (with Solar PV array).
- Step-up transformers, LT & HT switchgear panels, Auxiliary supply system, DC & AC power cables. Control and communication cables, along with RTU and related accessories for communication with the Plant SCADA
- BESS Energy Management System (EMS) for data acquisition and control of BESS parameters.
- Any other equipment / system required to comply with the relevant Procedures / Regulations.
- Auxiliary supply system including auxiliary transformers, distribution panels, cables and related accessories for plant internal consumption.
- Uninterrupted Power Supply (UPS) including Batteries, Distribution Boards, Cables and associated equipment.
- Battery Bank, Battery Charger, Distribution Boards, Cables and associated equipment.
- Communication cables including end terminations and other required accessories
- Supervisory Control and Data Acquisition (SCADA) and Power Plant Controller (PPC) for remote monitoring/control of plant facilities.
- Data Acquisition System and communication infrastructure to transfer real time data to Load Control Centers.
- Earthing system including earth strip/cables, earth electrodes, earth enhancing compound and all other associated materials for complete earthing of the plant.
- Lightning Protection System for entire plant area.

- Integration and configuration with the existing system.
- Weather monitoring station that shall include but not be limited to the following:
 - a) Pyranometers – Two in Horizontal Plane for GHI and two in inclined plane – Minimum 2 (Two) Nos.
 - b) Ultrasonic Anemometer (wind speed and direction) – 1 (one) no.
 - c) Temperature Sensor (ambient and module surface) – 5 (five) No. (2 for ambient and 3 for Module Surface)
 - d) Sensors required for measurement of following parameters
 - a. Sun rise and sun set timings
 - b. Cloud cover (Okta)
 - c. Rainfall (mm)
 - d. Relative humidity (%)
- Fire detection and fire protection system in buildings/containers, inverter / transformer yard and switchyard.
- Testing instruments
- Mandatory spares as specified.
- All cable containment necessary to offer physical protection to the cables.
- Any other item or material necessary for proper functioning of the system

4.0 PARTICULAR TECHNICAL SPECIFICATIONS

4.1 SOLAR PV MODULES.

The solar PV modules performance at Standard Test condition is based on an irradiance of 1000W/mm², Temperature of 25°C, Air Mass of 1.5 spectra.

The proposed Solar PV modules shall comply to all the necessary and relevant standards such as the following:

- a) IEC 61215 -Terrestrial photovoltaic (PV) modules -Design qualification and type approval
- b) UL 1703 (Type 2 UL Module Fire Rating), IEC61215, IEC1215, IEC61730, Class, IEC Fire Rating or Equivalent European and UK Tests.
- c) Standard Tests for VC Modules Only: UL 1991, UL1703 (Type 2 UL Module Fire Rating), IEC1741 or Equivalent European and UK Tests.
- d) IEC61701-Salt Mist Corrosion Testing of PV Modules
- e) IEC 61853-Part 1: PV Module Performance Testing and Energy Rating-Irradiance and Temperature Performance Measurement and Power Rating.
- f) IEC 62804: PV Modules, Test Methods for the Detection of Potential Induced Degradation (PID)
- g) IEC62759-1: PV Modules, Transportation Testing, Shipping of Modules Package Units
- h) IEC62716: PV Modules Ammonia Corrosion Testing
- i) Quality Tests: ISO 9001:2015, ISO 14001:2015
- j) EHS Compliance – RoHS, OHSAS 18001:2007, C2C (Cradle to Cradle), PV Cycle
- k) BS7430-1999: Code of Practice for Earthing
- l) BS7354: Code of Practice for Design of Open Terminal Station
- m) BS7671-2008 17th Edition: Requirement of Electrical Installations IEEE Wiring Regulations
- n) Operating Temperature: -40C to +85C
- o) 15-year material and workmanship warranty.
- p) Connectors: Compatible with cable lengths

The Photovoltaic PV module shall consist of Silicon mono (Mono PERC) Photovoltaic modules of capacity rated at STC. The PV modules shall comply with IEC 61215 and IEC 61730 or equivalent. An aluminium frame shall be applied around each module to protect the module from any damage during transport, installation and operation.

The junction box behind the module with their positive and negative terminals shall be equipped with bypass diodes and with at least IP 68 protection and UV resistant.

The DC cable used with the PV module shall be able to withstand thermal and mechanical loads. The insulation and jacket material shall be extremely resistant to weathering, UV-radiation, and abrasion. Further, the cables shall resist temperature up to 90°C. The wiring on the DC side shall be double insulated and with UV stable cables. Flexible cables shall be used for fixed installation as well as for thermal movement of modules.

4.1.1 IDENTIFICATION OF THE PV SOLAR PV

Each PV Module shall have Radio Frequency Identification (RFID) tag. The below data shall be shown in the RFID tag of each module. The tag shall be weatherproof to withstand the harsh severe environmental conditions.

- a) Name of the Manufacturer of the Panel
- b) Country of Origin
- c) Date of Production
- d) Electrical Parameters such as P_{max}, V_{mp}, V_{oc}, I_{mp}, I_{sc}, Module efficiency, Operating Temperature, Maximum System Voltage, Temperature Coefficient etc.

- e) IEC and ISO certifications

4.1.2 WARRANTIES FOR MODULES

4.1.2.1 Product Warranty

The PV Modules shall be free from defects arising out of the manufacturing process or due to the quality of the materials or deviation from the approved specifications.

4.1.2.2 Performance Warranty

The PV modules power generated degradation shall not exceed 0.5% per annum or guaranteed performance of 90% after 25 years of service. The modules shall be warranted for minimum of 10 years against all material/ manufacturing defects and workmanship.

4.1.2 Type Tests.

The bid shall include type tests confirming that (i) the PV modules are certified by an accredited laboratory by the worldwide certification system of the IEC in the photovoltaics category and (ii) according to the standards below.

IEC 61730	Photovoltaic (PV) module safety qualification: Part 1: Requirements for construction Part 2: Requirements for testing
IEC 61215	Terrestrial photovoltaic (PV) modules - Design qualification and type approval Part 1: Test requirements Part 2: Test procedures
IEC 61215 or UL 61215	Terrestrial photovoltaic (PV) modules - Design qualification and type approval: Part 1-2: Special requirements for testing of thin-film Cadmium Telluride (CdTe) based photovoltaic (PV) modules Part 1-4: Special requirements for testing of thin-film Cu(In,Ga)(S,Se) ₂ based photovoltaic (PV) modules
IEC 62804	Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation - Part 1: Crystalline silicon
IEC 60068	Environmental testing: Part 2-52: Tests - Test K b: Salt mist, cyclic (sodium chloride solution)

4.1.3 Factory Acceptance Tests

Factory Acceptance tests shall be carried out at the manufacturer's premises. The objective is to assure that the modules have no defect and comply with all the technical specifications prior shipment. The following shall apply:

- Measurement equipment shall have a valid calibration certificate indicating the required accuracy and precision.
- Tests and equipment used for the tests shall all comply with IEC 61215 and the international standards for the measurement equipment.
- Sampling will be done at inspection level S-4 according to UNE EN 66020-1,

- equivalent to ISO 2859-1.
- d. The following tests shall be conducted according to IEC 61853-1:2011:
 - Visual inspection to detect any visual defect in the module.
 - Power rate to determine the maximum power rate of the module.
 - Electroluminescence testing – to determine the quality of the PV cells.
 - Thermographic inspection – to determine defects.
 - Electrical insulation within the module.
 - e. The test will be passed if: (i) complies with the specifications according to IEC 61215; (ii) meets the acceptance level according to 2.5 of UNE EN 66020-1:2001 (equivalent to ISO 2859-1:1999).

4.1.4 Site acceptance

The PV modules shall be prior to installation and upon arrival at the site of the project be (i) inspected visually for defects; and (ii) the flash tests of all the modules shall be verified. Upon receipt of an item on Site, the Contractor and the Employer shall visually inspect the shipment. All deliveries within the Contract shall be checked and any discrepancies noted and recorded. Lost items shall be replaced. Damaged items shall be replaced, or repaired if permitted by the Employer, to conform to the Specifications. In all cases of irreparable damage, the Contractor shall immediately notify the relevant manufacturer for renewed manufacture and replacement of the damaged part(s). He shall also immediately notify the Employer of the actions he is going to undertake in order to repair or replace the damaged part(s) and of the consequences this damage will have on the completion date of the plant.

4.2 PV MODULE MOUNTING STRUCTURES

The PV mounting structures shall comply to the Standards below or equivalent.

- EN 1325 Geotextiles and geotextile-related products – Characteristics required for use in earthworks, foundations and retaining structures
 - ISO 12944-5 Paints and varnishes — Corrosion protection of steel structures by protective paint systems
- ISO 14713-1:2009 Guidelines and recommendations for protection against corrosion
- EN ISO 1461 Galvanization
- ISO 9223 and 9224 Corrosion on Metals and Alloys. Corrosivity of Atmospheres
 - EN 755-2:2008, Table 42: for mechanical properties
 - EN 573-3:2007, Table 06+: for Chemical Properties
 - ASTM B580-79: For Anodization
 - ASTM A123: Standard Specification for Zinc (Hot dipped galvanized) Coatings on iron and steel products
 - ASTM A6: Standard Specification for Carbon Structural Steel
 - EN 1990, Basis of structural design
 - EN 1991, Actions on structures
 - EN 1992, Design of concrete structures
 - EN 1993, Design of steel structures
 - EN 1994, Design of composite steel and concrete structures
 - EN 1995, Design of timber structures
 - EN 1996, Design of masonry structures
 - EN 1997, Geotechnical design
 - EN 1998, Design of structures for earthquake resistance
 - EN 1999, Design of Aluminium structures
 - EN 206, Concrete specification, performance, production and conformity

- EN 12350, Testing fresh concrete
- EN 12390, Testing hardened concrete

The Mounting Structure shall be Fixed-tilt type Azimuth 0° true South/north as per the project location. Tilt angle shall ensure that there no imposing shadow from the arrays.

All mounting steel structures shall be of galvanized type in compliant with IEC 61215& 61646.

The mounting structure shall be properly designed to withstand for mechanical and electrical installation. It shall support Solar PV modules at a given orientation, absorb and transfer the mechanical loads along with applicable wind loads to the base properly. The mounting structures used shall be capable to withstand the wind forces generated by heavy wind speed and the spacing between two adjacent modules shall be sufficient to allow wind passage to reduce pressure on structures. The minimum clearance between the lower edge of the modules and developed ground level shall be adequately elevated above relevant flood plain (800mm- 1000mm).

The structure shall be designed to allow replacement of any module. Nuts & bolts, supporting structures including module mounting structures shall be adequately protected against all climatic conditions prevailing in the area. All fasteners shall be of stainless steel of grade SS 304 or suitable equivalent. The mounting structure shall be grounded properly using a maintenance-free earthing kit.

i) GTPs: SOLAR PV MODULES
SPECIFICATION OF THE PV MODULES

ITEM NO.	SPECIFICATION OF THE PV MODULES	MINIMUM REQUIREMENT	BIDDER'S RESPONSE
1	Product Certification as per IEC 61215	Must be compliant	Bidder To Indicate
2	Cell Type	Mono Crystalline	Bidder To Indicate
3	Weight	-	Bidder To Indicate
4	Dimensions		Bidder To Indicate
5	No of Cells	-	Bidder To Indicate
6	Cable Cross Section area	6mm ² (IEC)	Bidder To Indicate
7	Junction Box	IP68 (with diodes)	Bidder To Indicate
8	Connectors	MC4 Plug (IP65)	Bidder To Indicate
9	Front glass coating	≥ 3.2mm anti reflect coating	Bidder To Indicate
10	Front glass Material	High Tempered Glass	Bidder To Indicate
11	Frame	Anodized Aluminium	Bidder To Indicate

12	Maximum Power Rated (Pmax) @ STC (is this per panel or total?)	-	Bidder To Indicate
13	Open Circuit Voltage (Voc)V	-	Bidder To Indicate
14	Maximum Power Voltage (Vmp) V	-	Bidder To Indicate
15	Short Circuit Current (Isc)A	-	Bidder To Indicate
16	Maximum Power Current (Imp)A	-	Bidder To Indicate
17	PV Module efficiency (%)	≥20%	Bidder To Indicate
18	Power Tolerances	0-/+3%	Bidder To Indicate
19	Temperature Coefficient of Isc	-	Bidder To Indicate
20	Temperature Coefficient of Voc	-	Bidder To Indicate
21	Temperature Coefficient of Pmax		Bidder To Indicate
22	Operating Temperature	-15°C≤T≤45°C	Bidder To Indicate
23	Mechanical Load as per IEC 61215	-	Bidder To Indicate
24	Protection Class as per IEC 61730	-	Bidder To Indicate
25	Salt Mist Corrosion Test as per IEC 61701	-	Bidder To Indicate
26	Wind Load Withstand	-	Bidder To Indicate
28	Load Pressure Withstand	-	Bidder To Indicate
29	Warranty	≥ 15 years	Bidder To Indicate
30	Linear Performance Guarantee	90% up to 15 years and 88% up to 25 years)	Bidder To Indicate
31	CE Conformity	Required	Bidder To Indicate
NAME OF BIDDER: SIGNATURE OF BIDDER:			

Table 2 Specification of the PV Modules

4.3 String Combiner Box (SCB)

Standards and Codes Standard/Code	Description
IEC 60529	Enclosure Ingress Protection
IEC 62262	Enclosure Impact Protection
IEC 60269-6	Fuse
IEC 61643-31 / EN 50539-11	Surge Protection Device
IEC 62852	Solar cable connector
IEC 60947-3	Switch disconnector
IEC 60695-2-11	Fire hazard testing

Table 3 : Standards and Codes Standard Descriptions

4.3.1 Construction

- SCB enclosure shall be made of UV resistant, fire retardant, thermoplastic material. Enclosure degree of protection shall be at least IP 65 and mechanical impact resistance shall be at least IK 08.
- Not more than two strings can be connected in parallel to a single input of SCB. One spare input terminal along with connector shall be provided for each SCB.
- Every SCB input shall be provided with fuses on both positive and negative side. In case of negative grounded system, fuse at positive side only is acceptable. The rating of the fuses shall be selected such that it protects the modules from reverse current overload. The fuses shall be 'gPV' type conforming to IEC 60269-6.
- DC switch disconnector of suitable rating shall be provided at SCB output / SIB to disconnect both positive and negative side simultaneously.
- Type-II surge protective device (SPD) conforming to IEC 61643-31 / EN 50539-11 shall be connected between positive/negative bus and earth.
- Connector conforming to IS 17293 / IEC 62852 shall be provided at each SCB input. Cable gland (double compression metallic) of suitable size for DC cables shall be provided at the SCB output.
- UV resistant printed cable ferrules for solar cables & communication cables and punched/ embossed aluminium tags for DC cables shall be provided at cable termination points for identification.

4.3.2 Warranty

The SCB unit shall be warranted against all material/ manufacturing defects and workmanship for minimum of 2 (two) years from the date of supply.

4.3.3 Tests

Routine tests and acceptance tests for the assembled unit shall be as per the Quality Assurance Plan approved by the Employer.

4.4 Solar and DC Cables

Item No.	Descriptions	Conductor/Insulation	Voltage Rating
1	Solar PV cables	Copper/XLPE	1.5kV DC
2	DC cables	Copper/XLPE	1.5kV DC

Table 4 : Descriptions of Solar and DC Cables

- Solar cable outer sheath shall be flaming retardant, UV resistant and black in colour. Solar cable with positive polarity should have marking of red line on black outer sheath.
- DC cables shall be single core, armoured, Flame-Retardant Low smoke (FRLS), PVC outer sheath. DC cable with positive polarity and negative polarity shall have red and black outer sheath respectively.
- In addition to the manufacturer's identification of cables as per relevant standards, following marking shall also be provided over the outer sheath.
- Cable size and voltage grade
 - a) Word 'HALOGEN FREE LOW SMOKE'
 - b) Sequential marking of length of the cable
- Cables shall be sized based on the following considerations:
 - a) Rated current of module
 - b) In the case of string Inverters, average voltage drops (from PV module to string inverter) shall be limited to 0.5% of the rated voltage drop. The Contractor shall provide voltage drop calculations in excel sheet.
 - c) Short circuit withstand capability.
 - d) De-rating factors according to the laying pattern

4.4.1 Warranty

The cables (Solar and DC) shall be warranted against all material/ manufacturing defects and workmanship for a minimum of 2 (two) years from the date of supply.

4.4.2 Tests

Type test, routine test, and acceptance test requirements shall be as per IEC 62930 for solar cables and IS 7098-II for DC cables.

4.4.3 Installation

- Only terminal cable joints shall be accepted. No cable joint to join two cable ends shall be accepted.
- Solar cables shall be provided with UV resistant printed ferrules and DC cables shall be provided with punched/ embossed aluminium tags. The marking shall be done with good quality letters and numbers of proper size so that the cables can be identified easily.
- Solar cables or groups of solar cables combined through branch connectors may be laid over ground on GI or FRP cable trays / underground through Double Wall Corrugated (DWC) HDPE conduits from PV String (Series connection of PV Modules) to SCB/String Inverter. The size of the conduit or pipe shall be selected on the basis of 40% fill criteria. Solar cable terminations shall be made with connectors complying with IEC 62852. The connectors shall have a degree of protection of IP 68.
- Solar cables shall be aesthetically tied to the Module Mounting Structure using GI/SS cable ties.
- DC cables from SCB to PCU shall be laid directly buried underground. DC cable terminations shall be made with properly crimped lugs and passed through cable glands at the entry & exit points of the cubicles. Bimetallic lugs shall be used for connecting the Cu bus bar and Al cables or vice-versa.

4.5 Power Conditioning Unit

- Minimum Recommended size of the PCU string inverter is 300kVA
- All PV inverters must be of the same type and manufacturer.
- All BESS inverters must be of the same type and manufacturer.
- BESS inverters must be AC coupled to the PV inverters.
- The inverters must have a minimum product warranty against defects of 10 years.
- The inverters must be designed and constructed for continuous operation under prevailing climatic and environmental conditions at the installation site. Maximum ambient temperatures of 40°C shall be expected. According to the requirements of the PV module manufacturer, the negative / positive pole must be grounded.
- The protection system must be selected and coordinated according to the requirements of the grid operator. Each inverter must be connected to the PV protective earth ground through an appropriate electrical scheme.
- The inverters must be able to synchronize automatically with the grid.
- The inverters shall provide LVRT and HVRT.
- 0.95 leading and lagging but will operate at 100% active power.
- Efficiency >= 98%
- Inverter shall Support 1500 Vdc
- Inverter shall have HD <= 3% No power reduction at temperatures below 40°C for outdoor inverters.

4.5.1 Standards and Codes

The power Conditioning Unit (PCU) shall comply with the specified edition of the following standards and codes.

Standard	Descriptions
IEC 61683 Ed.1	Photovoltaic systems - Power conditioners - Procedure for measuring efficiency
IEC 62109-1 Ed.1	Safety of power converters for use in photovoltaic power systems - Part 1: General requirements
IEC 62109-2 Ed.1	Safety of power converters for use in photovoltaic power systems - Part 2: Particular requirements for inverters
IEC 61000-6-2 Ed.3	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments
IEC 61000-6-4 Ed.3	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
IEC 62116 Ed.2	Utility-interconnected photovoltaic inverters - Test procedure of islanding prevention measures
IEC 60068-2-1 Ed.6	Environmental testing - Part 2-1: Tests - Test A: Cold
IEC 60068-2-2 Ed.5	Environmental testing - Part 2-2: Tests - Test B: Dry heat
IEC60068-2-14 Ed.6	Environmental testing - Part 2-14: Tests - Test N: Change of temperature

IEC60068-2-30 Ed.3	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)
--------------------	---

Table 5: Descriptions of Power Conditioning Unit (PCU)

Required Parameters

Table 6 : Required Parameters of Power Conditioning Unit (PCU)

Required Parameters	Required Specifications
Type	String
Rated AC power	Minimum 300kVA
Maximum input voltage	1500 V
Rated AC output voltage	800 V, 3W + PE
Tolerance on rated AC output voltage	+/- 10%
Rated frequency	50 HZ
Operating frequency range	47.5 Hz to 52 Hz
Power factor control range	0.8 lag to 0.8 lead
European efficiency	Minimum 98%
Maximum loss in Sleep Mode	0.05% of rated AC power
Total Harmonic Distortion	Less than 3% at 100% load

Table 6: Required Parameters of Power Conditioning Unit (PCU)

The rated/nameplate AC capacity of the PCU shall be AC power output of the PCU at 25°C.

Note: The equipment shall be suitably derated for the Altitude.

- Maximum power point tracker (MPPT) shall be integrated in the PCU to maximize energy drawn from the Solar PV array. The MPPT voltage window shall be sufficient enough to accommodate the output voltage of the PV array at the site.
- The PCU output shall always follow the grid in terms of voltage and frequency. The operating voltage and frequency range of the PCU shall be sufficient to accommodate the allowable grid voltage and frequency variations.

4.5.2 Construction

- Power Conditioning Unit (PCU) shall consist of an electronic three-phase inverter along with associated control, protection, filtering, measurement and data logging devices.
- Every DC input terminal of PCU shall be provided with fuse / MCB / MCCB of appropriate rating. The combined DC feeder shall have suitably rated isolators for safe start-up and shut down of the system. One spare DC input terminal shall be provided for each PCU.
- DC input current monitoring shall be provided at each input of the PCU.
- Type-II surge protective device (SPD) conforming to IEC 61643-31 shall be connected between positive/ negative bus and earth on the DC side. Type-II SPD conforming to IEC 61643-11 shall be provided on the AC side.
- In case external auxiliary power supply is required, UPS shall be used to meet auxiliary power requirement of PCU. It shall have a backup storage capacity of 2 hours.
- Circuit Breaker or Relay of appropriate voltage and current rating shall be provided at the output to isolate the PCU from grid in case of faults.
- The PCU shall be tropicalized, and the design shall be compatible with conditions prevailing at site. Suitable number of exhaust fan with proper ducting shall be provided for cooling keeping in mind the extreme climatic condition of the site as per the recommendations of OEM to achieve desired performance and life expectancy.
- All the conducting parts of the PCU that are not intended to carry current shall be bonded together and connected to dedicated earth pits through protective conductor of appropriate size. Grounding on DC side of the PCU shall be as per the requirements of PV Module Manufacturer.
- PCU front panel shall be provided with LCD/ LED to display all the relevant parameters related to PCU operation and fault conditions. It shall include, but not be limited to, the following parameters.
 - a) DC input power
 - b) DC input voltage
 - c) DC input current (for each terminal)
 - d) AC output power
 - e) AC output voltage (all the 3 phases and line)
 - f) AC output current (all the 3 phases and line)
 - g) Frequency
 - h) Power Factor

4.5.3 Operating Modes.

Operating modes of PCU shall include, but not limited to, the following modes. These operating modes and conditions for transition are indicative only. The Contractor shall provide the detailed flow chart indicating the various operating modes and conditions for transition during detailed engineering.

4.5.3.1 Standby Mode.

The PCU shall continuously monitor the input DC voltage and remain on Standby Mode until it reaches the pre-set value.

4.5.3.2 MPPT Mode.

When the input DC voltage is above the pre-set value and AC grid connection conditions are fulfilled, the PCU shall enter into MPPT mode

4.5.3.3 Sleep Mode.

When the AC output power/DC input voltage decreases below the pre-set value for pre-set time delay, the PCU shall switch into Sleep Mode.

The Contractor shall also provide the short-circuit characteristics of the PCU (Voltage and Time-dependent) as per the CTU requirements for Connectivity.

4.5.4 Protection Features

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

The PCU shall provide protection against the following types of faults, among others.

- A. DC/AC over current.
- B. DC/AC over voltage.
- C. DC reverse polarity.
- D. DC earth fault.
- E. AC under voltage
- F. AC under frequency/over frequency
- G. Islanding
- H. Over temperature
- I. Lightning surges

4.5.5 Grid Support Functions

4.5.5.1 Active power regulation

The PCU shall be able to limit the active power exported to the grid based on the set point provided through the PCU front control panel. The PCU shall also be able to automatically limit the active power after an increase in grid frequency above a pre-set value. The ramp rate shall be adjustable during operation and start-up after a fault. The applicability of the requirement shall be as per regulation and compliance.

4.5.5.2 Reactive power control

The PCU shall be able to inject /absorb reactive power to/ from the grid based on the set point provided through the PCU front control panel. The same shall be performed automatically with an adjustable ramp rate based on dynamic changes in grid voltage or reactive power reference.

4.5.5.3 Voltage Ride Through

The PCU shall remain connected to the grid during a temporary dip or rise in grid voltage as per the LVRT and HVRT requirements of Technical Standards for Connectivity to the Grid Regulations. The PCU shall also be able to inject reactive power during the period of voltage dip.

4.5.6 Warranty.

The complete Power Conditioning Unit shall be warranted against all material/ manufacturing defects and workmanship for a minimum of 10(Ten year) years from the date of supply.

4.5.7 Tests

4.5.7.1 Type Tests

The type test certificates as per the standards mentioned above should be from any of the ILAC/IECEE member signatory accredited test centers. Laboratory accreditation certificate or weblink along with the scope of accreditation shall also be submitted. The type test Reports shall be submitted with the technical bid.

4.5.7.2 Routine Tests

Routine tests and acceptance tests shall be as per the Quality Assurance Plan approved by the Employer.

4.6 INVERTER TRANSFORMER AND AUXILIARY TRANSFORMER *(Shall be in the same container with the LV panel and 3 GIS panel)*

4.6.1 Standards and Codes

The inverter transformer and auxiliary transformer, wherever applicable, shall comply with the latest edition of the following standards and codes including amendments, below Table 7: Standard and codes of the inverter transformer and auxiliary transformer.

Standard	Descriptions
IEC 60076	Specification of Power Transformers
IEC 60076-7:2018	Dry -Type Power Transformers
IEC 60137	Bushings for alternate voltage above 1000 V
IEC 60296	Insulating oil

Table 7: Shows Standards and Codes

4.6.2 Technical Requirement

Required Parameters	Required Specifications
kVA Rating	≥ 3150
Voltage Ratio	0.8kV/11kV
Duty, Service & Application	Continuous Solar Inverter application and converter Duty (Outdoor)
Winding	As per the system design requirement
Frequency	50 Hz
No. of Phases	3
Vector Group & Neutral earthing	As per the system/inverter manufacturer's requirement
Cooling	ONAN
Tap Changer	OFF-LOAD TC No. of steps shall be as per system requirement
Impedance at 75°C	As per the Inverter Manufacturer's requirement
Permissible Temperature rise over an ambient of 50°C (irrespective of tap)	
Top Oil	50°C
Winding	55°C
SC withstand time (thermal)	2 second
Short Circuit Apparent power	As per the system requirement

Bushing rating, Insulation class (Winding & bushing)	12 kV – porcelain bushings
Loading Capability	Continuous operation at rated MVA on any tap with voltage variation of +/-3%, also transformer shall be capable of being loaded in accordance with IEC 60076-7
Flux density	Not to exceed 1.9 Wb/sq.m. at any tap position with combined frequency and voltage variation from rated V/f ratio by 10% corresponding to the tap. The transformer shall also withstand the 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 characteristics up to 150%
Air Clearance	As per IEC

Table 8 : Required Specifications for Power Transformers.

4.6.3 Construction

- The transformer shall be provided with a conventional single-compartment conservator with a prismatic toughened glass oil gauge. The top of the conservator shall be connected to the atmosphere by indicating the type of cobalt-free silica gel breather with a transparent enclosure. Silica gel shall be isolated from the atmosphere by an oil seal. Inverter transformers shall be provided with a Magnetic Oil Gauge (MOG) with low oil level alarm contact.
- It is the responsibility of the Contractor to ensure that the inverter transformer complies with all the requirements of the inverter provided by the inverter manufacturer.
- The Inverter Transformer shall be designed for at least 5% total harmonic distortion (THD) to withstand distortion generated by the inverter as well as possible outside harmonics from the network.
- The transformer shall be suitable for continuous operation with a frequency variation of $\pm 2.5\%$ from a nominal frequency of 50 Hz without exceeding the specified temperature rise.
- Inverter Transformer shall have shield winding between LV & HV windings. Each LV winding must be capable of handling non-sinusoidal voltage with a voltage gradient as specified by the inverter manufacturer. Also, shield winding shall be taken out from the tank through shield bushing and the same shall be brought down to the bottom of the tank using a copper flat and support insulator for independent grounding.
- Neutral earthing of the inverter transformer shall be as per the recommendations of inverter manufacturer. Even if neutral earthing is not required, neutral bushing shall be brought outside the tank for the testing purpose. It shall be covered with MS sheet and a sticker "For testing purpose only. Do not earth". Neutral bushing of auxiliary transformer shall be brought outside the tank for earthing.
- Transformer shall have 150 mm dial-type Oil Temperature Indicator (OTI) and Winding Temperature Indicator (WTI) with alarm and trip contacts. All indicators shall have an accuracy of 1.5%. For inverter transformers, WTI shall be provided for all the windings.
- The 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.
- Marshalling 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 65. 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 10% spare terminals shall be provided on each panel. The gasket used shall be of neoprene rubber. 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.

- Buchholz relay, double float type with alarm and trip contacts, along with suitable gas collecting arrangement shall be provided.
- Inverter transformer shall be provided with spring operated Pressure Relief Device (with trip contacts) with suitable discharge arrangement for oil. For Auxiliary transformers, diaphragm type explosion vent shall be provided.
- Inverter transformer shall be provided with spring operated Pressure Relief Device (with trip contacts) with suitable discharge arrangement for oil. For Auxiliary transformers, diaphragm type explosion vent shall be provided.
- Filter valve at top the tank and drain cum sampling valve at bottom of the tank shall be provided.
- All external surface of the transformer shall be painted with two coats of epoxy-based paint of colour shade RAL 7032. Internal surface of cable boxes and marshalling box shall be painted with epoxy enamel white paint. The minimum dry film thickness (DFT) shall be 100 microns.
- LV and HV cable box shall be provided with disconnecting chamber to facilitate the movement of transformer without disturbing cable box and termination.
- Air release plug, bi-directional wheel/skids, cover lifting eyes, transformer lifting lugs, jacking pads, towing holes, core and winding lifting lugs, inspection cover, rating plate, valve schedule plate, accessories and terminal marking plates, two nos. of earthing terminals shall be provided.
- Rain hoods to be provided on Buchholz, MOG & PRD. Entry points of wires shall be suitably sealed.
- The accessories listed above are indicative only. Accessories that are not mentioned above but required for the satisfactory operation of the transformers are deemed to be included in the contract without extra charges.
- Fire protection for the inverter transformer shall be provided in accordance with relevant regulations as amended from time to time.

4.7 Dry Type Auxiliary Transformer

- Transformer shall be cast resin encapsulated dry type transformer, made of cold rolled grain-oriented silicon steel laminations of M4 grade or better. The winding conductor shall be electrolytic grade Copper/Aluminium and insulation shall be Class F or better.
- The transformers shall be housed in a metal protective housing, having a degree of protection of IP 23 suitable for indoor installation. The enclosure shall be provided with suitable hardware and accessories required for the satisfactory operation of the transformer per the relevant standard.

4.7.1 Warranty

The transformer shall be warranted against all material/ manufacturing defects and workmanship for a minimum of 10 (Ten) years from the date of supply.

4.7.2 Testing and Inspection

4.7.2.1 Type Tests and Special Tests

The following type of test and special test reports shall be submitted with the bid. The tests should have been conducted on a similar transformer by an accredited laboratory within the last five years from the date of bid submission.

4.7.2.1 Type Tests

- Lightning impulse (Full & Chopped Wave) test on windings as per IEC 60076-3.
- Temperature Rise test at a tap corresponding to maximum losses as per IEC 60076-2.
- Tank vacuum test & pressure test as per CBIP manual.

4.7.2.1 Special Tests

- Measurement of zero-sequence impedance as per IEC 60076-1
- Measurement of harmonics of no-load current as per IEC 60076-1
- Measurement of acoustic noise level as per NEMA TR-1
- Short-circuit withstand test as per IEC 60076-5

4.7.2.2 Routine Tests

Each completed transformer shall be subjected to the following routine tests as per the latest edition of IEC 60076 unless specified otherwise.

- Measurement of winding resistance at each tap.
- Measurement of voltage ratio between HV and LV windings at each tap.
- Check of vector group.
- Measurement of no-load loss and no-load current.
- Measurement of short-circuit impedance and load loss.
- Magnetic balance test.
- Separate source voltage withstand test.
- Induced over voltage withstand test.
- Measurement of insulation resistance.
- Marshalling box functional test.
- IR Measurement on the wiring of marshalling box.
- Breakdown voltage test on transformer oil as per IS 335.
- Oil leakage test on completely assembled transformer along with radiators.

4.7.2.3 Tests at Site

After erection at site, all transformer(s) shall be subjected to the following tests.

- Measurement of voltage ratio
- Check of vector group
- Magnetic balance test
- Measurement of insulation resistance
- Breakdown voltage test on transformer oil
- In case the equipment is not found as per the requirements of the Technical Specifications, all expenses incurred during site testing will be to the Contractor's account and the equipment shall be replaced by him free of cost.

4.8 SCOPE OF WORK - SUBSTATIONS

4.8.1 PARTICULAR TECHNICAL SPECIFICATIONS 11kV FOR GIS INSULATED SWITCHGEAR

The following standards contain provisions which, through reference in this text constitute provisions of this specification. Unless otherwise stated, the latest editions (including amendments) apply and shall be complied with by the manufacturer/ supplier.

- IEC 60694: Standard specification for common clauses for high voltage switchgear & control gear;
- IEC 62271-203: High voltage switchgear and control-gear. Part 203: Gas insulated metal-enclosed switchgear for rated voltages above 52kV
- IEC 60376: Specification for acceptance of new sulphur hexafluoride, SF6 gas
- IEC 60480: Guide to checking of sulphur hexafluoride, SF6 taken from Electrical equipment
- IEC 60099: Surge Arresters, Part 4: Metal Oxide surge arrestors without gaps for a.c systems
- IEC 60137: Insulated bushings for alternating voltages above 1000 V
- IEC 60859: Cable connections for gas insulated metal enclosed Switchgear for rated voltages of 72.5 KV and above.
- IEC 60060: High voltage test techniques.

- IEC 60071: Insulation coordination.
- IEC 60255: Electrical Relays.
- IEC 60265: High voltage switches, Part 2: Switches rate voltages of 52kV and above
- IEC 60270: High voltage techniques- Partial discharge measurement
- IEC 60529: Degree of protection provided by enclosures (IP Code)
- IEC 60815: Selection and dimensioning of high voltage insulators intended for use in polluted conditions
- IEC 61000: Electro-magnetic compatibility
- IEC 61634: Use and handling of SF6 gas in high voltage switchgear; IEEE STD 80: Standards for station grounding; CENELEC/SVDB: Pressure vessel code;
- IEC 60114: Recommendation for heat-treated aluminium alloy bus-bar material of the Aluminium-magnesium-silicon type
- IEEE STD C37.122.1-1993 IEEE: Guide for Gas-Insulated Substations
- IEEE STD693: Seismic design.
- IEC 60044: Instrument transformers.
- IEC 60185: Current transformers
- IEC 60186: Voltage transformers
- IEC 62271-100: High voltage alternating current circuit breakers
- IEC 60427: Synthetic testing of high voltage alternating current circuit breakers

4.8.2. REQUIREMENTS

Service Conditions on Climatic Conditions:

The equipment and the accessories to be supplied against this technical specification shall be suitable for satisfactory continuous operation under the following tropical conditions.

- Max ambient temperature: +40°C
- Min. ambient temperature: -10 °C
- Max daily average ambient temperature: 30° C
- Max relative Humidity (%): <95%
- Max altitude above M.S.L (meters): 290
- Average Annual Rainfall (mm): 108mm
- Pollution class / Creepage distance: “Very Heavy”; Level IV/ 31mm/kV, as per IEC
- Seismic Zone: Zone V, as per IEEE 693

Table: Equipment Characteristics

Technical Details	Units	Requirements
Frequency	Hz	50
Highest System voltage	kV	17.5
Rated Normal current(Ir)	A	1250
Rated Short time current withstand (3sec)	kA rms	31.5
Rated peak withstand current (Ip)	kA pk	78
Rated breaking capacity	kA	40
Minimum Lightning Impulse Withstand Voltage 1,2/50ps +ve, dry (peak)	kV peak	95
Minimum Power Frequency Withstand (wet and dry) Voltage (rms) (1 min)	kVrms	38

Class IV Site pollution severity (SPS) as per IEC7TS 60815	Very heavy	
Specific creepage distance as per 113(7IS 60815:2008 -class	mm/kV	31

4.8.3 DESIGN AND CONSTRUCTION

- The 11 kV switchgear shall be indoor, metal-enclosed primary distribution Gas-Insulated Switchgear (GIS), designed, manufactured and type-tested in accordance with IEC 62271-200 and the applicable IEC 62271 series standards, together with the requirements of this Specification.
- The switchboard shall be built up of individually metal enclosed cubicles or modules with earthed metal partitions. The circuit breakers shall be vacuum circuit breakers (VCBs) suitable for the offered GIS design. The circuit breakers may be fixed-mounted, with electrical isolation provided by a separate disconnect/isolator in accordance with the manufacturer's proven GIS design. The switching devices shall be operable from the front of the switchgear by one operator.
- The complete switchgear shall be Gas insulated fully metal enclosed and shall be such that the complete switchboard is of flush-front design. The maximum height of the board shall not exceed 2500mm.
- The switchgear shall incorporate separate functional compartments for the busbar system, MV cable connections, switching devices and low-voltage protection and control equipment, as applicable to the manufacturer's proven GIS design.
- The low voltage section shall be separate from the medium voltage section. All the Protection Relays, Auxiliary Relays, Indication Lamps, Instruments. Control and selection switches and any other associated accessories shall be mounted in this compartment.
- The switchgear shall be designed for erection with the rear side close to a wall as well as for free standing erection.
- The switchgear shall incorporate a pressure-relief system for the safe discharge of gases resulting from an internal arc, in accordance with the manufacturer's proven design and IEC 62271-200. Pressure relief shall be arranged so as not to endanger personnel in normal operating areas.
- The cable compartment shall have an anti-vermin guard plate giving protection against rats, rodents, snakes etc.
- Hinged and pad lockable doors shall be provided at the LV and Circuit breaker compartment. The front cubicle door shall be provided with a window through which the mechanical status of the circuit breaker (ON/OFF & SPRING Charged/Discharged) can be checked.
- All metallic instrument cases, protective relay, switches etc., shall be properly earthed to the switchgear board steelwork frame,
- Rear cable chamber covers shall be provided with handles and all bolts and nuts shall be stainless steel.
- The Gas insulated switchgear and protection panels shall be constructed to IP4x degree of protection as per IEC 60529.
- The busbar shall be a single, three-phase busbar system. The busbar insulation shall be in accordance with the manufacturer's proven GIS design.
- The primary bus bars and connections shall be of high conductivity and electrolytic Copper materials and be in unit lengths.
- The Bus bars shall be marked R, Y, B and all the jointing points/ends shall be tin-plated.
- Bus bars, connections and their support shall be rated 1250Amps continuously under ambient conditions and capable of carrying the short-time current associated with the short circuit ratings of the circuit breakers, for 3 seconds.

- Where shutters are incorporated in the manufacturer's design, they shall be automatically operated and appropriately identified. Where shutters are not applicable to the GIS design, equivalent protection against access to live parts shall be provided
- Suitable mechanical and/or electrical interlocks shall be provided between the circuit breaker, disconnect/isolator and earthing switch to prevent unsafe or incorrect switching operations
- The switchgear shall be provided with integral earthing facilities appropriate to the offered GIS design. Cable circuits shall be provided with fault-making earthing switches. Busbar earthing facilities shall be provided where required by the switchgear configuration
- All earthing facilities shall be rated for fault making, and padlocking facility provided for the earth switch.
- The material for Earth bus and cable shall be copper, and the earth bus shall be extended outside the switchboard panel
- The incoming panels HT cable cut outs per phase shall be capable of accommodating three cables, whereas the outgoing shall be capable of accommodating one cable.
- The panel wiring for protection, instruments, indication, signal/command and metering circuits and oilier control accessories shall be completely done using flexible copper 2.5mm- cables.
- All circuits for connection to external cables such as DC & AC auxiliary supplies, external tripping, supervisory control and indications shall be wired up to the terminal block at (he back or front of the panel where external cable shall be connected.
- Auxiliary 110VDC and single-phase 230VAC supplies for circuit breaker control, alarm circuits, protection relays, metering and motor supply for each panel shall be controlled by miniature circuit breakers rated to carry the full load of the equipment.
- The cubicle shall be tropical vermin proof. The cover plates shall be of mild steel thoroughly cleaned by shot blasting or other approved methods.
- The switchgear panels shall then be given a primary coat and two coats of contrasting colour of durable and weather resisting paint. The final coat shall be powder coating and of light grey RAL 7035.
- Anti-condensation heaters shall be provided inside each cubicle. They shall be located so as not to cause injury to personal or damage to equipment.
- The heaters and lighting shall be controlled from a two-position control switch with positions "ON-OFF" in each cubicle. The heaters and lighting shall operate from a single-phase supply (230 VAC).

4.8.4 SYSTEM CHARACTERISTICS

4.8.4.1 11kV CIRCUIT BREAKERS

- The circuit breaker shall be three poles operated, indoor, employing Vacuum Interrupter, complying with the requirement of IEC 62271-100.
- The circuit breaker shall be suitable for fixed installation within the GIS and shall operate in conjunction with the associated disconnect/isolator and earthing switch in accordance with the manufacturer's proven GIS design.
- The circuit breaker assembly shall comprise a three-pole vacuum circuit breaker, operating mechanism, auxiliary switches, mechanical position indication and all necessary control and monitoring wiring.
- The circuit breaker shall be provided with auxiliary contacts and associated wiring necessary for protection, control, interlocking, local indication and remote supervisory/SCADA functions.
- The circuit breakers shall be of the manufacturer's proven standard design and shall be suitable for the rated voltage, continuous current, short-circuit breaking current and operating duty specified for the switchgear.
- The circuit breaker operating mechanism shall be motor-wound spring operated, electrically closed and electrically tripped, with provision for manual spring charging..
- Mechanical indication shall be provided for circuit breaker OPEN/CLOSED status and

spring CHARGED/DISCHARGED status. Suitable auxiliary contacts shall be provided for local indication, protection, interlocking and remote supervisory/SCADA indication.

- Sufficient auxiliary contacts shall be provided for all protection, control, interlocking, indication and SCADA requirements, together with a minimum of two (2) spare normally-open and two (2) spare normally closed contacts wired to accessible terminal blocks.
- The circuit breaker control circuits shall be permanently wired or connected using the manufacturer's standard GIS secondary connection arrangement. All external protection, control, indication and SCADA interfaces shall be terminated at accessible terminal blocks within the LV compartment.

4.8.4.2 CURRENT TRANSFORMERS

- The incomers, feeders and Bus coupler shall be fitted with wound type epoxy cast resin current transformers.
- In addition, the incomers and outgoing feeders shall be fitted with ring core type epoxy cast resin current transformer for Sensitive Earth fault (SEE) protection.
- The current transformers shall be in accordance with the requirement of IEC 61 869-2 and shall have the specified accuracy under load conditions and shall be able to withstand the effect of short-circuit fault current rating of the switchgear for 1 seconds.
- Current transformers shall have rated burden sufficient for the connected numeric or static type relays, meters and instruments.
- The current transformer ratings shall be as shown in table below:

Description	Requirement
Type	Wound epoxy cast resin
Highest System Voltage	17.5kV
Short time Current withstand (STC)	3 1.5kA for 3 seconds
Maximum Continuous Thermal Rating	x 1.5 In
Lightning Impulse Withstand Voltage	95 kV peak
One-Minute Power frequency Withstand Voltage	38kVrms
Incoming (Incomer) and Bus coupler	4-cores
Class X/SP	2cores, Burden: 15 VA, Vk=250V
	Ik<30mA
Class 5P20	One core; Burden 15VA
Class 0.2	One core; Burden 15VA
Ratio	600-1500/1/1/1/1 A
Outgoing feeders	3core
Class 51'20	2cores; Burden 15VA
Class 0.2	1core; burden 15VA
Ratio	200-400-600/1/1/1A

4.8.4.3 VOLTAGE TRANSFORMERS

- Voltage transformers shall be suitable for operation of the protection relays, metering and transformer voltage regulation and their design and manufacturing shall meet requirements of IEC 61896-3 standards.
- The voltage transformer shall be epoxy cast resin type, three phases, and, star/star connected complete with removable HV fuses.

- Withdrawable type Voltage transformers is most preferable, and shall be fitted in the incomers and Bus PT/Bus riser panels.

Description	Requirement
Highest System Voltage	17.5kV
Short time current with stand	31.5KA/3sec
Ratio	11000/ $\sqrt{3}$ / 110/ $\sqrt{3}$ /110/ $\sqrt{3}$ V
Burden	30VA
Class	2 cores: 0.2 and 3P
Impulse Withstand Voltage	95kV peak
One-Minute Power Frequency Withstand Voltage	38kVrms

4.8.4.4 RELAYS

- The LV compartment Terminal Block shall include a test switch (block) which shall enable the CTs circuits to be isolated from (The Relay and shorted, to facilitate relay testing in situ and to allow isolation of VT circuits. Alarm and Trip Circuits.
- Relay secondary rating shall be 1 Amp (three phase) and Power Supply Voltage shall be 110VDC or (Universal 30-300VDC).
- The relays shall be of Numeric design and supports GOOSE messaging and communication protocols 60870-5-103 and 61850-9-2.
- The relays shall be flush mounted in design, and shall be manufactured in accordance to IEC 60255.
- Relay contacts shall be suitable for making and breaking the maximum currents, which they are required to control in normal service. Where contacts of the protective relays are not sufficient for Circuit Breaker Tripping, auxiliary Trip relays shall be provided, to prevent damage to relay output contacts.
- Operating time for auxiliary tripping relays shall not significantly affect the overall fault clearance time, i.e. The auxiliary trip relays must have short pick-up times (<30 ms).
- Relay contacts shall make firmly without bounce and the relay mechanism shall not be affected by panel vibration or external magnetic fields.
- Relays shall be provided with clearly inscribed labels describing their functions and Device Function numbers. The labels shall be put on the outside and in the inside when the doors are open.
- Relays shall be suitable for operation on 110VDC supply without use of dropping resistors or diodes.
- The protection relay shall have a minimum of 5 current inputs (I/I A) and 4No. Voltage transformer inputs (110VDC)
- To reduce the effect of electrolysis, relay coils operating on DC shall be so connected such that they are not continuously connected from the positive pole of the station battery.
- The relays thermal rating shall be such that the fault clearance times on any combination of current and time multiplier settings shall not exceed the thermal withstand capability of the relay. (Max. fault current = 31.5kA /3s).
- The protection relay shall conform to IEC 60255 and EMC 89/336/EEC' standards and shall provide following incoming/outgoing feeder protections/functions.
 - Non directional over current (50/51)
 - Non directional earth fault (50N, 51N)
 - Directional over current (67)
 - Sensitive earth fault through ring core C.T (64S)
 - Under/Over voltage protection (27/59)
 - Broken conductor protection (47)

- vii. Breaker failure protection (62 BF)
- viii. Auto reclose function & trip circuit supervision (for open and close circuits)
- ix. Under/over frequency protection (81)
- x. Synchro check (25) & Trip circuit supervision
- xi. Measurement of I, V, P, Q, P F.

4.8.4.5 INDICATING INSTRUMENTS

All indicating instruments shall be Hush mounted and shall be in accordance to requirement of IEC 60051.

Each switchboard panel shall have the following indications:

- i. One mechanical ON/OFF indicator, with inscription “ON” in white letters on red background and inscription “OFF” in white letters on green background. This should be an integral part of the circuit breaker.
- ii. One indicating lamp complete with push button switch to provide trip circuit healthy indication check, which must function for both circuit breaker open and close positions with inscription “TRIP CIRCUIT HEALTHY” black letters on white background.
- iii. One mechanical indication of the state of the spring inscription, “SPRING CHARGED” (white letters on red background). This should be an integral part of the Circuit Breaker.
- iv. One indicator lamp to show the breaker in closed position RED colour.
- v. One indicator lamp to show the breaker in open position GREEN colour.

4.8.4.6 POWER CABLE TERMINATION

- i. HT cable compartment design shall be suitable either for shrinkable (or equivalent) jointing application termination.
- ii. The following provisions shall be made:
- iii. The base plate of the incomers shall have cut out holes sealed with PVC sleeves for 3nos. HT cable entry per phase, whereas the outgoing feeders shall have provisions for one cable entry.
- iv. The HT cable entry provision shall be able to accommodate at least 11k V XLPE cables sizes of up to 630mm 2 single core (for Incomer panels), and three-core cable of up to 300mm² (for feeder panels).
- v. Anti-condensation heaters (minimum 100W) with MOB protection and humidistat control for cable compartment with heater 'ON' indication.

4.8.4.7 Other Features Required in the Switchgear Panels

- Trip circuit supervision for both CB ON and CB OFF.
- Detailed nameplate for the Circuit Breaker with all VCB rating details.
- Name plate for Current and Voltage Transformers with rating details.
- Two sets of NO + NC auxiliary contact of circuit breaker wired to (the controls cable termination block for status indication.
- High voltage presence indicator
- Alarm and Annunciator scheme for entire 11kV indoor switchboard, with audible Urgent and Non-Urgent Alarm.
- All indoor switchboard panels shall be provided with Bus-wires for all signal, commands, indications, metering etc. ready for looping to the next switchboard panel.
- All relays shall be software based incorporating features for fault records, event records and

- diagnostic data downloaded via RS232 serial port, USB-2 and higher versions,
- Auxiliary supplies for panel heating and lighting shall be 230VAC, 50Hz, single-phase 2- wire, while protection, spring charging motor. Control and Circuit Breaker Trip/ Close auxiliary supply shall be 110VDC.
 - All panels shall have names at the front and at the rear as per feeder or incomer name. The names shall be engraved on a high-quality long-life PVC or metal material.

4.8.4.8 PROTECTION RELAYS, INDICATING AND CONTROL LEDS REQUIREMENTS

a) OUTGOING FEEDER PANELS

All the outgoing feeders shall be equipped with but not limited to the following IEDs:

- a) Multi-functional numerical protection relay.
- b) Auxiliary relay for lockout.
- c) Trip circuit supervision.
- d) Ammeter selector switch.
- e) Ammeter with MDI.
- f) Voltage and phase IED.
- g) Digital energy multi-meter for tariff metering to measure the data such as *KW, KWH, KVAR, KVARH, P.F, Maximum demand. Load profile etc.***
- h) Digital MVar and MW meter
- i) MVar and MW transducers
- j) Circuit Breaker Control Switch (Close, Open & Neutral)
- k) Circuit Breaker ON (red) and OFF (green) Indication lamps.
- l) Anti-condensation heaters (minimum 100W) with MCB protection and humidistat control for LV compartment with heater 'ON' indication,
- m) SEF selection switch IN/OUT
- n) Auto-reclose selector switch
- o) HV voltage indication lamps
- p) Circuit earth switch interlock
- q) Manual Close/ Trip switch
- r) Cable Circuit Earth indications

b) TRANSFORMER INCOMING PANELS

All the incomer switchboard panels shall be equipped with but not limited to the following IEDs.

- i. Multi-functional numerical protection relay.
- ii. LV Master trip relay
- iii. Trip circuit supervision
- iv. Ammeter selector switch
- v. Ammeter with MDI
- vi. Digital energy multi-meter for tariff metering to measure following data; KW, KWH, KVAR, KVARH, P.F, Maximum demand, Load profile etc. Digital MVar and MW meter
- vii. MW and MVar transducer (optional) -20 / 0 / +20 Ma
- viii. KV meter
- ix. Voltage selector switch
- x. Circuit Breaker Control Switch (Close, Open & Neutral)

- xi. Circuit Breaker ON (red) and OFF (green) Indication Lamps.
- xii. Anti-condensation heaters (minimum 100W) with MCB protection and humidistat control for cable compartment with heater 'ON' indication.
- xiii. HV voltage indication lamps
- xiv. Cable Circuit Earth manual switch
- xv. Manual Close/Trip switch
- xvi. Circuit Earth Position indications

c) BUS COUPLER PANEL

The bus coupler shall be equipped with but not limited to the following IEDs: -

- i. Multi-functional numerical protection relay.
- ii. LV Master trip relay
- iii. Trip circuit supervision
- iv. Digital energy multi-meter to measure the data such as KW, KWH, KVAR, KVARH, P.F etc.
- v. MW and MVar transducer (optional) -20 / 0 / 4-20 mA
- vi. Circuit Breaker Control Switch (Close, Open & Neutral)
- vii. Circuit Breaker ON (red) and OFF (green) Indication lamps.
- viii. Heater ON/OFF switch, for control of the anti-condensation heater.
- ix. HV voltage indication lamps
- x. Cable Circuit Earth manual switch
- xi. Manual Close/Trip switch
- xii. Circuit Earth Position indications

d) BUS RISER/BUS PT PANEL

The Bus PT shall have digital kV meter

Interlocks requirements for the 11kV indoor switch board;

The Switchboard shall be equipped but not limited to the following electrical and mechanical interlocks for safe functioning and operation.

a) Panel Internal Interlocking

- The withdrawable part shall only be moved from (the test/disconnected position (and back) when the circuit breaker and earthing switch are off. the switch shall be off beforehand.
- The circuit breaker shall only be switched on when the withdrawable part is in the test or service position. In the intermediate position, the switch shall be mechanically interlocked.
- Connecting and disconnecting the control wiring plug shall only be possible in the test/disconnected position of the withdrawable part.
- The Bus coupler circuit breaker shall close at service position when only one incomer breaker is closed.
- The earthing switch shall only be switched on if the withdrawable part is in the test/disconnected position or outside of the panel (mechanical interlock).
- If the earthing switch is on, the withdrawable part shall not be moved from the test/disconnected position to the service position (mechanical interlock).
- The MV cable compartment door shall not be opened if the earthing switch is open.
- The earthing switch shall not be operated if the HT cable compartment door is open.
- The cable compartment door shall not be opened if the earthing switch is open.
- The earthing switch shall not be operated if the cable compartment door is open.
- To close the 11kV incomer circuit breaker, the upstream HT transformer bay circuit breaker shall be closed.

DOOR INTERLOCKING

- The MV cable compartment door shall not be opened if the earthing switch is open.
- The MV earthing switch shall not be operated if the HT cable compartment door is open.

4.8.5 SPECIFIC SWITCHGEAR TECHNICAL REQUIREMENTS

The 11 kV switchgear panels shall meet the below specific technical requirements.

4.8.5.1 Incomer and Bus coupler Switchgear Panel

Transformer Incomer and Bus coupler Switchgear Panel Specific Requirements

DESCRIPTION	REQUIREMENT
Panel and Switchgear Highest System Voltage	17.5kV
Rated power frequency withstand voltage, rms	38kV
Rated lightning impulse withstand voltage, peak	95kV
Rated short-time withstand current	31.5kA rms/3sec
Rated peak withstand current	78kA
Internal Arc Classification (I AC) as per I EC 62271 -200	25kA, 1s
Arcing time	10-15ms
Main Busbar rating	1250A
Circuit breaker design	Horizontal withdrawable type
Circuit breaker quenching medium	Vacuum
Circuit breaker breaking current	40 k Arms
Incomer and Bus coupler Circuit Breaker rating	12kV, 31.5kA, 3s, 1250A
Circuit break closing time	< 60ms
Circuit breaker opening time	< 45ms
Operation sequence	O-0.3s-CO-3min-CO
Incomer CT rating	200-600-1200-1250/1-1-1-1 A
Incomer CT cores	4 Cores
Incomer CT classes	0.2, X, X, 5P20
Switchgear Control voltage	1 10V DC
Spring charging motor voltage	110V DC
Heating and illumination Voltage	230V AC-Single phase
Protection relay	Numerical multifunction relay
Arc flash protection design	Arc protection relay with Fibre optic sensors
Arc flash protection relay	Ultra-fast acting
Arc flash protection operation time	< 8ms
Arc Hash protection covered compartments •	Bus bar, Circuit breaker, MV cable connection and Control chambers
Incomer VT rating	1100($\sqrt{3}$ /110/ $\sqrt{3}$ V

Switchgear Panel height	Not more than 2500mm
Protection degree	IP4X

4.8.5.2 FEEDER SWITCHGEAR PANEL

Feeder Switchgear Panel Specific Requirements

DESCRIPTION	REQUIREMENT
Panel and Switchgear Highest System Voltage	17.5kV
Rated power frequency withstand voltage, rms	38kV
Rated lightning impulse withstand voltage, peak	95kVp
Rated short-time withstand current	31.5kA, 3 sec
Rated peak withstand current	78kA
Arcing time	10-15 ms
Main bus bar rating	1250 A
Internal Arc Classification (1 AC) to 62271-200	25kA, 1s
Circuit breaker design	Horizontal withdrawable type
Circuit breaker quenching medium	Vacuum
Circuit breaker breaking current	40k Arms
Outgoing feeder Circuit Breaker	12kV, 31.5kA, 3s, 630A
Circuit break closing time	< 60ms
Circuit breaker opening time	< 45 ms
Operation sequence	O-0.3s-CO-3min-CO
Outgoing feeder CT rating	200-300-600/1-1-1A
Feeder CT cores	3 Cores
Feeder CT classes	0.2, 5P20, 5P20
Switchgear Control Voltage	110V DC
Spring charging motor voltage	110V DC
Heating and illumination voltage	230V AC
Protection relay	Numerical multifunction relay
Arc flash protection design	Arc protection relay with fibre optic sensors
Arc flash protection relay	Ultra-fast acting
Arc flash protection operation time	< 8 ms
Arc flash protection covered compartments	BB, CB MV cable and Control chambers
Switchgear panel height	Not more than 2500mm
Outgoing feeder Ring Core CT	50/1 A. minimum diameter 180mm
Protection degree	IP4X

4.8.5.3 Arc Flash over Protection

- The 11kV switchgear board shall be fitted with Ultra-fast detection and clearing arc flash protection system. The system shall be capable of detecting arc within 400nm spectrum and above.
- The maximum allowable arcing time due to fault for the 11kV switchgear boards shall be 15milliseconds, whereas the arc flash protection system shall operate in less than 8 milliseconds.
- Arc flash system shall meet the requirements of Institute of Electrical and Electronic Engineers (IEEE) and the US Occupational Safety and Health Administration (OSHA).
- Arc flash detection systems shall be standalone protection systems and shall not need to be coordinated with existing protection systems to achieve ultra-faster detection and clearing of
- The system shall ensure arc flash protection in all compartments of the switchgear board (Control compartment, MV Cable connection, Breaker and Bus bar compartments)
- The system shall automatically carry out regular self-checking of the sensor's integrity and continuity, and generate an alarm if a problem is detected,
- Each of the three compartments shall have one light sensor lens linked to the relay optical inputs through insulated fibre optic cable.
- The operation of arc protection shall be logically programmed to work on light only or light + current mode,
- The arc flash protection operating from the bus bar and circuit breaker compartments shall trip the two-incomer circuit breakers and the bus section circuit breaker.
- Two outputs of the arc protection relay shall be programmed for operation purposes: one output to be used for cable compartment arc sensor operation, the other output to be used for circuit breaker and bus bar compartment arc sensor operation.
- The arc flash protection operating from feeder cable compartment shall be wired to trip the feeder circuit breaker only.
- Additional output LEDs shall be programmed to indicate the following:
 - a) Cable compartment arc sensor operated.
 - b) Breaker/busbar compartment arc sensor operated,

4.8.6 DETAILED RELAY/DEVICE SPECIFICATIONS

These specifications indicate the required performance characteristics for the Protection Relays, Energy Meters and other devices listed above for all the different circuits and equipment.

4.8.6.1 Restricted Earth Fault relay.

Shall incorporate at least following features.

- The relays shall be of Numeric design and supports GOOSE messaging and communication protocols 60870-5-103 and 61850-9-2
- Relay shall reject harmonics produced by Current transformer (C.T) saturation.
- The relay shall include the associated stabilizing resistor and voltage dependent resistor (metrosil).
- Current setting range $0.05-0.8I_n$
- Operating time <25 ms at 5 times the settings

4.8.6.2 Three phase over current and earth fault relay.

Shall incorporate at least the following features: -

- The relays shall be of Numeric design and supports GOOSE messaging and communication protocols 60870-5-103 and 61850-9-2.
- Current setting range for over current relay of $0.5I_n-2.4I_n$,

- Current setting range for earth fault relay of $0.5I_n$ - $0.8I_n$.
- I.D.M. T characteristics according to IEC 60255 i.e. SI, VI, EL, LTI, including definite time for the high-set Elements.
- Time setting multiplier of 0.05-1.0
- Broken conductor protection feature
- Highest element for both overcurrent and earth fault Protection with a setting range of $I - 30I_n$.
- Thermal overload Protection
- Dedicated Breaker Fail Protection
- Circuit Breaker maintenance
- Fault records, Event Records and Disturbance records (minimum of 1000 records)
- Configurable output relays with ability to output starting elements to control-tripping of other upstream Protection relays.
- Drop off/picking up ratio $>90\%$
- Low transient overreach $<10\%$

4.8.6.3 Earth Fault relay.

Shall incorporate at least the following features.

- The relays shall be of Numeric design and supports GOOSE messaging and communication protocols 60870-5-103 and 61850-9-2
- Current setting range of $0.05I_n$ - $0.8I_n$
- I.D.M.T. characteristic according to IEC60255 i.e. SI, VI, EL, LTI, including definite time for the high-set Elements.
- Time settings multiplier of 0.05-1.0
- Highest Element with a setting range of I - $30I_n$.
- Circuit Breaker Maintenance
- Fault records, Event records and Disturbance records (minimum of 1000)
- Configurable output relays with ability to output starting elements to control tripping of other upstream Protection relays.
- Drop off/pickup ratio $> 90\%$
- Low transient overreach $<10\%$

4.8.6.4 Synchronous Switching Relay.

Shall incorporate at least of the following features:

- The relays shall be of Numeric design and supports GOOSE messaging and communication protocols 60870-5-103 and 61850-9-2.
- Must be equipped with adaptive control to enable it to automatically adjust to changes in the circuit breaker closing times.
- Shall have both synchronized closing and opening facility.

4.8.6.5 Three-phase Directional Overcurrent and Earth Fault Relay.

Shall incorporate at least the following features:

- The relays shall be of Numeric design and supports GOOSE messaging and communication protocols 60870 5-103 and 61850-9-2
- Current setting range for overcurrent relay of $0.5I_n$ - $2.4I_n$
- Current setting range for earth fault relay of $0.5I_n$ - $0.8I_n$
- Quadrature connection for polarizing voltage (V_n I 10 V)
- Applicable on the LV side of a Dyn1 transformer
- High set Element, with a setting range of $I - 32I_n$
- The phase and the directional elements shall be individually selectable.
- I.D.M.T characteristic according to IEC 60255 and Definite time characteristic
- The normal operating boundary shall be ± 90 degrees from relay characteristic angle

Relay

- sensitivity shall be 1 % of rated value of current and current polarizing voltage at an angle equal to the relay characteristic angle.
- Time setting multiplier of 0.05-1.0.
- Broken conductor protection feature.
- Negative sequence protection feature.
- Highest element for both overcurrent and earth fault protection, with a setting range of $1-30I_n$,
- Thermal protection.
- Dedicated Breaker Fail Protection.
- Circuit Breaker Maintenance
- Incorporate Fault record. Event Records and disturbance records (minimum 1000)
- Configurable output relays with ability to output starting elements to control of other upstream Protection relays.

4.8.6.5 Trip Relay

Shall incorporate at least the following features:

- High burden tripping relay, immune to capacitance discharge currents and leakage currents.
- At least 8 pairs of outputs contacts two of which should NC contacts.
- Instantaneous operation, $t < 12\text{ms}$.
- Flag or target should be a red L.E.D or bulb and should be electrically reset.

4.8.6.6 Trip Circuit Supervision Relay

The relay shall have at least the following features:

- Continuous supervision of trip circuit breaker in both OPEN & CLOSE position.
- Trip Circuit Fail - Red L.E.D
- Trip Circuit Healthy - Green L.E.D
- Two Normally Closed (NC) and three Normally Open (NO) output contacts

NB: The relay L.E. Ds shall be visible from the front of the panel without opening (the panel doors)

4.8.6.7 ANNUNCIATOR UNIT,

The relay shall at least have the following features: -

- Silence, Accept and Reset status
- Accommodate 18 signal alarms
- Relay output for audible alarm and self-supervision
- Integrated event register to provide analysis of the latest twenty (20) events

4.8.6.8 TRANSDUCERS

i) MW Transducer

- Connection shall be 3-Phase, 3 Wire
- Inputs I 10VAC and Amp
- Output shall be $0 \text{ to } \pm 20\text{mA}$
- Auxiliary power supply shall be 110VAC, separately connected.

ii) MVAR TRANSDUCER

- Connection shall be 3-Phase, 3 Wire
- Inputs I 10V AC' and Amp
- Output shall be 0- +/-20mA
- Auxiliary power supply shall be 110V DC, separately connected

iii) Current Transducer

- Input 0-1 Amp
- Output 0-20mA
- Auxiliary power supply shall be 110V DC

iv) Voltage Transducer

- Input 0-1 Amp
- Output 0-20mA
- Auxiliary power supply shall be 110V DC

v) Voltage Transducer

- Input 0-1 10 Volts
- Output 0-20mA
- Auxiliary power supply shall be 110V DC, separately connected

4.9 Battery Energy Storage System (BESS)

The Contractor shall provide detailed engineering and design documents for the BESS systems, including sizing calculation (DC to AC) to achieve the point of connection required size, cooling system sizing, fire detection and suppression system design, EMS design and functional requirements and auxiliary system design

a) Scope of Works

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

b) Design and Fabrication

For the design and fabrication of the equipment, the Contractor shall

- Design, fabricate, and assemble a fully functional, transportable BESS that meets the requirements delineated herein. This shall include a control system that provides standard input/output channels and appropriate control actions for all required operational and protective features.
- Fully document the design and expected performance of the BESS by means of documents, drawings, reports, data, and other submittals, as required herein.
- Perform factory acceptance testing of the BESS.
- Account for the geographical/climatic conditions of the Project site in the design.
- Obtain site-specific data in preparation for developing installation implementation plans.
- Provide warranty for the entire BESS and its constituent equipment.
- Develop site installation/construction drawings, specifications, and calculations
- Supply an initial complement of spare parts (as per OEM recommendations and to meet the BESS Availability Guarantee).
- Provide warranty for the entire BESS and its constituent equipment.

c) DEFINITIONS

- **PCC** – Point of common coupling, the electrical boundary between the Solar PV field of the Plant Facilities and the BESS at the common bus where the Energy injected from the BESS is metered.
- **Unit battery** – A unit battery is the minimum field-replaceable stored energy component or assembly. It may consist of one or more electrochemical cells, electrically interconnected in any series and/or series–parallel configuration. A unit battery has one (and not more than one) set of positive and negative terminals, by which it is interconnected with the rest of the storage system.
- **FAT** – Factory Acceptance Test
- **BESS** – AC Coupled energy storage system with electrochemical type accumulator subsystem, capable of receiving, storing and delivering electrical energy at specified rate(s) suitable for the application laid out in the specifications herein. For common reference in these specifications, BESS shall comprise of following subsystems/components:
 - a) Accumulation System, comprising unit batteries/battery packs/racks with battery management system (BMS)
 - b) Conversion Subsystem - Bi-directional PCU
 - c) Auxiliary sub-systems such as HVAC and fire suppression systems
 - d) Data Acquisition and Communication sub-systems
 - e) BESS Transformer.
 - f) BESS Energy Management System (EMS)/ BESS Data Acquisition System (DAS)

Note: The Accumulation system i.e. battery packs/modules/racks along with associated systems (BMS, HVAC, auxiliary subsystems etc.) deemed necessary to enable system operation shall be containerised.

BMS - or Battery Management System, is any electronic system that manages a rechargeable battery (cell or battery pack), including protecting the battery from operating outside its Safe Operating Area, monitoring its state, calculating secondary data, reporting that data, controlling its environment, authenticating it and / or balancing it.

Available or Dispatchable or throughput energy is the total of energy (kWh) delivered from the BESS at the PCC.

Nameplate Energy is the total of the rated energy capacity of the energy storage units i.e. battery packs/modules/racks.

4.9.2: Codes & Standards

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	Applicable only for Lead Acid and NiCd / NiMH batteries
UL 1642 or UL 1973, Appendix E (cell) or IEC 62619 (cell) + IEC 63056 (cell)	Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications	Required for Cell
UL 1973 (battery) or (IEC 62619	Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications / Secondary cells	Required for Battery

(battery) + IEC 63056 (battery))	and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications	
IEC 62281 / UN 38.3	Safety of primary and secondary lithium cells and batteries during transport: Applicable for storage systems using Lithium-Ion chemistries	Required for the unit transported
UL 9540 or (IEC TS 62933-5-1 + IEC 62933-5-2)	Electrical energy storage (EES) systems - Part 5-1: Safety considerations for grid integrated EES systems – General specification / Standard for Energy Storage Systems and Equipment	Either UL9540 or (IEC 62933-5-1 + IEC 62933-5-2) is required for BESS system level
UL 9540A	Standard for Thermal runaway	At cell/module/rack /system level, as required by standard

Table 1 : Codes & Standards

4.9.3 Technical Specification of Battery Energy Storage System

Specific Ratings and Requirements: The below table specifies project-specific BESS capabilities and ratings for this Project, Below Table 16: Technical specifications of BESS

Item Description	Requirement
Battery Technology	LFP suitable for operation in site-specific climatic conditions can be used.
Rated No of Cycles (Minimum)	5000 cycles at rated energy capacity at a minimum 95% Depth of Discharge (DoD) at 25°C and 0.5 C Rate of Discharge
Power rating	2.5MW, continuous
Use case requirements	Peak Management
Energy rating	Minimum 10 MWh Nameplate capacity with at least 9.5MWh dispatchable at the beginning of life and not less than 70% of this capacity at any point of time up to End of Battery Life.
BESS Availability (including scheduled and unscheduled maintenance)	About 95%
System AC-DC-AC Efficiency	>95%
Charge-discharge cycles (Cycling/throughput)	One discharge cycle per day

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.
Grid Charging	No
BESS point of connection (POC)	11 kV
Power Factor (PF) at POC	1
PV coupling	AC

Table 17 : Technical Specification of Battery Energy Storage System

Specified services/ operation modes/use cases:

1. PV shifting: BESS shall be capable of providing PV shifting, charging from PV and discharging during the evening peak hours. The system shall be configured to charge from PV only.
2. PV smoothing: BESS shall be capable of minimizing PV output fluctuations.
3. Ancillary services: BESS shall be capable to provide frequency response and reactive power support. Employer expected to operate the BESS in these modes at future stage, therefore functionality shall be implemented during the construction stage.
4. **Allowable containerized minimum BESS capacity is 2.0MWhr**
5. All batteries and complete BESS projects must:
 - a) Include a containerized BESS system including a thermal management system (Heating, Ventilation & Air-Conditioning HVAC system or suitable liquid cooling system) designed to ensure that the battery modules are kept within the operational temperature and humidity range as prescribed by the original equipment manufacturer (OEM) and within the nominal operation range as defined in the battery warranty. The thermal management system shall be designed for the site ambient climatic conditions existing on site throughout the year (site maximum temperature 45°C)
 - b) Includes Power Conversion System (PCS), power transformer(s), balance of plant and auxiliary systems back-up supply system (as required).
 - c) Includes a distributed Battery Management System (BMS) which monitors voltage, temperature, coolant flow/air-conditioning and current and is programmed to alarm when the battery is outside its safe operating area and shut down the battery when the temperature exceeds a set value. The BMS shall be supported by an Uninterrupted Power Supply.
 - d) Includes an Energy management System (EMS) to coordinate the actions and performance of all the elements of the BESS, perform the specified services, receive dispatch signals from the TSO, perform state of charge management and interface with the master controller (for hybrid operation PV and BESS).
 - e) Include a safety and security program with a fire detection and suppression system. A fire protection report must be completed to demonstrate system protection in the event of an external and internal fire risk. The fire detection and suppression system shall be included into the SCADA system, additionally a primary audible alarm shall be installed and a secondary alert system shall be designed and installed in the event that the SCADA system is offline in the event of a fire.
 - f) The scope shall comprehensively mitigate the risk of fire on an as-low-as-reasonably-practicable (ALARP) basis. The Contractor shall address fire risk in the project risk assessments and the construction health and safety management plan for both construction and operational phases of the project. This shall include engaging with the local authority and emergency services regarding system design and incident response planning as appropriate. The scope shall include means for detection and venting of any potentially harmful, flammable or explosive gasses that may arise during operation or failure

- g) conditions (during a thermal runaway), and deflagration features to mitigate the effects of any deflagration events. The design shall account for NFPA 855 guidelines and best practices for the fire safety components.
 - h) Shall be of the same type, from a single manufacturer.
6. During the above operation modes, the EMS shall monitor the BESS state of charge (SoC). The EMS shall continually calculate whether the SoC needs to be adjusted to maintain and shall calculate the level of the BESS power set-point required for each period.
 7. Respond to external real power and reactive power commands: BESS shall include all the telemetry equipment required for remote dispatch operation.

4.9.4 System Ratings (Overall System Real Power and Energy Ratings)

- During discharge, the BESS shall be rated to supply at the PCC, continuous net AC real power and AC energy output specified in Table 17 above: Supply-Specific Ratings and Requirements above. The Power and energy ratings shall be achievable during discharge for the full range of stated environmental conditions, provided that the battery is fully charged, and the HVAC system has stabilized. In any case, the BESS shall be capable of being discharged at reduced power levels from that specified above. The Contractor shall account for efficiencies of the BESS components up to the PCC as well as the expected losses from auxiliaries for system sizing.

4.9.5 Peak Management (PM)

- In the Peak Management use case, the BESS is charged from the Solar PV bus at the PCC during solar hours and discharged at any power level up to the maximum power level specified in this document. In this Use case, each daily operation is expected to consist of one discharge and charge cycle, in either a variable or a constant power output.
- **Note:** For system nameplate sizing subject to the minimum specified in Table 16 Supply-Specific Ratings and Requirements above, the Contractor shall consider 4 hours of discharge during the post-solar hours.

4.9.6 Design, Fabrication, and Construction Requirements of BESS

- The methods and materials specified in this technical specification are intended to represent minimum requirements. Reliance thereon shall not diminish the responsibility for meeting performance and other requirements stated herein. The design of the BESS shall incorporate the principle of modularity, with a view to reducing life-cycle costs and ease of replenishment of storage capacity while facilitating ease of maintenance, space requirements, and reliability. The design should also facilitate rapid and easy replacement of the unit batteries/battery packs/modules without significant downtime.

4.9.7 System-Level Design and Performance Requirements

- The major equipment items shall include battery packs/modules, battery management system (BMS), PCS, output/isolation transformer, and BESS EMS 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 set forth in this specification.

a) Containerization and Transportability.

- Containers for the accumulation subsystem shall comply with International Organization for Standardization (ISO) 668 or custom-designed power equipment centers. The container or containers shall be designed to be drop-shipped onto a properly prepared pad or foundation (such as compacted soil, concrete pad, or platform).
- Containers shall be designed and constructed to meet IP54/NEMA 3R requirements. The Outdoor enclosures shall be equipped to prevent condensation. The BESS container shall be designed for harshest expected environmental conditions which are coastal environments and

corrosion protection requirements. The class of pollution shall be “e” (i.e. “very heavy”) in accordance with SANS 60815-1:2009 or equivalent. The enclosure material shall be 6mm, 3CR12 or stainless steel. All enclosures both outdoor and indoor shall be protected against vermin and insects.

- All containers and packaging of separately shipped components shall be suitable for land or sea transport, including offering suitable protection of the equipment inside against damage from weather and vibration or shock from transportation.
- The containers and their contents shall be designed to be easily prepared for transport, shipped, connected, and operated at the site. Containers shall be transported along with all requisite bracing and shipping stabilization equipment.

4.9.8 Design Life and Life-Cycle Costs

- End of battery 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 accumulation 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 20 years from the date of Commissioning.
- The BESS shall be capable of unattended operation, with the provision of remote monitoring and control.

4.9.8.1 BESS Reliability, Availability, and Operability.

The BESS shall be designed for high reliability, defined in the following terms:

- a. Starting reliability: (99% starting reliability means that the unit shall start in 99 of 100 attempts)
- b. The BESS availability shall be at least 95% including planned maintenance. The Availability is defined as the BESS power capability compared to its rated Power Capacity, at the Point of Connection (POC) and shall consider downtime due to scheduled and unscheduled maintenance. The Availability of the BESS shall be calculated follows:

$$Availability = (H_{year} - SO - UO) / H_{year}$$

Where

- H_{year} is number of hours within a year (e.g., 8760 hours on a normal year or 8784 hours on a leap year)
- SO= equivalent scheduled outages hours as defined as scheduled outages duration in hours multiplied by power unavailable during outage divided by rated power capacity at Delivery Point. Power defined as an absolute value to account for BESS charge and discharge.
- UO= equivalent unscheduled outages hours as defined as unscheduled outages duration in hours multiplied by power unavailable during outage divided by rated power capacity at Delivery Point.

The BESS Availability shall be shown and recorded in the SCADA system, with changes in Availability level recorded to a time-resolution of 1 second. Availability of the BESS based on projected scheduled outage hours and projected unscheduled outage hours shall be at least equal to or greater than 95% on an annual basis.

4.9.8.2 Warranty.

BESS equipment will be subject to a guarantee covering manufacturing defects for at least 5 years and their replacement during this period, and a performance guarantee ensuring that the BESS will have at least 60% State of Health (SoH) (or equivalent end of life SOH if higher than 60%) and RTE during 15 years at the point of connection. Energy Capacity (or SOH) and RTE parameters will be verified and tested on a yearly basis, in case of shortfall, the contractor shall remedy such shortfall by doing one of the following: (i) Replace previously installed BESS or relevant components, such as inverters, battery modules and BMS; or (ii) If the product is discontinued, and replacement of previously installed BESS with equivalent product is not possible, supplier shall pay liquidated damages. No BESS equipment will be accepted until the contractor presents a performance guarantee for the modules. It is understood that any loss of performance over the first three years will be compensated under contract GCC 28.

4.9.9 Battery Subsystem Design Requirements

a) Electrochemical Cells

- Only cells that are commercially available and available on the open market shall be accepted. For both premature cell failures and end-of-battery-life replacement, the Contractor shall guarantee cell availability. The cells may be supplied as separate, individual units or as a group of cells combined into modules.
- Cell and module design shall accommodate the anticipated vibrations and shocks associated with the transportation of the BESS and shall resist deterioration due to vibrations resulting from the same. Associated hardware and paraphernalia should also be able to withstand the rigors of transportation. The transport plan shall be shared with the Employer and approved prior to dispatch.
- Labelling of the unit batteries/battery packs shall include manufacturer's name, cell type, nameplate rating, and date of manufacture, in fully legible characters and traceable to the point of origin for the purpose of addressing safety issues.

b) Electrochemical Storage System

- The storage system may consist of one or more-unit batteries/battery packs/racks. If the storage system consists of more than one unit battery, these may be electrically interconnected in any desirable series and parallel configuration to achieve the overall system storage and power rating requirements.
- Each electrically series-connected string of unit batteries shall include a means of disconnecting the string from the rest of the system and of providing over-current protection (during a fault). The means of disconnect shall provide for a physical interruption of the string electrical circuit, which shall be visible and accessible to maintenance personnel and shall be capable of being locked or secured in an open position.
- If the disconnect means consists of removal of a unit battery, the storage system shall be designed to allow maintenance personnel to determine that there is no current flowing in the string and provisions to ensure that the PCS is off before the unit battery is removed. Procedures for maintenance and/or field replacement of unit batteries shall neither require nor recommend removal of the unit battery without first ensuring that no current is flowing in the string circuit.
- Protection shall include a DC breaker, fuse, or other current-limiting device on the battery bus. This protection shall be coordinated with the PCS capabilities and battery string protection. The Contractor shall produce a fault analysis and protection coordination study for the battery dc subsystem during final design.
- Cells, wiring, switch gear, and all DC electrical components shall be insulated for the maximum expected voltages plus a suitable factor of safety.
- The BESS shall include appropriate self-protective and self-diagnostic features to protect itself and the battery from damage in the event of BESS component failure or from parameters beyond the BESS's safe operating range due to internal or external causes.

- Temperature sensors shall be incorporated in critical components within the BESS. The BESS shall alarm and go to standby/fault mode when an over-temperature condition is detected.
- Door interlock switches shall be provided for all BESS container doors. The BESS shall alarm and go to shutdown mode when a BESS Container door is opened. Doors shall be fitted with provisions for external locks.
- The battery system shall include a system to detect and alarm excessive ground leakage current levels. Ground fault detection shall be enabled for the container or, if more than one electrical series string is installed in the container, for each series string.
- The battery system shall include a monitoring/alarm system and/or prescribed maintenance procedures to detect abnormal unit battery conditions and notify proper personnel of their occurrence.
- The Battery Management System (BMS) shall have at least the following protection mechanisms for battery:
 - a) Reverse Polarity
 - b) Over/Under Voltage
 - c) Over Temperature
 - d) Over Charge
- Unit battery monitoring, whether automatic or manual, should be specified to alert the proper personnel in a timely manner that an abnormal unit battery condition exists or may exist. All alarms shall be part of the control system and shall include remote display or annunciation capability.
- The unit batteries shall be racked or shall be housed in stackable modules. The unit batteries or cells shall be arranged and installed to permit easy access for equipment and personnel. The moveable units shall be arranged and installed to permit easy access for equipment and personnel to carry out unit removal and replacement activities. For all systems, it shall be possible to remove and replace a prematurely failed unit battery or cell (as appropriate), when system performance specifications cannot be met. The lengths and widths of all aisles and spaces into which personnel may enter in the field for operations and/or routine or unscheduled maintenance purposes, as well as egress routes from these aisles and spaces, shall conform to applicable codes and standards.
- All racks and metallic conductive members of stackable modules shall be grounded to earth. Racks shall meet the seismic load requirements and shall include means to restrain cell movement during seismic events. The Contractor shall furnish analyses and/or other data that show that the rack and cell designs are designed to meet all potential seismic vibration requirements.
- The cells and battery system shall be supplied with all required and/or recommended accessories. This includes inter-cell connectors and monitoring devices for cell temperature and cell voltage if required.

4.9.8 Power Conditioning System Design Requirements

- The PCS shall be bi-directional type, capable of delivering Real power as specified in Table: 17. This rating shall be referred to in all project documentation, including this specification, as the nameplate VA rating. To account for losses in the PCS, the DC input power to the PCS will be higher than the rated PCS output power. The available DC input power will be the BESS nameplate watt rating divided by the PCS full load efficiency (as specified in the datasheet) during discharge.

- The PCS shall include provisions for disconnecting on both its AC and DC terminals for maintenance work. The detailed maintenance procedure shall be addressed in the O&M manual.

4.9.9 BESS Transformer

- BESS Transformer may be dry type or Oil type as per specifications provided elsewhere in this document.

Note: Transformer, LV panel, and GIS for specific Transformers shall be containerized.

4.9.10 AC System

- The BESS AC system shall include all switch gear, cables, connectors, transformers, and protective relaying. The metering arrangement required for connecting the BESS at the PCC shall be in line with codes and standards specified elsewhere in this document.
- **Protection and Control** - The protection system shall be capable of monitoring significant operating parameters and sensing all abnormal operations or fault conditions. It shall isolate the faulted circuits or components without causing damage to other circuits and components of the system. The protection system shall also provide adequate indications and/or alarms for identification of the faulted circuits, components, and abnormal conditions, allowing preventive action and rapid restoration of service.
- Other protections shall not be interlocked with the position of any isolating/interrupting devices.
- The BESS shall include provisions to protect against transient voltage surges from switching, lightning, and similar causes, in accordance with applicable standards.

4.9.11 Auxiliary Power

- The BESS shall include an auxiliary power system (separate or same as the Solar Plant auxiliary system). comprising step-down transformers, breakers, fuses, relaying, panels, enclosures, junction boxes, conduits, raceways, wiring, etc., as required for the BESS operation.
- The auxiliary supply to the BESS shall be metered separately. Meters shall be TVM of 0.2 accuracy.
- Auxiliary System shall provide for whatever emergency power backup is necessary for orderly shutdown during abnormal conditions such as loss of grid power.

4.9.12 Control and Communication

a) Control System General Requirements

- The control system shall be designed to provide for automatic, unattended operation. The control system design shall provide for local manual operation and remote operation or dispatch from a remotely located computer.
- The control system shall be programmable for establishing or adjusting all parameters, set points, algorithms, limits, and so on that are required for effective operation as described in this specification.
- Control Functions and Protocols
- All BESS control communications shall be built over MODBUS TCP/IP communication
- There shall be provision of redundant communication channels.

b) Additional Control System Functions

1. Shutdown/Startup/Standby

- The control system shall ensure orderly and safe shutdown, even in the absence of grid power; an orderly startup sequence, which shall provide for a safe system reset from any standby or operating condition so that the unit goes through a normal startup sequence in the same way it would when being powered up after loss of power or being in a shutdown state, and for a

standby state (that is, BESS but not charging or discharging), which shall be the end result of a normal startup sequence.

2. Initiation of Shutdown

- The control system shall initiate shutdown under the following conditions and shall remain in the shutdown state until a reset signal, either local or remote, is initiated. An appropriate alarm shall be set.
 - a) Emergency trip switch.
 - b) Loss of the low-voltage AC or utility grid voltage.
 - c) An AC circuit breaker trip (either side of transformer).
 - d) Door interlock: Initiate shutdown when the door is opened (with appropriate provision for maintenance work). Interlocks shall be self-resetting.
 - e) Smoke/fire alarm.
 - f) A DC ground fault (adjustable setting)
 - g) Remote disable (no reset required).
 - h) Grid system faults (balanced and unbalanced; line-to-ground, line-to-line, and three-phase).
 - i) Abnormal frequency
 - j) Abnormal voltage
 - k) Islanding condition.
 - l) Communication Failure
 - m) Protection or control scheme failures, including the following:
 - Failure of local interconnection protection system.
 - Failure of critical breaker trip coil.
 - Loss of Container DC control supply.

3. Reset Alarms

- For all system-generated alarms, the control system shall provide for the resetting of those alarms. This function is intended for alarms that, after they are set (for example, by a fault condition, as listed above and elsewhere in this specification), must be cleared by operator intervention to allow normal operation to be restored.

4. Modify Storage Settings

- The control system shall provide for modification of various set points and fixed operation/control settings associated with the various control functions.

5. Event/History Logging

- The control system shall provide for the automatic logging of the following information:
 - n) All errors or failures
 - o) All startup and shutdown actions
 - p) All control actions
 - q) All responses to control actions
 - r) All limit violations, including returns within limits

6. Status Reporting

- The control system shall provide for reading and reporting of various BESS-supplied status information in accordance with the data collection and reporting requirements specified in this technical specification.

7. Time Synchronization

- The control system shall provide for synchronization of its real-time clock with a GPS-synchronized time source.

8. Change Operational Mode

- The control functions are expected to be executed by command from a remote host, but may also be scheduled.

9. Perform Self Diagnostics

- The control system shall provide for self-diagnostic functions.

10. Control System Hardware

- All local control and monitoring system components shall be housed in appropriate controlled environment enclosures either as separate arrangements or in conjunction with the **Solar Plant SCADA system**.
- The BESS shall include, as a minimum, the following operator controls shall be provided in a local Control Panel or built into BESS EMS:
 - a) Trip/reset for the BESS AC circuit breaker or contactor.
 - b) Trip/reset for DC circuit breaker(s)/contactor(s).
 - c) PCS on/off.
 - d) Selector to select remote or local operation.
 - e) Selector to manually set the operating state or have the control system set the operating state automatically.
 - f) Meter readings, indicators, and displays.

11. Performance Monitoring and Data Acquisition

- The BESS shall include a (Data Acquisition System) DAS to provide continuous monitoring and display of key operational parameters, as well as permanent archival of all measured parameters. The DAS shall include sensors, transducers, wiring, signal isolation, and conditioning circuitry, and data acquisition and analysis hardware and software as required to perform the functions described in this section. The DAS shall be suitable for operation in the climatic conditions prevailing at the site.
- The DAS shall measure operational data, as described in this Clause, and shall record all data points to fixed and removable non-volatile memory. The DAS shall be capable of making all monitored data and events available through the DNP3 / IEC 61850 communication interface and shall permit the display of current values and recent historical trends on a local screen for all recorded points. In addition, the DAS shall provide panel meter displays of certain operational parameters, as prescribed below.
- Provision of monitoring and event data via the communication to capture at least the following data points:
 - g) Frequency at the AC bus
 - h) AC real power
 - i) Power factor
 - j) Real energy delivered
 - k) Real energy received
 - l) Auxiliary power
 - m) Auxiliary energy
 - n) DC power
 - o) DC voltage
 - p) DC current
 - q) Phase A voltage

- r) Phase A angle
- s) Phase B voltage
- t) Phase B angle
- u) Phase C voltage
- v) Phase C angle
- w) Battery state of charge
- x) Battery string currents
- y) Battery temperature
- Digital displays of the above shall update at least once per second. The DAS shall be integrated with the Solar PV SCADA described elsewhere in this Technical Specification either as an addendum or within an overall Energy Management System Interface.
- DAS shall continuously measure or calculate the data points and make them available via the communication network as specified. All measured parameters shall also be permanently archived in all modes of operation. For continuously varying quantities, the Contractor shall propose for the Employer's review and approval an approach to data archiving that is suitable for each quantity measured. The final approach will be decided during detailed engineering design.
- The DAS shall provide unsolicited message capability for reporting critical alarms. The Contractor and the Employer will agree on a list of alarms that are reported the instant they are detected. However, a minimum of following parameters shall be displayed on BESS local control panel, console, or SCADA:
 - a) Main temperature Alarm (on system temperature exceeding a predetermined threshold)
 - b) Smoke/fire Alarm (on system detection of smoke/fire)
 - c) DC leakage current (battery leakage current to ground exceeding a predetermined threshold)
 - d) Breaker status (connect/disconnect switch)
 - e) AC voltage OK (system ac voltage exceeding a predetermined threshold)
 - f) Battery temperature alarm (battery temperature exceeding a predetermined threshold)
 - g) Synchronization error shutdown
 - h) PCS fault
 - i) AC system fault
 - j) DC fuse blown
 - k) Container door open (BESS container door opening)
- The BESS shall include provisions for determining and storing in non-volatile memory the sequence of abnormal events, trips, and/or alarms that cause the BESS to go the disconnect or shutdown state.
- It is preferable that this function be implemented separately from the normal operations data acquisition function of the DAS so that failures in the latter (hardware/software failures or power interruptions) will not prevent the permanent logging of abnormal event sequences. The BESS shall include provisions to transmit, at a minimum, the data displayed on the panel meters and the alarm/status indicators to the remote computer.

4.9.13 Grounding

- All exposed non-current-carrying metal parts of the BESS shall be solidly grounded. This system shall be designed to be tied to an existing site grounding system. The system also shall be adequate for the detection and clearing of ground faults. Measures to mitigate galvanic corrosion shall be proposed, as required.

4.9.14 Wiring

- All wiring shall be continuous for each wiring run; splices are not acceptable.
- Wiring that may be exposed to mechanical damage shall be placed in conduit or armoured.

- Wires shall have identifying labels or markings on both ends. The labels or markings shall be permanent and durable. Stick-on labels will not be allowed. All field wiring between separate equipment items supplied by the Contractor shall be color-coded according to appropriate standards.
- In general, and where practicable, control and instrumentation wiring shall be separated from power and high-voltage wiring by use of separate compartments or enclosures or by use of separate wireways and appropriate barrier strips within a common enclosure.
- BESS and PCS control and instrumentation system wiring shall be bundled, laced, and otherwise laid in an orderly manner. Wires shall be of sufficient length to preclude mechanical stress on terminals. Wiring around hinged panels or doors shall be extra flexible and shall include loops to prevent mechanical stress or fatigue on the wires.
- Insulation and jackets shall be flame retardant and self-extinguishing.
- Wiring to terminal blocks shall be arranged as marked on wiring diagrams. Terminal groupings shall be in accordance with external circuit requirements.
- Raceway and cable systems shall not block access to equipment by personnel. There shall be no exposed current-carrying or voltage-bearing parts.

4.9.15 Fire Protection.

- The Contractor shall design and install a fire protection system that conforms to good engineering practice, and NFPA guidelines and considers thermal runaway fire characteristics of the Battery Unit/Packs provided by the OEM.
- The fire protection system design and associated alarms shall take into account that the BESS will be unattended. If required by the type of fire protection system provided, the Contractor shall calculate and consider the heat content of the battery cell materials in designing an appropriate fire protection system. Separate fire protection systems may be used in the battery, PCS, and control areas.

4.9.16 Type Tests (to be submitted as part of the bid in accordance with ITB 11.2(i))

All type testing shall be done at accredited international testing authorities/facilities (e.g. KEMA/TUV/UL). Only type tested and service proven BESS components shall be accepted. Where a BESS design is equipped with component/s that have not been proven for at least two years of service, the affected parts and the extent of the experience shall be declared in the tender / proposal. The type tests shall include (i) The BESS component type test certificates and (ii) entire energy storage system, whereby the individual components are integrated into the system providing overall system functionality shall be provided

4.9.17 Factory Acceptance Tests

The factory acceptance tests (FAT) shall be conducted at the manufacturer's premises and in accordance with GCC23. The tests shall be conducted on each BESS unit/components to verify the manufacturer's declared equipment performance criteria and rectify any defects arising on the equipment prior to shipment. As a minimum, factory acceptance test certificates shall be provided for the following components: (i) Battery modules; (ii) Power Converters; and (iii) Control and Management systems.

Where full-scale testing of larger systems at the factory may be difficult or impossible due to the large system, the FAT shall be carried out at a subsystem or module level and shall consist of tests of 100% of the subsystems or modules that comprise the complete BESS, to the extent possible. In the FAT plan, the Contractor shall clearly state what is being tested and shall fully explain any features or functions of the fully assembled BESS that would not be fully tested in the reduced-scale testing proposed. In such a case, the Site Acceptance Test (SAT) plan shall further describe how the tests that could not be carried out in the factory will instead be carried out at the site.

A completed pre-FAT report incorporating all the pre-fat results shall be provided to Employer at least 4 weeks prior to the commencement of the FAT. The pre-FAT and, FAT procedures shall include as a minimum the following: (i) Proposed FAT; (ii) Testing methodology and set up process; (iii) Tests to be performed and (iv) Test acceptance criteria. The FAT shall only commence once the Employer Project Manager has approved the pre-FAT report and results. The FAT shall include, but is not limited to, the following:

- a) Visual inspection of all equipment provided, including dimensions and overall design.
- b) Verification of proper mechanical construction such as electrical connection torques.
- c) Verification of sensors, metering, and alarms.
- d) Verification of all control functions, including remote control and monitoring, and communications interfaces.
- e) Verification of BESS performance at full and partial power and energy ratings.
- f) Verification of maintenance and replacement features for unit batteries and other key components.
- g) Verification of compliance with specifications.

During the FAT, the BESS shall meet the following:

- a. Be operated and function as specified and designed in all the operating states, use cases, and duty cycles specified herein
- b. Meet the power and energy requirements specified herein
- c. Be demonstrated to meet the safety and response to catastrophic failure requirement specified herein
- d. Have the efficiencies, response capabilities, and other features specified herein and/or proposed by the Contractor

Operation of all control, protective relaying, and instrumentation circuits shall be demonstrated by direct test, if feasible, or by simulating operating states for all parameters that cannot be directly tested. Automatic, local (control console), and remote operation of the controls shall be demonstrated.

Factory testing shall demonstrate operation at expected temperature extremes at the Employer's site. If this is not possible for the full BESS at the manufacturing facility, independent laboratory certification of operation of critical components and subsystems in the battery, PCS, and control systems shall be submitted at the time of the FAT. The Contractor shall submit to the Employer for approval, 90 days before the FAT, a list of components and subsystems for which independent lab testing certification will be sought.

The Contractor shall perform all system modifications required during start-up and testing. The testing may be suspended because of a BESS malfunction and resumed only on rectification of problem items. Such suspension and resumption will occur at the sole discretion of the Employer. The BESS will not be accepted for shipment until all FATs have been successfully completed.

4.9.18 Site Acceptance

The PV modules should be prior to installation and upon arrival at the site of the project be inspected visually for defects. Upon receipt of an item on Site, the Contractor and the Employer shall visually inspect the shipment. All deliveries within the Contract shall be checked and any discrepancies noted and recorded. Lost items shall be replaced. Damaged items shall be replaced, or repaired if permitted by the Employer, to conform to the Specifications. In all cases of irreparable damage, the Contractor shall immediately notify the relevant manufacturer for renewed manufacture and replacement of the damaged part(s). He shall also immediately notify the Employer of the actions he is going to undertake to repair or replace the damaged part(s) and of the consequences this damage will have on the completion date of the plant.

4.9.19 Functionality and Performance Tests.

Performance of the BESS or subsystems shall be conducted to agreed testing methodologies thereby verifying that the declared BESS parameters are in accordance with the technical requirements. Performance tests of the BESS shall conform to (or equivalent or better test standard):

- IEC 62933-2-1: Electrical energy storage (EES) systems – Part 2-1 and
- IEEE Std 2030.3-2016 Standard Test Procedures for Electric Energy Storage Equipment and Systems for Electric Power Systems Applications

The Bidder shall confirm (as part of Guaranteed Technical Particulars) conformance to the below minimum functionality tests. In addition, the bidder shall submit with the Bid, the BESS system performance parameters as detailed in **Appendix 2: BESS Performance Parameters**.

Table 18: BESS Minimum Functionality Tests

Item	Test Description	EC 62933-2-1 Sub-clause	Type Test	FAT	SAT	Periodic Test
1	Environmental Conditions	5.1.2 & 5.1.3	√			
2	Actual energy test	6.2.1	√	√	√	√
3	Input and output power rating test	6.2.2	√	√	√	√
4	Roundtrip efficiency test	6.2.3	√	√	√	√
5	Expected service life test	6.2.4	√			√
6	Dynamic Tests	6.2.5				
6.1	System response test	6.2.5	√			√
6.2	Step response time test	6.2.5	√			√
6.3	Ramp rate test	6.2.5	√			√
7	Auxiliary Power	6.2.6	√			√
8	Self-Discharge ESS system test	6.2.6	√			
9	Rated voltage and frequency test	6.2.8	√	√		
10	Visual Inspection	6.4.1	√		√	√
11	Continuity and validity of the conductors	6.4.2	√		√	
12	Earthing test	6.4.3	√		√	
13	Insulation test	6.4.4	√		√	
14	Protection Device Test	6.4.5	√	√	√	√
15	Equipment and basic function test	6.4.6	√		√	√
16	Grid connection compatibility test	6.4.7	√		√	
16.1	Voltage Immunity Test	6.4.8	√			
17	Available Energy test	6.4.9	√			√
18	EMC immunity test		√			
19	Voltage Unbalance (IEEE 2030)		√			√
20	Unintentional Islanding (IEEE 2030)		√			√

4.9.20. Commissioning and Functional Guarantee Test Procedure- to be conducted in accordance with the contract Clause GCC 24&25

The Contractor shall develop and submit to the Employer for its review and approval a comprehensive SAT plan that shall demonstrate to the Employer that the BESS will perform as specified at the Employer's site. The Employer shall have the right to request reasonable changes to the test plan.

The Contractor shall develop and perform SAT procedures to ensure that the BESS will perform as

designed and that the system meets the performance criteria specified elsewhere in these specifications. The SAT plan shall include procedures to test operating scenarios described in the specification. These procedures may involve special requirements and/or witnessing by the local independent system operator. To the extent achievable, all use cases and operating modes described in the specification shall be tested.

After the Contractor has determined that the BESS is fully operational, the Contractor shall conduct the SAT, witnessed by the Employer and/or the Employer's representative. The tests shall include, as a minimum, the following:

- a. Verification of sensors, metering, and alarms
- b. Verification of all control functions, including automatic, local, and remote control
- c. Verification that the performance criteria in the specification can be met or exceeded
- d. Demonstration of all the intended uses
- e. Demonstration of interface protection circuits and functions and control interfaces.

Tests shall demonstrate that the BESS capabilities, efficiencies, response, and features are as proposed by the Contractor. Testing shall include, as a minimum, measurement of harmonic content and power factor at full and partial power levels for both charge and discharge. Operation of all control, protective relaying, and instrumentation circuits shall be demonstrated by direct test, if feasible, or by simulating operating states for all parameters that cannot be directly tested. Automatic, local, and remote operation shall be demonstrated.

The SAT shall also specifically address discovery of problems or failures that may have occurred during or because of shipment. The Contractor shall perform any required modifications and repairs identified by the testing, before acceptance by the Employer. The Employer will not accept the BESS for commissioning until all acceptance tests have been successfully completed and all provisions of the contract have been met.

Functional Guarantee - Actual Operating Experience. Since it may not be possible, due to system constraints, to test all facets of the BESS function as part of the performance verification tests specified in the preceding sections the actual operating experience of the BESS during the performance guarantee period after initial startup shall be deemed an extension of the performance verification tests. The performance guarantee period shall not be construed as a substitute for the warranty requirements, as specified in the subsequent Clause. Actual operating experience will be documented through Contractor Furnished records, and other system monitoring equipment and associated BESS performance.

Documented failure or malfunctions of any BESS component during the performance guarantee period shall be deemed a failure of the system commissioning test. The Contractor shall, at no cost to the Employer, make the necessary repairs, replacements, modifications, or adjustments to prevent the same failure or malfunction from occurring again. The replacement of certain BESS components in response to a system failure may necessitate, at the discretion of the Employer, the duplication of certain performance verification tests, which shall be performed at the contractor's expense.

5.0 SUPERVISORY CONTROLLED AND DATA ACQUISITION (SCADA)

The Contractor shall provide a complete SCADA system with all accessories, auxiliaries and associated equipment and cables for the safe, efficient and reliable operation and monitoring of entire solar plant and its auxiliary systems.

The Contractor shall provide all the components including, but not limited to, Hardware, Software, Panels, Power Supply, HMI, Laser Printer, Gateway, Networking equipment and associated Cables, firewall, etc. needed for completeness.

SCADA System shall have provisions to perform the following features and/or functions:

- a) Web-enabled Operator Dashboards: Showing key information on Generation, Performance, and Current Status of various equipment in Single Line Diagram (SLD) format with the capability to monitor PV array Zone level (i.e. SCB level) parameters.
- b) Real-time Data Logging with Integrated Analytics & Reporting: Logging of all parameters - AC, DC, Weather, System Run Hours, Equipment Status and Alarms as well as derived/ calculated/ integrated values. The SCADA User interface shall be customizable and enable Report Generation and Graphical Analysis.
- c) Fault and System Diagnostics with time-stamped event logging.
- d) Generate, store, and retrieve user-configurable Sequence of Event (SOE) Reports.
- e) Interface with different field equipment in the plant and work seamlessly with field equipment supplied by different companies.
- f) The Control system shall be designed to operate in non-air-conditioned areas. However, the Contractor shall provide a Package/ Split AC of suitable capacity decided by heat load requirement in the SCADA room at the Main Control Room.

5.1 Architecture

- The SCADA System shall be built over Industrial IoT architecture with integrated Analytics, secure web access, enterprise software, and a Database.
- Data acquisition shall be distributed across MCR and LCRs while plant-level data aggregation shall be done in plant servers. The indicative SCADA Schematic Diagram along with the Indicative I/O List has been attached to this document.
- Analog and Digital IO modules shall have integrated processors for distributed IO processing and control.
- Data communication system shall be built over fiber optic cables/ wireless network with high bandwidth TCP/IP communication (Fast Ethernet or 802.11a/b/g/n) across all Inverter and Control Rooms with Internet/Intranet access at Main Control Room. Firewall shall be provided for network security.
- Plant SCADA Server shall have Industrial Grade server hardware running SCADA & Monitoring Software with data storage (complete plant data) space for 2 years.
- Note: One redundant server shall be provided along with separate SMPS power supply.
- Plant data for monitoring and control operations should be accessible without dependence on external network.
- Operator Workstation/PC shall be of Industrial Grade for browser-based access to plant data from Plant. Plant control & SLDC/Utility related operations shall only be initiated through browser-based interface requiring no client software or database to be installed on the Workstation. All critical software and Plant Data shall be installed/stored on local and remote servers only with user access control for protecting the software and data assets from accidental deletion or corruption.
- Internet/Intranet at Plant: Public or private network access shall be provided at the plant through any broadband/VSAT connectivity of 2Mbps or higher bandwidth. In case no

broadband/VSAT connectivity can be provided at the plant, a 3G/4G data card from any Internet Service Provider (ISP) may be provided.

- GPS-based Time Synchronization System: The SCADA system shall have a Master/Slave Clock system along with an antenna, receiver, cabinet, and internal interconnection cables. All SCADA controllers, servers, OWS, and communicating equipment shall be synchronized to the GPS clock.

A. Industrial IoT Controllers & Data Acquisition

- The Plant SCADA and Monitoring System may use one or more IoT Controllers at each Inverter Control Room and MCR for the purpose of data acquisition and data forwarding to the SCADA Servers. The IoT Controllers shall meet the following minimum requirements:
 - a) The IoT Controllers shall be distributed in nature and work independently of other IoT Controllers or any central controller in the system.
 - b) Shall be capable of supporting a wide range of field protocols to communicate with different field equipment (Modbus over RS485/Ethernet, etc.)
 - c) Shall have local storage for a minimum of 2 weeks (in case of network failure).
- Provide a web-based interface to configure the controller for various equipment in the field.
- IO Functionality: Shall support status monitoring of VCBs & Trip relays on GIS Panel/HT & Transformer panels through distributed DI/AI modules.
- Controls: Shall be capable of Controlling breakers (ON/OFF). Both ON/OFF and Parameter control of inverters shall be supported.
- Data Communication with Servers: Shall send the data collected, from all the equipment at the Inverter Control Room and/or Main Control Room to the Monitoring & Control Server.
- Controllers shall be capable of sending data over Internet connections, and USB data cards.

B. System Spare Capacity

Over and above the equipment and accessories required to meet the fully implemented system as per specification requirements, the Control System shall have spare capacity and necessary hardware/ equipment/ accessories to meet the following requirement for future expansion at the site:

- a) 10 % spare channels in input/output modules fully wired up to cabinets TB.
- b) Wired-in "usable" space for 10% modules in each of the system cabinets for mounting electronic modules wired up to corresponding spare terminals in system cabinets.
- c) Empty slots between individual modules/group of modules, kept for ease in maintenance or for heat dissipation requirement as per standard practice of Contractor shall not be considered as wired-in "usable" space for I/O modules.
- d) Terminal assemblies (if any in the offered system), corresponding to the I/O modules shall be provided for above mentioned 10 % blank space.
- e) Each processor / controller shall have 20% spare functional capacity to implement additional function blocks, over and above implemented logic/ loops. Further, each processor / controller shall have spare capacity to handle minimum 20% additional inputs/ outputs of each type including above specified spare requirements, over and above implemented capacity. Each of the corresponding communication controllers shall also have same spare capacity as that of processor/controller.
- f) The Data communication system shall have the capacity to handle the additions mentioned above.
 - a) Ten (10) percent spare relays of each type and rating mounted and wired in cabinets TB. All contacts of relays shall be terminated in terminal blocks of cabinets.
 - b) The spare capacity as specified above shall be uniformly distributed throughout all cubicles. The system design shall ensure that above mentioned additions shall not require any additional controller/processor/ peripheral drivers in the system delivered at site. Further, these additions shall not deteriorate the system response time/duty cycle, etc. from those stipulated under this specification.

C. Functionalities

- For String inverter configuration, the SCADA system shall enable PV array Zone monitoring i.e. the total current from each String shall be monitored on the DC side of the inverter.
- The SCADA system shall monitor instantaneous and cumulative electrical parameters from all DC& AC Equipment including inverters, weather station, MFM, Transformer and Switchgear (LT & HT Panels) at regular intervals not greater than one minute.
- The SCADA system shall monitor instantaneous and cumulative environment parameters from weather sensors or data loggers at same interval as electrical parameters and provide PR, CUF on the fly.
- The SCADA system shall provide Alarms and Alerts on equipment faults and failure in less than 5 seconds. Alarms on the status change of hardwired DI shall also be provided.
- The SCADA system shall provide configurable alerts on any parameter crossing settable thresholds. The list of such parameters shall be finalized in consultation with the operator.
- The SCADA system shall have a user-friendly browser-based User Interface for secure access from anywhere, for a minimum ten concurrent connections from the Operator PC or other securely connected laptop/mobile, for plant monitoring, O&M, daily reporting, and analysis. A dashboard providing summary details of total plant generation, day's export, irradiance, Inverter Control Room level generation, and performance indicators like PR and CUF.
- Reporting: The SCADA system shall provide downloadable reports in Excel/PDF, configurable for equipment parameters across the plant.
- Data Communication to SLDC/RLDC: The SCADA system shall provide a required interface to integrate with SLDC/RLDC, in compliance with grid code, to send any parameters specified by SLDC/RLDC.
- Power Plant Control: The SCADA system shall provide a required interface to the local SCADA operator to set various power control modes (active/reactive power/frequency/PF) through the inverters over industry standard communication protocols like Modbus over TCP/IP.
- All programming functionalities shall be password-protected to avoid unauthorized modification.
- The Contractor shall provide software locks and passwords to the Employer for all operating & application software. Also, the Contractor shall provide sufficient documentation and program listing so that it is possible for the Employer to carry out modification at a later date.

D. Communication Cable Laying

- All RS485, I/O and CAT6 cables shall be laid in separate conduits with a minimum separation of 1.5ft from AC/DC power cables all along.
- Power cables shall be laid deep in the trenches first. Data cables shall be laid in separate conduits after partially filling the trenches to ensure a minimum 1.5 ft separation between power and communication cables all along the trench.
- I/O Cables between switch gear panels and SCADA panels shall be laid on separate cable trays, with a minimum of 1.5ft separation from trays carrying AC Power cables.
- RS485 & CAT6 cables between switch gear panels or Inverters and SCADA panels shall be laid on separate cable trays, with a minimum of 1.5ft separation from trays carrying AC Power cables.
- Control Cabinets / Panels / Desks at Main Control Room
- The cabinets shall be IP 22, protection class. The Contractor shall ensure that the temperature rise is well within the safe limits for system components even under the worst condition and specification requirements for remote I/O cabinets.
- The cabinets shall be enclosed, free standing type and shall be constructed with minimum 2 mm thick steel plate frame and 1.6 mm thick CRCA steel sheet or as per supplier's standard practice for similar applications.

E. Software Licences

- The Contractor shall provide a software license for all software being used in the Contractor's System. The software licenses shall not be hardware/ machine specific.

F. Hardware at Main Control Room

- The Hardware shall be based on the latest state-of-the-art Workstations and Servers and technology suitable for industrial applications & power plant environments.
- The Local Monitoring & Control Server and the Operating Workstation, to be deployed in the Plant Control Room, shall have the following server hardware and operating system along with accessories

Server Hardware	Hex/Octal Core Xeon, 32GB RAM (expandable to 64 GB RAM), 4 × 2TB SATA hard discs in RAID 5 configuration, 2TB external USB hard disc (for backup), dual power supplies, 2 LAN ports, LCD console, keyboard & mouse. The Server hardware shall be housed in a rugged fan-cooled, and rodent-proof Server Rack.
Operating System	Operating System and Database shall be of enterprise scale (RedHat Linux or equivalent Linux OS, Oracle/MySQL or Windows or equivalent DB), with required AMC for 5 years.
Accessories	1. Monitor: Min 22" LED Flat Monitor with non-interfaced refresh rate min. 75 Hz. 2. Keyboard: ASCII type 3. Pointing Device: Mouse 1. Intelligent UPS (online): Minimum 2-hour battery backup.
Operator Workstation (OWS) – 2 Nos.	
Hardware	i7 CPU running at 3.0 GHz or faster with 8GB RAM, 2TB SSD hard disk, 28" LED monitor, keyboard and mouse, 4 USB ports, LAN port
Operating System	Windows operating system with necessary tools, and anti-virus software.
Accessories	1. UPS of required capacity with 2-hour battery backup. 2. Common for the Operator Workstations: 3. 1. Screen Display Unit: Min 50" LED Flat Monitor with wall mounted arrangement for the display of SCADA screen 1. 2. A4 size monochrome laser printer.
PPC Workstation – 1 No.	
Hardware	i7 CPU running at 3.0 GHz or faster with 8GB RAM, 2 TB SSD hard disk, 28" LED monitor, keyboard and mouse, 4 USB ports, LAN port
Operating System	Windows operating system with necessary tools, anti-virus software.
Accessories	UPS of required capacity with 2-hour battery backup.

Table 22: shows Required details of the Plant Server (2 Nos. - Main & Redundant)

All network components of LAN and Workstations shall be compatible with the LAN, without degrading its performance.

5.2 Power Plant Controller

- Power Plant Controller (PPC) shall be provided with two processors (main processing unit and memories), one for normal operation and one as hot standby. In case of failure of working PPC processor, there shall be an appropriate alarm and simultaneously the hot standby PPC processor shall take over the plant control function automatically. The transfer from main processor to standby processor shall be totally bump less and shall not cause any plant disturbance whatsoever. It shall be possible to keep any of the PPC processors as master and other as standby. The standby processor shall be updated in line with the changes made in working processor.
- SCADA and PPC networks shall be suitably designed, so that PPC shall directly and independently able to control the individual solar inverter. Provisions shall be enabled for the PPC to take voltage and current of POI as a reference to Power Plant Controller for giving command to individual PCUs. Detailed control logic in the PPC shall be finalized during detailed engineering stage. The control logic and setting of the PPC shall be in line with latest CEA (Technical Standards for Connectivity to Grid) and as per RLDC requirement.
- Suitable PQ meters (class-A type) at plant final output for measurement of required electrical parameters (active power, reactive power, power factor, voltage, current, frequency, etc.) shall also be provided for this purpose.
- The PPC shall comply with cyber security guidelines issued by the Central Government, from time to time, and the technical standards for communication systems in Power Sector laid down by the Authority.
- The Contractor shall provide the UPS/ DC Power supply of suitable rating to cater all the load requirements of PPC and its auxiliaries.

6. ENERGY MANAGEMENT SYSTEM

- The Energy Management System (EMS) system shall be a controller-based system along with required accessories and communication links for integrated, real-time monitoring, efficient operation, and control of active power, reactive power as well as voltage at the interconnection point of PV arrays and BESS.
- EMS shall be integrated with the SCADA described above to acquire/monitor real-time data of various equipment of Plant facilities and have in-built logic/programming to monitor, control, and optimize the performance of Plant facilities as per specification. The contractor shall provide a complete EMS system with all accessories, auxiliaries, and associated equipment and cables for the safe, efficient and reliable operation of entire Plant facilities and its auxiliary systems. The contractor shall include in his proposal all the Industrial Grade Hardware, Software, Panels, Power Supply, HMI, Gateway, Networking equipment, and associated Cable, etc. needed for completeness even if the same does not specifically appear in this specification.

7.1 EMS functionality for the BESS Control

The following operation modes of BESS shall be set from the EMS system.

- Automatic mode: This means that a part of the power quantity of the BESS behaves according to the selected operation mode.
- HMI mode or manual mode: in this mode, the operator shall have the possibility to:
 - a) Select the operation point
 - b) Direct control of active and reactive set points of the PCS.
 - c) Command of the balance of plants
- OFF-mode: A BESS is not producing any power. The system is disconnected from the grid.
- STANDBY-mode: the BESS is connected to the grid, but the IGBT's in the PCS system are in an off-state (i.e. open switching) Also, the performance of every application mode will be controlled and adaptable by this system.

- This energy management strategy will be operated by the SCADA in the Main Control Room. Any failure in the process or the control system including instrumentation must be detected and logged. This means that the instrumentation, electronic, and electrical equipment shall include those failure detections.
- A communication with the SCADA system must be possible to receive set points and transmit set points for each application mode. The SCADA shall be able to remotely control the BESS. The EMS should allow the SCADA at least the following:
 - a) Change the operation mode of each BESS independently
 - b) Start/Stop each application mode appointed to a BESS.
 - c) Change the application mode of each BESS (multiple modes can be selected together)
 - d) Select the amount of power dedicated to each selected application mode.
 - e) Specifically, for the following use cases:
 - i. Power ramp rate control.
 - ii. Power Curtailment.
 - iii. Change the set points for the SOC management.
 - iv. Direct control of active and reactive set points of a PCS.
 - v. Adapt the parameters needed for the operation of every application mode.

6.2 EMS functionality for the Plant Control

The EMS shall be able to monitor grid and Plant facility variables and shall be programmable for selecting the optimum operating mode of the whole plant with respect to active and reactive power, grid voltage, grid frequency, etc. Additionally, it shall be able to receive external set points and automatically adapt the Plant Facility behaviour to the new settings.

- The EMS shall perform the following functionality to Control the Plant facilities.
Communication with grid or SCADA
 - (a) Communications with PV Inverters, BESS and other power units
 - (b) Measuring and processing of the electrical magnitudes at EMS (voltage, current, PF)
 - (c) Control capability of PV Inverters, BESS and other power units
 - (d) The EMS shall allow following operation modes for the Plant facilities.
 - (e) Reactive Control (Q Control, setting point of reactive power Q at EMS)
 - (f) Power Factor Control (PF Control, setting point of $\cos(L)$ at EMS)
 - (g) Voltage Control (V closed-loop control, setting point of V at EMS)
 - (h) Voltage Droop (Reactive power vs Voltage programmable curve or droop)
 - (i) Apparent Power Control (S Lim, setting point of S Lim at EMS)
 - (j) Active Power Limitation (P Lim, setting point of P Lim at EMS)
 - (k) Power Ramp Rate Control (setting point of maximum %Pn/min)
 - (l) Frequency Regulation (Power vs Frequency programmable curve or droop)

In addition to these operating modes, the EMS shall be able to work under voltage dips, allowing the inverters to inject the corresponding reactive power to provide the corresponding voltage support at the EMS. The EMS shall be able to receive the target values specified by grid operators using a standard protocol (i.e. Modbus TCP/IP) and over different communication media

6.3 Measurements.

The measurements at the PCC shall include, but not limited to:

- a) Voltage
- b) Current
- c) Output power (Active and Reactive)

6.4 Control & Power Supply Scheme

The Contractor shall provide UPS/ DC Power supply of suitable rating to cater all the load requirements of EMS system and its auxiliaries.

6.5 Software Documentation & Listings

All technical manuals, reference manuals, user's guide etc. in English required for modification/editing/addition/deletion of features in the software of the EMS System shall be furnished. The Contractor shall furnish a comprehensive list of all system/application software documentation after system organization for Employer's review and approval. All The software listings for application software, Project data files etc. shall be submitted by the Contractor. All the EMS Software with license Key shall be provided to the Employer.

7.0 LOW VOLTAGE SWITCHBOARDS

- Switchboards, control, panel boards and cabinets shall be of robust construction, formed of a steel frame and covered with smooth steel plate (outdoor cabinets can be of aluminium). The steel plate shall be properly stiffened to prevent distortion. Panels shall normally be covered at their rear with hinged doors. The frames of the boards shall be designed to permit firm anchoring on the floor. The frames shall permit easy erection, and allowance shall be made for the extension of the board by similar additional panels. Panels for power circuits shall be in accordance IEC 6034 (minimum partly type tested apparatus (PTTA)). All enclosures shall be ventilated so that the temperature inside the enclosure does not rise more than 5C above ambient even with possible heaters connected.
- Outdoor cabinets and cabinets for moist environments shall be provided with thermostat-controlled heaters to inhibit the collection of moisture. The heater must be arranged not to overheat any cables or equipment. Openings for drainage of condense shall be provided at the lowest point in the cabinets.
- All major or important compartments containing electrical equipment shall be provided with a single phase 16 A socket and internal lighting facilities switched off by a door switch.
- Unless otherwise specified or agreed upon, all instruments, apparatus and devices on the panel fronts shall be provided for flush mounting. Flush mounted relays shall be provided with transparent cover. The cover shall be hinged to allow resetting and adjustment. All terminals and all equipment shall be accessible without dismantling other components. Equipment shall not be mounted in swing out doors. However, proper swing out frames may be used provided they can be opened with full load without twisting or distorting the panel. Windows shall be provided in front of rack mounted equipment.
- L.V. Switchboard panels shall be designed, supplied, installed, tested and commissioned by a specialist switchboard manufacturer complete with the automatic change over switches, ACBs, MCCB (Molded case circuit breakers), instruments etc. and all relays, metering and items necessary for the complete installation and setting to work.
- The main /sub L.V. Switchboard shall be of the industrial/enclosed cubicle type, constructed and installed as described below. The main L.V. switchboard, suitable for floor mounting, comprising of a sheet steel cubicle with front access, complete with busbars, incoming switch ACB, MCCB's etc. The switchgear shall be heavy duty, cast metal, enclosed type, dust proof, and capable of operating on load at the rated current. Contacts shall be heavy duty silver surfaced type. The cubicles shall be rigidly constructed and shall be provided with an angle iron or heavy gauge folded steel framework, panelled in zinc anneal or galvalume of not less than 1.6 mm gauge. The doors shall be of similar rigid construction free from twists and warps. The hinges and locks or latches shall be brass, and attached by brass screws. The locks shall be spring types, provided with two keys, and unless otherwise specified, all locks on the one installation shall have identical keys.
- The exposed unpainted metal shall be chrome plated, and removable panels where used, shall be attached by chrome plated captive milled headed brass screws and felt washers. The Contractor should ensure that entry of cables, ducts, and conduits shall be neatly made and head boxes provided as required. All entries and openings shall be vermin-proof. The floor mounted panel shall be erected on a 150 mm raised built-in base treated to be impervious to corrosion by rust.
- All mounting brackets and additional items shall be supplied and installed to suitably support the switchboard in the position in which it is to be erected. In general mounting height to the top shall be 2.0 m. Adequate ventilation shall be provided as necessary, and bronze mesh and suitable trim fitted to prevent entry of insects. Enclosures shall comply with IEC publication

144 IP 32 for indoor equipment and IP 54 for outdoor equipment and be **FORM 3B Fully Type – Tested Assemblies (TTA)** or equal but approved by the Engineer and manufactured in accordance with standards ICE 439-1 or BS 5486. The bus-bars and connections shall be completely screened within the switchboard. Technical brochure. **All MCCB units rated 160A and above shall be adjustable types** and sample test certificates from switchboard manufacturers to be submitted the tender.

7.1 Wiring and Terminal Blocks within Enclosures

- All wiring shall be stranded copper conductor, PVC. Insulated, suitable for operation at voltages below 1000 V, and in compliance with the provisions of the applicable IEC Recommendations. Conductors shall not be smaller than 2.5 mm² for current transformer circuits and 1.5mm² for all other control circuits. The selection of conductor sizes for current transformer circuits shall be supported by calculations.
- For wiring within boards, the "bunch" pattern shall be adopted. For a small number of connections, wiring may be grouped using flexible plastic bands or equivalent. For a large number of connections, a system using support strips or U-shaped troughs (with covers) shall be used. Ample space shall be provided for running of cable within the enclosures.
- The screens or screened pairs of multicore cables shall be earthed in accordance with a coherent earthing philosophy to be worked out by the main Contractor and approved by the Project Manager. The screen and earth wires shall be terminated in terminals dedicated for this use. All free conductors in connecting cables shall be terminated in terminals that shall be temporarily connected to earth and special marked. Though, in field boxes the free conductors can be laid orderly and short-circuited or insulated. The length shall allow future connection.
- Multi-stranded conductor ends shall be fitted with a suitable crimped thimble (bootlace ferrule type). The thimble shall be of correct type and length according to the core size and crimping tools shall be specially adapted to the thimble and cross section used. Each wire shall be separately terminated unless otherwise approved.
- It shall be possible to work on small wiring for maintenance or test purposes without making a switchboard dead.
- The wiring identification shall be by numbered ferrules, sleeves or other approved means.
- All wiring shall terminate at terminal blocks. The latter shall be of the moulded type not less than IP20 and provided with barriers to separate power from control cables. It shall be possible to replace a single terminal block without dismantling a whole row. They shall be clearly marked, the designations being those entered in the respective wiring diagrams. Terminal blocks using screws acting directly on the wire (conductor) as well as spring type terminal blocks are not acceptable. To avoid squeezing of the wire the screw pressure shall be applied by a pressure plate having smooth edges. 'OBA' terminal blocks are not acceptable. Only terminal blocks that are operated using screw drivers are acceptable.
- Terminal blocks for current and voltage transformers shall be separated and specially marked. They shall be equipped with a sliding splice for separation and "banana" sockets on both sides for testing. The splices shall be so arranged that they fall into closed position when loose. Where appropriate, other terminal blocks shall be equipped
- Terminal blocks shall be located at least 300mm from the bottom of the panel and shall be easily accessible. Terminal blocks for different voltages shall not be mixed between one another. All conductors in a multi-core cable shall be terminated on the same terminal block. The blocks shall be grouped for each voltage and they shall be clearly marked for easy identification of the system voltage. There shall be at least 20 % spare terminals on each block. with facilities for testing, such as short-circuiting, separating splices, plugs, etc. All such device shall be accessible even when paralleling strips are used.
- Only one conductor shall be connected to each side of a terminal block and the branch-offs shall be made by interconnecting the necessary number of neighbouring blocks by means of copper strips.

8. CABLES

All cables accessories and materials shall be in accordance with the latest editions (including all amendments) of IEC and ISO recommendations.

All cables shall be suitable for operation:

- a) on a system with direct earthing of the transformer neutral
- b) under maximum load (ONAF conditions) plus 10 % specified for respective transformers
- c) in the climatic conditions prevailing at the site

No joints shall be allowed. Only dry vulcanizing processes shall be used. Special precautions shall be taken to avoid ingress and spreading of moisture and the development of water-treeing. The Tenderers shall document the construction measures used to achieve these requirements.

8.1 Conductors

All conductors shall be stranded copper or Aluminium. The conductor shall be clean, uniform in size, shape, and quality, smooth, and free from scale, splits, sharp edges and other harmful defects. The conductor shall be in accordance with IEC 60228. The conductor shall be filled with swelling powder to stop axial ingress of moisture.

8.2 Cable

The conductor shall be covered with:

- An extruded semi-conducting layer
- A layer of dry vulcanized cross-linked polyethylene (XLPE) insulation
- An extruded strippable semi-conducting layer
- A watertight copper or aluminium seal
- A layer of swelling tape to prevent axial ingress of water along the screen
- A layer of the earthing screen of stranded aluminium or copper
- An outer LDPE (low-density polyethylene) sheath for water tightness and mechanical protection.

A. Laying-up and Fillers of Three Phase Cables

The cores of the three-phase cable shall be laid up together with suitable fillers, wormed circular, and binding tapes applied overall

B. Manufacturer's Identification

The manufacturer's identification shall be provided throughout the length of the cables by means of a tape under the sheath printed with the manufacturer's name. Alternatively, the identification may be embossed on the outer PVC sheet together with identification and voltage markings.

C. Armour

All cables shall be steel wire armoured according to the approved manner

D. Testing

Notwithstanding that cables are manufactured to the approved standards, all cables, accessories, and materials shall be subjected to and withstand satisfactorily the test requirements detailed in this specification. All materials shall withstand such routine tests as are customary in the manufacture

of the cables and accessories included in the Contract. The manufacturer shall have established a quality control system based on regularly accelerated tests of production samples according to CENELEC HD605. Or IEC 60227/8/9/30, 60270,60287

- This system shall be described in the Bid.

E. Current Carrying Capacity and Design Parameters

The maximum continuous current carrying capacity and maximum permissible continuous conductor temperature, and the factors for determining such rating and temperature shall be based on recommendations found in IEC 60287, subsequent amendments, and all conditions prevailing on the Site

F. Terminations

Detailed drawings showing the types of cable sealing ends, and terminal arrangements shall be submitted to the Project Manager for approval. Stress cones or other approved means shall be provided for grading the voltage stress on the core insulation of the cables.

The terminations for the cables shall be of an appropriate heat shrink design incorporating a suitable arrangement for stress control, and rain sheds for outdoor use.

Termination kits shall include suitable heat shrink tubing to effectively shroud, seal and insulate the exposed cable conductor and shall include a heat shrink glove to effectively seal the crutch of the cable to prevent ingress of moisture into the interstices of the cable. Suitable arrangements shall be provided to earth the cable screens and armour.

Terminations into cable boxes shall include brass compression glands and back nuts of the correct size, which shall secure the cable outer sheath and ensure effective continuity between the cable armouring wires and the metal enclosures on which the cables are terminated. At all rising terminations the cable inner sheath shall pass through the gland to terminate not less than 6 mm above the gland.

G. Heat Shrink Materials

Heat-shrinking tubing and moulded parts shall be flexible, flame retardant, Polyofin-based material of electrical insulating quality, and shall be obtained from an approved manufacturer. They shall be suitable for use indoors or outdoors in the conditions prevailing on site

The material shall reduce to a predetermined size and shape when heated above 120 °C. The components shall also be provided with an internal coating of hot melt adhesive compound that shall not flow or exude at temperature below 85 °C. All parts and materials shall be tested to a program of tests to be agreed with the manufacturer.

Each part shall bear the manufacturer's mark, part number and any other necessary marking to ensure correct identification for use on the correct size and type of cable. Each set of parts shall be packed as one unit with full and complete installation instruction and clearly marked to show the application.

H. Installation

The cables will be laid in trenches that will be as straight as possible avoiding sharp bends.

The areas where trenches are to be excavated will be marked clearly on the ground. If the location of other services is known, they will be marked in order to take necessary precautions.

Before construction commences trial pits will be made in order to confirm the soil strata of the planned trenches and to confirm the location of other services.

Safety precautions such as covering the trench, fencing, and warning signs will have to be provided for during the period of work.

When designing the plan for the trench layout, the minimum radius will be as in the following table.

Bending radii	Single core	3-core
Recommended	17xD	15xD
Minimum	15xD	12xD
At sealing ends	12xD	10xD

Table 23: shows required bending diameter

D = cable diameter

I. Cable Marker

- Cable markers shall be installed at the beginning and end of the cable run on the surface all along the route, at all changes of direction, and above all joints, above cable duct entries and exits and at an interval not exceeding 50m along the cable route. This information as well as details about the joint (i.e. joint location) will be also recorded on a map.

J. Excavation of Trenches

- The trench shall be dug vertically to a minimum depth of 600mm or more as required.
- All precautions must be made so as not to cover any services e.g. fire hydrants with soil that may be encountered in the path of the trench.
- During construction on public roads passage and access of motorists and pedestrians to commercial areas must be maintained.
- In order to reduce the cost of reinstatement on roads and pavements the digging shall be done at intervals of 2-3m and a gallery or tunnel dug underneath.
- If trenches are constructed in soggy or inconsistent soil, the cables shall be laid inside a duct as a protective measure and precautions taken to prevent the entry of water at the ends or joints of the ducts
- The bottom of the trench must be made of firm material in order to prevent collapse of the base that may subject the cable to mechanical stress.
- When several cables of different voltages are laid in the same trench they shall be placed at different depths. The cables of the higher voltage shall be placed deepest.
- Where the trench is too deep as to cause instability to the walls of the trench shoring shall be placed to provide lateral support to the trench walls.
- The separation between two groups of cables shall be a minimum of 250mm. If this separation cannot be attained, they shall be laid in ducts or shall be separated by a layer of bricks.

K. Joint Holes

- Where cable joints are required to be made in the course of a cable run, a joint hole shall be excavated of sufficient size to enable the cable jointer to work efficiently and unimpeded.

L. Backfilling of Trenches

- Once the cable has been laid the trenches must be back filled to an adequate compaction level. Care must be taken to ensure that the first layer covering the cables shall be free of rocks or any sharp mechanical objects.
- The backfill shall be laid in layers of 150mm, which should be compressed and watered, if necessary, in order to make the soil sufficiently compact.

M. Pavement Reinstating

- The pavement shall be reinstated back to the standard of the original pavement. New materials shall generally be used in accordance with Municipal regulations.

N. Ducts.

Road crossings, when necessary, shall be done with ducts in the following manner

- they shall be installed in a level position and concreted where possible to provide mechanical protection throughout its length, they shall have a depth of 1.2m.
- future expansion shall be provided by providing one or several spare ducts depending on the location of the crossing.
- at all times the cables should be adequately protected.
- road and railway crossings must be planned in full detail.
- drainage of the trenches must be provided for during and after construction.
- In crossings with other normal underground services, a prudent distance shall be maintained in view of future excavations, and when there is a possibility of service interference, as is the case of other electric cables, wastewater sewers etc.
- The ducts shall be fabricated from PVC or concrete with a smooth interior surface and an interior diameter of not less than 2 times the diameter of the cable to be housed inside it, and in no case shall this diameter be less than 150mm.
- The joints of ducts shall be sealed with cement, in which case the bottom of the trench must be carefully levelled after setting down a layer of fine sand or red soil in order to permit continuous joints.
- The ducts shall be laid in such a manner that there is no abrasion between the insulation of the cable and the surface of the duct.
- In the cases of single core cables, the cable shall have to be anchored to prevent movement due to magnetic effects by concreting the ducts at the ends of the joints. This shall not apply to three core cables.
- When constructing a duct, a length of wire shall be left inside to facilitate the fitting of cleaning elements as well as the cables themselves.
- The cleaning shall consist of passing inside a cylinder in order to remove concrete that shall pass through the joints and later passing a broom or a rag to remove the residue.

O. Direct Burial

For armoured cables, the following criteria for burial shall be met:

- the trench must have a 150mm layer of fine sand upon which the cable shall be laid to protect the cable from mechanical damage due to sharp objects. On top of the cable, another 150mm of fine sand shall be laid. Both layers shall cover the entire width of the trench.
- the sand should be well-graded
- any materials used for backfilling the trench must meet the approval of the Construction Supervisor in charge.
- the cables must be buried at a depth of not less than 600mm. Exceptions could be made for rocky areas where the minimum depth cannot be attained in this case the cable shall be laid in a duct.
- Cables must be protected with a layer of protecting slabs, which shall also indicate their presence.
- For armoured cables the excavated materials without mechanically sharp objects shall be adequate to backfill the trench.
- Cables shall not be buried in areas within the substation boundaries. Necessary cable trenches shall be prepared instead to the satisfaction of the client's Project Manager.

P. Galleries

- When the number of cables justifies the use, they shall be laid in galleries.
- The cables shall be fixed to the cable trays by means of brackets or clamps.
- All metallic elements shall be earthed with independent connectors if there are circuits of different voltages.
- Electric cables shall not be installed where there are inflammable materials.

Q. Parallel Separation

Low Voltage Cables

Medium Voltage cables may be laid parallel to Low voltage cables as long as there is always a minimum distance of 250 mm between them. When this distance cannot be attained, a solid brick wall shall separate them, or they shall be placed in ducts.

Medium Voltage Cables

The distance to be maintained in the case of parallel situations of underground Medium Voltage lines is 250mm. If this distance cannot be achieved a protective brick wall shall be installed between them, or one of them shall be installed within ducts.

R. Telecommunication Cables

In the case of parallel laying of subterranean electric cables and telecommunications wires, they must be as far as possible from each other. As long as the cables both electric and telecommunications are buried, a minimum separation of 2 meters must be maintained at all times. This distance could be reduced further to 250mm between ducts.

- The clearances must be in accordance with the common practice of separation.

S. Steam etc.

In parallel layouts between power cables and buried water pipes a minimum distance of 0.5m shall be maintained in a horizontal projection. If these clearances cannot be maintained the cables shall be laid in ducts.

T. Oil Pipelines

The minimum distance between the cables and the oil pipelines shall be 0.5 m. The cable shall be protected from any gas leaks.

U. Sewers

In parallel layouts of electric cables with sewerage conduits, a minimum distance of 0.5 m shall be maintained, and the cables shall be adequately protected if this distance cannot be maintained.

V. Fuel Storage Tanks

There shall be a minimum distance of 1.20 meters between cables and fuel storage tanks, apart from providing adequate protection for the electric cables.

W. Foundations of Other Services

When there are structural supports for public transport, suspended telecommunication wires, street lighting, the electric cables shall be laid at a distance of at least 500mm from the outer extremities of the supports or foundations of the structures. This minimum distance shall further be increased to 1.5m if the support or foundation is subject to continuous stress towards the curb sides.

If this separation cannot be maintained a resistant mechanical safety measure must be used throughout the length of the support and its foundation, extending to a length of 500mm, on both sides of outer extremes.

X. Crossing of Roads

When crossing streets and roads cables shall be laid at depths of at least 1.2m. The ducts must be durable and mechanically strong and must have a minimum diameter of 150mm in order to permit the easy passage of the cables within the tubes. Spare ducts must be provided where necessary.

Y. Crossing Other Services

Low Voltage Cables

When medium voltage cables cross low voltage cables, a minimum distance of 250mm must be kept between them. If this cannot be achieved, medium voltage and low voltage cables must be separated by pipes, conduits, or solid brick divisor walls.

Medium Voltage Cables

When crossing other medium voltage cables, the minimum distance to be observed between them is 250mm. If this distance cannot be maintained solid bricks must be laid between them.

Z. Telecommunication Wires

When crossing telecommunication wires, the electric cables must be situated within conduits of appropriate mechanical resistance, maintaining a minimum distance of at least 250mm, between the outer sides.

The electric cable must be protected in PVC or concrete duct and in such a way that it guarantees that the distance between the cables is greater than the minimum established for parallel layouts.

The crossing must be at least 1m from a junction box for telecommunications wires and joints for electric cables shall not be installed next to crossings of telecommunications cables.

AA. Water Steam etc.

There should never be a water pipe joint over the cable. A water pipe joint must be at least 2.0 m from a crossing.

BB. Gas

The minimum distance in crossings with gas pipelines shall be of 250mm. The crossing shall not be made over gas pipelines joints.

CC. Sewers

In crossing sewage pipes, it is recommended that the electric cable should be above the sewer line where possible.

DD. Fuel Depots

Electric cable crossings over fuel deposits shall be avoided at all times, the electric cables must be laid bordering the fuel tanks, maintaining a minimum distance of 1.2 meters.

EE. Transporting Cable Drums

Loading and unloading from trucks or appropriate trailers shall always be made through an adequate bar that passes through the center of the cable drum.

- The cable drums shall always be transported upright and never on its side.
- When several cable drums are transported together, they must be aligned back-to-back and have stopping blocks to prevent movement.
- The stoppers should be uniform so that they do not pierce the cable insulation. The stoppers should span the whole length of the cable drum.
- An alternative to stoppers may be to have wooden pieces nailed to the platform supporting cable drums. The stoppers shall be placed at the reels of the cable drums.
- The cable drum must not be tied down with ropes, cables or chains. Upon off loading the cable drum the roll must not drop down from the truck or trailer, a provisional ramp with an inclination of not more than 1/4 shall instead be constructed in the case where there are no pulleys for lifting the drum. The roll can be rolled off the ramp by means of guide ropes. Sand can be placed at the bottom of the ramp to act as shock absorber and brake for the cable drum.
- When rolling the drum on the ground the rotational direction must be observed so that the cable does not come loose.
- When the drum is rolled care must be taken to ensure that the drum is not rolled on rough ground. Care must also be taken to ensure the reel is not broken because the splinters can puncture the cable.
- Where possible the cable drums should not be exposed to the elements.

FF. Laying of the Cable

- The cable drum shall be installed on the site in such a way that the cable is reeled out of the top part of the drum and is not forced when the cable is laid.
- During cable laying the drum shall always be supported by means of a mechanical jack and a bar of the appropriate strength.
- The base of the jacks shall be sufficiently large as to ensure stability during operation.
- When taking off the wood stoppers care must ensure that the material used in nailing them does no damage to the cable.
- The cables must always be unrolled and laid with the greatest care to avoid torsion or kinks and always maintain the correct bending radius of the cables
- When the cables are being laid the workers must be distributed uniformly along the trench.
- The cables should also be laid using cable rollers.

GG. Mechanical Protection

- Underground electric lines must be protected against possible breakdowns caused by landslides, contact with hard bodies, and clashing of metal tools. For this purpose, a protective layer of Hatari slabs of class 15 concrete shall be placed.

HH. Warning Signs

- All cables must have a protection slab placed over the cables buried at least 200 mm above the cable layer. When the cables or groups of cables of different voltages are placed in vertical layers the protection slab must be placed over each layer.

II. Identification

- The cables must bear marks indicating the year of manufacture, manufacturer's name, and cable characteristics (size and voltage level).
-

9.0 LIGHTNING & EARTHING PROTECTION SYSTEM

IEC 62561 Series (Part 1,2 &7) (Chemical earthing)	IEC 62561-1 Lightning Protection System Components (LPSC) -Part 1: Requirements for connection components
	IEC 62561-2 Lightning Protection System Components (LPSC) - Part 2: Requirements for conductors and earth electrodes
	IEC 62561-7 Lightning Protection System Components (LPSC) - Part 7: Requirements for earthing enhancing compounds
NFC17-102	E S E lightning conductor/arrester
IEC 99-4 Part.4	Surge arresters without gap for AC system.
IEC 61643-11:2011	Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems – Requirements and test methods
IEEE 80	IEEE Guide for Safety in AC Substation Grounding
IEEE142	IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems

Table 30: Shows Codes and Standards for Earthing & Lightning Protection Systems

a) General Requirements

- Earthing system shall be designed based on system fault current and soil resistivity value obtained from the geo-technical investigation report. Earth grid shall be formed consisting of a number of earth electrodes sufficient enough to dissipate the system fault current interconnected by earthing conductors.
- The earth electrode shall be made of a high tensile low carbon steel rod, molecularly bonded by high conductivity copper on the outer surface with coating thickness not less than 250 microns as per relevant standards. Suitable earth enhancing material shall be filled around the electrode to lower the resistance to earth. Inspection chamber and lid shall be provided as per standards. For Plant Pooling Substation earthing, mild steel rod may be used as earth electrode.
- Earth conductors shall be made of copper bonded steel or galvanized steel of sufficient cross section to carry the fault current and withstand corrosion.
- Earth conductors buried in ground shall be laid minimum 600 mm below ground level unless otherwise indicated in the drawing. Back filling material to be placed over buried conductors shall be free from stones and harmful mixtures.
- Earth electrodes shall not be situated within 1.5m from any building whose installation system is being earthed. Minimum distance between earth electrodes shall be two times the driven depth of the electrode.
- Transformer yard and switchyard fence shall be connected to the earth grid by one GS flat and gates by flexible lead to the earthed post.
- All welded connections shall be made by electric arc welding. For rust protection, the welds should be treated with red lead compound and afterwards thickly coated with bitumen compound.

- Earthing system network / earth mat shall be of interconnected mesh as per requirements/specifications. The earth conductors shall be free from pitting, laminations, rust, scale and other electrical or mechanical defects.
- The metallic frame of all electrical equipment shall be earthed by two separate and distinct connections to the earthing system, each of 100% capacity, with the exception of solar panels, for which alternate means of code-compliant earthing shall be admissible if integrated with racking design.
- Metallic sheaths/screens and armour of multi-core cables shall be earthed at both ends. Metallic sheaths and armour of single-core cables shall be earthed at the switchgear end only unless otherwise approved.
- Each continuous laid length of cable tray shall be earthed at a minimum of two places to the earthing system, the distance between earthing points shall not exceed 30 meters. Wherever earth mat is not available, necessary connections shall be made by driving an earth electrode in the ground.
- Neutral connections and metallic conduits/pipes shall not be used for the equipment earthing.
- Lightning protection system down conductors shall be terminated to separate earth electrodes & not be connected to other earthing conductors.
- Connections between earth leads and equipment shall normally be of bolted type. Contact surfaces shall be thoroughly cleaned before connections. Equipment bolted connections after being tested and checked shall be painted with anti-corrosive paint/compound.
- Back filling material to be placed over buried conductors shall be free from stones and harmful mixtures. Back filling shall be placed in layers of 150 mm.
- Earth pit shall be constructed as per IEC standard specified in Table xx. Minimum spacing between electrodes shall be 2000 mm. Earth pits shall be treated with salt and charcoal/chemical Powder Earthing.
- Earth resistance at earth terminations shall be measured and recorded. All equipment required for testing shall be furnished by successful bidder.
- Each array structure of the PV plant yard/shed shall be grounded properly as per standard. The Array Structure is to be connected to earth pits as per standards. Junction boxes shall be connected to the main earthing conductor/electrode.
- The arrays shall be in protected zone of lightning arrester/spheres by installation of suitable lightning surge diverters/arrestors. The earth electrodes for the same shall have to be completely separate from the plant/array earthing.
- All metal casing/shielding of the plant shall be thoroughly grounded in accordance with applicable electricity act/rules/guidelines. Total earthing system installation shall be in strict accordance with the latest editions of Electricity Rules, relevant Standards and code of practices and the local statutory authority regulations.
- Necessary test point provision shall be made for bolted isolating joints of each earthing pit for periodic checking of earth resistance.
- All non-current-carrying metal parts shall be earthed with two separate and distinct earth continuity conductors to an efficient earth electrode.

9.1 Earthing of PV array field

- All PV Modules, Module Mounting Structures (MMS) and String Combiner Box (SCB) structures in the PV array field shall be bonded to the earthing system by two distinct connections.

- Earthing of PV Modules shall be as per the requirements of the PV Module Manufacturer.
- The connection between MMS and DC earth grid shall be bolted or welded. Portion of the MMS which undergoes welding at site shall be coated with two coats of cold galvanising and anti-corrosion paint afterwards.
- Earth electrodes of the DC earth grid shall be uniformly distributed throughout the PV array field so that optimum earth resistance is offered to leakage current flowing from any module frame or MMS.
- SCB equipment earthing point shall be connected to the DC earth grid using flexible copper cable of sufficient cross section as recommended by the manufacturer.
- The connection with the DC earth grid shall be done using suitable bimetallic lugs and stainless-steel fasteners.

9.2 PCU Earthing

- Grounding on DC side of the PCU shall be as per the requirements of PV Module Manufacturer. PCU earth bus shall be connected to earth electrodes through flexible copper cable of sufficient cross section as mentioned by PCU manufacturer.
- The interconnection of PCU earth electrodes with DC earth grid shall be as per PCU manufacturer recommendation.

9.3 Transformer Earthing

- Inverter transformer neutral earthing shall be as per the recommendation of inverter manufacturer.
- Transformer tank, cable box, marshalling box and all other body earth points shall be earthed.
- Inverter transformer shield shall be earthed separately using minimum two no. of earth electrodes. Earthing conductor between shield bushing and earth electrodes shall be copper flat of suitable size not less than 25 x 6 mm.
- Neutral and body of the auxiliary transformer shall be earthed.

9.4 Inverter Room and Main Control Room Earthing

- Metallic enclosure of all electrical equipment inside the inverter room and main control room shall be connected to the earth grid by two separate and distinct connections.
- Cable racks and trays shall be connected to the earth grid at minimum two places using galvanized steel flat.
- SCADA and other related electronic devices shall be earthed separately using a minimum two no. of earth electrodes.

9.5 Switchyard Earthing

- The metallic framework of all switchyard equipment and support structures shall be connected to the earth grid by means of two separate and distinct connections.
- Switchyard shall be shielded against direct lightning stroke by provision of overhead shield wire or earth wire or spikes(masts).

9.6 Earthing Design and Layout

- The successful bidder shall submit the Design along with drawings showing the location of lightning arresters and protection zones to cover all arrays against lightning for approval from the Employer.
- The earth mesh system design shall be submitted for approval of the Employer.

- Total plant earthing system shall be designed to give an earth resistance of less than 1 ohm all along the earth mesh.
- Earthing conductors in outdoor areas shall be buried 1.5 to 2M below the finished graded level and these buried conductors shall be brought 500 mm above ground level for making tap connections to the equipment.
- All the electrodes shall be as per standards/specifications.

9.7 Lightning & Over Voltage Protection

- The PV power plant and associated substation shall be provided with lightning and over-voltage protection connected to proper earth pits. Earthing pits shall be measured to have an earthing resistance of 1Ω or less at the time of installation. If this level cannot be obtained with the soil at the facility, then soil conditioning (engineered backfill) shall be implemented to improve the earthing resistance within acceptable levels.
- Lightning mast/conductor, placed at strategic locations, shall be used to protect the arrays against lightning protection. The bidder shall give a detailed design showing the location of the lightning conductor/masts and the protection coverage on the array without causing any shadow on the modules to the Employer.
- All designs shall be submitted to the Employer before its implementation.
- Necessary concrete foundation for holding the lightning conductor in position to be made after giving due consideration to maximum wind speed and maintenance requirements at the site in the future.
- The lightning conductor shall be earthed through Galvanized Iron (GI) flat strips and connected to earth pits per applicable International Standards. Each lightning conductor shall be fitted with an individual earth pit as per required Standards including accessories.
- Design calculations, technical specifications, and requisite test reports of lightning mast conforming to international standards along with a detailed write-up in 4 sets shall be provided for approval to the Employer.

9.8 Lightning Protection System for Plant Pooling Substation

- Direct Stroke Lightning Protection (DSLP) for Plant Pooling Substation shall be provided by Lightning Mast and Shield Wires.
- The lightning protection system shall not be in direct contact with underground metallic service ducts and cables.
- Down conductors shall not be connected to other conductors above ground level. Down conductors shall be cleated on the structures at 2000 mm interval.
- Every down conductor shall be provided with a test joint at about 1000 mm above ground level. The test joint shall be directly connected to the earthing system.

10 CIVIL AND STRUCTURAL WORKS

10.1 TYPES OF WORKS

The following facilities shall be provided by the Employer:

- a) Water harvesting and Storage.
- b) Perimeter fence, solar field barricade fence, gate, guard house with the provision of a storeroom, CCTV system, perimeter lighting, plant area lighting, and building security lighting.
- c) Office building (for Employer's Staff) containerized technology fitted with furniture (cabinets, chairs and office table) to accommodate 5-7 operators.
- d) VIP Pit latrine.

The civil and structural works to be constructed under this Contract include the following: -Work for access and Power plant internal roads. The contractor shall be responsible for designs of all the civil and structural components and implementation of approved designs for the civil-related works that falls within its scope. Detailed Geotechnical investigation and Topographical survey at required locations for the purposes of foundation design will be done. The required locations for the geotechnical survey shall be agreed with the employer. The details of beacons and benchmarks shall be provided in the topographical drawings.

- Earthworks for Power plant platform and associated works.
- 100mm layer of ballast aggregates to solar field platform.
- Stormwater drainage.
- Concrete foundation bases and Mounting works.
- Plinth foundation for various equipment
- Cable network and conduits.
- Lightning protection system.
- Fire protection system. (Fire extinguishers, fire detection and fire suppression)
- Any other works necessary for full completeness of SPGP.

10.2 Sequence of Construction

- The Contractor must complete all the civil and structural works in time to provide a clean and complete site for the mechanical and electrical erection.
- The Contractor shall be responsible for timely delivery of materials to site and for compliance with the specified or agreed construction Programme.
- The office building, control room, guard house and pit latrine shall be constructed away from the solar field to avoid shading effect by the Beneficiary.

10.3 Drawings

- Any Drawings issued with these documents are for tendering purposes only. Drawings for this project shall be made by the Contractor or his civil consultant and shall be to the approval of the Employer.

10.4 Plan of Operations and Temporary Works

- The Contractor shall, submit to the Employer a fully detailed programme showing the order of procedure and method by which he proposes to carry out the construction and completion of the Civil Engineering works, and particulars of the organization and staff proposed to direct

and administer the performance of the Works.

- The information to be supplied to the Employer shall include Drawings showing the general arrangements of his temporary offices, camps, storage sheds, buildings and access roads, and details of Constructional Plant and Temporary Works proposed.

A. Water Supply

- The Contractor shall make his own arrangements for the supply of palatable water for his staff on site and water for construction works and all the mini-grids water needs for including soft water for regular cleaning of solar panels as per specifications.
- The Contractor shall obtain the Employer's or the Project managers prior approval before utilizing any water source for the Works.
- The quality of water shall be safe for drinking and washing of panels and should be tested to meet the requirements. Important to Note is that, washing of solar panels does not require salty water and also the quality of drinking water should be within acceptable standards as guided by relevant authorities, otherwise it should be treated and purified if it does not meet the threshold. Storage tanks and distribution tanks shall be provided, with one 10,000 liters water tank and one 5000 liters water tank for water harvesting, both grounds mounted to supply water in the mini-grids.
- The cleaning of the panels shall be done using soft water or any other suitable alternative method subject to employers' approval.
- The Contractor must make all arrangements to abstract water and must pay royalty to the owners. These costs shall be included in his prices.

10.5 Employer's Approval of Finished Works

- The Contractor shall obtain the approval of the Employer for each section and each stage of construction. The Contractor shall not proceed with any subsequent stage, until all tests required by the Employer have been carried out, and the results have shown that the section complies with the Specification. Any works rejected by the Employer as not complying with the Specification and quality standards, shall be replaced by the Contractor at his own expense.

10.6 Basic Survey and Setting Out

- The Contractor will survey the sites in detail, and the exact locations shall be agreed with the Employer.
- The details of beacons and benchmarks shall be provided in the topographical drawing.
- The Works shall be located on the drawings and the Contractor shall appoint a suitably qualified Surveyor to set out the Works from the beacons and shall plot cross sections at 20 m intervals and submit to the Employer for approval.
- No separate payment will be made for any work in connection with the setting out of the Works, nor any other Works required by the Contractor to ensure the accurate location and construction of the Works.

10.7 Earthworks

- Earthworks shall be under the contractors' scope and considered fully priced by the contractor. The turnkey contractor is responsible for making the site ready by clearing of bushes, removal of trees (if required), leveling of ground (wherever required) etc. for commencing the SPGP.
- The contractor is also responsible for any necessary earthworks (cut and fill) to modify the site to suitable profiles. Slope protection and landscaping shall also be carried out on any areas with steep Cuts or fills.

- All earthworks up to formation shall be formed and completed to the correct lines, slopes, widths and levels shown on the Drawings and with the sub grade parallel to and at the correct depth below the profile, camber, cross fall or super elevation shown for the finished level, unless otherwise directed by the Employer.
- Embankments and fills shall be constructed only of suitable material obtained from the excavation of cuttings. If the Contractor encounters material which he considers unsuitable for earthworks, then he shall forthwith inform the Employer, who shall instruct the method of use or disposal of such material. If insufficient material can be obtained from the cuttings, additional material may be borrowed from approved borrow pits.
- The Employer may direct that certain soils be excluded from certain layers and other soils set apart or obtained from borrow and used only for these layers, in which case the Contractor shall comply with the Employer's or the Employer's directions and shall allow in his price for such selection 83. of materials.
- Where, in the opinion of the Employer, unsuitable material occurs in cuttings, the Contractor shall excavate it to the depths and widths specified in the Geotechnical report and replace it with selected fill material to form an improved formation.

10.8 Order of Work

- The construction of cuttings, side drains and embankments shall proceed in a methodical and orderly manner. It shall be solely the Contractor's responsibility to arrange his methods and programme of work so as to ensure that the earthworks are carried out by the most efficient and economical method possible with the type of plant employed on the Works.
- All trimming of cuttings and embankments, drains and shoulders to the specified slopes and shapes, shall be carried out concurrently with the earthworks that are being carried out at that particular site and level.

10.9 Fill Material

- "Fill-material" shall mean material deposited in accordance with these specifications from any of the classes specified in order to build up an earthworks construction to formation level as shown on the Drawings or as ordered by the Employer. The Contractor shall obtain the fill material from a source approved by the Employer.
- After doing the necessary earthworks (cut and fill) to modify the SPGP site to suitable approved design profiles, the contractor shall fill the finished ground level (FGL) of the solar field with Murram and compact to the designed FGL formation. In addition to the murram layer at the solar field, a ballast surfacing of minimum thickness of 100mm will be done.
- Fill materials will generally be obtained from cuttings. If the material obtained from this source is insufficient or unsuitable, extra material shall be obtained from borrow areas. All fill material (other than rock fill in lower layers) shall pass 75mm BS sieve size.
- The aggregates for the solar field ballast surfacing will be **obtained from the nearest quarry, subject to employer's approval.**
- The following materials are generally unsuitable for construction of fills.
 - i. All materials containing more than 5% by weight of organic matter (such as top soil, materials from swamps, plants and vegetable matter)
 - ii. **All expansive soils such as black cotton soils with swells of more than 3% as measured in the CBR test.**
 - iii. **All clay soils with plasticity index exceeding 50.**
 - iv. **All materials having a moisture content of 105% of the optimum moisture content (standard compaction)**
- Rock fill can be used provided that boulders greater than 0.2 M3 in volume or 600 mm in size

- are not used and that this material is not placed within the top 600 mm to formation level.
- The best materials from cuttings or borrow areas should be reserved for the upper layers of the fill.

10.10 . Compaction of fill

- Embankments and fills shall be laid out and compacted to achieve a stable platform with sufficient bearing capacity and stability.
- Materials other than rock fill shall be placed in layers of compacted thickness not exceeding 300 mm. thicker layers can only be permitted where very heavy compacting equipment is available and trial sections have proved that the required compaction will be readily achieved over the layer depth. The minimum layer thickness shall be twice the maximum particle size of the compacted material.
- Fill material shall be compacted throughout to a dry density of at least 95% MDD at OMC (standard Compaction AASHTOT99) except the top 300 mm of the fill which shall be compacted to 100% MDD (AASHTO T99).
- Where rock fill is used it should be placed in the bottom of the embankment. The largest sizes shall be placed in layers of 1.0 meter thick. The interstices shall then be filled with smaller rocks and approved filler material. The whole layer shall then be compacted until the interstices are completely filled or until the required settlement is obtained. Heavy vibratory rollers are generally the most suitable machines for compacting rock fill.
- The specified compaction shall be achieved over the full width of the embankment.
- Any area inaccessible to the roller shall be consolidated and compacted using approved mechanical tampers.

10.11 Compaction of in situ Sub grades

- After removing the top soil and/or 600 mm of unsuitable /expansive soils or as directed in the geotechnical report and before placing fill, improved sub grade or gravel wearing course, the upper 300 mm of in situ sub grade will be compacted to 100% MDD standard compaction. Compaction in cuts without improved sub grade will likewise be compacted to 100% MDD standard compaction.

10.12 Spoil Material

- "Spoil-material" shall mean material excavated in accordance with these specifications from any of the classes specified, and which, being obtained from the excavation of side drains, cuttings or below the road, embankment is unsuitable for the requirements of the Works. Spoil material shall be removed from the Site to a spoil tip which should be to an approved site acceptable by respective authorities.

10.13 Expansive Material

- When expansive material is encountered, it shall be removed to a depth 600 mm below the formation or the existing ground level, whichever is greater. Material removed shall be stockpiled for later use in slope protection or spoiled to a tip as instructed by the Employer.

10.14 Surplus Material

- "Surplus-material" shall mean material excavated in accordance with these specifications from any of the classes specified and which is temporarily surplus to the fill requirements and shall be carted to a designated stockpile for re-use later elsewhere in the Works, or to an approved spoil tip.

10.15 Excavation in "Rock"

Excavation Level

- Unless otherwise directed, the formation of the platform can be founded on rock. However, rock shall be excavated to an average level 150 mm below the formation and in no place less than 100 mm below the formation.

Backfilling for Surfaces

- Any excess excavation in rock below the formation shall be backfilled and compacted. Excess excavation in the invert of drains shall not be backfilled, but the rock surfaces shall be trimmed, and all loose particles removed, to allow free drainage of water.

Excess Excavation of Slopes

- Where side slopes are over-excavated, no backfilling will be required but the slopes shall be trimmed to a neat shape and safe angle as is acceptable to the Employer. The sloping sides of all cuttings shall be cleared of all rock fragments, which move when prized with a crowbar.

Hard Material

- The provisions of this Clause do not apply to hard and common materials, which materials shall be excavated to the lines and levels shown on the Drawings or as instructed, within the permitted tolerances.

10.16 Drainage of Earthworks

- All cuttings, embankments and borrow pits shall be kept free of standing water and drained during the whole of the construction.
- Should water accumulate on any part of the earthworks, either during construction or after construction, until the end of the maintenance period, giving rise to soaking or eroding conditions in the earthworks, the Employer may order the Contractor to remove and replace at the Contractor's expense any material which has been so affected.
- All drains shall be maintained throughout the Contract in proper working order.
- The Contractor must allow in his price for draining the earthworks satisfactorily at all stages during the construction and arrange his methods and order of working accordingly.
- The entire platform shall be adequately drained and all buildings; control room and office should be well drained.

10.17 Removal of Top Soil

- The top soil within the areas of the development of SPGP shall be stripped to an approximate depth of 200 mm and stockpiled at locations agreed with the Employer for later use on embankment slopes or dumbered in approved areas.
- Overburden in the borrow pit shall also be stripped to a depth specified by the Employer and stockpiled for later use in rehabilitation.

10.18 Access and Internal Road

- Suitable approach road and internal access road in the plant area within the complex boundary of SPGP as per approved design shall be made to ensure safe and easy transportation of equipment and material.
- Where necessary access roads to the SPGP sites shall be constructed to gravelling / murrum standard. In general, for gravel access, gravel wearing course materials should comply with the following:

- They should have sufficient cohesion to bind the particles together and prevent the surface from raveling and becoming corrugated in the dry season.
- The number of fines and plasticity should be limited so as to avoid the occurrence of dusty and slippery conditions during the dry and wet weather respectively.
- Gravel materials are excessively coarse in their “as dug” state. Appropriate processing is therefore necessary to bring them to the required gradation. This is normally done on the road by using grid, cleat or sheep’s foot rollers. Oversized particles which cannot be broken down to the required size shall be removed.
- The minimum thickness of a compacted layer shall not be less than 125 mm.
- Internal plant road and walk paths shall be compacted to 100% MDD after grading. The road shall have a well-done gravel finish. The road shall be constructed to a fall that will allow proper drainage of the road. The road shall have adequate drainage provided. The design shall be to road design manuals.
- For the gravel finish internal plant road, the single gravel layer should consist of a minimum thickness necessary to avoid excessive compressive strain in the sub grade and to compensate for the expected gravel loss under traffic during the period between re-gravelling.
- Where the top 300 mm layer of the formation level embankment or natural ground sub grade has a CBR greater than 5%, the following thicknesses shall be provided:
 - a) Roads not subjected to heavy commercial vehicles- The minimum compacted thickness of 125mm.
 - b) Access roads outside the SPGP plant and roads within the site likely to be subjected to heavy commercial vehicles during construction and during periodic maintenance. - Provide a 250 mm thick compacted layer.
- In addition to the above, where the in-situ sub grade or the embankment material has CBR strength of less than 5% then:
 - Top 300 mm layer of the fill / embankment shall be made with selected imported material with CBR (after 4 days soak) of between 7 and 13%.
 - Where in situ sub grade, an improved sub grade 300 mm thick of imported materials with CBR (4 days Soak) of between 7 and 13% shall be laid.
- The above thickness shall extend to cover the shoulders. A cross fall of 4% shall be provided.
- Compaction will be in layers not thicker than 200 mm and will achieve compacted densities of 95% MDD (Modified AASHTO T180) at compaction moisture contents of between 80% and 105% OMC.

10.19 Grading Requirements

- Grading curve of the gravel should be within the class 1 envelope (initial daily number of commercial vehicles less than 150) to guarantee good stability. The grading to consider is that obtained after processing and compaction.

Grading after compaction		
Sieve Size (mm)	% Passing by weight	
	Class 1	Class 2
37.5		100
28	100	95 - 100
20	95 - 100	85 - 100
14	80-100	65 - 100
10	65 - 100	55 - 100
5	45-85	35-92
2	30-68	23-77
1	25-56	18-62
0.425	18-44	14-50
0.075	12 - 32	10 - 50

Table 31: Gravel Grading Details

10.20 Plasticity Requirements

- Plasticity index of the gravel should not exceed 15 and shall not be less than 5 in wet areas (annual rainfall greater than 500 mm per year). In dry areas (annual rainfall less than 500 mm per year) maximum plasticity index shall be 30 but subject to a minimum of 10.

10.21 Bearing Strength Requirements

- A minimum CBR (after 4 days soak) of 20% at 95% MDD and OMC (Modified AASTO T180) is required.

10.22 Quality Control

Tests shall be performed by the contractor on soils and gravels undergoing compaction under the supervision of and at frequencies determined by the Employer and shall include:

- Determination of the Atterberg Limits in accordance with BS 1377.
- Determination of particle size distribution in accordance with BS 1377.
- Determination of dry density / moisture content relationship in accordance with BS standard compaction and modified AASHTO T180 as appropriate.
- California Bearing ratio (CBR) in accordance with AASHTO T193.
- Field dry density as set out in BS 1377.

10.23 Tolerances

The following tolerances will be permitted in the finish of the formation to roads and platform:

- The level of the formation should be within +/- 100 mm of that specified.

- On the final trimmed slope of earthworks, a variation of + or - one fifth of the specified slope will be allowed.
- The tolerances permitted in the overall width of the bottom of cuttings shall be plus or minus 150 mm in the distance between center lines and the toe of cuttings slopes, and plus 150 mm in the case of embankments.

10.24 Materials for The Works

a) General

- All materials shall comply with appropriate local or regional standards unless otherwise required hereinafter. Such standards shall be to the approval of the Employer.
- The Contractor shall before place any order for materials or manufactured articles for incorporation in the Civil and structural Works, submit for the approval of the Employer the names of the firms from whom he proposes to obtain such materials, etc., together with a list of the materials and manufactured articles giving the origin, quality, weight, strength, description, etc., which he proposes that the firms should supply. No materials or manufactured articles shall be ordered or obtained from any firm of which the Employer shall not have previously approved.
- All materials shall be delivered to the site within sufficient period of time before they are required for use in the Works to enable the Employer to take such samples as he may wish for testing and approval. Any materials condemned as unsuitable for Works shall be removed from the Site at the Contractor's expense. Contractors price to include these testing of materials.
- The Contractor may propose alternative materials to those specified, provided that they are of equivalent quality and, subject to the Employer's or the Employer's approval such materials may be used in the Works.

b) Standards

- Concrete pipes, porous concrete pipes, cast iron manhole covers and gratings, bricks, concrete kerbs, bituminous surfacing, cement, steel and aggregates shall comply with local or regional standards as per specified standards in the document.
- Stone for Pitching Stone for pitching to drains, inlets and outlets of culverts, to embankments and around structures shall consist of sound un-decomposed rock. Precast concrete tiles may also be used.
- Stone for Solar Field Platform Surfacing
- The stone shall be hard and durable crushed rock with a maximum particle size of 60 mm and not more than 15% shall pass a 9.5 mm sieve.
- The stone layer to be spread uniformly over the finished surface of the platform shall have a thickness of 100 mm.

10.25 Drainage and Storm Water

- The contractor shall construct the Power Plant station to a fall that will allow proper self-drainage of the site. This shall be done in conjunction with the earthworks design to ensure no flooding shall be experienced within the site. The drainage designs shall refer to data acquired from the Meteorological department with site-specific criteria over a period of a minimum 50 years and shall provide for the worst-case scenarios. The number of runs and outfalls and pipe sizing must be sufficient to cope with the severest precipitation, with a

factor of safety of 1:2 within the SPGP site and other areas in the site. The drainage must allow uninterrupted access.

- Drainage shall be in accordance with relevant Codes for Practice published by authoritative Standards organizations such as the British Institution, e.g., BS 8301, BS 6031, and Eurocodes.
- Embankments and cuttings are to have drainage facilities at their top or bottom. The formation level of the site is to be formed with uniform cross-falls of about 1 in 300 in the same direction as the natural drainage path of the surrounding environment. Drainage minimum slope shall be 1 in 200.
- Surface water from roofs of buildings shall be drained to downpipes, which connect with the general site drainage system. Surface water from the control room building and office roof shall be drained to the main storage reservoir tank.
- In areas where there is a risk of water runoff the SPGP Plant shall be protected from failure by **means of gabions, retaining walls, and stone pitching or otherwise to the employer's approval.**

10.26 Concrete Works

a) Soil Investigations

- The contractor shall collect all data he deems necessary for preparation of his bid. The foundation design shall be based on the bearing strength data, obtained from the geotechnical survey.
- The Contractor shall be required to perform sub-soil tests within the area of the SPGP to the depth and by the method of test specified by the Employer. The details of performing the test, tools and equipment to be used for, shall be submitted to the Employer for approval.
- The sub-soil tests shall be carried out by any method as stated hereafter under the supervision of a qualified person, who shall be subject to approval of the Employer.

b) Excavation

- Excavation for concrete foundations shall be carried out in strict accordance with the requirements of the Employer and to fit in with the programme of construction.
- Shoring and Timbering of Excavation
- The Contractor shall be entirely responsible for the safety of all excavations, for the prevention of injury to workmen and for the stability of the faces of the excavation.
- The adjacent road surfaces must remain trafficable, and cracking or cave-ins must be avoided. All shoring and timbering shall be done to the approval of the Employer, who may order such shoring or timbering to be strengthened or altered if he considers this necessary in the interests of the work or to safeguard against accidents to workmen or cave-ins. For the purpose of measurement, the following categories of shoring shall apply:

c) Dewatering

- The whole Works shall be constructed in dry conditions and the Contractor shall be held responsible for keeping all excavations free from water, whatever the source or cause may be, and shall properly deal with and dispose of water by use of sufficient temporary works, plant and appliances so as to ensure that the whole Works is executed in a satisfactory dry and safe manner, and costs for all dewatering operations shall be included in the price for

civil works.

d) Excavation to be approved

- In no case shall broke stone for under drainage or concrete be placed in an excavation until the surface on which such materials are to be placed has been approved by the Employer.
- The Contractor shall advise the Employer whenever the bottom of any excavation is ready for inspection or whenever it is necessary to cover up the work. In default of such notice the foundation shall on the order of the Employer be uncovered by the Contractor and reinstated without extra charge.

e) Disposal of Excavated Material

- All material excavated under this Contract shall be disposed of in accordance with the instructions issued by the Employer. Selected material required for back-filling shall be removed to a tip found by the Contractor and the Contractor shall be responsible for ensuring that the required amount of spoil is set aside.

f) Other Services

- Where trenches pass near or across other services, the Contractor shall take every precaution against damaging such services. These services shall be properly supported in the trench until back-filling is complete and the backfilling shall be thoroughly compacted under and around such services.

g) Backfilling

- Back-filling shall be carried out either with selected spoil as set aside, or with imported selected spoil, or other material to the approval of the Employer. No backfilling shall be done until all the formwork has been removed together with pieces of timber, cement bags, vegetation and or other rubbish.
- All back-filling shall be compacted in layers not exceeding 150 mm thick and shall be sprayed with water to bring the moisture content to the optimum for dense compaction.

h) Compaction shall be to an approved standard.

10.27 Concrete, Formwork and Reinforcement

a) Materials

- Aggregates Shall conform to BS 882.
- Shall be heaped separately on hard, self-draining surfaces.
- The normal size of coarse aggregate shall be 20 mm.
- Water Shall be fit to drink.
- Reinforcement Shall conform to BS 4449.
- Reinforced Concrete Shall be designed to BS 8110, Foundation BS 8004
- Steel Shall be designed to BS 5950
- Cement Shall Conform to BS 12.

- Be either normal Portland or P.C. 15.
- Be used within 6 weeks of manufacture.
- Be stored in a manner to excludes any moisture.
- Be stored in a manner to ensure the use of the earliest consignment.
- Different types of cement from different manufacturers shall not be mixed for a single cast or structural element. Additives shall not be used before concreting.
- Design Mixes Not less than 2 weeks before the start of concrete work, the Contractor shall submit to the Employer for his approval a statement of proposed mix proportions for the various grades required in the project. (Note: the grade is the characteristic strength or the cube strength below which not more than 5% of the result may be expected to fall when tested at 28 days).
- The statement shall include proportions of cement, fine and coarse aggregate, and water, the maximum and minimum slump, and the target strength for each grade.
- A certificate by the recognized laboratory that the proposed mix will meet the requirements must accompany the statement.
- The proportions stated may not later be altered without the written approval of the Employer:
- The cost of mixed designs is to be borne by the Contractor.

b) Formwork

- Formwork shall be sufficient to leave the concrete finishes specified on drawings and to be within the tolerances specified in the following table and to provide an acceptable surface for applied finish, where required.
- Line and Level 1 mm per meter not exceeding 5 mm
 - Pockets, Sleeves etc. +/- 5 mm
 - Bases +/- 50 mm
- The concrete shall have a smooth finish free of projections, voids, etc. The type of ties to be used shall be such that the required finish is achieved and does not become marred by subsequent corrosion. Ties are to be set out to definite pattern to the Employer's or the Employer's approval. Rubbing down is allowed only after the Employer's approval of the surface to be treated.

c) Reinforcement

- Shall not be heated or re-bent without the Employer's permission.
- Shall be free from any material likely to impair bond or initiate corrosion.
- Shall be bent and fixed according to the Employer's approved bending schedules.
- Shall be tied with soft iron wire.
- Shall be supported to maintain the following minimum cover during concreting.
- The greater of the diameter of the bar or 40 mm for the external un-plastered face.
- The greater diameter of the bar or 15 mm for the internal face.

d) Construction Joints

- Shall be avoided, if possible, but if inevitable shall be pre-planned in consultation with the Employer and temporary stop ends inserted. Before placing concrete against a construction

joint, the formed face shall be hacked down to expose the coarse aggregate and kept continuously wet for 24 hours. Vertical faces should be covered with cement/water slurry and horizontal faces should be covered with 15 mm layer of cement/sand grout. New concrete should then be placed immediately.

- Camber To formwork shall not be at the expense of the overall depth of the concrete.

e) Weather

- The contractor shall adopt the use of membranes for curing, to manage the desired moisture and temperature conditions and hydrate the cement to avoid concrete cracking.
- Batching Shall Be by mass in accurately calibrated scales or be volume in soundly constructed gauge boxes making do allowance for bulking of the fine aggregate. be in proportion to whole sacks of cement.
- Mixing Shall Be in a machine in good condition, large enough to carry the whole mix, and controlled by a competent experienced operator. Be for sufficient time to ensure complete mixing of the ingredients.
- Placing Shall Be under the control of a competent, experienced overseer, be in a manner to prevent separation of the ingredients.
- Be a continuous process until the pour is complete.

f) Compaction

- Shall be by immersion (poker) vibrator in the hands of experienced operators.
- Concrete shall not be moved by vibrator.
- Shall be sufficient to remove all air pockets and honey-combing and to ensure complete dense concrete cover to all reinforcement.

g) Testing

- a) Making of concrete cubes by Contractor under Employer's supervision. Contractor shall arrange for transport of cubes to approved testing laboratories. Cubes to be in sets of 3.

h) Curing

- Shall commence early on the morning following the placing of the concrete.
- Shall be effected by keeping the concrete in a permanently wet state.
- Membranes shall be used due to expected high temperatures.
- Shall continue for a minimum of fourteen (14) days or such longer time as may be required by the Employer.

i) Stripping of Formwork

- To soffits shall not be struck until 7 days after placing of concrete (but see below for props).
- To vertical faces shall not be struck until 14 days after placing concrete.
- Props to soffits shall not be struck until 14 days after placing concrete.
- Shall not be stripped without the Employer's approval who has the power to vary the above items.

j) Patching

- To defective work shall not be undertaken before the item has been shown to the Employer.
- Is a sign of poor workmanship. The Employer shall have the right to reject the complete element if an unreasonable amount of patching has to be done, or if patching will spoil the appearance of the finished concrete.

k) Records

- Are to be kept by the Contractor, showing date and time of each concrete pour, the weather conditions, the temperature, the number of the cubes which represent the concrete, the slump and any other items which the Contractor and/or the Employer consider relevant. These records are to be made available for the Employer's inspection when required.

l) Foundations

- The contractor shall construct reinforced concrete structural foundations for the Equipment Enclosure as well as for the Solar Equipment as required. These shall be designed to relevant standards and reviewed by the Employer before implementation.

m) Cable Ducts and Conduits.

- The Contractor is responsible for all civil engineering works required for the cable runs between the Solar field site and the control room and/buildings, in buried heavy gauge installation ducts of minimum 150mm to connect cables from the solar panels and equipment to the Control room and/office as required. Manholes for inspections shall be provided at approved intervals.
- Where the cable trench is crossing roads, the ducts shall be constructed in such way that they will be able to withstand the weight imposed on them.
- The contractor shall appropriately mark the cable route.
- Cable entries into buildings/control room and road crossings shall be through 150 mm diameter heavy gauge ducts.
- Two (2) lines of 150 mm diameter heavy gauge of spare ducts shall be provided.
- After installation of cables the ducts shall be sealed with duct sealing compound where required. Cable entries into building/control room shall be sealed to prevent the entry of dust, vermin water, etc., using suitable materials
- The cable system design including manholes shall be subject to employer's approval.

13.23 Builder's Work

a) Setting out Walling

- The Contractor shall provide proper setting out rods and set out all work on the same for courses, openings, heights, etc. and shall build the walls and piers, etc. to the widths, depths and heights indicated on the drawings and as directed and approved by the Employer.

b) Cement

- Cement shall be as described in concrete Works.

c) Fine Aggregates

- Fine aggregates for concrete blocks shall be as described for fine aggregate in Concrete Works.

d) Coarse Aggregate

- Coarse aggregate for concrete blocks shall be good, hard, clean aggregates from an approved quarry. It shall be free from all de-composted materials and shall be graded up to 7 mm, and all

as described for coarse aggregate, Concrete Works.

e) Machine cut stone.

- This shall be to approval of employer and meet minimum required specifications.

f) Concrete Blocks.

- Concrete blocks for walling shall be provided by the Contractor complying with B.S. 6073, and made in approved block manufacturing machines.
- Minimum thickness of blocks in external walls shall be 150 mm, and in internal walls the thickness shall be minimum 100 mm.
- Samples of the proposed block types shall be approved by the Employer before any walling work is commenced.
- Blocks shall be cast under sheds in suitable block manufacturing machines either power driven or hand operated.
- The form shall be of steel, and accurately made to size to give the required shape and squareness of block. The concrete shall be vibrated during casting to achieve a dense and uniform concrete. The material shall contain only sufficient water to obtain full chemical reaction of the cement and to give proper workability of the constituents.
- The ratio of combined aggregate to cement shall not exceed 3:1.
- The Contractor shall present his proposal for mix recipe supported by test results for the Employer's approval.
- Concrete shall have minimum 28 days strength of 20 N/mm² in accordance with B.S. 1881. Mixing shall take place in mechanical mixers so as to thoroughly mix the constituents to a uniform consistency before casting.
- On removal from the machine the blocks shall be carefully deposited on edge on boarding or a clean concrete floor under sheds so as to prevent drying out by the sun for 3 days. During this time blocks shall be kept constantly damp. The blocks may then be laid on edge in the open and kept damp by spraying or covering with wet hessian or by other means for a further 5 days. The blocks may then be stacked if required, but not more than one meter high, and in such a way as to prevent damage to the edges and corners.
- No blocks may be used in building or be transported to site before having reached required 28 days strength criterion.
- All concrete blocks shall be of even texture and properly mixed ingredients and all portions of the block shall be properly set and hardened concrete.
- Blocks shall be free from cracks or blemishes and shall be true to shape and size with clean sharp, edges and corners and with corners truly square. Damaged blocks shall immediately be removed from the site. No dimension of a block shall deviate individually by more than 3 mm from the correct size. The average length, width and height of a sample of 15 blocks should neither be longer nor less than 2 mm than the correct size.
- Dressed natural/foundation stone blocks at least 200mm width may be used as alternative to the concrete blocks.

g) Cement Mortar

- The cement mortar is to be mixed in the proportions of 1 Cement, 4 Sand, and thoroughly incorporated with a sufficiency of water. Any cement mortar which has been left for more than one hour shall not be used in the Works.

h) Building Walling

- All blockworks shall be laid in raking stretcher bond solidly bedded, jointed and flushed up in mortar. Where wall faces are to be plastered the joints shall be raked out to form a key. The blocks shall be thoroughly wetted for at least 24 hours before laying. Walls shall be carried up evenly course by course. During laying an open joint not less than 15 mm wide shall be left between the ends of all concrete lintels, whether pre-cast or cast in-situ and the blocks adjacent to these ends. These open joints shall be left as long as possible during construction and not filled until plastering or other works render such filling necessary. All such joints shall be properly filled in before the completion of the work. External walls shall be reinforced with two 8 mm high yield steel bars in every third horizontal mortar joint. The building shall be designed as a framed structure.
- Blockwork which is not to be rendered or plastered shall be finished with a fair face and the blocks shall be selected for even texture and unmarked faces, regular shape and square unbroken arises. The blockwork shall be pointed as the work proceeds with a neat joint. Where blockwork is to be rendered or plastered the joint shall be raked out 10 mm deep as the work proceeds to form an adequate key. Galvanized steel ties with fishtailed end cast into the concrete spaced at alternate courses and extending not less than 150 mm into the block joints. All mortar joints are not to exceed 15 mm or less than 12 mm.

i) Lintels

- Concrete lintels shall be used for all openings and shall be reinforced and constructed as per approved structural designs for the gourd house.

10.28 Structural Steelworks

- Structural steelwork shall be shop-fabricated from structural shapes of medium grade carbon steel in suitable lengths for easy transport and erection. The structural members shall be jointed or fixed on site by bolting or welding. Site welds should be minimized. Design shall comply with BS 5950.
- All workmanship and fabrication shall be in accordance with the best practice and shall generally comply with the requirements of B.S.4449. The greatest accuracy shall be observed to ensure that all parts fit together correctly on erection within the tolerances stated in this section. Steelworks shall include all materials, bolts and attachments, cleats, brackets, gussets, etc.
- Where required in the Contract, the Contractor shall design the steelwork to comply with the information given on the Contract Drawings. Loading and factors of safety shall comply with relevant codes and regulations. Shop drawings shall be prepared using welding symbols to B.S. 499 where appropriate. Design calculations and shop drawings must be submitted to the Employer for his approval prior to fabrication of members. The approval of shop drawings and calculations by the Employer shall not relieve the Contractor of the full responsibility for any discrepancies, errors, omissions or failure arising therefrom.
- All steelwork shall be transported, handled, stored on Site and erected so that members are not damaged or subjected to excessive stresses. Fabrication and erection shall comply with B.S. 5950 Part 2.
- The contractor shall provide steel support structures to support all equipment and solar panels at a minimum of 1m clearance from the finished ground level, on the lower side of the elevated panels.
- The structures shall be galvanized to the required specification, with a minimum coating of 614mg/m².
- The Mounting of the Solar panels shall be done on steel rails and frames and shall be designed to carry all the loadings and in accordance to provision of B.S 5950 and any other relevant BSI standards.

a) Roofing-Control Room, Office Building Guard House and VIP Latrine

- Materials, accessories and fixings shall be ordered from an approved supplier and the Contractor shall as and when required by the Employer, submit and deliver samples of all materials for inspection and testing. Roof trusses shall be in steel.
- Roof sheeting shall be hot dip galvanized troughed mild steel sheeting and shall be of minimum thickness 0.5 mm. The sheeting shall have approved plastic coating on face side. Type and brand of such sheeting shall be proposed by the Contractor with his Tender together with supporting specifications.
- The sheets shall be laid with 200 mm end laps and double corrugation side laps away from the prevailing wind. The sheets shall be fixed to light gauge steel purlins with galvanized coach screws and seating washers.
- Holes for screws shall be carefully drilled in the ridges of the corrugations. Great care shall be exercised to avoid damage and disfiguration to the surface coating of the sheets.
- Maximum load acting on the building shall be in accordance with local or regional standards.

b) Roof Drainage

- Gutters and down pipes shall, unless otherwise shown on the drawings, be approved plastic coated steel or heavy gauge PVC of diameters 200 mm and 150 mm respectively.
- Joints shall be lapped 150 mm in the direction of the flow and soldered. Slip joints shall be provided to allow for expansion. All hangers, brackets, and fastenings should be of the same metal as the gutter or of compatible materials. Gutters and down pipes including supports shall be designed for a concentrated load of 100 kg. Screens or strainers shall be provided to prevent debris from clogging the down pipes.

10.29 Metalwork and Containerized Control Room Solutions.

- Unless otherwise specified, metalwork shall be carried out in accordance with the provision of B.S. 5950 and other relevant BSI standards.
- All steel shall unless otherwise specified, be hot dip galvanized. The minimum galvanized coating shall be 614mg/m².
- For the case of containerized control room, the material shall be in good condition, Durable and environmentally friendly. The containers shall be fitted with insulations for temperature regulations, as an addition to Air conditioners installed for temperature control to specification, **due to sensitivity of the equipment to high temperature conditions. Rejected containers due to poor Quality**, shall be replaced at the contractor's expense. The container shall be painted with the first coat of red Oxide primer and then consequently painted with Zinc Chromate, anti-rust primer to approved layers and the final coat of paint shall be in accordance to the employer's approved company color codes.
- Prior to fabrication the Contractor shall submit shop drawings for the Employer's approval.

a) Metal Doors

General

- Metal doors shall be supplied by approved manufacturers.
- All doors shall be painted as specified under Painting and Decorating. All locks shall be master-keyed with three master keys supplied in addition to three regular keys for each door or gate.
- Doors shall be measured by the number of doors of specified dimensions. The rate shall include all supplies, site works, painting and hardware.

Doors

- Door frames shall be pressed steel frames made from minimum 2 mm thick steel sheeting and reinforced where door closers are fixed.
- Thresholds shall be made from rolled steel sheeting approximately 100 mm wide and 12 mm high. Placing of doors in accordance with control room and office building drawing.
- Internal door frames are to be built to walls truly vertical and square with three ties per frame. External door frames are to be built in to walls truly vertical and square with six ties per frame.
- All door frames are to be from an approved manufacturer and illustrated in the Manufacturer's Catalogue.
- Door frames are to be complete with 100 mm, loose pin steel hinges welded in position and adjustable striking plate.
- Door frames and similar components shall be fixed with countersunk screws or bolts with heads set into the frames.
- Doors wider than 800 mm shall have three 100 mm hinges. Other doors may have two hinges except where specified or detailed otherwise.
- Doorstops shall be fitted by screwed fixings where necessary.

Aluminium or Steel Windows

- Unless otherwise indicated windows shall consist of aluminium sub frame with clear glass. Windows shall be from an approved supplier and the details thereof shall be approved by the Employer. Windows shall be operable and provided with corrosion resistant metal insect screens or as directed by the Employer.
- Frames shall generally be built-in during construction of the walls and securely fixed.
- Placing of windows in accordance with approved control room and office building drawings. Windows are to be built in to walls truly vertical square with six - ties per frame.
- All aluminium or steel windows are to be from an approved manufacturer and illustrated in the Manufacturer's Catalogue.
- Windows are to be fitted complete with casement fastening, stays etc.
- All windows shall have approved burglar bars, and approved means of opening/locking.

Door and Window Furniture

- Ironmongery shall be strongly made, well finished and of good quality. Ironmongery for windows and doors shall be galvanized or other approved manufacture for external use. Samples of all items shall be submitted to the Employer for approval before they are used for the Works.
- All doors shall be lockable. External doors shall have approved security locks.
- Three keys for each lock, clearly labelled, shall be placed in a key cabinet in the control room and all ironmongery shall be cleaned, oiled, adjusted and left in perfect working order.
- Emergency doors shall be provided accordingly as per the safety requirements.

b) Control room, Guard House, VIP Latrine and office building

- The specifications of the finishing should be read in conjunction to section for the containerized control room and office.

Table 33: Schedule of Materials and Finish

ROOM	FLOOR	WALLS	CEILING	REMARKS/NOTES

Control room/ Office building	Wood tiles/ Ceramic tiles/steel	Cladding with approved material	Cladding with approved material	Subject to employer's approval
----------------------------------	------------------------------------	---------------------------------	---------------------------------	--------------------------------

Table 33 : Schedule for Materials & their finishing

NOTES:

- Sheets for ceilings: prefabricated/manufactured color and type in according to approval of the employer.
- Control room and office building: External/internal color in accordance with approval of the employer.

Plaster and Floor Coverings

- **Materials:** - Cement and water to be as before described. The sand to be screened through a sieve of 10 to 15 and meshes to 1 cm and to be washed if directed.

Mixing

- All materials for mixing are to be used in proper gauge boxes and they are to be strike measured and not tamped down in boxes. Proper non-absorbent stages are to be used for mixing and storing mortar. No foreign matter must be mixed with the mortar.
- The materials are to be mixed dry before adding water through a fine hose spray. No cement mortar which has taken its initial set will be allowed to be used.

Plaster Thickness

- Unless otherwise specified all wall plasters should not be less than 13 mm thick and not more than 19 mm thick.

Cement Plaster

- Cement plaster for external use to be composed of one part cement to four parts sand and for internal use to be one part cement to five parts sand.

Form Key

- Rake out joints and roughen if necessary to form key for plaster.
- For concrete surfaces, hack and apply 1:1 cement sand slush to form key. Continuously wet for 7 days and then apply plaster.
- All brickwork and concrete works should be brushed down to remove dust and any other loose material.

Wetting

- All internal and external brick or concrete surfaces are to be wetted well before plastering.
- All cement plaster must be kept wet for at least 7 days.

Repairing Defects

- All defective plaster, cracks, hollows, etc., are to be cut out to a rectangular shape, the edges undercut to form a dovetail key and to be made good to finish flush with the edge of the surrounding plasterwork.
- All patches will be to the approval of the Employer and if the defects cannot be made good satisfactorily then the whole surface is to be removed and re-plastered at the Contractor's expense.

Glazing and Painting

- Glass: - All glass is to be of approved manufacture, free from bubbles, waviness, scratches or other imperfections and is to be well bedded, puttied and back puttied and secured with glazing pins or clips in steel sashes or with sprigs in wood sashes.
- All glass shall be carefully cut to the required sizes so that all panes of figured or textured glass are uniform in appearance with the pattern parallel to the edges and wired glass shall be so cut that the wires are parallel to the edges.

The window glass for control room shall be shatterproof type.

- Putty: - Putty for glazing to steel sashes is to be of approved proprietary brand. Rebates are to be thoroughly back puttied before glazing and all putty is to be carefully trimmed and cleaned off so that back putty finishes level with the top of sections internally, external putty covers sight lines exactly and finished straight and true. Rough surfaces to putty will not be allowed and any defective putty will be cut out and replaced at the Contractor's expense.
- Rebates of wood sashes are to be given one coat of priming immediately before glazing.
- Mirrors: - Glass mirrors are to be of the thickness specified, of selected quality glass, silvered on back, with protective sealing coat and arised edges, unless otherwise described.
- Generally: - Allow for removing and replacing all cracked, broken or defective glass and leave thoroughly clean and perfect at completion.

Materials for Decoration

- All paints, primers, varnishes, emulsions, stopping, etc., to be of approved manufacture.
- The contractor is to use proprietary ready mixed paints obtained from an approved supplier.
- When a coat of proprietary paint is applied, the manufacturer's priming and previous coats suitable for the particular type are to be used.
- All materials must be brought on to the site in unopened tins, and no dilution or adulteration will be permitted, unless approved by the Employer.

Emulsion Paint

- Emulsion paint shall be PVA (Polyvinyl Acetate) alkali-resisting formulated with high washability and capable of resisting a 8000 scrub test. The first coat to be specially formulated base coat for direct application to the specified surface.

Fillers

- Higher grade cellulose fillers are to be used internally and premixed filler to be used externally.

High Gloss Paints

- Primers for application to bare metal to be red oxide primer for iron and steel. For galvanized metal to be an approved zinc chromate or galvanized iron primer. For application on wood or plaster etc., to be an approved alkali primer.

Finish enamels

- Finish enamels to be synthetic enamel high-capacity paint with high coverage and high gloss finish unless otherwise described.

Workmanship

- All surfaces are to be free from moisture, dust, grease and dirt and rubbed down smooth

according to approved practice.

- All plaster to be free from efflorescence and treated with one coat of petrifying liquid, approved sealer or alkali primer if required. Hard wall plaster to be glass papered before decorating.
- Rectifying defects to decorated surfaces due to dampness, efflorescence, chemical reaction, etc., will be to the Contractor's account, as these surfaces must be checked and the appropriate precautions taken before applying the decoration.
- Metalwork must be scraped free of rust, primed as described and finished as later specified.
- Galvanized sheet iron, pipes, etc., are to be cleaned down to remove manufacturer's ammoniated dichromate protective covering, primed as described and finished as later specified.
- Coated pipes are to be cleaned down, stopped and primed with one coat of aluminium primer and finished as later specified.
- All metal to have the specified number of coats in addition to the priming coat.
- Every coat of paint must be a good covering coat and must dry hard and be well rubbed down to a smooth surface before the next coat is applied, otherwise the Contractor will be required to apply extra coats at his own expense.
- Each coat of paint to be of a distinctive color: sample colors are to be prepared for the final coat which is to be an approved color scheme and must not be applied without the permission of the Employer. After undercoats are on, the painter shall check all work and grain fill as necessary with filler as described.

NOTE:

- All paints specified are to be obtained from an approved manufacturer and used in strict accordance with their instructions. Their representative will check the paints being used and the method of application and will advise accordingly.
- This section of the work to be carried out by an approved firm of decorators who must allow for the very best finish possible and of the highest quality obtainable.
- The prices must allow for the removal and refitting of all beads, fittings, fastenings, ironmongery, etc., removed for decoration purposes to be carried out by skilled tradesmen of the appropriate trade.

c) Control Room Sizes.

Ironmongery and Metalwork

General

- All ironmongery shall be of the best respective types required and no alternative articles will be accepted unless approved. Articles described as brass must be solid brass and not brass finish. Chromium plated articles must be plated satin finish on solid brass or other approved metal.
- Where items for ironmongery are required to be fitted to steel door frames, etc., the Contractor must ensure that the Manufacture makes provisions for the correct fitting or lock striking plates, hinges, cleat holes, bolt keeps, etc.

Locks and Keys

- Locks are to be two levers unless otherwise described. All locks are to be provided with two keys which must be handed over to the owner on completion of the Works with identification labels attached.

Steel

- Steelwork for general building construction is to be of approved manufacture complying

generally with the appropriate British Standards and free from all defects, oil, dirt, loose rust, scale or other deleterious matter.

Electrical Installation

- The contractor shall supply, install, test and commission the complete electrical services within the Control room both outdoor and indoor, office building both outdoor and indoor, Guard house, VIP latrine and SPGP outdoor security lighting/perimeter lighting.
- The complete electrical installation shall comply with all local standards and rates and shall be as per requirements/specifications.

Lighting

- Luminaries shall be fluorescent lamps except for the toilets and outdoor lighting. SPGP and/Perimeter Outdoor lighting to use flood lights subject to employer's approval.
- All luminaries shall be supplied, installed and tested by the electrical sub-contractor.
- Outdoor lighting shall be controlled from an automatic photocell.
- Lighting control switches shall be flush pattern with white finished plates.
- The outdoor SPGP flood lights/perimeter security lighting to be achieve the recommended luminaries and mounted on concrete poles.
- Socket outlets to be mounted at 300 mm above floor level in the office, guard house and control room.
- Conduit cast into the building structure shall be of the heavy-duty PVC type. PVC conduits shall not be fixed to the surface of the structure.

AC Installation

- The contractor to supply the ACs in the control room. The Contractor shall supply and install a minimum of two number AC units, including wiring and all necessary accessories. The number of ACs and its capacity shall be determined by calculations and design will be based on the equipment manufacturers ratings adopted and the rooms requirement (Including Lithium-Ion Batteries) and subject to approval by the employer.

Fire Safety Facilities

- Portable fire extinguishers shall be provided under this Contract. Portable, wall mounted, handheld extinguishers shall be 6kg pressurized control discharge Bromochlorodifluoromethane (BCF) units in the office and control room. The number of units within the Control room and office shall be a minimum of 3 Number.
- A minimum of 1 No. 13 kg pressurized control discharge BCF units shall be provided in the SPGP area.
- The body of the extinguisher shall be seamless, welded and brazed as appropriate.
- The extinguisher shall be capable of being released by means of a lever-operated valve provided with a safety pin.
- Extinguishers shall be capable of controlled partial discharge.
- The type shall be of that recharge unit that is locally available.
- The extinguishers shall be wall mounted and attached and located in a manner affording quick release from the supporting bracket. They shall be installed so that the top of the extinguisher is not more than 1.5meters above the floor. In no case shall the clearance between the bottom of the extinguisher and the floor be less than 0.1 meter. The extinguishers shall be positioned so that the instructions for operation face outwards.
- BESS to be housed in one room in the control room. The battery room shall have an automated fire detection, prevention and suppression system fitted with a suitable dry aerosol agent to put-

out Lithium-Ion battery fires. The system shall include smoke detectors, horn strobes and other components required to enable it function properly and suppress fires while preventing unintended release. Suitable Fire protection and suppression system shall be designed for BESS in line with IEC or international requirements/specifications regulation as applicable and system requirement considering project site.

- The fire safety design shall be subject to approval by the employer. The contractor shall train the local staff on use of the installed system

11. Commissioning and Acceptance Tests. These shall be undertaken in accordance with the contract clauses GCC 24 &25

11.1 Mechanical Tests.

The mechanical test shall be the first test to be performed with respect to the PV and BESS systems and shall occur on a date to be proposed by the Contractor and as approved by the employer. The notice should not be less than 10 days before.

The Mechanical test shall verify that the PV and BESS systems have been installed according to the requirements and includes: (i) Visual inspection and (ii) Verification of installation of all equipment.

Areas for inspection shall at least include:

- a) Mounting structure, bolts and fixtures.
- b) PV modules.
- c) DC and AC cables.
- d) Inverters.
- e) Batteries, if applicable.
- f) DC distribution system.
- g) Monitoring system for PV field, batteries and associated ancillary equipment.
- h) Transmission line and associated grid interconnection equipment

11.2 Functional Tests

The functional tests shall be done after the successful completion of the mechanical tests

11.3 PV Array

The Functional Tests on the PV array shall be done according to IEC 62446 and include at least:

- a) Continuity of earthing tests.
- b) Polarity test.
- c) String open circuit voltage test.
- d) String short circuit current test.
- e) Insulation resistance of the DC circuits.
- f) Thermographic tests

11.4 BESS

The functional tests of the BESS, shall include at least and according to IEC 62933-2 the following:

- a) Continuity and validity of conductors.
- b) Earthing test.
- c) Insulation test.
- d) Protective and switching device test.
- e) Equipment and basic function test.
- f) Available Energy test.
- g) EMC immunity test.
- g) Thermographic tests

- h) Functioning of fire-safety related systems.
- i) Functioning of thermal management system.
- j) SCADA, EMS and BMS functionality.
- k) Cold start-up of all systems.
- l) Normal shut-down and restart; and
- m) emergency procedures and emergency shutdown
- n) Dry runs (charging and discharging)

11.5 System Performance Tests

The performance test for the PV plant shall be undertaken in accordance with IEC 61724 to determine both the performance ratio (PR) and the AC capacity. The Performance Test shall be done after the successful completion of the functional tests.

The performance test shall have the duration of 5 days according to the following criteria: (i) Total daily irradiation at the PV modules shall be at least 3.5 kWh / m²; and (ii) If the minimum daily irradiation is not reached, the test days shall be extended until the reach the minimum irradiation of 3.5 kWh / m². The availability of the PV system and the Grid should be 100%. In case of unavailability, the test period should be extended. The PV system performance ratio (PR) shall be calculated on the basis of the operating data recorded by the monitoring system and in accordance to IEC 61724:

$$PR_{meas} = \frac{\sum_j E_{meas,j}}{P_{nom} \cdot \sum_j \left(\frac{G_j}{G_{ref}} \cdot \left(1 - \frac{\beta}{100} \cdot (T_{mod} - T_{meas,j}) \right) \right)}$$

Where

- $E_{meas,j}$ = Produced energy (in kWh) over each metering interval j;
- P_{nom} = Nominal power of the PV system in kWp. Sum of the individual module power of all installed modules as per the relevant datasheets.
- G_j = Irradiation in kWh/m² measured per each metering interval j with an on-site pyranometer with an identical inclination to the modules.
- G_{ref} = 1 kW/m², irradiance at the reference STC conditions.
- PR_{meas} = the average PV system Performance Ratio during the testing period.
- $T_{meas,j}$ = the average module temperature measured during each Metering Interval j by the temperature sensors placed on the reverse side of the modules (in °C). When several module temperature sensors are installed then the average measurement of the installed module temperature sensors will be considered.
- T_{mod} = the average monthly PV module temperature expected.
- β = Maximum power temperature coefficients of the PV modules as per the relevant datasheets. For the avoidance of doubt β shall be a negative value.
- j = 10 minutes' interval

The BESS, as a complete system, shall be grid code compliance, therefore grid code compliance tests shall be performed in accordance with IEC 62933-2 and shall at least include:

- a) Actual energy capacity test to determine the SOH (state of health) guarantee.
- b) Input and output power rating test.
- c) Round trip efficiency test to verify the round-trip efficiency guarantee.

- d) System response test: time and ramp rate;
- e) Self-discharge system test;
- f) Rated voltage and frequency range test.

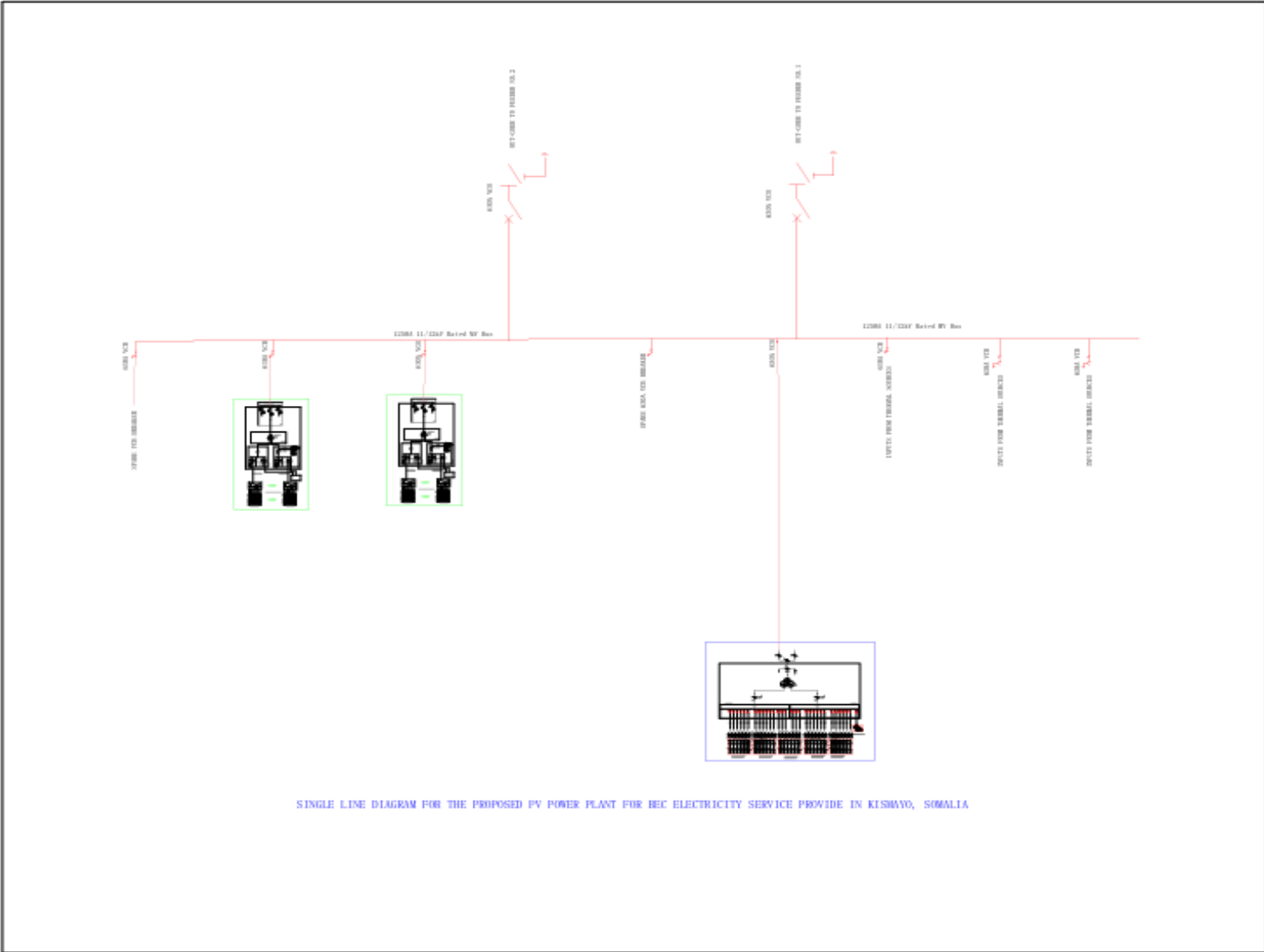
In addition, other performance tests shall be undertaken, including but not limited to PV shifting, PV smoothing and ancillary services such as frequency regulation.

11.6 Trial operation tests

After passing the above tests, the trial operation period shall be conducted. Successful Trial Operation will be deemed achieved when the system has first achieved and maintained an average Availability of 97% for a minimum of 168 consecutive hours without the need for any on-site presence excluding external faults.

12. APPENDICES

APPENDIX 1: SLD FOR THE POWER PLANT



REVISIONS, ADDITIONS & ALTERATIONS		
NO	DATE	DESCRIPTION

CONSULTANTS	

CLIENT	

PROJECT	
WESCO- PROPOSED HYBRID SOLAR PV POWER PLANT WITH BESS	

DRAWING NAME	

DRAWING NAME	

PROJECT NO	
A201	

DATE	

DATE	

REVISION NO	

REVISION NO	

APPENDIX 2: BESS PERFORMANCE PARAMETERS

Item	Parameter	Definition	Units	Specification
Power Conversion System Specification				
P1	Power Conversion System	Nominal voltage level at converter output terminal	V	
P2		Maximum voltage level at converter output terminal	V	
P3		Minimum voltage level at converter output terminal	V	
P4		Rated power of total converter (kW)	KW	
P5		Basic module size (kW)	KW	
P6		Converter type (e.g. Voltage or current source)	-	
P7		Semiconductor valve type (e.g. IGBT, transistor)	-	
P8		Parasitic load (kW)	KW	
P9		Converter Efficiency at 100% Power output	%	
P10		Details of the cooling system employed on the converter	-	
P11		Reactive Power Capability (Leading / Lagging)	KVAr	
Technical Availability				
P12	Total Technical Availability	Total Technical Availability	Hours/year	
P13	Expected Unavailability	Planned (hours per year); describe how planned hours are calculated	Hours/year	
		Unplanned (hours per year); describe how unplanned hours are calculated	Hours/year	
P14	Redundancy	State whether there is any redundancy in the system such as HVAC etc.	-	
Power Ratings				
P15	Rated Discharge Power - ESS	The maximum steady state active power at which the ESS can continuously deliver at the AC terminals of the PCS	KW	
P16	Rated Charge Power - ESS	The maximum steady state active power at which the ESS can continuously absorb at the AC terminals of the PCS	KW	
P17	Rated Reactive Power - ESS	The maximum steady state reactive power (active power = 0, lagging or leading) at which the ESS can continuously deliver/absorb at the AC terminals of the PCS	KVAr	
P18	Rated Apparent Power - ESS	The maximum steady state apparent power at which the ESS can continuously deliver/absorb at the AC terminals of the PCS	KVA	
P19	Active Power versus Reactive Power Curve	Provide a plot showing the operating area of active power versus reactive power of the system output	-	
P20	Overload Discharge Power	The magnitude of temporary active power (reactive power = 0) and the duration that the ESS can deliver before overheating.	KW	
			Min	
P21	Overload Charge Power		KW	

Item	Parameter	Definition	Units	Specification
		The magnitude of temporary active power (reactive power = 0) and the duration that the ESS can absorb before overheating.	Min	
P22	Overload Reactive Power	The magnitude of temporary reactive power (Active Power = 0) and the duration that the ESS can deliver/absorb before overheating.	KW	
			Min	
Energy Ratings				
P23	Available Discharge Energy - ESS	The accessible energy that can be provided by the ESS when discharging at rated power at the Beginning of Life (BOL).	KWh	
P24	Recommended Discharge Energy - BOL	The quantity of manufacturer-defined usable energy at BOL to maximize life of the asset when subjected to daily or more frequent cycling	KWh	
State of Charge				
P25	Recommended Maximum State of Charge	The maximum percentage state of charge the manufacturers recommends to maximize life of the asset when subjected to daily or more frequent cycling	%	
P26	Recommended Minimum State of Charge	The minimum percentage state of charge the manufacturers recommends to maximize life of the asset when subjected to daily or more frequent cycling	%	
Reactive Power Ramp Rate				
P27	Charge Reactive	Maximum rate of change of reactive power (increasing and decreasing, both lagging and leading)	KVAr/s	
		Charge Cycle Characteristics		
P28	Charge Duration	The minimum amount of time required for the ESS to be charged at rated charge power over entire SOC range: from 0% - 100% SOC	Hours	
P29	Charge Ramp Rate	The maximum rate that the ESS can change its input power. This may vary in multiple dimensions such as SOC and/or other parameters of the system. Break out into multiple line item values, as applicable. In the latter case provide a graph of Ramp Rate (y-axis) vs. SOC (x-axis).	KW/s	
P30	Charge Start up time	Start up time from shutdown – standby	Seconds	
P31	Charge Ramp up time	Ramp up time (in standby): 0 - Pmax	Seconds	
		Discharge Cycle Characteristics		
P32	Discharge Duration	The amount of time that the ESS can be discharged at rated charge power over entire SOC range: from 100% - 0% SOC.	Hours	
P33	Discharge Ramp Rate	The maximum rate that the ESS can change its output power. This may vary in multiple dimensions such as SOC and/or other parameters of the system. Break out into multiple line item values, as applicable. In the latter case provide a	KW/s	

Item	Parameter	Definition	Units	Specification
		graph of Ramp Rate (y-axis) vs. SOC (x-axis).		
P34	Discharge Start up time	Start-up time from shutdown – standby	Seconds	
P35	Discharge Ramp up time	Ramp up time (in standby): 0 - Pmax	Seconds	
Response Times				
P36	Response Time	received at the ESS boundary and continuing until the ESS discharge power output (electrical or thermal) reaches 100% of its rated power when the PCS is in Ready mode.	Seconds	
		Maximum time response between a charge order and a discharge order	Seconds	
		Time between when the external signal (command) is received at the ESS boundary and continuing until the ESS discharge power output (electrical or thermal) reaches 100% of its rated power when the power changes from full rated charge to full rated discharge	Seconds	
P37	Settling Time	Time measured between when the ESS reaches 100% of the control setpoint value to when it maintains the power value at $\pm 5\%$ of the control setpoint.	Seconds	
P38	System Latency	Time measured between when the control signal is sent and the ESS responds to the signal by changing the discharge or charge power value by more than 1% of the control setpoint.	Seconds	
Total AC-AC roundtrip efficiency (RTE_{AC}) of the ESS at BOL defined as the ratio of the delivered discharge energy to the delivered charge energy at the PCS output terminals, including ESS parasitic loads. Evaluation of the system performance at different SOC levels and at different charge / discharge power levels				
P39	ESS Efficiency Power Curves	If available provide associated system efficiency power curves (inclusive of all parasitics) from 100% down to the minimum SOC level. The graph shall display curves for different power ratings indicated below with Efficiency (y-axis) vs. SOC (x-axis).	-	
P40	Pmax (maximum power output)	State of Charge (or SOC) 100%	%	
		SOC 75%	%	
		SOC 50%	%	
		SOC 25%	%	
		SOC 10%	%	
P41	50% of Pmax	SOC 100%	%	
		SOC 75%	%	
		SOC 50%	%	
		SOC 25%	%	
		SOC 10%	%	
P42	Pmin (minimum output)	SOC 100%	%	
		SOC 75%	%	
		SOC 50%	%	
		SOC 25%	%	
		SOC 10%	%	
P43	Poptimal (power at maximum efficiency)	SOC 100%	%	
		SOC 75%	%	
		SOC 50%	%	
		SOC 25%	%	

Item	Parameter	Definition	Units	Specification
		SOC 10%	%	
Maximum discharge duration from full SOC				
P44	Pmax	Power	KW	
		Duration	Min,hrs, etc.	
P45	75% of Pmax	Power	KW	
		Duration	Min,hrs, etc.	
P46	50% of Pmax	Power	KW	
		Duration	Min,hrs, etc.	
P47	25% of Pmax	Power	KW	
		Duration	Min,hrs, etc.	
P48	P optimal	Power	KW	
		Duration	Min,hrs, etc.	
Cycle Life Ratings - The number of cycles that the energy storage system can perform until EOL, independent of calendar life degradation, at indicated average depth of discharge				
P49	Cycle Life Ratings	Cycle life at 100% DoD	Cycles	
		Cycle life at 90% DoD	Cycles	
		Cycle life at 80% DoD	Cycles	
		Cycle life at 70% DoD	Cycles	
		Cycle life at 60% DoD	Cycles	
		Cycle life at 50% DoD	Cycles	
		Cycle life at 40% DoD	Cycles	
		Cycle life at 30% DoD	Cycles	
		Cycle life at 20% DoD	Cycles	
		Cycle life at 10% DoD	Cycles	
		Expected equivalent full cycles for the duty cycle specified for the site	Cycles	
Energy Throughput				
P50	BOL Energy Throughput	Specify the Rated Energy Throughput at BOL	KWh	
P51	Energy Throughput Degradation	Specify the annual Rated Energy Throughput degradation over the specified expected life. If not linear, then a graph shall be provided	%/Year	
P52	Guaranteed Energy Throughput	Confirm that the required minimum Energy Throughput for the life of the BESS will be maintained	Yes/No	
P53	Energy Throughput Maintenance	Indicate the proposed methodology for maintaining capacity (augmentation vs. over-size).	-	
Self-Discharge Rates				
P54	Self-Discharge Rate & Shelf Life	Self-discharge rate (from 100% SOC) in standby mode	% over time	
		Self-discharge rate (from 100% SOC) in shutdown mode	% over time	
		Shelf life of inactive device	years, months, etc.	
BESS Degradation				
P55	Calendar Life Degradation	Annual degradation of rated discharge energy, independent of cycle life degradation under normal operating conditions. Specify the conditions	Graph	
P56	Specified Duty Cycle	Site specific cycling requirement (e.g. 1 full discharge per day or kwh throughput per day). Supplier to confirm this requirement can be met	Yes/No	

Item	Parameter	Definition	Units	Specification
P57	Annual Rated Discharge Energy Degradation for Specified Duty Cycle	Graph of the degradation rate of rated discharge energy and impedance (if applicable) with buyer specified duty cycle. Specify Charge/Discharge, DoD, and EOL conditions. Over the expected life expectancy of 20 years	Graph	
P58	Annual ESS Efficiency Degradation for Specified Duty Cycle	Graph of the degradation of efficiency with buyer specified duty cycle. Specify Charge/Discharge, DoD, and EOL conditions. Over the expected life expectancy of 20 years	Graph	
P59	End of Life (EOL) Criteria	The condition of the ESS at the beginning to end of life in terms of capacity, internal resistance, efficiency, and other pertinent parameters.	Graph	
P60	Internal resistance test	The condition of the ESS at the beginning of life in terms of internal resistance	Ohm	

APPENDIX 3: GUARANTEED TECHNICAL PARTICULARS

The Bidder shall submit duly filled Guaranteed Technical Particulars (GTP) for each major equipment; duly completed and signed by the Manufacturer of the equipment and submitted together with relevant copies of the Manufacturer's Technical data sheet, catalogues, brochures, drawings, technical data & calculations, copies of complete type test reports and accreditation certificate for the testing laboratory for tender evaluation, all in English language. The foregoing technical specifications requirements contained in this chapter shall guide the filling in of the GTPs. The GTPs should include at the following

- a) PV Modules
- b) String Inverters
- c) BESS
- d) Inverter Transformer
- e) GIS Synchronization/ Combiner Panel
- f) Cables (3 core 70mm² and 185mm²)
- g) SCADA & EMS I/O Sheet

a) GTP FOR PV MODULES

ITEM NO.	SPECIFICATION OF THE PV MODULES	REQUIREMENT	BIDDER'S RESPONSE
1	Product Certification as per IEC 61215	Must be compliant	Bidder to indicate
2	Cell Type	Mono Crystalline / Polycrystalline	Bidder to indicate
3	Weight	-	Bidder to indicate
4	Dimensions	-	Bidder to indicate
5	No of Cells	-	Bidder to indicate
6	Cable Cross Section area	6mm ² (IEC)	Bidder to indicate
7	Junction Box	IP68 (with diodes)	Bidder to indicate
8	Connectors	MC4 Plug (IP65)	Bidder to indicate
9	Front glass coating	Minimum 3.2mm anti reflect coating	Bidder to indicate
10	Front glass Material	High Tempered Glass	Bidder to indicate
11	Frame	Anodized Aluminium	Bidder to indicate
12	Maximum Power Rated (Pmax) @ STC	-	Bidder to indicate
13	Open Circuit Voltage (Voc)V	-	Bidder to indicate
14	Maximum Power Voltage (Vmp) V	-	Bidder to indicate
15	Short Circuit Current (Isc)A	-	Bidder to indicate
16	Maximum Power Current (Imp)A	-	Bidder to indicate
17	PV Module efficiency (%)	Minimum 20%	Bidder to indicate
18	Power Tolerances	0-/+3%	Bidder to indicate
19	Temperature Coefficient of Isc	-	Bidder to indicate
20	Temperature Coefficient of Voc	-	Bidder to indicate
21	Temperature Coefficient of Pmax	-	Bidder to indicate
22	Operating Temperature	$-15^{\circ}\text{C} \leq T \leq 45^{\circ}\text{C}$	Bidder to indicate
23	Mechanical Load as per IEC 61215	-	Bidder to indicate
24	Protection Class as per IEC 61730	-	Bidder to indicate
25	Salt Mist Corrosion Test as per IEC 61701	-	Bidder to indicate
26	Wind Load Withstand	-	Bidder to indicate

28	Load Pressure Withstand	-	Bidder to indicate
29	Warranty	Minimum 15 years	Bidder to indicate
30	Linear Performance Guarantee	90% up to 15 years and 88% up to 25 years)	Bidder to indicate
31	CE Conformity	Required	Bidder to indicate
NAME OF BIDDER:			
SIGNATURE OF BIDDER:			

b) GTP FOR STRING INVERTERS

<i>Note. MINIMUM RECOMMENDED CAPACITY SHALL BE OF 330KVA</i>			
ITEM NO.	SPECIFICATION OF THE INVERTER	REQUIREMENT	BIDDER'S RESPONSE
1	Max. Efficiency	> 99.0%	Bidder to indicate
2	European Efficiency	> 98.8%	Bidder to indicate
3	Max. Input Voltage	1,500 V	Bidder to indicate
4	Number of MPPT	6	Bidder to indicate
5	Max. Current per MPPT	65	Bidder to indicate
6	Max. Short Circuit Current per MPPT	115 A	Bidder to indicate
7	Max. PV Inputs per MPPT	4/5/5/4/5/5	Bidder to indicate
8	Start Voltage	550 V	Bidder to indicate
9	MPPT Operating Voltage Range	500 V ~ 1,500 V	Bidder to indicate
10	Nominal Input Voltage	1,080 V	Bidder to indicate
11	Nominal AC Active Power	275,000 W ¹	Bidder to indicate
12	Max. AC Apparent Power	330,000 VA	Bidder to indicate
13	Max. AC Active Power (cos ϕ =1)	330,000 W	Bidder to indicate
14	Nominal Output Voltage	800 V, 3W + PE	Bidder to indicate
15	Rated AC Grid Frequency	50 Hz / 60 Hz	Bidder to indicate
16	Nominal Output Current	198.5 A	Bidder to indicate
17	Max. Output Current	240.3 A	Bidder to indicate
18	Adjustable Power Factor Range	0.8 LG ... 0.8 LD	Bidder to indicate
19	Total Harmonic Distortion	THDi < 1% (Rated)	Bidder to indicate
20	Smart String-level Disconnection (SSLD)	Yes	Bidder to indicate
21	Smart Connector-level Detection (SCLD)	Yes	Bidder to indicate
22	AC Overcurrent Protection	Yes	Bidder to indicate
23	DC Reverse-polarity Protection	Yes	Bidder to indicate
24	PV-array String Fault Detection	Yes	Bidder to indicate
25	DC Surge Arrester	Type II	Bidder to indicate
26	AC Surge Arrester	Type II	Bidder to indicate
27	DC Insulation Resistance Detection	Yes	Bidder to indicate
28	Residual Current Detection Unit	Yes	Bidder to indicate
29	Display	LED Indicators, WLAN + APP	Bidder to indicate
30	USB	Yes	Bidder to indicate
31	MBUS	Yes	Bidder to indicate
32	RS485	Yes	Bidder to indicate
33	Dimensions (W x H x D)	1,048 x 732 x 395 mm	Bidder to indicate
34	Weight (with mounting plate)	< 112 kg	Bidder to indicate

35	Operating Temperature Range	-25°C ~ 60°C	Bidder to indicate
36	Cooling Method	Smart Air Cooling	Bidder to indicate
37	Max. Operating Altitude without Derating	4,000 m	Bidder to indicate
38	Relative Humidity	0 ~ 100% (non-condensing)	Bidder to indicate
39	DC Connector	HH4SMM4TMSPA / HH4SFM4TMSPA	Bidder to indicate
40	AC Connector	Support OT / DT Terminal (Max. 400 mm ²)	Bidder to indicate
41	Protection Degree	IP 66	Bidder to indicate
42	Anti-corrosion Protection	C5-Medium	Bidder to indicate
43	Topology	Transformer less	Bidder to indicate
45	Warranty	10 years	Bidder to indicate
	IEC 62109-1/-2, IEC 62920, IEC 60947-2, EN 50549-2, IEC 61683, etc.		Bidder to indicate
NAME OF BIDDER:			
SIGNATURE OF BIDDER:			

c) GTP FOR BESS

BESS			
ITEM NO.	SPECIFICATION OF THE BATTERY STORAGE SYSTEMS	REQUIREMENT	BIDDER'S RESPONSE
1	Minimum Rated Capacity (kWhr)	2.0MWh	Bidder to indicate
2	DC Rated Voltage	1,250 V	Bidder to indicate
3	DC Max. Voltage	1,500 V	Bidder to indicate
4	Nominal Energy Capacity	2,032 kWh	Bidder to indicate
5	Charge & Discharge Rate	< 0.5C	Bidder to indicate
6	Rated Power	338.7 kW * 3	Bidder to indicate
7	Container Configuration (W x H x D)	6,058 x 2,896 x 2,438 mm	Bidder to indicate
8	Container Weight	< 30 t	Bidder to indicate
9	Operation Temperature Range	-30°C ~ 55°C	Bidder to indicate
10	Storage Temperature Range	-40°C ~ 60°C	Bidder to indicate
11	Relative Humidity	0 ~ 100% (non-condensing)	Bidder to indicate
12	Max. Operating Altitude	4,000 m	Bidder to indicate
13	Cooling Method	Smart Air Cooling	Bidder to indicate
14	Configuration of HVAC	4 HVACs	Bidder to indicate
15	Fire Suppression Agent	FM-200 or Novec 1230™	Bidder to indicate
16	Communication Interface	Ethernet / SFP	Bidder to indicate
17	Communication Protocol	Modbus TCP / IEC104	Bidder to indicate
18	Protection Degree	IP55	Bidder to indicate
19	Anti-corrosion Protection	C5-Medium	Bidder to indicate
20	Black Start	Yes	Bidder to indicate
21	Warranty	10years	Bidder to indicate
22	Standard Compliance	RoHS6, IEC62477-1, IEC62040-1, IEC61000-6-2, EN55011, UL9540A, IEC62619, UN3536, etc.	Bidder to indicate
NAME OF BIDDER:			
SIGNATURE OF BIDDER:			

d) GTP FOR INVERTER TRANSFORMER

Take Note: - It is highly recommended to have Transformer, Auxiliary Transformer, 3 Panel GIS and LV Panel (Inverter Panel) in the same Container

ITEM No.	DESCRIPTIONS	UNITS	REQUIREMENT	BIDDER'S RESPONSE
1	Applicable Standards		IEC 60076, EN 5058801	Bidder to indicate
2	Power transformer Make/Model			Bidder to indicate
3	Transformer nominal capacity	MVA	3.15	Bidder to indicate
4	Rated Input Voltage	kV	0.8	Bidder to indicate
5	Rated Output Voltage	kV	11	Bidder to indicate
6	Transformer Type		Oil Immersed Conservator Type	Bidder to indicate
7	Transformer Oil Type		Mineral Oil	Bidder to indicate
8	Cooling Type		ONAN	Bidder to indicate
9	Tappings		+/- 2x2.5%	Bidder to indicate
10	Transformer Vector group		DY 11	Bidder to indicate
11	Transformer Load Losses	kW	27.5	Bidder to indicate
12	Transformer No- Load Losses	kW	2.2	Bidder to indicate
13	Impedance	kVA	7% (0~+ 10 %) 3150	Bidder to indicate
14	One-minute Power frequency Voltage withstand, 50Hz, 60 sec, wet			
	- Primary winding Insulation level	kVrms	10	Bidder to indicate
	Secondary winding Insulation level	kVrms	38	Bidder to indicate
15	Lightning impulse withstand voltage 1.2/50µs, dry +Ve			
	Primary winding	kVrms		
	Secondary winding	kVrms	95	Bidder to indicate
16	Continuous maximum rating current on Nominal and extreme tapping at ambient conditions @ 800V	A	2525	Bidder to indicate
17	Insulation Level		A	Bidder to indicate
18	Average Temperature rise winding	k	65	Bidder to indicate
19	Oil Temperature rise	k	60	Bidder to indicate

20	Rated no-load voltage at rated frequency on			
	HV, principal tapping	kV	11	Bidder to indicate
	HV, Highest tapping	kV	11.275	Bidder to indicate
	HV, Lowest tapping	kV	10.725	Bidder to indicate
	LV winding	kV	0.8	
21	Tapping ranges from principal tapping			
	HV no of plus tapings	No	2x2.5	Bidder to indicate
	HV no of minus tapings	No	2x2.5	Bidder to indicate
	Neutral positions		0	Bidder to indicate
22	HV steps in % of rated voltage ($\pm 2 \times 2.5$)			Bidder to indicate
23	Method of system earthing:			Bidder to indicate
	HV system			Bidder to indicate
	LV system			Bidder to indicate
24	Maximum working flux density at rated voltage on principal tapping and rated frequency		1.9 Wb/sq.m.	Bidder to indicate
25	Core design type		Core Type	Bidder to indicate
26	Grade of laminated and maximum thickness			Bidder to indicate
	Winding conductor material			Bidder to indicate
27	HV Winding	Copper		Bidder to indicate
28	LV Winding	Copper		Bidder to indicate
29	Neutral Winding	Copper		Bidder to indicate
30	Bushing's material			Bidder to indicate
	HV		solid porcelain.	Bidder to indicate
	LV		solid porcelain.	Bidder to indicate
	Neutral		solid porcelain.	Bidder to indicate
31	Principal bushing insulator materials			
	HV			
	LV			
	Neutral			
33	Total creepage distance over porcelain			
	HV bushing	kV	31	Bidder to indicate
	LV bushing	kV	31	Bidder to indicate
34	Off-load tap changer			
35	Model and manufacturer			Bidder to indicate
36	Type Vacuum (In-tank			Bidder to indicate

37	Total number of tappings including principal		5	Bidder to indicate
38	Colour		RAL 7032	Bidder to indicate
39	Warranty	Years	10	Bidder to indicate
NAME OF BIDDER:				
SIGNATURE OF BIDDER:				

e) GTP FOR 11 kV GIS SYNCHRONIZING/ COMBINER PANEL

ITEM No.	DESCRIPTION	UNIT	REQUIREMENT	BIDDER'S RESPONSE
1.	a) Manufacturer's Name & address with website, official domain email.	-	-	Bidder to indicate
	b) Year of Manufacturing	Year	Not before 2023	Bidder to indicate
2.	Type/ Model	-	-	Bidder to indicate
3.	Manufacturer & country of origin	-	-	Bidder to indicate
4.	Applied Standard	-	Latest version of IEC 62271 fully complied and as that of specs	Bidder to indicate
5.	Rated nominal Voltage	kV	11	Bidder to indicate
6.	Rated Voltage	kV	12	Bidder to indicate
7.	Rated Frequency	Hz	50	Bidder to indicate
8.	Material of Bus-Bar	-	HDHC Copper	Bidder to indicate
9.	Busbar Scheme	-	Single Bus with Bus Coupler	Bidder to indicate
10.	Installation	-	Free Standing	Bidder to indicate
11.	Rated Current for Main Bus			Bidder to indicate
	Single Bus (As per scope)	A	1250	Bidder to indicate
12.	Cross Section of bus bar	mm ²	(As per IEC62271)	Bidder to indicate
13.	Rated symmetrical short circuit breaking current for Single Bus	kA	31.5	Bidder to indicate
14.	Short time current rated duration	Sec.	3	Bidder to indicate
15.	Pressure relief device is integrated with each gas chamber	-	Yes	Bidder to indicate
16.	Mimic diagram is depicted in front of switchgear panel	-	Yes	Bidder to indicate
17.	Electrical and Mechanical interlock between Circuit breaker, isolator and earth switch	-	Yes	Bidder to indicate

18.	Capacitive Voltage Indicator with Interlock contact for ES operation	-	Yes	Bidder to indicate
19.	Circuit Breaker:			
	Type of interrupter	-	VCB	Bidder to indicate
	Class of Circuit Breaker (Supported by Type Test report)	-	E2M2 or better	Bidder to indicate
	Designation of Internal Arc Classification (Supported by Type Test Report)	-	IAC AFLR 31.5kA, 1 Sec	Bidder to indicate
	Insulation media	-	SF ₆	Bidder to indicate
	Interrupting media	-	Vacuum	Bidder to indicate
	Manufacturer's name and country of origin of vacuum interrupter	-	-	Bidder to indicate
	Manufacturer's model no. of Vacuum Interrupter (Model no. shall be supported by Type Test)	-	-	Bidder to indicate
	Guaranteed nos. of operation for Vacuum Interrupter			Bidder to indicate
	a) at rated Current switching	Nos.	Min. 10,000	Bidder to indicate
	b) at circuit current switching	Nos.	>50	Bidder to indicate
	Rated Voltage	kV	12	Bidder to indicate
	Rated Current for Incoming as per scope	A	1250	Bidder to indicate
	Rated Current for Outgoing	A	1250	Bidder to indicate
	Rated Current for Power Transformer	A	1250	Bidder to indicate
	Rated Current for Bus coupler (Single Bus) as per scope.	A	1250	Bidder to indicate
	Rated Short Circuit Breaking Current for Single Bus.	kA	31.5	Bidder to indicate
	Rated duration of short circuit current	sec	3	Bidder to indicate
	Rated Short Circuit Making Current for Single Bus.	kA	80	Bidder to indicate
	Rated Breaking time	Cycle	<5	Bidder to indicate
	Opening time	Sec.	-	Bidder to indicate
	Closing time	Sec.	-	Bidder to indicate

	Rated operating Sequence	-	0-0.3 sec-CO-3 min-CO	Bidder to indicate
	Control Voltage	V	DC 110	Bidder to indicate
	AC Voltage for the Universal Motor for spring charge	V	AC 230	Bidder to indicate
	Power Consumption of Charging motor	W	Max 250	Bidder to indicate
	Power consumption of opening/trip coil	W	Max 300	Bidder to indicate
	Nos. of Trip coils	Nos.	2	Bidder to indicate
20.	Three position disconnecter Switch (Both Motor and Manual)			
	Type/ Model	-	-	Bidder to indicate
	Rated Voltage	kV	12	Bidder to indicate
	Rated Current for Incoming as per scope	A	1250	Bidder to indicate
	Rated Current for Outgoing	A	1250	Bidder to indicate
	Rated Current for Power Transformer	A	1250	Bidder to indicate
	Rated Current for Bus coupler (Single Bus) as per scope.	A	1250	Bidder to indicate
	Rated short time current for Single Bus.	kA	31.5	Bidder to indicate
	Short time current rated duration	Sec	3	Bidder to indicate
	Switch Position	-	close, open, earth	Bidder to indicate
	Electrical and Mechanical interlock	-	As per IEC 62271-200	Bidder to indicate
	Mechanical Endurance Class	-	Shall be mentioned	Bidder to indicate
21.	Current Transformer:			
	Type	-	Ring core/block type with sensor	Bidder to indicate
	Rated Voltage	kV	12	Bidder to indicate
	Accuracy Class, Metering	-	0.2 S	Bidder to indicate
	Accuracy Class, Protection	-	5P20	Bidder to indicate
	Rated Current Ratio for incoming as per scope	A	1250/5-5A	Bidder to indicate
	Rated Current Ratio (for Outgoing, Station Auxiliary Feeder)	A	600-1250/5-5A	Bidder to indicate
	Rated Current Ratio (for Bus Coupler; Single Bus)	A	1250/5-5A	Bidder to indicate
	Rated Current Ratio (for power transformer panel)	A	400-1250/5-5-5A	Bidder to indicate
	Burden for metering	VA	20 (at max CT ratio)	Bidder to indicate

	Burden for protection	VA	20 (at max CT ratio)	Bidder to indicate
	Extended Current Rating for metering	A	120 % of rated Current	Bidder to indicate
	Instrument Security factor (metering)	-	<5	Bidder to indicate
	RCT at 75°C			Bidder to indicate
	(a) Measuring Core	mQ	-	Bidder to indicate
	(b) Protection Core	mQ	-	Bidder to indicate
	Knee Point Minimum Voltage (Supported by Calculation)			Bidder to indicate
	(a) Measuring Core	V	-	Bidder to indicate
	(b) Protection Core	V	-	Bidder to indicate
	Rated frequency	Hz	50	Bidder to indicate
	CT burden shall meet the Short Circuit Current (31.5 kA, 3 Sec) (Supported by Calculation)	-	Yes	Bidder to indicate
22	33 kV Cable Compartment: (For INCOMING/OUTGOING & TRANSFORMER Feeder)			
	Material	-	Highly Conductive Copper	Bidder to indicate
	Bus bar type	-	Single	Bidder to indicate
	Cross Section	mm ²	Min 1250 Bus or (As per IEC62271)	Bidder to indicate
	Nominal Current	A	2000	Bidder to indicate
	Cable connection as per scope			Bidder to indicate
23.	Bus Voltage Transformer :			
	Type/ Model	-	-	Bidder to indicate
	Number of Phase	-	Single Phase	Bidder to indicate
	Rated Primary Voltage	kV	11/√3	Bidder to indicate
	Rated Secondary Voltage	V	110/√3	Bidder to indicate
	Rated burden, Secondary	VA	20	Bidder to indicate
	Accuracy class (Metering & Protection)	-	0.2 & 3P	Bidder to indicate
	LV Compartment	-	IP40	Bidder to indicate
24	Line Voltage Transformer:			
	Type/ Model	-	-	Bidder to indicate
	Number of Phase	-	Single Phase	Bidder to indicate
	Rated Primary Voltage	kV	11/√3	Bidder to indicate
	Rated Secondary Voltage	V	110√3	Bidder to indicate
	Rated Burden	VA	20	Bidder to indicate
	Accuracy class (Metering & Protection)		0.2 & 3P	Bidder to indicate

25.	SF6 Safety and life			
	SF6 Pressure	KPa	-	Bidder to indicate
	Rated pressure at 20 degree C	KPa	-	Bidder to indicate
	Bursting Pressure	KPa	-	Bidder to indicate
	Gas leakage rate/year (Supported by Type Test report)	KPa	<0.1%	Bidder to indicate
	Safety indication		To be incorporated	Bidder to indicate
	Capacitive voltage indicator	-	In the front of the panel	Bidder to indicate
	Gas pressure Manometer	-	As per IEC 62271-1	Bidder to indicate
	Bus Bar Gas Pressure Manometer		As per IEC 62271-1	Bidder to indicate
	Life/ Endurance of switchgear switches			Bidder to indicate
	a) Circuit Breakers		As per IEC 62271-100	Bidder to indicate
	b) Disconnectors & Earthing switches		As per IEC 62271-102	Bidder to indicate
	Alarm level for insulation	KPa	140	Bidder to indicate
	Rated filling level for insulation	KPa	150	Bidder to indicate
26.	Dimension and Weight			
	Height	mm		Bidder to indicate
	Width	mm		Bidder to indicate
	Depth	mm		Bidder to indicate
	Weight including Circuit Breaker	Kg.		Bidder to indicate
27.	Construction:			Bidder to indicate
	a) Stainless steel tank	-		Bidder to indicate
	b) Equipped with disconnector and earthing switch. The earthing switch shall have full fault-making capacity.	-		Bidder to indicate
	c) Each gas filled compartment shall be equipped with density sensors giving alarm by low gas density.	-		Bidder to indicate
28.	Degree of Protection			Bidder to indicate
	Enclosure	-	IP3X	Bidder to indicate
	HV Compartment	-	IP65	Bidder to indicate
	LV Compartment	-	IP40	Bidder to indicate
29.	Insulation level:			Bidder to indicate
	AC withstand voltage 1 min. dry	kV	38	Bidder to indicate

	Impulse Withstand, full wave	kV	95	Bidder to indicate
30.	Type Test Report (as per IEC 62271-200)			
	Lightning Impulse Voltage Withstand tests	-		Bidder to indicate
	Power frequency withstand tests	-		Bidder to indicate
	Temperature/ Gas pressure Rise Tests.	-		Bidder to indicate
	Measurement of resistance of the main circuit.	-		Bidder to indicate
	Short circuit performance tests	-		Bidder to indicate
	Mechanical Endurance tests.	-		Bidder to indicate
	Arc fault test	-		Bidder to indicate
	Gas Leakage Test	-		
A. Protection Control & Metering (Transformer Feeder)				
31.	Differential and Restricted Earth Fault Relay			
	Manufacturer's Name			Bidder to indicate
	Country of Origin	-		Bidder to indicate
	Manufacture's Model no.	-		Bidder to indicate
	Type of Relay	-		Bidder to indicate
	Maximum through fault at which the protective equipment is stable with recommend settings:			
	a) Earth faults		rating % of CT rating	Bidder to indicate
	b) Phase faults		rating % of CT rating	Bidder to indicate
	Maximum time delay between initiation of fault and energize of breaker trip circuit.		ms	Bidder to indicate
	The Relay shall be IEC 61850 protocol type.	-	Yes	Bidder to indicate
	Relay Nominal operating voltage	-	110 Vdc	Bidder to indicate
	Relay CT Current rating	-	5A	Bidder to indicate
	No of Binary Input (Minimum)		There shall be total 42 BI in Transformer Feeder Panel	Bidder to indicate
	No of Binary Output (Minimum)		There shall be total 32 BO in Transformer Feeder Panel	Bidder to indicate
	No of Communication Ports	-		Bidder to indicate
	i) Electrical			Bidder to indicate
	ii) Optical			Bidder to indicate

	Protection Functions	-	Differential and Restricted earth fault protection (for a Two winding transformer considering Vector group of Dyn 11 and other mandatory functions)	Bidder to indicate
	Relay Configuration Software (Name, Manufacturer, Version, License Requirement (with name and version))	-		Bidder to indicate
	Range of current setting: (a) Earth Faults (b) Phase Faults		%of CT rating	Bidder to indicate
	Range of timing settings		Sec	Bidder to indicate
	Burden of relay at 20-time CT rating		VA	Bidder to indicate
	Percentage of current setting at which relay will reset.		%	Bidder to indicate
	The relay shall have IEC 61850 communication Protocol	-	Yes	Bidder to indicate
32.	Over Current & Earth Fault Protection Relay			
	Manufacture's Name Country of Origin			Bidder to indicate
	Manufacture's Model no.	-	-	Bidder to indicate
	Type of relay	-	Numerical programmable Multifunction	Bidder to indicate
	Range of current setting:	-		Bidder to indicate
	a) Phase element		%of CT rating	Bidder to indicate
	b) Each fault element		%of CT rating	Bidder to indicate
	Relay Nominal operating voltage	-	110 Vdc	Bidder to indicate
	Relay CT Current rating	-	5A	Bidder to indicate
	No of Binary Input (Minimum)	-	There shall be total 42 BI in Transformer Feeder Panel	Bidder to indicate
	No of Binary Output (Minimum)	-	There shall be total 32 BO in Transformer Feeder Panel	Bidder to indicate
	No of Communication Ports iii) Electrical iv) Optical	-	Shall be mentioned with type.	Bidder to indicate
	Protection Function	-	Non-Directional O/C, E/F Other Necessary Functions.	Bidder to indicate

	Maximum time delay between initiation of fault and energize of breaker trip circuit.	-	-	Bidder to indicate
	Relay Configuration Software (Name, Manufacturer, Version, License Requirement (with name and version))	-	-	Bidder to indicate
	Range of timing settings		Sec	Bidder to indicate
	Burden of relay at 20 time CT rating		VA	Bidder to indicate
	Drop off to Pick up ratio		%	Bidder to indicate
	Reset time after removal of fault current		Sec	Bidder to indicate
	The relay shall have IEC 61850 communication Protocol	-	Yes	Bidder to indicate
	Manufacture's Model no.	-	-	Bidder to indicate
	Type of Relay	-	-	Bidder to indicate
34	Trip Relay (Separate Relay) for Differential and O/C & E/F)			
	Manufacture's Name	-	-	Bidder to indicate
	Country of Origin	-	-	Bidder to indicate
	Manufacture's Model no.	-	-	Bidder to indicate
	Type of Relay	-	-	Bidder to indicate
	Operating Time	ms	<10	Bidder to indicate
	Operating Coil Voltage- 110V DC	-	Yes	Bidder to indicate
	Self-reset type for O/C, E/F protection	-	Yes	Bidder to indicate
	Hand & Electrical reset type for Differential, REF and Transformer Selfprotection	-	Yes	Bidder to indicate
35	Separate Auxiliary Flag Relays for Transformer self-protection (OTA, OTT, WTA, WTT, BA, BT, OLTC Surge, PRO for main tank & OLTC.			
	Manufacture's Name	-	-	Bidder to indicate
	Country of Origin	-	-	Bidder to indicate
	Manufacture's Model no.	-	-	Bidder to indicate
	Type of Relay	-	-	Bidder to indicate
36	Annunciator			
	Manufacture's Name	-		Bidder to indicate
	Country of Origin	-		Bidder to indicate
	Manufacture's Model no.	-		Bidder to indicate

	Windows	Nos.	30	Bidder to indicate
	Built in buzzer and buttons for accept, mute, test, reset, etc.	-	Yes	Bidder to indicate
	AC /DC Dual Supply Provision	-	Yes	Bidder to indicate
37	Control Switch			Bidder to indicate
	Manufacture's Name	-	-	Bidder to indicate
	Country of Origin	-	-	Bidder to indicate
	Manufacture's Model no.	-	-	Bidder to indicate
	Separate TNC/Discrepancy switch and Local Remote (L/R) selector switch	-	Yes	Bidder to indicate
B. Protection Control & Metering (Incoming/Outgoing Feeder & Bus Coupler				
38.	Over Current & Earth Fault Protection Relay			
	Manufacture's Name	-		Bidder to indicate
	Country of Origin	-		
	Manufacture's Model no.	-	-	Bidder to indicate
	Type of relay	-	11kV Incoming/ Outgoing line feeders numerical relay shall have both directional and non-directional O/C & E/F protection (IDMT, DMT, Inst.) feature with monitoring functions” 11kV Bus coupler feeders numerical relay shall have non- directional O/C & E/F protection (IDMT, DMT, Inst.) and synchro check feature with monitoring functions.	Bidder to indicate
	Range of current setting:	-		Bidder to indicate
	a) Phase element		%of CT rating	
	b) Each fault element		%of CT rating	Bidder to indicate
	Relay Nominal operating voltage	-	110 Vdc	Bidder to indicate
	Relay CT Current rating	-	5A	Bidder to indicate
	No of Binary Input (Minimum)	-	24 for line Feeder, 32 for Bus Coupler	Bidder to indicate
	No of Binary Output (Minimum)	-	24 for line Feeder, 24 for Bus Coupler	Bidder to indicate
	No of Communication Ports v) Electrical vi) Optical	-	-	Bidder to indicate

	Protection Function		Directional and Non-Directional O/C, E/F, Over/ Under Voltage, Over and Under Frequency, Sync Check and Other Necessary Functions.	Bidder to indicate
	Maximum time delay between initiation of fault and energize of breaker trip circuit.	-	-	Bidder to indicate
	Relay Configuration Software (Name, Manufacturer, Version, License Requirement (with name and version))	-	-	Bidder to indicate
	Maximum time delay between initiation of fault and energize of breaker trip circuit.	-	-	Bidder to indicate
	Drop off to Pick up ratio	-		Bidder to indicate
	Reset time after removal of fault current	-		Bidder to indicate
	Range of timing settings		Sec	Bidder to indicate
	Burden of relay at 20 time CT rating		VA	Bidder to indicate
	The relay shall have IEC 61850 communication Protocol	-	Yes	Bidder to indicate
39	Trip Circuit Supervision (TCS) Relay (Separate Relay for each trip coil)			
	Manufacture's Name	-		Bidder to indicate
	Country of Origin	-		Bidder to indicate
	Manufacture's Model no.	-		Bidder to indicate
	Type of Relay	-		Bidder to indicate
40	Trip Relay (Separate Relay)			
	Manufacture's Name	-		Bidder to indicate
	Country of Origin	-		Bidder to indicate
	Manufacture's Model no.	-		Bidder to indicate
	Type of Relay	-		Bidder to indicate
	Operating Time	ms	<10	Bidder to indicate
	Self-reset type for O/C, E/F protection	-	Yes	Bidder to indicate
	Operating Coil Voltage- 110V DC	-	Yes	Bidder to indicate
41	Annunciator			Bidder to indicate
	Manufacture's Name	-		Bidder to indicate

	Country of Origin	-		Bidder to indicate
	Manufacture's Model no.	-		Bidder to indicate
	Windows	nos.	14	Bidder to indicate
	Built in buzzer and buttons for accept, mute, test, reset, etc.	-	Yes	Bidder to indicate
	AC /DC Dual Supply Provision	-	Yes	Bidder to indicate
42	Control Switch			Bidder to indicate
	Manufacture's Name	-		Bidder to indicate
	Country of Origin	-		Bidder to indicate
	Manufacture's Model no.	-		Bidder to indicate
	Separate TNC/Discrepancy switch and Local Remote (L/R) selector switch	-	Yes	Bidder to indicate
43	Metering and Instrumentation (for Incoming/Outgoing, Power Transformer & Bus Coupler feeder)			
	a) Energy Meter (Multi Tariff Programmable Meter) (N.B. Not applicable for Bus Coupler Panel)			Bidder to indicate
	Manufacture's Name	-	-	Bidder to indicate
	Manufacture's Country		-	Bidder to indicate
	Manufacture's Model no.	-	-	Bidder to indicate
	Type of Meter	-	Numerical programmable	Bidder to indicate
	Class of Accuracy		0.2 S	Bidder to indicate
	b) VOLT METERS with Selector Switch			
	Manufacturer's Name and Country	-	-	Bidder to indicate
	Manufacture's Model no.		-	Bidder to indicate
	Type of Meter	-	Analogue, 90-degree scale range	Bidder to indicate
	Class of Accuracy	-	1.0	Bidder to indicate
	Bus Coupler panel shall have 2 nos. voltmeter with seven (7) position voltage selector switch		-	
	c) Ampere Meters			Bidder to indicate
	Manufacturer's Name and Country			Bidder to indicate
	Manufacture's Model no.			Bidder to indicate
	Type of Meter		Analogue, 240 degree scale range	Bidder to indicate
	Class of Accuracy	-	1.0	Bidder to indicate
	Separate A-meter for each phase		Yes	Bidder to indicate
C. Station Auxiliary Transformer Switchgear Unit				
44.	Manufacturer's Name & Address	-	-	Bidder to indicate

45.	Manufacturer country of origin	-	-	Bidder to indicate
46.	Type	-	-	Bidder to indicate
47.	Rated nominal Voltage	kV	33	Bidder to indicate
48.	Rated Voltage	kV	36	Bidder to indicate
49.	Material of Bus-Bar	-	HDHC Copper	Bidder to indicate
50.	Rated Current for main bus			Bidder to indicate
	Single Bus (As per scope)	Amps	1250	Bidder to indicate
51.	Cross Section of busbar	mm2	1250	Bidder to indicate
52.	Rated short time current	kA	31.5	Bidder to indicate
53.	Short time current rated duration	Sec.	3	Bidder to indicate
54.	Circuit Breaker :			Bidder to indicate
	Manufacturer's model no. of vacuum interrupter	-	-	Bidder to indicate
	Rated Voltage	kV	11	Bidder to indicate
	Rated Current	A	1250	Bidder to indicate
	Rated Short Ckt. Breaking Current	kA	31.5	Bidder to indicate
	Rated duration of short circuit current	sec	3	Bidder to indicate
	Rated Short CKt. Making Current	kA	80	Bidder to indicate
	Rated Breaking time	Cycle	<5	Bidder to indicate
55.	TPS (DS-ES) (Motor & Manually Operated)			
	Rated Maximum Voltage	kV	12	Bidder to indicate
	Operating Mechanism	-	-	Bidder to indicate
	Insulating media	-	SF6	
	Rated Current	A	1250	
	Rated short time current	kA	31.5	
	Short time current rated duration	Sec	3	Bidder to indicate
	Switch Position	-	close, open, earth	Bidder to indicate
	Electrical and Mechanical interlock	-	As per IEC 62271-200	Bidder to indicate
	Mechanical Endurance Class	-	-	Bidder to indicate
56.	Insulation level:			Bidder to indicate
	AC withstand voltage Imin. dry	kV	38	Bidder to indicate
	Impulse Withstand, full wave	kV	95	Bidder to indicate
58.	Degree of Protection			Bidder to indicate
	Enclosure	-	IP3X	Bidder to indicate

	HV Compartment	-	IP65	Bidder to indicate
	LV Compartment	-	IP40	Bidder to indicate
59.	Dimension and Weight			Bidder to indicate
	Height	mm	-	Bidder to indicate
	Weight	mm	-	Bidder to indicate
	Depth	mm	-	Bidder to indicate
60.	Type Test Report (as per IEC 62271-200)			
	Lightning Impulse Voltage Withstand tests	-	-	Bidder to indicate
	Power frequency withstand tests		-	Bidder to indicate
	Temperature/Gas pressure Rise Tests.		-	Bidder to indicate
	Measurement of resistance of the main circuit.	-	-	Bidder to indicate
	Short circuit performance tests	-	-	Bidder to indicate
	Mechanical Endurance tests.	-	-	Bidder to indicate
	Arc fault test		-	Bidder to indicate
	Gas Leakage Test		-	Bidder to indicate
D. Protection Control & Metering for station transformer				
61	Over Current and Earth Fault Protection Relay			Bidder to indicate
	Manufacture's Name Country of Origin	-	-	Bidder to indicate
	Manufacture's Model no.	-	-	Bidder to indicate
	Type of relay		Numerical programmable, multifunction with both directional and non-directional O/C & E/F protection (IDMT, DMT, Inst.) feature and monitoring functions.	Bidder to indicate
	Relay Nominal operating voltage	-	110Vdc	Bidder to indicate
	Relay CT Current rating	-	5A	Bidder to indicate
	No of Binary Input (Minimum)	-	24	Bidder to indicate
	No of Binary Output (Minimum)	-	24	Bidder to indicate
	No of Communication Ports vii) Electrical viii) Optical	-	-	Bidder to indicate
	Protection Function		Non-Directional O/C, E/F Other Necessary Functions.	Bidder to indicate

	Maximum time delay between initiation of fault and energize of breaker trip circuit.	-	-	Bidder to indicate
	Relay Configuration Software (Name, Manufacturer, Version, License Requirement (with name and version))	-	-	Bidder to indicate
	Maximum time delay between initiation of fault and energize of breaker trip circuit.	-	-	Bidder to indicate
	Range of Current Setting a) Phase Fault Element b) Earth Fault Element	-	-	Bidder to indicate
	Range of timing settings	-	-	Bidder to indicate
	Drop off to Pick up ratio	-	-	Bidder to indicate
	Reset time after removal of fault current	-	-	Bidder to indicate
	Burden of Relay At 20 time CT rating.	VA	-	Bidder to indicate
	The relay shall have IEC 61850 communication Protocol.	-	Yes	Bidder to indicate
62	Trip Circuit Supervision (TCS) Relay (Separate Relay)			
	Manufacture's Name	-	-	Bidder to indicate
	Country of Origin	-	-	Bidder to indicate
	Manufacture's Model no.	-	-	Bidder to indicate
	Type of Relay	-	-	Bidder to indicate
63	Trip Relay (Separate Relay)		-	Bidder to indicate
	Manufacture's Name	-	-	Bidder to indicate
	Country of Origin	-	-	Bidder to indicate
	Manufacture's Model no.	-	-	Bidder to indicate
	Type of Relay	-	-	Bidder to indicate
64	Annunciator		-	Bidder to indicate
	Manufacture's Name	-	-	Bidder to indicate
	Country of Origin	-	-	Bidder to indicate
	Manufacture's Model no.	-	-	Bidder to indicate
	Windows	Nos.	14	Bidder to indicate
	Built in buzzer and buttons for accept, mute, test, reset, etc.	-	Yes	Bidder to indicate

	AC /DC Dual Supply Provision	-	Yes	Bidder to indicate
65	Metering			
	a) Energy Meter (Multi Tariff Programmable Meter)			Bidder to indicate
	Manufacture's Name	-	-	Bidder to indicate
	Manufacture's Country		-	Bidder to indicate
	Manufacture's Model no.	-	-	Bidder to indicate
	Type of Meter	-	Numerical	Bidder to indicate
	Class of Accuracy	-	0.2 S	Bidder to indicate
	b) Volt Meters			Bidder to indicate
	Manufacturer's Name and Country	-	-	Bidder to indicate
	Manufacture's Model no.	-	-	Bidder to indicate
	Type of Meter	-	Analogue, 90-degree scale range	Bidder to indicate
	Class of Accuracy	-	1.0	Bidder to indicate
	c) Ampere Meters			Bidder to indicate
	Manufacturer's Name and Country	-	-	Bidder to indicate
	Manufacture's Model no.	-	-	Bidder to indicate
	Type of Meter	-	Analogue, 240-degree scale range	Bidder to indicate
	Class of Accuracy	-	1.0	Bidder to indicate
	Separate A-meter for each phase	-	Yes	Bidder to indicate
66	Marking	-		Bidder to indicate
NAME OF BIDDER:				
SIGNATURE OF BIDDER:				

f) GTP FOR GIS PANEL 630A (3 PANELS, ONE INCOMER & 2 OUT-GOERS)

ITEM NO.	ITEM DESCRIPTIONS	UNITS	REQUIREMENT	BIDDER'S RESPONSE
1	Type & Model Number			Bidder to Indicate
2	Name of Manufacturer & Country of Origin of equipment being offered			Bidder to Indicate
	Applied Standards		IEC 62271-1/100/102/103/200	
3	Service Conditions		As per the Specs	Bidder to Indicate
4	Design standards complied with		As per the Specs	Bidder to Indicate
5	Insulation media-Busbars and Ring Switches		SF6	Bidder to Indicate
6	Circuit Breaker and switch arrangement			Bidder to Indicate
7	Operating Mechanism of the switches			Bidder to Indicate
8	Available Interlocks			Bidder to Indicate
9	Type of Cable box			Bidder to Indicate
10	Size, type and rating of cable terminals			Bidder to Indicate
11	Overall dimensions for a 3 panel unit (3CB panel) Height x Width x Depth in mm			Bidder to Indicate
12	Equipment service life	years	40	Bidder to Indicate
13	Manufacturing experience			
	(a) MV Panel			Bidder to Indicate
	(b) Vacuum CB			Bidder to Indicate
	(c) Vacuum Ring switches			Bidder to Indicate
14	Internal Arc fault design safety		IAC A 20kA/1s	Bidder to Indicate
15	RATINGS:			
16	Nominal System Voltage	kV	11	Bidder to Indicate
17	Maximum System Voltage	kV	12	Bidder to Indicate
18	Equipment Voltage Class			
19	Frequency	Hz	50	Bidder to Indicate
20	Impulse Withstand Voltage, peak (1.2/50µs dry)	kVrms	95	Bidder to Indicate
21	Power Frequency Withstand Voltage, rms (50 Hz: 60s wet)	kVrms	38	Bidder to Indicate
22	MV Main Switch Rated Current (temperature rise within I EC requirements)	A	630	Bidder to Indicate
23	Main and Earth Switches rated short time current (3 seconds)	kA	20	Bidder to Indicate
24	Rated Peak Withstand Current	kA	50	Bidder to Indicate
25	Gas Leakage Rate Per Year	%	0.10%	Bidder to Indicate

26	Tee-off rated current	A	630	Bidder to Indicate
NAME OF BIDDER:				
SIGNATURE OF BIDDER:				

g) GTP FOR THE 3C 70mm² AL/XLPE/STA/PVC 11kV(12kV) MULTI CORE CABLE

3C 70mm ² AL XLPE/STA/PVC 11kV(12kV) MULTI CORE CABLE				
ITEM NO.	ITEM DESCRIPTIONS	UNITS	REQUIREMENT	BIDDER'S RESPONSE
1	Applicable standards		As per the specs	Bidder to Indicate
2	Cable Application		HV connection	
3	System Conditions		As per the specs	Bidder to Indicate
4	Anti-termite protection			
5	Fire Performance (indicate applicable IEC standards)		IEC 60331 & other related relevant standards	Bidder to Indicate
6	Minimum Design Service Life		As per the specs	Bidder to Indicate
7	Applicable Standards		As per the specs	Bidder to Indicate
8	Continuous Operating Temperature		90°C-250°C	Bidder to Indicate
9	Short Circuit Temperature (1 second duration)	kA	25	Bidder to Indicate
10	Conductor		Aluminium Conductor, XLPE Insulated	Bidder to Indicate
11	Conductor Screen		Extruded semiconducting XLPE	
12	Insulation		XLPE	
13	Insulation application			Bidder to Indicate
14	Insulation Colour			Bidder to Indicate
15	Individual Cores			Bidder to Indicate
16	Insulation Screen			Bidder to Indicate
17	Laying-up			Bidder to Indicate
18	Separation Layer			Bidder to Indicate
19	Armour		STA	Bidder to Indicate
20	Oversheath		HDPE	Bidder to Indicate
21	Embossing on Oversheath			Bidder to Indicate
22	Conductor nominal sectional area, mm ²	mm ²	70	Bidder to Indicate
23	Voltage Designation	kV	11/12	Bidder to Indicate
24	Conductor shape		Circular	Bidder to Indicate

25	Thickness of insulation	mm	8.8	Bidder to Indicate
26	Thickness of separation layer			Bidder to Indicate
27	Armour wire diameter, mm			Bidder to Indicate
28	Thickness of oversheath, mm			Bidder to Indicate
29	Approximate overall diameter, mm			Bidder to Indicate
30	Power frequency withstand voltage of cable	kVrms	38	Bidder to Indicate
31	Test Voltage (after installation), d.c., kV/5min			
32	Maximum conductor resistance, Ω/km	DC @ 20 °C (Ω/km)/ AC @ 90°C (Ω/km)	0.443/ 0.5682	Bidder to Indicate
33	Current carrying capacity	In Air	275	Bidder to Indicate
34		in Duct	219	Bidder to Indicate
35	Test report showing the below			
	a) Bending test, followed by a partial discharge test;			Bidder to Indicate
	b) Tan δ measurement;			Bidder to Indicate
	c) Heating cycle test, followed by a partial discharge test;			Bidder to Indicate
	d) Impulse test, followed by a voltage test;			Bidder to Indicate
	e) Voltage test for 4 h			
NAME OF BIDDER:				
SIGNATURE OF BIDDER:				

h) I/O SHEETS FOR THE SCADA & EMS

ITEM No.	DESCRIPTIONS		SIGNAL TYPE	SIGNAL	UNIT	ALARM	SOE	TREND	REPORT
	33 kV Line Bays								
1	SF6CB	Open/Close	DI	PF			Y		
2	SF6CB	Auto Trip Operated/ Not Operated	DI	PF			Y		
3	SF6 CB Gas Pressure Low	SF6 Gas Pressure Low	DI	PF		Y			
4	CB L/R SWITCH	CB Local/Remote Mode	DI	PF			Y		
5	CB TRIP CIRCUIT SUPERVISION RELAY	Operated/Not Operated	DI	PF			Y		
6	CB TRIP CIRCUIT	Healthy/ Not Healthy	DI	PF			Y		
7	CB SPRING CHARGE	Charged/ Uncharged	DI	PF			Y		
8	CB D.C SUPPLY	Fail/ Not Fail	DI	PF		Y			
9	MASTER TRIP RELAY (86 RLY)	Operated/Not Operated	DI	PF		Y	Y		
10	MASTER TRIP RELAY RESET	Operated/Not Operated	DI	PF		Y			
11	Main -1 TRIP	Operated/Not Operated	DI	PF		Y			
12	Main -2 TRIP	Operated/Not Operated	DI	PF		Y			
13	OVER CURRENT/ EARTH FAULT (51N/ 50 RLY)	Trip/ Not Trip	DI	PF		Y			
14	OVER VOLTAGE/UNDER VOLTAGE (59/27 RLY)	Operated/Not Operated	DI	PF		Y			
15	SYNCHRONISING RLY (25 RLY)	Fail/ Not Fail	DI	PF		Y			
16	BREAKER FAILURE RLY (50BF RLY)	Fail/ Not Fail	DI	PF		Y			
17	AC RECLOSING RELAY/AUTO RECLOSE RELAY (79 RLY)	Operated/Not Operated	DI	PF					
18	ISOLATOR	Open/Close	DI	PF			Y		
19	EARTH SWITCH	Open/Close	DI	PF			Y		
	33 kV - Transformer Bay	Signal							
1	Tr. BUCHHOLZ RLY	Alarm - Bucchoz Relay Operation	DI	PF		Y			
2	Tr. PR REL VLV	Alarm - Pressure Release Valve	DI	PF		Y			
3	Tr. LO OIL LVL	Alarm - Low Transformer Oil	DI	PF		Y			
4	Tr. WNDG TEMP	Alarm - Transformer Winding Temperature High	DI	PF		Y			

5	Tr. WNDG TEMP	Alarm - Transformer Winding Temperature Breach/Trip	DI	PF					
6	Tr. OIL TEMP	Alarm - Transformer Oil Temperature High	DI	PF		Y			
7	Tr. OIL TEMP	Alarm - Transformer Oil Temperature Breach/Trip	DI	PF					
8	Tr. WNDG TEMP	Transformer Winding Temperature	AI	4-20MA	Deg C				
9									
10	Tr. OIL TEMP	Transformer Oil Temperature	AI	4-20MA	Deg C				
11	Tr. TAP POSITION	Transformer Tap Position	AI	4-20MA					
12	TAP	Increase Tap Position	DO	110V DC			Y		
13	TAP	Decrease Tap Position	DO	110V DC			Y		
14	DIFFERENTIAL RELAY(87T)	Operated/Not Operated	DI	PF					
15	GROUND PROTECTIVE RELAY (64 HV)	Operated/Not Operated	DI	PF					
16	GROUND PROTECTIVE RELAY (64 LV)	Operated/Not Operated	DI	PF					
17	R PH VOLTAGE	R Phase Voltage	SOFT AI		KV			Y	
18	Y PH VOLTAGE	Y Phase Voltage	SOFT AI		KV			Y	
19	B PH VOLTAGE	B Phase Voltage	SOFT AI		KV			Y	
20	R PH CURRENT	R Phase Current	SOFT AI		A			Y	
21	Y PH CURRENT	Y Phase Current	SOFT AI		A			Y	
22	B PH CURRENT	B Phase Current	SOFT AI		A			Y	
	33 kV - Bus Bar and Bus Coupler Bay								
1	ACTIVE POWER	Active Power Generated	SOFT AI		KW			Y	
2	REACTIVE POWER	Reactive Power Generated	SOFT AI		KV A R			Y	
3	ENERGY	Energy Injected	SOFT AI		KW H			Y	
4	SF6 CB CMD	Close Command	DO	110V DC			Y		
5	SF6 CB CMD	Open Command	DO	110V DC			Y		
6	ISOLATOR	Open/Close	DI	PF			Y		
7	EARTH SWITCH	Open/Close	DI	PF			Y		
8	Energy Meters								
9	Energy Exported in 15 min to GRID	Plant End ABT Meter	SOFT AI	RS485	MW h				Y
	33 kV CB PANEL INCOMER FEEDER (FROM INVERTER TRANSFORMER)								
1	CB OPEN/CLOSE	VCB Open/ Close	DI	PF			Y		
2	CB IN REMOTE	VCB in Remote Mode	DI	PF			Y		
3	CB IN SERVICE	VCB in Service Mode	DI	PF			Y		
4	CB 86 OPERATED	VCB Master Trip Operated	DI	PF			Y		
5	CB TRIP CKT UNHEALTHY	CB Trip Circuit Unhealthy	DI	PF			Y		
6	CB SPRING CHARGED	VCB Spring Charged	DI	PF			Y		

7	CB PROTECTION TRIP	Protection Trip Operated	DI	PF			Y		
8	CB CONTROL SUPPLY HEALTHY	Control Supply Healthy	DI	PF			Y		
9	CB IN LOCAL	CB in Leal Mode	DI	PF			Y		
10	CB IN TEST	CB in Test Mode	DI	PF			Y		
11	Tr. WNDG TEMP TRIP	Transformer Winding Temperature Tripped	DI	PF			Y		
12	Tr. WNDG TEMP ALARM	Transformer Winding Temperature Alarm	DI	PF		Y			
13	Tr. OIL TEMP TRIP	Transformer Oil Temperature Tripped	DI	PF			Y		
14	Tr. OIL TEMP ALARM	Transformer Oil Temperature Alarm	DI	PF		Y			
15	Tr. PRV TRIP	Pressure Release Valve Tripped	DI	PF			Y		
16	Tr. PRV ALARM	Pressure Release Valve Alarm	DI	PF		Y			
17	Tr. BUCHHOLZ TRIP	Buccholz Relay Tripped	DI	PF			Y		
18	Tr. BUCHHOLZ ALARM	Buccholz Relay Alarm	DI	PF		Y			
19	Tr. MOG TRIP	Magnetic Oil Gauge Trip	DI	PF			Y		
20	Tr. MOG ALARM	Magnetic Oil Gauge Alarm	DI	PF		Y			
21	R PH CURRENT	R Phase Current	SOFT AI	RS485	A			Y	
22	Y PH CURRENT	Y Phase Current	SOFT AI	RS485	A			Y	
23	B PH CURRENT	B Phase Current	SOFT AI	RS485	A			Y	
24	ACTIVE POWER	Active Power	SOFT AI	RS485	KW			Y	
25	REACTIVE POWER	Reactive Power	SOFT AI	RS485	KV A R			Y	
26	ENERGY	Energy Export	SOFT AI	RS485	MW H			Y	
27	CB CMD	CB Clode Command	DO	110V DC			Y		
28	CB CMD	CB Open Command	DO	110V DC			Y		
	33kV CB PANEL OUTGOING FEEDERS								
1	CB CLOSE/OPEN	CB Open or Close	DI	PF			Y		
2	CB IN REMOTE	CB in Remote Mode	DI	PF			Y		
3	CB IN SERVICE	CB in Service Mode	DI	PF			Y		
4	CB 86 OPERATED	CB Master Trip Relay Operated	DI	PF			Y		
5	CB TRIP CKT UNHEALTHY	CB Circuit Healthy/Unhealthy	DI	PF			Y		
6	CB SPRING CHARGED	CB Spring Charged Status	DI	PF			Y		
7	CB PROTECTION TRIP	Protection Trip Operated	DI	PF			Y		
8	CB CONTROL SUPPLY HEALTHY	Control Supply Healthy	DI	PF			Y		
9	CB IN LOCAL	CB in Leal Mode	DI	PF			Y		
10	CB IN TEST	CB in Test Mode	DI	PF			Y		
11	CB UV PROTECTION OPTD	CB Undervoltage Protection	DI	PF			Y		
12	R PH CURRENT	R Phase Current	SOFT AI	RS485	A			Y	

13	YPH CURRENT	Y Phase Current	SOFT AI	RS485	A			Y	
14	B PH CURRENT	B Phase Current	SOFT AI	RS485	A			Y	
15	ACTIVE POWER	Active Power	SOFT AI	RS485	KW			Y	
16	REACTIVE POWER	Reactive Power	SOFT AI	RS485	KV A R			Y	
17	ENERGY	Energy	SOFT AI	RS485	MW H			Y	
18	CB CMD	Breaker Close Command	DO	110V DC			Y		
19	CBCMD	Breaker Open Command	DO	110V DC			Y		
	INVERTER TRANSFORMER & AUXILIARY TRANSFORMER								
1	TR WNDG TEMP (HV side)	HV Winding Temperature	AI	4-20MA	Deg C				
2	TR WNDG1 TEMP (LV side)	LV Winding Temperature	AI	4-20MA	Deg C				
3	TR OIL TEMP	Transformer Oil Temperature	AI	4-20MA	Deg C				
	415V PANEL FOR ACDB								
1	ACDB CB	Operated/Not Operated/Ready	DI	PF			Y		
2	ACDB Bus Voltage								
3	ACDB R PH VOLTAGE (P-P)		SOFT AI	RS485	V			Y	Y
4	ACDB Y PH VOLTAGE (P-P)		SOFT AI	RS485	V			Y	Y
5	ACDB B PH VOLTAGE (P-P)		SOFT AI	RS485	V			Y	Y
6	ACDB R PH CURRENT (Incomer)		SOFT AI	RS485	A			Y	Y
7	ACDB Y PH CURRENT (Incomer)		SOFT AI	RS485	A			Y	Y
8	ACDB B PH CURRENT (Incomer)		SOFT AI	RS485	A			Y	Y
9	ACDB ACDB ENERGY (Incomer)		SOFT AI	RS485	MW H			Y	
10	ACDB ACDB POWER (Incomer)		SOFT AI	RS485	MW			Y	
	LT Panel at different locations								
1	CB Status		DI	PF			Y		
	SOLAR and BESS PCU								
1	PCU IGBT Module Trouble	Yes/NO	DI	PF					
2	Input DC Voltage VOLT	DC Input Voltage	SOFT AI	TCP/I P	V			Y	Y
3	Input DC Current AMP	DC Input Current	SOFT AI	TCP/I P	A			Y	Y
4	Input DC Power KW	DC Input Power	SOFT AI	TCP/I P	KW			Y	Y
5	AC Voltage VOLT	AC Output Voltage	SOFT AI	TCP/I P	V			Y	Y
6	AC Current AMP	AC Output Current	SOFT AI	TCP/I P	A			Y	Y
7	AC Power KW	AC Power	SOFT AI	TCP/I P	KW			Y	Y
8	Frequency	Frequency	SOFT AI	TCP/I P	Hz			Y	Y
9	Power Factor	Power Factor							
10	Watt-hour meter KWH Export		SOFT AI	TCP/I P	KW H				Y

11	Reactive Power Output								
12	PCU Temperature		SOFT AI	TCP/I P	Deg C				Y
13	ON CMD	On Command	SOFT DO	TCP/I P					
14	OFF CMD	Off Command	SOFT DO	TCP/I P					
15	Active Power Limit		SOFT AO	TCP/I P					
16	Reactive Power Limit		SOFT AO	TCP/I P					
17	LVRT Start/End		SOFT AI	TCP/I P					
18	HVRT Start/End		SOFT AI	TCP/I P					
	Weather Monitoring Station								
1	SOLAR Irradiance Horizontal		AI	4- 20MA	W/ M 2			Y	Y
2	SOLAR Irradiance Tilted surface		AI	4- 20MA	W/ M 2			Y	Y
3	SOLAR ENERGY Horizontal		SOFT					Y	Y
4	SOLAR ENERGY Tilted surface		SOFT					Y	Y
5	WIND VELOCITY AND DIRECTION		AI	4- 20MA	km/ h			Y	Y
6	Ambient Temperature		AI	4- 20MA	deg C			Y	Y
7	Module Surface Temperature		AI	4- 20MA	deg C			Y	Y
	Other Signals (MCR/ ICR)								
1	FIRE ALARM PANEL		DI	PF		Y			
2	DC SYSTEM SIGNAL		DI	PF		Y			
3	UPS BATTERY		DI	PF		Y			
4	UPS INVERTER		DI	PF		Y			
5	UPS BATTERY		DI	PF		Y			
6	UPS CHARGER		DI	PF		Y			
7	UPS VOLTAGE		SOFT AI	RS48 5					
8	UPS CURRENT		SOFT AI	RS48 5					
9	GPS CLOCK STATUS	GPS Clock Status/Alarm	DI	PF		Y			