भारतीय प्रौद्योगिकी संस्थान भुवनेश्वर
INDIAN INSTITUTE OF TECHNOLOGY BHUBANESWAR
प्रायोजित अनुसंधान एवं औद्योगिक परामर्श
Sponsored Research and Industrial Consultancy (SRIC)
प्रशासनिक भवन, अरगूल , जटनि, भुवनेश्वर – 752051
ADMINISTRATIVE BUILDING, ARGUL, JATANI – 752051
www.iitbbs.ac.in

1.निविदा के लिए आमंत्रण / NOTICE INVITING TENDER

ENQUIRY NO. : SRIC/RP562/Pilot1/2026/1 **DATE: 10/11/2026**

To
All Eligible Bidders
Dear Sirs / Madams,

विषय /Sub : निविदा के लिए अनुरोध / Notice Inviting Tender for supply installation and commission of Microgrid with 1.6 MWh containerized Battery Energy Storage System

1.1 SRIC, Indian Institute of Technology Bhubaneswar invites online Tenders through CPP Portal **https://eprocure.gov.in/eprocure/app** from eligible Local Suppliers (Class-1 & Class-2 only) for procurement of above mentioned item. **Only Local Suppliers (Class-1 & Class-2) are eligible to bid.**

1.2 All interested vendors are requested to send their quotation in **Two Bid System** for supply of the above item as per details Technical Specification, General Terms and Conditions and other details including **Annexure I to XIII**. **Details of tender are as follows;**

Sl. No	Particulars	Remarks
1	**Tender Reference No. & Date**	**SRIC/RP562/Pilot1/2026/1 ; Date 10/11/2026**
2	**Type of Tender**	**Two Bid System**
3	**Publish Date & Time**	As per CPPP
4	**Sale/document Download Start Date & Time**	
5	**Bid Submission Start Date & time**	
6	**Bid Submission End Date & Time**	
7	**Time and Date for Opening of Bid**	
8	**Pre-Bid Conference:**	A Pre-Bid Conference will be held on **20/11/2026 at 11:00 Hrs IST in Hybrid Mode.** Pre-bid queries must be submitted in Excel format to office.sric@iitbbs.ac.in on or before **18/11/2026 by 18:00** Hrs IST.
9	**Clarifications regarding Tender Document**	A Bidder requiring any clarification regarding the Tender Document may ask in writing before the clarification end date i.e. before 7 days of the deadline for the bid submission.
10	**EMD / Bid Securing Declaration Form (Annexure –II) if applicable**	The bidders have to submit EMD of **Rs.33,00,000/- (Rupees Thirty Three Lakhs only)**
11	**Onsite Warranty**	**05 Year from the date of Installation and acceptance by the user**
12	**Delivery, Installation and Commissioning**	**Within 90 days from the date of Purchase Order**
13	**Contact Telephone Numbers**	**0674 7134832**

1.2.1 Please refer CPPP system generated DATE SHEET for Tender ID and Critical Dates.

1.3 The Tender document and details of terms and conditions can be downloaded from our website www.iitbbs.ac.in & https://eprocure.gov.in/eprocure/app

1.4 **The bidders may submit their bid only though uploading in the CPP Portal https://eprocure.gov.in/eprocure/app. No bids received by post or by hand or by FAX/E-mail would be considered for evaluation.**

1.5 The Purchaser may, at its discretion, extend the deadline for submission of bids by amending the bid documents in accordance with Clause relating to Amendment of Bidding Documents in which case all rights and obligations of the Purchaser and Bidders previously subject to the deadline will thereafter be subject to the deadline as extended.

2. Instructions for Online Bid Submission

2.1 The bidders are required to submit soft copies of their bids electronically on the CPPP Portal, using valid Digital Signature Certificates. The instructions given below are meant to assist the bidders in registering on the CPPP Portal, prepare their bids in accordance with the requirements and submitting their bids online on the CPPP Portal.
2.2 More information useful for submitting online bids on the CPPP Portal may be obtained at: **https://etender.gov.in/eprocure/app**

2.3 REGISTRATION

2.3.1) Bidders are required to enroll on the e-Procurement module of the Central Public Procurement Portal (URL: **https://etender.gov.in/eprocure/app**) by clicking on the link "Click here to Enroll". Enrolment on the CPPP Portal is free of charge.

2.3.2) As part of the enrolment process, the bidders will be required to choose a unique username and assign a password for their accounts.

2.3.3) Bidders are advised to register their valid email address and mobile numbers as part of the registration process. These would be used for any communication from the CPPP Portal.

2.3.4) Upon enrolment, the bidders will be required to register their valid Digital Signature Certificate (Class III Certificates with signing key usage) issued by any Certifying Authority recognized by CCA India (e.g. Sify / nCode / eMudhra etc.), with their profile.

2.3.5) Only one valid DSC should be registered by a bidder. Please note that the bidders are responsible to ensure that they do not lend their DSCs to others which may lead to misuse.

2.3.6) Bidder then logs in to the site through the secured log-in by entering their user ID / password and the password of the DSC / e-Token.

2.4 SEARCHING FOR TENDER DOCUMENTS

2.4.1) There are various search options built in the CPPP Portal, to facilitate bidders to search active tenders by several parameters. These parameters could include Tender ID, Organization Name, Location, Date, Value, etc. There is also an option of advanced search for tenders, wherein the bidders may combine a number of search parameters such as Organization Name, Form of Contract, Location, Date, Other keywords etc. to search for a tender published on the CPPP Portal.

2.4.2) Once the bidders have selected the tenders they are interested in, they may download the required documents / tender schedules. These tenders can be moved to the respective 'My Tenders' folder. This would enable the CPPP Portal to intimate the bidders through SMS / e-mail in case there is any corrigendum issued to the tender document.

2.4.3) The bidder should make a note of the unique Tender ID assigned to each tender, in case they want to obtain any clarification / help from the Helpdesk.

2.5 PREPARATION OF BIDS

2.5.1) Bidder should take into account any corrigendum published on the tender document before submitting their bids.

2.5.2) Please go through the tender advertisement and the tender document carefully to understand the documents required to be submitted as part of the bid. Please note the number of covers in which the bid documents have to be submitted, the number of documents - including the names and content of each of the document that need to be submitted. Any deviations from these may lead to rejection of the bid.

2.5.3) Bidder, in advance, should get ready the bid documents to be submitted as indicated in the tender document / schedule and generally, they can be in PDF / XLS / RAR / DWF/JPG formats. Bid documents may be scanned with 100 dpi with black and white option which helps in reducing size of the scanned document.

2.5.4) To avoid the time and effort required in uploading the same set of standard documents which are required to be submitted as a part of every bid, a provision of uploading such standard documents (e.g. PAN card copy, annual reports, auditor certificates etc.) has been provided to the bidders. Bidders can use "My Space" or ''Other Important Documents'' area available to them to upload such documents. These documents may be directly submitted from the "My Space" area while submitting a bid, and need not be uploaded again and again. This will lead to a reduction in the time required for bid submission process.
Note: *My Documents space is only a repository given to the Bidders to ease the uploading process. If Bidder has uploaded his Documents in My Documents space, this does not automatically ensure these Documents being part of Technical Bid.*

2.6 SUBMISSION OF BIDS

2.6.1) Bidder should log into the site well in advance for bid submission so that they can upload the bid in time i.e. on or before the bid submission time. Bidder will be responsible for any delay due to other issues.

2.6.2) The bidder has to digitally sign and upload the required bid documents one by one as indicated in the tender document.

2.6.3) Bidders are requested to note that they should necessarily submit their financial bids in the format provided and no other format is acceptable. If the price bid has been given as a standard BoQ format with the tender document, then the same is to be downloaded and to be filled by all the bidders. Bidders are required to download the BoQ file, open it and complete the (unprotected) cells with their respective financial quotes and other details (such as name of the bidder). No other cells should be changed. Once the details have been completed, the bidder should save it and submit it online, without changing the filename. If the BoQ file is found to be modified by the bidder, the bid will be rejected.
2.6.4) The server time (which is displayed on the bidders' dashboard) will be considered as the standard time for referencing the deadlines for submission of the bids by the bidders, opening of bids etc. The bidders should follow this time during bid submission.

2.6.5) All the documents being submitted by the bidders would be encrypted using PKI encryption techniques to ensure the secrecy of the data. The data entered cannot be viewed by unauthorized persons until the time of bid opening. The confidentiality of the bids is maintained using the secured Socket Layer 128 bit encryption technology. Data storage encryption of sensitive fields is done. Any bid document that is uploaded to the server is subjected to symmetric encryption using a system generated symmetric key. Further this key is subjected to asymmetric encryption using buyers/bid opener's public keys. Overall, the uploaded tender documents become readable only after the tender opening by the authorized bid openers.
2.6.6) The uploaded tender documents become readable only after the tender opening by the authorized bid openers.

2.6.7) Upon the successful and timely submission of bids (i.e. after Clicking "Freeze Bid Submission" in the portal), the portal will give a successful bid submission message & a bid summary will be displayed with the bid no. and the date & time of submission of the bid with all other relevant details.

2.6.8) Kindly add scanned PDF of all relevant documents in a single PDF file of compliance sheet.
2.6.9) The bid summary has to be printed and kept as an acknowledgement of the submission of the bid. This acknowledgement may be used as an entry pass for any bid opening meetings.
2.6.10) The bidder may please note that there is no facility of extension of the bid submission date for what so ever reason. Therefore they should ensure that the bid is uploaded well in advance without waiting for the last date and time as there could be issues like server not responding, internet speed slow, and document not getting uploaded and so on. IIT Bhubaneswar shall not be responsible for any of these factors.

2.7 ASSISTANCE TO BIDDERS

2.7.1) Any queries relating to the tender document and the terms and conditions contained therein should be addressed to the Tender Inviting Authority for a tender or the relevant contact person indicated in the tender.

2.7.2) Any queries relating to the process of online bid submission or queries relating to CPPP Portal in general may be directed to the 24x7 CPPP Portal Helpdesk.

2.7.3) Tenderer are advised to follow the instructions provided in the 'Instructions to the Tenderer for the e-submission of the bids online through the Central Public Procurement Portal for e Procurement at https://etender.gov.in/eprocure/app.

3. INSTRUCTIONS

1. Bidders must submit their digitally signed bids in first Envelop contains the following documents:

A. Cover 1

i) Make & Model offered along with literature
ii) EMD Details
iii) Local content % & Country of Origin (Annexure-I)
iv) Bid-Securing Declaration Form (Annexure-II) If applicable
v) Bidder Information Form (Annexure-III)
vi) Acceptance of Terms & Conditions of Bid (Annexure-IV)
vii) Vendor Master Form (Annexure-V)
viii) Manufacturers' Authorization Form (Annexure-VI)
ix) Undertaking regarding restrictions under Rule 144(xi) of the GFR 2017 (Annexure-VII)
x) Price reasonability Declaration (Annexure-IX)
xi) INTEGRITY PACT (Annexure-X)
xii) Technical Specifications and Quality Assurance – Compliance (Annexure-XI)
xiii) Form Of Bank Guarantee For Bid Security (Earnest Money Deposit) (Annexure-XII) If used
xiv) Past Performance/Experience (Similar Purchase order must be submitted)
xv) SME Udyam Registration/ Startup DPIIT Recognition certificate (if applicable)
xvi) Firm Registration certificate,
xvii) Firm GST Registration certificate & PAN of the firm
xviii) Audited Financial Statements /CA Certificate for Annual Turnover and any other documents as mentioned in eligibility criteria.

B. Cover 2

i) Price Bid. (**In Second Envelop in BoQ Ms-Excel format**.)
ii) Detailed price break-up. (PDF format).

2. The offer must be submitted in **Two Bid - Two Envelope** only through uploading in the CPP Portal, before the last date & time for bid submission.

3. Quotation document (s) and all enclosures must contain the signature of the competent authority of the firm.

4. In case, the firm quoting for above-mentioned items is the Authorized Dealer / Distributor of the manufacturer. Copy of authorization certificate should be enclosed with the quotation. Offers submitted without proper authorization shall be rejected summarily.

5. **Original Equipment Manufacturer (OEM) and their Authorized Dealer / Distributor both shall not be participating in tendering process. In such case, OEM Bid will be considered as per CVC guidelines.**

6. EMD: The bidders have to submit EMD of **Rs. 33,00,000/- (Rupees Thirty Three Lakhs only)** in the form of DD/FDR Pledge in favour of SRIC IIT Bhubaneswar, payable at Jatni, Bhubaneswar OR online transfer or Bank Guarantee in the prescribed format (Annexure-XII) OR for eligible MSE/Startup bidders Bid Securing Declaration as per (Annexure II). Photo copy financial instrument (DD/FDR/BG) in respect of depositing the EMD must accompany the Bid and Original instrument EMD must be submitted to the SRIC Office, IIT Bhubaneswar, Argul, Jatni, 752051 within 15 days from the submission of Bid.

7. SRIC Bank Details for EMD Submission : **A/c Name: SRIC IIT BHUBANESWAR A/c No.: 38605214766 ; IFSC: SBIN0061223; STATE BANK OF INDIA, IIT Argul.**

8. The eligible MSE and Startup bidders having valid Udyam Registration/ DPIIT Recognition Certificate mentioning the similar nature activity applicable for this bid [For eg. (NIC-2025): 272003 Activities Covered: Manufacturing of non-rechargeable batteries, rechargeable batteries, battery packs, and containerized or standard Battery Energy Storage Systems (BESS)], are exempted for payment of EMD, however, such bidders need to submit Bid Security Declaration as per the Annexure-II) to avail EMD exemption.

9. **Eligibility Criteria for the Bidder:**

Shall be having international reputation while meeting the following criterion:

1. Technical Eligibility Criteria

- Completion of similar work in the past 5 years
    - Minimum number of similar projects executed 5, each with a value of not less than Rs. 10 Crores, during the preceding 05 financial years (for eligible SME and Startup bidders similar project executed is 03)
- Availability of qualified staff or equipment
- Certifications like ISO, BIS, or product-specific licences
- Authorizations from OEMs (Original Equipment Manufacturers)

2. Financial Eligibility Criteria

- Minimum average annual turnover for the last 05 financial years shall be not less than Rs. 50 Crores (for eligible SME and Startup bidders average annual turnover shall be not less than Rs. 30 Crores).
- No default or NPA declarations from your bank.
- Audited Financial Statement/CA Certificate for annual turnover to be submitted.

3. Legal and Regulatory Criteria

Bidders must always comply with legal requirements. These are like:

- Valid PAN, GSTIN, and business registration
- UDYAM registration for SMEs (if applying under SME benefits)
- EPF, ESI registrations (if manpower supply is involved)
- Non-blacklisting certificate
- Affidavit or declaration on the company's legal status

Note: Falsification of any legal document or suppression of disqualifying facts can lead to permanent blacklisting.

4. Work Experience Requirements

Successful bidder is required to submit:

- Work order copies

- Completion certificates from clients
- Performance certificates, especially for government works

6. Certifications and Authorisations

- Authorization letters from OEMs
- Safety or environmental compliance certificates
- BIS or FSSAI registration (for food products)
- NABL accreditation (for testing labs)

4. TERMS & CONDITIONS

The offer must comprise of the following failing which it will be treated as non-responsive hence rejected:

1. **Conditional tenders will not be accepted.**
2. **Price Bid must be submitted in as per BoQ in MS-ExceL format only, no other format will be accepted.**
3. **Bidders shall fill all the boxes in BoQ to be filled by Bidders. No Box should be left blank. As the comparative statement will be generated by system. As system generates the comparative statement on the basis of the final landing cost. In case, any box left blank by Bidder such as taxes etc. system presumed that all break up prices included in the final landing cost.**
4. **The bidder shall complete the BOQ as provided in the bidding documents. The BoQ must be completed without any alterations to its format and no substitutes shall be accepted. All blank spaces shall be filled in with the information requested in BoQ.**
5. **Optional items. There is no scope to quote optional items in BoQ. Bidders shall quote the price for all stores offered in Techno-commercial bid.**
6. **Late and delayed quotation:** Late and delayed tender will not be considered. If, in any case, unscheduled holiday occurs on prescribed closing/opening date, the next working day shall be the prescribed date of closing/opening. It will be the sole responsibility of the firm that bid should submitted on or before the due date and time on CPPP.
7. **Pre-installation Requirement:** The bidder should mention pre-installation requirements for the equipment like ambient temperature, humidity, weather specification, power specifications, etc., when items are provided full performance satisfactions, should be demonstrated.
8. E-Waybill: E-Waybill may be issued by the institute against the invoice of the vendor on request. If required as per the GoI notification w.e.f 01.07.2017 & subsequent amendments.
9. **TAXES:** Taxes must be either inclusive/extra in exact figure should be mentioned clearly by the bidder in Price Bid BoQ.
10. Authorization Dealer Certificate of Principal.
11. The exact days of delivery period, installation & commissioning schedule.
12. **The quoted price (final offer) must be F.O.R. i.e. IIT Bhubaneswar, Permanent Campus, Argul, near Jatni, 752051 including Packing & Forwarding, Freight, and Insurance etc.**
13. **Institute may ask L1 Bidder to submit the sample within stipulated time period for approval. Purchase Order will be issued only after the sample approval.**

14. **<u>Award of the Contract:</u> Contract will be awarded to lowest evaluated bidder subject to Purchase Preference Policies in Pursuant to Public Procurement Policy for Micro and Small Enterprises (MSEs) Order 2018 and Preference in pursuant to Make In India Modified Order dated 04/06/2020 & its subsequent amendments.**

15.1 Price Preference to Local Supplier as defined by to Make In India Modified Order dated 04/06/2020 & its subsequent amendments.

a) **<u>Tendered goods are divisible in nature</u>, the following procedure shall be followed to evaluate L1 with the margin of purchase preference of 20% to Local supplier:**

i. Among all qualified bids, the lowest bid will be termed as L1. If L1 is from a local supplier, the contract for full quantity will be awarded to L1.

ii. If L1 bid is not from a local supplier, 50% of the order quantity shall be awarded to L1. Thereafter, the lowest bidder among the local suppliers, will be invited to match the L1 price for the remaining 50% quantity subject to the local supplier's quoted price falling with in the margin of purchase preference i.e. (L1+20%), and contract for that quantity shall be awarded to such local supplier subject to matching the L1 price. In case such lowest eligible local supplier fails to match the L1 price or accepts less than the offered quantity, the next higher local supplier within the margin of purchase preference shall be invited to match the L1 price for remaining quantity and so on, and contract shall be awarded accordingly. In case some quantity is still left uncovered on local suppliers, then such balance quantity may also be ordered on the L1 bidder.

b) <u>Tendered goods are not divisible in nature</u>, the following procedure shall be followed to evaluate L1 and award of contract:

i. Among all qualified bids, the lowest bid will be termed as L1. If L1 is from a local supplier, the contract will be awarded to L1.

ii. If L1 is not from a local supplier, the lowest bidder among the local suppliers, will be invited to match the L1 price subject to local supplier's quoted price falling within the margin of purchase preference i.e. (L1+20%), and the contract shall be awarded to such local supplier subject to matching the L1 price.

iii. In case such lowest eligible local supplier fails to match the L1 price, the local supplier with the next higher bid within the margin of purchase preference shall be invited to match the L1 price and so on and contract shall be awarded accordingly. In case none of the local suppliers within the margin of purchase preference matches the L1 price, then the contract may be awarded to the L1 bidder.

c) For more clarity in this regard, following table is furnished:

Quantity of Tendered goods	Price quoted by Local suppliers	Finalization of tender
Can be Split	L1	Full order on Local supplier
Can be Split	Not L1 but within L1 + 20%	50% order on Local supplier subject to matching L1 price
Cannot be Split	L1	Full Order on Local supplier
Cannot be Split	Not L1 but within L1+20%	Full Order on Local supplier subject to matching L1 price

d) Definitions of terms applicable to this clause:

i. 'Local content ' means the amount of value added in India which shall be the total value of the item procured (excluding net domestic indirect taxes) minus the value of imported content in the item (including all customs duties) as a proportion of the total value, in percent.

ii. Self certification that the item offered meets the minimum local content of 50% giving details of the location(s) at which the local value addition is made in case the bidder wishes to avail the benefits under the Start up India/ make in India policy.

iii. 'Local supplier' means a supplier or provider whose product offered for procurement, has Local Content equal to or more than 50% as defined under Make In India Modified Order dated 04/06/2020 & its subsequent amendments:

iv. 'L1' means the lowest tender or lowest bid or the lowest quotation received in this tender, bidding process or other procurement solicitation as adjudged in the evaluation process as per the tender or other procurement solicitation.

v. 'Margin of purchase preference ' means the maximum extent to which the price quoted by a local supplier may be above the L1 for the purpose of purchase preference.

e) Verification of local content :

i. The local supplier at the time of tender, bidding or solicitation shall be required to provide self-certification that the item offered meets the minimum local content and shall give details of the location(s) at which the local value addition is made.

ii. In cases of procurement for a value in excess of ₹ 10 crores, the local supplier shall be required to provide a certificate from the statutory auditor or cost auditor of the company (in the case of companies) or from a practicing cost accountant or practicing chartered accountant (in respect of suppliers other than companies) giving the percentage of local content.

iii. False declarations will be in breach of the Code of Integrity under Rule 175(1)(i)(h) of the General Financial Rules for which a bidder or its successors can be debarred for up to two years as per Rule 151 (iii) of the General Finance Rules along with such other actions as may be permissible under law.

15.2 Price Preference to MSEs in Pursuant to Public Procurement Policy for Micro and Small Enterprises (MSEs) Order, 2018 subsequent amendments.:

a). <u>Tendered goods are divisible in nature</u> , The following procedure shall be followed to evaluate L1 with the margin of purchase preference of 15% to MSEs bidder:

i) In case MSE bidder is L1 entire value of the tender is to be ordered on the L1 MSE bidder.

ii) In tender, participating Micro and Small Enterprises quoting price within price band of L1 + 15% shall also be allowed to supply a portion of requirement by bringing down their price to L1 price in a situation where L1 price is from someone other than a Micro and Small Enterprise and such Micro and Small Enterprise shall be allowed to supply upto 25 percent of the total tendered value **(where the tender quantity can be split)**. Within this 25% (Twenty five Percent) quantity, a purchase preference of (4%) four percent is reserved for MSEs owned by Scheduled Caste (SC)/Scheduled Tribe (ST) entrepreneurs & (3%) three percent is reserved for MSEs owned by the Women entrepreneurs. (*if they participate in the tender process, price quoted by them within the L1+ 15% and match the L1 price*).

Illustration: Say total tender quantity is 100 Nos. Then L1 will get 75 Nos, L1+15% MSE(other than SC/ST or women ownership) will get 18 Nos, L1+15% MSE owned by SC/ST will get 4 Nos and L1+15% MSE owned by Women will get 3 Nos, if they match L1 price.

b) <u>Tendered goods are not divisible in nature,</u> The following procedure shall be followed to evaluate L1 with the margin of purchase preference of 15% to MSEs bidder:

i) In case MSE bidder is L1 entire value of the tender is to be ordered on the L1 MSE bidder.

ii) In case MSE bidder is not L1, then MSE shall be allowed to supply total tendered quantity provided their quoted price is within a price band of L1 + 15% and they match the L1 price.

iii) If there are more than one eligible MSE bidders (price band within L1+15%) then the opportunity to match the L1 rate of the tender shall be given first to MSE (who have quoted lowest rate among the MSEs within the price band of L1+15%) and the total quantity shall be awarded to him after matching the L1 price of the tender.

vi) If the MSE who have quoted lowest rate among the MSEs in the price band of L1 + 15% do not agree to match the rate of L1 of the tender, then the next ranked MSE bidder who has quoted within the price band of L1 + 15% in order shall be given chance to match the rate of L1 for award of the quantity/order.

v) For more clarity in this regard, following table is furnished:

Quantity of Tendered goods	Price quoted by MSE	Finalization of tender
Can be Split	L1	Full order on MSE
Can be Split	Not L1 but within L1+15%	25% order on MSE subject to matching L1 price subject to sub quota of SC/ST or Women MSE
Cannot be Split	L1	Full Order on MSE
Cannot be Split	Not L1 but within L1+15%	Full Order on MSE subject to matching L1 price

c) The purchase preference to MSE is not applicable for works contracts where supply of goods not produced by MSEs is involved.

d) The aforesaid Policy is meant for procurement of only goods produced and Services rendered by MSEs and not for any trading activities by them. An MSE unit will not get any Purchase Preference over any other MSE Unit.

e) Definition of MSEs unit ownership for SC/ST or Women (as applicable):

i) In case of proprietary MSE, proprietor(s) shall be SC /ST or Women.

ii) In case of partnership MSE, the SC/ST or Women partners shall be holding at least 51% (fifty-one percent) shares in the unit.

iii) In case of Private Limited Companies, at least 51% (fifty-one percent) share shall be held by SC/ST or Women promoters.

(**Note: Certificate to this effect to be submitted along with bid for availing purchase preference failing which not considered for purchase preference)**

15.3 Purchase preference to all eligible bidders falling within the ambit of the L1+15% (MSE) or L1+20% (Class-I Local Supplier) as the case may be, the only bidder closest to L1 amongst them will be invited first to match L1 price, in case the offer is not accepted then the next higher eligible bidder within the margin of purchase preference shall be invited to match the L1 price. Preference priority in aggregate contracts: MSE (L1 + 15%) applies first, followed by Class-I Local Supplier (L1 + 20%), as per OM No.F.1/4/2021-PPD dated 18/05/2023. This tender is non divisible.

15.4 The Eligible MSEs / Local Supplier Bidder who intend to match the L1 Price (ultimately decided by the Institute) shall indicate the willingness to match the L1 **Price within 2 working** days from the date of communication from the Institute to avail the purchase preference. In the absence of a reply, it shall be presumed that MSE / the Local Supplier Bidder has rejected the offer and the Institute shall proceed further to Award the contract to lowest evaluated bidder.

16 **Option Clause:** The Purchaser reserves the right at the time of contract award to increase or decrease the quantity of goods and services originally specified in the tender document without any change in unit price or other terms and conditions. Further, at the discretion of the purchaser, the quantities in the contract may be enhanced by 30% within the delivery period.

17 The quotations must be neatly typed or computer printed. **Hand written offer will be rejected**. Quotations must carry the numbers of GST No. invariably on the top.

18 **SPECIFICATION AND MAKE:** Quotation should be given for the exact specification and make as shown in the enquiry against Sl. No. of the item., if in the view of the supplier there is any other alternative item which can serve out purpose, quotation may also be given for the same separately client list along with the order copy of similar equipment supplied to any IITs / any Govt. Organization including detail of price & all charges must be attached.

19 In the case of items quoted having specifications different than those mentioned in the enclosed Tender format, kindly submit the information and the prices in the same format but on additional Sheet.

20 **The supplier must have submitted the catalogue of the product along with the technical bid. The supplier must also provide a list of premier institutions (Like IITs/ NITs or Internationally reputed Universities, Government Departments, etc.) to which similar stores has been supplied with product details. A compliance certificate to be provided item wise as per the specification.**

21. **DELIVERY**: **Items should be supplied on the FOR basis of free delivery at IIT Bhubaneswar**, **Argul, near Jatni, Pin-752051**. **Items manufactured outside Bhubaneswar should be supplied on the basis of door delivery on working days.**

22. The date of delivery should be strictly adhered to failing which the purchase order is liable to be cancelled. Penalty may be imposed as per P.O. terms & conditions. Goods should be securely, safely and adequately packed & dispatched at the risk of supplier and packing costs quoting this order reference should be kept in all package. Local firms are requested to deliver the goods in our stores before 3.00 PM on any working day.

23. **VALIDITY PERIOD:** The validity period of the offer should be clearly specified. It should be at least for **180 days** from the last date of submission of quotations.

24. **PERFORMANCE BANK GUARANTEE (PBG)**: The firm has to submit Performance Security of **5% of the total order value.** Performance Security must be **valid for 62 (Sixty Two) months i.e. 2 months** beyond the warranty period to cover the warranty obligations. Performance security is to be issued and sent directly from an Indian Scheduled/Nationalized bank**.**

25. **WARRANTY:** a) The ordered materials should have Comprehensive Warranty for a period of **60 (Sixty) Months** from the date of installation & acceptance by the user. The equipment under warranty period must be attended & problems rectified immediately within 48 hours of lodging of complaint by the Institute and this may be considered as the down time. The warranty period shall automatically be extended for such period for which the equipment is not attended & rectified on lapses of the down time.

    b) On receipt of the Cargo by the Buyer, if it is found that the same has either been wrongly shipped or damaged in transit for inadequate packing etc, the supplier has to arrange for FREE REPLACEMENT including TO and FRO (where applicable) charges of freight forwarder, insurance premium and charges for clearing at International Airport.

26. **PAYMENT:**
    100% Payment within 30 days from successful Installation, Commissioning and acceptance by the user, subject to submission of 5% PBG(as per S.No 24).Full payment within 30 days from the date of received, tested/inspected/commissioned and found satisfactory with regard to quality, quantity and specifications and acceptance by the Indenter.

    NB: The necessary documents need to be submitted i.e Delivery challan, Original Tax invoice, Warranty Certificate, Installation Report & PBG etc.

27. **LIQUIDATED DAMAGES:** As time is the essence of this order, the date of delivery should be strictly adhered to, otherwise the delivery in full or in part may not be accepted and penalty for late delivery will be imposed @ 0.5% per week and part thereof, subject to a maximum of 10% of the total value of supply order. In case of delay in installation the same rate of penalty shall be leviable. In case of cancellation of order no compensation will be paid towards progress of order/procurement.

28. **PACKING:** The suppliers shall be responsible for the material being properly packed for the transport by Road/Air/Sea (as the case may be) so as to ensure there being free from lost or damage or arrival at destinations.

29. All communications are to be addressed to the undersigned only. Any kind of canvassing visit to the Institute Premises for enquiry of the status of the tender without prior permission may lead to rejection of the bid.

30. After the Pre-bid conference, if required, before the deadline for submitting bids, the Procuring Entity may update, amend, modify, or supplement the information, assessment or assumptions contained in the Tender Document by issuing corrigenda and addenda. The corrigenda and addenda shall be published in the same manner as the original Tender Document. Without any liability or obligation, the Portal may send intimation of such corrigenda/ addenda to bidders who have downloaded the document under their login. However, the bidders' responsibility is to check the website(s) for any corrigenda/ addenda. Any corrigendum or addendum thus issued shall be considered a part of the Tender Document. To give reasonable time to the prospective bidders to take such corrigendum/ addendum into account in preparing their bids, the Procuring Entity may suitably extend the deadline for the bid submission, as necessary. After the procuring entity makes such modifications, any Bidder who has submitted his bid in response to the original invitation shall have the opportunity to either withdraw his bid or re-submit his bid superseding the original bid within the extended time of submission.

31. **Disclaimers and Rights of Procuring Entity:**
    The issue of the Tender Document does not imply that the Procuring Entity is bound to select bid(s), and it reserves the right without assigning any reason to reject any or all of the Bids, or cancel the tender process; or abandon the procurement of the Goods; or issue another tender for identical or similar Goods.

32. The Procuring Entity reserves its right to accept or reject any or all Bids, abandon/ cancel the Tender process, and issue another tender for the same or similar Goods at any time before the award of the contract. It would have no liability to the affected Bidder or Bidders or any obligation to inform the affected Bidder or Bidders of the grounds for such action(s).

33. **Dispute Resolution**
    1) **Settlement:** Parties must attempt to settle the dispute amicably within 45 days of notice of dispute send by one party to the other through good faith negotiations.
    2) **Arbitration:** If unresolved, disputes go to a single arbitrator under the Arbitration and Conciliation Act 1996.
    3) **Jurisdiction:** Legal proceedings will be in English, held in Bhubaneswar, and governed by Indian Law. the place of jurisdiction shall be Bhubaneswar, India only.

5. Eligibility Of Bidders

5.1 Further in pursuant to recent amendment to GFR and Order (procurement) dt. 23/7/2020 issued by Fin. Min. GoI , following annexure is added to NIT for eligibility of bidders. Only those Bidders who meet the following eligibility criteria will be considered in addition to other eligibility criteria mentioned in NIT.

Annex III

Model Clause /Certificate to be inserted in tenders etc.

(While adhering to the substance of the Order, procuring entities and GeM are free to appropriately modify the wording of the clause/ certificate based on their past experience, local needs etc.)

Model Clauses for Tenders

I. Any bidder from a country which shares a land border with India will be eligible to bid in this tender only if the bidder is registered with the Competent Authority.

II. "Bidder" (including the term 'tenderer', 'consultant' or 'service provider' in certain contexts) means any person or firm or company, including any member of a consortium or joint venture (that is an association of several persons, or firms or companies), every artificial juridical person not falling in any of the descriptions of bidders stated hereinbefore, including any agency branch or office controlled by such person, participating in a procurement process.

III. "Bidder from a country which shares a land border with India" for the purpose of this Order means: -

a. An entity incorporated, established or registered in such a country; or
b. A subsidiary of an entity incorporated, established or registered in such a country; or
c. An entity substantially controlled through entities incorporated, established or registered in such a country; or
d. An entity whose *beneficial owner* is situated in such a country; or
e. An Indian (or other) agent of such an entity; or
f. A natural person who is a citizen of such a country; or
g. A consortium or joint venture where any member of the consortium or joint venture falls under any of the above

IV. The *beneficial owner* for the purpose of (iii) above will be as under:

1. In case of a company or Limited Liability Partnership, the beneficial owner is the natural person(s), who, whether acting alone or together, or through one or more juridical person, has a controlling ownership interest or who exercises control through other means.
Explanation—

a. "Controlling ownership interest" means ownership of or entitlement to more than twenty-five per cent. of shares or capital or profits of the company;

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b. "Control" shall include the right to appoint majority of the directors or to control the management or policy decisions including by virtue of their shareholding or management rights or shareholders agreements or voting agreements;

2. In case of a partnership firm, the beneficial owner is the natural person(s) who, whether acting alone or together, or through one or more juridical person, has ownership of entitlement to more than fifteen percent of capital or profits of the partnership;

3. In case of an unincorporated association or body of individuals, the beneficial owner is the natural person(s), who, whether acting alone or together, or through one or more juridical person, has ownership of or entitlement to more than fifteen percent of the property or capital or profits of such association or body of individuals;

4. Where no natural person is identified under (1) or (2) or (3) above, the beneficial owner is the relevant natural person who holds the position of senior managing official;

5. In case of a trust, the identification of beneficial owner(s) shall include identification of the author of the trust, the trustee, the beneficiaries with fifteen percent or more interest in the trust and any other natural person exercising ultimate effective control over the trust through a chain of control or ownership.

V. An Agent is a person employed to do any act for another, or to represent another in dealings with third person.

VI. *[To be inserted in tenders for Works contracts, including Turnkey contracts]* The successful bidder shall not be allowed to sub-contract works to any contractor from a country which shares a land border with India unless such contractor is registered with the Competent Authority.

Model Certificate for Tenders (for transitional cases as stated in para 3 of this Order)

"I have read the clause regarding restrictions on procurement from a bidder of a country which shares a land border with India; I hereby certify that this bidder is not from such a country and is eligible to be considered."

Model Certificate for Tenders

"I have read the clause regarding restrictions on procurement from a bidder of a country which shares a land border with India; I certify that this bidder is not from such a country or, if from such a country, has been registered with the

Competent Authority. I hereby certify that this bidder fulfills all requirements in this regard and is eligible to be considered. [Where applicable, evidence of valid registration by the Competent Authority shall be attached.]"

Model Certificate for Tenders for Works involving possibility of sub-contracting

"I have read the clause regarding restrictions on procurement from a bidder of a country which shares a land border with India and on sub-contracting to contractors from such countries; I certify that this bidder is not from such a country or, if from such a country, has been registered with the Competent Authority and will not sub-contract any work to a contractor from such countries unless such contractor is registered with the Competent Authority. I hereby certify that this bidder fulfills all requirements in this regard and is eligible to be considered. [Where applicable, evidence of valid registration by the Competent Authority shall be attached.]"

S/d
AR SRIC
(for and behalf of SRIC, IIT Bhubaneswar)

6.Technical Specification of Microgrid with 1.6 MWh containerized Battery Energy Storage System

PILOT 1

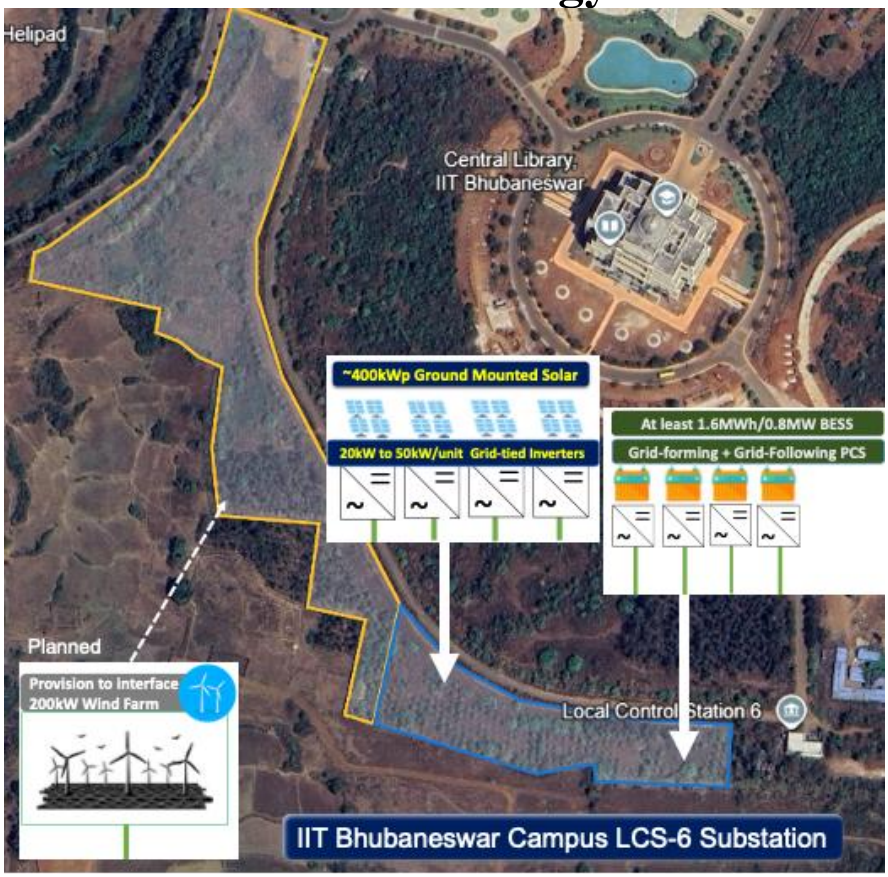
MICROGRID PLATFORM TENDER : TECHNICAL SPECIFICATIONS

Site Location : IIT-BBS, Odisha

This document covers the design, details and compliance requirements of the envisioned Microgrid Pilot Project to be deployed at Indian Institute of Technology - Bhubaneswar (IIT-BBS). This pilot is to be designed and developed as a benchmarking platform equipped with state-of-the-art technologies and grid solutions dedicated to Odisha's Energy Transition and future roadmap. This initiative is part of the ongoing research program between IIT-BBS, Nanyang Technological University (NTU) Singapore, and Grid Corporation of Odisha Limited (GRIDCO) in collaboration with Energy Department - Odisha.

PILOT - 1: MICROGRID PLATFORM

Indian Institute of Technology - Bhubaneswar



Location: IIT-BBS, Odisha, India

Objective: Design, Development, Deployment and Demonstration of Microgrid Platform a total capacity of with at least 0.4MWp Solar farm and 1.6MWh/0.8MW Energy Storage System with seamless GRID-FORMING, GRID FOLLOWING inverter functionalities and grid ancillary services. BESS shall equally be distributed into four containerized solutions of at least 0.4MWh/0.2MW each. The microgrid shall be equipped with digital command center for 24x7 autonomous operation, monitoring and control features. The pilot is intended to serve as a benchmarking platform for Odisha; therefore, the tenderer shall ensure strict adherence to Grid Codes, Regulations, Requirements and Compliance of the components and the overall system and as per the local agencies and organizations.

ALMM	Approved List of Models and Manufacturers
BIS	Bureau of Indian Standards
CEA	Central Electricity Authority
DISCOM	Distribution Company
MNRE	Ministry of New and Renewable Energy
NABL	National Accreditation Board for Testing and Calibration Laboratories
OERC	Odisha Electricity Regulatory Commission
OREDA	Odisha Renewable Energy Development Agency
OPTCL	Odisha Power Transmission Corporation Limited
TPCODL	TATA Power Central Odisha Distribution Limited

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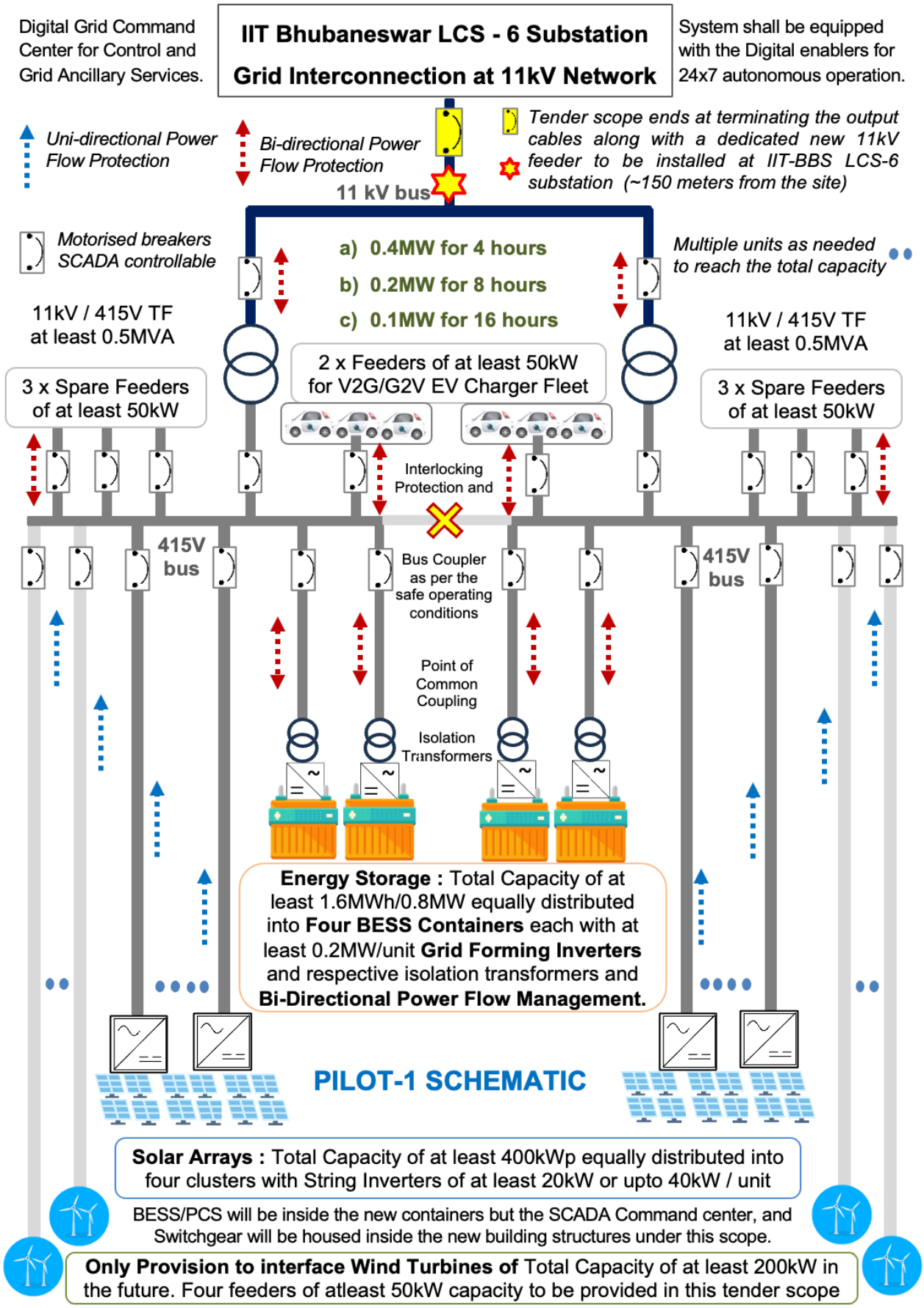
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INTRODUCTION: PILOT-1 MICROGRID PLATFORM

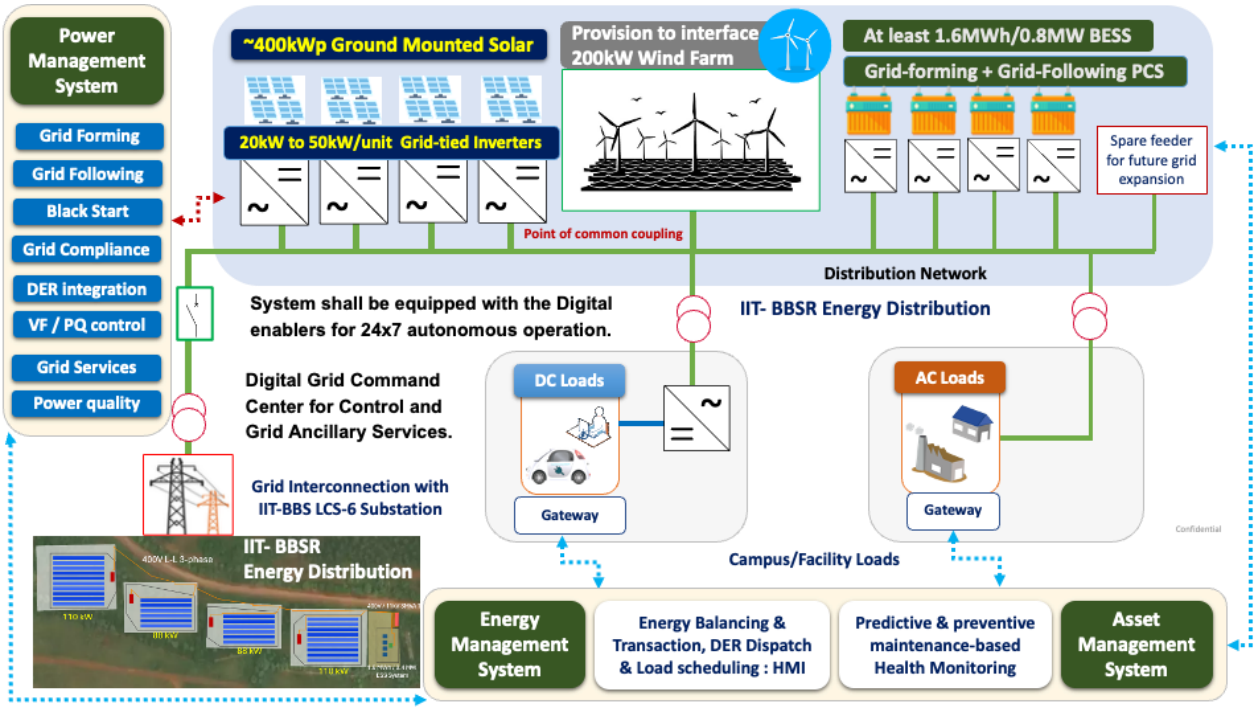


Category of Grid Assets	**Pilot-1 : MICROGRID PLATFORM** Description of System Components
1. Battery Energy Storage System - BESS	• Total Capacity of at least 1.6MWh/0.8MW equally distributed into Four BESS Banks each with BMS and at least 0.2MW Grid Forming Inverters. Integrated system as benchmarking platform with advanced functions. • Tenderer shall provide the unit cost of both 0.4MWh/0.2MW Li Ion and Sodium Ion. Project Owner shall decide the number of units and type of technology to form the total capacity of 1.6MWh. For example, a) 2 x 0.4MWh Li Ion and 2 x 0.4MWh Sodium Ion b) 3 x 0.4MWh Li Ion and 1 x 0.4MWh Sodium Ion
2. GFM : Grid Forming / Grid Following PCS	• Four units of at least 0.2MW Power Conversion System (PCS) : Total aggregated capacity of at least 0.8MW PCS for 1.6MWh ESS. • Rate of Charging / Discharging Operation : 0.25C nominal / 0.5C capable • Each GFM unit will run at ~50% capacity ~0.1MW for nominal operation such that overall system ~1.6MWh ESS will deliver 0.4MW for four hours.
3. Solar Arrays and Mounting Structures	• Total Capacity of at least 400kWp equally distributed into four feeders with Grid-tied PV String Inverters of at least 20kW or up to 40kW / unit. • Structural Integrity to withstand at least 250km/h wind speed for disaster resiliency. Plug-and -Play mounting/dismounting methods preferred.
4. Grid Inter-connection	• Tender scope ends at terminating the output cables along with a dedicated new 11kV feeder to be installed at IIT-BBS LCS-6 substation (~150 meters from the allocated Microgrid site).
5. Digital Grid Center	• Command Center : Grid Monitoring, Control and Ancillary Services. • PMS EMS SCADA Servers and Digital Interfaces for 24x7 autonomous operation.
6. Protection Switchgear	• 415V AC and 11kV AC bus Feeders, AC/DC busbars, HT/LT Protection Relays and Circuit Breakers sized according to the integration of grid assets. • Power Quality Meters, Power/Energy Meters, UPS auxiliary power supply for Switchgear operation and black-start capabilities.
7. Power Grid Transformers	• Two units of 11kV/415V Transformers of at least 0.5MVA and Duty Transformers for interfacing Power Converters with Bidirectional Power Flow Management.
8. Cables and Interfaces	• 230V/415V/11kV Low and Medium Voltage Cables Installation (Underground / Overground) Junction boxes and termination points. • LV/MV Cable routing around the site and AC/DC cabling inside the containers.
9. Containers and Buildings	• BESS/PCS assets will be integrated with safety features and to be housed inside the new 40 ft containers. • Digital Grid Center, SCADA Servers and Switchgear will be integrated with safety features and to be housed inside the new building structures.
10. Lightning and Earthing	• Earthing - Lightning - Grounding Protection for each grid asset / component and overall integrated system to ensure safe pilot deployment and commissioning.

i. **Section-1 : Lithium/Sodium Ion BESS, GFM Inverters, Solar Arrays and GTI Inverters.**
ii. **Section-2** : Grid Digitalization, SCADA, Communication and Control Systems
iii. **Section-3** : Grid Core Infra, Switchgear, Cables, Transformers, Meters Containers

The tenderer/developer shall comply with all applicable grid codes, CEA, MNRE regulations and mandates concerning component sourcing, system quality, and specific asset testing protocols.

SECTION 1.1: battery ess GRID-FORMING INVERTERS



Microgrid Platform ; Site Interconnection with IIT-BBS 11kV Feeder

- Total Capacity of at least 1.6MWh/0.8MW equally distributed into Four BESS Banks each with at least 0.2MW unit with Grid Forming Inverters. Each GFM unit will run at ~50% capacity ~0.1MW for nominal operation such that overall system ~1.6MWh ESS will deliver 0.4MW for four hours. Integrated system as benchmarking platform with advanced functions.

- SCADA Grid Digitalization of overall system: Power and Energy management, 24x7 autonomous operation in both grid forming/grid tied operations. (Refer Section 2). For this project 250km/h structure withstanding capability is considered for disaster resiliency.

- The BESS units and sub-components must carry BIS marking. Key certifications include:
    - **IS 17092: / IEC 62933 / UL 1741 / UL 9540**: For overall stationary grid-connected BESS design, operation, and safety baseline.
    - **IS 16046 (Part 2) / IEC 62133-2**: Lithium cell and module-level safety.
    - **IEC 62619 / UL 9540**: For industrial battery safety management systems (thermal runaway and internal short-circuit protection.

- **IS 16221 (Part 2) / IEC 62109-2 / IS 17980/ IEEE 1547**: Standard for functionalities, capabilities, safety of power converters used in storage power systems.
- **IS 16169 / IEC 62116 / IS 61683**: Test procedures for anti-islanding protection.

- At least 1.6MWh BESS with 0.8MW Inverter total capacity: [units of Containerized solution with 0.4MWh ESS + 0.2MW PCS + BMS each]. Performance validation of grid ancillary services and different ESS technologies Lithium Ion / Sodium Ion.
- Tenderer shall provide the unit cost of both 0.4MWh/0.2MW Li Ion and Sodium Ion. Project Owner shall decide the number of units and type of technology to form the total capacity of 4MWh. For example,

a) 2 x 0.4MWh Li Ion and 2 x 0.4MWh Sodium Ion
b) 3 x 0.4MWh Li Ion and 1 x 0.4MWh Sodium Ion

Grid Forming (GFM) Inverters testing standards are closely aligning with international frameworks, the converter should be certified to ensure strict adherence to grid codes and standards.

1. Providing Synthetic Inertia and Frequency Control

- **Instant response:** Emulates physical inertia to counter rapid frequency swings during sudden load changes or generation drops.
- **Frequency damping:** Smooths out transient frequency spikes across regional Indian grids, avoiding localized power shedding.
- **Active power control:** Adjusts power outputs autonomously via local droop control mechanics without relying on centralized communication networks.

2. Voltage Regulation and System Strength Support

- **Independent voltage source:** Establishes its own voltage reference, making it perfect for remote, low Short-Circuit Ratio (SCR) renewable clusters.
- **Reactive power support:** Inject or absorbs reactive power dynamically to combat voltage drops or surges during grid faults.
- **Weak grid stabilization:** Prevents control-loop interactions and converter instabilities that plague older GFL setups in weak transmission corridors.

3. Black Start Capabilities and Grid Resilience

- **Self-starting system:** Restores un-energized networks independently without needing power inputs from the main utility grid.
- **Islanded operations:** Seamlessly transitions into a microgrid or isolated pocket to supply critical local loads during natural disasters or major grid collapses.
- **System restoration:** Speeds up the recovery of meshed networks across India's five integrated power regions.

4. Fault Ride-Through (FRT) and Overcurrent Mitigation

- **Phase jump adaptation:** Withstands severe phase angle jumps (up to ±60°) caused by lightning strikes or transmission line tripping.

- **Current limiting:** Employs wave-by-wave current limiting to prevent delicate power electronics from overloading during short circuits.
- **Dynamic fault current:** Injects predictable current to trip local protection relays correctly, ensuring safety breakers function as intended.

Standard / Regulation	Critical Compliance Parameters
IS 16221 (Parts 1 and 2)	Shock prevention, environmental testing, thermal safety
IS 17980 / IEC 62891	Efficiency verification (96–97% minimum threshold)
CEA Connectivity Codes	LVRT/HVRT, THD <5%, active/reactive power injection control
GFM Amendments (2026)	Virtual inertia, autonomous voltage profiling, grid building
IEC 62116 / IS 16169	Islanding detection window restricted to under 2 seconds
IS/IEC 60529	Weather protection (IP65 minimum, IP66 for coastal/monsoon zones)

Standard	Focus Area	Requirement for GFM BESS
IEEE 2800 / IEEE 1547	Inverter-Based Resource (IBR) Interconnection	Mandates Low/High Voltage Ride Through (L/HVRT), frequency ride-through, and phase jump immunity.
IEC 62477-1	Safety Requirements for Power Electronic Converters	Governs thermal, electrical, and mechanical construction safety before grid connection.
IEC 61000 Series	Electromagnetic Compatibility (EMC)	Ensures the high-frequency switching of the 500kW converter does not create radio-frequency interference in local industrial/commercial zones.

GFM unit must functionally adhere to benchmarking standards to validate its "grid-forming" capability, power quality, anti-islanding, and safety standards to register and run in parallel.

- **Voltage Source Behavior**: Unlike normal grid-following inverters that track an existing grid voltage phasor, a GFM inverter must act as an internal voltage source behind a transient impedance.
- **Near-Instantaneous Response**: The primary control loop must react sub-transiently (within **5 to 20 milliseconds**) using internal virtual synchronous generator (VSG) algorithms to inject or absorb power during sudden local voltage or frequency steps.
- **Seamless Islanding**: The system must feature **seamless transition** (bumpless transfer) from grid-tied to intentional islanded mode.

- **Black Start**: It must be able to energize a dead localized microgrid block (Black Start) safely without expecting an external utility voltage reference.
- **Intrinsic Software Loops:** The GFM converter must leverage its control techniques to support rapid secondary/tertiary frequency response to help maintain the state grid close to 50 Hz
- **Fault Current Injection :** Must feed high-bandwidth, sub-transient current during system faults to activate grid safety relays.
- **Phase-Jump Immunity** : Must maintain an uncompromised internal voltage phasor during instant phase angle shifts.
- **Fault Ride-Through (FRT):** Inverters must possess strict Low-Voltage Ride-Through (LVRT) and High-Voltage Ride-Through (HVRT) capability. GFM units are expected to dynamically inject active and reactive currents during extreme voltage dips without disconnecting.
- **Harmonic Distortion Limits:** Total Harmonic Distortion (THD) must be restricted to **under 5%** at the Point of Common Coupling (PCC).
- **DC Injection and Power Factor:** DC current injection into the grid must remain below 0.5% of the rated inverter current, operating within a programmable power factor range (typically 0.95 lagging to 0.95 leading).

OPERATING MODES:

1. Grid-Connected Mode (Normal and Weak Grid Support)

In normal conditions, the inverter exchanges high-quality real (P) and reactive (Q) power based on plant dispatch schedules. However, in "weak grid" corridors.

- **Droop Control Mode:** Modulates frequency and voltage proportionally to real-time power variations to balance load.
- **Virtual Synchronous Machine (VSM) Mode:** Emulates the physical damping and mechanical traits of conventional thermal turbines to counter dynamic oscillations.

2. Islanded (Autonomous) Mode

- If a regional grid disturbance triggers a line detachment, the GFM inverter switches seamlessly to islanded operation without a Phase-Locked Loop (PLL) tracking unit. It establishes an independent local voltage reference to maintain continuous power flow.

3. Black-Start (System Restoration) Mode

- During total grid outages, GFM units act as "anchor" nodes. They provide the sub-transient voltage required to **energise unpowered transmission networks** and step-up transformers from scratch, eliminating the historical reliance on base stations.

NOTE: Grid Connectivity and Power Quality Standards

- GFM inverters must comply with the technical threshold norms set by the **Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations**.

SECTION 1.2: LITHIUM-ION energy storage system

Integrated System : The technical specifications and regulatory requirements for at least **0.4MWh / 0.2MW Lithium-Ion Battery Energy Storage System (BESS)**, must comply with the latest standard mandates from the **CEA** and local grid rules governed by the DISCOMS. The system shall be integrated with the sub components ; comprises battery modules, a Battery Management System (BMS), a Power Conversion System (PCS), an Energy Management System (EMS), and auxiliary systems (HVAC, fire suppression) enclosed in a containerized unit (40 ft).

Parameter	Technical Requirement / Standard Specification
Rated Power (AC side)	**At least 0.2MW** continuous discharge/charge capability. Inverters with seamless Grid Forming and Grid Following Capabilities
Useful Energy Capacity	**At least 0.4MWh** usable energy at the output of the PCS.
Battery Chemistry	**Lithium Iron Phosphate (LFP)** or Lithium Titanate Oxide (LTO). LFP is standard for grid deployment in India due to high thermal stability.
Depth of Discharge (DoD)	**≥ 80% to 85%** as per CEA design benchmarks.
Round Trip Efficiency (RTE)	**≥ 70% (AC-to-AC)** including auxiliary consumption; **≥ 90% (DC-to-DC)**.
Expected Design Life	**At least 10–15 years** or 4,000+ cycles at rated DoD.

Category	Compliance Parameter	Mandatory Technical Specification and Requirement
Grid Connectivity and Integration	**Interconnection Voltage**	System interconnection typically executed at the **0.415kV / 11kV busbar** of the local distribution network or State Transmission Utility (OPTCL) substation.
	Frequency Operating Range	Continuous, stable operation within the **47.5 Hz to 52.0 Hz** band; must support primary frequency response and grid ramping. (CEA)
	Active and Reactive Power Control	Configurable power factor and reactive power injection/absorption modes to maintain local voltage stability. **IEEE 1547 and UL 1741**

Power Quality	**Harmonics Control**	Total Harmonic Distortion (THD) limits: **Voltage THD < 5%** and **Current THD < 5%**. Dedicated harmonic analysers must be installed at the incoming bay. **IEEE 519 , IEC 62109-1 and 2 / IEC 62477-1 (PCS)**
	DC Injection and Flicker	DC current injection capped at **< 0.5%** of the rated inverter current. Voltage flicker must stay within IEC 61000 defined parameters.
	Fault Ride-Through	**LVRT (Low Voltage Ride-Through)** and **HVRT (High Voltage Ride-Through)** capabilities required to remain online during short-duration grid voltage sags or swells.
Safety and Construction	**System Safety and Thermal Runaway**	Mandatory **two-fault tolerance** design. Real-time continuous thermal runaway, off-gas, temperature, and overcurrent tracking inside the containerized system.
	Fire Suppression and Spacing	Multi-layered hazard detection (smoke, gas, heat, flame) with **automatic fire suppression systems**. Physical boundary separation between the DC bus, Power Conversion System (PCS), and AC switchgear.
	Civil, Structural Integrity and Transportation Safety	Enclosures must carry certified weather, dust, corrosion, and vibration resistance. **Seismic bracing** is mandatory for all structural component racks. **UL 9540 / UL 9540A and NFPA 855 : UN 3536 / UN 38.3**
Battery Performance and Hardware	**Cell-Level Safety**	Compulsory Registration Scheme (CRS) certification showing resilience to mechanical abuse, thermal shocks, and overcharging. (BIS IS 16046 (Part 2) / IEC 62619)
	Battery Pack Design	Mandatory verification of large-format cell design optimized for extreme local ambient temperatures and deep discharge cycles. (BIS IS 16893 / IS 16270:2023)
	Battery Management System (BMS)	Regulated safety system monitoring cell balancing, state-of-charge (SoC), and fault isolation. (BIS IS 17387:2020)
	Degradation Benchmarks	Guaranteed asset health benchmarks: **≥ 90%** energy capacity output at Year 5, **≥ 80%** at Year 10, and a baseline Round-Trip Efficiency (RTE) **≥ 70%**.
Metering and Dispatch	**Commercial Metering**	Main, Check, and Standby Availability-Based Tariff (ABT) meters with 0.2S accuracy class tracking bi-directional power exchange at the Point of Interconnection (POI).

	Telemetry and SLDC Communication	Seamless data casting to the **Odisha State Load Despatch Centre (SLDC)** using secure IEC 60870-5-104 or IEC 61850 protocols. On-site loggers must retain operational data for 90 days.
	Ancillary Services Rules	The system software must align with the state framework enabling participation in **Secondary Reserve (SRAS)** and **Tertiary Reserve (TRAS)** grid-balancing markets.

SECTION 1.3: sodium ion energy storage system

Integrated System : The technical specifications and regulatory requirements for a **0.4MWh / 0.2MW Sodium-Ion Battery Energy Storage System (BESS)**, must comply with the latest standard mandates from the **CEA** and local grid rules governed by the DISCOMS. The system shall be integrated with the sub components ; comprises battery modules, a Battery Management System (BMS), a Power Conversion System (PCS), an Energy Management System (EMS), and auxiliary systems (HVAC, fire suppression) enclosed in a containerized unit (40 ft).

As sodium-ion is an emerging commercial battery chemistry in India, regulatory bodies require strict technical validation at the design, factory, and grid-integration stages. The pilot aims to add Sodium Ion BESS to the system portfolio due to its unique safety and thermal advantages over traditional lithium-ion systems but require distinct operational boundaries.

Parameter	Technical Requirement / Standard Specification
Rated Power (AC side)	**At least 0.2MW** continuous discharge/charge capability. Inverters with seamless Grid Forming and Grid Following Capabilities
Nominal Capacity:	**At least 0.4MWh** usable energy at the output of the PCS.
Battery Chemistry	**Sodium-Ion**
Depth of Discharge (DoD)	**≥ 85% to 90%** as per CEA to optimize aging
Round Trip Efficiency (RTE)	≥ 85% expected for the DC-DC system (slightly lower than LFP). **70% expected AC-to-AC** factoring in local auxiliary consumption (cooling/heating)
Shipping Condition	0V stable state capability to allow safe logistics and warehousing
Degradation Thresholds	○ **90% output** at year 5. ○ **80% output** at year 10. ○ **70% output** at year 15
Operating Temperature	Enhanced stability without thermal runaway risks up to 50°C.

Regulatory Layer	Key Compliance Requirements for 1MWh Sodium-Ion BESS
National Grid Connectivity	Mandatory compliance for high/low-voltage ride-through (HVRT/LVRT), reactive power support, and frequency response.
State Grid Integration	Controls the boundary requirements for injection/absorption at the STU substation, scheduling, and operational harmony under the Odisha SLDC.
Ancillary Grid Services	Enables the BESS to actively trade and participate in Secondary (SRAS) and Tertiary (TRAS) Reserve Ancillary Services for frequency regulation.

System Safety and BMS	Mandates a Battery Management System (BMS) with **Two-Fault Tolerance** capability, automated audiovisual hazard alarms, and emergency shutdowns.
Data and Accountability	Requires precision data logs of cell parameters (voltage, temperature, current) to be securely stored for a minimum of 90 days.
Commercial Metering	Directs the setup of interface meters capable of 15-minute time-block energy accounting at the designated delivery/interconnection point.
Sodium-Ion Chemistry Safety	Covers safety requirements for secondary sodium-ion cells and batteries in industrial stationary applications. **IEC 63281**
System Performance	Validates system-level grid integration, unit parameters, environmental testing, and long-duration storage performance indicators. **IEC 62933 Series (Part 2-1 / 5-2) and UL 1741**
Power Conversion (PCS)	Ensures safe operations of the inverter and power electronic converters against electrical, thermal, and mechanical grid hazards. **IEC 62109-1 and 2 / IEC 62477-1: IEEE 1547 and UL 1741**
Enclosure and Fire Safety	Evaluates large-scale fire propagation characteristics and containment measures within the containerized 1MWh system. **UL 9540 / UL 9540A and NFPA 855**
Transportation Safety	Requires the fully integrated containerized battery unit to be certified as Class 9 hazardous goods for safe transit to site: **UN 3536 / UN 38.3**

SECTION 1.4: solar arrays and grid tied inverters

Total Capacity of at least 400kWp equally distributed into two clusters with Grid-tied PV String Inverters of at least 20kW or up to 40kW / unit. Minimum ground clearance of 1 meter, and Structural Integrity to withstand at least 250km/h wind speed for disaster resiliency.

Component	Target Standard / Regulation	Testing Parameter and Compliance
Solar PV Modules	IS 14286 / IEC 61215	Design qualification and mechanical/thermal type-testing.
	IS 16077 / IEC 61730	Electrical safety, fire resistance, and insulation tests.
	IS 16826 / IEC 62804 IEC 61701	Potential Induced Degradation (PID) resistance testing.
	ALMM Mandate 2026 List I and II	Inclusion in the MNRE Approved List of Models and Manufacturers.
Solar Inverters	IS 16221 (Parts 1 and 2)	General safety norms and active anti-islanding protection. Maximum Power Point Tracking (MPPT) Digitalized grid control driven PV inverters with Power Curtailment and Grid services features
	IEC 61683	Power conditioning efficiency measurement protocols.
	IEC 60068-2	Environmental profiling for high heat and humidity.
	CISPR 11 / IEC 61000	Electromagnetic Compatibility (EMC) compliance testing. Voltage flicker boundaries
BOS Components	IS 17293 / EN 50618	Outdoor solar DC cable UV and zone degradation testing.
	IEC 62852 / IEC 62271	IP67/IP68 ingress protection for connectors and switchgears.

Power Conversion Systems:

- Grid-tied PV inverters with provisions for SCADA interface, PQ control and curtailment modes.
- 20kW/unit up to string inverters to interface. Total capacity at least ~0.4MWp solar.
- Ex: 20kW x 20 Units to 40kW x 10 Units (2% to 5% loading steps).

Max Efficiency	>=98%
Max Input Voltage	1100V
Rated Output Power	≥20kW, with total installed capacity ~400kWp
Rated Output Voltage	3 x 415VAC+N+PE
Rated Power Frequency	50Hz
Power Factor	≥0.95
Max Total Demand Distortion	< 5% (TDD)
Input-side Disconnection Protection	Yes
Anti-Islanding Protection	Yes
AC Over-current Protection	Yes
DC Reverse Polarity Protection	Yes
PV Array String Fault Monitoring	Yes
DC Surge Arresters	Type II
AC Surge Arresters	Type II
Insulation Monitoring	Yes
Residual Current Detection	Yes
Display	Graphic LCD/LED
Communication Protocol	The PV inverter communication interface must support standard communication protocols such as the following to ensure seamless integration with SCADA and interoperability. • MODBUS TCP/IP - IEC 61850
Operational Temperature	0 – 50 Degree C
Enclosure	IP65 (outdoor application)
Topology	Transformerless

Photovoltaic Panels

Power Density	> 157 W/m^2
Efficiency	> 20%
Peak Power Watts-Pmax (Wp)	≥ 530 Wp
Maximum System Voltage	1500V DC (IEC)
Positive Power Tolerance	>0 and <= 3% (0 - 3%]
Operational Temperature	0 – 50 Degree C
PV J-box	IP65 or above
Cable	4.0mm^2 solar cable
Connectors	MC4 compatible

GRIDE CODES AND COMPLIANCE

Technical Parameter	Statutory Requirement / Limit	Compliance Required
Connectivity Voltage	Primary: 0.415 kV based on local feeder capacity.	Install step-up transformer (0.415 kV / 11kV).
Operating Frequency	Must operate normally within 47.5 Hz to 52.0 Hz.	Configure inverter under-frequency and over-frequency protection thresholds.
Voltage Variations	Steady-state voltage variations must remain within ± 6% at the Interconnection Point.	Inverters must dynamically adjust output voltage using automatic tap changers or reactive support.
Power Factor and Reactive Support	Must operate between 0.95 lagging to 0.95 leading.	Program smart inverters to supply or absorb reactive power (Q) as requested by the DISCOM.
Harmonics and Power Quality	Total Harmonic Distortion (THD) ≤ 5%; Individual Harmonic ≤ 3%. IEEE 519 / CEA	Integrate passive/active harmonic filters or use high-grade multi-level string inverters.
DC Injection Limit	DC current injection at the grid interface point must be < 0.5% of the full rated output current.	Inverter isolation circuits must feature embedded continuous DC leakage monitoring.
Anti-Islanding Protection	Must trip and isolate from the grid within 2.0 seconds of a utility outage. IEEE 1547 / IS 16221	Program active frequency shift or passive voltage vector shift protection in the inverters.
Metering and Billing	Must feature Availability Based Tariff (ABT) compliant, secure, bi-directional energy meters.	Install Main and Check meters with real-time AMR capability at the plant end.
Data and Telemetry	Real-time generation data (MW, MVAR, Voltage) must stream directly to the SLDC/DISCOM.	Deploy an RTU (Remote Terminal Unit) paired with robust SCADA and fiber/GPRS communication modems.
Grounding and Lightning Protection	Earth resistance must measure < 1.0 Ω. Grounding grids must resist worst-case fault currents.	Build a chemical earthing matrix. Install early streamer emission (ESE) lightning arrestors.

TESTING AND CERTIFICATION

All hardware deployed must hold valid type-test certifications as per NABL and BIS guidelines.

Component / Hazard	Applicable Standard	Purpose
Li-Ion Cells and Packs	**IS 16046-2 / IEC 62619**	Safety requirements for industrial lithium batteries.
Performance Testing	**IEC 62620**	Validates electrical capacity and cycle behaviour.
System Safety Integration	**IEC 62933-5-2**	Safety requirements for grid-integrated BESS.
Power Conversion (PCS)	**IEC 62477-1 / IEC 61000**	Inverter safety, islanding protection, and electromagnetic compatibility.

Transport Safety	**UN 38.3**	Lithium battery transportation safety validation.

Test reports of system and sub components to validate the compliance of standards and safety:

- **Cell Level Safety**: IEC 62619 / UL 1973 (safety parameters for stationary storage).
- **Inverter / PCS Compliance**: IEC 62109 or equivalent grid-tied inverter safety standards.
- **System Level Fire Risk**: Large-Scale Fire Testing (LSFT) validation under UL 1741, UL 9540 / UL 9540A
- **Power Quality:** Stringent compliance limiting total harmonic distortion (THD), voltage flicker, and DC injection in line with IEEE 519 / CEA rules.
- **Grid Support Function:** Complete **LVRT** (Low Voltage Ride-Through) down to ~0.2 p.u. and **HVRT** up to ~1.3 p.u. protection without tripping.

Parameter	Technical Requirement / Standard Specification
AC Voltage Output	415V to 690V low-voltage termination prior to the step-up transformer.
Power Factor	Adjustable within a range from 0.9 leading to 0.9 lagging.
Total Harmonic Distortion (THD)	Current distortion rate < 3% at full rated load.
DC Component	Strictly limited to < 0.5% of the rated AC current
Enclosure Rating	Minimum IP55 weather-resilient outdoor cabinet rating for dust and moisture.

FUNCTIONS AND REQUIREMENTS

Power Conversion Systems:

Required Capabilities for Grid Stability and System Safety.

1. **Seamless Grid forming and following VF/PQ Capabilities: IEEE 1547 and UL 1741**
2. **Low/High Voltage and Fault Ride-Through** (LVRT / HVRT): Inverters must stay connected to the grid during temporary voltage dips or surges with ride through capabilities.
3. **Active Power Modulation:** Systems must support active power setpoint adjustments with a ramp rate limit not exceeding 10% per minute.
4. **Frequency Response and Control:** Automatic power reduction is required when grid frequency exceeds 50.05 Hz to prevent over-frequency tripping.
5. **Reactive Power Control:** Plants must dynamically regulate reactive power across a power factor range as per the code.

6. **SCADA and Telemetry Integration:** Real-time operational data (voltage, current, frequency, active/reactive power) must stream continuously to the regional SLDC/RLDC via CEA-compliant SCADA links.

7. **Anti-Islanding Protection:** The system must automatically isolate itself from the grid within 2 seconds during a utility supply blackout or grid failure to guarantee line-worker safety. Inverters must feature built-in anti-islanding protection meeting IS 16221/IEC 62116 standards to isolate the plant during a grid failure.

8. **Fault Isolation:** The system needs a dedicated, lockable Automatic Disconnection Switch accessible by DISCOM officials externally.

9. **Circuit Breakers**: Standard three-phase automatic circuit breakers with electronic controls are mandatory.

10. **Earthing and Lightning Protection:** Separate, dedicated earthing must be provided for DC circuits, AC circuits, and structural components. A dedicated lightning arrestor must clear the higher elevation profiles typical of tall structures.

11. **Clear Disconnect Switch:** A manual, triple-pole isolation switch with a visible break and lockable mechanism must be accessible to utility engineers outside the premises.

12. **Two-Fault Tolerant BMS**: The Battery Management System (BMS) must be engineered to maintain a completely safe state even if two independent system components experience simultaneous failure.

13. **Physical Siting Constraints**: Battery containers must be isolated to block thermal runaway propagation. Under standard layout parameters, containers must be placed at least **7.5 metres away from exterior walls/roof overhangs** and maintain a **3-metre separation distance** from one another, unless Large Scale Fire Testing (LSFT) proves a closer layout is safe. Container walls must hold a minimum **2-hour fire-resistance rating**.

PV-BESS developers must adhere to the latest stringent CEA and Safety Rules as below.

1. **Two-Fault Tolerance**: The battery system and BMS must be engineered to maintain a safety state and/or thermal breaches or trigger a secure shutdown even if two independent, concurrent faults occur (e.g., simultaneous overcharge and temperature spikes). The system architecture must maintain total safety or trigger a safe shutdown even after experiencing **two independent, concurrent electrical or thermal faults**.
2. **Chemistry-Specific PCS**: Inverters and chargers must be configured exclusively for the voltage curves and thermal profile of **Sodium-Ion chemistry**.
3. **SCADA Integration**: The container must relay core real-time metrics including DC voltage, module/container temperatures, relative humidity, active/reactive power, and power factor directly to the master control room SCADA.
4. **Data Retention**: High-resolution event logs (at least 1,000 samples/second) covering protection operations like Low/High Voltage Ride Through (LVRT/HVRT) must be **stored for a minimum of 90 days.**

5. **Thermal Runaway Protection**: The BMS must actively monitor real-time tracking of voltage, current, temperature, and thermal runaway parameters at individual cell, module, and rack levels. It must trigger automatic audio-visual alarms and emergency shutdowns during abnormal conditions.
6. **Fire Detection and Suppression**: Mandatory water-based or specialized gas/aerosol automatic fire suppression systems since the container capacity exceeds 200 kWh.
7. **Container Clearance**: Enclosures must be placed at least **7.5 meters** from exterior walls/roof lines and **3 meters** from adjacent containers. If this spatial buffer cannot be met, Large Scale Fire Testing (LSFT) certification is mandatory.
8. **Bi-Annual External Audits**: BESS installations are required to undergo a mandatory third-party safety audit every two years. Audits must involve a minimum 3-day field inspection by certified experts, and the reports must be submitted to the CEA.
9. **Enclosure Protection**: Minimum **IP54 rating** for outdoor electrical cabinets/containers.
10. **Cooling Fluid Isolation**: Coolant lines must be isolated and routed to completely mitigate any leakage risks onto live electrical components.
11. **Physical Security**: Mandatory **1.8-meter fencing** around the BESS footprint, equipped with perimeter CCTV and automated intrusion detection sensors.
12. **Grid Connectivity** : Interconnection typically occurs via 11kV or 33 kV underground lines or standard regional substations.
13. **Operational Frequency:** Uninterrupted performance within a continuous active range of **47.5 Hz to 52 Hz**.
14. **Dispatch Interface**: Fully integrated SCADA system responsive to real-time dispatch instructions from Odisha SLDC.
15. **Communication Protocol**: Standardized native compatibility with IEC 61850, Modbus TCP.
16. **Grid Interaction:** Precise active and reactive power injection control to regulate voltage fluctuations.
17. **SLDC Telemetry Integration**: The BESS must integrate with the **Odisha State Load Dispatch Centre (OSLDC)** via dedicated SCADA communication channels for real-time dispatch instructions.
18. **Grid Code Adherence**: Connectivity and metering must follow local distribution/transmission interconnection conditions and the CEA.
19. **Climatic Adaptations**: Odisha's extreme summer temperatures and high coastal humidity require advanced, climate-resilient **Thermal Management Systems (HVAC or Liquid Cooling)** to prevent thermal runway or premature sodium-ion cell degradation.
20. **ALMM Compliance**: All assets used in the projects must be sourced strictly from the updated MNRE Approved List of Models and Manufacturers (ALMM) List-I and List II. Non-ALMM modules will be rejected during DISCOM commissioning inspections.

PV, BESS Container Structures, Command Center Buildings:

1. **Clearance Height:** Ground mounted PV panel structures must be elevated to a minimum height of **1 meter** above the ground.

2. **Civil Protection:** Structural footings must feature concrete encasements buried deep enough to fully protect structural columns from accelerated corrosion.

3. **Wind Load Resistance :** Must withstand at least 250km/h wind speed and comply with IS 875 (Part 3). Driven Pile / Concrete Piers: Deep cast-in-situ concrete piles to withstand high uplift wind forces.

4. **Structure Material :** Hot-Dip Galvanized (HDG) Steel - Minimum 100-micron zinc coating (complying with IS 4759) or specialized high-grade Pre-Galvanized steel to counter fertilizer/soil chemical corrosion.

5. **Structural Safety**: Structural calculations must strictly satisfy the relevant standards, wind speed structural codes for Odisha's high-cyclone risk zones. **Soil Bearing Capacity (SBC)**: Minimum **10 to 15 tonnes/m²** (≈ 100 to 150 kN/m²).

6. **Inverter Chassis Earthing**: Inverters require independent earthing lines separate from the AC output ground cable.

7. **Surge and Protection Regimes:** Systems must include Dedicated Surge Protection Devices (SPDs) alongside over/under-voltage and thermal shutdown protection.

8. **Wind Load Stability Certificate**: Structural vetting via STAAD-Pro calculations matching IS 875 Part 3 high-wind zone requirements for coastal Odisha. (250km/h)

9. **Galvanization and Corrosion Certificate**: Testing for minimum 100 microns coating thickness under IS 2629 to withstand environmental stress.

10. **Drainage Systems:** Ground levels must feature a smart, gentle slope network paired with perimeter trenches. This avoids pooling during Odisha's severe monsoon seasons.

11. **Inverter and Control Rooms:** 40ft Containers and buildings must be constructed to house the BESS, digital command center, electrical switchgear, inverters, and monitoring units.

12. **Plinth Height Above Ground:** Minimum 300 mm to 500 mm above the local historical High Flood Level (HFL) to prevent BESS from water contamination.

13. **Concrete Exposure Class:** "Very Severe" class requires a minimum grade of M30 or M35 concrete structure built RCC slab.

14. **Flatness and Tolerance**: The horizontal surface error across the concrete contact pad must not exceed **±3 mm over the entire span** to prevent structural twisting of the BESS container.

15. **Waterproofing**: Apply a **250-micron polyethylene waterproofing membrane layer** beneath the concrete pour to block underground water capillary action from deteriorating electronic components.

16. **Cable Trenches**: Integrated RCC cable trenches lined with angles and covered with anti-skid checkered plates are required to safely route DC cables from batteries to the 0.2MW inverter and AC cables to the transformer.

17. **Clearance :** Maintain a minimum clear perimeter buffer of 1.5 meters around all sides of the foundation block for maintenance access, safety egress, and HVAC airflow efficiency.
18. **Fire-Rated Enclosure**: Container walls must possess a minimum **two-hour fire resistance rating**.
19. **Explosion-Proof Design**: The container structure must be inherently **explosion-proof**, featuring forced ventilation and automated louvers designed to safely release flammable gas build-ups.
20. **Container Clearance**: Enclosures must be placed at least **7.5 meters** from exterior walls/roof lines and **3 meters** from adjacent containers. If this spatial buffer cannot be met, Large Scale Fire Testing (LSFT) certification is mandatory **(by CEA mandates).**
21. **Interior Segregation**: The layout must enforce strict structural segregation between the **DC busbars, inverter rooms, and AC switchgear rooms** to prevent cascading faults.
22. **Intrusion Alarms**: Structural doors must be equipped with sensors that automatically **trigger an alarm when a container door is opened**.
23. **Perimeter Security**: The installation site must feature security fencing of at least **1.8 meters** in height, reinforced with CCTV surveillance and motion or break-glass sensors.
24. **Ingress Protection:** Containers must meet high-grade Ingress Protection (IP) ratings suitable for Odisha's coastal and high-humidity tropical conditions.
25. **Spill Containment:** Since certain sodium-ion chemistries use liquid/aqueous electrolytes, specialized internal structural spill containment bunds are required.

All civil works and foundation designs must strictly follow these national regulations:

- **IS 875 (Part 3):** For Wind and Cyclone Load calculations (critical for Odisha's coast).
- **IS 456: 2000**: Code of practice for plain and reinforced concrete (RCC).
- **IS 1893 (Part 1):** For Seismic (Earthquake) resistant designs (Odisha falls primarily under Zone II and Zone III).
- **IS 1904: 1986**: For structural foundations in soils.

Hazard Detection and Fire Suppression

1. **Automatic Fire Suppression**: The container **must be equipped with a water-based automatic fire suppression system** built to Indian/relevant global standards.
2. **Multi-Hazard Detection**: Actively monitored detection arrays for **smoke, gas, heat, and flame** must be operational within the enclosure.
3. **Component Protection**: Fire suppression components must be heavily shielded from external ambient weather and unauthorized tampering while remaining fully accessible for testing and maintenance.
4. **Electrolyte Containment**: Spill containment systems must be integrated structurally beneath or around the battery racks to contain any liquid chemical leakages.
5. **Emergency Infrastructure**: Dedicated emergency lighting with independent power and structural **manual emergency stop buttons** must be accessible from the container exterior.

6. **Automated Shutdowns**: The BMS is legally required to execute automated emergency shutdowns and trigger instant audiovisual alarms if current, thermal, or voltage limits are breached.
7. **Fire Safety Audits**: An independent third-party fire safety audit must be executed and submitted to the local Electrical Inspector prior to receiving grid synchronization approval.

Ventilation and Thermal Compliance

1. **Failsafe Mechanical Ventilation**: In the event of primary heating, ventilation, and air conditioning (HVAC) or forced-cooling system failing, the container **must initiate an automatic shutdown** to ensure flammable materials remains within the safe concentration thresholds.
2. **Interlocked Interruption**: If the mechanical ventilation system fails, an automated **interlocked shutdown** must trigger to stop cell operations.
3. **Coolant Integrity**: If liquid cooling is utilized, lines must be routed and physically shielded to entirely mitigate the risk of dielectric fluid leaking onto live electrical circuitry.

GRID MODELING VALIDATION REPORT

Once the project is awarded to the shortlisted tenderer/developer, IIT-BBS shall provide the network details for the project design and validation. The tenderer shall ensure all the data is kept strictly confidential. And this to be used only by the tenderer to provide the following system level Grid compliance reports of the proposed components to ensure that renewable energy systems can be safely and reliably connected to the power grid while satisfying utility grid codes and regulatory requirements.

These modelling tools validation is mandatory to prevent voltage instability, equipment overloading, poor power quality, and system reliability issues. To justify the holistic system level integration and coordination, the tenderer/developer shall submit the complete simulation models, design files, and compliance reports to the project owner as part of the engineering deliverables.

Key Compliance Studies

- **Steady-State Analysis (RMS)**
  - Load flow analysis to verify voltage profiles and thermal loading.
  - Reactive power capability assessment.
  - Short-circuit studies to evaluate fault levels and protection coordination.
- **Transient, Power Quality Analysis (EMT)**
  - Protection Relays Coordination.
  - Harmonic distortion assessment.
  - DC current injection analysis.
  - Voltage flicker and fluctuation studies.
- **Dynamic Stability Analysis (RMS and EMT)**
  - Low Voltage Ride Through (LVRT).

- High Voltage Ride Through (HVRT).
- Frequency Ride Through (FRT).
- Active power ramp-rate performance.
- Reactive and active power control validation.

Simulation Tools

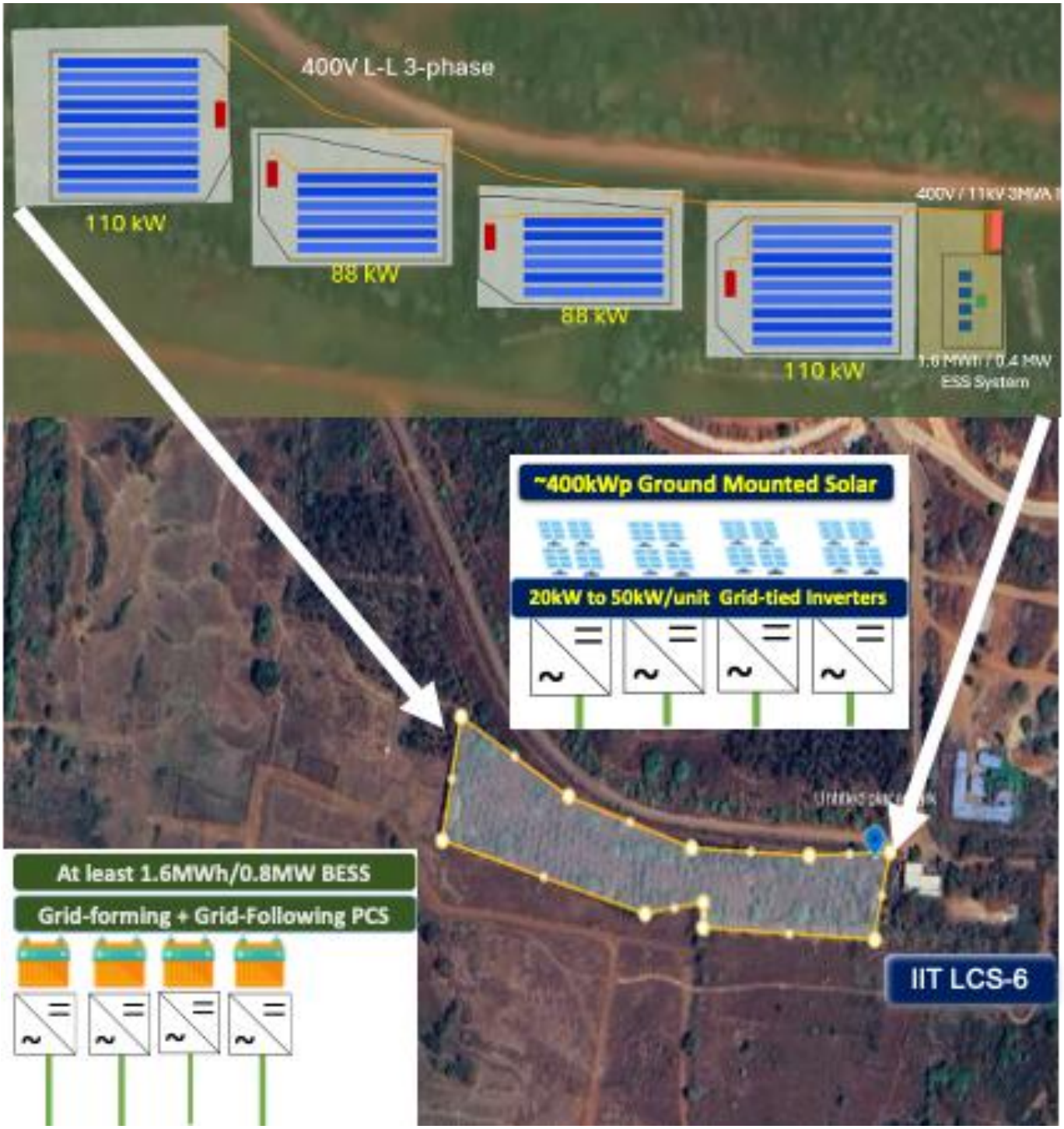
Industry-standard software commonly used includes:

- **ETAP** – Electrical network, transformer, and cable modelling.
- **PSSE** – Load flow, short-circuit, and dynamic stability studies.
- **PSCAD** – Electromagnetic transient (EMT), harmonics, and power quality analysis.
- **DIgSILENT PowerFactory** – Integrated steady-state, dynamic, and power quality simulations.

Regional utility requirements (e.g., CEA, CTU, NRLDC in India, or local transmission/distribution operator grid codes).

- Demonstrated regulatory and grid code compliance.
- Safe integration of renewable generation into the grid.
- Improved voltage regulation and power quality.
- Enhanced system stability and operational reliability.
- Reduced technical risks, project delays, and non-compliance penalties.
- Optimized system performance and readiness for future grid developments.

ANNEX:



A) PV DC Array Junction Boxes (JBs)

1. Inverters DC Distribution panel to receive the DC output from the array field.
2. DC Array JBs are to be provided in the PV array for termination of connecting cables. The JBs shall be made of GRP/FRP/Powder Coated Aluminum /cast aluminum alloy with full dust, water and vermin proof arrangement. All wires/cables must be terminated through cable lugs. The JBs shall be such that input and output termination can be made through suitable cable glands.
3. Copper bus bars/terminal blocks housed in the junction box with suitable termination threads Conforming to IP65 standard and IEC 62208, and hinged door with EPDM rubber gasket to prevent water entry. Single compression cable glands. Provision for proper groundings.

4. Each Junction Box shall have high-quality Suitable Capacity Metal Oxide Varistors (MOVs) / DC surge arrestors, suitable Reverse Blocking Diodes. The Junction Boxes shall have suitable arrangement monitoring and disconnection for each of the groups.
5. Suitable markings shall be provided on the bus bar for easy identification, and the cable ferrules must be fitted at the cable termination points for identification.

B) PV Cables

Cables of appropriate size to be used in the system shall have the following characteristics:

Operational Temperature	0 – 90 Degree C
Voltage Rating	0.6/1kV (AC) / 1.5kV (DC)
Excellent Resistance to	Heat, cold, water, oil, abrasion, UV radiation and etc.
Compliance	IEC60227/IS694 - IEC60502/IS1554 IS 7098 Part 1 - IS 17293:2020

1. Sizes of cables between array interconnections, array to junction boxes, junction boxes to Inverter etc. shall be so selected to keep the voltage drop (power loss) of the entire solar system to be acceptable as per common practice. The cables (as per IS) should be insulated with a special grade PVC compound formulated for outdoor use.
2. Cable Routing/ Marking: All cable/wires are to be routed in a GI cable tray and suitably tagged and marked with the proper manner by good quality ferrules or by other means so that the cable could be easily identified.
3. The Cable should be so selected that it should be compatible up to the life of the solar PV panels i.e. 25 years.
4. The ratings given are approximate. EPC to indicate size and length as per system design requirement. Any change in cabling sizes if desired by the EPC /approved after citing appropriate reasons. All cable schedules/layout drawings approved prior to installation.
5. All cable trays including covers are to be provided. All cables conform to latest edition of IEC/ equivalent BS Standards as specified below: BOS item/component Standard Description Standard Number Cables General Test and Measuring Methods, PVC/XLPE insulated cables for working Voltage up to and including 1100 V, UV resistant for outdoor installation IS /IEC 69947.
6. The size of each type of DC cable selected shall be based on minimum voltage drop, however; the maximum drop shall be limited to 1%. The size of each type of AC cable selected shall be based on minimum voltage drop, however; the maximum drop shall be limited to 2 %.

C) PV Switches

1. Solar PV on-load switch disconnector shall be suitable for 1100Vdc operational voltage having minimum insulation voltage of 1100 V dc.
2. For reduced power dissipation and to ensure proper DC isolation, the PV switch shall be available in 2x2 poles configuration, comprising dedicated poles for + and − input and + and − output. Each input shall be connected to its corresponding output pole to maintain polarity continuity. Where such connections are implemented using cables or links, they shall be properly rated, securely terminated, and installed in accordance with the

manufacturer's recommendations. The use of loose, temporary, or inadequately rated bridging conductors shall not be permitted.

3. The Air insulation distance shall be higher than 25 mm and the creepage distance shall be higher than 50 mm.
4. It shall be type-tested to carry the nominal current at Rated Voltage till ambient Temperature of 60 Deg C without any derating inside the combiner box.
5. The Solar PV switch disconnector shall have positive break indication, fully comply with IEC 60947-3 and must be tested to be able to operate at any operational current up to its nominal current (critical current test as per IEC 60947-3) of electrical and instrumentation cables according to the approved design of the PV system, including cable-trays, junction boxes and/or minor civil work where necessary.

D) Applicable ESS Standards and Certification Basis

1. **CEA and Standards Hierarchy:** Apply the CEA Safety Regulations, relevant Indian Standards, the National Electrical Code and the National Building Code. Where an applicable Indian Standard is unavailable, use the latest relevant international standard in accordance with CEA Regulation 14, subject to approval by the Purchaser, utility and Electrical Inspector.
2. **Lithium Cell and Battery Safety:** Submit a valid report for IS 16805:2018, the Indian adoption of IEC 62619:2017, where applicable to the offered industrial battery. Where specified, supplement this with IEC 62619:2022 and IEC 63056:2020 evidence for lithium cells and batteries used in stationary electrical energy storage systems.
3. **System-Level BESS Safety:** Demonstrate system risk assessment and safety compliance to the latest applicable IEC 62933 requirements, particularly IEC 62933-5-1 and IEC 62933-5-2. IEC 62933-5-4:2026 may be used as supplementary evidence for lithium-ion BESS safety test methods when accepted by the Engineer.
4. **Associated Equipment and Transport:** PCS, switchgear, protection, EMC, IP and earthing shall comply with their applicable IS/IEC standards. Batteries transported to site shall be of a type tested under UN Manual of Tests and Criteria, subsection 38.3, with test summary, packaging, state-of-charge and dangerous-goods documentation as applicable.

E) BESS Factory Acceptance and Rated-Performance Tests

1. **Battery Production and Incoming Tests:** Record cell traceability, open-circuit voltage, capacity or accepted production capacity data, internal resistance, insulation, dimensional checks and module/rack workmanship. Confirm that production cells, BMS hardware and firmware are identical to those covered by the submitted certification and propagation evidence.
2. **Rated Power and Energy:** Demonstrate continuous discharge of output for the guaranteed duration and delivery of minimum usable AC energy under the specified initial SOC, ambient condition, power factor and end-of-discharge limits. Repeat the corresponding charge test and record DC/AC energy, temperatures, auxiliary consumption and limiting functions.
3. **Efficiency and Dynamic Performance:** Verify charge efficiency, discharge efficiency, AC round-trip efficiency, standby loss, response time, ramp rate, set-point tracking, charge-to-discharge reversal and operating limits. Test PCS voltage and frequency range, current limiting, reactive-power or power-factor control, harmonics, DC injection and phase unbalance.

4. **Integrated FAT and Duty Cycle:** Demonstrate BMS-PCS-EMS-SCADA communications, local/remote control, time synchronization, alarms, event records, communication-loss response and emergency shutdown. Run the tender duty cycle and agreed endurance sequence, reporting energy throughput, cell imbalance, temperature spread, available capacity and unresolved alarms.

F) Cell, Module, Rack and Container Safety Tests

1. **Electrical Abuse Testing:** Perform applicable overcharge, over-discharge, forced discharge, external short circuit, abnormal charging, overcurrent and insulation-failure tests at cell, module or representative battery level. Verify vents, fuses, contactors and BMS action, and demonstrate that fault energy is safely contained or isolated.
2. **Thermal and Environmental Testing:** Characterize operation and safe shutdown at the specified high and low temperatures, including thermal cycling, storage exposure, humidity and condensation where applicable. Establish permitted charge/discharge limits and BMS derating curves using test data for the offered cell rather than generic chemistry assumptions.
3. **Mechanical and Transport Robustness:** Conduct applicable vibration, mechanical shock, drop, impact or crush tests on cells, modules and shipping assemblies. Inspect for leakage, venting, fire, rupture, isolation degradation and loss of protective function, and verify rack anchoring and restraint for the installed configuration.
4. **Gas, Fire and Propagation Assessment:** Determine the composition, quantity, flammability and toxicity of gases released under credible sodium-ion faults. Use representative module/rack or system tests to justify detection thresholds, ventilation, pressure relief, separation, fire suppression and emergency-response procedures; a lower perceived fire risk shall not replace test evidence.

G) Factory Performance and Functional-Safety Tests

1. **Rated Capacity and Two-Hour Duty:** Demonstrate continuous AC discharge and at minimum usable AC energy under the specified SOC, temperature, DC voltage and end-of-discharge limits. Record cell voltages, current, temperature, delivered energy, PCS limits and auxiliary consumption, followed by the guaranteed charge and recovery sequence.
2. **Dynamic and Efficiency Tests:** Measure response and settling time, ramp rate, command tracking, charge/discharge reversal, charge efficiency, discharge efficiency, round-trip efficiency, standby loss and SOC estimation accuracy. Confirm performance across the guaranteed operating-temperature and SOC ranges and identify all BMS or PCS derating zones.
3. **Endurance and Degradation:** Complete the agreed accelerated duty cycle and report energy throughput, capacity and power retention, internal-resistance growth, cell imbalance and alarm occurrence. The test shall represent the tendered cycling profile, including partial-state-of-charge or high-power operation, and support the guaranteed life and augmentation assumptions.
4. **Integrated Controls and Fault Injection:** Verify BMS-PCS-EMS-SCADA communication, time synchronization, local/remote control, protection coordination, pre-charge, contactors, insulation monitoring, emergency stops and event records. Inject representative sensor, fan, communication and auxiliary-power failures to demonstrate safe derating, isolation or shutdown.

H) Site Commissioning and Odisha Certification

1. **Electrical and Mechanical SAT:** Confirm foundation and anchoring, transport restraints, cable size and torque, DC polarity, phase sequence, insulation resistance, protective bonding, earth-grid resistance, surge protection, AC/DC segregation, interlocks, auxiliary supplies and calibrated operation of all protection devices.
2. **Integrated Safety SAT:** Functionally test smoke, gas, heat and flame detection, HVAC and ventilation trips, automatic louvres, suppression release logic, emergency stops, remote alarm transmission, shutdown sequencing and safe isolation. Conduct evacuation and emergency-response demonstrations with the Owner and local fire-safety representatives as required.
3. **Point-of-Connection Tests:** At the approved connection point, prove minimum output capability, usable energy, ramping and response performance, metering, protection coordination, anti-islanding or transfer logic, reactive-power control and power quality. Complete any utility- or grid-code-specific frequency-response and disturbance tests required by the approved scheme.
4. **Approval:** Submit approved drawings and studies, licensed-tenderer completion certificate, product and system test reports, UN 38.3 summary, FAT/SAT records, calibration certificates, fire-risk assessment, Operation and Maintenance manuals and emergency plan. Obtain Odisha EIC/PCEI written approval before energization where required.

I) Factory Acceptance Test (FAT), Installation, Site Acceptance Test (SAT) Commissioning

1. To provide approved and required lifting equipment, temporary and permanent structures including temporary power supply, if necessary, for the installation of photovoltaic panels, inverters, and auxiliary components.
2. To deliver the routing of electrical and instrumentation cables according to the approved design of the PV system, including cable-trays, junction boxes and/or minor civil work where necessary.
3. To provide electrical termination as per approved design.
4. To design and provide grounding and lightning protection according to local grid codes.
5. To provide site co-ordination to obtain necessary information for the completion of the scope of work described, including but not limited to risk assessment, safe work procedure, site permit application, progress meeting and safety coordination to comply with local grid codes and requirements.
6. To provide testing and commissioning method statement and report.
7. To provide 3 endorsed sets of all basic design as-built documents and 1 set of soft copy.
8. CEIG Inspection: For agrivoltaic farms (typically exceeding the statutory voltage limits), a physical safety inspection by the Odisha CEIG is legally required before energization. They will formally audit the Single Line Diagram (SLD), structural stability, and protection logic.
9. Licensed Workmanship: All electrical installations must be certified by a licensed electrical contractor registered directly with the Odisha State Electricity Licensing Board (ELBO).

SECTION 2 :

GRID DIGITALIZATION

TECHNICAL SPECIFICATIONS

PILOT-1 : Microgrid Systems

Document Reference	SECTION 2 : GRID DIGITALIZATION
Revision	Final
Date	29 July 2026
Status	

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1. Introduction

1.1 PURPOSE OF THIS DOCUMENT

This Technical Specification defines the digitalisation requirements for Theme 1 of the project, consisting 4MWh of BESS. The said installation is to be carried out in IIT Bhubaneswar Campus in Odisha, India. The specification covers five functional layers: Monitoring and Visibility (Layer 1), Control and Automation (Layer 2), Communication Infrastructure (Layer 3), Data and Analytics (Layer 4), and Cybersecurity (Layer 5).

This document is intended to supplement a tender package for procurement of the digitalisation systems described herein. It establishes the minimum technical requirements that all tenderers must demonstrate compliance with, and identifies desirable capabilities that will be evaluated as part of the tender assessment.

1.2 PROJECT BACKGROUND

The project owner is IIT Bhubaneswar in Odisha, India, with the objective of developing a flagship microgrid as a capability-building initiative. The primary objectives are: research and data collection; testing of new technologies; showcase and demonstration; and training of staff and students.

The microgrid comprises the following physical assets:

- 400 kWp of ground-mounted PV
- 200 kWp of windfarm
- 1.6MWh of BESS with grid forming, grid tied capabilities
- An estimated 5 LV feeders, 1 each for PV, windfarm and BESS + 2 spare
- Grid connection to the Odisha state grid via OPTCL infrastructure at the Point of Common Coupling (PCC)

The digitalisation scope covers all systems required to monitor, control, communicate, analyse, and secure the microgrid from initial commissioning through long-term operation. **The contractor shall supply the necessary hardware including but not limited to controllers, network switches, communication gateways, computing devices, servers, peripherals, monitor displays, etc. unless specifically excluded under exclusions throughout this document.**

1.3 SCOPE OF THIS SPECIFICATION

This specification splits technical requirements across five layers as below:

- SCADA system and field instrumentation (Layer 1)
- Energy Management System (EMS) and Microgrid Controller / PLC with protection relays (Layer 2)
- OT communication network infrastructure including time synchronisation (Layer 3)
- Data historian, analytics platform, and dashboards (Layer 4)
- Cybersecurity systems, framework, and governance (Layer 5)

The following are explicitly excluded:

- Primary electrical plant — transformers, HV/MV switchgear, cables (covered in separate electrical specification)
- Civil and structural works (covered in separate civil specification)

- BESS packs, and BMS hardware (covered in separate equipment specification)
- University campus IT network infrastructure
- Electricity market participation platform (market-readiness interface is in scope; the market platform is not)

2. Definitions, Abbreviations, and Standards

2.1 DEFINITIONS

Term	Definition
Microgrid	A localised group of electricity sources and loads that operates connected to and synchronised with the state grid, and can disconnect and function autonomously.
Point of Common Coupling (PCC)	The electrical point at which the microgrid connects to the OPTCL distribution network.
Energy Management System (EMS)	Software system responsible for optimising dispatch of microgrid assets based on forecasts, tariffs, and operational constraints.
Microgrid Controller / PLC	Hardware implementing real-time control of microgrid operating modes and transitions, programmed per IEC 61131-3.
SCADA	Supervisory Control and Data Acquisition — the system providing monitoring and supervisory control of all microgrid assets.
Historian	A time-series database storing all operational data at defined resolutions and retention periods.
OT Network	Operational Technology network — dedicated communication infrastructure for control and monitoring, separated from campus IT.
Security Level (SL)	IEC 62443 classification defining the protection required for a zone or conduit against cybersecurity threats.
Algorithm Sandbox	Isolated environment for researchers to develop and test dispatch algorithms against live or historical data without affecting live operations.

2.2 ABBREVIATIONS

BESS	Battery Energy Storage System
BMS	Battery Management System
CEA	Central Electricity Authority (India)
COD	Commercial Operation Date
DNP3	Distributed Network Protocol 3

FAT	Factory Acceptance Test
GOOSE	Generic Object-Oriented Substation Event (IEC 61850)
HMI	Human Machine Interface
IEC	International Electrotechnical Commission
MMS	Manufacturing Message Specification (IEC 61850)
MQTT	Message Queuing Telemetry Transport
OERC	Odisha Electricity Regulatory Commission
OPC-UA	Open Platform Communications Unified Architecture
OPTCL	Odisha Power Transmission Corporation Limited
OT	Operational Technology
PAR	Photosynthetically Active Radiation
PCC	Point of Common Coupling
PLC	Programmable Logic Controller
PTP	Precision Time Protocol (IEEE 1588)
RBAC	Role-Based Access Control
ROCOF	Rate of Change of Frequency
SAT	Site Acceptance Test
SLDC	State Load Despatch Centre
SoC	State of Charge
SoH	State of Health
THD	Total Harmonic Distortion

2.3 APPLICABLE STANDARDS

All systems shall comply with the following standards as a minimum. Where conflict exists, the more stringent requirement applies.

Standard	Scope
IEC 61850 Ed. 2	Communication networks in substations — SCADA, GOOSE, MMS
IEC 62443	Industrial cybersecurity — OT zones, conduits, security levels
IEEE 1588v2 (PTP)	Precision time protocol — time synchronisation across OT network
IEC 61131-3	PLC programming languages — SFC, FBD, and ST
IEEE 2030.7	Standard for specification of microgrid controllers

Standard	Scope
IEC 62351	Power systems data and communications security
IS 16046 / IEC 62619	Battery energy storage systems — safety and performance
CEA Regulations	Technical standards for grid connectivity (India)
OERC Grid Code	Odisha grid code for grid-connected generation
IS 13947 / IEC 60947	Low-voltage switchgear and controlgear

3. General Requirements

3.1 DESIGN PHILOSOPHY

The digitalisation systems shall be designed in accordance with the following overarching principles:

- Open and interoperable: All systems shall communicate via open, internationally standardised protocols. Proprietary protocols between major subsystems are not acceptable.
- Vendor-neutral data access: All operational data shall be accessible to the project team via open, documented APIs without dependency on any single vendor's software or licences.
- Research-ready: The architecture shall provide a secure, documented interface for researchers to access live and historical data and to test dispatch algorithms without risk to live operations.
- Security by design: IEC 62443 cybersecurity requirements shall be designed in from concept stage — not treated as a commissioning activity.
- Layered and modular: Each functional layer shall be procurable and replaceable independently using open protocol interfaces.

3.2 ENVIRONMENTAL AND SITE CONDITIONS

Contractor shall ensure that the hardware/system supplied by them comply with the following operating environment.

Location	IIT Bhubaneshwar Campus, Site Theme 2
Ambient temperature	5°C to 50°C outdoor; up to 55°C in direct sun exposure
Relative humidity	Up to 100% RH — heavy monsoon season June to September
Enclosure rating	IP54 minimum outdoor; IP42 minimum indoor control rooms
Corrosion protection	Conformal coating, dehumidification, anti-corrosion treatment mandatory for PCB-based equipment in non-climate-controlled enclosures

3.3 DOCUMENTATION DELIVERABLES

The contractor shall duly submit the following documents to the project team at the completion of the mentioned milestones.

Document	Description	Milestone
System Architecture Drawing	All subsystems, interfaces, and communication links	Detailed design
Network Architecture Drawing	OT topology, VLANs, firewall rules, zone boundaries	Detailed design
Data Flow Diagram	All data sources, protocols, resolution, and retention	Detailed design
Data Dictionary	Every SCADA tag, engineering unit, source device, update rate — in CSV/JSON and PDF	FAT

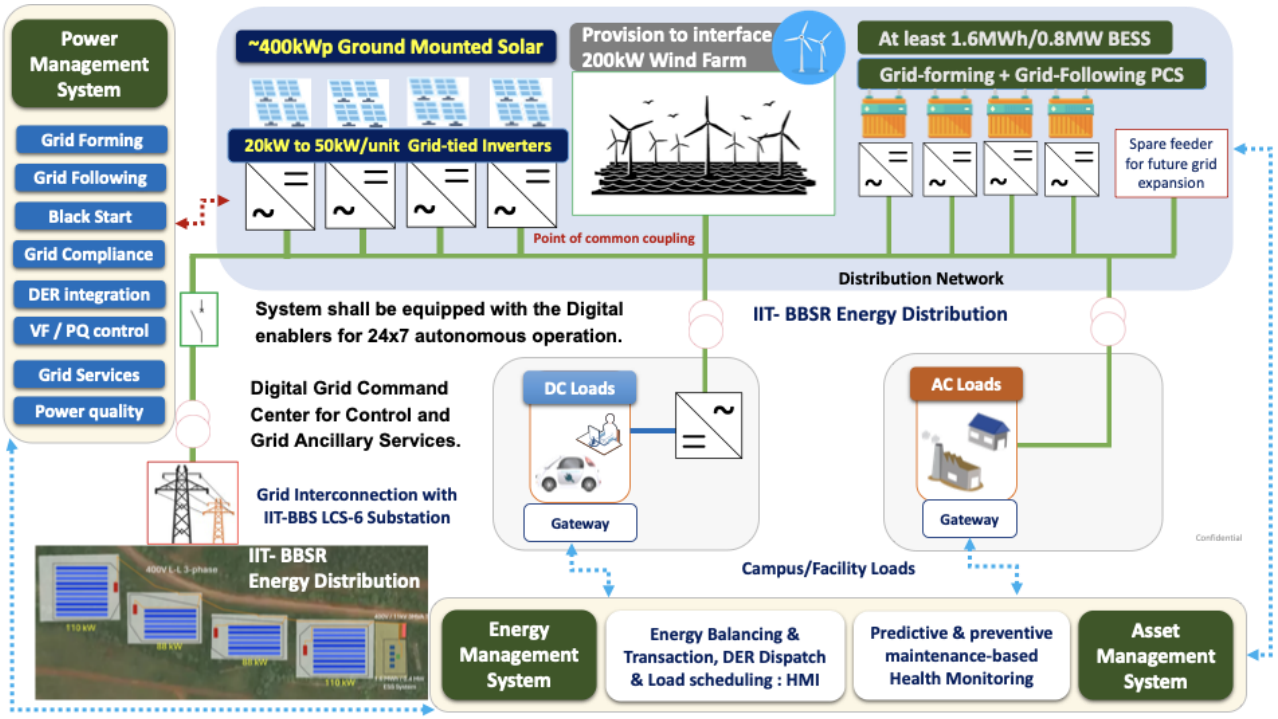
Document	Description	Milestone
FAT Procedure	To be reviewed and approved ≥ 30 days before FAT	Pre-FAT
SAT Procedure	To be reviewed and approved ≥ 30 days before SAT	Pre-SAT
O&M Manual	System-specific — not generic vendor documentation	COD
Cybersecurity Documentation	Zone/conduit design, firewall rules, access policy, pentest report	COD
As-Built Drawings	Full set reflecting final installed configuration	60 days post-COD

4. Layer 1 — Monitoring and Visibility

4.1 SCADA SYSTEM

The contractor shall supply, install, configure, and commission a SCADA system providing real-time monitoring and supervisory control of all microgrid assets. The SCADA system shall be the primary operational interface for the facility operations team.

The procurement of electrical hardware BESS is not in the scope of this document. However, in order to size the digitalisation requirements, the contractor may consider the following reference drawing.



Important considerations for the contractor

i. Estimated number of PV inverters: ~25
ii. Estimated battery capacity : 1.6 MWh
iii. Number of LV electrical feeders: ~ 4 (+ if and any spare)
iv. Exclusions: Electrical hardware such as switchgears, busbars, power cables etc.

The contractor shall supply the necessary number of Power Meters, Protection Relays, bus voltage and current measurement sensors. Any clarification needed shall be promptly sought. The contractor shall not proceed with the system design under any unagreed assumptions.

Reference architecture is attached in Annex A. If needed, the contractor shall request for a high-resolution version of the architecture drawing.

S. No	Requirement	Classification
1	The SCADA system shall support communication via Modbus TCP, IEC 61850 MMS and OPC-UA as a minimum. Proprietary field bus protocols between SCADA and field devices are not acceptable.	**Mandatory**
2	The SCADA system shall provide an OPC-UA server interface to the historian and EMS, implementing certificate-based authentication.	**Mandatory**
3	The SCADA system shall provide a real-time single-line diagram (SLD) with live power flow values, device status, and alarm indicators.	**Mandatory**
4	The SCADA system shall provide alarm management including categorisation (critical/major/minor), acknowledgement, suppression, and tamper-evident audit trail.	**Mandatory**
5	The SCADA system shall implement role-based access control with a minimum of four roles: Administrator, Operator, Viewer, and Researcher. All user actions shall be logged.	**Mandatory**
6	The SCADA system shall buffer a minimum of 72 hours of data locally on historian communication failure, with automatic back-fill on restoration. Zero data loss is required.	**Mandatory**
7	The SCADA software shall be deployable on a virtualised environment (VMware ESXi or equivalent).	**Mandatory**
8	A web-based HMI shall be provided, accessible from authorised devices without additional client software installation.	Desirable
9	The SCADA system shall provide a read-only data feed to a public-facing display or web portal, updateable at a configurable interval of 1 to 60 minutes.	Mandatory

4.2 ASSET MONITORING

4.2.1 Solar PV Monitoring

S. No	Requirement	Classification
1	String-level current and voltage monitoring shall be provided for all PV strings via string monitoring units or smart combiners. String-level data shall be available in the SCADA historian.	**Mandatory**
2	Inverter monitoring shall include: AC output power (per phase and total), DC input power, conversion efficiency, operating mode, fault status, and energy totals.	**Mandatory**
3	Module temperature monitoring shall be provided via dedicated sensors — minimum one sensor per 25 kWp of installed PV capacity.	**Mandatory**
4	The SCADA system shall calculate and display performance ratio (PR) at string, inverter, and total plant level, updated at intervals not exceeding 15 minutes.	**Mandatory**

S. No	Requirement	Classification
5	All PV monitoring data shall be logged to the historian at a minimum resolution of 1 minute.	**Mandatory**
6	There must be provision/feature to extract data for transient analysis. This may be through extraction of stored data in the power meter.	**Mandatory**

4.2.2 BESS Monitoring

S. No	Requirement	Classification
1	BESS monitoring shall include state of charge (SoC), state of health (SoH), available capacity (kWh), rated capacity (kWh), charge power, discharge power, cumulative energy throughput (MWh), total cycle count and estimated remaining cycle life.	**Mandatory**
2	Cell-level temperature monitoring shall be provided. High-temperature deviation shall trigger a configurable alarm in the SCADA system.	**Mandatory**
3	All BMS fault and alarm signals shall be integrated into the SCADA alarm management system with individual alarm categorisation.	**Mandatory**
4	BESS energy and power data shall be logged at 1-minute resolution. Temperature and protection data shall be logged at 10-second resolution.	**Mandatory**
5	There must be feature/provision to extract fast transient data from the BMS through locally stored data	**Mandatory**
6	The analytics platform shall provide a BESS degradation tracking display showing capacity fade and Ah-throughput ageing trends. **Provisions shall be provided in the system**	**Mandatory**

4.2.4 Windfarm Monitoring

S. No	Requirement	Classification
1	Wind turbine monitoring shall include turbine-level active power, reactive power, voltage, current, frequency, rotor speed, nacelle direction, wind speed, and energy generation data. All turbine-level data shall be available in the SCADA historian	**Mandatory**
2	Meteorological monitoring shall include wind speed, wind direction, ambient temperature, humidity, atmospheric pressure, and solar irradiance (optional for hybrid assessment). Minimum one met mast or LiDAR system shall be provided for the 200 kWp wind farm.	**Mandatory**
3	Turbine condition monitoring shall include gearbox temperature, generator winding temperature, bearing temperatures, vibration status, hydraulic system status, yaw system status, and brake system alarms	**Mandatory**
4	The SCADA system shall calculate and display wind farm performance indicators including turbine availability, capacity factor, performance ratio (if hybridized), and specific yield. Update interval shall not exceed 15 minutes	**Mandatory**
5	All wind farm monitoring data shall be logged to the historian at a minimum resolution of 1 minute. Critical transient and fault signals shall support higher-resolution event recording where available from turbine controllers	**Mandatory**
6	There shall be provision/feature to extract disturbance and transient data for fault analysis, including turbine trip events, grid disturbances, and power quality events. This may be through extraction of stored data from turbine controllers, protection relays, or power quality meters.	**Mandatory**
7	Grid interconnection monitoring shall include PCC breaker status, export/import power, grid frequency, grid voltage, power factor, harmonics, and protection relay alarms/events.	**Mandatory**
8	The SCADA system shall support centralized alarm management for all turbines, met stations, substations, and auxiliary systems, including alarm acknowledgement and event sequence recording with timestamp synchronization.	**Mandatory**
9	Communication architecture shall support industrial Ethernet and/or fiber optic communication between turbines and the central SCADA system. Communication health and network status alarms shall be continuously monitored.	**Mandatory**
10	The wind farm SCADA system shall support remote monitoring and control functions including turbine start/stop, active/reactive power setpoint control, curtailment commands, and operator audit logging.	**Mandatory**

4.2.4 Grid Connection Monitoring

S. No	Requirement	Classification
1	Revenue-grade metering compliant with Class 0.5S per IEC 62053-22 or better shall be installed at the PCC as per local grid code standards. Accuracy shall be independently certified prior to COD.	**Mandatory**
2	Grid metering shall measure: active power import/export, reactive power, power factor, per-phase voltage and current, frequency, and energy totals.	**Mandatory**
3	A dedicated power quality analyser shall be installed at the PCC monitoring voltage sag/swell, THD for voltage and current, and transient events.	**Mandatory**
4	Grid data shall be logged at 1-second resolution for power quality events and 1-minute resolution for energy and power data.	**Mandatory**
5	The metering and telemetry system shall provide data to OPTCL/SLDC in the required protocol and format at the time of grid connectivity approval.	**Mandatory**

4.2.4 Environmental Monitoring

The weather station shall be a device or datalogger which can interface environmental measurement sensors and function as a data server to the SCADA system through open protocols such as Modbus TCP. The sensor specific requirements are below

S. No	Requirement	Classification
1	An on-site weather station shall be installed providing: GHI, POA irradiance, ambient temperature, wind speed and direction, relative humidity, and rainfall.	**Mandatory**
2	The weather station shall comply with WMO standards. Pyranometers shall be ISO 9060 Class C or better.	**Mandatory**
3	Weather station data shall be logged at 5-second resolution and accessible via the SCADA protocols like Modbus/OPC-UA server.	**Mandatory**
4	Lightning detection shall be included with configurable alarms in the SCADA system on lightning activity within a configurable radius.	**Mandatory**

5. Layer 2 — Control and Automation

5.1 ARCHITECTURE

The control and automation system shall comprise two functionally distinct layers operating in hierarchy:

- Upper layer — Energy Management System (EMS): optimisation, scheduling, and economic dispatch on timescales of seconds to hours.
- Lower layer — Microgrid Controller / PLC with certified standalone protection relays: real-time control, protection, and mode transitions on timescales of milliseconds to seconds.

The EMS and controller layer shall communicate via open, documented protocols (OPC-UA as a minimum). Bundling of EMS and controller from a single vendor using proprietary internal communication is not acceptable. The project team shall retain the right to replace either layer independently.

5.2 MICROGRID CONTROLLER / PLC

S. No	Requirement	Classification
1	The contractor shall supply a microgrid controller system in which the system function can be customisable with the help of Functional Block Diagrams. The reference network drawing may accordingly be modified and shall be submitted to the project team for review.	**Mandatory**
2	The microgrid controller shall be supplied with any applicable license to operate the assets in a specific mode	**Mandatory**
3	The microgrid controller shall implement a documented operating state machine with a minimum of the following states: Grid-Connected Normal, Grid-Connected Curtailed, Islanded, Emergency, and Maintenance. The state transition shall be seamless. In Grid-connected mode, the controller shall regulate power exchange at the Point of Common Coupling (PCC) and ensures active/reactive power set-point execution based on local utility or State Load Dispatch Centre (SLDC) commands. In Islanded mode, the controller shall Automatically balance local Distributed Energy Resources (DERs) and loads to maintain stable frequency and voltage profiles without external utility power. For resynchronisation, the controller shall match the phase angle, frequency, and voltage profile of the microgrid back to the utility grid before closing the PCC breaker to eliminate harmful transient currents	**Mandatory**
4	The microgrid controller must satisfy the technical requirements set by Central Electricity Authority of India (CEA), Central Electricity Regulatory Commission (CERC), the local State DISCOM grid codes while aligning with internationally relevant IEEE 2030.7 core dispatch and transition standards.	**Mandatory**

S. No	Requirement	Classification
	The controller must keep DER assets connected and stable during momentary voltage sags or swells down to zero voltage, matching CEA's strict fault-propagation timelines (Low/High Voltage Ride Through). The controller must remain operational across the Indian standard frequency tolerance band of **47.5 Hz to 52 Hz**, while maintaining rated power between **49.5 Hz and 50.5 Hz**. The controller must actively restrict the rate of change of output power to ≤ ± **10% per minute** to prevent distribution transformer stress and severe grid voltage fluctuations	
5	The controller must be able to i. Actively monitor and manage system current distortions to ensure the total system stays fully compliant with **IEEE 519 / CEA harmonic injection standards**. ii. Manage complex mixtures of solar PV, wind, BESS iii. Prioritize low-cost renewable generation over battery usage. iv. Regulate localized power factors dynamically within **0.95 lagging to 0.95 leading** using available Battery Energy Storage Systems (BESS) or solar inverters. v. Execute multi-stage, high-speed load shedding of non-critical feeders when battery banks drain or renewable output drops during islanded operations. vi. Compute and holds active upwards and downwards spinning power margins to damp heavy step-load additions or sudden solar profiling drops. vii. Controls storage systems and synchronous generators to restart localized power distribution safely from a total collapse state without relying on utility voltage hooks.	**Mandatory**
6	All mode transitions shall be logged with millisecond-resolution timestamps and cause codes to the SCADA historian.	**Mandatory**
7	The controller shall accept EMS dispatch setpoints via OPC-UA with a minimum update rate of 1 second. The OPC-UA interface shall be fully documented.	**Mandatory**
8	All dispatch setpoints shall be subject to controller-enforced safety guardrails including configurable SoC limits, power ramp rate limits, and voltage/frequency limits. Safety guardrails shall remain active regardless of the source of setpoints.	**Mandatory**
9	Manual override of EMS setpoints shall be provided via the SCADA HMI with full audit trail. Manual override shall not bypass Controller safety guardrails.	**Mandatory**

S. No	Requirement	Classification
10	The controller scan cycle for protection-class logic shall not exceed 100 milliseconds. This shall be demonstrated and documented during FAT.	**Mandatory**
11	All vendor remote access to the controller shall be through the site Privileged Access Workstation (PAW) with session recording. Direct remote access to the controller bypassing the PAW is not permitted.	**Mandatory**

5.3 Protection Relays

Grid protection functions shall be implemented in certified standalone protection relays. Protection logic shall not be implemented solely within PLC software. The protection relay scheme shall be reviewed by the consultant and approved by OPTCL/SLDC prior to energisation.

S. No	Requirement	Classification
1	Protection relays shall be supplied from established manufacturers with demonstrated track record in grid-connected generation (e.g. SEL, GE Grid Solutions, Siemens SIPROTEC, ABB REF, or equivalent).	**Mandatory**
2	Protection relays shall comply with CEA Regulations 2010 and OERC grid code requirements applicable to grid-connected generation in Odisha.	**Mandatory**
3	Protection functions shall include as a minimum: overcurrent (ANSI 51/51N), under/overvoltage (27/59), under/overfrequency (81U/81O), ROCOF (81R), and loss-of-mains / anti-islanding.	**Mandatory**
4	Protection relays shall communicate with SCADA via IEC 61850 MMS for event/alarm monitoring, and via IEC 61850 GOOSE for inter-relay trip signals on a dedicated VLAN.	**Mandatory**
5	A full protection relay settings register shall be prepared, reviewed by the consultant, and submitted to OPTCL/SLDC for approval prior to site commissioning.	**Mandatory**
6	Primary and secondary injection test records for all protection relays shall be provided as commissioning deliverables prior to COD.	**Mandatory**

5.4 ENERGY MANAGEMENT SYSTEM (EMS)

S. No	Requirement	Classification
1	The EMS shall be based on an open-core or open-API platform. The project shall have full, unrestricted access to all EMS configuration, setpoints, and historical data without vendor dependency or additional licences.	**Mandatory**

S. No	Requirement	Classification
2	The EMS shall provide day-ahead and intra-day solar generation forecasting using on-site irradiance measurements and numerical weather prediction (NWP) data.	**Mandatory**
3	The EMS shall provide day-ahead and intra-day campus load forecasting based on historical consumption patterns and, where provided, university timetable and occupancy data.	**Mandatory**
4	The EMS shall optimise BESS charge and discharge scheduling to achieve configurable combinations of: peak shaving, self-consumption maximisation, grid tariff optimisation, and BESS cycle life extension.	**Mandatory**
5	The EMS shall expose a documented REST or MQTT API enabling authorised researchers to read all live and historical EMS data including setpoints, forecasts, and dispatch decisions.	**Mandatory**
6	The EMS shall be capable of receiving and executing dispatch instructions from an external electricity market operator or aggregator via a configurable, documented interface (REST, MQTT, or ICCP).	**Mandatory**
7	The EMS API shall support submission of researcher-defined dispatch setpoints to the live system, subject to PLC safety guardrails, with authentication and rate-limiting.	**Mandatory**
8	The EMS shall provide a scenario modelling environment for comparison of dispatch strategies on historical data with energy cost, carbon, and reliability metrics.	**Mandatory**

6. Layer 3 — Communication Infrastructure

6.1 NETWORK ZONE ARCHITECTURE

The OT network shall be physically separated from the campus IT network, implementing a three-zone architecture per IEC 62443:

- Zone 1 — Field / Device Level: inverters, BESS BMS, protection relays, smart meters, sensors, and field I/O
- Zone 2 — Control / SCADA Level: PLC, SCADA server, historian, HMI workstations, and engineering workstation, privileged access workstations.
- Zone 3 — Enterprise / Research Level: EMS server, research dashboard, MQTT broker, and university IT interface (read-only)

All traffic between zones shall pass through industrial firewalls or data diodes. Direct communication between Zone 1 and Zone 3 is prohibited. Wireless access to Zone 1 or Zone 2 is prohibited.

Within Zone 1 and Zone 2, CAT6A ethernet cable shall be used as the default communication media. It is expected that devices such as EMS server in zone 3 may be centrally located and shall be common for the other themes of the Gridco project. The L3 switch depicted in the LAN drawing in Annex A is expected to be located together with the EMS servers in Zone 3. The contractor shall provideSFP+ 10GBase-LR FOC connection between Theme 1 Site and the Zone 3 site.

6.2 PHYSICAL NETWORK REQUIREMENTS

S. No	Requirement	Classification
1	The OT network backbone shall use single-mode fibre optic cable in a ring topology providing automatic path redundancy on fibre break or switch failure.	**Mandatory**
2	All network switches shall be industrial-grade managed switches rated for site environmental conditions — minimum IP40 indoor, IP54 outdoor or non-climate-controlled.	**Mandatory**
3	All network switches shall support IEEE 1588v2 PTP with hardware timestamping on all ports.	**Mandatory**
4	All network switches shall support VLAN segmentation, IGMP snooping, and RSTP/MSTP ring redundancy protocols.	**Mandatory**
5	All network switches shall have redundant power supply inputs. Field-level switches shall be powered from UPS-backed supply with minimum 4-hour autonomy.	**Mandatory**
6	IEC 61850 GOOSE traffic shall operate on a dedicated VLAN with QoS highest-priority delivery. GOOSE frames shall not share a VLAN with routine data traffic.	**Mandatory**
7	Dedicated research access VLAN shall be provisioned in Zone 3 for research workstations with read-only access to the data broker and research dashboard.	**Mandatory**

S. No	Requirement	Classification
8	A testbed VLAN shall be provisioned in Zone 3 for connecting test equipment or prototypes without access to the live system.	**Mandatory**
9	Network equipment shall be from established industrial OT networking vendors (e.g. Hirschmann, Cisco IE series, Moxa, Phoenix Contact, or equivalent).	**Mandatory**

6.3 TIME SYNCHRONISATION

S. No	Requirement	Classification
1	A GPS-referenced IEEE 1588v2 grandmaster clock shall be installed on site as the primary time reference. Reliance on internet NTP as the primary reference is not acceptable.	**Mandatory**
2	The grandmaster clock shall distribute PTP to all OT network devices via PTP-capable managed switches.	**Mandatory**
3	All SCADA-connected devices shall achieve time synchronisation accuracy of ≤ 1 millisecond relative to UTC, verified and documented during SAT.	**Mandatory**
4	NTP shall be configured as fallback for non-protection devices in the event of GPS signal loss.	**Mandatory**

6.4 PROTOCOL REQUIREMENTS SUMMARY

Protocol	Application	Requirement
Modbus TCP	BESS BMS, meter polling	Mandatory — register maps to be provided to project team at FAT
IEC 61850 MMS	Protection relay to SCADA	Mandatory — IEC 61850 Edition 2 minimum
IEC 61850 GOOSE	Protection relay inter-tripping	Mandatory — dedicated VLAN; delivery ≤ 4 ms
OPC-UA	SCADA to historian; EMS to PLC	Mandatory — certificate-based authentication required
MQTT	Research data streaming; IoT sensors	Mandatory — MQTT broker provided in Zone 3
REST / HTTPS	EMS API; research access; public display	Mandatory — OpenAPI specification required from contractor

7. Layer 4 — Data and Analytics

7.1 DATA HISTORIAN

S. No	Requirement	Classification
1	A time-series historian shall be provided storing all operational data from all SCADA-connected assets.	**Mandatory**
2	The historian platform shall be open-source or open-core with no vendor lock-in on data export. Recommended platforms include InfluxDB or TimescaleDB. Platform selection shall be approved by the project team.	**Mandatory**
3	All historian data shall be exportable in CSV, JSON, and Apache Parquet formats without additional licences.	**Mandatory**
4	The historian shall store data at minimum resolutions of: 1-second for protection-class assets; 1-minute for energy, power, and BESS data; 1-minute for environmental data.	**Mandatory**
5	Raw 1-second data shall be retained for minimum 90 days before downsampling to 1-minute resolution for long-term archive.	**Mandatory**
6	Long-term 1-minute archive shall be retained for a minimum of 10 years. Storage capacity to meet this requirement shall be provided within this contract.	**Mandatory**
7	The historian shall provide an SQL, OPC-UA server interface or a query API (REST or equivalent) accessible to authorised Zone 3 research workstations	**Mandatory**
8	The historian shall support automated backups to secondary storage. Backup schedules (full and incremental), storage location, and retention period shall be configurable. The system shall support long-term archival of historical data for a minimum retention period of 10 years.	**Mandatory**
9	The historian solution shall support disaster recovery with a Recovery Time Objective (RTO) of no more than 4 hours and a Recovery Point Objective (RPO) of no more than 1 hour. The supplier shall provide the recovery procedures and demonstrate compliance with these objectives.	**Mandatory**
10	The historian shall support high-availability deployment through redundant servers and/or database replication to minimize service interruption in the event of a hardware or software failure. Automatic failover shall be supported where specified by the project requirements.	**Mandatory**

7.2 DASHBOARDS

7.2.1 Operations Dashboard

S. No	Requirement	Classification
1	An operations dashboard shall display real-time power flows, BESS SoC, operating mode, active alarms, and daily KPIs for the facility operations team.	**Mandatory**
2	The operations dashboard shall be accessible from authorised OT network workstations without internet connectivity dependency.	**Mandatory**
3	The operations dashboard shall display trend charts for any SCADA tag over a minimum 7-day look-back without requiring historian export.	**Mandatory**

7.2.2 Research Dashboard

S. No	Requirement	Classification
1	A separate research dashboard shall allow ad-hoc plotting of any historian tag over any time range at native resolution.	**Mandatory**
2	The research dashboard shall allow direct dataset export in CSV and JSON formats from the dashboard interface.	**Mandatory**
3	The research dashboard shall be accessible from Zone 3 workstations and from the university campus network via authenticated HTTPS.	**Mandatory**
4	Researchers shall participate in the design of the research dashboard during detailed design. The contractor shall incorporate agreed requirements at no additional cost.	**Mandatory**

7.2.3 Public-Facing Display

S. No	Requirement	Classification
1	A public-facing display suitable for a lobby kiosk or web portal shall update at a maximum interval of 60 seconds and expose no operational control functions.	**Mandatory**
2	The public display shall show as a minimum: solar generation today (kWh), BESS state (SoC%), grid import/export, estimated CO2 avoided (kg), and campus energy self-sufficiency ratio (%).	**Mandatory**

7.3 ANALYTICS CAPABILITIES

S. No	Requirement	Classification
1	BESS cycle counting and capacity fade tracking shall be implemented, with alerts when available capacity falls below a configurable threshold (default 80% of rated).	**Mandatory**
2	Integration points shall be provided for ingestion of real-time grid carbon intensity data from a national grid operator or third-party API.	**Mandatory**

S. No	Requirement	Classification
3	An interface for ingestion of university timetable and occupancy data shall be provided to support load forecasting model improvement.	**Mandatory**

7.4 DATA GOVERNANCE FRAMEWORK

The contractor shall deliver a Data Governance Framework document as a contractual deliverable covering:

- Data ownership — who owns operational data and research datasets, including publication rights
- Access tier definitions — specifying what each role (ops, researcher, student, vendor, external) can access, read, or write
- Retention and downsampling schedule — formal definition of all retention periods and down-sampling rules
- Data dictionary — formal register of all tags, units, source devices, and update rates in CSV/JSON format
- Data sharing and publication policy — conditions under which operational data may be used in research publications

7.5 CANONICAL INFORMATION MODEL AND INTEROPERABILITY

- The Solution shall adopt a vendor-neutral canonical information model to ensure semantic interoperability and support modular replacement or enhancement of software components.
- All data exchanged between software components, including measurements, commands, alarms, events, asset metadata, DER information, schedules, forecasts, optimisation results and asset health data, shall conform to a common information model independent of the communication protocol.
- The information model shall be based on recognised industry standards, including IEC 61850 for field devices and DERs, IEC 61970/IEC 61968 (CIM) for enterprise-level information, and SunSpec Information Models for DER equipment where applicable.
- Communication interfaces, including IEC 61850, OPC-UA, Modbus TCP (preferably SunSpec Modbus), MQTT and REST API, shall serve only as transport mechanisms and shall not alter the underlying data semantics.
- The Contractor shall ensure that SCADA, Historian, Microgrid Controller, EMS, APM (Asset Performance Management), Forecasting, Analytics, and Dashboard applications interface through the canonical information model using documented, standards-based adapters. Complete interface specifications, object mappings and data dictionaries shall be provided as part of the project documentation.

8. Layer 5 — Cybersecurity

8.1 FRAMEWORK AND TARGET SECURITY LEVELS

All cybersecurity provisions shall be designed and implemented in accordance with IEC 62443. The general objective of implementing cybersecurity is for the system to be protected against localized network manipulation, strictly enforcing access control, encryption, and log histories as dictated by the **Ministry of Power / CERT-In guidelines** for Indian power systems. The following Security Levels are targeted:

Zone 1 — Field / Device Level	Security Level 2 (SL2)
Zone 2 — Control / SCADA Level	Security Level 2 (SL2)
Zone 3 — Enterprise / Research Level	Security Level 1 (SL1)
All inter-zone conduits (firewalls)	Conduit SL2 minimum

8.2 ZONE AND CONDUIT DESIGN

S. No	Requirement	Classification
1	The contractor shall provide a formal Zone and Conduit diagram per IEC 62443-3-2 as a design deliverable, reviewed and approved by the consultant prior to detailed design.	**Mandatory**
2	Industrial firewalls shall be installed at all inter-zone boundaries. Consumer-grade or enterprise IT firewalls are not acceptable for OT zone separation.	**Mandatory**
3	The OT network (Zones 1 and 2) shall be physically separated from the university campus IT network. Shared switching infrastructure is not acceptable.	**Mandatory**
4	IEC 61850 GOOSE traffic shall be confined to Zones 1 and 2 and shall not traverse inter-zone firewalls.	**Mandatory**
5	Wireless access (WiFi, cellular, or any RF technology) to Zone 1 or Zone 2 is prohibited under any circumstances.	**Mandatory**
6	A unidirectional data gateway shall be evaluated for the Zone 2 to Zone 3 historian export path, preventing inbound writes from Zone 3 to Zone 2.	**Mandatory**

8.3 IDENTITY AND ACCESS MANAGEMENT

S. No	Requirement	Classification
1	RBAC shall be implemented with a minimum of five roles: System Administrator, Operations Engineer, SCADA Operator, Researcher, and Vendor. Each role shall have documented access privileges.	**Mandatory**
2	Multi-factor authentication (MFA) shall be required for all remote access sessions to Zone 1 and Zone 2 systems.	**Mandatory**

S. No	Requirement	Classification
3	All vendor remote access shall be through a site Privileged Access Workstation (PAW) with session recording, time-limited credentials, and logging. Permanent always-on VPN tunnels for vendor access are not acceptable.	**Mandatory**
4	All default credentials on supplied equipment shall be changed prior to commissioning. A credential management procedure shall be documented and provided to the project team.	**Mandatory**
5	All user access events across all OT systems shall be logged to a tamper-evident audit log retained for minimum 2 years.	**Mandatory**

8.4 EQUIPMENT PROCUREMENT SECURITY REQUIREMENTS

S. No	Requirement	Classification
1	All equipment vendors shall declare in writing, prior to contract award, all outbound network connections made by their equipment by default.	**Mandatory**
2	All default cloud connectivity and manufacturer telemetry shall be capable of being completely disabled without affecting operational functionality or voiding warranty.	**Mandatory**
3	Equipment vendors shall provide a Software Bill of Materials (SBOM) for all firmware supplied.	**Mandatory**
4	Major system components shall have IEC 62443-4-2 product certification, or the vendor shall provide a documented compensating controls plan approved by the consultant.	**Mandatory**

8.5 SECURITY TESTING AND MONITORING

S. No	Requirement	Classification
1	An independent OT penetration test shall be conducted after SAT and prior to COD by a qualified OT security firm. All critical and high findings shall be remediated prior to COD.	**Mandatory**
2	An OT network monitoring tool shall be deployed in Zone 2 providing continuous passive monitoring and automated anomaly detection, generating alerts to the SCADA alarm system.	**Mandatory**
3	A vulnerability management procedure shall be established defining how CVEs affecting supplied equipment will be assessed, communicated to the project team, and remediated.	**Mandatory**
4	The contractor shall conduct cybersecurity awareness training for all project team staff with OT system access prior to COD.	**Mandatory**

9. Testing and Commissioning

9.1 FACTORY ACCEPTANCE TEST (FAT)

A FAT shall be conducted for all major digitalisation subsystems prior to shipment. The FAT shall be witnessed by the project team and/or consultant. The FAT procedure shall be submitted for review and approval a minimum of 30 days prior to the FAT date.

The FAT shall demonstrate as a minimum:

- Microgrid Controller state machine — all operating modes and transitions with simulated inputs
- EMS forecasting, scheduling, and dispatch algorithm operation against historical datasets
- SCADA communication with simulated field devices using production Modbus register maps
- Historian data ingestion, storage, query, and export in all required formats
- All dashboard views, trend displays, and alarm functions
- OPC-UA, MQTT, and REST API interfaces — including authentication and role enforcement
- Cybersecurity configuration — RBAC, firewall rules, audit logging, PAW session recording
- Time synchronisation — ≤ 1 ms accuracy from GPS grandmaster to all simulated devices

9.2 SITE ACCEPTANCE TEST (SAT)

A SAT shall be conducted after all site installation is complete, witnessed by the project team's representative and consultant. The SAT procedure shall be submitted for review minimum 30 days prior.

In addition to all FAT items re-demonstrated on live hardware, the SAT shall include:

- End-to-end data verification from every field sensor through to historian and dashboards
- Time synchronisation verification — ≤ 1 ms from GPS grandmaster to all field devices, measured and documented
- All operating mode transitions in live grid-connected configuration
- Islanded mode test — scope to be agreed with OPTCL/SLDC and project team
- Protection relay secondary injection tests — all functions tested and documented
- 72-hour reliability run — continuous operation with zero SCADA data loss
- OT penetration test completed and report provided prior to COD

9.3 TRAINING

Facility operations team	Minimum 3 days: SCADA operation, alarm management, BESS and EMS manual override, basic fault diagnosis and escalation procedure
Research engineers	Minimum 2 days: historian query, dashboard customisation, EMS API access, algorithm sandbox operation
System administrator	Minimum 2 days: SCADA administration, user management, backup and recovery, cybersecurity procedures, vulnerability management
Training materials	All materials shall be in editable digital format and remain the intellectual property of the project team

10. Odisha-Specific Requirements

10.1 REGULATORY INTERFACE

S. No	Requirement	Classification
1	The SCADA and metering system shall provide telemetry to OPTCL/SLDC in the required protocol, format, and frequency. The contractor shall coordinate directly with OPTCL/SLDC to confirm interface requirements.	**Mandatory**
2	The contractor shall obtain all metering test certificates required by OERC for revenue-grade metering at the PCC and provide copies to the project team prior to COD.	**Mandatory**
3	A protection relay settings document shall be prepared, reviewed by the consultant, and submitted to OPTCL for approval. The contractor shall attend any OPTCL review meetings required.	**Mandatory**
4	The EMS market interface (ref. EMS-07) shall be capable of interfacing with the Indian Energy Exchange (IEX) or any aggregator designated by the project team.	**Mandatory**

10.2 LOCAL CONDITIONS AND INFRASTRUCTURE

- All outdoor field equipment shall be rated for tropical operation — conformal coating, dehumidification, and anti-corrosion treatment are mandatory for all PCB-based equipment in non-climate-controlled enclosures.
- UPS backup with minimum 4-hour autonomy is mandatory for all OT network equipment and control systems to account for power supply instability.
- All civil conduit routes for communication cables shall avoid areas identified as flood-prone in the site drainage survey, to be completed during detailed design.
- The contractor shall demonstrate local service and maintenance capability in India for all major system components, including contact details for in-country service representatives and response time commitments.

Microgrid Use Cases – Performance Validation & Improvements (Effectiveness & Efficiency)

For Distribution Network Operator (DNO):

- Future Distribution Grid Architecture
- DERs Integration & Control Upgrades
- Demand & Flexibility Management Tools
- Grid Stability & Power Quality

For Power System Operator (PSO):

- Clean Energy Market Interfaces
- Grid Services Settlement
- Low Carbon Credits - Programs
- Clean Energy Trading Services



Envisioned Grid Ancillary Services Demonstration Planned Through This Pilot Project

11. Tender Response Requirements

Tenderers shall provide the following information in their tender submission. Non-compliance may result in disqualification.

11.1 TECHNICAL COMPLIANCE SCHEDULE

Tenderers shall provide a completed Compliance Schedule listing every requirement (Sections 4 through 10) and for each stating: COMPLY / COMPLY WITH DEVIATION (deviation described) / NOT COMPLY (reason stated). Blanket compliance statements are not acceptable.

11.2 PROPOSED SYSTEM ARCHITECTURE

- System architecture diagram showing all proposed subsystems, vendors, and inter-system interfaces
- Network architecture diagram showing OT topology, zone boundaries, VLANs, and firewall positions
- Written confirmation that EMS and PLC will be procured from separate vendors with OPC-UA inter-communication, or written justification if a bundled solution is proposed

11.3 PROTOCOL AND INTERFACE REGISTER

Tenderers shall provide a protocol register listing every system interface, the protocol used, and confirmation of compliance with Section 6.4.

11.4 CYBERSECURITY DECLARATIONS

- Written declaration confirming target IEC 62443 security levels and approach to achieving them
- IEC 62443-4-2 product certifications for all major components, or compensating controls plan
- Cloud connectivity declaration for all equipment — listing all outbound connections and confirming they can be disabled

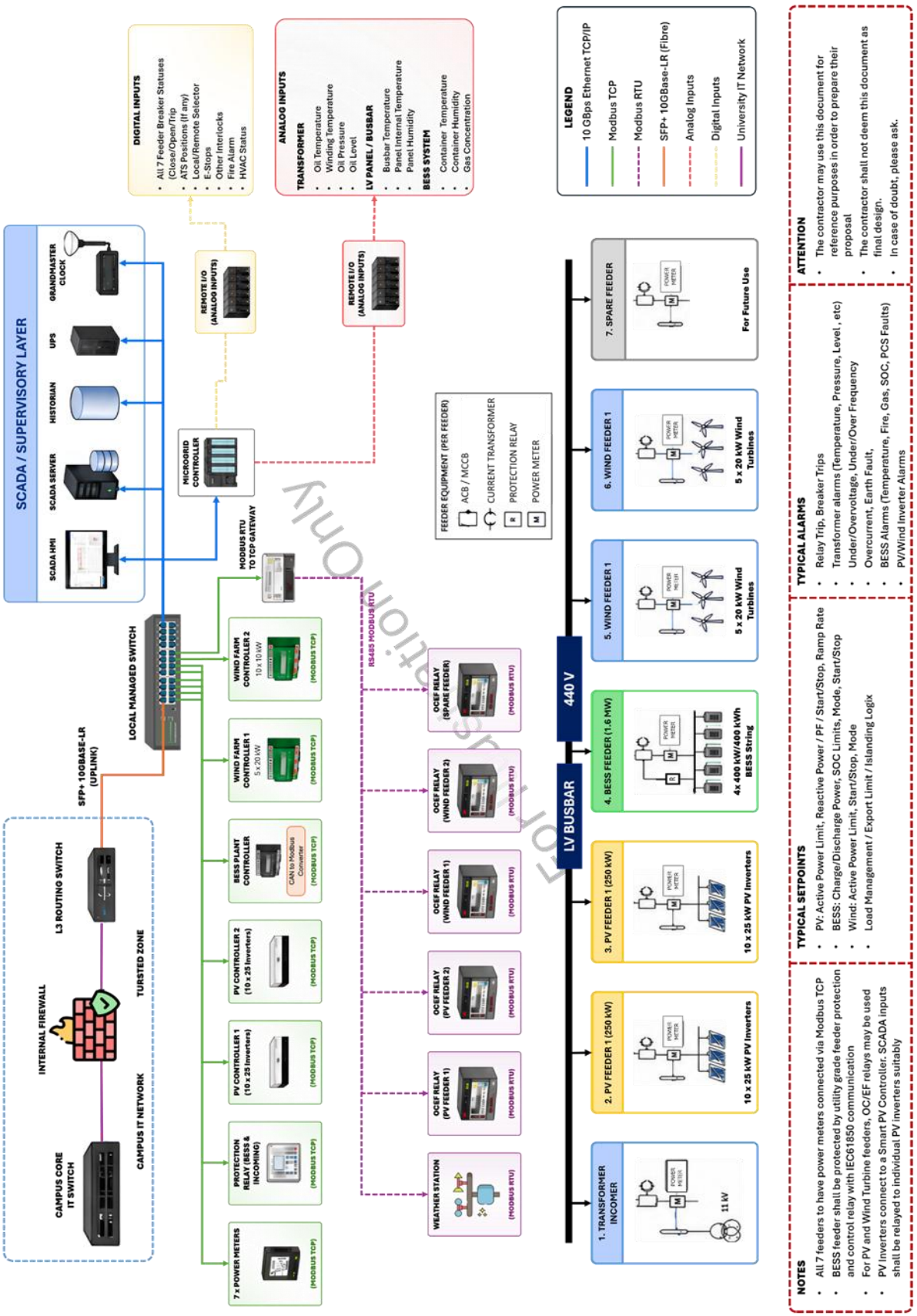
11.5 LOCAL SERVICE CAPABILITY

Tenderers shall provide evidence of authorised service capability in India for all major system components, including contact details for in-country service representatives and response time commitments for Odisha.

11.6 REFERENCE PROJECTS

Tenderers shall provide a minimum of two reference projects of comparable scope (grid-connected microgrid or renewable energy digitalisation, >500 kW, completed within the past five years) with client contact details for verification

Annexe A - Communication Architecture for Theme 1



SECTION 3 :

GRID CORE INFRASTRUCTURE

TECHNICAL SPECIFICATIONS

PILOT PROJECT

Document Reference	SECTION 3 : GRID CORE INFRA
Revision	Final
Date	29 July 2026
Status	

iv. **Section-1** covers Grid Assets Specific to the Pilot Project.

v. **Section-2** covers Grid Digitalization, SCADA, Communication and Control Systems

vi. **Section-3** covers Switchgear, Transformers, Meters, Containers, Structures, Earthing

The tenderer/developer shall comply with all applicable grid codes, CEA, MNRE regulations and mandates concerning component sourcing, system quality, and specific asset testing protocols.

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9. Circuit Breakers 114

10. Cables (LT/HT) 119

Objective:

Section-3 document covers the functional requirements, specifications of the grid core infrastructure for the Development, Deployment and Demonstration of the envisioned pilot project (refer to Section-1 and 2). Please note that the sizing and capacity of the following components in Section-3 shall be calculated by the tenderer/developer according to the bid submission of the proposed components and grid assets in Section-1.

1. Power Grid Transformers (Inverters and Substations)
2. 11kV and 415V Switchgear HT / LT Cables
3. Power Quality Meters, Protection Relays, Circuit Breakers
4. 40ft Containers and Building Structures
5. Earthing and Lightning Protection Systems

The overall system shall be holistically integrated for seamless operation and equipped with a digital grid command center for 24x7 autonomous operation, monitoring, control features and grid ancillary services. This pilot is to be designed and developed as a benchmarking platform equipped with state-of-the-art technologies and grid solutions dedicated to Odisha's Energy Transition and future roadmap. Thus, the tenderer shall ensure strict adherence to Grid Codes, Regulations, Requirements and Compliance of the system as per the relevant agencies and organizations.

ALMM	Approve List of Models and Manufacturers
BIS	Bureau of Indian Standards
CEA	Central Electricity Authority
DISCOM	Distribution Company
MNRE	Ministry of New and Renewable Energy
NABL	National Accreditation Board for Testing and Calibration Laboratories
OERC	Odisha Electricity Regulatory Commission
OREDA	**Odisha Renewable Energy Development Agency**
OPTCL	**Odisha Power Transmission Corporation Limited**
TPCODL	**TATA Power Central Odisha Distribution Limited**

1. Power Grid Transformers

In this project, transformers are required to interface the Power Conversion Systems and as well as Substation Grid Interconnection. Ranging from 0.5MVA to 3MVA as per the expected power flow sizing and capacity of grid assets in Section-1.

Microgrid transformers must comply with a combination of statutory guidelines from the Central Electricity Authority (CEA), Bureau of Indian Standards (BIS) mandates, and Bureau of Energy Efficiency (BEE) star-rating metrics. Because microgrids handle dynamic distributed energy resources (DERs) like solar, wind, and energy storage, their transformers must manage bidirectional power flows, power quality fluctuations, and islanding conditions. The primary standards governing these installations include IS 1180 (Part 1) for outdoor distribution transformers up to 2.5 MVA, IS 2026 for power transformers, and CEA Technical Standards for Connectivity.

Standards & Compliance

Operational Category	Applicable Standards / Regulations	Key Parameters & Technical Requirements	Compliance Mandate Details
General Product & Design Safety	**IS 1180 (Part 1): 2014** **IS 2026 (Parts 1–16)**	• Standard ratings up to 2500 kVA • Voltage classes up to 11 kV, 22 kV, and 33 kV • Insulation Levels & Temperature Rise	Mandatory **BIS certification** (ISI Mark). Transformers must undergo design verification and strict type testing before field deployment.
Energy Efficiency & Losses	**IS 1180 (Part 1)** **BEE Schedule**	• Maximum Total Losses at 50% and 100% loads • Standardized **Star Labeling** (1-Star to 5-Star)	Must meet the maximum allowable loss values. **Minimum 3-Star rating** is typically mandated by Indian DISCOMs and state renewable agencies to minimize microgrid self-consumption losses.
Grid Connectivity & Integration	**CEA Regulations, 2019 (Grid Connectivity Standards)**	• **Low Voltage Ride Through (LVRT)** • Active/Reactive Power Control Integration • Bidirectional flow handling	The transformer and associated switchgear must stay connected during brief grid voltage dips. Design must prevent core saturation during sudden bidirectional power flips from battery storage/solar.
Power Quality & Harmonics	**IEEE 519 / CEA Grid Standards**	• Total Harmonic Distortion (THD) limits • DC Bias current injection limits (≤ 0.5% of rated current)	Microgrid inverters inject significant high-frequency harmonics. Transformers must be designed with an appropriate **K-Factor**(typically K-4 to K-13) to prevent localized overheating.
Dry-Type / Indoor Installations	**IS 11171** **IEC 60076-11**	• Fire safety, environmental, and climatic classes • F1 (Fire risk), C2 (Climatic), E2 (Environmental)	Mandated for rooftop solar microgrids or indoor commercial basements. Requires self-extinguishing materials that do not emit toxic gases during faults.

Testing & Protection Framework	**IS 2026 (Part 5) CEA Sub-transmission Criteria**	**• Dynamic Short-Circuit Withstand** • Routine & Type Testing (Impulse/Dielectric)	Type-test certificates must be valid and verified by independent labs like CPRI or ERDA. Must incorporate islanding/anti-islanding coordination protections.
Environmental & Insulating Media	**IS 335** **IS 16659**	• Flash point (> 250°C for synthetic esters) • Biodegradability and moisture tolerance	For eco-sensitive microgrids (rural, forested, or highly congested areas), natural or synthetic ester oils are preferred over standard mineral oil to reduce fire risks.

Category	Key Technical Parameters & Requirements
Transformer Inrush & Protection	• **Inrush Blocking:** Transformers paired with GFM BESS require **2nd/4th harmonic restraint** protection relays (e.g., 87T). • GFM black start causes severe magnetic inrush that resembles internal winding faults. • **IEC 60076** (POWER TRANSFORMERS)
Transformer Core Design	• **Saturation Margin:** GFM voltage-source behaviour can inject momentary DC offsets. • Cores must have a high flux margin (typically operating lower than standard 1.7 Tesla limits) to prevent flux saturation.
Power Quality & Harmonics	• Total Harmonic Distortion (**THD**) limited to **< 5%** at the Point of Common Coupling (PCC). • Step-up transformers often utilize delta-wye (Δ-Y) winding configs to trap 3rd-order triplen harmonics generated by high-speed PWM switching. **IEEE 519 / IEC 61000 series**

Regulatory Framework / Parameter	Applicable Standard Code	Mandated Technical Compliance Value / Requirement
Vector Group Configuration	**IS 2026 / CEA Distribution Spec**	**Dyn11** (Delta connected primary, Star connected secondary with neutral brought out).
Percentage Impedance (%Z)	**IS 2026 / CEA Technical Standards**	**4.5% to 5.0%** at 75°C (subject to standard IS tolerances).
Temperature Rise Limits	**IS 2026 (Part 2)**	Top oil: max **50°C** over ambient; Winding: max **55°C** (oil-immersed) or 65°C (dry-type).
Short-Circuit Withstand	**IS 2026 (Part 5) / CEA Rules**	Dynamic short-circuit test validity required to withstand symmetric/asymmetric external faults.
Insulation & Impulse Levels	**IS 2026 (Part 3)**	11 kV Class: Lightning Impulse **75 kVp**, Power Frequency Withstand **28 kV rms**.
Harmonics Limitation	**IEEE 519 / CEA Grid Standards**	Max Total Harmonic Distortion (<5%) at the point of common coupling.
Operational Frequency Band	**IEGC / CEA Grid Regulations**	Must continuously withstand grid frequency excursions within the **47.5 Hz to 52.0 Hz** band.
Earthing & Fault Factor	**CEA Safety Regulations / IS 3043**	Neutral must be solidly earthed; Earth Fault Factor must be **≤ 1.4** for effective grounding.

Technical Parameter	Standard Requirements	Regulatory Reference
Rated Capacity	500 kVA (0.5 MVA)	IS 1180 / IS 2026
Voltage Ratio	Nominal 11 kV / 0.433 kV or 33 kV / 0.415 kV	IS 1180 (Part 1)
Frequency	50 Hz (± 5%)	CEA Guidelines
Vector Group	**Dyn-11** (Delta Primary, Star Secondary with Neutral)	IS 2026 (Part 4)
Cooling Method	**ONAN** (Oil Natural Air Natural)	IS 2026 (Part 2)
% Impedance	4.5% to 5.0% (± 10% tolerance)	IS 2026 (Part 5)
Max Temperature Rise	45°C (Top Oil) / 55°C (Winding) over 50°C ambient	IS 2026 / CEA
Core Material	CRGO (Cold Rolled Grain Oriented) Silicon Steel	CEA / BIS Mandate
Tap Changer	Off-Circuit Tap Changer (OCTC) typically +5% to -7.5%	IS 1180 / BIS

Critical Technical Requirements - Substations Power Grid Transformers

1) **IS 1180 Mandatory Certification**: In India, any distribution transformer up to 2.5 MVA and 33 kV class cannot legally be connected to the grid unless it carries a valid **BIS certification mark** matching IS 1180 criteria.
2) **Fault Performance**: 0.5 MVA transformer is regularly exposed to distribution system transient faults, type test certification for short-circuit withstand capabilities (per IS 2026 Part 5) is non-negotiable for project clearance by State DISCOMs.
3) **Renewable Integration Rule (If applicable)**: If this transformer links a 500 kW commercial solar PV roof or The system must support dynamic network functions (like anti-islanding protection) under the **CEA Distributed Generation Connectivity Regulations dedicated to** interfacing microgrid to the local DISCOM.
4) **Conservator Tank**: Manages oil volume variations under thermal cycling.
5) **Magnetic Oil Gauge (MOG)**: Provides visual and electrical low-oil warnings.
6) **Silica Gel Breather**: Extracts moisture from incoming air during transformer breathing.
7) **Explosion Vent / PRV**: Relieves internal overpressure during electrical faults.
8) **Buchholz Relay**: Triggers alarms or circuit trips when internal gas builds up.
9) **Thermometers (OTI / WTI)**: Tracks top oil and winding hot-spot conditions.
10) **Earthing Terminals**: Safe fault-current mitigation via two separate tank earth points.
11) **Drain & Filter Valves**: Enables oil sampling and regular filtration maintenance.
12) **Rating & Diagram Plate**: Weatherproof technical reference detailing vector layouts and parameters.
13) **K-Factor Sizing**: Standard distribution transformers assume linear loads. Microgrids require explicit **K-factor filtering or oversized neutral conductors** to counter triplen harmonics generated by solar/wind inverters.

14) **Bidirectional Tap Changers**: Microgrid transformers frequently utilize On-Load Tap Changers (OLTC) governed by smart controllers. This design continuously mitigates voltage swells or sags caused by erratic localized generation.

15) **Galvanic Isolation**: For inverter-heavy standalone systems, an isolation transformer configured in **Delta-Wye (Δ-Y)** is highly recommended. This acts as a buffer to block direct current (DC) injections into the localized distribution network.

Testing & Certification

Test Category	Specific Test Name	Mandatory Indian Standard (IS)	Objective & Purpose
1. Routine Tests (DONE ON 100% OF MANUFACTURED UNITS)	**Winding Resistance Measurement**	IS 2026 (Part 1)	Verifies loose electrical connections or winding defects.
	Voltage Ratio & Vector Group	IS 2026 (Part 1)	Confirms voltage turns ratio and phase displacement.
	Impedance Voltage & Load Loss	IS 2026 (Part 1)	Measures copper loss at 75°C to comply with maximum allowable limits.
	No-Load Loss & Excitation Current	IS 2026 (Part 1)	Evaluates structural iron/core loss parameters.
	Insulation Resistance (Megger)	IS 2026 (Part 1)	Checks dielectric health between windings and the ground/tank.
	Dielectric/Induced Overvoltage AC Withstand	IS 2026 (Part 3)	Validates inter-turn and fundamental insulation strength.
	Transformer Oil Breakdown (BDV)	IS 335 / IS 1866	Ensures dielectric strength of the insulating fluid matches grid requirements.
2. Type Tests	**Temperature Rise Test**	IS 2026 (Part 2)	Proves winding and top-oil temperature remain within 55°C/50°C limits.
	Lightning Impulse Withstand Test	IS 2026 (Part 3)	Simulates high-voltage lightning surges to ensure insulation survives.
3. Special Tests	**Short-Circuit Withstand Capability**	IS 2026 (Part 5)	Proves mechanical resilience against severe grid faults. (MUST BE < 5 YEARS OLD)
	Measurement of Acoustic Noise	IS 2026 (Part 10)	Confirms hum levels stay within pollution control limits.
	Oil Dissolved Gas Analysis (DGA)	IS 9434	Baseline analysis to monitor gas generation over time.
4. Regulatory Compliances	**BIS Certification (ISI Mark)**	IS 1180 (Part 1)	Statutory market-entry license required before commissioning.
	BEE Star Labeling	Energy Conservation Act	Mandatory energy rating showing strict adherence to maximum loss limits.

2. HT Switchgear 11kV Network

In this project, 11kV switchgear is required to interface the Power Conversion Systems and as well as Substation Grid Interconnection. Each LT/HT feeders are ranging from 50kW to 5MVA as per the expected power flow sizing and capacity of grid assets in Section-1. Core functions as below.

- Compartmentalized Enclosures: Separate, sealed gas-tight compartments for busbars, circuit breakers, current/voltage transformers, and cable termination chambers to isolate internal faults.
- Integrated Disconnector & Earth Switch: Three-position disconnectors (OPEN – CLOSED – EARTHED) with mechanical interlocks to prevent unauthorized or unsafe switching sequences.
- SCADA & Automation Integration: Equipped with numerical protection relays supporting the IEC 61850 protocol for seamless integration into Substation Automation Systems (SAS) and remote monitoring.
- Pressure Monitoring: Density monitors/gauges with alarm contacts for continuous monitoring of gas pressure and leak detection.
- Hermetically Sealed Tank: Stainless steel enclosure preventing ingress of moisture, dust, or atmospheric contaminants.
- Plug-In Cable Terminations: High-voltage cable compartments equipped with outer cone or inner cone plug-in bushings supporting screen-shielded cable joints.

Standard	Description
IS/IEC 62271-200	Factory-assembled metal-enclosed switchgear and controlgear for voltages above 1kV and up to 52kV.
IS/IEC 62271-100	High-voltage alternating current circuit breakers.
IS/IEC 62271-102	Alternating current disconnectors and earthing switches.
IS/IEC 62271-207	Seismic qualification for gas-insulated switchgear assemblies.
IS/IEC 62271-1	Common specifications for high-voltage switchgear and controlgear standards.
IS 2705 / IEC 61869	Instrument Transformers (Current Transformers).
IS 3156 / IEC 61869	Instrument Transformers (Voltage Transformers).
IS 60529	Degrees of protection provided by enclosures (IP Codes, typically IP67 for gas tanks).
IS 1248	Direct acting indicating analogue electrical measuring instruments.

Technical Requirement	Compliance Specification (India Local Norms)	Reference Standard
Rated System Voltage	12 kV for 11kV networks	IS 60038
System Frequency	50 Hz ± 3%	IS/IEC 62271-1
Rated Short Time Withstand	21 kA to 25 kA for 3 seconds	IS/IEC 62271-200
Lightning Impulse Voltage	75 kVp	IS/IEC 62271-200
Power Frequency Withstand	28 kV (for 1 minute)	IS/IEC 62271-200
Insulating Medium	SF_6 Gas (at low pressure, < 0.05 MPa relative)	IS/IEC 62271-203
Busbar Current Rating	630 A (Outgoing), 1250 A - 2500 A (Incomer)	IS 5082
Arc Fault Withstand	Internal arc classification (IAC) AFL/AFLR (e.g., 20 kA for 1s)	IS/IEC 62271-200

Test Certificates

Submit certified copies of test certificates for the following normal and special type tests as stipulated in IEC 62271-200:

Normal type tests:

- Dielectric tests to verify the insulation level of any part of the equipment including tests at power-frequency test voltages on auxiliary circuits
- Tests to prove the temperature rise of any part of the equipment and measurement of the resistance of the main circuit
- Tests to prove the capability of the main and earthing circuits to be subjected to the rated peak and the rated short-time withstand currents
- Test to prove the making and breaking capacity of the included switching devices
- Tests to prove the satisfactory operation of the included switching devices and removable parts
- Tests to verify the protection of persons against approach to live parts and contact with moving parts
- Tests to verify the protection of persons against dangerous electrical effects
- Tests to verify the strength of gas-filled compartments
- Tests to verify gas tightness of gas-filled compartments

Special type tests:

- Tests to verify the protection of the equipment against mechanical damage
- Tests to assess the effects of arcing due to an internal fault
- Tests to detect certain defects in the solid insulation of the equipment by the measurement of partial discharges

Routine tests:

Carry out the following routine tests on the switchgear at the manufacturer’s works prior to shipment:

- Mechanical operation tests
- Tests of auxiliary electrical, pneumatic and hydraulic devices
- Verification of correct wiring
- Pressure tests of gas-filled compartments
- Gas tightness tests of gas-filled compartments
- AC pressure test
- Voltage transformers
- Current transformers

Site Tests

- After erection on site, conduct the following tests carried out by an Licensed/qualified Electrical Engineer and present the results duly certified by him to the SO/Engineer. Ensure that test equipment has been calibrated within the last 12 months and copies of valid calibration certificates shall be provided for the SO / Consulting Engineer.

Mechanical tests

- Ensure busbars and circuit cables are earthed. Install temporary earthing clamps if necessary.
- Check all busbar joints and cable terminations for tightness.
- Check all circuit breakers for correct operation of the following as applicable:

    a) closing mechanism

    b) opening mechanism

    c) manual spring charging

    d) electric spring charging

    e) operations counter

    Check all gas pressure indicators for correct operating pressures.

Secondary wiring tests

- Measure the insulation resistance of the secondary circuits with an insulation tester.

Low voltage system tests

- Check correct operation of battery chargers for tripping and closing of circuit breakers as well as the state of the batteries.

Tests on interlocks

- The correct operation of the mechanical and electrical interlocks shall be tested.

Power frequency voltage withstand tests /AC Pressure tests

- With circuit breakers withdrawn, apply AC pressure tests to the busbar sections of the erected switchgear using the test voltage appropriate to the nominal system voltage for 1 minute in accordance with the test method specified in IEC 62271.
- Also apply the AC pressure test to the withdrawn circuit breakers.

Sample System :

Short-Circuit Breaking Capacity	25 kA for 3 seconds (or 31.5 kA for 3 sec)
Power Frequency Withstand Voltage	28 kV RMS for 1 minute
Lightning Impulse Withstand Voltage	75 kV Peak
Auxiliary DC Control Voltage	110 V DC or 220 V DC (operate within 70% to 110% rating)
Auxiliary AC Supply	240 V Single-Phase / 415 V Three-Phase AC
Degree of Protection	Gas Compartments: IP65/IP67; External Panel Structure: IP4X / IP5X

Testing and Certification

Category	Specific Test / Requirement	Applicable Standard	Purpose & Indian Context
Mandatory Certification	**BIS Scheme X License**	IS/IEC 62271-200 IS/IEC 62271-100	**Compulsory ISI Mark**. Legally required for manufacturing, importing, or deploying HT panels in India.
Type Tests (Design Validation)	**Dielectric Tests**	IS/IEC 62271-200 (Clause 6.2)	Verifies insulation performance via Lightning Impulse Withstand and Power-Frequency tests.
	Temperature-Rise Test	IS/IEC 62271-200 (Clause 6.5)	Confirms busbars and contacts handle rated continuous current without overheating.
	Short-Time & Peak Withstand	IS/IEC 62271-200 (Clause 6.6)	Proves mechanical and thermal strength during microgrid/grid short circuits (e.g., 31.5 kA for 1 sec).
	Internal Arc Fault Test (IAC)	IS/IEC 62271-200 (Clause 6.106)	Crucial for safety in confined microgrid spaces; verifies explosion and gas containment.
	Mechanical Operation Test	IS/IEC 62271-100 / 102	Verifies durability and proper alignment of vacuum circuit breakers (VCB) and earthing switches.
Microgrid Grid-Connectivity	**Anti-Islanding Protection**	CEA Regulations 2013/2026 IEEE 1547	Ensures switchgear automatically isolates the microgrid from the utility grid during utility power failure to protect lineworkers.
	Power Quality Monitoring	CEA Connectivity Regulations IEEE 519	Evaluates switchgear integrated meters for managing harmonic current injection, DC offset (≤ 0.5%), and voltage flicker.
	Synchronization Capability	CEA Technical Standards	Mandates automatic check-synchronization relays for safe re-connection of the microgrid to the utility grid.
Routine Tests (Every Unit)	**Power Frequency Voltage Test**	IS/IEC 62271-200 (Clause 7.1)	Conducted on the main circuit at the factory to check insulation integrity post-assembly.
	Voltage Tests on Control Circuits	IS/IEC 62271-200	Checks low-voltage wiring, auxiliary relays, and tripping mechanisms.
	Resistance of Main Circuit	IS/IEC 62271-200 (Clause 7.3)	Contact resistance check using a micro-ohmmeter to ensure minimal power loss.
Site Commissioning (SAT)	**High Potential (Hi-Pot) & IR**	IS 3427 / CEA Safety Regs	Insulation Resistance (IR) measurement via a 5000V tester prior to system charging.
Environmental & Special	**Seismic & Environmental**	IS/IEC 62271-207 IS 2147 (IP Ratings)	Verifies seismic qualification and ingress protection against dust/moisture (critical for outdoor microgrids).

Compliance	Mandatory Technical / Procedural Requirements
Statutory Authorization	• Mandatory inspection and **Written Approval to Energize** from the Chief Electrical Inspector (EIC Electricity, Odisha) prior to commissioning. • Annual or periodic statutory inspections.

Installation Licensing	• Installation work must be executed exclusively by an Electrical Licensing Board of Odisha (ELBO) licensed **HT/EHT Contractor**. • Supervised directly by a certified Competent Supervisor.
Mandatory Design Standards	• Switchgear panels must be fully metal-enclosed, floor-mounted, and single-front. • National Electrical Code (NEC) and National Building Code (NBC) alignment is **strictly mandatory**. • IS/IEC 62271-200 / 201
System Insulation Levels	• Rated Voltage: **11 kV (rms)**; Highest System Voltage: **12 kV (rms)**. • Lightning Impulse Withstand: **75 kV (peak)**. • One-minute Power Frequency Withstand: **28 kV (rms)**. • IS 12063 / IEC 60529
Short-Circuit Performance	• Symmetrical Short-Circuit Breaking Capacity: **25 kA for 3 seconds**(Rural/Semi-Urban) or **31.5 kA** (Urban/Industrial clusters).
Enclosure Protection & Safety	• Ingress Protection: Minimum **IP4X** for indoor enclosures; **IP55** for outdoor kiosks. • Internal Arc Classification (**IAC AFLR**) verified to protect operators from explosive thermal faults.
Breaker Operating Mechanism	• Circuit breakers must be **trip-free** and fitted with an **anti-pumping device**. • Operating sequence: **O - 0.3s - CO - 3min - CO** (Standard duty cycle). • IEC 62271-100
Earthing & Fault Isolation	• **Solidly earthed neutral system**. Duplicated, distinct earthing paths using copper/GI flats bonded to the substation main earth grid. • Outgoing feeders must include integrated mechanical earth blades.
Protection & Remote Control	• Numerical IDMT relays with built-in **Overcurrent (50/51)** and **Earth Fault (50N/51N)** protection. • Must feature remote SCADA integration capability using standard communication protocols (IEC 61850 or Modbus).
Pre-Commissioning Testing	• **Insulation Resistance (IR):** Minimum 5 Mega-Ohm tested at 2.5 kV DC between phases and phase-to-earth for 1 minute. • Submission of factory **Type Test Certificates** from an independent NABL-accredited lab.

3. LT Switchgear 415V Network

In this project, 415V switchgear is required to interface the Power Conversion Systems and as well as Substation Grid Interconnection. Each LT/HT feeders are ranging from 50kVA to around 5MVA as per the expected power flow sizing and capacity of grid assets in Section-1.

Standard	Description	Key Focus Area
IS/IEC 61439-1/2	Low-voltage switchgear assemblies	General rules and performance requirements for assemblies.
IS/IEC 60947-1/2	Low-voltage switchgear and controlgear	General rules and circuit-breaker requirements (ACBs/MCCBs).
IS/IEC 60947-4-1	Electromechanical contactors/motor-starters	Specific rules for Motor Control Center (MCC) components.

IS/IEC 60529	Enclosure protection (IP Code)	Defines sealing effectiveness against foreign bodies/moisture.
IS 13703 / IEC 60269	Low-voltage fuses	Ensures fuse-links perform safely under fault conditions.
IEC 61641	Internal arc fault containment	Standard for protecting against arc faults.

Because microgrids feature bi-directional power flows, rapid islanding transitions, and high penetration of distributed energy resources (DERs), their LT switchgear requires specialized microgrid control testing alongside standard switchgear design verification.

Testing & Certification

Category	Test Name	Applicable IS / IEC Standard	Compliance Objective
Type Tests(DESIGN VERIFICATION)	**Temperature Rise Test**	IS/IEC 61439-1 & 2, IS/IEC 60947	Verifies the switchgear can handle continuous full-load rated current without overheating.
	Dielectric Properties Test	IS/IEC 61439-1, IEC 60947-1	Checks insulation withstand voltage and impulse voltage strength.
	Short-Circuit Withstand Strength	IS/IEC 61439-2	Ensures busbars and breakers withstand short-circuit fault forces (e.g., 25kA for 0.5s).
	Mechanical Operation & Durability	IEC 60947-1, IS/IEC 61439	Confirms the physical durability of breakers and mechanisms over thousands of open/close cycles.
	Ingress Protection (IP) Test	IS/IEC 60529, IS/IEC 61439	Verifies dust and water resistance ratings (crucial for outdoor microgrids).
	Internal Arc Fault Test	IEC 61641 V3	Assesses containment safety in the event of an internal explosive arc fault.
	Seismic Zone Test	IEC 60068-3-3	Validates structural integrity under simulated earthquake forces.
Microgrid & Grid Integration Tests	**Anti-Islanding & Protection**	IEC TS 62898-2, IEEE 1547	Ensures rapid disconnection from the utility grid during main grid outages to protect service personnel.
	Grid Synchronization Test	IEC TS 62898-2, IEC TS 62898-3-4	Tests the switchgear's capacity to smoothly reconnect and synchronize voltage, phase, and frequency with the main grid.
	Bi-Directional Power & Control	IEC TS 62898-3-4	Validates the Energy Management System (EMS) interface and real-time active/reactive power monitoring.

	Cybersecurity & Malware Scan	Ministry of Power / CEA Directives	Mandated scanning of any embedded systems/firmware in imported components for trojans or malware.
Routine & Acceptance Tests (EVERY UNIT)	**Visual & Mechanical Inspection**	IS/IEC 61439	Confirms physical dimensions, clear labeling, drawing conformity, and proper component torque.
	Insulation Resistance (IR) Test	IS 10118-3, IS/IEC 61439	Uses a high-voltage Megger (typically 1000V DC for LT systems) to verify insulation integrity.
	High Voltage (Hi-Pot) Test	IS/IEC 61439-1	Subjects the panel to a high power frequency AC voltage for 1 minute to check for flashovers.
	Contact Resistance Measurement	IS/IEC 61439	Measures micro-ohm drop across busbar joints and breaker contacts to prevent hot spots.
	Primary/Secondary Injection Test	IS/IEC 60947	Injects current to verify protection relay trip settings, metering, and circuit breaker interlocks.

Compliance Parameter	Requirement (415V, 3-Phase, 50 Hz)	Standard
Operational Voltage	415V AC ± 10%	IS/IEC 61439-1
Short-Time Current	Typically 50 kA/65 kA for 1 sec	IS/IEC 61439-1
Impulse Voltage	8 kV minimum	IS/IEC 61439-1
Degree of Protection	Indoor: IP42-IP54; Outdoor: IP55-IP65	IS/IEC 60529
Busbar Material	Electrolytic Grade Copper/Aluminum	IS 1897 / IS 5084
Temperature Rise	Continuous 45ºC ambient, no de-rating	IS/IEC 61439-1
Internal Arc	Tested for operator protection	IEC 61641

415V Microgrid Switchgear Specifications

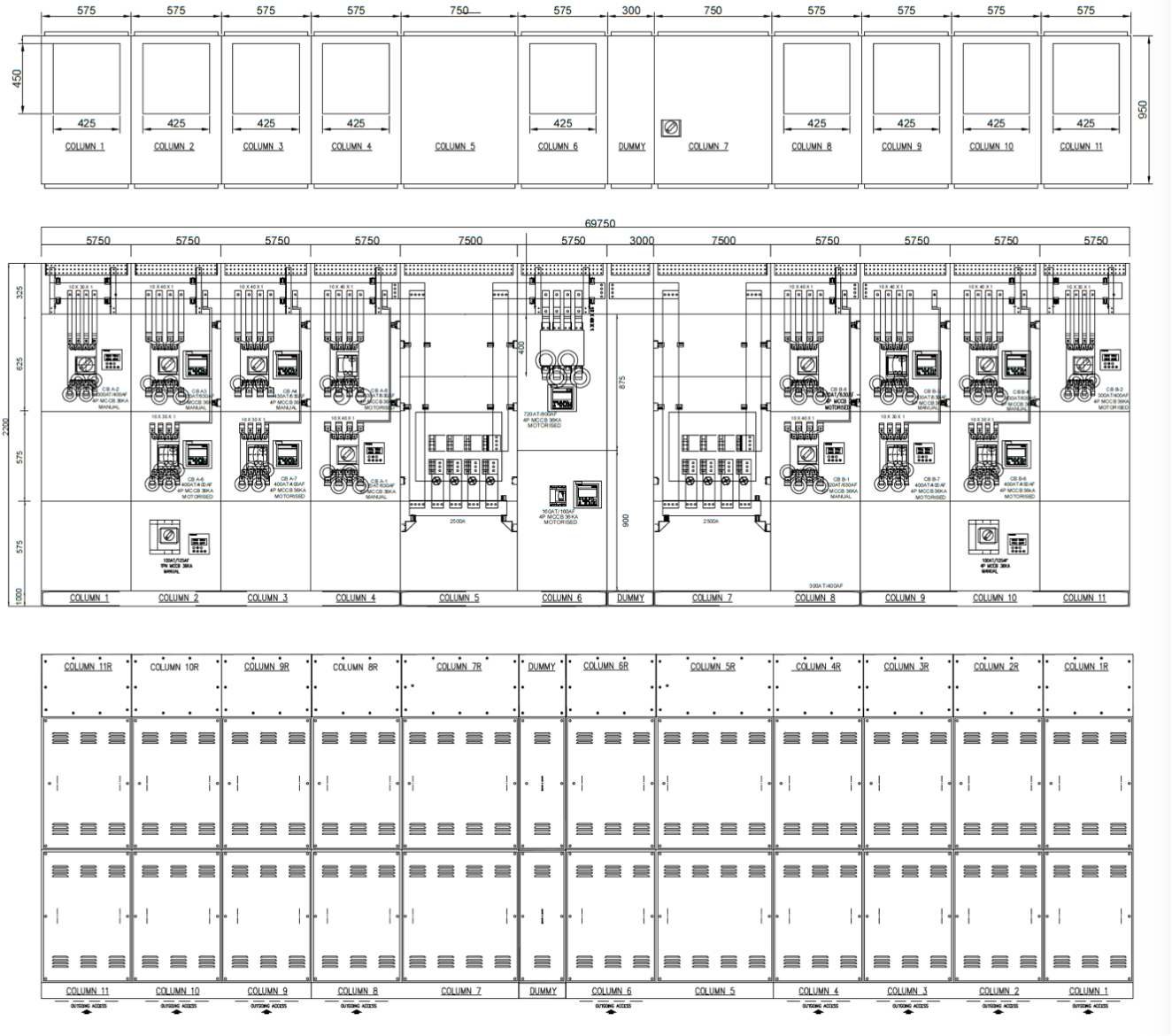
Parameter	Technical Specification	Compliance & Standards
Rated Voltage	415V AC, 3-Phase, 4-Wire (Neutral solidly grounded)	CEA Technical Standards, IS 4237
Highest System Voltage	470V AC	IEC 61439-1 / IS 8623
Rated Frequency	50 Hz ± 5%	Indian Electricity Grid Code (IEGC)
Short-Time Withstand Current	10 kA to 50 kA RMS for 1 second (dependant on site capacity)	IEC 60947-2 / IS 13947
Insulation / Withstand Voltage	3 kV RMS (Power Frequency) for 1 minute; 12 kV (Impulse)	IS 2516, IEC 60947
Degree of Protection	IP-54 (Indoor) to IP-65 (Outdoor)	IS 2147 / IEC 60529

Busbar Material & Rating	Electrolytic grade Copper or Aluminum; up to 1600A	IS 1897
Main Switching Device	Air Circuit Breaker (ACB) or Molded Case Circuit Breaker (MCCB)	IEC 60947-2
Controller / Protection	Microprocessor-based numerical relays supporting directional overcurrent (67), earth fault (64), and under/over voltage (27/59)	CEA Regulations
Islanding & Synchronization	Automatic disconnection & synchronization upon grid restoration	IEC 61850 / IEEE 1547

System level Testing

Test Category	Test Name	Relevant Standards	Purpose & Acceptance Criteria
Verification of Limits	**Temperature Rise Test**	IS/IEC 61439-2, IS 8623	Verifies that busbars and components do not overheat beyond specified limits at maximum rated current.
Dielectric Properties	**Power Frequency Voltage**	IS/IEC 61439-1	Tests the panel's ability to withstand system overvoltages and ensures insulation integrity.
Dielectric Properties	**Impulse Voltage Withstand**	IS/IEC 61439-1	Checks capability to withstand atmospheric or switching surges (typically 8kV or 12kV for 415V systems).
Short-Circuit Protection	**Short-Time Withstand Current (Short Circuit)**	IS/IEC 61439-1, IS 8623	Verifies that busbars and supports can withstand dynamic and thermal stresses during high fault currents (e.g., 50kA or 65kA for 1 sec).
Short-Circuit Protection	**Short-Circuit Making Capacity**	IS 13947	Ensures switching devices (like ACBs/MCCBs) can safely close onto a pre-existing fault.
Operational & Mechanical	**Degree of Protection (IP Test)**	IEC 60529	Verifies ingress protection against dust and water (typically IP 52 to IP 65 for indoor/outdoor panels).
Operational & Mechanical	**Mechanical Operation**	IS/IEC 61439-1	Confirms durability and correct operation of mechanical interlocks, withdrawable mechanisms, and shutters.
Safety	**Internal Arc Test**	IEC 61641	Tests the switchgear's ability to safely contain and vent gases in the event of an internal arc flash.
Quality & Routine	**Routine Factory Tests (FAT)**	IS/IEC 61439-1	Includes insulation resistance, wiring continuity, and operational checks on every manufactured panel before dispatch.

Conceptual Schematic of 40 ft Containerized LV Switchgear for reference



4. Containers and Building Structures

For this pilot project, components to interface DER (distributed energy resources : PV / ESS) will be housed inside the new 40 ft containers but the SCADA Digital Grid Command center, and Switchgear will be housed inside the new building structures.

Container Structures :

40ft container housing heavy, sensitive equipment like battery energy storage systems (BESS), inverters, and power conversion systems (PCS)—must feature structural modifications that balance global transport criteria with specific Indian climatic and seismic standards.

1. Structural Standards & Regulatory Compliance

- **IS 13288 / ISO 1496-1**: The core frame must fulfill basic dry cargo structural tests (stacking, lifting, and transverse racking resistance) to protect heavy utility-scale internal gear.
- **CSC Certification**: A valid International Convention for Safe Containers (CSC) safety plate is required if the container is manufactured abroad or will be shipped via Indian sea ports.
- **IRS Certification**: Certification by the **Indian Register of Shipping (IRS)** guarantees that custom local structural welding and penetrations satisfy transit safety limits.

2. Understructure & Floor Load Reinforcements

- **Equipment Weight Distribution**: Standard 40ft payload limits are capped around **26,600 to 28,000 kg**. Because BESS modules concentrate high dead loads, standard marine plywood floors must be removed.
- **Crossmember Beefing**: Steel C-channels or I-beams must be closely spaced (every 200 mm to 300 mm) along the base frame to support concentrated rack loads.
- **Steel Plating**: Floor areas must be topped with 4 mm to 6 mm anti-skid chequered steel plates, directly welded to crossmembers, preventing localized sagging under heavy battery blocks.

3. Shell Modification & Wall Reinforcements

- **Cut-out Framing**: HVAC ducts, explosion vents, and cable glands require wall panel cut-outs. Every penetration must be reinforced with a perimeter frame of structural steel hollow structural sections (HSS) to prevent structural warping.
- **Corten Steel Thickness**: Side and end walls should maintain a minimum thickness of 1.6 mm to 2.0 mm corrugated Corten steel to preserve structural rigidity under Indian transport conditions.

4. Environmental & Climatic Adjustments (IS 875)

- **Wind Load Resistance (IS 875 Part 3)**: Microgrid housings positioned in high-velocity wind zones must be structurally anchored to withstand wind speeds up to **250km/h**.
- **Seismic Anchoring (IS 1893 Part 1)**: Internal heavy battery racks must feature robust, floor-to-ceiling structural bracing anchored to the main frame beams. This design must prevent internal shifting during seismic events.

- **Thermal Protection**: Dual-layer wall insulation (50 mm to 100 mm of Rockwool or PUF panels) is needed to withstand extreme ambient temperatures up to 50°C, keeping internal cooling demands viable.

5. Lifting, Transport, & Foundation Interaction

- **Corner Castings**: All primary lifting dynamics must rely exclusively on the corner castings. Forklift pockets must either be heavy-duty reinforced or entirely omitted to avoid base bucking when lifting a fully loaded, 30-tonne microgrid system
- **Foundation Interfacing**: The base frame must be engineered to securely interface with outdoor concrete plinths or civil foundations via twist-locks or heavy anchor plates, preventing structural shift or base corrosion over a 20+ year lifespan.

Standards and Compliance

Compliance Domain	Standard / Regulation	Core Requirements & Technical Parameters
Structural Integrity & Logistics	**ISO 668 & ISO 1496**	Standardizes the dimensions and structural strength of the 40ft container. It must survive structural load testing (stacking, lifting, and racking forces).
	CSC Certification	A **Convention for Safe Containers (CSC)** plate is mandatory for international and domestic freight transit before deployment.
Grid Safety & Electricity Rules	**CEA Measures Relating to Safety & Electric Supply (Amendment) Regulations, 2026 (Chapter XA)**	Dictates mandatory legal provisions for BESS structures connected at voltages above 650 V. Enforceable framework as of April 1, 2027.
	CEA Technical Standards for Connectivity	Strict regulations governing SCADA compatibility, grid synchronization, and active/reactive power dispatch control.
Battery Safety & Quality	**IS 16270:2023 / IS 16270:2014**	Compulsory Registration Scheme (CRS) through BIS. Mandatory for all battery packs to prevent failure in harsh Indian conditions (high temperature/humidity).
	IEC 62619 / UL 1973	International alignment for cell and module-level safety under industrial applications.
Fire & Explosion Protection	**CEA Chapter XA / NFPA 855**	Mandates explosion-proof container engineering with a minimum **2-hour fire resistance rating** on structure walls.
	UL 9540 / UL 9540A	System-level safety validation and Large-Scale Fire Testing (LSFT) to review thermal runaway propagation.
Environmental & Cyber Compliance	**CEA Cybersecurity Guidelines**	Mandates compliance with the Power Sector Cybersecurity framework for remote Energy Management Systems (EMS).
	IEC 60529 (IP Ratings)	External container enclosures must meet minimum **IP55** criteria to keep out water and dust.

Structural and Mechanical Requirements

- **ISO 668 / ISO 1496:** Specifies 40ft container dimensions, ratings, and stacking/lifting structural tests.
- **CSC (Convention for Safe Containers):** Mandatory safety plating for transport loads, handling, and stacking forces.
- **NDT & Quality Assurance:** Weld non-destructive testing (NDT), corrosion protection review, and structural load calculations via agencies like Indian Register of Shipping (IRClass).

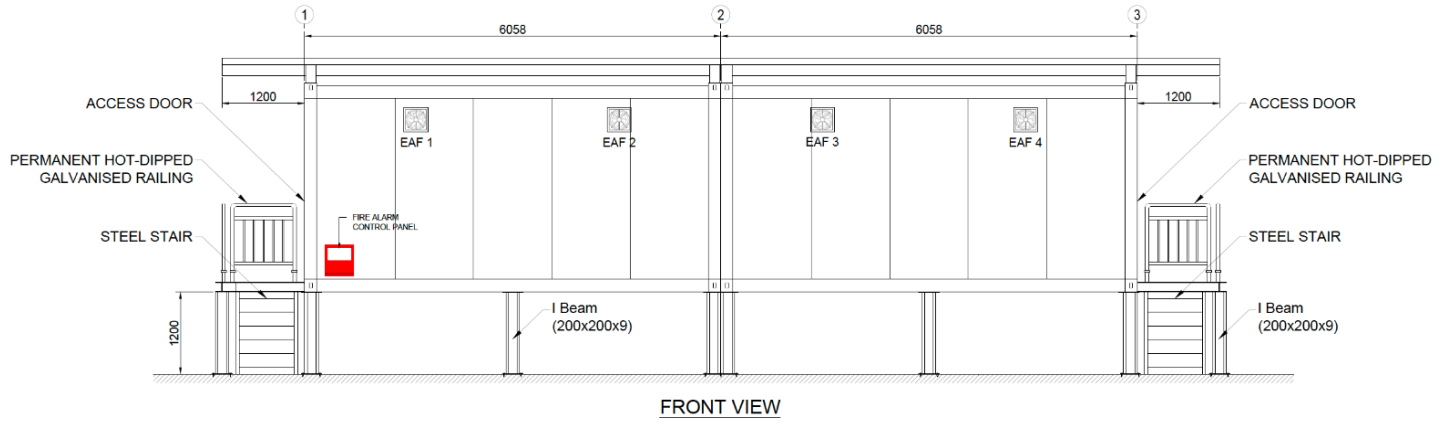
Electrical and System Safety Standards

- **IEC 62933 / IEC 62477:** Electrical energy storage (EES) systems and power conversion equipment safety.
- **UL 9540 / UL 1973:** Energy storage system integration and stationary battery safety validation.
- **IEC 60502 / IEC 60332:** Flame-retardant and low-smoke zero-halogen (LSZH) cabling specifications inside the 40ft enclosure.

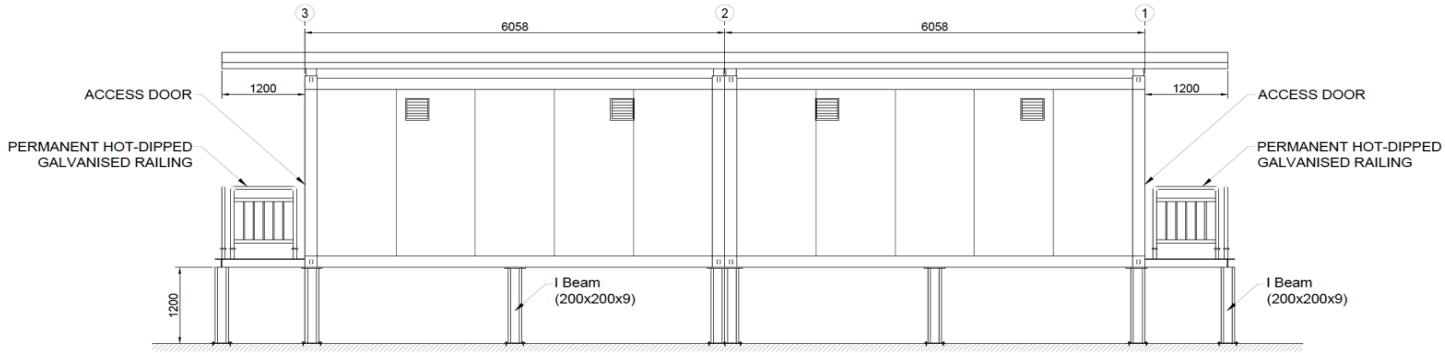
Fire Safety and Environmental Compliance

- **UL 9540A:** Large-scale fire test evaluation for thermal runaway propagation inside container units.
- **NFPA 855 / CEA Guidelines:** Standard for the installation of stationary energy storage systems, applied heavily for local Indian utility and safety approvals.
- **IP Enclosure Rating:** Minimum IP54/IP55 ingress protection for dust and monsoon weather operational resilience in Indian climatic extremes.
- **Fire Wall Isolation**: Container shell walls must provide a verified 2-hour thermal barrier.
- **Forced Deflagration Venting**: The 40ft structure must integrate automatic gas/smoke detection linked to automated louvers and forced exhaust ventilation. This prevents the dangerous accumulation of flammable gases if thermal runaway occurs

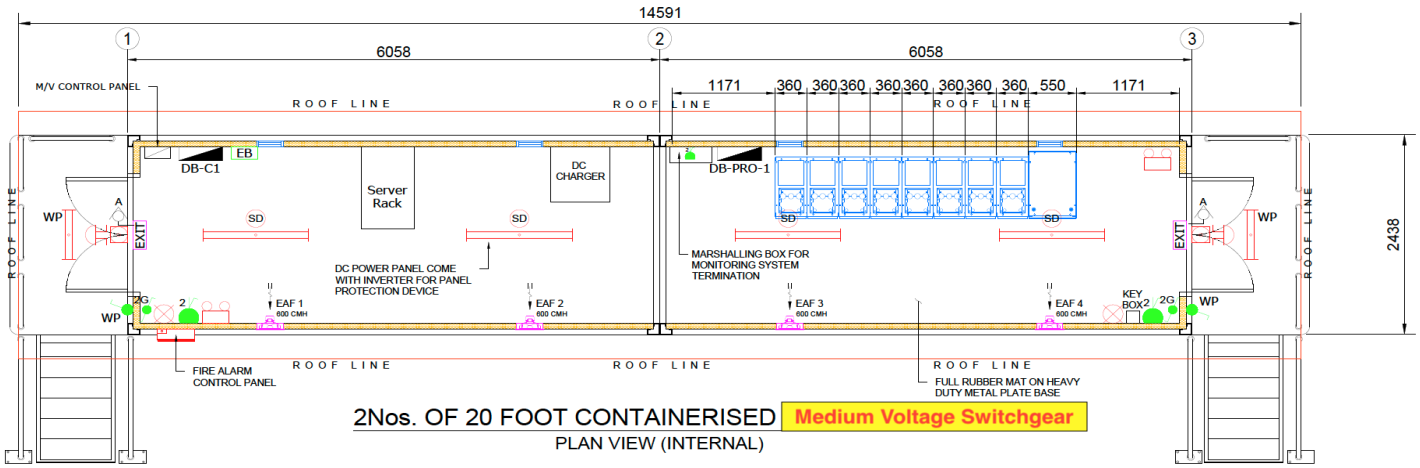
Reference Layout Drawing : 40 Ft Container LV/MV Switchgear



FRONT VIEW

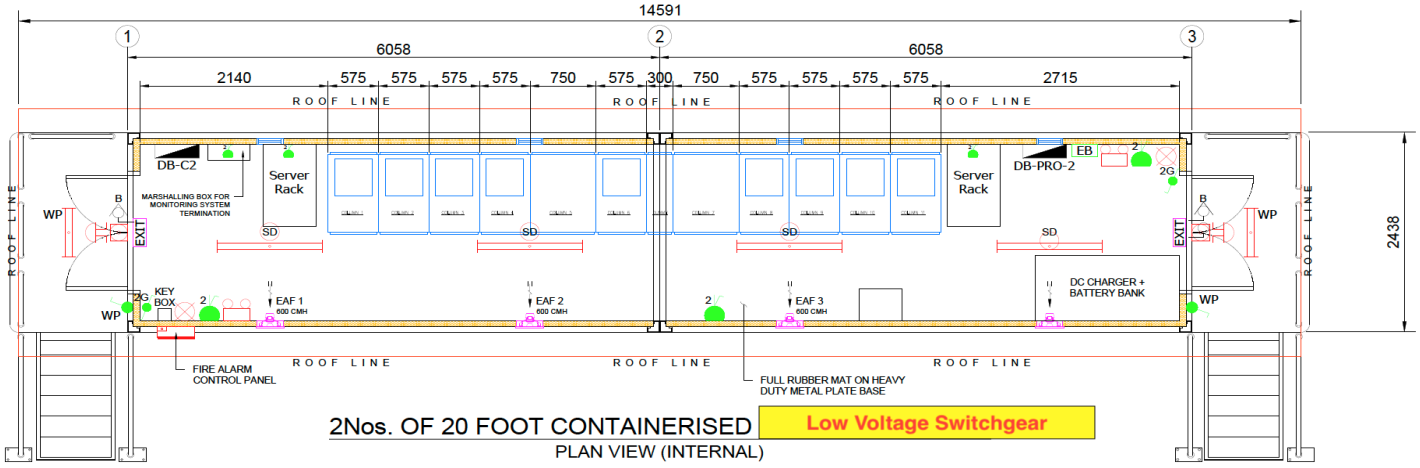


REAR VIEW



2Nos. OF 20 FOOT CONTAINERISED **Medium Voltage Switchgear**

PLAN VIEW (INTERNAL)



2Nos. OF 20 FOOT CONTAINERISED **Low Voltage Switchgear**

PLAN VIEW (INTERNAL)

Concrete Building Structures for Switchgear Substation and Digital Grid Command Center

Building Safety and Structural Codes

- **IS 456:** Plain and reinforced concrete design code for structures.
- **IS 875:** Design loads (wind, snow, and imposed loads) for buildings.
- **IS 1893:** Criteria for earthquake-resistant design of structures.

Testing and Electrical Certification Standards

- **CEA Regulations 2010:** Safety and connectivity requirements for grid integration.
- **IS/IEC 61850:** Communication networks and system integration for substations.
- **IS 3043:** Code of practice for earthing and grounding safety.

Substation Structural Safety & Testing Reference Table

Structural Component / Focus Area	Applicable Indian Standard (IS) / Regulation	Mandatory Testing & Verification Methods	Required Certification / Approving Authority
Foundation & Civil Substructure	IS 456 (Plain & Reinforced Concrete), IS 1904 (Foundations in Soils)	Soil investigation (SBC testing), Core drilling, Concrete cube compressive strength testing, Ultrasonic Pulse Velocity (UPV).	Soil Investigation Report, Structural Stability Certificate by a **Chartered Structural Engineer**.
Seismic & Earthquake Resilience	IS 1893 (Part 1 & Part 4)(Criteria for Earthquake Resistant Structures)	Dynamic analysis, Response spectrum analysis of the substation building, Seismic withstand evaluation of equipment mounts.	Vetted Structural Design Calculations (typically by an IIT/NIT or institutional body).
Wind Load & Tower Gantry Structures	IS 875 (Part 3) (Wind Loads), IS 802 (Structural Steel for Overhead Lines)	Deflection testing, Tensile strength verification of TMT steel bars (IS 1786), Zinc coating thickness (Galvanization test) for outdoor gantries.	Prototype Test Certificate, Mill Test Certificate (MTC) from the steel manufacturer.
Electrical Enclosures & Prefabricated Kiosks	IS/IEC 62271-202 (High-voltage switchgear – Common Rooms / CSS)	Internal Arc Classification (IAC) testing, Ingress Protection (IP) rating verification, Enclosure mechanical impact test (IK code).	Type Test Certificate from an accredited laboratory (e.g., **CPRI** or **ERDA**).
BESS Enclosure & Fire Protection	CEA Safety Regulations (2023), **NFPA 855**(Reference Standard for BESS Safety)	Thermal runaway propagation assessment, Fire suppression system discharge verification, Gas detection mechanism checks.	**National Fire Service / State Fire NOC** (No Objection Certificate), Safety Clearance by Chief Electrical Inspector (CEIG).

Earthing & Grounding Grid Mat	IS 3043 (Code of Practice for Earthing), CEA Regulations (Reg. 48)	Earth resistance loop testing using the Fall-of-Potential method, Step and Touch potential safety evaluations.	Earthing Integrity Log, **CEIG Interconnection Clearance**.
Overall Plant Occupational Safety	**IS 18001 / ISO 45001**(Occupational Health and Safety Management)	Periodical safety audits, Mock drills, Verification of hazard signage, Clearances between machinery.	Mandatory **IS-18001 / ISO 45001 Accreditation Certificate** (Required within 2 years of construction).

Structural & Building Requirements :

Component / Parameter	Standard / Code Requirement	Technical Specification / Value
Plinth & Floor Level	CEA Reg. 49(1)(i) / NBC Part 3	Must be built **above the outside road level** to avoid water ingress. Underground basements require strict drainage and mechanical ventilation.
Floor Loading & Construction	NBC / IS 456 (Concrete)	**Minimum 100 mm thick RCC floor slab** laid over 200 mm compacted stone soiling, finished with anti-static/dust-preventive heavy-duty tiling.
Fire Resistance Rating	NBC 2016 Part IV / IS 1642	Control rooms and switchgear bays must feature structural elements providing a **minimum 2-hour fire-resistance rating**.
Cable Trenches & Drains	CEA Regulations	Outside drains must prevent water from seeping into cable trenches. Indoor trenches must be covered with non-slip, fire-resistant chequered plates.
Ventilation & Climate Control	NBC Part 8 / CEA Switchgear limits	Indoor battery/control rooms require mechanical exhaust systems to prevent hydrogen accumulation. Control rooms house sensitive microgrid energy management controllers, requiring dust-free **Air Conditioning**.
Perimeter Security	CEA Reg. 49(1)(i) / IS 14786	Outdoor substations must be enclosed by **fencing/boundary walls not less than 1.8 metres** in height to prevent public access.

Equipment Layout & Clearance Standards

Equipment Type	Standard / Reference	Minimum Clearance / Requirement
Oil-Cooled Transformers	IS 10028 / CEA Safety Regs	Placed outdoors or in isolated fire-rated vaults. If oil capacity exceeds 2,000 litres, **soak pits and oil-baffling bund walls** must be integrated into the foundation civil works.
Dry-Type Transformers	NBC / Substation Guidelines	Allowed in a single room with switchgear. Periphery wall spacing must be **minimum 750 mm to 1000 mm** to ensure free air cooling corridor.
Switchboards / LT Panels	IS 8623 / Substation Guidelines	Clear space in front of panels must be **minimum 1000 mm** for maintenance access. Clearance from the rear of the panel to the wall must be at least **800 mm**.

Electrical Safety, Earthing, & Protection

Sub-system	Governing Indian Standard (IS)	Core Requirement
Earthing System	**IS 3043**	Combined or dedicated earth mats using pipe/plate electrodes. Combined earth resistance of the grid must be **less than 1.0 Ohm** to handle high fault levels.
Lightning Protection	IS/IEC 62305 / IS 3070	Mandatory structural lightning protection (Faraday cage or shielding masts) on the substation roof, directly grounded to the earth mat.
Fire Suppression	IS 2190 / CEA Safety Regs	Mandatory portable CO_2 and Clean Agent fire extinguishers near panels. Water-sprinkler lines are strictly **prohibited** inside electrical panel rooms.

5. Earthing and Lightning Protection Systems

Microgrid earthing and lightning protection must comply with IS 3043 for earthing design, IS 2309 / IEC 62305 for lightning protection, and CEA Technical Standards for grid connectivity. These codes govern safe earth resistance levels, surge clamping, and equipment safety.

Standards and Compliance

Category	Standard / Regulation	Core Requirement	Technical Compliance Metrics
Statutory Framework	**CEA Regulations 2023** (Safety & Electric Supply)	Mandates safe earthing of all generation, storage, and consumer equipment.	Regular testing by certified engineers; continuous monitoring of earth fault currents.
Grid Interconnection	**CEA Distributed Generation Regulations 2013**	Governs electrical safety and isolation at the Point of Common Coupling (PCC).	Mandates strict anti-islanding protection and clear identification of earthed conductors.
General Earthing	**IS 3043 : 2018** (Code of Practice for Earthing)	Base design criteria for system, equipment, and structural earthing.	Earth loop impedance must limit touch/step voltages; independent earthing pits for system neutral.
Lightning Protection	**IS/IEC 62305 : 2010**(Reaffirmed 2022)	Multi-part risk calculation and design of external/internal Lightning Protection Systems (LPS).	Requires a full risk assessment based on IMD data to select Lightning Protection Level (LPL I to IV).
Legacy Buildings/LPS	**IS 2309 : 1989**	Traditional code for building and structure protection.	Requires lightning earth resistance to be $\leq 10\ \Omega$ per dedicated pit.
Internal Protection	**IEC 61643 / IS 16221**	Rules for surge protection devices (SPDs) inside microgrid electronics.	Mandates Type 1 SPDs at service entries and Type 2 SPDs at inverter DC and AC inputs.
Energy Storage (ESS)	**IEEE 142 / IEC 60364**	Earthing topology guidance for Battery Energy Storage Systems (BESS).	Recommends resistance-grounded systems in **island mode** to limit inverter-damaging fault currents.

Testing and Certification

System Component	Mandated Test / Parameter	Target Regulatory Limit	Reference Standard / Code	Mandatory Certification / Authority
System & Maintenance Earthing	**Earth Pit Resistance(**Three-probe Fall-of-Potential method)	• ≤ 1.0 Ω (Substations / Central Inverter Rooms) • ≤ 2.0 Ω (Distribution panels / BESS)	IS 3043 / IEEE 80	• **CPRI** / NABL Accredited Lab Report • CEA Electrical Inspectorate Clearance
	Earth Loop Impedance & Continuity	Continuous metallic path; automatic trip activation	**IS 732** / CEA Grid Code	• CEIG (Chief Electrical Inspector to Govt.) Pre-commissioning
	Equipotential Bonding	Solidly welded structural joins; No isolated metal masses	IS 3043 / IS 732	• EPC Quality Inspection Register
	Soil Resistivity Survey	Site-specific configuration layout profiling	IS 3043 Clause 30	• Certified Geo-technical Expert Report
Lightning Protection System (LPS)	**LPS Earth Pit Resistance**	≤ 10 Ω dedicated independent grounding	**IS 2309** / **IEC 62305-3**	• OEM Test Certificate (UL 467 for components)
	Down-Conductor Continuity	Electrical path verification from Air Terminal to Ground	IS 2309 / **IEC 62561**	• NABL Lab Stamp / Factory Acceptance Test (FAT)
	Separation Distance Test	Prevention of side-flashover (≈ 75 cm isolation air gap)	IEC 62305-3/ **IEC 62561-8**	• International / NABL Lab High Voltage Type Test
Surge Protection Devices (SPDs)	**Clamping Voltage & Health Indicator**	Voltage protection level ≤ 1.5 kV	IS 16463 / IEC 61643	• Type Test Certificate (BIS / KEMA / VDE)
Inverters & BESS Protection	**Insulation Resistance & Earth Fault Protection**	Isolation monitoring threshold mapping (automatic trip)	**CEA Connectivity Regulations**	• **BIS Certification** / **UL India Procedure**
	Anti-Islanding Earthing Transitions	Safe dynamic changeover from system grounding (Grid to Island mode)	**IEEE 1547** / CEA 2023	• DISCOM / Pre-commissioning Field Validation

Testing and certification for microgrid earthing and lightning protection in India are governed by the Central Electricity Authority (CEA) Safety Regulations, IS 3043 (Code of Practice for Earthing), and IS/IEC 62305 (Lightning Protection). Microgrids require distinct testing protocols due to their hybrid nature (integrating Solar PV, Energy Storage Systems (ESS), and other Generators) and their alternating Grid-Connected and Islanded operating states.

Earthing Standards and Requirements

- **IS 3043:** Code of practice for earthing covering soil resistivity measurement, electrode sizing, and installation methods.
- **Earth Resistance Limit:** Maximum target of ≤ 10 Ω for general microgrid installations (and lower for sensitive electronics/substations per local codes).
- **Electrode Materials:** Copper-bonded rods, galvanized iron (GI) pipes, or strips matching mechanical durability and corrosion criteria.

Lightning Protection Standards (LPS)

- **IS 2309 / IEC 62305:** Governs the risk assessment, air termination placement (Franklin rods or ESE), and down-conductor routing.

- **Down Conductors:** Minimum 50 mm² copper or 70 mm² aluminum configuration to safely channel high-energy impulse currents.
- **Surge Protection Devices (SPD):** Type 1 SPDs at service entry points and Type 2 SPDs at inverter DC/AC inputs to clamp residual surges below 1.5 kV.

Grid Connectivity and Equipment Safety

- **CEA Regulations 2013:** Central Electricity Authority technical standards for connectivity of distributed generation resources, dictating grounding and anti-islanding compliance.
- **IS 16221 / IEC 62116:** Safety and anti-islanding compliance testing mandates for microgrid power inverters.

Component Type	Standard Reference	Engineering Mandate
Surge Protection Devices (SPDs)	IEC 61643-11/ IS/IEC 62305-4 (mkp.gem.gov.in)	**Type 1 + Type 2 SPDs** must protect power incoming entry lines; Type 2/3 for secondary internal control circuits.
Equipotential Bonding	IS 3043 (IEEE 1100	An internal copper **Main Earthing Terminal (MET)** or ring bus must link all structural panel doors, cable trays, glands, and the metal floor to eliminate touch potential differences.
Lightning Earth Separation	IS/IEC 62305-3	Lightning earth pits must be tied to the electrical earth grid **sub-surface** to create an interconnected equipotential network. This configuration eliminates ground potential rise (GPR) differences while keeping the structural terminations separate at the surface level.

1. Earthing System Design

- **Electrode Separation:** System/Equipment earth pits (governed by IS 3043) must be physically segregated from the Lightning Protection System (LPS) pits.
- **Equipotential Bonding:** All independent earth pits must be inter-bonded underground or via an Equipotential Bonding Bar (EBB) to prevent dangerous potential differences during a fault or strike.
- **Solar Arrays:** All module frames and structural structures must be mechanically and electrically bonded using Minimum 50 mm² copper or 70 mm² aluminium down conductors.

2. External Lightning Protection (LPS)

- **Air Terminals:** Use conventional Franklin Rods or Early Streamer Emission (ESE) arresters to achieve the correct protection radius over solar modules, wind turbines, and control kiosks.
- **Down Conductors:** Shortest possible vertical paths down the structure wall using continuous copper/GI strips. Avoid routing near sensitive communication or SCADA cables.

3. Internal Surge & Component Protection

- **Surge Arresters:** Metal Oxide Varistors (MOVs) and coordinated SPDs must clamp transient voltage surges below 1.5 kV to safeguard power electronics like smart inverters.

- **Inverter Earthing:** The inverter chassis must have a dedicated, direct earth connection completely independent of the AC output cable's internal grounding wire.

Protection Domain	Indian Standard (IS / CEA)	International Equivalent	Core Compliance Requirement / Key Values
General Earthing Code	**IS 3043:1987**	IEEE 142 / BS 7430	Guidance on calculation, design, and grid selection. Requires structured fault current routing.
Grid Connectivity & Integration	**CEA Connectivity Regulations**	IEEE 1547	Mandates safe boundary earthing between Distributed Generation (DG) and state utility networks.
Equipment & Supply Safety	**CEA Safety Regulations**	IEC 60364	Minimum **two separate and distinct connections** to separate earth pits for generation assets.
Lightning Protection (General)	**IS/IEC 62305 (Parts 1-4)**	EN 62305	Four-part framework governing Risk Assessment, Physical Damage, and Electronic Protection.
Lightning Components	**IS 62561 (Parts 1-7)**	IEC 62561	Verification and certification for air terminals, clamps, and down-conductors.
Solar PV Arrays	**IS 16221 / CEA 2013**	IEC 61730-2	Earthing of all metallic modules, structures, and frames. Integration with an array lightning grid.
Storage & Hybrid Systems (BESS)	**CEA Technical Amendment**	IEC 62933	Alternative earthing protocols for battery enclosures, PCS containers, and floating islands.
Wind Generation Assets	**IEGC Grid Code**	IEC TR 61400-24	High-altitude specialized lightning strike dissipation for WTG blades and towers.

40FT Container Earthing Lightning Protection:

1. Earthing System Compliance (IS 3043 / IEEE 80)

Because a 40ft shipping container features a highly conductive steel hull, structural fault prevention and step/touch potential management are paramount.

- **Dual-Point Equipment Bonding**: Every major power asset inside the container (Transformers, MV/LV Switchgears, DG Sets, UPS systems) must be bonded to the main earth grid via at least **two separate and distinct connections**.
- **System Neutral Grounding**: The neutral point of any transformer or generator inside the container must be routed to **two independent, dedicated earth pits** using copper or GI flats. Do not loop neutral conductors across equipment.
- **Container Hull Earthing**: The structural steel frame of the 40ft container must be grounded at diagonally opposite external corners using heavy-duty hot-dip galvanized iron (GI) strips (minimum 50 × 6 mm or 50 × 10 mm) connected to the site's main earth grid.
- **Target Resistance Values**:
    - **Power / Substation Earth Grid Grid**: Less than 1.0 Ω.
    - **Neutral / Control Pits**: Less than 1.0 Ω.

- **Earth Pit Architecture**: Pits must match DISCOM specs (typically a 3-meter long, 40mm diameter Class-B GI pipe or an advanced maintenance-free chemical electrode pit) enclosed inside a concrete test chamber with a disconnecting link.

3. Lightning Protection System (IS/IEC 62305 & NBCS 2026)

A container sits exposed on an open-air plinth, acting as a highly attractive termination point for atmospheric discharges.

- **Risk Assessment**: A mandatory Class of Lightning Protection System (LPS Type I to IV) assessment must be run based on Odisha's local lightning flash density using the framework outlined in IS/IEC 62305-2.
- **Air Termination System**:
    - **Option A**: A structural lightning rod system mounted directly on the container roof providing a protective zone via the rolling sphere or angle method.
    - **Option B**: An isolated lightning mast installed outside the container footprint to shield the structure without transferring high currents to the chassis.
- **Down Conductors**: At least **two down conductors** located at opposite corners must route lightning current to ground. They must follow the straightest path to the ground, avoiding sharp 90° bends to eliminate inductive flashovers.
- **Isolation**: The down conductors connected to lightning rods must not pass inside any iron/steel containment pipes to avoid choking impedance.

4. Internal Protection & Equipotential Bonding

To secure sensitive interior control components (SCADA, RTUs, Protection Relays) against high electromagnetic fields (EMPs) generated during a lightning event:

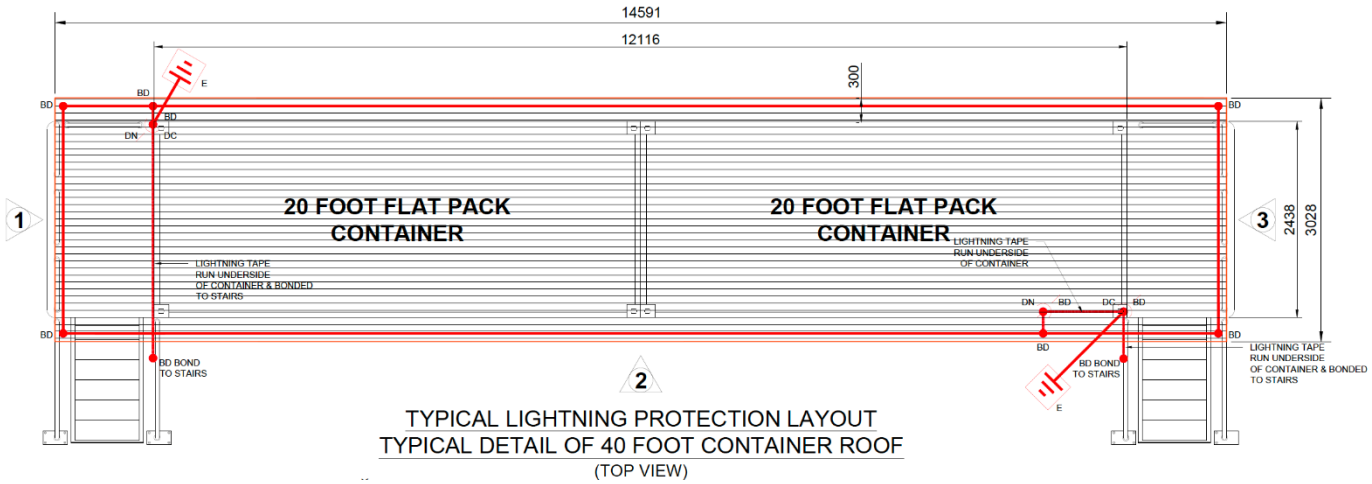
- **Earth Pit Resistance Test:** Measured via fall-of-potential method using a digital earth tester; must achieve specified low ohmic values (≤ 1 Ω to ≤ 10 Ω depending on application).
- **Earth Continuity Test:** Verifies seamless metallic connection from all structural frames, poles, and enclosures back to the main earth mat using a low-resistance ohmmeter.
- **Surge Protection Device (SPD) Function Test:** Checks clamping voltages and operational status of Type 1 and Type 2 SPDs for residual clamping below 1.5 kV.
- **Coating Thickness & Material Certification:** Validates hot-dip galvanization or copper coating thickness (≥ 254 microns for UL/IS compliance) via magnetic/electronic gauges.
- **Authorized Certification Bodies:** Pre-commissioning approvals and type-testing are typically validated by accredited labs such as Central Power Research Institute (CPRI) or state electrical inspectorates.

Critical Field Testing Protocols

1. **The Fall-of-Potential Testing Method**: Auxiliary current probes must be placed at a distance spanning at least 62% of the maximum diagonal distance of the earth grid under assessment. Incorrect spacing yields erroneously low parameters.

2. **Isolation of Earthing Pits**: Lightning protection system (LPS) earth pits must remain physically segregated from the primary system/equipment earth pits. They must be connected below ground only via an **equipotential bonding bar** to prevent lightning surge feedback into active controls.
3. **Dynamic Earthing in Islanding Mode**: Microgrids featuring an active Energy Storage System (ESS) must utilize dedicated relays to transition grounding schemes (e.g., from solid grounding to **Resistance Grounding** during off-grid operations) to clamp prospective fault currents and safeguard inverter electronics.

Reference Layout Drawing : 40 Ft Container LV/MV Switchgear



TYPICAL LIGHTNING PROTECTION LAYOUT
TYPICAL DETAIL OF 40 FOOT CONTAINER ROOF
(TOP VIEW)

6. Power Quality Meter

Power quality meters (PQMs) installed in microgrids and grid-interactive distributed energy resource (DER) systems must satisfy a layered architecture of domestic and international standards. These are overseen by the Bureau of Indian Standards (BIS), the Central Electricity Authority (CEA), and state-level Electricity Regulatory Commissions (SERCs).

Standards and Compliance

Metric Category	Standard Reference	Primary Compliance & Measurement Requirement
Measurement Methods	**IS 18475 : 2023 / IEC 61000-4-30** (Class A)	Mandates strict time-aggregation, synchronization, and calculation methods for precision field auditing.
Harmonics & Distortion	**IEEE 519 / CEA Grid Standards**	Limits Total Harmonic Distortion for Voltage (THD) and Current (THD) at the Point of Common Coupling (PCC).
Meter Testing & Design	**IEC 62586-1 / IEC 62586-2**	Governs product design, environmental testing, and functional safety of PQ instruments.
Basic Metering Accuracy	**CEA Metering Regulations**	Mandates Class **0.2S** accuracy for active interface points and billing-grade monitoring.
Smart Grid Data Exchange	**IS 15959 (Parts 1, 2, 3) / DLMS/COSEM**	Standardizes data profiles, companion specifications, and communication architecture for smart sub-metering grids.
Environmental Ingress	**IS/IEC 60529**	Establishes minimum **IP51** (indoor) or **IP55/IP65** (outdoor) shell protection protocols.

Performance & Technical Parameters

- **Voltage Swells, Sags, and Interruptions**: Meters must capture variations beyond ± 10% of nominal values, logging timestamps and root-mean-square (RMS) profiles.
- **Harmonic Range**: Devices must measure up to the **50th order harmonic** to fulfill state-level power quality audit codes.
- **Time Synchronization**: Units require a GPS or Network Time Protocol (NTP) clock alignment to ensure accurate event sequence recording.
- **Data Integration**: Real-time Modbus, DLMS, or MQTT data mapping is necessary to upload telemetry metrics directly to State Load Despatch Centres (SLDCs).

Evaluation Category	Standards / Guidelines	Essential Requirements & Parameters
Power Quality Measurement	**IEC 61000-4-30 Class A IEEE 519**	• **Class A compliance mandatory** for contractual and legal verification. • Measures voltage unbalance factor (VUF), dips, swells, and rapid voltage changes (RVC). • Must provide 10-minute aggregation and 3-second intervals for real-time monitoring.
Harmonics & Interharmonics	**IEC 61000-4-7 IEEE 519-2014 IS 18968**	• Measures individual and Total Harmonic Distortion (THD) up to the 50th order. • Covers high frequencies up to 9 kHz (Supraharmonics monitoring). • Evaluates harmonic current injections at the Point of Common Coupling (PCC).
Flicker Monitoring	**IEC 61000-4-15 IEC 61000-3-7**	• Measures Short-Term Flicker, 10-minute interval). • Measures Long-Term Flicker , 2-hour interval). • Sampling rates must be ≥ 4 kHz for flicker.
Metrology & Base Billing	**IS 16444 (Part 1 & 2) IS 14697 IS 13779**	• Active energy accuracy: Class 0.2S or 0.5S. • Reactive energy accuracy: Class 0.5S or 1S. • Mandated for multi-functional smart billing in microgrids.
Data Exchange Protocol	**IS 15959 (Parts 1, 2 & 3)**	• **DLMS/COSEM compliant** architecture. • Standardized data packets for smart grid and microgrid controllers. • Secure communication profiles for event logging and tamper alerts.
Electromagnetic Compatibility (EMC)	**IEC 62052-11 IS 16444**	• Electrostatic Discharge (ESD) up to 15 kV. • Surge immunity test up to ± 6 kV. • Voltage dips and short interruptions immunity.
Environmental & Safety	**IEC 60068 Series IS 16444**	• Ingress Protection (**IP51 or IP54 minimum** for field installation). • Dry heat, cold temperature, and damp cyclic humidity tests. • Insulation resistance and high-voltage impulse test.

The PQM shall have the following main features:

- 4 Voltage and 5 current channels.
- Voltage inputs for direct connection until 1000 Vac phase-phase or through Voltage Transformer.
- Current inputs availability for standard CT 1A/5A.
- Voltage characteristics monitoring according to IEC/EN 61000-4-30:2015 Ed. 3 Class A.
- Parameter recording for statistical analysis according to local grid codes and standards.
- Harmonic and interharmonics measurement.
- Voltage Flicker measurement.
- Main Signalling Voltage detection and recording.
- EN50160 Event detection and recording (sag, swell, outage).
- Current Overload detection and recording.
- Transient detection and recording (down to 20 microseconds).
- High sampling frequency of 50 kHz.
- Three-phase 3 and 4 wire or single-phase operating mode.
- Integrated web server for complete device management.
- Two Ethernet and one RS485 ports for easy communication.
- One front USB host port for memory stick.
- RTC synchronization for accurate time information by NTP or internal GPS module.
- 4 Gb internal memory for data recording.
- Data recorded in standard PQDIF and CSV formats.
- Panel mount 192x144 DIN size.
- High resolution TFT screen with capacitive touch.
- 4x Isolated digital inputs, 4x digital outputs and 4x 4-20mA analog outputs.
- Integrated backup rechargeable battery.
- Multi measurement of currents, voltages, powers, power factors, harmonics and energies.
- Communication protocols: HTTP, HTTPS, FTP, SFTP, NTP, Modbus TCP.

This device made for power quality analysis will be able to detect and record events such as:

- Voltage events recording (sags, swells, interruptions) with storage of 1/2c RMS values and waveforms.
- Rapid voltage changes characteristics.
- Fast current variation recording with storage of RMS values and waveforms.
- Data LOG recording function of MIN/AVG/MAX values of selectable parameters and programmable rate time.

- Functional event LOG for the device operating status.
- Digital input status change LOG.
- Automatic data upload to FTP server in case of events.
- Scheduled data upload to FTP server.

The quality meter conforms to the following standards and certifications:

- Active and apparent energy: IEC 62053-22 class 0.5s
- Reactive energy: IEC 62053-23 class 1
- Harmonics and interharmonics measurement method: IEC 61000-4-7
- Flicker measurement method: IEC 61000-4-15 and local grid codes and standards.
- Supply quality measurement method: IEC 61000-4-30 Class A
- Power quality measurement requirements: IEC 62586-2 Class A
- Characteristics of the voltage supplied by public distribution networks

Core Functions :

1. Continuous Harmonics & Distortions Monitoring
    - Measures Total Harmonic Distortion (THD) and Total Demand Distortion (TDD) for both current and voltage.
    - Tracks compliance against CEA thresholds: THD V ≤ 5% and THD I ≤ 8% at the Point of Common Coupling (PCC).
    - Detects and records DC current injection into the AC grid (must remain below 0.5% of rated output).
2. Grid Event & Disturbance Logging
    - Real-time detection, duration measurement, and waveform capture for:
        - Voltage Sags (Dips), Swells, and Transient Interruptions.
        - Voltage Unbalance (calculated via symmetrical components, maintained <2% for distribution).
        - Rapid Voltage Changes (RVC) and Flicker.
3. Multi-Tariff Energy & Demand Measurement
    - Four-quadrant active, reactive (Q_1, Q_2, Q_3, Q_4), and apparent energy metering.
    - Time-of-Day (TOD) / Time-of-Use (TOU) billing registers and Maximum Demand (MD) integration intervals.
4. Data Storage & Non-Volatile Memory
    - Minimum storage capability of 45 to 90 days of interval/load profile data at 15-minute intervals.
    - Dedicated non-volatile memory block for event logging (capturing pre- and post-event cycle waveforms during grid disturbances).
5. Interoperability & Grid Connectivity Communications

- Open Protocols: DLMS/COSEM (IS 15959), Modbus RTU/TCP, or IEC 60870-5-104.
- Physical Interfaces: Dual ports including RS-485, Ethernet (RJ-45), and Optical Port for local data downloading.
- Capability for seamless integration with utility SCADA, Head-End Systems (HES), and State Load Despatch Center (SLDC) software.

6. Tamper Detection & Anti-Theft Protection
    - Logs unauthorized box/terminal opening, phase sequence reversal, CT primary/secondary reversals, CT open circuits, PT missing-potential conditions, and external magnetic interference.

Grid Connectivity Rules at 11 kV / 415V

- Compliance Mandate: Per CEA Grid Connectivity Amendment Regulations, commercial consumers, industrial plants, and renewable energy generators connected at 11 kV or above must install PQ meters and make raw data available to the distribution licensee or SLDC upon request.
- Instrument Transformers: Associated Current Transformers (CTs) and Potential Transformers (PTs) must have an accuracy class equal to or better than the PQ meter (typically Class 0.2S / 0.5S).
- Testing & Calibration: PQ meters must undergo routine testing and periodic calibration (at least once every 5 years or per state utility norms) in NABL-accredited testing facilities.

Energy Measurement Features

Requirement Category	Core Compliance Specifications
Smart Metering & Functional Requirements	Covers single-phase and three-phase static smart meters; mandates two-way communication and load control. **IS 16444**
Accuracy Class Requirements	**0.2S** for interface meters; **0.5S to 1.0S** for consumer, energy accounting, and microgrid audit meters.
Data Exchange & Companion Protocols	Standardizes the DLMS/COSEM communication protocol layers for uniform data exchange and optical port routing. **IS 15959**
Installation & Operational Audits	Mandates specific meter placement at the renewable generation point and the utility interconnection point.
Telecom Module Compliance	Mandatory testing for internal communication modules (cellular/RF) focusing on EMI/EMC safety.
Data Storage & Log Intervals	Requires non-volatile memory storing up to 15–30 days of data; transitions to 5-minute time block intervals.

7. Power Meters

Power meters deployed in microgrids in India must handle bidirectional energy flow, high-frequency harmonics, and advanced communications. They are heavily regulated under the Bureau of Indian Standards (BIS), the Central Electricity Authority (CEA), and the Ministry of Power.

Requirements for Power Meters dedicated to Microgrids

Meter Type / System	Indian Standard (BIS)	International Equivalent	Core Compliance Focus
Smart/AMI Meters (Direct Connection)	IS 16444 (Part 1)	IEC 62053-21 / 22	Direct connected consumer and microgrid boundary energy tracking.
Smart/AMI Meters (CT/PT Operated)	IS 16444 (Part 2)	IEC 62053-22 / 23	Transformer-operated boundary and high-load distribution nodes.
Power Quality Meters	IS 14697 / IS 15959	IEC 61000-4-30 (Class A)	Harmonics, voltage dips, swell, and microgrid islanding distortions.
Data Interoperability	IS 15959 (Parts 1, 2, 3)	IEC 62056 (DLMS/COSEM)	Standardized open communication protocols for multi-vendor smart grids.
Installation & Field Care	IS 15707	—	Field evaluation, anti-tampering setup, and asset maintenance.

Mandatory Testing Parameters

All microgrid meters must undergo rigorous destructive and non-destructive type tests to earn the regulatory **ISI Mark**.

Test Category	Core Parameters Evaluated	Relevant Technical Clauses
Metrology & Accuracy	Bidirectional active/reactive energy, power factor, self-heating under maximum load	IS 16444 Cl 6.12 & Cl 6.10.4
Power Quality	Total Demand Distortion (TDD), harmonics up to 9 kHz, voltage unbalances	IEC 61000-4-30 Class A
Electrical Safety	AC high-voltage insulation, impulse voltage survival, and short-time overcurrent	IS 16444 Cl 6.2, 6.3 & 6.10.6
Environmental Survival	IP51/IP55 ingress dust/water protections, relative humidity, wide temperature swings	IS 16444 Physical Requirements
Interference & Grid Supply	Voltage dips, short interruptions, transient immunity, and surge protection	IS 16444 Cl 6.10.2 & 6.10.3
Communications & Telemetry	RF/Cellular/PLC module validation, EMI/EMC profiling, and MTCTE traceability	Telecommunication Engineering Centre (TEC) Guidelines

1. Energy & Power Parameters

- Multi-Quadrant Measurement: Measures Active Energy (kWh), Reactive Energy (kVARh import/export/lag/lead), and Apparent Energy (kVAh).

- Time-of-Day (TOD) / Time-of-Use (TOU) Tariff: Minimum of 6 customizable time zones to record peak and off-peak consumption.
- Maximum Demand (MD): Automatic monthly MD reset (00:00 hours on 1st of the month) calculated over 15-minute or 30-minute integration periods

2. Advanced Metering Infrastructure (AMI) & Communication

- Dual Communication Interfaces: Equipped with an Optical Port for local data download via Meter Reading Instrument (MRI) and a Remote Port (Cellular 4G/NB-IoT, RF Mesh, or PLC).
- Open Protocols: Native support for DLMS/COSEM (IS 15959) for seamless integration with Head-End Systems (HES) and Meter Data Management (MDM).
- Two-Way Communication: Enables remote firmware upgrades, tariff configuration changes, and load-connect/disconnect control via built-in latching relays (where applicable).

3. Power Quality (PQ) & Grid Monitoring

- Harmonics Measurement: Captures Total Harmonic Distortion (THD) up to the 31st or 50th harmonic order as required by CEA Grid Connectivity Amendments for consumers connected at 11 kV or above.
- Grid Disturbance Tracking: Continuous monitoring of voltage sags, swells, spikes, supply interruptions, and frequency variation (47.5 Hz to 52.0 Hz).

4. Anti-Tamper & Security Mechanisms

- Tamper Detection: Records time-stamped events for phase reversal, neutral disconnect, magnetic interference, top cover opening, CT/VT circuit open/short, and voltage unbalance.
- Non-Volatile Memory (NVM): Retains configuration data, load survey logs (minimum 35 to 90 days), and event logs for at least 10 years without external power.
- Hardware Anti-Tamper Seals: Provision for dynamic electronic seals on the meter cover and terminal block.

Standards & Compliance

Regulatory Authority / Standard	Focus Area	Specific Microgrid Compliance Requirement
CEA Regulations (2006 / 2013)	**Grid Integration & Net Metering**	Dictates the mandatory installation of bidirectional **Interface Energy Meters (IEM)** for Net/Gross metering. Mandates **0.2S class accuracy** for utility interface points and Class 1.0 or better for general consumers.
IS 16444 (Part 1 & 2)	**Smart Metering Hardware**	**Mandatory BIS certification** for all AC Static Smart Meters used in microgrids. Covers single-phase, three-phase, and transformer-operated meters, including remote connect/disconnect capability.
IS 15959 (Part 1, 2 & 3)	**Data Exchange & Protocols**	Based on DLMS/COSEM standards. Ensures interoperability across varying meter manufacturers within the microgrid, defining standardized object identification codes (OBIS) for data extraction.

IS 13779 / IS 14697	**Static & Sub-Metering**	Defines base specifications for legacy electrical measurements, serving as the benchmark testing standard for general accuracy, insulation, and environmental durability.
IEEE 1547 / IEEE 2030	**Interoperability & Controllers**	Controls the integration of Distributed Energy Resources (DER). Power meters must seamlessly link with microgrid controllers handling anti-islanding and automated demand response.
IEC 61000-4-30 (Class A)	**Power Quality (PQ)**	Essential for microgrids utilizing highly volatile renewable sources. Meters must record precise voltage swells, sags, interruptions, and Total Harmonic Distortion (THD).
Wi-SUN FAN Standard	**Communication Networks**	Adopted natively by BIS as the structural RF mesh communication standard for reliable, high-density smart meter networking across rural or localized urban microgrids.

Parameter	11 kV Meters (Medium Voltage)	415 V Meters (Low Voltage)
Meter Category	CT/PT-operated Static Smart/ABT Meter	CT-operated or Whole Current Meter IS 16444
System Connection	3-Phase, 3-Wire or 3-Phase, 4-Wire	3-Phase, 4-Wire (415V L-L / 240V L-N)
Accuracy Class	0.2S or 0.5S (Class 0.2S required for interface/boundary points)	Class 1.0 (Consumer) / Class 0.5S (Energy Audit & Commercial)
Current / Voltage Input	Secondary ratings: 11kV/sqrt (3) or 110V AC; CT secondary 1A or 5A	Directly connected whole current (e.g., 10–60A) or CT secondary 5A
Reference Frequency	50 Hz ± 5%	50 Hz ± 5%
Applicable Standards	IS 14697 / IEC 62053-22	IS 13779 / IS 16444 Part 1 & Part 2

The Power Meter shall provide the following, true RMS metered quantities:

Real-Time Readings

a. Current (per phase & neutral, 3 phase average)

b. Voltage (line-line, line-neutral, 3 phase average)

c. Real, Reactive & Apparent Power (Per-Phase, 3-Phase Total)

d. Power Factor, True & Displacement (Per-Phase, 3-Phase Total)

e. Frequency

f. THD (Current and Voltage)

Energy Readings

a. Accumulated Energy - Real kWh, Reactive kVArh, Apparent kVAh (Signed/Absolute)

b. Reactive Energy by Quadrant

Demand Readings

a. Demand Current Calculations - peak, present, running average, last completed interval (per-phase, 3-phase avg, Neutral)

b. Demand Real, Reactive & Apparent Power Calculations - peak, present, running average, last completed interval (3-Phase Total)

c. Average Power Factor Calculations, Demand Coincident (3-Phase Total)

Power Analysis Values

a. THD – Voltage, Current (3-Phase, Per-Phase, Neutral)

b. Displacement Power Factor (Per-Phase, 3-Phase)

c. Fundamental Voltage & Current, Magnitude and Angle (Per-Phase)

d. Fundamental Real Power (Per-Phase, 3-Phase)

e. Fundamental Reactive Power (Per-Phase)

f. Harmonic Power (Per-Phase, 3-Phase)

g. Phase Rotation

h. Unbalance (Current and Voltage)

i. Each harmonic Magnitudes & Angles for Current and Voltages (Per Phase) up to the 31st Harmonic.

The Power Meter shall provide minimum and maximum values for the following parameters:

(1) Voltage line-line, line-neutral

(2) Current per phase

(3) Voltage Unbalance line-line, line-neutral

(4) Power Factor, true & displacement

(5) Real, Reactive & Apparent Power Total

(6) THD Voltage & Current

(7) Frequency

For each min/max value listed above, the Power Meter shall record the following attributes:

(1) Date/Time of the min/max value

(2) Min/Max. Value

(3) Phase of recorded Min/Max (for multi-phase quantities)

(4) Minimum and maximum values shall be available via communications and display.

Alarm events shall be user definable.The user shall be able to define over 50 alarm conditions. The following shall be available as alarm events:

(1) Over/under current & voltage

(2) Current & voltage imbalance

(3) Phase loss, current & voltage

(4) Over kW Demand

(5) Phase reversal

(6) Digital Input OFF/ON

(7) End of incremental energy interval

(8) End of demand interval

For each over/under metered value alarm, the user shall be able to define a pick-up, drop-out, and delay. There shall be four alarm severity levels in order make it easier for the user to respond to the most important events first. Indication of an alarm condition shall be given on the front panel.

Control Power : The Power Meter shall operate properly over a wide range of control power including 90-457 VAC or 100-300 VDC or as required to comply the local grid codes and standards.

Communications: The Power Meter shall communicate Ethernet Modbus TCP protocol.

Grid Integration & Compliance Framework

The Power Meter display shall provide local access to the following metered quantities:

(1) Current, per phase rms, 3-phase average and neutral (if applicable)

(2) Voltage, phase-to-phase, phase-to-neutral, and 3-phase average (phase-to-phase and phase-to-neutral)

(3) Real power, per phase and 3-phase total

(4) Reactive power, per phase and 3-phase total

(5) Apparent power, per phase and 3-phase total

(6) Power factor, 3-phase total and per phase

(7) Frequency

(8) Demand current, per phase and three phase average

(9) Demand real, apparent power, three phase total

(10) Accumulated Energy, (MWh and MVARh)

(11) THD, current and voltage, per phase

Reset of the following electrical parameters shall also be allowed from the Power Meter display:

(12) Peak demand current

(13) Peak demand power (kW) and peak demand apparent power (kVA)

(14) Energy (MWh) and reactive energy (MVARh)

Setup for system requirements shall be allowed from the Power Meter display. Setup provisions shall include:

(15) CT rating

(16) PT rating

(17) System type [three-phase, 3-wire] [three-phase, 4-wire]

(18) Watt-hours per pulse

Energy Auditing: Energy accounting meters installed at 11 kV/400 V distribution transformers help DISCOMs monitor Distribution Transformer (DT) loading and track Aggregate Technical and Commercial (AT&C) losses below 10%.

1. Instrument Transformer Compatibility: Accuracy class of CTs and PTs connected to the meter must not be inferior to the meter's accuracy class.
2. Periodic Testing: Performed on-site using standard reference meters of higher accuracy at least once every 5 years per CEA guidelines.

8. Protection Relays

Microgrid protection is highly complex because the relay must handle dual operational modes (Grid-connected and Islanded), bidirectional power flows, and drastically varying fault current levels caused by Inverter-Based Resources (IBRs). Strict adherence to grid codes and compliance is required. (CEA / IEC / IEEE / IEGC).

- Technology Mandatory: All primary protective relays must be of numerical (microprocessor-based) design with self-monitoring and event recording functionality. Electromechanical or static relays are restricted to non-critical auxiliary roles.
- Communication Standards: Must support IEC 61850 protocol for integration with Substation Automation Systems (SAS), SCADA, and Remote Terminal Units (RTUs).
- Grid Interconnection & Distributed Generation: Under CEA (Technical Standards for Connectivity of Distributed Generation Resources), all 11kV/415V solar/distributed generators must have anti-islanding protection and immediate fault isolation capability.
- Auxiliary DC Supply: Relay trip circuits and relays must operate on direct current (e.g., 24V, 48V, 110V, or 220V DC) backed by station batteries to maintain protection during complete AC power failure.
- CT/VT Compatibility: Relay inputs must be compatible with standard secondary ratings—1A or 5A for Current Transformers (CTs) and 110V AC (Phase-to-Phase) for Voltage Transformers (VTs).

415V systems (Distribution Transformer LV side, Main Low Voltage Switchboards) handle local power distribution and customer step-down connections.

- 415V Transformer Neutral / Incomer Protection:
    - Overcurrent & Earth Fault (50/51, 50N/51N): Provides backup protection for downstream LT short circuits.
    - Standby Earth Fault (SBEF / 51N): Fitted on the 415V neutral point of distribution transformers to clear sustained earth faults on the LT network.

- Under/Over-Voltage (27/59): Monitors LT voltage variations within statutory limits (± 6%).

- Distributed Generation / Solar / BESS (415V Interconnection):
  - Anti-Islanding Protection (IEEE 1547 / IEC 62116): Mandated by CEA Regulations to disconnect solar inverters instantly when the 415V grid supply fails.
  - Under/Over-Frequency (81U/81O): Operational tripping window set per CEA Grid Standards (47.5 Hz to 52.0 Hz).
  - Rate of Change of Frequency (ROCOF / 81R) & Vector Shift: Used for ultra-fast islanding detection on distributed generation points.

Mandatory Technical & Functional Features

1. Self-Monitoring & Alarms: Continuous self-diagnostics with watchdog output contacts that trigger an alarm in case of internal hardware or software failure.
2. Disturbance & Event Recording:
   - Fault waveform recording (oscillography) with sampling rates of at least 1.0 kHz to 1.6 kHz.
   - Event logger capturing sequence of events (SOE) with 1 ms time stamping accuracy.
3. Trip Circuit Supervision (TCS / 95): Continuous monitoring of the circuit breaker trip coil integrity in both open and closed breaker states.
4. Cybersecurity & Password Protection: Multi-level password access control to prevent unauthorized relay parameter configuration.

The relay must have a web browser-based human-machine interface (WHMI) with secured communication (TLS) and shall provide the following functions:

a) Programmable LEDs and event lists

b) System supervision

c) Parameter settings

d) Measurement display

e) Disturbance records

f) Phasor diagram

g) Single-line diagram (SLD)

h) Importing and exporting of parameters

Standards & Compliance

Requirement Category	Core Compliance Parameter & Value Limits	Relay Functional Impact
Grid Connectivity & Interconnection	• **DC Injection Limit**: < 0.5% of full rated output at Point of Common Coupling (PCC). • **Flicker**: Limits governed by **IEC 61000**. • **Harmonics**: Managed via **IEEE 519**limits.	**ANSI 51V / 51** Requires strict power quality monitoring and voltage-restraint overcurrent settings.
Anti-Islanding Protection	• Must detect and decouple from utility grid within **≤ 2.0 seconds** upon loss of mains. **IS 16221 (Part 1) / IEC 62116**	**ANSI 78 / 81R** Mandates Vector Shift (VS) or Rate of Change of Frequency (ROCOF) elements in the relay.
Voltage Ride-Through & Tripping	• **HVRT / LVRT**: Must ride through specified transient deviations. **IEEE 1547** • Clears microgrid faults quickly but stays connected during external grid dips.	**ANSI 27 / 59** Dual-stage overvoltage (59) and undervoltage (27) settings matching localized clearing curves.
Frequency Ride-Through & Tripping	• **Operational Band**: Normal output required between 49.5 Hz to 50.5 Hz. • **Ride-Through Band**: Safe operational profile spanning 47.5 Hz to 52 Hz. **IEGC 2023**	**ANSI 81O / 81U** Over/under frequency elements mapped to grid code operational resilience limits.
Dynamic Protection Coordination	• Mandates **adaptive protection** configurations across variable source architectures. **IEGC 2023**	**Adaptive Group Switching** Relays must auto-switch logic groups between Grid-Tied (high fault current) and Islanded (low fault current) states.
Substation & Equipment Earthing	• Requires an equipotential ground mat to safely limit step and touch potentials under worst-case fault currents. **IEEE 80**	**ANSI 50N / 51N / 67N** Sensitive earth fault protection, tailored to solid, resistive, or ungrounded configurations.
Substation Automation & Inter-Relay Comm.	• Peer-to-peer messaging using **GOOSE** protocol must feature a latency of **< 10 ms** **IEC 61850** (Parts 7-420 for DERs).	**Digital I/O & Teleprotection** Allows logic exchange for directional interlocking and real-time wide-area coordination.
Hardware Reliability & Environmental Tests	**IEC 60255 Series** (e.g., IEC 60255-26)	• Must undergo Type Testing for **Electromagnetic Compatibility (EMC)**, vibration, and thermal stress. **Physical Integrity** Ensures numeric relay hardware operates reliably inside high-interference industrial or solar environments.
Testing & Certification		

Category	Requirement Type	Indian Standard (IS) / Equivalent International Standard	Core Testing Parameters & Objective
Functional & Performance Testing	**Product & Measuring Relays**	**IS 60255 / IEC 60255 Series**	Verifies accuracy limits, pickup/drop-out ratios, and operation curves (IDMT, Definite Time).
	Application & Coordination Guide	**IS 3842**	Establishes uniform settings for overcurrent, earth fault, and directional protection.
	Adaptive Setting Groups	**CEA Grid Standards / Connectivity Regulations**	Relays must demonstrate seamless switching between **Grid-tied** and **Islanded** modes.
Grid Integration & Safety	**Anti-Islanding Protection**	**IS 16221 (Part 1) / IEC 62116**	Ensures the relay safely disconnects Distributed Energy Resources (DERs) during unintentional grid isolation.
	Voltage & Frequency Protection	**CEA Technical Standards for Connectivity**	Tests under/over voltage (59/27) and under/over frequency (81U/81O) trip limits and ride-through capabilities.
Environmental & Insulation	**Insulation Tests**	**IS 12083 (Part 2) / IEC 60255-5**	Verifies dielectric strength, insulation resistance (Megger test), and impulse voltage (typically up to 5 kV).
	Environmental & Mechanical	**IS/IEC 60255-21 / IS 9000**	Tests relay resilience against vibration, shock, seismic forces, dry heat, and cyclical humidity.
Communication Conformance	**Substation & Automation Protocols**	**IEC 61850 Conformance**	Validates fast, reliable peer-to-peer data exchange via **GOOSE messaging** for coordinated microgrid tripping.
	Cyber Security Verification	**CEA Cyber Security Guidelines**	Ensures data transmission protection and prevents unauthorised override access to relay parameters.
Mandatory Certifications	**Market Access Approval**	**BIS Compulsory Registration Scheme (CRS)**	Mandatory for selling, importing, or deploying protection relays commercially in India.
	Laboratory Testing Credit	**NABL Accreditation**	All valid type test certificates must be issued by a National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited body like the CPRI India.

9. Circuit Breakers

Low Voltage Air Circuit Breakers (LV ACBs) used in 415 V Low Tension (LT) switchgear must meet the guidelines established in the Central Electricity Authority (CEA) Technical Standards Regulations and BIS/IEC standards. These requirements dictate that 415 V LT ACBs must be fully draw-out type, trip-free, stored-energy operated, and equipped with electrical anti-pumping features.

- Voltage & Frequency:

- Nominal System Voltage: 415 V (3-Phase, 4-Wire / Solidly Earthed Neutral)
- Insulation Voltage: 1000 V AC
- Rated Impulse Withstand Voltage: 8 kV to 12 kV
- Frequency: 50 Hz (± 3% to 5%)

- Current & Short-Circuit Ratings:
  - Rated Current : 630 A to 4000 A+ (varies by panel/substation capacity)
  - Short-Circuit Breaking Capacity: 50 kA to 100 kA RMS for 1 second
  - Short-Time Withstand Current: 100% for 1 second.
- Design & Standard Compliance:
  - Operational Standard: IS/IEC 60947-2 (Utilization Category B)
  - Switchgear Enclosure: IS/IEC 61439 / IS 8623
  - Configuration: Fully Draw-out type with service, test, and disconnected positions.

Functionalities:

- Mechanical Operating Features:
  - Stored-energy spring mechanism (manual or motorized charging).
  - Electrical and mechanical anti-pumping protection.
  - Safety interlocks preventing rack-in/rack-out while breaker is closed.
- Microprocessor-Based Protection (LSIG):
  - Self-powered release offering Long-time (Overload), Short-time (Short-circuit) with delay, Instantaneous, and Ground Fault (Earth fault) protections.
  - Dual-setting protective groups and thermal memory.
- Monitoring & Grid Integration:
  - Real-time metering (V, I, kW, kVA, Frequency, Harmonics) via integrated LED/LCD displays.
  - RS485 / Modbus communication interfaces for SCADA and Smart Grid integration
- Safety Provisions:
  - Neutral pole isolation for 4-pole breakers.
  - Arc chute management to handle high-level fault currents safely.

Moulded Case Circuit Breakers (MCCBs) serve as vital protection and switching devices in low-voltage distribution networks across power generation plants, substations, and industrial power grids.

- Compliance Standard: MCCBs must comply with IS/IEC 60947-2 (Low-Voltage Switchgear and Control gear — Part 2: Circuit Breakers).
- Quality Control Order (QCO): Under Ministry of Heavy Industries guidelines, all MCCBs installed in grid

operations must carry the mandatory ISI mark.

- 415V Auxiliary Systems: Switchgear panels feeding station auxiliaries must incorporate 415V MCCBs with dual feeders (2 × 100%) for critical redundancy.
- Environmental Sizing: Sizing requires a 10% thermal margin for ambient operating temperatures between 0°C and 50°C.

Functionalities:

- Auxiliary Power Distribution: MCCBs protect low-voltage auxiliary motors, oil pumps, and cooling fans in power stations.
- Short-Circuit and Overload Protection: They employ adjustable thermal-magnetic or electronic trip mechanisms to isolate downstream electrical faults instantly.
- Grid Selectivity & Coordination: Time-graded short delays enable selective discrimination so that downstream faults do not trip upstream Air Circuit Breakers (ACBs).
- DC System Protection: Heavy-duty DC-rated MCCBs safeguard power grid battery banks, UPS units, and solar PV junction boxes.
- Remote Control & Monitoring: Integrated shunt trip coils, auxiliary contact blocks, and digital communication protocols (Modbus/IEC 61850) enable remote grid SCADA tripping.

Residual Current Circuit Breakers (RCCBs) and Earth Leakage Circuit Breakers (ELCBs) in power plants and utility systems are governed by the Central Electricity Authority Regulations on Measures Relating to Safety and Electric Supply along with relevant Bureau of Indian Standards (BIS).

- Mandatory Residual Current Protection: Under the CEA Safety Regulations, auxiliary LV systems, lighting panels, socket outlets, and low-voltage power circuits in generating stations must be protected by RCCBs or ELCBs to prevent electric shock and electrical fires caused by earth leakage.
- Grounded Neutral Conductor Identification: Neutrals must be clearly identified and earthed according to CEA Safety Mandates to ensure core balance transformers inside RCCBs accurately detect earth leakage currents without false trips.
- System Design & Earthing Integration: Power plant ground mats and substations must strictly adhere to IEEE-80 ground potential safety limits. Auxiliary power distribution boards must ensure earth continuity so that leakage currents immediately trigger protective RCCBs.

Functionalities:

1. Direct Shock & Human Life Protection: Detects minute residual earth leakage current (30 mA) and isolates power within milliseconds to prevent lethal shock hazards.
2. Fire Prevention & Insulation Fault Protection: Higher thresholds (100 - 300 mA) isolate low-level ground faults before continuous arcing can ignite insulation fires in auxiliary plant areas.
3. Core Balance Current Sensing: Operates via a Toroidal Core Balance Current Transformer (CBCT). Under normal conditions, vector sum of current IL + IN = 0. Any mismatch induces voltage in the trip coil, triggering the breaker mechanism.

4. Selective Time-Delayed Protection (S-Type): Upstream supply panels use time-delayed RCCBs to allow downstream 30 mA devices to trip first, preserving power grid selectivity and operational continuity.

Standards and Compliance

Regulatory Authority / Standard	Technical Scope	Key Compliance Requirements for Microgrid Breakers
IS/IEC 60898-1 / **IS 8828**	Low Voltage AC Miniature Circuit Breakers (MCBs)	• Mandatory **ISI marking** for Low Voltage AC applications. • Standardized short-circuit breaking capacity tests. • Strict thermal and magnetic overcurrent response limits.
IS/IEC 60947-2	Moulded Case (MCCBs) & Air Circuit Breakers (ACBs)	• Govern high-capacity industrial breaker operations. • Define critical Ultimate and Service breaking capacities. • Essential for multi-source microgrid main incomer lines.
IS 12640 (Part 1 & 2)	Residual Current Circuit Breakers (RCCBs / RCBOs)	• Crucial for detecting tiny earth-leakage faults. • **< 30 mA trip thresholds** enforced for human safety. • Mandatory under Quality Control Orders (QCO).
CEA Grid Connectivity Regulations	Technical Standards for Connectivity to the Grid	• Breakers must clear grid faults via dynamic coordination. • Support Fault Ride-Through (**LVRT/HVRT**) boundaries. • Must interface with anti-islanding schemes during grid loss.
IEC 62898-2 (ADOPTED GLOBALLY/INDIA)	Microgrids - Guidelines for Protection & Operations	• **Adaptive setting zones** for grid-tied vs. islanded modes. • Lowered overcurrent thresholds during low fault current inverter modes. • Reliable isolation timing when transitioning between operational states.

Critical Operational Requirements

1. Bidirectional & Low Fault Current Tripping

Microgrids with solar PV or battery energy storage systems (BESS) experience drastically lower fault currents when operating in islanded mode compared to when they are grid-tied. Breakers or integrated numerical relays must utilize **dual-setting groups**. This enables them to transition automatically from high-threshold grid faults to sensitive, low-threshold islanded faults without blinding the protection architecture.

2. Anti-Islanding and Grid Synchronization

Under CEA guidelines, microgrids must disconnect safely from the main distribution grid during an unscheduled blackout to protect utility personnel. Breakers operating at the Point of Common Coupling (PCC) must be coupled with relays that monitor the following system boundaries:

- **Under-voltage**: Trip if the grid falls below **85% of nominal voltage**.

- **Frequency limits**: Operational trip windows set strictly between **47.5 Hz and 50.5 Hz**.
- Normal Operating Range: 49.90 Hz to 50.05 Hz (vital for standard grid balance)
- Permissible Operating Band: 49.0 Hz to 50.5 Hz (continuous full generation allowed)
- Under-Frequency Trip Threshold: 47.5 Hz (disconnects instantly or within 0.2s if breached)
- **Reconnection Delay**: Breakers must remain locked out for a **minimum of 60 seconds** after utility grid restoration to guarantee grid stabilization.

3. Interfacing with Intelligent Electronic Devices (IEDs)

Modern microgrid setups heavily employ Solid-State Circuit Breakers (SSCBs) or smart breakers. These devices must feature rapid, microsecond-scale isolation speeds. They must also support digital protocols like **IEC 61850** to coordinate seamlessly with automated Distribution Management Systems (DMS) and SCADA setups.

Testing Protocols

To secure regulatory approval in India, manufacturers must complete rigorous verification testing:

- **Type Testing**: Done at accredited national test laboratories (e.g., CPRI or ERDA) to validate mechanical endurance, dielectric strength, and ultimate short-circuit performance.
- **Model Validation Studies**: Developers must provide dynamic system models confirming the breaker coordination scheme operates properly under simulation.
- **Pre-Commissioning Grid Checks**: Field verification of proper earthing, operational telemetry links, and localized relay trip times before final grid energization.
- **IS/IEC 60898-1:2015**: Covers low-voltage circuit breakers for overcurrent protection in household and similar installations operated by non-skilled persons.
- **IS/IEC 60947-2:2016**: Governs low-voltage switchgear and controlgear circuit breakers intended for industrial or commercial microgrid applications operated by trained personnel.

Testing and Certification

Equipment / Application Type	Governing Indian Standard (IS)	Aligned International Standard	Core Mandatory Tests Required
Low-Voltage Microgrid Breakers (MCBS UP TO 630A, ≤ 440V)	**IS/IEC 60947 Part 2**	IEC 60947-2	• Tripping characteristics • High-temperature load • Dielectric isolation • Mechanical/electrical endurance
Domestic/Commercial Infeed MCBs (FOR SMALL-SCALE LOCALIZED MICROGRIDS)	**IS/IEC 60898-1**	IEC 60898-1	• Thermal/magnetic tripping • Short-circuit performance • Resistance to abnormal heat

			& fire • Mechanical shock/impact
Medium & High Voltage Breakers (GRID INTERFACE / AGGREGATED SYSTEMS)	**IS 13118**	IEC 62271 series	• Short-time withstand current • Peak withstand current • Out-of-phase making & breaking • Capacitive current switching
DC Circuit Breakers (BATTERY ENERGY STORAGE SYSTEMS / SOLAR PV)	**IS/IEC 60947-2** (with DC Annex)	IEC 60947-2 Annex P	• DC arc-extinguishing capability • Time-constant (L/R) fault verification • Reverse-current isolation
Smart / Bi-directional Breakers (WITH MICROGRID CONTROL INTEGRATIONS)	Relevant parts of **IS/IEC 60947** + **CEA Grid Code**	IEC 61850 (PROTOCOL)	• Anti-islanding verification • Automatic remote reclosing delay • Power-quality harmonic limits

10. Cables (LT/HT)

Cables used for Low Tension (LT) and High Tension (HT) microgrid networks are subject to specific manufacturing, material, testing, and safety rules to accommodate the bi-directional flow, harmonic variations, and weather conditions typical of decentralized green energy grids.

Low Tension (LT) Cable Requirements

- **Voltage Grade:** Up to and including 1100 Volts (1.1 kV).
- **Conductor Material:** Stranded Aluminium (Grade H2/H4) or High-Conductivity Annealed Copper.
- **Insulation & Sheathing:** Extruded XLPE or PVC Type A insulation with FRLS (Flame Retardant Low Smoke) PVC outer sheath.
- **Armouring:** Galvanized steel round wire or strip armouring for multi-core configurations.
- **Governing Standards:** IS 7098 (Part 1) for XLPE or IS 1554 (Part 1) for PVC.

High Tension (HT) Cable Requirements

- **Voltage Grade:** From 3.3 kV up to 33 kV (commonly 11 kV or 33 kV grids).
- **Conductor Material:** Heavy-duty stranded Aluminium or Copper conductors.
- **Insulation & Screening:** Cross-linked polyethylene (XLPE) insulation with metallic copper tape/wire screen for uniform stress distribution.
- **Outer Sheath:** Extruded PVC, ST2, or LSZH (Low Smoke Zero Halogen) compound with UV and termite protection.
- **Governing Standards:** IS 7098 (Part 2) for heavy-duty XLPE cables.

Standards and Compliance

Cable Classification / Component	Operational Voltage / Criteria	Governing Standard (IS / IEC)	Key Technical & Compliance Requirements
LT Power Cables	Up to 1100 V (1.1 kV)	**IS 7098 (Part 1)** (XLPE) **IS 1554 (Part 1)** (PVC)	Stranded Aluminium (Grade H2) or Copper conductor. Compaction degree up to 92% for multi-core variants. Mandatory ISI certification.
HT Power Cables	3.3 kV up to 33 kV	**IS 7098 (Part 2)** **IEC 60502-2**(International)	Cross-linked Polyethylene (XLPE) or Tree-Retardant (TR-XLPE) insulation. Conductor and insulation screening required to prevent electrical stress tracking.
Solar DC Cables(Microgrid Source)	Up to 1.5 kV DC	**IS 17293** / **EN 50618**	Tinned copper conductors, electron-beam cross-linked halogen-free (XLPO) compound. Designed to resist UV radiation and harsh outdoor weather for 25+ years.
Conductors	General Material Specs	**IS 8130**	Specifies maximum DC resistance limits at 20°C. Strict mandates for plain/tinned annealed copper or EC grade aluminium.
Insulation Materials	PVC / XLPE Properties	**IS 5831**	Categorizes compound types (Type A insulation, ST1/ST2 sheaths). Dictates tensile strength, thermal stability, and aging traits.
Armouring & Mechanical Protection	Mechanical safety for buried lines	**IS 3975** **IS 7098**	Galvanized steel wire (for under 13mm diameter) or flat strip (for over 13mm) to shield buried lines from external stresses. Single-core cables must use non-magnetic armouring (Aluminium).
Fire & Sheath Compliance	Safety against grid fires	**IS 10810** / **IEC 60332**	Mandatory use of Flame Retardant Low Smoke (**FRLS**) or Low Smoke Zero Halogen (**LSZH**) outer sheaths (Type ST2) inside microgrid control stations.
Current Ratings & Derating Factors	Thermal limitations	**IS 3961 (Part 2 & 3)**	Establishes explicit derating variables based on soil thermal resistivity, ambient air temperature, laying depth, and cable grouping.

.Testing and Certification

Cable Variant & Voltage Grade	Primary Indian Standard (IS)	Type Tests (Design Validation)	Acceptance Tests (Batch Testing)	Routine Tests (100% Production Reels)
LT AC Cables (UPTO 1.1 KV)	**IS 7098 (Part 1)**(XLPE) **IS 1554 (Part 1)**(PVC)	• Tensile strength & elongation • Hot set test (XLPE) • Shrinkage & water absorption • Insulation resistance	• Conductor resistance • Thickness measurement • Tensile/Elongation checks • Hot set sample test	• Conductor DC resistance • High-voltage AC test • Visual & dimensional check

HT AC Cables (3.3 KV TO 33 KV)	**IS 7098 (Part 2)**	• Lightning impulse withstand • Partial discharge (PD) • Bending & heating cycles • Short-circuit thermal stability	• Annealing check (Copper) • Conductor resistance • Hot set test • Partial discharge check	• Conductor DC resistance • Partial discharge (PD) • High-voltage AC test
Microgrid DC Cables (UPTO 1.5 KV DC)	**IS 17293** (Solar PV applications)	• UV/Ozone weather resistance • Damp heat & acid/alkali resistance • Cold impact & low-temp bend	• Dimensional verification • Elongation & tensile limits • Hot set compliance	• Conductor DC resistance • Spark test / High Voltage test • Insulation resistance
Special Properties (ALL VOLTAGE VARIANTS)	**IS 10810**(Relevant testing parts)	• **FRLS/FS:** Flammability, Smoke density, Halogen Acid Gas emission • Anti-rodent / Anti-termite	• Oxygen index test • Temperature index test	• Visual surface verification • Sequential length marking

High Tension (HT) System-level Functions and Requirements

- **Voltage Rating**: Standardized at 11 kV (up to 33 kV for larger setups) to minimize line losses over longer microgrid distribution distances.
- **Primary Functions**: Interfacing large renewable energy plants, battery energy storage systems (BESS), and connecting to the main utility grid via HT switchgear.
- **Core Components**: Vacuum Circuit Breakers (VCB) or SF6 Circuit Breakers, Current/Voltage Transformers (CT/PT), and protection relays.
- **Regulatory/Technical Standards**: Compliance with CEA (Central Electricity Authority) guidelines and relevant IS/IEC standards (e.g., IEC 62271) for impulse voltage withstand and fault isolation.

Low Tension (LT) System-level Functions and Requirements

- **Voltage Rating**: 415V three-phase and 230V single-phase (± 10% variation tolerance at 50Hz).
- **Primary Functions**: Distributing power safely to local commercial, agricultural, or residential loads; housing Power Control Centers (PCC) and distribution boards.
- **Core Components**: Main LT panels, molded case circuit breakers (MCCB), automatic changeovers, energy meters, and capacitor banks for power factor correction.
- **Regulatory/Technical Standards**: Built to withstand local environmental conditions, compartmentalized enclosures, and adherence to standards like IEC 61439 for low-voltage assemblies.

Mandatory Testing Categories

Testing protocols for microgrid cables are divided into three distinct operational phases:

1. **Type Tests**: Mandatory design verification tests performed by an accredited laboratory (e.g., CPRI or NABL labs). According to the **CEA Type Test Guidelines**, these tests hold a **validity period of 10 years** provided no design changes are made.

2. **Acceptance Tests**: Conducted on samples selected from each manufacturing batch before delivery.
3. **Routine Tests**: Performed by the manufacturer on 100% of production lengths.

ANNEX : for Section-3

(A) Underground Cables Installation

- Low Voltage (< 650 V): Minimum burial depth of 0.75 metres.
- High Voltage (3.3 kV to 11 kV): Minimum burial depth of 0.90 metres.
- Extra High Voltage (22 kV to 33 kV and above): Minimum burial depth of 1.05 to 1.20 metres.

Underground electrical piping must withstand environmental stresses, chemical leaks, and heavy structural weights.

- High-Density Polyethylene (HDPE) Pipes: Evaluated under IS 4984 / IS 14930. These are preferred for power grids due to their flexibility, smooth interior (reducing friction during cable pulling), and high chemical resistance.
- Ductile Iron (DI) / Hume Pipes (Precast Concrete): Used primarily at crossings or where maximum physical armor is required.
- Flame Retardancy: Pipes must comply with strict fire-retardant metrics to ensure that any localized cable fault or short-circuit does not spread along the duct run.
- Bending Radius: Mechanical routing must accommodate the minimum allowable bending radius of XLPE (Cross-linked Polyethylene) insulated power cables to avoid kinking.
- Soil Surface - Warning Tape / Tile Layer (CEA Mandated)
- ~1.0m below ground - HDPE / Hume Protective Conduit with XLPE Insulated Grid Conductor inside (Smooth Interior, Thermal Dissipation, Waterproof Seal)
- Thermal Dissipation: High-voltage power grids generate significant heat. Underground conduits must be designed alongside specific backfill materials (like thermal sand) to avoid heat entrapment, preventing cable derating.
- Waterproofing and Moisture Exclusion: Grid systems must remain entirely free of waterlogging. Conduits must feature watertight joints to prevent moisture from entering, which can cause electrical treeing in high-voltage cables.
- Mechanical Shielding: Pipes safeguard fragile power and fiber-optic communication lines against soil shifts, tectonic activity, and deep excavations.
- Safety Mapping: The CEA mandates that all underground grid paths include continuous, brightly colored warning tapes or concrete protective tiles laid right above the pipes. This acts as a visual signal for future excavation work.

(B) Cable Trays Installation

- **IS 7098 / IS 1554**: Standards for PVC/XLPE power cables used in grid installations.

- **IS 2629 / IS 4759**: Indian standards governing hot-dip galvanizing process and quality testing.
- **Structural & Mechanical Strength**: Must support total working cable mass plus wind/seismic forces with a safety factor of at least 1.3 to 1.5.
- **Fire Safety & Resistance**: Must withstand temperatures up to 500°C for at least 1 hour without supporting combustion. Fire barriers or seals are mandated at wall and floor penetrations.
- **Galvanization & Corrosion Resistance**: Indoor/outdoor steel trays must be hot-dip galvanized after fabrication (minimum 2.0 mm thickness or 14/16 SWG steel). Outdoor trays require UV-stabilized coating.
- **Earthing & Grounding**: Trays must be continuously bonded with an earthing conductor (e.g., GI or copper strip) and connected directly to the station ground mat.
- **Tray Fill Factor**: Maximum cable fill capacity must not exceed 40% to 50% of the tray cross-sectional area to prevent overheating and ensure air circulation.
- **Cable Routing & Physical Protection**: Prevents mechanical damage, excessive sagging, and tension on high-voltage and control cables.
- **Thermal Management**: Ladder and ventilated perforated trays allow maximum heat dissipation, preserving current-carrying capacity.
- **Phase & Circuit Separation**: Segregates high-voltage (HV/MV) power cables, low-voltage (LV) cables, and control/instrumentation cables onto distinct tray tiers.
- **System Grounding**: Acts as a continuous secondary equipment ground loop during fault conditions.
- **Maintenance & System Upgrades**: Allows easy inspection, cable tracing, and future circuit additions without civil works.

Specification	CEA Standard Requirement
Sheet Material & Thickness	Cold rolled or hot rolled steel sheet, minimum **2.0 mm (14 SWG)**
Coating / Finish	Hot-Dip Galvanized (HDG) as per **IS 2629 / IS 4759**
Types Allowed	Ladder type, Perforated (Ventilated), Solid Bottom, and Wire Mesh
Support Spacing	Maximum **1.5 m to 2.0 m** intervals with vertical adjustability
Lateral Restraints	Installed at bends, intersections, and every **15 m** on straight runs
Drop Rod Diameter	Minimum **6 mm** diameter with double-nut trapeze clamps

(C) Exposed Cable Conduit Installation:

- Mechanical Protection & Material: Rigid metallic conduits (GI/Galvanized Iron or Stainless Steel) must be used wherever exposed cables are susceptible to mechanical impact, vibration, UV radiation, or thermal stress.

- Equipotential Bonding & Earthing: As per CEA Safety Regulations, all exposed conductive metal conduits must be continuously bonded to the main station earth mat. Grounding must prevent touch/step potentials from becoming hazardous under fault conditions.
- Ingress & Environmental Sealing: Conduits exposed to outdoor switchyards must maintain an IP65 protection rating minimum at entry boxes, termination glands, and pull boxes to prevent ingress of water, dust, and moisture.
- Fire Barrier Requirements: Fire-stop sealants or intumescent barriers must be installed where metal conduits pass through fire-rated walls, cable basements, or control room partitions to limit fire propagation.
- Corrosion Protection: Metallic conduits installed in outdoor or coastal power grid environments must be hot-dip galvanized internally and externally.

Parameter	Specification Standard	Grid Application Detail
Material Grade	IS 9537 (Part 2) / Heavy-duty rigid GI	ERW Hot-Dip Galvanized Mild Steel with smooth interior surface to prevent cable insulation abrasion.
Conduit Fill Ratio	Max 40% to 50% internal cross-section	Ensures adequate heat dissipation and prevents cable damage during pulling.
Bending Radius	Min 6× Outer Diameter (8×–10× for large sizes)	Cold-bent using mechanical benders; no crimping or flattening permitted.
Support Spacing	Every 1.0 m to 1.5 m (Max 2.0 m for large diameters)	Supported using hot-dip galvanized channel saddles, clamps, and unistrut channels.
Flexible Conduit Ends	IS 3480 / Liquid-tight flexible metallic conduit	Used at transformer terminals, motor junction boxes, and vibrating equipment.

(D) Low Voltage Cables Installation

Key Technical Specifications

- Voltage Rating: Rated for standard operational limits up to 1100 V (1.1 kV).
- Conductor Material: High-conductivity stranded electrolytic copper (per IS 613 / IS 8130) or EC grade stranded aluminium.
- Insulation Standard:
    - XLPE (Cross-linked Polyethylene): Per IS 7098 (Part 1) for higher thermal tolerance (up to 90°C continuous operation).
    - PVC Insulation: Per IS 694 (domestic/light-duty up to 1100V) and IS 1554 (Part 1) for heavy-duty power applications.
- Sheathing & Armor: Extruded inner and outer PVC sheathing (Type ST-2). Galvanized steel wire or strip armor is mandatory for direct underground burial to protect against mechanical strain.

- Flame Retardancy: Cables in sub-stations or enclosed conduits must use FR (Flame Retardant) or FRLSH (Flame Retardant Low Smoke Zero Halogen) properties.

Core CEA Installation Requirements

1. Depth and Direct Burial:
    - Underground LV cables must be laid at a minimum depth of 0.75 meters to 0.9 meters below ground level.
    - Cables must be laid over a cushion of fine sand (75 mm) and covered with protective concrete slabs or brick layers before backfilling.
2. Clearances & Separations:
    - Minimum clear distance of 0.2 meters must be maintained between parallel LV cables and communications/telecom lines.
    - A minimum vertical clearance of 0.3 meters is required when crossing other power circuits or utility pipes.
3. Earthing & Bonding:
    - All metallic armors, sheaths, and metallic cable trays/conduits must be continuously bonded and connected to an earth grid as per IS 3043 / CEA Safety Guidelines.
    - The earth resistance for the installation neutral/ground point must not exceed state DISCOM limits (typically < 5 ohms).
    - Cable entries into substations or basements must be water-sealed to prevent water logging and ingress.

Grid Functionalities & Applications

Functionality Area	Role of LV Cables	Key BIS/CEA Compliance
Secondary Distribution	Connects distribution transformer secondaries (415V 3-phase / 230V 1-phase) to end consumers.	IS 7098 Part 1
Substation Auxiliary Power	Supplies local AC/DC auxiliary power to station transformers, battery banks, and lighting.	IS 1554 Part 1
Distributed Energy (Solar PV)	Connects string inverters to low-voltage AC combiner boxes and net-meters.	CEA Connectivity Regulations 2013
Protection & Control	Transmits CT/PT signals, trip circuit signals, and interlocks to switchgear.	IS 1554 / Screened Cables

(E) Medium Voltage Cable Installation

11kV high-voltage (HV) power cables and auxiliary cables in Indian power grids must strictly comply with CEA

(Central Electricity Authority) Regulations and applicable Indian Standards (IS: 7098 Part II), and amendments thereof.

1. Specifications

- 11kV HV Power Cables:
    - Conductor: Stranded compacted circular aluminium (or copper), H4 Grade.
    - Insulation: Cross-Linked Polyethylene (XLPE) applied via single-pass triple extrusion with dry-curing. Nominal insulation thickness is 3.6 mm.
    - Screening: Extruded semi-conducting screen over the conductor (0.5 mm thick) and over insulation.
    - Armouring: Single layer of galvanized steel flat strips or round wires for 3-core cables; non-magnetic (aluminium) armouring for single-core cables.
    - Sheathing: Extruded PVC Type ST-2 or Flame Retardant Low Smoke (FRLSH) outer sheath.
- Auxiliary & Control Cables:
    - Conductor: Multi-strand annealed flexible copper, minimum 2.5 mm^2 cross-section for control and protection loops.
    - Insulation & Sheath: PVC or XLPE insulated, steel wire/strip armoured, with FRLS PVC outer sheath.

2. Technical Functionalities in Power Grids

- 11kV HV Power Cables: Transmit medium-voltage bulk electrical energy between sub-transmission substations, primary distribution networks, and industrial/commercial centers.
- Auxiliary Cables: Transmit measurement signals, control commands, interlocking logic, and protection tripping signals between switchgear, protective relays, and SCADA/RTU panels.

3. CEA Installation Requirements & Safety Standards

- Trench Depth & Clearance:
    - Direct-buried underground 11kV cables must be installed at a minimum depth of 0.9 meters (90 cm) below ground level.
    - Cables must be laid over a cushion of fine sand and covered with protective RCC tiles or bricks before backfilling.
    - Clearances from other utilities (water, gas, telecommunications) must be maintained to prevent thermal and mechanical interference.
- Overhead Clearances:
    - Minimum ground clearance for 11kV overhead insulated lines is 4.0 meters, and 5.2 meters for bare conductors.
    - Vertical safety clearance from building structures must be maintained at a minimum of 3.7 meters.
- Testing and Commissioning:
    - Insulation Resistance: Prior to energization, insulation resistance for 11kV installations must be at least

5 MΩ when tested with a High-Voltage Megger.

- Pre-commissioning Inspection: Mandatory inspection, testing, and approval by an official Electrical Inspector or designated Electrical Safety Officer under Regulation 43.

- Earthing and Shielding:
  - Metallic armouring and screens must be continuously earthed at both ends or single-point grounded per system earthing design.
  - Neutral point grounding must be effectively earthed as per network design standards.

IEC / ISO	Indian Standard	Title
IEC 811	IS-18-10810:1982	Testing cables
IEC 502	IS-7098:1985 (part 2)	LT and 3.3 - 33kVXLPE cables
IEC 502	IS - 1554:1988 (part 1)	PVC Cables .65/1.IkV
IEC 227	IS - 5819 :1970	Short circuit ratings for PVC cables
IEC 228	15-8130:1984	Conductors for insulated cables
IEC 502	IS - 6474: 1984	XLPE Cables
IEC 502		Extruded solid dielectric insulated power cables for rated voltages from 1kV to 30kV
IEC 540	IS - 5831: 1984	Test Methods for insulation and sheaths of electric cables and cords
IEC 287		Calculation of the continuous current rating of cables.
	IS - 3975 : 1979	Mild steel wires, strips and tapes for armoring of cables

Field Test Reports:

1. 11kV HV Power Cables (XLPE)

- Insulation Resistance (IR) Test: Measured using a 2.5 kV or 5 kV motorized Megger before and after the high-voltage test. Per CEA standards, the 1-minute minimum IR value for an 11kV system must be at least 5 MΩ.
- Very Low Frequency (VLF) AC High Voltage Test: This is the preferred modern site standard (0.1 Hz) to evaluate dielectric integrity without damaging the insulation structure. The test voltage is typically applied at $3 \times U_0$ (19 kV rms for an 11kV cable) for a continuous duration of 30 to 60 minutes per phase.
- Alternative DC High Voltage (Hypot) Test: If VLF equipment is completely unavailable, a DC high voltage test can be deployed. It must be carefully controlled, and the cable must be subsequently discharged through a 2 MΩ safety resistor, never directly to the ground to eradicate dangerous residual dielectric absorption charges.
- Conductor Resistance & Continuity / Phase Check: Verifies cross-sectional structural uniformness and core orientation across end terminations.

2. Cable Accessories (Joints & Terminations)

- Type Tests: All 11kV straight-through joints, outdoor terminations, and GIS-separable connectors must strictly hold valid type-test certifications from an independent NABL-accredited laboratory (such as the Central Power Research Institute - CPRI) as specified by IS 13573 (Part 2 & 3).
- Shielding & Armour Grounding: Metallic sheaths, screens, and steel wire armours must be structurally bonded and firmly earthed at designated points to eliminate risky circulating or induction currents.

3. Auxiliary and Control Cables

- Insulation Resistance: Verified using a 500 V insulation tester to confirm a minimum requirement of 1 MΩ between cores and ground.
- Point-to-Point Continuity: Checked to validate correct schematic loop routing to multi-functional control switchgear panel auxiliary switches, tripping circuit batteries, and safety interlocks.

The primary regulatory standards governing these installations are **IS 7098 (Part 1)** for LT XLPE cables, **IS 7098 (Part 2)** for HT XLPE cables, and **IS 1554 (Part 1)** for PVC insulated cables. Additionally, solar-tied microgrids often integrate **IS 17293** for specific DC connections

Schedule of Guaranteed Technical Particulars for Power Cable.
(To be furnished by the Bidder)

The particulars given in this schedule will be binding upon the contractor and must be departed from without the written permission of the General Manager / Competent authority.

Sl.No.	Description.	
1	System voltage	
2	Make of cable	
3	Type of cable.	
4	IS or other specification to which the cable is manufactured.	
5	Conductor material and its grade	
6	i) Number of wires in each conductor in nos. ii) Nominal dia of wire dia each conductor in No. X mm	
7	No.of cores and nomi8nal cross sectional area of each conductor in No. X sq.mm	
8	Shape of conductors.	
9	Core identification.	
10	Material used for insulation	
11	Total thickness of insuloation used over each conductor in mm.	
12	Specific insulation resistance of dielectric ohm-cum.	
13	Maximum thermal resistivity of dielectric in electric measure (i.e. difference in C between opposite faces of a cm. Cube of the dielectric to transfer 1 Watt of heat).	
14	Type width and thickness of screen -mm a) Conductor b) Insulation.	
15	Type of extrusion /cuing process	
16	Minimum thickness of Inner Sheath	
17	Material used for Inner Sheath.	
18	Method of application of Inner Sheath	
19	Minimum thickness of Outer Sheath in mm	
20	Material used for Outer Sheath	
21	Type and size (i.e. Nominal diameter of armour wire) of Armouring in sq.mm.	
22	Total cross sectional area of Armouring in sq.mm	
23	Calculated diameter over layuing up cores (calculated as per fictitious method to IS 10462 Part-I) in mm.	
24	Calculated diameter of cable over inner sheath in mm (calculated as per IS 10462 Part-I)	
25	Calculated diameter of cable over armouring (as per fictitious method to IS 10462 Part-I) in mm.	
26	Approximate overall diameter of ccable in mm.	
27	Approximate total weight of Aluminium	

	conductor in 1000 mtrs. Length of finished cable in Kgs.	
28	Max. thermal resistivity of outer sheath in electrical measure (i.e. difference in C between opposite face of cm. Cube of the dielectric to cause transfer of 1 watt of heath).	
29	Total length of cable for each drum in meters.	
30	Total weight of each drum length of cable in Kg.	
31	Total weight of each drum length of cable with drum	
32	Size of each drum.	
33	No.of years the design of the cable offered is in service.	
34	Continuous safe current carrying capacity for following conditions for a single cable- a) Ground temperature b) Thermal resiistivity of soil 120 C cm/w c) Depth of layuing 1070 mm.	
35	Continuous current rating in air at 40 C.	
36	Maximum permissible temperature rise of the conductor for continuous capacity.	
37	Current density under conditions stipulated in 34 above a) Duct b) Air c) Ground	
38	Insulation resistance- Meg. Ohms. Per 1000 Metres of finished cable at 20 C	
39	Coductor resistance =-ohmsper 1000 Metres of finished cable at 20 C	
40	Conductor reactance0 Ohms per 1000 Metres of finished cable at 20C	
41	Specific inductive capacity Micro-farads per 1000 Metres of finished cable at 20 C	
42	Impulse level.	
43	Positive sequence impedance of cable peer 1000 metres in ohms.	
44	Megative sequence impedance of ccable per 1000 metres in ohms.	
45	Zero sequence impedance of cable per 1000 metres in ohms.	
46	Maximum allowable assymetrical fault current to earth for 1 sec.	
47	Maximum allowable symmetrical short circuit current for a duration of one second.	

Signature of the_____

Pre-Commissioning (Site) Tests

- **Insulation Resistance (Megger Test)**: Conducted using a 5000V Megger for HT lines and 1000V for LT systems to map phase-to-phase and phase-to-earth values.
- **DC High Potential (Hi-Pot) Test**: High-voltage testing to screen out internal structural layout defects.
- **Controlled Discharging**: CEA standard 6.19.9 strictly mandates discharging high-voltage lines through a **2 Mega-ohm resistance** loop post-testing to nullify hazardous residual dielectric charge.

	Test	Requirement Reference	Test Method as a Part of IS-10810/IEC 811
(a)	**Tests on conductor**		
	Annealing test (copper)	IS-8130: 1984/IEC 502	1
	Tensile test (aluminium)	IS-8130: 1984/IEC 502	2
	Wrapping test (aluminium)	IS-8130: 1984/IEC 502	3
	Resistance test	IS-8130: 1984/IEC 502	5
(b)	**Tests for Armour wires/strips**	IS - 3975: 1979/IEC 502	36 - 42
(c)	**Tests for thickness of insulation and sheath**	IS-5831:1984/IEC 540	6
(d)	**Physical tests for Insulation**		
	Tensile strength and elongation at break	IS-5831:1984/IEC 540	7
	Ageing in air oven	IS-5831:1984/IEC 540	11
	Hot test	IS-5831:1984/IEC 540	30
	Shrinkage test	IS-5831:1984/IEC 540	12
	Water absorption (gravimetric)	IS-5831:1984/IEC 540	33
(e)	**Physical tests for outer sheath**		
	Tensile strength and elongation at break	IS-5831: 1984/IEC 540	7
	Ageing in air oven	IS-5831: 1984/IEC 540	11
	Shrinkage test	IS-5831: 1984/IEC 540	12
	Hot deformation	IS-5831: 1984/IEC 540	15
	Loss of mass in air oven	IS-5831: 1984/IEC540	10
	Heat shock	IS-5831: 1984/IEC540	14
	Thermal stability	IS-5831: 1984 IEC 540 IS-5831: 1984 Appendix B	
(f)	**Partial discharge test (11 and 33kV only)**	Section 8.2 of this specification	46
(g)	**Bending test (11 and 33kV only)**	Section 8.3 of this specification	50
(h)	**Dielectric power factor test (11 and 33kV only)** As a function of voltage As a function of temperature	Section 8.4 of this specification	48
(j)	**Insulation resistance (volume resistivity) test**	IS-8130: 1984/IEC502	43
(k)	**Heating cycle test (11 and 33kV only)**	Section 8.5 of this specification	49
(1)	**Impulse withstand test (11 and 33kV only)**	Section 8.6 of this specification	47
(m)	**High voltage test**	Section 8.6 of this specification	45
(n)	**Flammability test**	Section 8.7 of this specification	53

Tests (g), (h), (j), (1) and (m) are only applicable to screened cables.

F) Site Commissioning and Odisha Certification

5. **Electrical and Mechanical SAT:** Confirm foundation and anchoring, transport restraints, cable size and torque, DC polarity, phase sequence, insulation resistance, protective bonding, earth-grid resistance, surge protection, AC/DC segregation, interlocks, auxiliary supplies and calibrated operation of all protection devices.
6. **Integrated Safety SAT:** Functionally test smoke, gas, heat and flame detection, HVAC and ventilation trips, automatic louvres, suppression release logic, emergency stops, remote alarm transmission, shutdown sequencing and safe isolation. Conduct evacuation and emergency-response demonstrations with the Owner and local fire-safety representatives as required.
7. **Point-of-Connection Tests:** At the approved connection point, prove minimum output capability, usable energy, ramping and response performance, metering, protection coordination, anti-islanding or transfer logic, reactive-power control and power quality. Complete any utility- or grid-code-specific frequency-response and disturbance tests required by the approved scheme.
8. **Approval:** Submit approved drawings and studies, licensed-contractor completion certificate, product and system test reports, UN 38.3 summary, FAT/SAT records, calibration certificates, fire-risk assessment, O&M manuals and emergency plan. Obtain Odisha EIC/PCEI written approval before energisation where required.

G) Factory Acceptance Test (FAT), Installation, Site Acceptance Test (SAT) Commissioning

10. To provide approved and required lifting equipment, temporary and permanent structures including temporary power supply if necessary, for the installation of photovoltaic panels, inverters, and auxiliary components.
11. To deliver the routing of electrical and instrumentation cables according to the approved design of the ESS system, including cable-trays, junction boxes and/or minor civil work where necessary.
12. To provide electrical termination as per approved design.
13. To design and provide grounding and lightning protection according to local grid codes.
14. To provide site co-ordination with to obtain necessary information for the completion of the scope of work described herein, including but not limited to risk assessment, safe work procedure, site permit application, progress meeting and safety coordination with complying with local grid codes and requirements.
15. To provide testing and commissioning method statement and report.
16. To provide 3 endorsed sets of all basic design as-built documents and 1 set of soft copy.
17. CEIG Inspection: BESS safety inspection by the Odisha CEIG is legally required before energisation. They will formally audit the safe operating modes, Single Line Diagram (SLD), structural stability, and protection logic.
18. Licensed Workmanship**:** All electrical installations must be certified by a licensed electrical contractor registered directly with the Odisha State Electricity Licensing Board (ELBO).

Annexure-I

FORMAT OF MAKE-IN-INDIA DECLARATION CERTIFICATE

(In compliance to the Public Procurement (Preference to Make-in-India) Order 2017 issued by Department of Promotion of Industry and Internal Trade (Public Procurement Section), Ministry of Commerce and Industry, Government of India, dated 16.06.2020, 04.03.2021 & 19.07.2024 (as amended time to time).

To,

SRIC, IIT Bhubaneswar, Argul, Jatni 752051.

I/We **M/s**…….certifies that the following component wise breakup indicated below is in line with the Make in India policy with respect to the value addition to the total price quoted by us against this **Tender No**…….

I/We **M/s…**…….. also solemnly declare that component wise breakup given below are true and correct and understand that "false declarations will be breach of Code of Integrity under Rule 175(1)(i)(h) of General Financial Rule (GFR) for which a bidder or its successors can be debarred for up to two years as per Rule 151 (iii) of the General Financial Rules along with such other actions as may be permissible under law".

I/We **M/s**…….. also solemnly declare and understand that incase the given "data does not meet the stipulated Local content requirement and the category of the supplier changes from Class 1 to Class 2/Non-Local or from Class 2 to Non-Local, a penalty up to 10% on the contract value may be imposed".

I/We agree to provide the component-wise value (in Rs.) of the local content upon request.

Sl. No.	**Name of the Item(s)**	**Name of the manufacturer (OEM)**	**Country of Origin**	**Percent (%) Local value addition**	**Location (s) and address at which the Local value addition is made.**
1					
2					
3					
n					
Total value (in %) to the total cost					

M/s……..., hereby declare that we are a: ***(Strike out non applicable category)***

Class-1 Local Supplier: (Local content equal to or more than 50%.) **OR**

Class-2 Local Supplier: (Local content equal to or more than 20% but less than 50%.) **OR**

Non-Local Supplier: (Local content less than to 20%.)

Further, it is certified that local content is certified adhering to the following points:

i) For **Class-1 Local Supplier,** the local content shall be certified by the OEM. In case the bid value is more than Rs. 10 Crore, the declaration relating to percentage of local content shall be certified by the statutory auditor or cost auditor, if the OEM is a company and by a practicing cost accountant or a chartered accountant for OEMs other than companies as per the Public Procurement (preference to Make-in -India) order 2017 dated 04.06.2020 (amended time to time).

ii) For item(s) sold by Bidder as Re-seller, OEM Certificate for country of origin is to be submitted.

iii) Supply of Re-packaged/Re-furbished/Re-branded "IMPORTED" product should be treated as " Re-selling of imported products" and **must not be included while calculation of Local content.**

iv) Services such as Transportation, Insurance, Installation, Commissioning, and Training and after sales service support like AMC/CMC, etc. **must not be included as Local content.**

I/We hereby declare that all the details furnished above are true. If any information is found incorrect as per points mentioned above, then I/We agree to actions as per applicable Rules.

Date :

Place :

Signature of authorized signatory of the OEM/Supplier/Chartered Accountant
(with stamp & Seal)

Annexure – II

Bid-Securing Declaration Form

(Only applicable for eligible MSE/Startups bidders with valid Udyam registration/DPIIT recognition certificate)

Date: *[_____]*

Tender No.:_____

To: **SRIC, IIT Bhubaneswar, Argul – 752051, Odisha**

I/We. The undersigned, declare that:

I/We understand that, according to your conditions, bids must be supported by a Bid Securing Declaration.

I/We accept that I/We may be disqualified from bidding for any contract with you for a period of Two Year from the date of notification if I am /We are in a breach of any obligation under the bid conditions, because I/We

(a) have withdrawn/modified/amended, impairs or derogates from the GeM Bid, my/our Bid during the period of bid validity specified in the form of Bid; or

(b) having been notified of the acceptance of our Bid by the purchaser during the period of bid validity (i) fail or reuse to execute the contract, if required, or (ii) fail or refuse to furnish the Performance Security, in accordance with the Instructions to Bidders.

I/We understand this Bid Securing Declaration shall cease to be valid if I am/we are not the successful Bidder, upon the earlier of (i) the receipt of your notification of the name of the successful Bidder; or (ii) thirty days after the expiration of the validity of my/our Bid.

Signed: (insert signature of person whose name and capacity are shown) in the capacity of (insert legal capacity of person signing the Bid Securing Declaration).

Name: (insert complete name of person signing he Bid Securing Declaration)

Duly authorized to sign the bid for an on behalf of: (insert complete name of Bidder)

Dated on _____ day of _____ (insert date of signing)

Corporate Seal (where appropriate)

(Note: In case of a Joint Venture, the Bid Securing Declaration must be in the name of all partners to the Joint Venture that submits the bid).

Annexure – III

Bidder Information Form

The Bidder shall fill in this Form in accordance with the instructions indicated below. No alterations to its format shall be permitted and no substitutions shall be accepted. This should be done of the letter head of the firm]

Date: *[**insert date (as day, month and year) of Bid Submission***]

Tender No.: _____*]*

Page 1 of_____ pages

01.	Bidder's Legal Name *[insert Bidder's legal name]*
02.	In case of JV, legal name of each party: *[insert legal name of each party in JV]*
03.	Bidder's actual or intended Country of Registration: *[insert actual or intended Country of Registration]*
04.	Bidder's Year of Registration: *[insert Bidder's year of registration]*
05.	Bidder's Legal Address in Country of Registration: *[insert Bidder's legal address in country of registration]*
06.	Bidder's Authorized Representative Information Name: *[insert Authorized Representative's name]* Address: *[insert Authorized Representative's Address]* Telephone/Fax numbers: *[insert Authorized Representative's telephone/fax numbers]* Email Address: *[insert Authorized Representative's email address]*
07.	Attached are copies of original documents of: *[check the box(es) of the attached original documents]* Articles of Incorporation or Registration of firm named in 1, above.
08.	**Whether firm is MSEs Unit: YES/ NO** **If YES then please Specify the category of ownership: SC/ST or Women:** **(Please Submit the Documentary Evidence for UAM and ownership details.)**
09.	**Whether firm is Local Supplier as per Make in India Order: YES/NO** **If Yes then Please Specify: Class I or Class II** **(Please Submit the Documentary Evidence for Local Content as per Annexure I)** **Country of Origin of quoted Goods:**
10	**Bidder Undertaking: "I certify that (Name of the Bidder) is not from such a country or, if from such country, has been registered with the Competent Authority. I hereby certify that this bidder fulfils all requirements in this regard and is eligible to be considered. (Where applicable, evidence of valid registration by the Competent Authority shall be attached.)" Annexure attached.**

Signature of authorized signatory & Seal of Bidder_____

Name _____

Business Address _____

Annexure –IV

Acceptance of Terms & Conditions of Bid.

(To be given on Company Letter Head)

Dated:_____

To,
Registrar,
Indian Institute of Technology Bhubaneswar,
Argul, Jatani – 752051

Sub: Acceptance of Terms & Conditions of Bid.

Tender No: _____

Name of Bid / Work: _____

Dear Sir,

1. I/ We have downloaded / obtained the Bid document(s) for the above mentioned 'Bid/Work' from the web site(s) namely: ……..
as per your advertisement, given in the above mentioned website(s).

2. I / We hereby certify that I / we have read the entire terms and conditions of the GeM Bid documents from **Page No. _____ to _____** (including all documents like annexure(s), schedule(s), etc .,), which form part of the contract agreement and I / we shall abide hereby by the terms / conditions / clauses contained therein.

3. The corrigendum(s) issued from time to time by your department/ organisation too have also been taken into consideration, while submitting this acceptance letter.

4. I / We hereby unconditionally accept the GeM Bid conditions of above mentioned GeM Bid document(s) / corrigendum(s) in its totality / entirety.

5. I / We do hereby declare that our Firm has not been blacklisted/ debarred by any Govt. Department/Public sector undertaking.

6. I / We certify that all information furnished by the our Firm is true & correct and in the event that the information is found to be incorrect/untrue or found violated, then your department/ organisation shall without giving any notice or reason therefore or summarily reject the bid or terminate the contract, without prejudice to any other rights or remedy including the forfeiture of the full said earnest money deposit absolutely.

Yours Faithfully,

(Signature of authorized signatory of the Bidder, with Official Seal)

Annexure – V

VENDOR MASTER FORM

(To facilitate registration under PFMS and fund transfer through RTGS, NEFT/ INTRA BANK Transfer- One time information required on Bidder's letter head)

Sl No.	Information required	Data furnished
1	Name of the supplier company /firm	
2	CIN Number (in case of company)	
3	Complete contact address with PIN number	
4	Landline phone number	
5	Mobile number of contact person/ Finance Executive (for SMS on payment details)	
6	e-Mail ID (for receiving payment details)	
7	PAN Number	
8	GST Registration Number (with copy of GST registration certificate)	
9	TAN Number	
10	Bank account number (with a copy of cancelled cheque or Xerox copy of cheque leaf)	
11	Name of the Bank	
12	Name of the Bank Branch	
13	IFSC Code of Bank	
14	MICR Code of Bank	
15	Bank Account details where LC is to be opened in case of foreign suppliers (if applicable)	

I / We hereby declare that the particulars given above are correct and complete. If the transaction is delayed or credit is not effected at all for reason of incomplete or incorrect information, the Indian Institute of Technology, Bhubaneswar will not be responsible.

Authorized signatory with date and seal

Annexure –VI

MANUFACTURERS' AUTHORIZATION FORM

[The Bidder shall require the Manufacturer to fill in this Form in accordance with the instructions indicated. This letter of authorization should be on the letterhead of the Manufacturer and should be signed by a person with the proper authority to sign documents that are binding on the Manufacturer.

Date: **[insert date (as day, month and year) of Bid Submission***]*

Tender No.: _____

To: SRIC, IIT Bhubaneswar, Argul – 752051, Odisha.

WHEREAS

We *[insert complete name of Manufacturer],* who are official manufacturers of *[insert type of goods manufactured],* having factories at [***insert full address of Manufacturer's factories & % of local content & Country of Origin***], do hereby authorize ***[*insert complete name of Bidder***]*** to submit a bid the purpose of which is to provide the following Goods, manufactured by us ***[*insert name and or brief description of the Goods***]*** *,* and to subsequently negotiate and sign the Contract.

We hereby extend our full guarantee and warranty in accordance with Bid of the General Conditions of Contract, with respect to the Goods offered by the above firm.

Signed:(*insert signature(s) of Original Equipment Manufacturer (s) of the Manufacturer)*

Name: *(insert complete name)*

Title: *(insert title)*

Duly authorized to sign this Authorization on behalf of: *[insert complete name of Bidder]*

Dated on _____ day of _____, _____ *[insert date of signing]*

Annexure –VII

Undertaking regarding restrictions under Rule 144(xi) of the GFR 2017 as per GoI, Ministry of Finance, Department of Expenditure letter No F.7/10/2021-PPD and F.7/10/2021-PPD all dt 23.02.2023.

Date: _____

Tender No.: _____

To: SRIC, IIT Bhubaneswar, Argul – 752051, Odisha.

1. "I have read the clause regarding restrictions on Procurement from a bidder of a country which shares a land border with India, and on sub contracting to contractors from such countries ; I certify that _____(Name of the Bidder) is not from such a country or, if from such country, has been registered with the Competent Authority and will not sub-contract any work to a contractor from such countries unless such contractor is registered with the Competent Authority. I hereby certify that this bidder fulfils all requirements in this regard and is eligible to be considered. (Where applicable, evidence of valid registration by the Competent Authority shall be attached.)"

2. "I have read the clause regarding restrictions on Procurement from a bidder having Transfer of Technology (ToT) arrangement. I certify that _____(Name of the Bidder) does not have any TOT arrangement requiring registration with the Competent Authority."

Or

"I have read the clause regarding restrictions on Procurement from a bidder having Transfer of Technology (ToT) arrangement. I certify that _____(Name of the Bidder) has valid registration to participate in this procurement."

(Signature of the Authorized signatory of the bidder, with Official Seal & Date)

Annexure –VIII

FORMAT FOR PERFORMANCE BANK GUARANTEE

(To be typed on Non-judicial stamp paper of the value of Indian Rupees of One Hundred) (TO BE ESTABLISHED THROUGH ANY OF THE NATIONAL BANKS (WHETHER SITUATED AT BHUBANESWAR OR OUTSTATION) WITH A CLAUSE TO ENFORCE THE SAME ON THEIR LOCAL BRANCH AT BHUBANESWAR OR ANY SCHEDULED BANK (OTHER THAN NATIONALISED BANK) SITUATED AT BHUBANESWAR. BONDS ISSUED BY CO-OPERATIVE BANKS ARE NOT ACCEPTED.)

To,
Dean SRIC,
Indian Institute of Technology Bhubaneswar,
Argul, Jatani – 752051

LETTER OF GUARANTEE

WHEREAS Indian Institute of Technology Bhubaneswar (Buyer) have invited Tenders vide Tender Bid No _____ and Purchase Order/ Contract No _____, for purchase of _____ AND WHEREAS the said tender document requires that any eligible successful tenderer (seller) wishing to supply the equipment /machinery etc. in response thereto shall establish an irrevocable Performance Guarantee Bond in favour of **"SRIC, Indian Institute of Technology Bhubaneswar, Bhubaneswar"** in the form of Bank Guarantee for **Rs.**_____ and valid till _____ from the date of issue of Performance Bank Guarantee may be submitted within 30 (Thirty) days from the date of acceptance as a successful bidder.

NOW THIS BANK HEREBY GUARANTEES that in the event of the said tenderer (seller) failing to abide by any of the conditions referred in tender document / purchase order / performance of the equipment / machinery, etc. this bank shall pay to Indian Institute of Technology, Bhubaneswar on demand and without protest or demur Rs ..... (Rupees.....).

This bank further agrees that the decision of Indian Institute of Technology, Bhubaneswar (Buyer) as to whether the said Tenderer (Seller) has committed a breach of any of the conditions referred in tender document / purchase order shall be final and binding.

We, ... (name of the bank & branch) hereby further agree that the guarantee herein contained shall not be affected by any change in the constitution of the Tenderer (Seller) and/ or Indian Institute of Technology Bhubaneswar, Bhubaneswar(Buyer).

Notwithstanding anything contained herein:

1. Our liability under this Bank Guarantee shall not exceed Rs..... (Indian Rupees ..... only).

2. This Bank Guarantee shall be valid up to _____(date, ___ months from the date of Installation) and

3. We are liable to pay the guaranteed amount or any part thereof under this bank guarantee only and only if Institute serve upon us a written claim or demand on or before .....(date).

This Bank further agrees that the claims if any, against this Bank Guarantee shall be enforceable at our branch office at ..... situated at ..... (Address of local branch).

Yours truly,
Signature and seal of the guarantor:
Name of Bank:
Address:
Date:

Instructions to Bank: Bank should note that on expiry of Guarantee Period, the Original Guarantee will not be returned to the Bank. Bank is requested to take appropriate necessary action on or after expiry of bond period.

Annexure –IX

Price reasonability Declaration

(On the bidder's letterhead)

To
Indian Institute of Technology Bhubaneswar
Argul-752051, Khurda, Odisha

Ref: (i) Tender No.
(ii) In response to your bid, our offer No. …….. dt ……

Sir,

With reference to the above, this is to confirm that the price quoted for supply & installation of …… is best lowest price offered by us to IIT Bhubaneswar.

Further we certify that, we have not supplied the same equipment to any other organization with a lesser price than the offered price to IIT Bhubaneswar in past one year.

Details of the past Purchase orders (copy of same to be enclosed)				
SL. No.	**Description of the stores (item)**	**Name of Buyer**	**PO. No. & date**	**Amount**

(Signature of the Authorized signatory of the bidder)

Name of the Firm: M/s ……

Place :……...
Date:……..

Annexure –X

(To be printed on Supplier's letterhead)

INTEGRITY PACT

This pre-contract Agreement, hereinafter called the Integrity Pact, is made on ____ day of the month of _____ _____ between, on one hand, the Director of IIT Bhubaneswar acting through the Registrar/Assistant Registrar SRIC, IIT Bhubaneswar hereinafter called the "BUYER" of the First Part and M/s_____ represented by Shri _____ _____ Director /Chief Executive Officer/ General Manager hereinafter called the "BIDDER/Seller" of the Second Part.

WHEREAS the BUYER proposes to procure _____ (Name of the Stores / Equipment / Item) and the BIDDER/Seller is willing to offer/has offered the stores and WHEREAS the BIDDER is a proprietorship/private company/public company/Government undertaking/partnership/registered export agency, constituted in accordance with the relevant law in the matter and the BUYER is an Autonomous Body/Department of the Government of India performing its functions on behalf of the President of India.

NOW, THEREFORE, to avoid all forms of corruption by following a system that is fair, transparent and free from any influence/prejudiced dealings prior to, during and subsequent to the currency of the contract to be entered into with a view to Enabling the BUYER to obtain the desired said stores / equipment at a competitive price in conformity with the defined specifications by avoiding the high cost and the distortionary impact of corruption on public procurement, and Enabling BIDDERs to abstain from bribing or indulging in any corrupt practice in order to secure the contract by providing assurance to them that their competitors will also abstain from bribing and other corrupt practices and the BUYER will commit to prevent corruption, in any form, by its officials by following transparent procedures. The parties hereto hereby agree to enter into this Integrity Pact and agree as follows:

1. COMMITMENTS OF THE BUYER:

1.1 The BUYER undertakes that no official of the BUYER, connected directly or indirectly with the contract, will demand, take a promise for or accept, directly or through intermediaries, any bribe, consideration, gift, reward, favour or any material or immaterial benefit or any other advantage from the BIDDER, either for themselves or for any person, organization or third party related to the contract in exchange for an advantage in the bidding process, bid evaluation, bid award, contracting or implementation process related to the Contract.

1.2 The BUYER will, during the pre-contract stage, treat all BIDDERs alike, and will provide to all BIDDERs the same information and will not provide any such information to any particular BIDDER, which could afford an advantage to that particular BIDDER in comparison to other BIDDERs.

1.3 All the officials of the Buyer will report to the appropriate authority of the Institute for any attempted or completed breaches of the above commitments as well as any substantial suspicion of such a breach.

2. In case any such preceding misconduct on the part of such official (s) is reported by the BIDDER to the

BUYER, with full and verifiable facts and the same is prima facie found to be correct by the BUYER, necessary disciplinary proceedings, or any other action as deemed fit, including criminal proceedings may be initiated by the BUYER and such a person shall be debarred from further dealings related to the contract process. In such a case, while an enquiry is being conducted by the BUYER the proceedings under the contract would not be stalled.

3. COMMITMENTS OF BIDDERS:

3.1 The BIDDER commits itself to take all measures necessary to prevent corrupt practices, unfair means and illegal activities during any stage of its bid or during any pre-contract or post-contract stage in order to secure the contract or in furtherance to secure it and in particular commit itself to the following:

3.2 The BIDDER will not offer, directly or through intermediaries, any bribe, consideration, gift, reward, favour, any material or immaterial benefit or other advantage, commission, fees, brokerage or inducement to any official of the BUYER, connected directly or indirectly with the bidding process, or to any person, organization or third party related to the contract in exchange for any advantage in the bidding, evaluation, contracting and implementation of the Contract.

3.3 The BIDDER further undertakes that it has not given, offered or promised to give, directly or indirectly any bribe, gift, consideration, reward, favour, any material or immaterial benefit or other advantage, commission, fees, brokerage or inducement to any official of the BUYER or otherwise in procuring the Contract or forbearing to do or having done any act in relation to the obtaining or execution of the Contract or any other Contract with the Government for showing or for bearing to show favour or disfavour to any person in relation to the Contract or any other Contract with the Government.

3.4 BIDDERs shall disclose the name and address of agents and representatives and Indian BIDDERs shall disclose their foreign principals or associates.

3.5 BIDDERs shall disclose the payments to be made by them to agents / brokers or any other intermediary, in connection with this bid/contract.

3.6 The BIDDER further confirms and declares to the BUYER that the BIDDER is the original manufacturer/ integrator/ authorized government sponsored export entity of the defense stores and has not engaged any individual or firm or company whether Indian or foreign to intercede, facilitate or in any way to recommend to the BUYER, or any of its functionaries, whether officially or unofficially to the award of the contract to the BIDDER, nor has any amount been paid, promised or intended to be paid to any such individual, firm or company in respect of any such intercession, facilitation or recommendation.

3.7 The BIDDER, either while presenting the bid or during pre-contract negotiations or before signing the contract, shall disclose any payments he has made, is committed to or intends to make to officials of the BUYER or their family members, agents, brokers or any other intermediaries in connection with the contract and the details of services agreed upon for such payments.

3.8 The BIDDER will not collude with other parties interested in the contract to impair the transparency, fairness and progress of the bidding process, bid evaluation, contracting and implementation of the contract.

3.9 The BIDDER will not accept any advantage in exchange for any corrupt practice, unfair means and illegal activities.

3.10 The BIDDER shall not use improperly, for purposes of competition or personal gain, or pass on to others, any information provided by the BUYER as part of the business relationship, regarding plans, technical proposals and business details, including information contained in any electronic data carrier. The BIDDER also undertakes to exercise due and adequate care lest any such information is divulged.

3.11 The BIDDER commits to refrain from giving any complaint directly or through any other manner without supporting it with full and verifiable facts.

3.12 The BIDDER shall not instigate or cause to instigate any third person to commit any of the actions mentioned above.

3.13 If the BIDDER or any employee of the BIDDER or any person acting on behalf of the BIDDER, either directly or indirectly, is a relative of any of the officers of the BUYER, or alternatively, if any relative of an officer of the BUYER has financial interest/stake in the BIDDER's firm, the same shall be disclosed by the BIDDER at the time of filing of tender. The term relative for this purpose would be as defined in Section 6 of the Companies Act 1956/sec-2(77) of companies act,2013.

3.14 The BIDDER shall not lend to or borrow any money from or enter into any monetary dealings or transactions, directly or indirectly, with any employee of the BUYER.

4. PREVIOUS TRANSGRESSION:

4.1 The BIDDER declares that no previous transgression occurred in the last three years immediately before signing of this Integrity Pact, with any other company in any country in respect of any corrupt practices envisaged hereunder or with any Public Sector Enterprise in India or any Government Department in India, that could justify BIDDER's exclusion from the tender process.

4.2 The BIDDER agrees that if it makes an incorrect, false or misleading statement on this subject, BIDDER can be disqualified from the tender process or the contract, if already awarded, can be terminated for such a reason.

5. PERFORMANCE SECURITY:

5.1 Performance Security is mandatory / wherever it applicable

5.2 Successful tenderer/ bidder should submit performance security as prescribed above to be sent to The Registrar, IIT Bhubaneswar on or before 15 days from the due date of issue of order acknowledgement. The performance security to be furnished in the form of Insurance Security Bonds, Account Payee Demand Draft, Fixed Deposit Receipt, Performance Bank Guarantee (PBG) including e-Bank Guarantee from a commercial/nationalized/scheduled banks for an amount covering 5% of the purchase order / contract value.

5.3 The performance security should be established in favour of "The Registrar, IIT Bhubaneswar". Performance

Bank Guarantee (PBG) format is to be submitted as per the Annexure of the tender/bid documents,

5.4 The performance security shall be for the due and faithfully performance of the contract and shall remain binding, notwithstanding such variations, alterations for extensions of time as may be made, given, conceded or agreed to between the successful tenderer and the purchaser under the terms & conditions of acceptance to the tender.

5.5 The successful tenderer is entirely responsible for due performance of the contract in letter and spirit and all other documents referred to in the acceptance of tenders.

5.6 The performance security shall be kept valid during the period of contract and shall continue to be enforceable for a period of sixty days beyond the date of completion of all contractual obligations of the supplier including warranty obligations. In case performance security needs further extensions then supplier shall initiate extensions to performance security one month prior to expiry of performance security.

5.7 For successful suppliers, if performance security is not submitted within 15 days from the date of Order Acknowledgement, then the Purchase Order will be cancelled with the forfeiture of EMD.

5.8 No interest shall be payable by the buyer to the Bidder on performance security.

6. SANCTIONS FOR VIOLATIONS:

6.1 Any breach of the aforesaid provisions by the BIDDER or any one employed by it or acting on its behalf (whether with or without the knowledge of the BIDDER) shall entitle the BUYER to take all or any one of the following actions, wherever required: -

i. To immediately call off the pre-contract negotiations without assigning any reason or giving any compensation to the BIDDER. However, the proceedings with the other BIDDER(s) would continue.

ii. The Earnest Money Deposit (in pre-contract stage) and/or Security Deposit/Performance Bond (after the contract is signed) shall stand forfeited either fully or partially, as decided by the BUYER and the BUYER shall not be required to assign any reason therefore.

iii. To immediately cancel the contract, if already signed without giving any compensation to the BIDDER.

iv. To recover all sums already paid by the BUYER, and in case of an Indian BIDDER with interest thereon at 2% higher than the prevailing Prime Lending Rate of State Bank of India, while in case of a BIDDER from a country other than India with interest thereon at 2% higher than the LIBOR. If any outstanding payment is due to the BIDDER from the BUYER in connection with any other contract for any other stores, such outstanding payment could also be utilized to recover the aforesaid sum and interest.

v. To encash the advance bank guarantee and performance bond/warranty bond, if furnished by the BIDDER, in order to recover the payments, already made by the BUYER, along with interest.

vi. To cancel all or any other Contracts with the BIDDER. The BIDDER shall be liable to pay compensation for any loss or damage to the BUYER resulting from such cancellation/rescission and the BUYER shall be entitled to deduct the amount so payable from the money(s) due to the BIDDER.

vii. To debar the BIDDER from participating in future bidding processes of the Institute for a minimum period of two years, which may be further extended at the discretion of the BUYER.

viii. To recover all sums paid in violation of this pact by the BIDDER(s) to any middleman or agent or broker with a view to securing the contract.

ix. In cases where irrevocable Letters of Credit have been received in respect of any contract signed by the BUYER with the BIDDER, the same shall not be opened.

x. Forfeiture of Performance Bond in case of a decision by the BUYER to forfeit the same without assigning any reason for imposing sanction for violation of this Pact.

6.2 The BUYER will be entitled to take all or any of the actions mentioned at para 7.1(i) to (x) of this Pact also on the Commission by the BIDDER or any one employed by it or acting on its behalf (whether with or without the knowledge of the BIDDER), of an offence as defined in Chapter IX of the Bharatiya Nyaya Samhita (BNS), 2023 or Prevention of Corruption Act 1988 or any other statute enacted for prevention of corruption.

6.3 The decision of the BUYER to the effect that a breach of the provisions of this Pact has been committed by the BIDDER shall be final and conclusive on the BIDDER. However, the BIDDER can approach the CVO, IIT Bhubaneswar appointed for the purposes of this Pact.

7. **FALL CLAUSE:** The BIDDER undertakes that it has not supplied/is not supplying similar product/systems or subsystems at a price lower than that offered in the present bid in respect of any other Ministry / Department of the Government of India or PSU and if it is found at any stage that similar product/system or sub-system was supplied by the BIDDER to any other Ministry/Department of the Government of India or PSU at a lower price, then that very price, with due allowance for elapsed time, will be applicable to the present case and the difference in the cost would be refunded by the BIDDER to the BUYER, if the contract has already been concluded.

8. **INDEPENDENT EXTERNAL MONITORS (IEMs):** The BUYER has appointed the following Independent External Monitors (IEMS) as the authority to monitor all the procurement processes independently and objectively:

a) Shri Nand Lal Singh, CES (Retd.).
Address: D-2/1904 Cleo County, Sector - 121, Noida (U.P.) – 201301 E-mail: nlsingh3@gmail.com

b) Shri Amitabh Gautam, IFoS (Retd.).
Address: D6, 601 CGEWHO Kendriya Vihar, Pocket 4 Phi II Greater Noida, Uttar Pradesh – 201315
E-mail: agautamifs@gmail.com

9. **FACILITATION OF INVESTIGATION:** In case of any allegation of violation of any provisions of this Pact or payment of commission, the BUYER or its agencies shall be entitled to examine all the documents including the Books of Accounts of the BIDDER and the BIDDER shall provide necessary information & documents in English and shall extend all possible help for the purpose of such examination.

10. **LAW AND PLACE OF JURISDICTION:** This Pact is subject to Indian Law. The place of performance and Jurisdiction is the Seat of the BUYER.

11. **OTHER LEGAL ACTIONS:** The actions stipulated in this Integrity Pact are without prejudice to any other legal action that may follow in accordance with the provisions of the extant law in force relating to any civil or criminal proceedings.

12. VALIDITY:

12.1 The validity of this Integrity Pact shall be from date of its signing and extend up to 2 years or the complete execution of the contract to the satisfaction of both the BUYER and the BIDDER/ Seller, including warranty period, whichever is later. In case BIDDER is unsuccessful, this Integrity Pact shall expire after six months from the date of the signing of the contract.

12.2 Should one or several provisions of this Pact turn out to be invalid, the remainder of this Pact remains valid. In this case, the parties will strive to come to an agreement to their original intentions. The Parties hereby sign this Integrity Pact.

BUYER	BIDDER (Authorized Signatory)
The Asst. Registrar, SRIC, IIT Bhubaneswar Date & Place:	Signature with seal Date & Place:
Witness	Witness
1. _____(Indenter)	1. _____
2. _____	2. _____

Annexure –XI

Technical Specifications and Quality Assurance – Compliance
Technical Specifications and Quality Assurance)
(To be submitted as part of technical bid) (On Company Letter-head)

Tender Document No. & Date: _____

Bidder's Name: _____

Sl. No.	Ref of Technical Specification and Quality Assurance Clause	Subject	Confirmation/ Deviation/ Exception/ reservation	Justification/ Reason
1				
2				
n				

We shall comply with, abide by, and accept without variation, deviation, or reservation all Technical Specifications, Quality Assurance and Warranty requirements in the Tender Document, except those mentioned above. If mentioned elsewhere in our bid, contrary terms and conditions shall not be recognised and shall be null and void.

.....
(Signature with date)

.....
(Name and designation)

Duly authorized to sign bid for and on behalf of:

….....

[name & address of Bidder and seal of company]

DA: Relevant documents like technical data, literature, drawings, and other documents.

Annexure –XII

FORM OF BANK GUARANTEE FOR BID SECURITY (EARNEST MONEY DEPOSIT)

Bank Guarantee No.: _____ **Date:** _____

To:
The Dean (SRIC) / Registrar,
Indian Institute of Technology Bhubaneswar,
Bhubaneswar, Odisha – 751051.

WHEREAS _____ [Name and Address of the Bidder] (hereinafter called "the Bidder") has submitted its bid dated _____ in response to Tender Bid No. _____ for _____ [Description of Goods/Services/Works] (hereinafter called "the Bid").

AND WHEREAS it has been stipulated by you in the said Tender Bid documents that the Bidder shall furnish you with a Bank Guarantee issued by a Scheduled Commercial Bank for the sum specified therein as Bid Security / Earnest Money Deposit (EMD) for compliance with its obligations in accordance with the Tender Bid terms and conditions.

AND WHEREAS we, _____ [Name and Address of the Bank], having our Head Office at _____ (hereinafter called "the Bank"), have agreed to give the Bidder such a Guarantee;

NOW THEREFORE we hereby affirm that we are guarantors and responsible to you, on behalf of the Bidder, up to a total amount of _____ [Amount of the Guarantee in Figures and Words], and we undertake to pay you, upon your first written demand declaring the Bidder to be in default under any of the following conditions, without any reservation, protest, cavil, or argument:

1. If the Bidder withdraws or amends, impairs or derogates from the tender in any respect within the period of validity of its Bid; or

2. If the Bidder, having been notified of the acceptance of its Bid by the Purchaser during the period of bid validity, fails or refuses to:

   a. Execute the Contract Form, or
   b. Furnish the Performance Security in accordance with the Instructions to Bidders.

Any such demand made by IIT Bhubaneswar shall be conclusive and binding on the Bank, irrespective of any dispute or difference raised by the Bidder.
We hereby waive the necessity of your demanding the said debt from the Bidder before presenting us with the demand.

This Guarantee shall remain valid and in full force and effect for a period of **45 (forty-five) days beyond the final bid validity period** [or specify total validity in days], i.e., up to _____ [Expiry Date].
In witness whereof, the Bank, through its authorized officer, has set its hand and stamp on this _____ day of _____ 20____ at _____.

_____

(Signature of Authorized Official)
Name: _____
Designation: _____
Staff Code / Employee No.: _____
Bank Stamp / Official Seal: _____
Date: _____

Annexure-XIII

CHECK LIST

Sl. No.	Documents asked for	Documents submitted Yes/No	If Yes PDF Page Number
1.	Make & Model offered	Yes/No	
2.	EMD Details	Yes/No	
3.	Local content % & Country of Origin (Annexure-I)	_____% CoO____ Yes/No	
4.	Bid-Securing Declaration Form (Annexure-II) If applicable	Yes/No	
5.	Bidder Information Form (Annexure-III)	Yes/No	
6.	Acceptance of Terms & Conditions of Bid (Annexure-IV)	Yes/No	
7.	Vendor Master Form (Annexure-V)	Yes/No	
8.	Manufacturers' Authorization Form (Annexure-VI)	Yes/No	
9.	Undertaking regarding restrictions under Rule 144(xi) of the GFR 2017 (Annexure-VII)	Yes/No	
10.	Format For Performance Bank Guarantee (Annexure-VIII)	Yes/No	
11.	Price reasonability Declaration (Annexure-IX)	Yes/No	
12.	INTEGRITY PACT (Annexure-X)	Yes/No	
13.	Technical Specifications and Quality Assurance – Compliance (Annexure-XI)	Yes/No	
14.	Form Of Bank Guarantee For Bid Security (Earnest Money Deposit) (Annexure-XII) If used	Yes/No	
15.	Past Performance/Experience (Similar Purchase order must be submitted)	Yes/No	
16.	SME Udyam Registration/ Startup DPIIT Recognition certificate (if applicable)	Yes/No	
17.	Firm Registration certificate,	Yes/No	
18.	Firm GST Registration certificate & PAN of the firm	Yes/No	
19.	Audited Financial Statements /CA Certificate for Annual Turnover and any other documents as mentioned in eligibility criteria.	Yes/No	

Note:
Technical bid to be submitted as per above order with clearly mentioning the page number duly signed by Bidder. The specification is to be supported with Brochure and make and model of the offered product, failing which the bid may not be considered for evaluation.

(Authorized Signature of the Bidder with Date)

Digitally signed by ANKIT P BAGDE
Date: 2026.11.09 14:58:54 IST
Location: eProcure-EPROC